DAQ

PCI/PXI™-6704 User Manual

Voltage and Current Output Device
for PCI/PXI/CompactPCI Bus Computers

NATIONAL INSTRUMENTS™

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About This Manual

This manual describes the mechanical and electrical aspects of the 6704 devices and contains information concerning their configuration, installation, and operation. The 6704 devices are designed for precise DC setpoint applications and provide general-purpose digital I/O. Unless otherwise noted, text applies to both 6704 devices: the PCI-6704 and PXI-6704.

Organization of This Manual

The *PCI/PXI-6704 User Manual* is organized as follows:

- Chapter 1, *Introduction*, describes the 6704 devices, lists what you need to get started, describes software programming choices, optional equipment, and custom cables, and explains how to unpack your 6704 device.
- Chapter 2, Installation and Configuration, explains how to install and configure your 6704 device.
- Chapter 3, *Signal Connections*, provides connection instructions for the signals on your 6704 device's I/O connector.
- Chapter 4, *Hardware Overview*, contains a functional overview of the 6704 devices and explains the operation of each functional unit making up the devices.
- Chapter 5, *Calibration*, discusses the calibration procedures for your 6704 device.
- Appendix A, *Specifications*, lists specifications for the 6704 devices.
- Appendix B, *Common Questions*, contains commonly asked questions and their answers relating to usage and special features of your 6704 device.
- Appendix C, *Customer Communication*, contains forms you can use to request help from National Instruments or to comment on our products.
- The *Glossary* contains an alphabetical list and description of terms used in this manual, including abbreviations, acronyms, definitions, metric prefixes, mnemonics, symbols, and terms.
- The *Index* alphabetically lists the topics in this manual, including the page where you can find each one.

Conventions Used in This Manual

The following conventions are used in this manual:

☞	This icon to the left of bold italicized text denotes a note, which alerts you to important information.
	This icon to the left of bold italicized text denotes a warning, which advises you of precautions to take to avoid being electrically shocked.
< >	Angle brackets containing numbers separated by an ellipsis represent a range of values associated with a bit or signal name. (For example, Line<0..7> stands for Line 0 through 7.)
♦	The ♦ symbol indicates that the text following it applies only to a specific 6704 device.
bold	Bold text denotes the names of menus, menu items, or dialog box buttons or options.
bold italic	Bold italic text denotes a note, caution, or warning.
italic	Italic text denotes emphasis, a cross reference, or an introduction to a key concept.
`monospace`	Text in this font denotes text or characters that are to be literally input from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, variables, file names and extensions, and for statements and comments taken from program code.
NI-DAQ	NI-DAQ refers to the NI-DAQ driver software.

Abbreviations, acronyms, definitions, metric prefixes, mnemonics, and symbols are listed in the Glossary.

National Instruments Documentation

The *PCI/PXI-6704 User Manual* is one piece of the documentation set for your data acquisition system. You could have any of several types of documentation, depending on the hardware and software in your system. Use the different types of documentation you have as follows:

- Your DAQ hardware user manuals—These manuals have detailed information about the DAQ hardware that plugs into or is connected to your computer. Use these manuals for hardware installation and configuration instructions, specification information about your DAQ hardware, and application hints.
- Software documentation—Examples of software documentation you may have are the LabVIEW, LabWindows/CVI, Virtual Bench, Component Works, Measure, and NI-DAQ documentation. After you set up your hardware system, use either the application software or the NI-DAQ documentation to help you write your application. If you have a large, complicated system, it is worthwhile to look through the software documentation before you configure your hardware.
- Accessory installation guides or manuals—If you are using accessory products, read the terminal block and cable assembly installation guides or accessory board user manuals. They explain how to physically connect the relevant pieces of the system. Consult these guides when you are making your connections.

Customer Communication

National Instruments wants to receive your comments on our products and manuals. We are interested in the applications you develop with our products, and we want to help if you have problems with them. To make it easy for you to contact us, this manual contains comment and configuration forms for you to complete. These forms are in Appendix C, *Customer Communication*, at the end of this manual.

1 Introduction

This chapter describes the 6704 devices, lists what you need to get started, describes software programming choices, optional equipment, and custom cables, and explains how to unpack your device.

About the PCI/PXI-6704

Thank you for purchasing a National Instruments 6704 device. The 6704 devices are precise DC setpoint devices for PCI and PXI. They have a total of 32 analog output channels: 16 voltage output and 16 current output channels. The 6704 devices also have eight digital I/O lines.

You can use the 6704 devices in a wide variety of DC setpoint and digital I/O applications. With the 6704 devices, your PC system can serve as a digital I/O system controller for laboratory testing, production testing, and industrial process monitoring and control. These devices can do the following:

- Generate experimental stimuli
- Generate analog functions
- Connect to a variety of signal types, including:
  - Electromechanical relays
  - LEDs
  - Optically isolated, solid-state relays and I/O module mounting racks
  - Voltage and current excitation for precision transducers

Detailed specifications for the 6704 devices are in Appendix A, *Specifications*.

What You Need to Get Started

To set up and use your 6704 device, you will need the following:

- ❑ One of the following devices:
  - PCI-6704
  - PXI-6704
- ❑ *PCI/PXI-6704 User Manual*
- ❑ One of the following software packages and documentation:
  - ComponentWorks
  - LabVIEW for Windows
  - LabWindows/CVI for Windows
  - Measure
  - NI-DAQ for PC compatibles
  - VirtualBench
- ❑ PC with a free PCI slot or PXI chassis with a free slot
- ❑ 68-pin cable (type SH68-68-D1)
- ❑ 68-pin terminal block (type CB-68)

Unpacking

Your 6704 device is shipped in an antistatic package to prevent electrostatic damage to the device. Electrostatic discharge can damage several components on the device. To avoid such damage in handling the device, take the following precautions:

- Ground yourself via a grounding strap or by holding a grounded object.
- Touch the antistatic package to a metal part of your PC chassis before removing the device from the package.
- Remove the device from the package and inspect the device for loose components or any other sign of damage. Notify National Instruments if the device appears damaged in any way. *Do not* install a damaged device into your computer.

Never touch the exposed pins of connectors.

Software Programming Choices

There are several options to choose from when programming your National Instruments DAQ hardware. You can use LabVIEW, LabWindows/CVI, ComponentWorks, VirtualBench, or other application development environments in conjunction with NI-DAQ.

National Instruments Application Software

ComponentWorks contains tools for data acquisition and instrument control built on NI-DAQ driver software. ComponentWorks provides a higher-level programming interface for building virtual instruments through standard OLE controls and DLLs. With ComponentWorks, you can use all of the configuration tools, resource management utilities, and interactive control utilities included with NI-DAQ.

