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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Compliance

FCC/Canada Radio Frequency Interference Compliance*

Determining FCC Class

The Federal Communications Commission (FCC) has rules to protect wireless communications from interference. The FCC places digital electronics into two classes. These classes are known as Class A (for use in industrial-commercial locations only) or Class B (for use in residential or commercial locations). Depending on where it is operated, this product could be subject to restrictions in the FCC rules. (In Canada, the Department of Communications (DOC), of Industry Canada, regulates wireless interference in much the same way.)

Digital electronics emit weak signals during normal operation that can affect radio, television, or other wireless products. By examining the product you purchased, you can determine the FCC Class and therefore which of the two FCC/DOC Warnings apply in the following sections. (Some products may not be labeled at all for FCC; if so, the reader should then assume these are Class A devices.)

FCC Class A products only display a simple warning statement of one paragraph in length regarding interference and undesired operation. Most of our products are FCC Class A. The FCC rules have restrictions regarding the locations where FCC Class A products can be operated.

FCC Class B products display either a FCC ID code, starting with the letters **EXN**, or the FCC Class B compliance mark that appears as shown here on the right.

Consult the FCC web site `http://www.fcc.gov` for more information.

FCC/DOC Warnings

This equipment generates and uses radio frequency energy and, if not installed and used in strict accordance with the instructions in this manual and the CE Mark Declaration of Conformity**, may cause interference to radio and television reception. Classification requirements are the same for the Federal Communications Commission (FCC) and the Canadian Department of Communications (DOC).

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

Class A

Federal Communications Commission

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.

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.

Class B

Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Canadian Department of Communications

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

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

Compliance to EU Directives

Readers in the European Union (EU) must refer to the Manufacturer's Declaration of Conformity (DoC) for information** pertaining to the CE Mark compliance scheme. The Manufacturer includes a DoC for most every hardware product except for those bought for OEMs, if also available from an original manufacturer that also markets in the EU, or where compliance is not required as for electrically benign apparatus or cables.

To obtain the DoC for this product, click **Declaration of Conformity** at `ni.com/hardref.nsf/`. This web site lists the DoCs by product family. Select the appropriate product family, followed by your product, and a link to the DoC appears in Adobe Acrobat format. Click the Acrobat icon to download or read the DoC.

* Certain exemptions may apply in the USA, see FCC Rules §15.103 **Exempted devices**, and §15.105(c). Also available in sections of CFR 47.

** The CE Mark Declaration of Conformity will contain important supplementary information and instructions for the user or installer.

Conventions

The following conventions are used in this manual:

♦ The ♦ symbol indicates that the following text applies only to a specific product, a specific operating system, or a specific software version.

This icon denotes a note, which alerts you to important information.

This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash. When you see this symbol on the device, refer to the *Safety Information* section in the user manual.

italic Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text that is a placeholder for a word or value that you must supply.

`monospace` Text in this font denotes text or characters that you should enter 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, operations, variables, filenames and extensions, and code excerpts.

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1 Introduction

This chapter describes the IMAQ PCI/PXI-1407 devices and your software programming choices.

About Your 1407 Device

The PCI-1407 and PXI-1407 are high-accuracy, monochrome IMAQ devices for PCI, PXI, or CompactPCI chassis that support RS-170 and CCIR video standards. The PCI/PXI-1407 acquires frames in real time and transfers them directly to system memory. Revisions E and later of the PCI-1407 and revisions C and later of the PXI-1407 support progressive scan formats 25, 30, 50, and 60 frames per second and feature gain calibration, high-impedance mode, and an 8-bit flash analog-to-digital converter (ADC) that converts video signals into digital form.

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

Featuring low cost and high accuracy, the PCI/PXI-1407 is ideal for both industrial and scientific environments. As a stand-alone device, 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.

See Appendix A, *Specifications,* for detailed PCI/PXI-1407 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 or 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.

Software Programming Choices

Using NI-IMAQ, the National Instruments image acquisition driver software, you can program your IMAQ device to acquire and save images. You can use NI-IMAQ with other National Instruments software for a complete image acquisition and analysis solution, as shown in Figure 1-1. NI-IMAQ works with LabVIEW and LabWindows/CVI, as well as with conventional programming languages. National Instruments' IMAQ Vision adds powerful image processing and analysis to these programming environments. You can also use IMAQ Vision Builder to quickly and easily prototype your IMAQ image analysis applications.

