IMAQ™

IMAQ PCI/PXI™-1407 User Manual

High-Quality Monochrome Image Acquisition Boards
for PCI, PXI, and CompactPCI Bus

NATIONAL INSTRUMENTS™

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This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Notices to User: ***Changes or modifications not expressly approved by National Instruments could void the user's authority to operate the equipment under the FCC Rules.***

This device complies with the FCC rules only if used with shielded interface cables of suitable quality and construction. National Instruments used such cables to test this device and provides them for sale to the user. The use of inferior or nonshielded interface cables could void the user's authority to operate the equipment under the FCC rules.

If necessary, consult National Instruments or an experienced radio/television technician for additional suggestions. The following booklet prepared by the FCC may also be helpful: *Interference to Home Electronic Entertainment Equipment Handbook.* This booklet is available from the U.S. Government Printing Office, Washington, DC 20402.

Canadian Department of Communications

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

Contents

About This Manual

Chapter 1
Introduction

Chapter 2
Installation

Chapter 3
Hardware Overview

Chapter 4
Signal Connections

Appendix A
Specifications

Appendix B
Customer Communication

Glossary

Index

Figures

Tables

About This Manual

The *IMAQ PCI/PXI-1407 User Manual* describes the features, functions, and operation of the IMAQ PCI/PXI-1407.

The PCI-1407 and PXI-1407 devices are high-accuracy, monochrome image acquisition (IMAQ) boards for PCI, PXI, and CompactPCI chassis that support RS-170 and CCIR video standards. The *IMAQ PCI/PXI-1407 User Manual* is intended for users with a basic knowledge of image acquisition.

Organization of This Manual

The *IMAQ PCI/PXI-1407 User Manual* is organized as follows:

- Chapter 1, *Introduction*, describes the IMAQ PCI-1407 and PXI-1407 devices; lists what you need to get started; describes software programming choices, optional equipment, and custom cables; and explains how to unpack and set up your PCI/PXI-1407.
- Chapter 2, *Installation*, explains how to install your PCI/PXI-1407.
- Chapter 3, *Hardware Overview*, presents an overview of the hardware functions on your PCI/PXI-1407 and explains the operation of each functional unit making up the PCI/PXI-1407.
- Chapter 4, *Signal Connections*, describes cable connections for the PCI/PXI-1407.
- Appendix A, *Specifications*, lists the specifications of the PCI-1407 and PXI-1407.
- Appendix B, *Customer Communication*, contains forms you can use to request help from National Instruments or to comment on our products and manuals.
- The *Glossary* contains an alphabetical list and description of terms used in this manual, including abbreviations, acronyms, metric prefixes, mnemonics, and symbols.
- The *Index* contains an alphabetical list of key terms and 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.

italic — Italic text denotes emphasis, a cross reference, or an introduction to a key concept. This font also denotes text for which you supply the appropriate word or value, such as in Windows 3.*x*.

bold italic — Bold italic text denotes a note, caution, or warning.

National Instruments Documentation

The *IMAQ PCI/PXI-1407 User Manual* is one piece of the documentation set for your image acquisition system. You could have any of several types of manuals, depending on the hardware and software in your system. Use the different types of manuals you have as follows:

- Software documentation—You may have both application software and NI-IMAQ software documentation. National Instruments application software includes LabVIEW and LabWindows/CVI. After you set up your hardware system, use either the application software (LabVIEW or LabWindows/CVI) documentation, or the NI-IMAQ documentation to help you write your application. If you have a large and 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.

Related Documentation

The following documents contain information that you may find helpful as you read this manual:

- Your computer technical reference manual
- *PCI Local Bus Specification, Revision 2.1*

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 B, *Customer Communication*, at the end of this manual.

1

Introduction

This chapter describes the IMAQ PCI-1407 and PXI-1407 devices; lists what you need to get started; describes software programming choices, optional equipment, and custom cables; and explains how to unpack and set up your PCI/PXI-1407.

About Your PCI/PXI-1407

The PCI-1407 and PXI-1407 are high-accuracy, monochrome IMAQ boards for PCI, PXI, or CompactPCI chassis that support RS-170 and CCIR video standards. The boards feature an 8-bit flash analog-to-digital converter (ADC) that converts video signals into digital form. The PCI/PXI-1407 acquires frames in real time and transfers them directly to system memory.

The PCI/PXI-1407 is simple to configure so that you can easily install the board and begin your image acquisition. The PCI/PXI-1407 ships with NI-IMAQ, the National Instruments complete image acquisition driver software you can use to directly control your board. Using NI-IMAQ, you can quickly and easily start your application without having to program the board at the register level.

Featuring low cost and high accuracy, the PCI/PXI-1407 is ideal for both industrial and scientific environments. As a standalone board, the PCI/PXI-1407 supports one video source and an external I/O line that you can use as a trigger or digital I/O line. If you require more advanced triggering or additional I/O lines (either digital or analog), you can use the PCI/PXI-1407 and NI-IMAQ with the National Instruments data acquisition (DAQ) product line.

Detailed specifications of the PCI/PXI-1407 are in Appendix A, *Specifications*.

Using PXI with CompactPCI

Using PXI-compatible products with standard CompactPCI products is an important feature provided by the *PXI Specification*, Revision 1.0. If you use a PXI-compatible plug-in device in a standard CompactPCI chassis, you will be unable to use PXI-specific functions, but you can still use the basic plug-in device functions.

The CompactPCI specification permits vendors to develop sub-buses that coexist with the basic PCI interface on the CompactPCI bus. Compatible operation is not guaranteed between CompactPCI devices with different sub-buses nor between CompactPCI devices with sub-buses and PXI. The standard implementation for CompactPCI does not include these sub-buses. Your PXI-1407 device will work in any standard CompactPCI chassis adhering to the *PICMG 2.0 R2.1 CompactPCI* core specification.