LabVIEW features interactive graphics, a state-of-the-art user interface, and a powerful graphical programming language. The LabVIEW Data Acquisition VI Library, a series of VIs for using LabVIEW with National Instruments DAQ hardware, is included with LabVIEW. The LabVIEW Data Acquisition VI Library is functionally equivalent to the NI-DAQ software.

LabWindows/CVI features interactive graphics, a state-of-the-art user interface, and uses the ANSI standard C programming language. The LabWindows/CVI Data Acquisition Library, a series of functions for using LabWindows/CVI with National Instruments DAQ hardware, is included with the NI-DAQ software kit. The LabWindows/CVI Data Acquisition Library is functionally equivalent to the NI-DAQ software.

VirtualBench features VIs that combine DAQ products, software, and your computer to create a standalone instrument with the added benefit of the processing, display, and storage capabilities of your computer. VirtualBench instruments load and save waveform data to disk in the same forms that can be used in popular spreadsheet programs and word processors.

Using ComponentWorks, LabVIEW, LabWindows/CVI, or VirtualBench software will greatly reduce the development time for your data acquisition and control application.

NI-DAQ Driver Software

The NI-DAQ driver software is included at no charge with all National Instruments DAQ hardware. NI-DAQ is not packaged with accessory products. NI-DAQ has an extensive library of functions that you can call from your application programming environment. These functions include routines for analog input (A/D conversion), buffered data acquisition (high-speed A/D conversion), analog output (D/A conversion), waveform generation, digital I/O, counter/timer operations, SCXI, RTSI, self-calibration, messaging, and acquiring data to extended memory.

NI-DAQ maintains a consistent software interface among its different versions so that you can change platforms with minimal modifications to your code. Whether you are using conventional programing languages or National Instruments application software, your application uses the NI-DAQ driver software, as illustrated in Figure 1-1.

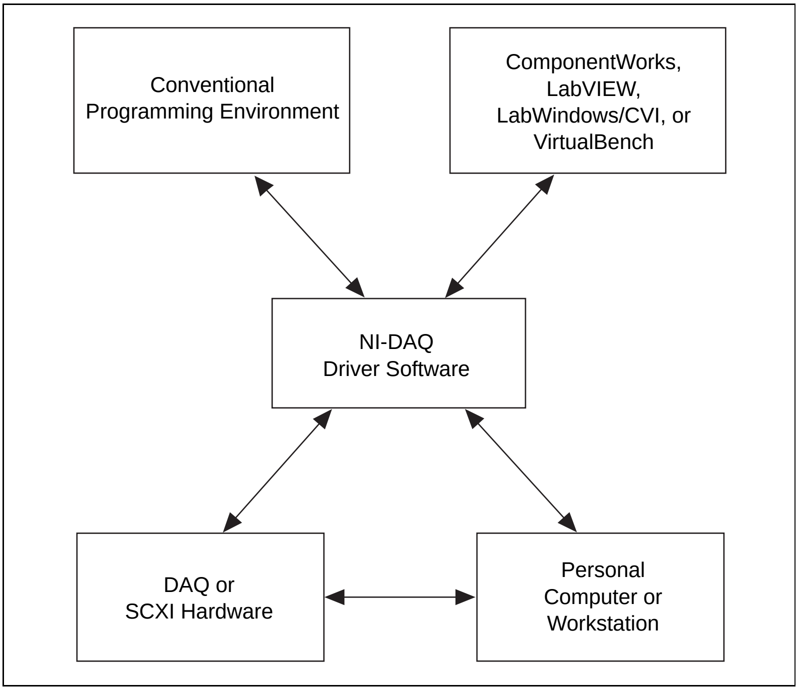

Figure 1-1. The Relationship between the Programming Environment, NI-DAQ, and Your Hardware

Optional Equipment

National Instruments offers a variety of products to use with your 6704 device, including cables, connector blocks, and other accessories, as follows:

- Cables and cable assemblies, shielded and ribbon
- Connector blocks, shielded and unshielded screw terminals

For more specific information about these products, refer to your National Instruments catalogue or call the office nearest you.

Custom Cabling

National Instruments offers cables and accessories for you to prototype your application or to use if you frequently change module interconnections.

If you want to develop your own cable, mating connectors and a backshell kit for making custom 68-pin cables are available from National Instruments (part number 776832-01).

Refer to your National Instruments catalogue for specific information.

2

Installation and Configuration

This chapter explains how to install and configure your 6704 device.

Software Installation

Install your software before you install your 6704 device. Refer to the appropriate release notes indicated below for specific instructions on the software installation sequence.

1. Install your application software—If you are using LabVIEW, LabWindows/CVI, or other National Instruments application software packages, refer to the appropriate release notes.
2. Install the NI-DAQ driver software—Refer to your NI-DAQ release notes and follow the instructions given there for your operating system and application software package.

You can now install your hardware.

Hardware Installation

You can install the 6704 device in any available expansion slot in your computer. However, to achieve best noise performance, leave as much room as possible between the 6704 device and other boards and hardware. The following are general installation instructions, but consult your computer user manual or technical reference manual for specific instructions and warnings.

♦ PCI-6704

1. Write down your PCI-6704 device serial number in the *PCI/PXI-6704 Hardware and Software Configuration Form* in Appendix C, *Customer Communication*, of this manual.
2. Turn off and unplug your computer.
3. Remove the top cover or access port to the I/O channel.
4. Remove the expansion slot cover on the back panel of the computer.

5. Insert the PCI-6704 into a 5 V PCI slot. Gently rock the device to ease it into place. It may be a tight fit, but *do not force* the device into place.
6. Screw the mounting bracket of the PCI-6704 device to the back panel rail of the computer.
7. Replace the cover.
8. Plug in and turn on your computer.

Your PCI-6704 is installed. You are now ready to configure your software. Refer to your software documentation for configuration instructions.

- PXI-6704
  1. Write down your PXI-6704 device serial number in the *PCI/PXI-6704 Hardware and Software Configuration Form* in Appendix C, *Customer Communication*, of this manual.
  2. Turn off and unplug your PXI controller.
  3. Choose an unused PXI slot in your system.
  4. Remove the filler panel for the slot you have chosen.
  5. Insert the PXI-6704 into a PXI chassis slot. Use the injector/ejector handle to fully insert the device into the chassis.
  6. Screw the front panel of the PXI-6704 to the front panel mounting rail of the system.
  7. Plug in and turn on your computer.

  Your PXI-6704 is installed. You are now ready to configure your software. Refer to your software documentation for configuration instructions.