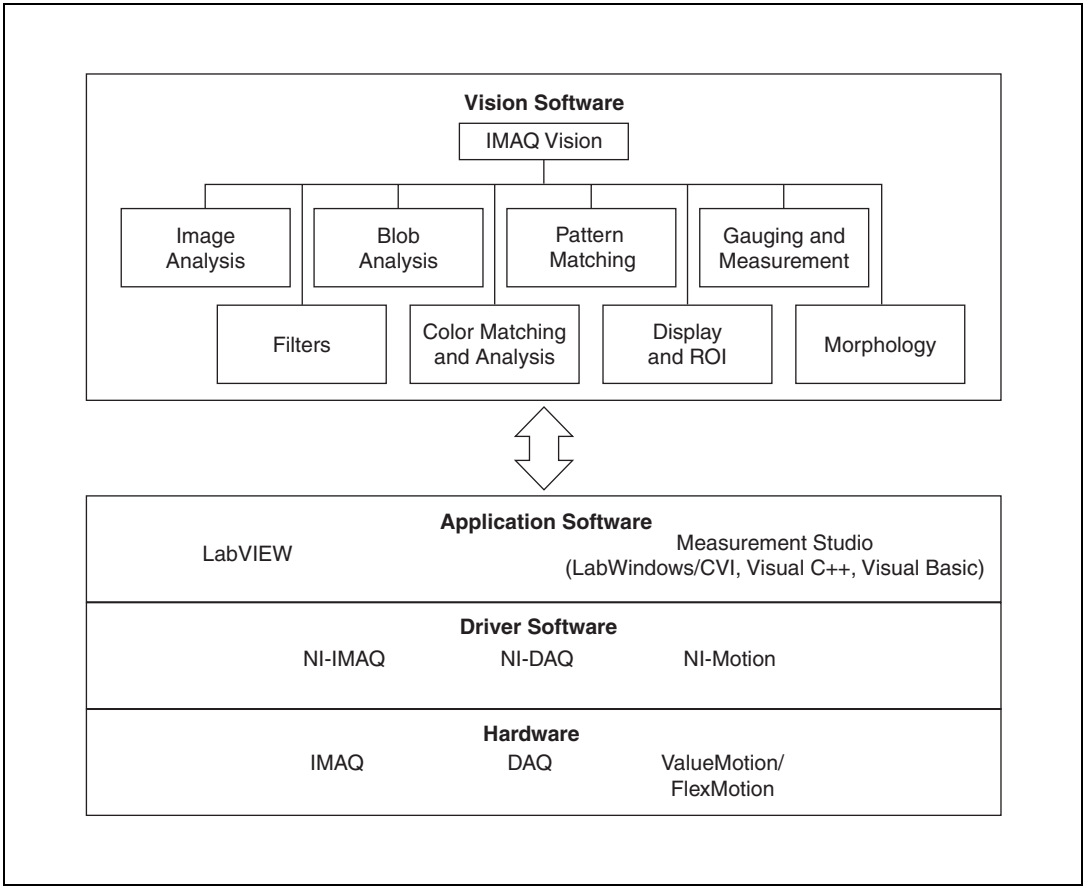


Figure 1-1. The Relationship between the Programming Environment, NI-IMAQ, and Your Hardware

NI-IMAQ Driver Software

The NI-IMAQ driver software is included with your IMAQ device. 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, as shown in Figure 1-2.

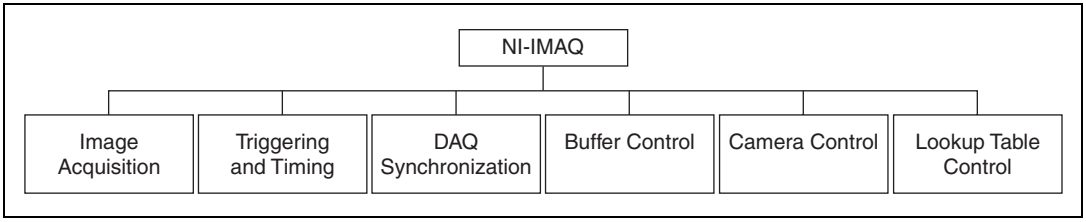


Figure 1-2. NI-IMAQ Functions

The NI-IMAQ driver software performs all of the functions required for acquiring and saving images. However, the NI-IMAQ software does not perform image analysis. For image analysis functionality, refer to the *IMAQ Vision* section in this chapter.