What You Need to Get Started

To set up and use your PCI/PXI-1407, you will need the following:

- ❑ One of the following 1407 devices:
  - PCI-1407
  - PXI-1407
- ❑ *Set up and Test the PCI/PXI-1407*
- ❑ *NI-IMAQ for Windows 95/98/NT Release Notes*
- ❑ *IMAQ PCI/PXI-1407 User Manual*
- ❑ NI-IMAQ for Windows 95/98/NT and online documentation
- ❑ Optional software packages and documentation:
  - LabVIEW
  - BridgeVIEW
  - LabWindows/CVI
  - IMAQ Vision for G
  - IMAQ Vision for LabWindows/CVI
  - ComponentWorks IMAQ Vision

- ❑ IMAQ BNC-1 shielded, 75 Ω BNC cable for VIDEO (included with your PCI-1407)
- ❑ Your Pentium-based PCI, PXI, or CompactPCI computer running Windows 95, Windows 98, or Windows NT
- ❑ A video camera or other video source

☞ **Note** ***The IMAQ PCI/PXI-1407 relies on your computer's PCI interface chipset for the highest throughput to system memory. For the best results, your computer should have a Pentium or better processor and an Intel 430 or 440 series, or compatible PCI interface chipset.***

Software Programming Choices

You have several options to choose from when programming your National Instruments IMAQ hardware. You can use National Instruments application software such as LabVIEW, BridgeVIEW, and LabWindows/CVI; National Instruments image analysis software such as IMAQ Vision; the ComponentWorks IMAQ Vision collection of ActiveX controls; or the NI-IMAQ driver software.

National Instruments Application Software

LabVIEW and BridgeVIEW feature interactive graphics, a state-of-the-art user interface, and a powerful graphical programming language, G. The NI-IMAQ VI Library for G, a series of virtual instruments (VIs) for using LabVIEW and BridgeVIEW with the PCI/PXI-1407, is included with the NI-IMAQ software kit. The NI-IMAQ VI Library for G is functionally equivalent to the NI-IMAQ software.

LabWindows/CVI features interactive graphics, a state-of-the-art user interface, and uses the ANSI standard C programming language. The LabWindows/CVI IMAQ Library, a series of functions for using LabWindows/CVI with the PCI/PXI-1407, is included with the NI-IMAQ software kit. The LabWindows/CVI IMAQ Library is functionally equivalent to the NI-IMAQ software.

IMAQ Vision for G is an image acquisition, processing, and analysis library that consists of more than 400 VIs for using the PCI/PXI-1407 with LabVIEW and BridgeVIEW. You can use IMAQ Vision for G functions directly or in combination for unique image processing. There are two versions of IMAQ Vision for G. The Base version gives you the ability to acquire, display, manipulate, and store images. The Advanced version is a

complete set of functions for image analysis, processing, and interpretation. Using IMAQ Vision for G, an imaging novice or expert can perform graphical programming of the most basic or complicated image applications without knowledge of any algorithm implementations.

IMAQ Vision for LabWindows/CVI is an image acquisition and analysis library consisting of a series of routines for using the PCI/PXI-1407 with LabWindows/CVI. IMAQ Vision for LabWindows/CVI brings the same functionality to LabWindows/CVI as IMAQ Vision for G does for LabVIEW and BridgeVIEW.

ComponentWorks IMAQ Vision is an image acquisition, processing, and analysis library for use in Visual Basic, Visual C++, Borland Delphi, and Microsoft Internet Explorer. ComponentWorks IMAQ Vision brings the same functionality to ComponentWorks as IMAQ Vision for G does for LabVIEW and BridgeVIEW. The ComponentWorks IMAQ hardware interface control, an ActiveX control for controlling the PCI/PXI-1407, is included with the NI-IMAQ software kit. The ComponentWorks IMAQ hardware interface control is functionally equivalent to the NI-IMAQ software.

NI-IMAQ Driver Software

The NI-IMAQ driver software is included at no charge with the PCI/PXI-1407. NI-IMAQ has an extensive library of functions that you can call from your application programming environment. These functions include routines for video configuration, image acquisition (continuous and single-shot), memory buffer allocation, trigger control, and board configuration. The NI-IMAQ driver software performs all functions required for acquiring and saving images. The NI-IMAQ software does not perform any image analysis. For image analysis functionality, refer to the *National Instruments Application Software* section earlier in this chapter.

NI-IMAQ has both high-level and low-level functions for maximum flexibility and performance. Examples of high-level functions include the functions to acquire images in single-shot or continuous mode. An example of a low-level function is configuring an image sequence since it requires advanced understanding of the PCI/PXI-1407 and image acquisition.

NI-IMAQ also internally resolves many of the complex issues between the computer and the PCI/PXI-1407, such as programming interrupts and DMA controllers. NI-IMAQ is the interface path between LabVIEW, BridgeVIEW, LabWindows/CVI, or a conventional programming environment and the PCI/PXI-1407.

Any platform that supports NI-IMAQ also supports NI-DAQ and a variety of National Instruments DAQ boards, so your PCI/PXI-1407 and NI-IMAQ development can integrate with National Instruments DAQ products.

Whether you are using conventional programming languages or National Instruments software, your application uses the NI-IMAQ driver software, as illustrated in Figure 1-1.