Device Configuration

Due to the National Instruments standard architecture for data acquisition and the PCI and PXI bus specifications, 6704 devices are completely software configurable.

The PCI-6704 is fully compatible with the industry-standard *PCI Local Bus Specification Revision 2.0*, and the PXI-6704 is fully compatible with the *PXI Specification Revision 1.0*. These specifications allow the PCI and PXI systems to automatically perform all bus-related configurations and require no user interaction. Bus-related configuration includes setting the device base memory address and interrupt channel.

3

Signal Connections

This chapter provides connection instructions for the signals on your 6704 device's I/O connector.

Warning ***Connections that exceed any of the maximum ratings of input or output signals on the 6704 device can damage the 6704 device and the computer. Maximum input ratings for each signal are given in this chapter under the discussion of that signal. National Instruments is NOT liable for any damages resulting from any incorrect signal connections.***

I/O Connector Pin Assignments

Figures 3-1 shows the I/O connector pin assignments for the 6704 devices.

+5V	1	35	DGND
DIO0	2	36	DGND
DIO1	3	37	DGND
DIO2	4	38	RFU
DIO3	5	39	DGND
DIO4	6	40	RFU
DIO5	7	41	DGND
DIO6	8	42	DGND
DIO7	9	43	AGND
ICH31	10	44	VCH15
AGND15/AGND31	11	45	ICH30
VCH14	12	46	AGND14/AGND30
ICH29	13	47	VCH13
AGND13/AGND29	14	48	ICH28
VCH12	15	49	AGND12/AGND28
ICH27	16	50	AGND11/AGND27
VCH11	17	51	ICH26
AGND10/AGND26	18	52	VCH10
AGND	19	53	ICH25
AGND9/AGND25	20	54	VCH9
ICH24	21	55	AGND8/AGND24
VCH8	22	56	AGND
ICH23	23	57	VCH7
AGND7/AGND23	24	58	ICH22
VCH6	25	59	AGND6/AGND22
ICH21	26	60	VCH5
AGND5/AGND21	27	61	ICH20
VCH4	28	62	AGND4/AGND20
ICH19	29	63	VCH3
AGND3/AGND19	30	64	ICH18
VCH2	31	65	AGND2/AGND18
ICH17	32	66	VCH1
AGND1/AGND17	33	67	ICH16
VCH0	34	68	AGND0/AGND16

Figure 3-1. I/O Connector Pin Assignments

Signal Connection Descriptions

Pin	Signal Name	Description
<2..9>	DIO<0..7>	Digital Input/Output lines—Line 7 is the MSB and Line 0 is the LSB.
<35..37>, 39, 41, 42	DGND	Digital Ground—These pins are connected to the 6704 device digital ground plane. All 6704 device ground planes connect to the computer system's ground signal.
1	+5V	+5 V—This pin is connected to the computer system's +5 VDC supply through a self-resetting circuit breaker.
38, 40	RFU	Reserved for future use.
34, 66, 31, 63, 28, 60, 25, 57, 22, 54, 52, 17, 15, 47, 12, 44	VCH<0..15>	Voltage output channels.
67, 32, 64, 29, 61, 26, 58, 23, 21, 53, 51, 16, 48, 13, 45, 10	ICH<16..31>	Current output channels
68, 33, 65, 30, 62, 27, 59, 24, 55, 20, 18, 50, 49, 14, 46, 11	AGND<0/16..15/31>	Analog Grounds—Each ground pin is shared between one voltage and one current channel. These pins are connected to the 6704 device analog ground plane. All 6704 device ground planes connect to the computer system's ground signal.
19, 43, 56	AGND	Additional pins connected to analog ground.

Analog Output Signal Connections

Both voltage and current outputs are available on the 6704 devices. This section describes how to make connections for each type of output. A 68-pin cable such as the SH68-68-D1 cable is required. Figure 3-2 shows how to connect the voltage channel (VCH) outputs.

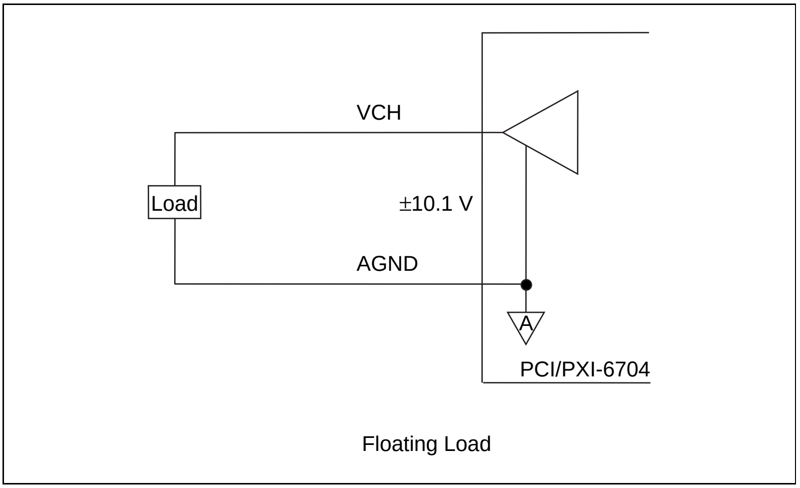

Figure 3-2. VCH Connection as a Voltage Output

Voltage Output

You can connect a floating load to your 6704 device at the voltage output channel.

Warning ***Because 6704 devices are not electrically isolated from high voltages, a load with high common mode voltages can damage the 6704 devices. National Instruments is NOT liable for any damages resulting from any such signal connections.***

Your 6704 device has a bipolar voltage range of –10.1 to +10.1 V. Maximum load current is ±10 mA for 16-bit linearity.

Power-up Condition

All voltage outputs are at their user-defined values to full accuracy within 1 s of power-up board reset.

Current Output

You can connect a floating or grounded load to your 6704 device at the current output channel. You do not need an external floating power supply to complete the controlled current loop. You can control the current loop from 0.1 to 20.2 mA. The compliance for the current loop is 0 V to 10 VDC.

Warning ***Because 6704 devices are not electrically isolated from high voltages, a load with high common mode voltages can damage the 6704 devices. National Instruments is NOT liable for any damages resulting from any such signal connections.***

Figure 3-3 shows how to connect a current channel (ICH) as a current output.