For maximum flexibility and performance, NI-IMAQ has both high-level and low-level functions. The functions to acquire images in single-shot or continuous mode are examples of high-level functions. Configuring an imaging sequence is an example of a low-level function, since it requires advanced understanding of your IMAQ device and image acquisition.

NI-IMAQ internally resolves many of the complex issues between the computer and your IMAQ device, such as programming interrupts and DMA controllers.

NI-IMAQ is also the interface path between LabVIEW, LabWindows/CVI, or a conventional programming environment and the IMAQ device. The NI-IMAQ software kit includes a series of libraries for image acquisition for LabVIEW and Measurement Studio, which contains libraries for LabWindows/CVI, Visual C++, and Visual Basic. These libraries are functionally equivalent to the NI-IMAQ software.

IMAQ Vision

National Instruments' IMAQ Vision is an image acquisition, processing, and analysis library of more than 200 functions for grayscale, color, and binary image display; image processing; pattern matching; shape matching; blob analysis; gauging; and measurement.

You can use IMAQ Vision functions directly or in combination for unique image processing. With IMAQ Vision, you can acquire, display, manipulate, and store images, as well as perform image analysis, processing, and interpretation. Using IMAQ Vision, 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 is available for LabVIEW and Measurement Studio, which includes support for LabWindows/CVI, Visual C++, and Visual Basic.

IMAQ Vision Builder

National Instruments' IMAQ Vision Builder is an interactive prototyping tool for machine vision and scientific imaging developers. With IMAQ Vision Builder, you can prototype vision software quickly or test how various vision image processing functions work.

As shown in Figure 1-3, IMAQ Vision Builder generates a Builder file, which is a text description that contains a recipe of the machine vision and image processing functions. This Builder file provides a guide you can use for developing applications into any development environment, such as LabWindows/CVI or Visual Basic, using the IMAQ Vision machine vision and image processing libraries. Using the LabVIEW VI creation wizard, you can create a LabVIEW VI that performs the prototype that you created in IMAQ Vision Builder.

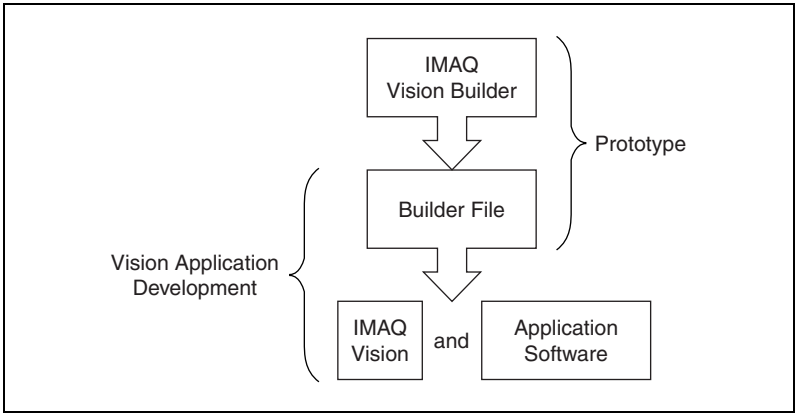


Figure 1-3. IMAQ Vision Builder and Application Development Tools

Integration with DAQ

Any platform that supports NI-IMAQ also supports NI-DAQ and a variety of National Instruments' DAQ devices, allowing your IMAQ device and NI-IMAQ development to integrate with National Instruments' DAQ products.

Vision and Motion

With National Instruments' IMAQ hardware and IMAQ Vision pattern matching software, you can quickly and accurately locate objects in instances when objects vary in size, orientation, focus, and even when the part is poorly illuminated. Use National Instruments' high-performance stepper and servo motion control products with pattern matching software in inspection and guidance applications, such as locating alignment markers on semiconductor wafers, guiding robotic arms, inspecting the quality of manufactured parts, and locating cells.

2

Installation

This chapter lists items you need to get started acquiring images with your IMAQ device. This chapter also describes optional equipment and custom cables and explains how to unpack, configure, and install your IMAQ device.