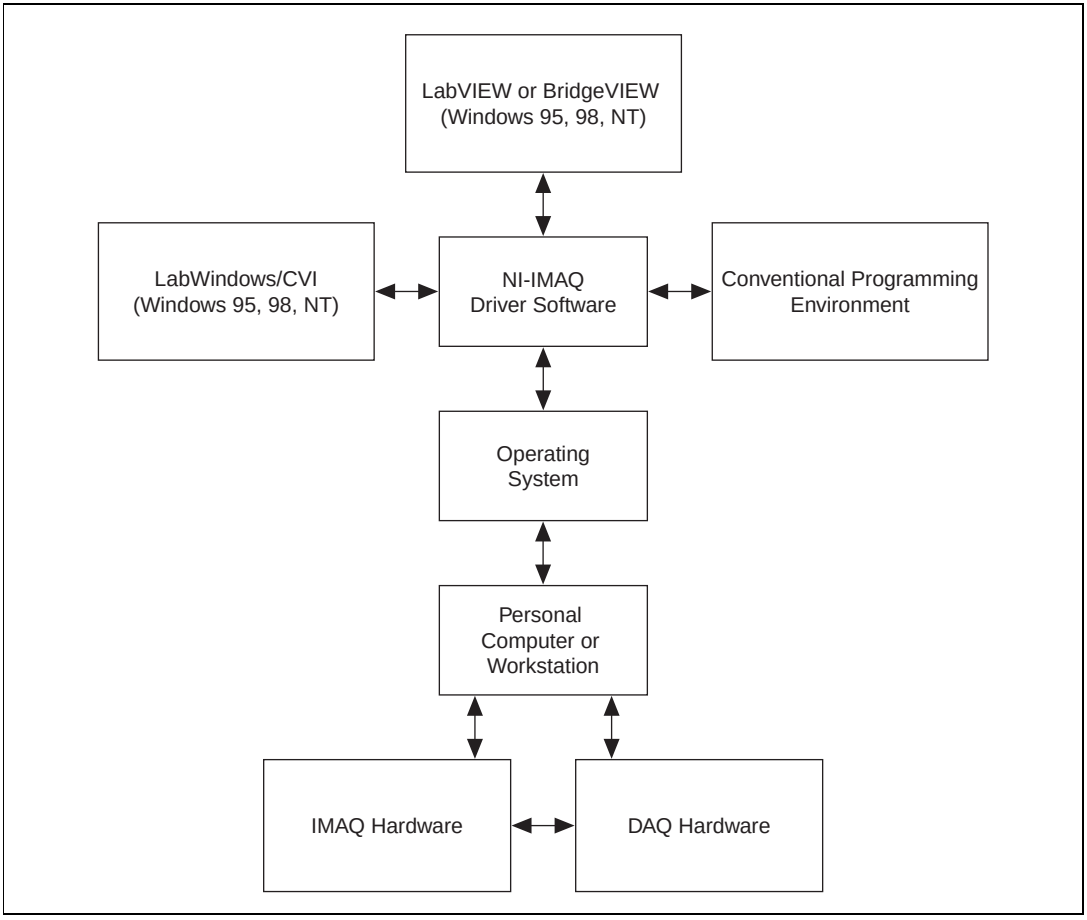

Figure 1-1. The Relationship between the Programming Environment, NI-IMAQ, and Your Hardware

Optional Equipment

National Instruments offers a variety of products for use with your PCI/PXI-1407, including other National Instruments DAQ devices for enhanced triggering, timing, or input/output.

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

Unpacking

Your PCI/PXI-1407 is shipped in an antistatic package to prevent electrostatic damage to the board. Electrostatic discharge can damage several components on the board. To avoid such damage in handling the board, 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 computer chassis before removing the board from the package.
- Remove the board from the package and inspect the board for loose components or any other signs of damage. Notify National Instruments if the board appears damaged in any way. Do *not* install a damaged board in your computer.
- *Never* touch the exposed pins of connectors.

How to Set up Your IMAQ System

Use Figure 1-2 to install your software and hardware, configure your hardware, and begin using NI-IMAQ in your application programs.

Follow the instructions in the *Set up and Test the PCI/PXI-1407* document to install your NI-IMAQ software and IMAQ hardware.

If you will be accessing the NI-IMAQ device drivers through LabVIEW or BridgeVIEW, you should read the NI-IMAQ release notes and the *NI-IMAQ VI Reference Manual* to help you get started.

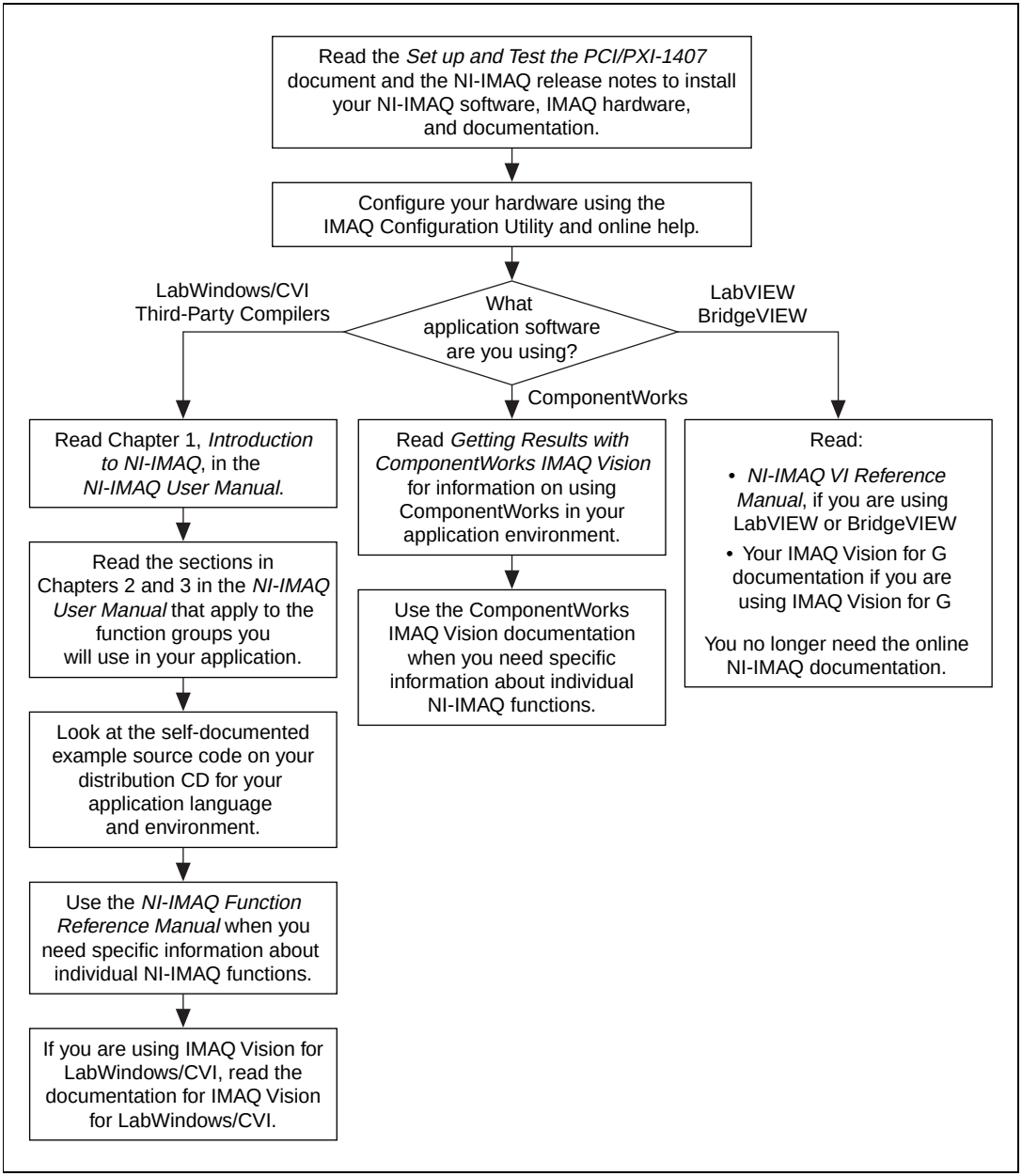

Figure 1-2. How to Set up Your IMAQ System

2

Installation

This chapter explains how to install your PCI/PXI-1407.