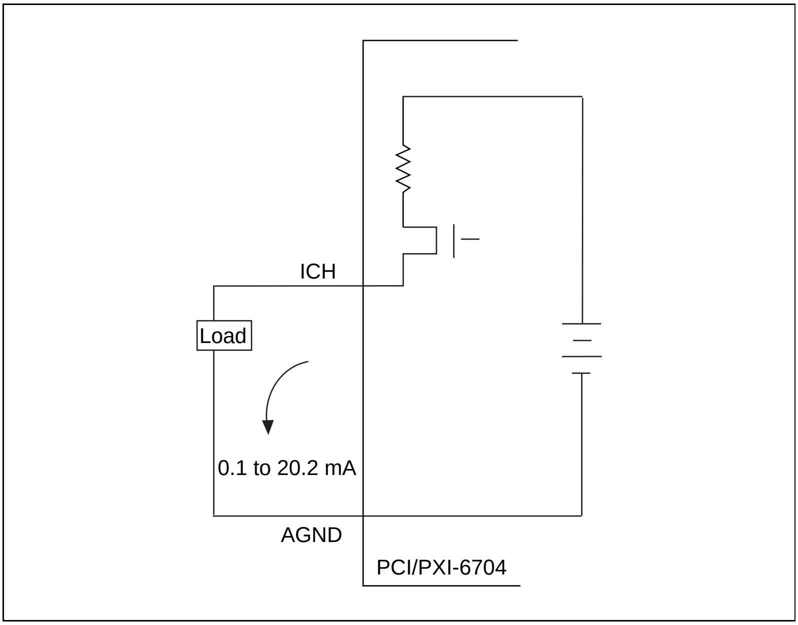

Figure 3-3. ICH Connection as a Current Output

Because each current channel shares a ground line with a voltage channel, you should try to minimize the effect of the return current from your current channel on the voltage that you are outputting on your voltage channel. For example, if you output 20 mA on a current channel and return that current to the 6704 device along the shared ground line in a cable with an impedance of 0.1 Ω, you will see a 2 mV drop in the voltage output by the voltage channel sharing the ground line. You can approach this problem in the following ways:

– Use a shorter cable to minimize the impedance of the shared ground line.
– Use separate wiring for VCH and ICH ground return to minimize common ground impedance.
– Use different pairs of voltage and current channels to keep your sensitive voltage outputs separate from your higher output current channels.

Power-up Condition

All current outputs are within ± 1.1 mA maximum of their user-defined values within 0.5 s of power-up board reset. The current outputs will settle to their user-defined values to full accuracy within 7 s of power-up board reset.

Digital I/O Signal Connections

Figure 3-4 illustrates example signal connections for three typical digital I/O applications.

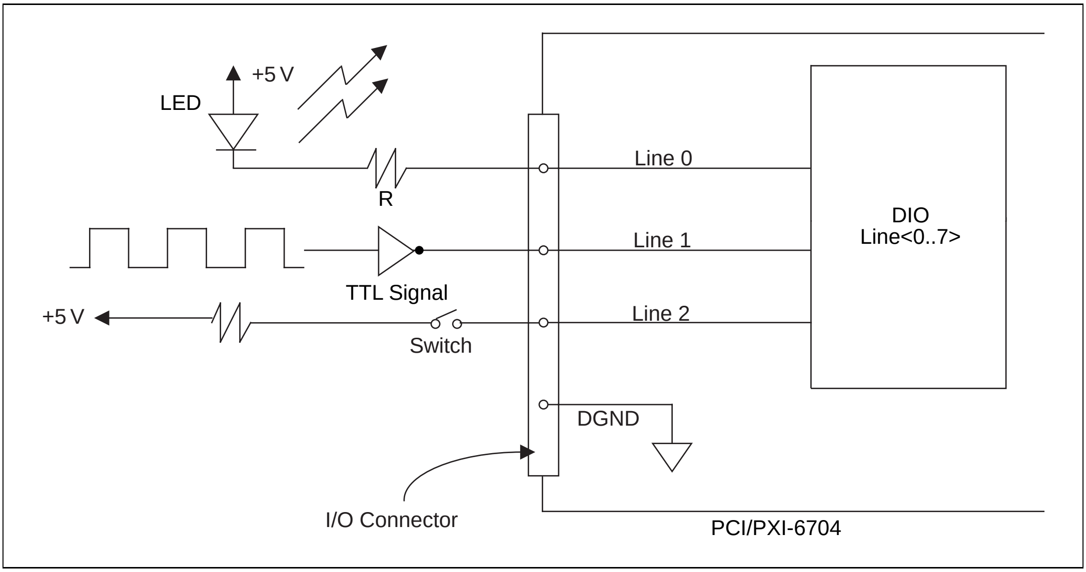

Figure 3-4. Example Digital I/O Connections

In Figure 3-4, line 0 is configured for digital output; lines 1 and 2 are configured for digital input.

Digital input applications include receiving TTL signals and sensing external device states such as the switch in Figure 3-4. Digital output applications include sending TTL signals and driving external devices such as the LED shown in Figure 3-4.

Note ***The 6704 devices allow line-by-line direction control of digital I/O connections.***

Refer to Appendix A, *Specifications*, for a list of the digital I/O signal ratings.

Power-up Condition

At power up, all of the DIO lines on the 6704 devices are configured as input lines.

Power Connections

Pin 1 on the I/O connector is connected to the +5 V supply from the PCI or PXI bus power supply. This pin is referenced to DGND and can supply power to external circuitry. The +5 V supply has a total of 0.75 A available.

The +5 V power supply has a self-resetting protection circuit breaker in series. If the circuit breaker protection is activated, simply remove the circuit causing the heavy current load and the circuit breaker will reset itself. For more information on these output pins, see the *Digital I/O* and *Power Requirement* sections in Appendix A, *Specifications*.

Power rating	0.75 A at +5 V ±10%, +4.55 to +5.25 VDC at 0.75 A

Warning ***Under no circumstances should you connect these +5 V power pins directly to ground or to any other voltage source on your 6704 device or any other device. Doing so can damage your 6704 device and your computer system. National Instruments is NOT liable for damage resulting from such a connection.***

4

Hardware Overview

This chapter contains a functional overview of the 6704 devices and explains the operation of each functional unit making up the devices.

The block diagram in Figure 4-1 illustrates the key functional components of the 6704 devices.