What You Need to Get Started

To set up your 1407 device, you will need the following items:

- ❑ One of the following 1407 devices:
  - PCI-1407
  - PXI-1407
- ❑ *Getting Started with Your IMAQ System*
- ❑ *NI-IMAQ Release Notes*
- ❑ *IMAQ PCI/PXI-1407 User Manual*
- ❑ NI-IMAQ for Windows 2000/NT/Me/9*x* and online documentation
- ❑ Optional software packages and documentation:
  - IMAQ Vision for LabVIEW or Measurement Studio (LabWindows/CVI, Visual C++, Visual Basic)
  - IMAQ Vision Builder
  - LabVIEW
  - Measurement Studio (LabWindows/CVI, Tools for Visual Basic)
- ❑ 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 2000/NT/Me/9*x*
- ❑ An analog video camera or other video source. See Appendix A, *Specifications,* for supported formats.

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 faster processor and an Intel 430 or 440 series or compatible PCI interface chipset.

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 the National Instruments catalog or Web site, or call the office nearest you.

How to Set up Your IMAQ System

Use Figure 2-1 as a guide when installing the software and hardware, configuring the hardware, and using NI-IMAQ in your application programs.

To install your NI-IMAQ software and IMAQ hardware, follow the instructions in the *Getting Started with Your IMAQ System* document.

If you plan to access the NI-IMAQ device drivers through LabVIEW, read the *NI-IMAQ Release Notes* and the *NI-IMAQ User Manual* for information on getting started.