Installation

Note ***You must install the NI-IMAQ driver software before installing your PCI/PXI-1407. For information on how to install NI-IMAQ, please see the*** *Set up and Test the PCI/PXI-1407* ***document and your NI-IMAQ release notes.***

- PCI-1407

  You can install the PCI-1407 in any available PCI expansion slot in your computer. However, to achieve the best noise performance, you should leave as much room as possible between the PCI-1407 and other boards and hardware. The following are general instructions, but consult your computer user manual or technical reference manual for specific instructions and warnings.

  1. Plug in but do not turn on your computer before installing the PCI-1407. The power cord grounds the computer and protects it from electrical damage while you are installing the module.

Warning ***To protect both yourself and the computer from electrical hazards, the computer should remain off until you finish installing the PCI-1407.***

2. Remove the top cover or access port to the PCI bus.
3. Select any available PCI expansion slot.
4. Locate the metal bracket that covers the cut-out in the back panel of the chassis for the slot you have selected. Remove and save the bracket-retaining screw and the bracket cover.
5. Touch the metal part of the power supply case inside the computer to discharge any static electricity that might be on your clothes or body.
6. Line up the PCI-1407 with the BNC connectors near the cut-out on the back panel. Slowly push down on the top of the PCI-1407 until its card-edge connector is resting on the expansion slot receptacle. Using slow, evenly distributed pressure, press the PCI-1407 straight down until it seats in the expansion slot.

7. Reinstall the bracket-retaining screw to secure the PCI-1407 to the back panel rail.
8. Check the installation.
9. Replace the computer cover.

Your PCI-1407 is now installed.

- PXI-1407

  You can install a PXI-1407 in any available 5 V peripheral slot in your PXI or CompactPCI chassis.

  1. Turn off and unplug your PXI or CompactPCI chassis.
  2. Choose an unused PXI or CompactPCI 5 V peripheral slot. Install the PXI-1407 in a slot that supports bus arbitration or bus-master cards. PXI-compliant chassis must have bus arbitration for all slots.
  3. Remove the filler panel for the peripheral slot you have chosen.
  4. Touch a metal part on your chassis to discharge any static electricity that might be on your clothes or body.
  5. Insert the PXI-1407 in the selected 5 V slot. Use the injector/ejector handle to fully inject the device into place.
  6. Screw the front panel of the PXI-1407 to the front panel mounting rails of the PXI or CompactPCI chassis.
  7. Visually verify the installation.
  8. Plug in and turn on the PXI or CompactPCI chassis.

  Your PXI-1407 is now installed.

3

Hardware Overview

This chapter presents an overview of the hardware functions on your PCI/PXI-1407 and explains the operation of each functional unit making up the PCI/PXI-1407.

Functional Overview

The PCI/PXI 1407 features an 8-bit flash ADC that converts analog video signals into digital form. The board has both gain and offset circuitry to optimize the input signal range of the ADC. It also features a PCI interface for high-speed data transfer. The scatter-gather DMA controllers transfer the digitized image data from a set of first-in, first-out (FIFO) memory buffers to the computer's system memory via the PCI bus. The board also includes a trigger for controlling the image acquisition.

The block diagram in Figure 3-1 illustrates the key functional components of the PCI-1407 and PXI-1407.

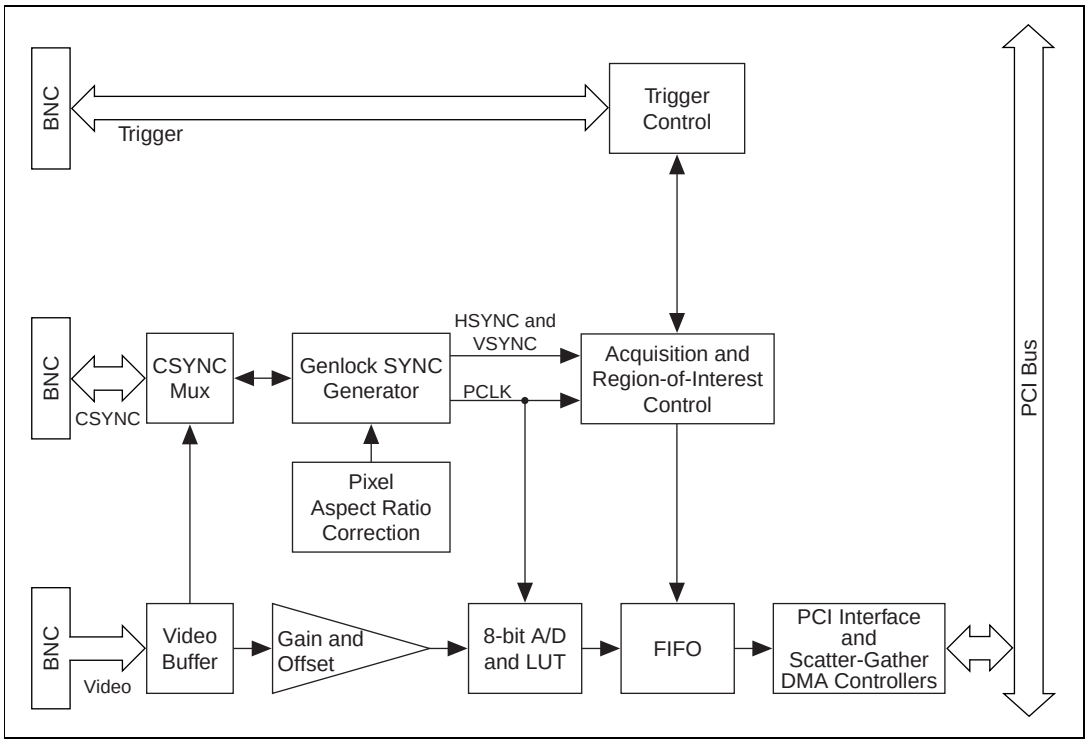

Figure 3-1. PCI/PXI-1407 Block Diagram

Video Buffer

The video buffer provides a 75 Ω termination for the incoming video signal and drives the onboard electronics.

Gain and Offset Circuitry

The PCI/PXI-1407 uses programmable gain and offset circuitry to optimize the input signal range.

8-Bit ADC and LUT

An 8-bit flash ADC digitizes the image, which is passed to a 256-by-8 bit lookup table (LUT) RAM. You can configure the input LUT to implement simple imaging operations such as contrast enhancement, data inversion, gamma manipulation, or other nonlinear transfer functions.