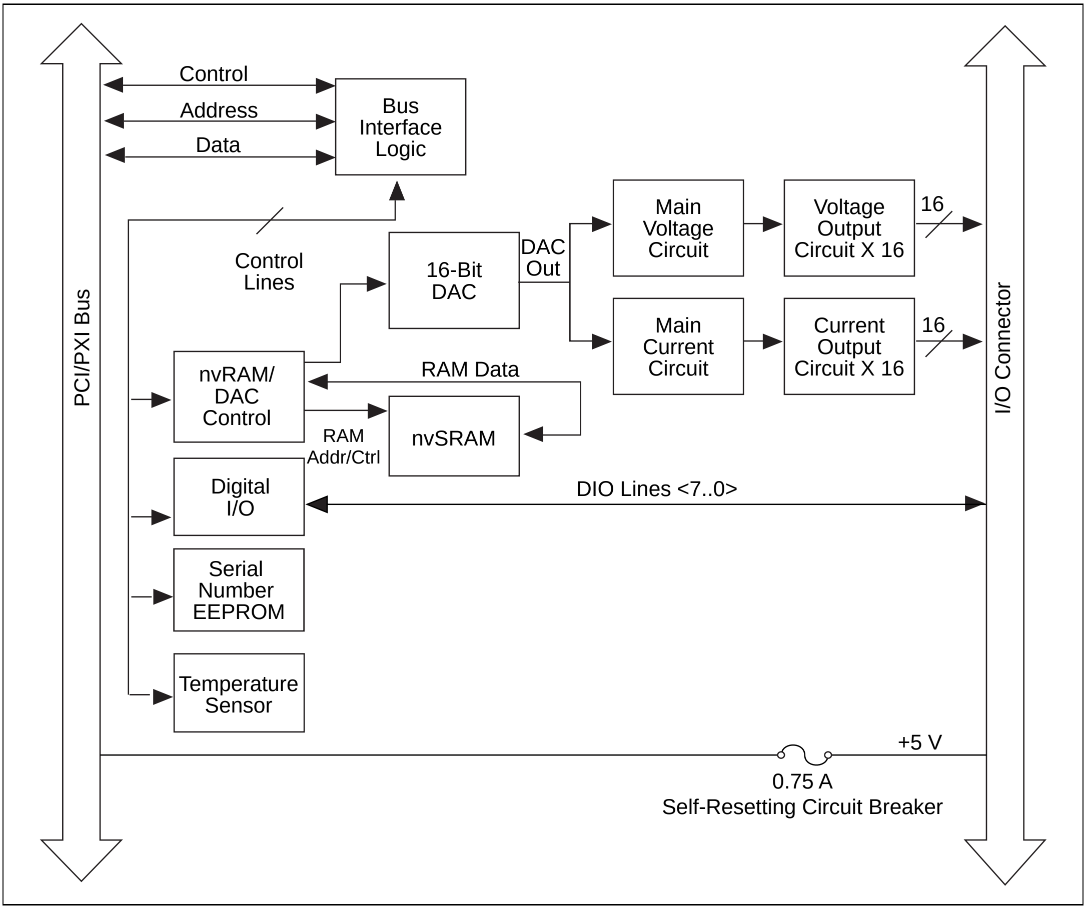

Figure 4-1. PCI/PXI-6704 Block Diagram

Bus Interface Circuitry

The bus interface circuitry monitors the PCI or PXI bus. If the bus address matches the 6704 device's address, the board is enabled and the corresponding register on the 6704 is accessed.

I/O Connector

All user I/O is transmitted through a 68-pin connector. Refer to the *Custom Cabling* section in Chapter 1, *Introduction*, and to Chapter 3, *Signal Connections*, for additional information.

Nonvolatile RAM/DAC Control

The 6704 devices have one 16-bit DAC that is time-division multiplexed to create the 16 voltage output, 16 current output, and four calibration channels. Each channel has a track-and-hold circuit to maintain the channel value between DAC updates.

Data is stored in a nonvolatile RAM (nvRAM). The nvRAM/DAC control reads the DAC channel data stored in the nvRAM and updates the DAC periodically. The nvRAM/DAC control also controls the analog demultiplexing circuits to route the DAC output to the correct analog output channel. You can choose to save nvRAM data so that the current output values will become the power-on states.

Digital I/O Control

The 6704 devices have eight digital I/O lines configured as one 8-bit port. You can configure each line independently as an input or output. The DIO lines have 16 mA of sink capability and 16 mA of source capability. All digital lines are TTL compatible. At power up, all digital lines are configured as inputs.

Temperature Sensor

The onboard temperature sensor measures the air temperature flowing over the board. This sensor is positioned near the onboard precision voltage reference, which can be affected by extreme temperatures. This sensor has a serial digital interface.

5

Calibration

This chapter discusses the calibration procedures for your 6704 device. Calibration is the process of minimizing output errors by making small circuit adjustments. On your 6704 device, you write values to four calibration channels to make these adjustments.

Self-Calibration

The 6704 devices perform continuous self-calibration. In addition to the 16 accessible voltage channels and 16 accessible current channels, there are two voltage channels and two current channels that are continuously updated and refreshed along with the others. These four channels are the voltage offset, the voltage gain, the current offset, and the current gain channels. The outputs of these four channels are compared to onboard references, and the 16-bit DACs offset and gain are adjusted to minimize the errors of the four outputs. Since 6704 devices have excellent channel-to-channel matching of offset and gain errors, minimizing the errors of the four calibration channels also minimizes the errors for all the voltage and current outputs.

External Calibration

Because of the nature of the 6704 device's calibration circuitry, the only calibration adjustment you must make is to adjust the values of the four calibration channels to account for time- or temperature-related drift of the onboard references. These four values are loaded into nonvolatile RAM at factory calibration, and you should not need to adjust them for at least one year after the date of factory calibration, unless you are operating your device at an extreme temperature.

To perform calibration, you need a voltage and current measuring device that is much more accurate than your 6704 device. A DMM with an accuracy of at least 10 ppm will generally suffice, but be sure to check its specifications. Also, be sure that no other devices are connected to your 6704 when you calibrate it to ensure that no ground loops can corrupt the calibration.

Your 6704 device contains a calibration enable bit in a control register to prevent you from accidentally writing to the calibration channels. Before you can calibrate the board, you must set this bit. If you are using NI-DAQ, calibration is enabled by calling the NI-DAQ function `Set_DAQ_Device_Info` (**deviceNumber**, **infoType**, **infoValue**) with **infoType** equal to `ND_CALIBRATION_ENABLE` and **infoValue** equal to `ND_YES`. You may then write to the calibration channels by calling `AO_VWrite` (**deviceNumber**, **chan**, **voltage**) where **char** is the calibration channel number, and **voltage** is the channel value to be written.

Table 5-1 lists the channel numbers of the calibration channels.

Table 5-1. Calibration Channel Numbers

Calibration Channel	Channel Number
Voltage offset	Channel 32
Voltage gain	Channel 34
Current offset	Channel 33
Current gain	Channel 35

Voltage Output Calibration

There are two adjustments to make for the voltage outputs: offset and gain. You should perform offset adjustment first. It is a good idea to calibrate twice, because a large change in the voltage gain channel value could impact the accuracy of the offset calibration.