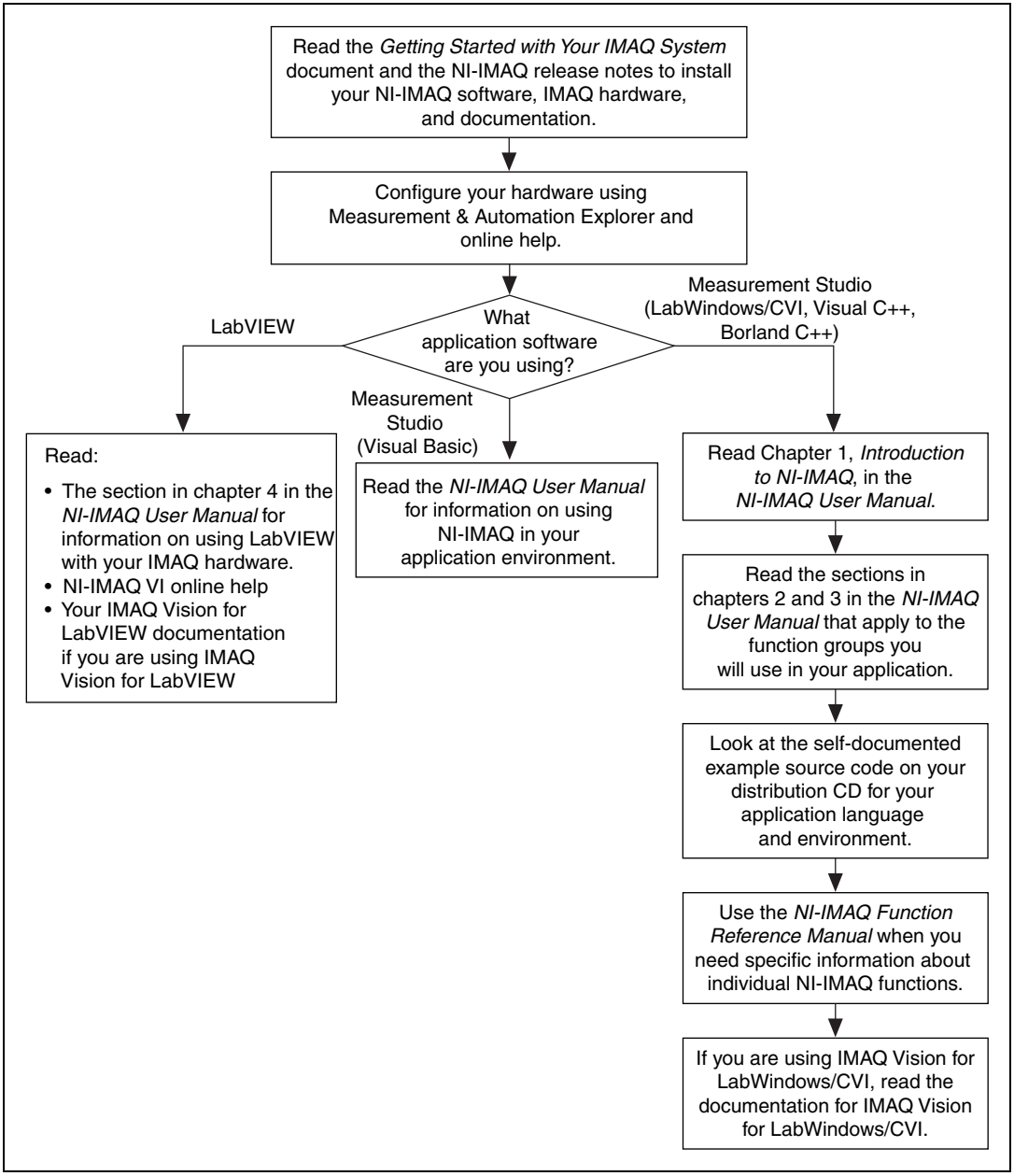


Figure 2-1. How to Set up Your IMAQ System

Safety Information

Caution The following paragraphs contain important safety information you *must* follow when installing and operating the device.

Do *not* operate the device in a manner not specified in the documentation. Misuse of the device may result in a hazard and may compromise the safety protection built into the device. If the device is damaged, turn it off and do *not* use it until service-trained personnel can check its safety. If necessary, return the device to National Instruments for repair.

Keep away from live circuits. Do *not* remove equipment covers or shields unless you are trained to do so. If signal wires are connected to the device, hazardous voltages can exist even when the equipment is turned off. To avoid a shock hazard, do *not* perform procedures involving cover or shield removal unless you are qualified to do so. Disconnect all field power prior to removing covers or shields.

If the device is rated for use with hazardous voltages (>30 V_{rms}, 42.4 V_{pk}, or 60 V_{dc}), it may require a safety earth-ground connection wire. See the device specifications for maximum voltage ratings.

Because of the danger of introducing additional hazards, do *not* install unauthorized parts or modify the device. Use the device only with the chassis, modules, accessories, and cables specified in the installation instructions. All covers and filler panels must be installed while operating the device.

Do *not* operate the device in an explosive atmosphere or where flammable gases or fumes may be present. Operate the device only at or below the pollution degree stated in the specifications. Pollution consists of any foreign matter—solid, liquid, or gas—that may reduce dielectric strength or surface resistivity. Pollution degrees are listed below.

- Pollution Degree 1—No pollution or only dry, nonconductive pollution occurs. The pollution has no effect.
- Pollution Degree 2—Normally only nonconductive pollution occurs. Occasionally, nonconductive pollution becomes conductive because of condensation.
- Pollution Degree 3—Conductive pollution or dry, nonconductive pollution occurs. Nonconductive pollution becomes conductive because of condensation.

Clean the device and accessories by brushing off light dust with a soft, nonmetallic brush. Remove other contaminants with a stiff, nonmetallic brush. The unit *must* be completely dry and free from contaminants before returning it to service.

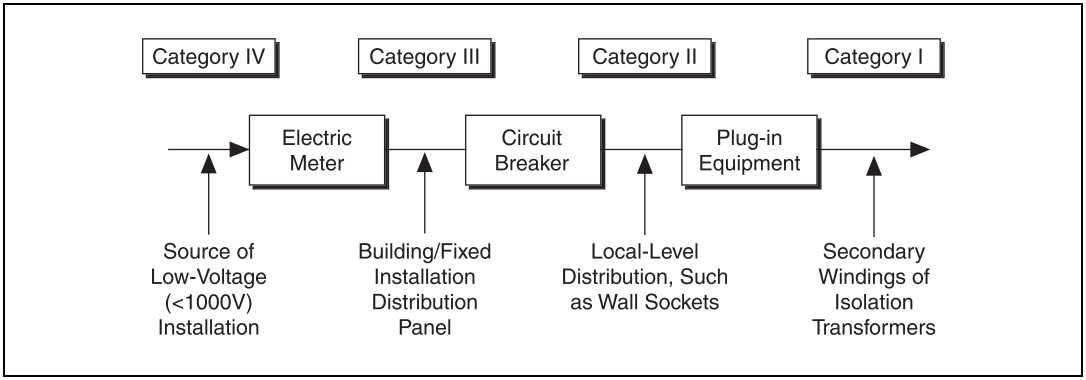
You *must* insulate signal connections for the maximum voltage for which the device is rated. Do *not* exceed the maximum ratings for the device. Remove power from signal lines before connection to or disconnection from the device.

Operate this device only at or below the installation category stated in the specifications. Installation categories are listed below.