CSYNC Mux

This multiplexer routes either the video signal or an external CSYNC signal to the genlock circuit. If this circuit routes the video signal to the genlock circuit, then the internally generated CSYNC can be routed to the BNC as an output signal.

Genlock SYNC Generator

This circuit generates the necessary clock and synchronization signals to digitize the incoming video signal correctly. The genlock circuit can produce pixel clock frequencies between 11.66 MHz and 15.78 MHz, which accommodate RS-170 and CCIR-601 video standards.

Pixel Aspect Ratio Circuitry

The pixel aspect ratio is the ratio between the horizontal size to the vertical size of the pixel. Use this value to adjust or correct the picture aspect ratio. For more information, see the *Acquisition Window Control* section later in this chapter.

Acquisition and Region-of-Interest Control

The acquisition and region-of-interest control circuitry monitors the incoming video signal and routes the active pixels to the FIFO buffers. The PCI/PXI-1407 can digitize an entire frame and perform pixel and line scaling and region-of-interest acquisition. Pixel and line scaling lets certain multiples (2, 4, or 8) of pixels and lines to be transferred to the PCI bus. In region-of-interest acquisition, you select an area in the acquisition window to transfer to the PCI bus.

FIFO Buffer

The PCI/PXI-1407 uses a 4 KB FIFO buffer for temporary storage of the image being transferred to the PCI system memory or display memory. The buffer stores six full video lines during image acquisition.

Scatter-Gather DMA Controllers

The PCI/PXI-1407 uses three independent onboard direct memory access (DMA) controllers. The DMA controllers transfer data between the onboard first-in first-out (FIFO) memory buffers and the PCI bus. Each of these controllers supports scatter-gather DMA, which allows the DMA

controller to reconfigure on-the-fly. Thus, the PCI/PXI-1407 can perform continuous image transfers to either contiguous or fragmented memory buffers.

PCI Interface

The PCI/PXI-1407 implements the PCI interface with a National Instruments custom application-specific integrated circuit (ASIC), the PCI MITE. The PCI interface can transfer data at a maximum rate of 132 Mbytes/s in master mode, which maximizes the available PCI bandwidth. The PCI/PXI-1407 can generate 8-, 16-, and 32-bit memory read and write cycles, both single and multiple. In slave mode, the PCI/PXI-1407 is a medium speed decoder that accepts both memory and configuration cycles. The interface logic ensures that the PCI/PXI-1407 meets the loading, driving, and timing requirements of the PCI specification.

Trigger Control

This circuit controls the direction and functionality of the external trigger line. The trigger can start an image acquisition when used as an input signal. As an output signal, the control circuit can drive the line asserted or unasserted to trigger an external event. Also, it can connect internal signals such as HSYNC and VSYNC to the trigger line.

Video Acquisition

The PCI/PXI-1407 can acquire video signals in a variety of modes and transfer the digitized fields or frames to PCI system memory.

Start Conditions

The PCI/PXI-1407 can start acquisition on a variety of conditions:

- Software control—The PCI/PXI-1407 supports software control of acquisition start and stop. In addition, you can configure the PCI/PXI-1407 to capture a fixed number of frames. Use this configuration to capture single frames or a sequence of frames.
- Trigger control—You can also start an acquisition by using the external trigger line, which can start video acquisition on a rising or falling edge.
- Delayed acquisition—You can use either software or the trigger to start and stop acquisitions instantaneously or after capturing a desired number of frames or fields. Use this feature for trigger applications.

- Frame/field selection—With an interlaced camera and the PCI/PXI-1407 in frame mode, you can program the PCI/PXI-1407 to start acquisition on any odd field or any even field.

Acquisition Window Control

You can configure numerous parameters on the PCI/PXI-1407 to control the video acquisition window. A brief description of each parameter follows:

- Active pixel region—The active pixel region is the region of pixels actively being stored. The active pixel region is defined by a pixel start (relative to HSYNC) and a pixel count.
- Horizontal count—The horizontal count is the total number of pixels between two HSYNC signals. The horizontal count determines the frequency of the pixel clock.
- Active line region—The active line region is the region of lines actively being stored. The active line region is defined by a line start (relative to VSYNC) and a line count.
- Line count—The line count is the total number of horizontal lines in the picture.
- Video line—A video line consists of an HSYNC, back porch, active pixel region, and a front porch. The 1407 device requires a positive video signal, as shown in Figure 3-2.

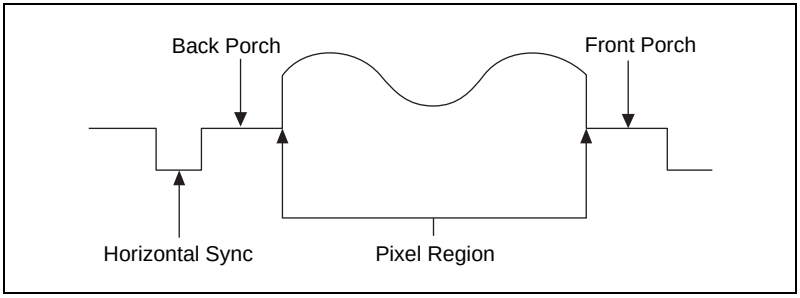

Figure 3-2. Positive Video Line

- Picture aspect ratio—The picture aspect ratio is the ratio of the active pixel region to the active line region. For standard video signals like RS-170 or CCIR, the full-size picture aspect ratio normally is 4/3 (1.33).
- Pixel aspect ratio—The pixel aspect ratio is the ratio between the physical horizontal size and the vertical size of the region covered by the pixel. An acquired pixel should optimally be square, thus the

optimal value is 1.0, but typically it falls between 0.95 and 1.05, depending on camera quality.

- Field—For an interlaced video signal, a field is half the number of horizontal lines needed to represent a frame, as shown in Figure 3-3. The first field of a frame contains all the odd-numbered lines. The second field contains all of the even-numbered lines.

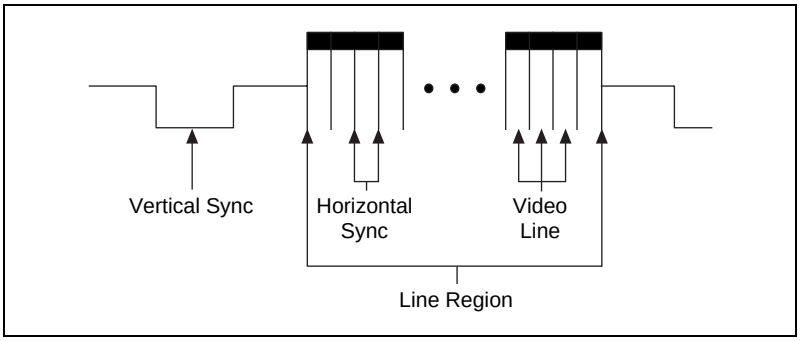

Figure 3-3. Video Field

- Frame—A frame is a complete image. In interlaced formats, a frame is composed of two fields.