Offset Adjustment

To calibrate the offset, set one of the voltage output channels to 0 V and measure it with a precise voltmeter. Then change the voltage offset channel value until the output is zero. The voltage you write to the voltage offset channel will be close to zero, and increasing it will lower the voltage you measure.

Gain Adjustment

To calibrate the gain, set the voltage output channel to a voltage near full-scale, such as +10 V. Then, change the voltage gain channel value until the output that you measure is as close as possible to the voltage that you wrote to the output channel. The voltage you write to the voltage gain channel will be close to +10 V, and increasing it will lower the magnitude of the voltage you measure.

You can also calibrate using several output channels, instead of just one, by averaging channels together. Do this by writing the values to all the channels you wish to average and using a resistive averaging circuit to average the outputs. This will reduce the sensitivity of the calibration process to interchannel mismatch—the slight differences in the output characteristics of the channels by averaging out these differences.

Current Output Calibration

There are two adjustments to make for the current outputs: offset and gain. You should perform offset adjustment first. It is a good idea to calibrate twice, because a large change in the current gain channel value could impact the accuracy of the offset calibration.

Offset Adjustment

To calibrate the offset, set one of the current output channels to 100 µA and measure it with a precise ammeter. Then, change the current offset channel value until the output is as close as possible to 100 µA. The current you write to the current offset channel will be close to 10 µA, and increasing it will lower the current you measure.

Gain Adjustment

To calibrate the gain, set the current output channel to a current near full-scale, such as 20 mA. Then, change the current gain channel value until the output that you measure is as close as possible to the current that you wrote to the output channel. The current you write to the current gain channel will be close to 19.608 mA, and increasing it will lower the current you measure.

You can also calibrate using several output channels instead of just one by adding channels together. Do this by writing the values to all the channels you wish to add and summing the outputs by connecting them together. This will reduce the sensitivity of the calibration process to interchannel mismatch—the slight differences in the output characteristics of the channels by averaging out these differences

Saving Calibration Values

When you have finished calibration, you will want to write your calibration values into nonvolatile RAM. This will ensure that your new calibration values are permanently saved and automatically loaded when the card is powered-on. Calibration values are saved and restored through the `AO_Calibrate` (**deviceNumber**, **operation**, **EEPROMloc**) function call in NI-DAQ. To save your calibration values, make the following call: `AO_Calibrate` (**deviceNumber**, 2, 1), where **deviceNumber** refers to the device number assigned by the NI-DAQ Configuration Utility. If you need to restore the factory calibration values, load them by calling `AO_Calibrate` (**deviceNumber**, 1, 5). For more information, consult the *NI-DAQ Function Reference Manual*.

A

Specifications

This appendix lists specifications for 6704 devices. These specifications are valid for an ambient temperature of 0° to 55° C, unless otherwise stated.

Analog Output

Number of voltage channels 16

Number of current channels 16

Resolution 16-bit

Recommended warm-up time .... 15 minutes

Transfer Characteristics

INL .... ±1 LSB max

DNL .... ±1 LSB max

Monotonicity.. 16 bits, guaranteed

Voltage Output

Range .... ±10.1 V

Output coupling...................................... DC

Output impedance .... 0.1 Ω max

Current drive .... ±10 mA max

Load capacitance.................................... 10,000 pF max

Protection .... Short-circuit to ground

Absolute accuracy .... ±1 mV max

Noise ....100 µV rms, DC to 1 MHz

Power-up state ....Independent, user-defined values

Current Output

Range ....0.1 to 20.2 mA

Type ....Source, does not require external excitation source

Output impedance..................................1 GΩ min

Output compliance.................................0 to 10 V

Absolute accuracy..................................±2 µA max

Noise ....1 µA rms, DC to 1 MHz

Protection...Short-circuit and open circuit

Power-up state ....Independent, user-defined values

Dynamic Characteristics

Settling time (including channel latency)

Accuracy	Time
±0.1%	1.8 ms typ, 5.6 ms max
±0.01%	3.6 ms typ, 11.2 ms max
±0.001%	14.4 ms typ, 48.8 ms max

Stability

Offset temperature coefficient

voltage ....5 µV/ ºC

current...10 nA/ ºC

Gain temperature coefficient

voltage ....1 ppm/ ºC

current...2 ppm/ ºC

Digital I/O

Number of channels .... 8 I/O

Compatibility .... TTL

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

Digital logic levels

Level	Min	Max
Input low voltage	—	0.8 V
Input high voltage	2.0 V	—
Output low voltage	—	0.45 V, I_{OL} = 16 mA
Output high voltage	2.4 V, I_{OH} = 16 mA	—
Input leakage current	—	10 µA

Bus Interface

Type .... Slave

Power Requirement

+5 V.. 1 A

+12 V.. 70 mA

–12 V.. 70 mA

☞ **Note** ***These power usage figures do not include the power used by external devices that are connected to the fused supply present on the I/O connector. They assume that all voltage and current outputs are fully loaded.***

Physical

Dimensions (not including connectors)
PCI-6704..9.9 by 17.5 cm (3.9 by 6.9 in)
PXI-6704 ....10 by 16 cm (3.9 by 6.3 in)

I/O connector ....68-pin male

Environment

Operating

Temperature..0° to 55° C ambient

Relative humidity ....5% to 90% noncondensing

Storage

Temperature..–20° to 70° C ambient

Relative humidity ....5% to 90% noncondensing

B

Common Questions

This appendix contains commonly asked questions and their answers relating to usage and special features of your 6704 device.

General Information

1. **What if I short-circuit the power supply on the 6704 connector?**

   Pin 1 of the I/O connector is connected to the +5 V supply from the PCI or PXI bus power supply. This pin is referenced to GND and can be used to power external circuitry. The +5 V supply has a total of 0.75 A available.

   This power supply has a self-resetting protection circuit breaker in series. If the circuit breaker protection is activated, simply remove the circuit causing the heavy current load and the circuit breaker will reset itself. For more information on this output pin, see the *Power Requirement* section in Appendix A, *Specifications*.

Installation and Configuration

2. **Which National Instruments document should I read first to get started using DAQ software?**

   The release notes document for your application or driver software is always the best starting place.

3. **What version of NI-DAQ must I have to program my 6704 device?**

   You must have NI-DAQ for PC compatibles version 6.5 or higher for your 6704 device.

4. **What is the best way to test my device without having to program it?**

   The NI-DAQ Configuration Utility has a **Test** menu with some excellent tools for doing simple functional tests of the device, such as testing the digital I/O lines. Also, the **Test Configuration** option will verify that the logical address for the device is current.