Programming Video Parameters

You can program all of these video parameters on the PCI/PXI-1407:

- Programmable pixel and line count—The PCI/PXI-1407 uses an advanced genlock circuit to generate an internal PCLK. This circuit generates a PCLK frequency from 11.7 to 15.8 MHz, depending on the total number of pixels per line. The standard sampling rate for RS-170 video signals is 12.27 MHz, and the standard sampling rate for CCIR is 14.75 MHz.

  The PCI/PXI-1407 also includes a programmable line count, which you use to switch between RS-170 (525 lines) and CCIR (625 lines).
- Acquisition window—After setting the pixel and line count, you must program the active pixel region and active line region. The active pixel region selects the starting pixel and number of pixels to be acquired relative to the HSYNC signal. The active line region selects the starting line and number of lines to be acquired relative to the VSYNC signal.
- Region of interest—The PCI/PXI-1407 uses a second level of active pixel and active line regions for selecting a region of interest. When you disable the region-of-interest circuitry, the board stores the entire acquisition window in system memory. However, when you enable the

region-of-interest circuitry, the board transfers only a selected subset of the digitized frame to system memory.

- Scaling down—The PCI/PXI-1407 can scale down a frame by reducing pixels, lines, or both. For active pixel selection, the PCI/PXI-1407 can select every pixel, every other pixel, every fourth pixel, or every eighth pixel. For active line selection, the PCI/PXI-1407 can select every line, every odd line, or multiples of odd lines, for example, every other odd line or every fourth odd line. You can use the scaling-down circuitry in conjunction with the region-of-interest circuitry.
- Interlaced video—The PCI/PXI-1407 supports both interlaced and noninterlaced video signals. In interlaced mode, the PCI/PXI-1407 combines the odd and even field into one contiguous frame for analysis. In noninterlaced mode, each field is treated as an independent frame.

Acquisition Modes

The PCI/PXI-1407 supports two video acquisition modes:

- Standard mode—In standard mode, the PCI/PXI-1407 receives an incoming composite video signal from the external BNC connector and generates CSYNC, HSYNC, VSYNC, and PCLK signals. The generated CSYNC signal can be used by other image acquisition boards or to synchronize multiple cameras.
- CSYNC external mode—In CSYNC external mode, the PCI/PXI-1407 receives an incoming video signal (composite or luminance) and an external CSYNC signal from an external connector. The PCI/PXI-1407 takes the incoming CSYNC signal and generates HSYNC, VSYNC, and PCLK signals.

4

Signal Connections

This chapter describes cable connections for the PCI/PXI-1407.

BNC Connectors

The BNC external connectors supply an immediate connection to the PCI/PXI-1407 VIDEO, CSYNC and TRIG inputs. Use BNC cables to connect a camera to these inputs. You can configure the BNC connector only for referenced single-ended (RSE) mode.

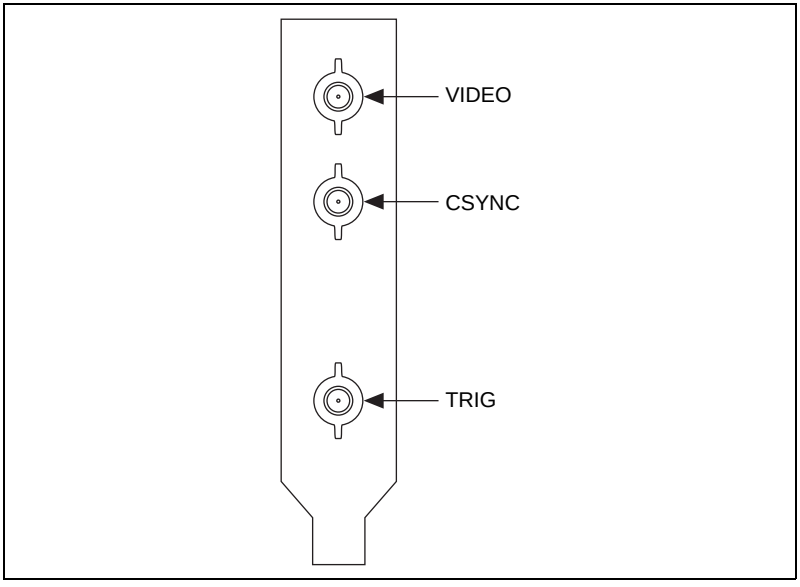

Figure 4-1. PCI/PXI-1407 BNC I/O Connectors

I/O Connector Signal Connection Descriptions

Table 4-1 describes each signal connection on the three BNC connectors.

Table 4-1. I/O Connector Signals

Signal Name	Description
VIDEO	VIDEO± allows for an RSE connection to the video channel. The incoming video signal must be positive, as shown in Figure 3-2.
CSYNC	CSYNC is a TTL I/O line that is software programmable to be an input or an output. When the PCI/PXI-1407 is in CSYNC external mode, use the connector to input a CSYNC signal from the camera. In standard acquisition mode, the internally generated CSYNC can be routed to this connector as an output signal.
TRIG	The TRIG signal is a TTL I/O line used to start an acquisition or to control external events. You can program the triggers to be rising or falling edge sensitive. You can also program the triggers to be programmatically asserted or unasserted similar to the function of a digital I/O line or to contain internal status signals (by using the onboard events) or specific pulse widths.

A

Specifications

This appendix lists the specifications of the PCI-1407 and PXI-1407. These specifications are typical at 25 °C, unless otherwise stated.

Formats Supported

RS-170 ..... 60 Hz
(Interlaced mode: 30 frames/s)

CCIR ..... 50 Hz
(Interlaced mode: 25 frames/s)

Video Input

Quantity ..... 1 monochrome

Input impedance ..... 75 Ω

VIDEO ..... RSE (BNC)

Frequency response ..... 20 MHz (–3 dB) typ

Gain ..... Programmable (1, 1.33, or 2)

Black reference ..... Programmable (0–1.26 V)

White reference ..... Programmable (0–1.26 V)

A/D Conversion

Gray levels ..... 256 (8 bit)

RMS noise ..... < 0.5 LSB rms

Signal-to-noise ratio ..... 48 dB typ

Sampling rate ..... 5 to 20 MHz

External Connections

Trigger sense.....TTL

Trigger level .....Programmable (rising or falling)

CSYNC sense .....TTL

CSYNC level .....Programmable (rising or falling)

Minimum pulse width.....50 ns

V_{IH} (TTL) .....2 V

V_{IL} (TTL).....0.8 V

Internal Pixel Clock

Generated frequency.....11.66 to 15.78 MHz

Aspect correction for
standard video sources.....–5% to +7%

Pixel jitter .....< 5 ns peak

PCI Interface

PCI initiator (master) capability .....Supported

PCI target (slave) capability .....Supported

Data path.....32 bits

Card voltage.....5 V only

Card type.....32-bit half-size card

Parity generation/checking,
error reporting.....Supported

Target decode speed .....Medium (1 clock)

Target fast back-to-back capability .....Supported

Resource locking .....Supported as a master and slave

PCI interrupts.....Interrupts passed on
INTA# signal

Expansion ROM..... 4 KB

PCI master performance

Ideal ..... 133 Mbytes/s

Sustained..... 100 Mbytes/s

Power Requirements

Voltage..... +5 V (1.34 A)
+12 V (100 mA)
–12 V (50 mA)

Physical

Dimensions

PCI-1407..... 10.668 by 17.463 cm (4.2 by 6.875 in.)

PXI-1407..... 16 × 10 cm (6.3 × 3.9 in.)

Weight

PCI-1407..... 0.127 kg (0.028 lb.)

B

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.

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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

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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`

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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: _____

_____

_____

_____

_____

IMAQ 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

IMAQ hardware _____

Interrupt level of hardware _____

DMA channels of hardware _____

Base I/O address of hardware _____

Programming choice _____

National Instruments application software and version _____

Other boards in system _____

Base I/O address of other boards _____

DMA channels of other boards _____

Interrupt level of other boards _____

Other Products

Computer make and model _____

Microprocessor _____

Clock frequency or speed _____

PCI chipset _____

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 _____

DMA channels of other boards _____

Interrupt level of other boards _____

Documentation Comment Form

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Title: *IMAQ PCI/PXI-1407 User Manual*

Edition Date: December 1998

Part Number: 322156A-01

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

_____

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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 _____

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Glossary

Prefix	Meanings	Value
p-	pico	10^{-12}
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

%	percent
+	positive of, or plus
/	per
Ω	ohm
±	plus or minus
–	negative of, or minus

A

A	amperes
AC	alternating current
acquisition window	the image size specific to a video standard or camera resolution
active line region	the region of lines actively being stored; defined by a line start (relative to VSYNC) and a line count

active pixel region	the region of pixels actively being stored; defined by a pixel start (relative to HSYNC) and a pixel count
A/D	analog-to-digital
ADC	analog-to-digital converter—an electronic device, often an integrated circuit, that converts an analog voltage to a digital number
address	character code that identifies a specific location (or series of locations) in memory
ANSI	American National Standards Institute
API	application programming interface
AQ_DONE	signals that the acquisition of a frame or field is completed
AQ_IN_PROGRESS	signals that the acquisition of video data is in progress
area	a rectangular portion of an acquisition window or frame that is controlled and defined by software
array	ordered, indexed set of data elements of the same type
ASIC	Application-Specific Integrated Circuit—a proprietary semiconductor component designed and manufactured to perform a set of specific functions for a specific customer
aspect ratio	the ratio of a picture or image's width to its height

B

b	bit—one binary digit, either 0 or 1
B	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
back porch	the area of the video signal between the rising edge of the horizontal sync signal and the active video information
black reference level	the level that represents the darkest an image can get. *See also* white reference level.

buffer	temporary storage for acquired data
bus	the group of conductors that interconnect individual circuitry in a computer, such as the PCI bus; typically the expansion vehicle to which I/O or other devices are connected

C

C	Celsius
cache	high-speed processor memory that buffers commonly used instructions or data to increase processing throughput
CCIR	Comite Consultatif International des Radiocommunications—a committee that developed standards for video signals
CMOS	complementary metal-oxide semiconductor
CompactPCI	refers to the core specification defined by the PCI Industrial Computer Manufacturer's Group (PICMG)
compiler	a software utility that converts a source program in a high-level programming language, such as Basic, C or Pascal, into an object or compiled program in machine language. Compiled programs run 10 to 1,000 times faster than interpreted programs. *See also* interpreter.
conversion device	device that transforms a signal from one form to another; for example, analog-to-digital converters (ADCs) for analog input and digital-to-analog converters (DACs) for analog output
CPU	central processing unit
CSYNC	composite sync signal; a combination of the horizontal and vertical sync pulses

D

D/A	digital-to-analog
DAC	digital-to-analog converter; an electronic device, often an integrated circuit, that converts a digital number into a corresponding analog voltage or current

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 or DIO boards plugged into a computer, and possibly generating control signals with D/A and/or DIO boards in the same computer
dB	decibel—the unit for expressing a logarithmic measure of the ratio of two signal levels: dB = 20log10 V1/V2, for signals in volts
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*
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 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
DMA	direct memory access—a method by which data can be transferred to and from computer memory from and to a device or memory on the bus while the processor does something else; DMA is the fastest method of transferring data to/from computer memory
DRAM	dynamic RAM
drivers	software that controls a specific hardware device such as an IMAQ or DAQ device
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

EEPROM	electrically erasable programmable read-only memory—ROM that can be erased with an electrical signal and reprogrammed
external trigger	a voltage pulse from an external source that triggers an event such as A/D conversion

F

field — For an interlaced video signal, a field is half the number of horizontal lines needed to represent a frame of video; the first field of a frame contains all the odd-numbered lines, the second field contains all of the even-numbered lines

FIFO — first-in first-out memory buffer—the first data stored is the first data sent to the acceptor; FIFOs are used on IMAQ devices to temporarily store incoming data until that data can be retrieved. For example, an analog input FIFO stores the results of A/D conversions until the data can be retrieved into system memory, a process that requires the servicing of interrupts and often the programming of the DMA controller. This process can take several milliseconds in some cases. During this time, data accumulates in the FIFO for future retrieval.

flash ADC — an ADC whose output code is determined in a single step by a bank of comparators and encoding logic

frame — a complete image; in interlaced formats, a frame is composed of two fields

front porch — the area of a video signal between the start of the horizontal blank and the start of the horizontal sync

ft — feet

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; examples of functions are:

y = COS (x)
status = `AO_config`(**board**, **channel**, **range**)

G

gamma — the nonlinear change in the difference between the video signal's brightness level and the voltage level needed to produce that brightness

genlock — circuitry that aligns the video timing signals by locking together the horizontal, vertical, and color subcarrier frequencies and phases and generates a pixel clock to clock pixel data into memory for display or into another circuit for processing

GND	ground signal
GUI	graphical user interface—an intuitive, easy-to-use means of communicating information to and from a computer program by means of graphical screen displays; GUIs can resemble the front panels of instruments or other objects associated with a computer program.