Timing and Digital I/O

5. **What are the power-on states of the DIO lines on the I/O connector?**

   At system power-on and reset, all lines are configured as inputs. Refer to the *Digital I/O Control* section in Chapter 4, *Hardware Overview*, for more information.

Analog Output

6. **What are the power-on states of the voltage and current outputs?**

   At system power-on and reset, all analog outputs are at the values you last saved.

7. **How fast do the 6704 devices scan channels?**

   The 6704 devices have one 16-bit DAC that is time-division multiplexed to create the 16 voltage output, 16 current output, and four calibration output channels. The channels are scanned at a rate of 50 µs per channel, thus a channel can change value a maximum of 1.8 ms after it has been updated by software.

8. **How are the voltage and current outputs related?**

   They are completely independent of each other.

C

Customer Communication

For your convenience, this appendix contains forms to help you gather the information necessary to help us solve your technical problems and a form you can use to comment on the product documentation. When you contact us, we need the information on the Technical Support Form and the configuration form, if your manual contains one, about your system configuration to answer your questions as quickly as possible.

National Instruments has technical assistance through electronic, fax, and telephone systems to quickly provide the information you need. Our electronic services include a bulletin board service, an FTP site, a fax-on-demand system, and e-mail support. If you have a hardware or software problem, first try the electronic support systems. If the information available on these systems does not answer your questions, we offer fax and telephone support through our technical support centers, which are staffed by applications engineers.

Electronic Services

Bulletin Board Support

National Instruments has BBS and FTP sites dedicated for 24-hour support with a collection of files and documents to answer most common customer questions. From these sites, you can also download the latest instrument drivers, updates, and example programs. For recorded instructions on how to use the bulletin board and FTP services and for BBS automated information, call 512 795 6990. You can access these services at:

United States: 512 794 5422
Up to 14,400 baud, 8 data bits, 1 stop bit, no parity

United Kingdom: 01635 551422
Up to 9,600 baud, 8 data bits, 1 stop bit, no parity

France: 01 48 65 15 59
Up to 9,600 baud, 8 data bits, 1 stop bit, no parity

FTP Support

To access our FTP site, log on to our Internet host, `ftp.natinst.com`, as `anonymous` and use your Internet address, such as `joesmith@anywhere.com`, as your password. The support files and documents are located in the `/support` directories.

Fax-on-Demand Support

Fax-on-Demand is a 24-hour information retrieval system containing a library of documents on a wide range of technical information. You can access Fax-on-Demand from a touch-tone telephone at 512 418 1111.

E-Mail Support (Currently USA Only)

You can submit technical support questions to the applications engineering team through e-mail at the Internet address listed below. Remember to include your name, address, and phone number so we can contact you with solutions and suggestions.

`support@natinst.com`

Telephone and Fax Support

National Instruments has branch offices all over the world. Use the list below to find the technical support number for your country. If there is no National Instruments office in your country, contact the source from which you purchased your software to obtain support.

Country	Telephone	Fax
Australia	03 9879 5166	03 9879 6277
Austria	0662 45 79 90 0	0662 45 79 90 19
Belgium	02 757 00 20	02 757 03 11
Brazil	011 288 3336	011 288 8528
Canada (Ontario)	905 785 0085	905 785 0086
Canada (Québec)	514 694 8521	514 694 4399
Denmark	45 76 26 00	45 76 26 02
Finland	09 725 725 11	09 725 725 55
France	01 48 14 24 24	01 48 14 24 14
Germany	089 741 31 30	089 714 60 35
Hong Kong	2645 3186	2686 8505
Israel	03 6120092	03 6120095
Italy	02 413091	02 41309215
Japan	03 5472 2970	03 5472 2977
Korea	02 596 7456	02 596 7455
Mexico	5 520 2635	5 520 3282
Netherlands	0348 433466	0348 430673
Norway	32 84 84 00	32 84 86 00
Singapore	2265886	2265887
Spain	91 640 0085	91 640 0533
Sweden	08 730 49 70	08 730 43 70
Switzerland	056 200 51 51	056 200 51 55
Taiwan	02 377 1200	02 737 4644
United Kingdom	01635 523545	01635 523154
United States	512 795 8248	512 794 5678

Technical Support Form

Photocopy this form and update it each time you make changes to your software or hardware, and use the completed copy of this form as a reference for your current configuration. Completing this form accurately before contacting National Instruments for technical support helps our applications engineers answer your questions more efficiently.

If you are using any National Instruments hardware or software products related to this problem, include the configuration forms from their user manuals. Include additional pages if necessary.

Name ____

Company ____

Address ____

____

Fax (___) ________________ Phone (___) ______________________________

Computer brand____________ Model ________________ Processor ________________

Operating system (include version number) ______________________________________

Clock speed ______MHz RAM _____MB Display adapter __________________________

Mouse ___yes ___no Other adapters installed________________________________

Hard disk capacity _____MB Brand____

Instruments used ____

____

National Instruments hardware product model _____________ Revision ______________

Configuration ____

National Instruments software product ________________ Version _________________

Configuration ____

The problem is: ____

____

____

____

____

List any error messages: ____

____

____

The following steps reproduce the problem: _______________________________

____

____

____

____

PCI/PXI-6704 Hardware and Software Configuration Form

Record the settings and revisions of your hardware and software on the line to the right of each item. Complete a new copy of this form each time you revise your software or hardware configuration, and use this form as a reference for your current configuration. Completing this form accurately before contacting National Instruments for technical support helps our applications engineers answer your questions more efficiently.

National Instruments Products

6704 device serial number ____

Interrupt level of 6704 device ____

Base memory address of hardware ____

Programming choice ____

National Instruments software ____

Other boards in system ____

Base I/O address of other boards ____

Interrupt level of other boards ____

Other Products

Computer make and model ____

Microprocessor ____

Clock frequency or speed ____

Type of video board installed ____

Operating system version ____

Operating system mode ____

Programming language ____

Programming language version ____

Other boards in system ____

Base I/O address of other boards ____

Interrupt level of other boards ____

Documentation Comment Form

National Instruments encourages you to comment on the documentation supplied with our products. This information helps us provide quality products to meet your needs.

Title: *PCI/PXI-6704 User Manual*

Edition Date: September 1998

Part Number: 322110A-01

Please comment on the completeness, clarity, and organization of the manual.

____

____

____

____

____

____

____

If you find errors in the manual, please record the page numbers and describe the errors.

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Thank you for your help.

Name _______________________________________

Title _______________________________________

Company ____________________________________

Address ____________________________________

____

E-Mail Address ______________________________

Phone (___) ____________________ Fax (___) ____________________

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Fax to: Technical Publications
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512 794 5678

Glossary

Prefix	Meaning	Value
n-	nano-	10^{-9}
μ-	micro-	10^{-6}
m-	milli-	10^{-3}
k-	kilo-	10^{3}
M-	mega-	10^{6}
G-	giga-	10^{9}

Numbers/Symbols

°	degrees
–	negative of, or minus
Ω	ohms
/	per
%	percent
±	plus or minus
+	positive of, or plus

A

A	amperes
A/D	analog-to-digital
ANSI	American National Standards Institute
API	application programming interface

B

base address	a memory address that serves as the starting address for programmable registers. All other addresses are located by adding to the base address.
bit	one binary digit, either 0 or 1
bus	the group of conductors that interconnect individual circuitry in a computer. Typically, a bus is the expansion vehicle to which I/O or other devices are connected.
byte	eight related bits of data, an eight-bit binary number. Also used to denote the amount of memory required to store one byte of data.

C

C	Celsius
channel	pin or wire lead to which you apply or from which you read the analog or digital signal. Analog signals can be single-ended or differential. For digital signals, you group channels to form ports. Ports usually consist of either four or eight digital channels.

D

D/A	digital-to-analog
DAC	D/A converter
DAQ	data acquisition—(1) collecting and measuring electrical signals from sensors, transducers, and test probes or fixtures and inputting them to a computer for processing; (2) collecting and measuring the same kinds of electrical signals with A/D and/or DIO boards plugged into a computer, and possibly generating control signals with D/A and/or DIO boards in the same computer
DC	direct current

default setting	a default parameter value recorded in the driver. In many cases, the default input of a control is a certain value (often 0) that means use the current default setting. For example, the default input for a parameter may be *do not change current setting*, and the default setting may be *no AMUX-64T boards*. If you do change the value of such a parameter, the new value becomes the new setting. You can set default settings for some parameters in the configuration utility or by manually using switches located on the device.
device	(1) a plug-in data acquisition board, card, or pad that can contain multiple channels and conversion devices. Plug-in boards, PCMCIA cards, and devices such as the DAQPad-1200, which connects to your computer parallel port, are all examples of DAQ devices.
digital input group	a collection of digital input ports. You can associate each group with its own clock rates, handshaking modes, buffer configurations, and so on. A port cannot belong to more than one group.
digital output group	a collection of digital output ports. You can associate each group with its own clock rates, handshaking modes, buffer configurations, and so on. A port cannot belong to more than one group.
DIO	digital input/output
DLL	Dynamic Link Library—A software module in Microsoft Windows containing executable code and data that can be called or used by Windows applications or by other DLLs. Functions and data in a DLL are loaded and linked at run time when they are referenced by a Windows application or other DLLs.
DRAM	Dynamic RAM
drivers/driver software	software that controls a specific hardware device such as a DAQ board
dynamic configuration	a method of automatically assigning logical addresses to PCI devices at system startup or other configuration times
dynamic range	the ratio of the largest signal level a circuit can handle to the smallest signal level it can handle (usually taken to be the noise level), normally expressed in decibels

E

EPROM	Erasable Programmable Read-Only Memory (ROM) that can be erased electrically and reprogrammed
EEPROM	Electrically Erasable Programmable Read-Only Memory (ROM) that can be erased (usually by ultraviolet light exposure) and reprogrammed

F

floating signal sources	signal sources with voltage signals that are not connected to an absolute reference or system ground. Also called nonreferenced signal sources. Some common examples of floating signal sources are batteries, transformers, or thermocouples.
function	a set of software instructions executed by a single line of code that may have input and/or output parameters and returns a value when executed.

G

GND	ground signal or bit

H

hardware	the physical components of a computer system, such as the circuit boards, plug-in boards, chassis, enclosures, peripherals, cables, and so on
hex	hexadecimal
Hz	hertz—the number of scans read or updates written per second

I

IC	integrated circuit
in.	inches
INL	Integral Nonlinearity—a measure in LSB of the worst-case deviation from the ideal A/D or D/A transfer characteristic of the analog I/O circuitry

interrupt	a computer signal indicating that the CPU should suspend its current task to service a designated activity
interrupt level	the relative priority at which a device can interrupt
I/O	Input/output—the transfer of data to/from a computer system involving communications channels, operator interface devices, and/or data acquisition and control interfaces
I_{OH}	current, output high
I_{OL}	current, output low

K

KB	kilobytes—1,024 bytes when referring to memory
kS	1,000 samples

L

LED	light-emitting diode
LSB	least significant bit

M

m	meters
MB	megabytes of memory
MSB	most significant bit
multitasking	a property of an operating system in which several processes can be run simultaneously

N

NC	normally closed, or not connected
NI-DAQ	National Instruments driver software for DAQ hardware

noise	an undesirable electrical signal—Noise comes from external sources such as the AC power line, motors, generators, transformers, fluorescent lights, soldering irons, CRT displays, computers, electrical storms, welders, radio transmitters, and internal sources such as semiconductors, resistors, and capacitors. Noise corrupts signals you are trying to send or receive.
nvRAM	nonvolatile RAM

O

operating system	base-level software that controls a computer, runs programs, interacts with users, and communicates with installed hardware or peripheral devices
output limits	the upper and lower voltage or current outputs for an analog output channel. The output limits determine the polarity and voltage reference settings for a board.
output settling time	the amount of time required for the analog output voltage to reach its final value within specified limits

P

PC	personal computer
port	(1) a communications connection on a computer or a remote controller (2) a digital port, consisting of four or eight lines of digital input and/or output.
ppm	parts per million

R

RAM	random access memory
resolution	the smallest signal increment that can be detected by a measurement system. Resolution can be expressed in bits, in proportions, or in percent of full scale. For example, a system has 12-bit resolution, one part in 4,096 resolution, and 0.0244 % of full scale.
RTSI	Real-Time System Integration

S

s	seconds
settling time	the amount of time required for a voltage to reach its final value within specified limits
slot	a position where a module can be inserted into the PCI bus
system RAM	RAM installed on a personal computer and used by the operating system, as contrasted with onboard RAM

T

transfer rate	the rate, measured in bytes/s, at which data is moved from source to destination after software initialization and set up operations; the maximum rate at which the hardware can operate
TTL	transistor-transistor logic

U

update	the output equivalent of a scan. One or more analog or digital output samples. Typically, the number of output samples in an update is equal to the number of channels in the output group. For example, one pulse from the update clock produces one update which sends one new sample to every analog output channel in the group.
update rate	the number of output updates per second

V

V	volts
VDC	volts direct current
VI	Virtual Instrument—(1) a combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument (2) a LabVIEW software module (VI), which consists of a front panel user interface and a block diagram program

W

W	watts

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