H

h	hour
hardware	the physical components of a computer system, such as the circuit boards, plug-in boards, chassis, enclosures, peripherals, cables, and so on
HSYNC	horizontal sync signal—the synchronization pulse signal produced at the beginning of each video scan line that keeps a video monitor's horizontal scan rate in step with the transmission of each new line
Hz	hertz—the number of scans read or updates written per second

I

IC	integrated circuit
ID	identification
IEEE	Institute of Electrical and Electronics Engineers
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
instrument driver	a set of high-level software functions, such as NI-IMAQ, that controls specific plug-in computer boards; instrument drivers are available in several forms, ranging from a function callable from a programming language to a virtual instrument (VI) in LabVIEW
interlaced	a video frame composed of two interleaved fields; the number of lines in a field are half the number of lines in an interlaced frame
interpreter	a software utility that executes source code from a high-level language such as Basic, C or Pascal, by reading one line at a time and executing the specified operation *See also* compiler.

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
IRQ	interrupt request

K

k	kilo—the standard metric prefix for 1,000, or 10^3, used with units of measure such as volts, hertz, and meters
K	kilo—the prefix for 1,024, or 2^{10}, used with B in quantifying data or computer memory
kbytes/s	a unit for data transfer that means 1,000 or 10^3 bytes/s
Kword	1,024 words of memory

L

library	a file containing compiled object modules, each comprised of one of more functions, that can be linked to other object modules that make use of these functions.
line count	the total number of horizontal lines in the picture
LSB	least significant bit
luminance	the brightness information in the video picture. The luminance signal amplitude varies in proportion to the brightness of the video signal and corresponds exactly to the monochrome picture.
LUT	look-up table—a selection in the IMAQ Configuration Utility that contains formulas that let you implement simple imaging operations such as contrast enhancement, data inversion, gamma manipulation, or other nonlinear transfer functions

M

m	meters
M	(1) Mega, the standard metric prefix for 1 million or 10^6, when used with units of measure such as volts and hertz; (2) mega, the prefix for 1,048,576, or 2^{20}, when used with B to quantify data or computer memory
MB	megabytes of memory
Mbytes/s	a unit for data transfer that means 1 million or 10^6 bytes/s
memory buffer	*See* buffer.
memory window	continuous blocks of memory that can be accessed quickly by changing addresses on the local processor
MSB	most significant bit
MTBF	mean time between failure
mux	multiplexer—a switching device with multiple inputs that selectively connects one of its inputs to its output

N

NI-IMAQ	driver software for National Instruments IMAQ hardware
noninterlaced	a video frame where all the lines are scanned sequentially, instead of divided into two frames as in an interlaced video frame
NVRAM	nonvolatile RAM—RAM that is not erased when a device loses power or is turned off

O

operating system	base-level software that controls a computer, runs programs, interacts with users, and communicates with installed hardware or peripheral devices

P

PCI	Peripheral Component Interconnect—a high-performance expansion bus architecture originally developed by Intel to replace ISA and EISA; it is achieving widespread acceptance as a standard for PCs and workstations and offers a theoretical maximum transfer rate of 132 Mbytes/s
PCLK	pixel clock signal—times the sampling of pixels on a video line
picture aspect ratio	the ratio of the active pixel region to the active line region; for standard video signals like RS-170 or CCIR, the full-size picture aspect ratio normally is 4/3 (1.33)
pixel	picture element—the smallest division that makes up the video scan line; for display on a computer monitor, a pixel's optimum dimension is square (aspect ratio of 1:1, or the width equal to the height)
pixel aspect ratio	the ratio between the physical horizontal size and the vertical size of the region covered by the pixel; an acquired pixel should optimally be square, thus the optimal value is 1.0, but typically it falls between 0.95 and 1.05, depending on camera quality
pixel clock	divides the incoming horizontal video line into pixels
pixel count	the total number of pixels between two HYSNCs; the pixel count determines the frequency of the pixel clock
protocol	the exact sequence of bits, characters, and control codes used to transfer data between computers and peripherals through a communications channel
pts	points
PXI	PCI eXtensions for Instrumentation. PXI is an open specification that builds off the CompactPCI specification by adding instrumentation-specific features.

R

RAM	random-access memory
real time	a property of an event or system in which data is processed as it is acquired instead of being accumulated and processed at a later time

relative accuracy	a measure in LSB of the accuracy of an ADC; it includes all nonlinearity and quantization errors but does not include offset and gain errors of the circuitry feeding the ADC
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 percent of full scale.
ROI	region of interest—a hardware-programmable rectangular portion of the acquisition window
ROM	read-only memory
RS-170	the U.S. standard used for black-and-white television
RSE	referenced single-ended—all measurements are made with respect to a common reference measurement system or a ground. Also called a grounded measurement system.
RTSI bus	Real-Time System Integration Bus—the National Instruments timing bus that connects IMAQ and DAQ boards directly, by means of connectors on top of the boards, for precise synchronization of functions

S

s	seconds
scaling down circuitry	circuitry that scales down the resolution of a video signal
scatter-gather DMA	a type of DMA that allows the DMA controller to reconfigure on-the-fly
sync	tells the display where to put a video picture; the horizontal sync indicates the picture's left-to-right placement and the vertical sync indicates top-to-bottom placement
syntax	the set of rules to which statements must conform in a particular programming language
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
TRIG	trigger signal
trigger	any event that causes or starts some form of data capture
trigger control and mapping circuitry	circuitry that routes, monitors, and drives the external trigger line; you can configure this line to start an acquisition on a rising or falling edge.
TTL	transistor-transistor logic

V

V	volts
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
video line	a video line consists of a HSYNC, back porch, active pixel region, and a front porch
VSYNC	vertical sync signal—the synchronization pulse generated at the beginning of each video field that tells the video monitor when to start a new field

W

white reference level	the level that defines what is white for a particular video system. *See also* black reference level.

Index

H

I

L

M

N

P

R

S

T

V