- Installation Category IV—for measurements performed at the source of the low-voltage (<1000 V) installation. Examples include electricity meters, measurements on primary overcurrent protection devices, and ripple-control units.
- Installation Category III—for measurements performed in the building installation. Examples include measurements on distribution boards, circuit-breakers, wiring (including cables), bus bars, junction boxes, switches, socket outlets in the fixed installation, equipment for industrial use, and some other types of equipment, such as stationary motors permanently connected to the fixed installation.
- Installation Category II—for measurements performed on circuits directly connected to the low-voltage installation. Examples include measurements on household appliances, portable tools, and other similar equipment.
- Installation Category I—for measurements performed on circuits not directly connected to mains[1]. Examples include measurements on circuits not derived from mains, and specially-protected (internal) mains-derived circuits

[1] Mains is defined as the electricity suppy system to which the equipment concerned is designed to be connected for either powering the equipment or for measurement purposes.

The following diagram shows a sample installation.



Unpacking

Your PCI/PXI-1407 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:

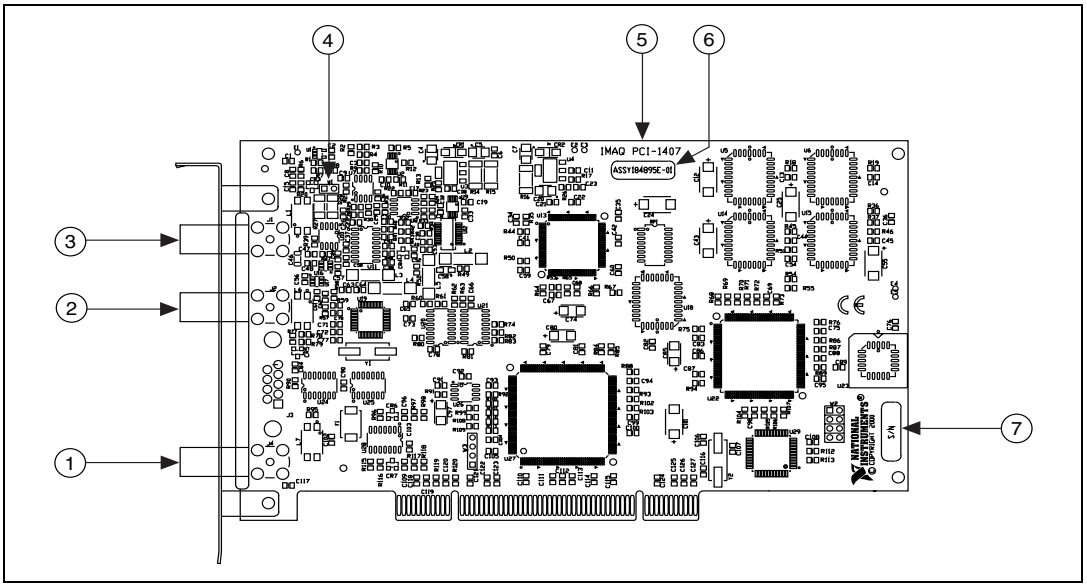
- Ground yourself via a grounding strap or by holding a grounded object.
- Touch the antistatic package to a metal part of your computer chassis before removing the device from the package.
- Remove the device from the package and inspect it for loose components or any other signs of damage. Notify National Instruments if the device appears damaged in any way. Do *not* install a damaged device in your computer.
- *Never* touch the exposed pins of connectors.

Installation

Note You must install the NI-IMAQ driver software before installing the 1407 device. For information on how to install NI-IMAQ, see the *Getting Started with Your IMAQ System* document and the *NI-IMAQ Release Notes*.

For proper operation of the PCI-1407 revisions E and later and the PXI-1407 revisions C and later, make sure one of the video devices is terminated at 75 Ω, while any other video devices are set to high impedance. Populate the W1 jumper to terminate the 1407 at 75 Ω.

Depopulate the W1 jumper to set the 1407 to high impedance. Figure 2-2 shows the location of the W1 jumper and other 1407 parts.



1 Trigger	4 W1 Jumper	6 Assembly Number
2 CSYNC	5 Product Name	7 Serial Number
3 Video		

Figure 2-2. PCI-1407 Parts Locator Diagram

- PCI-1407

You can install the PCI-1407 in any available PCI expansion slot in your computer. However, to achieve the best noise performance, 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. Turn off and unplug your computer.

Caution To protect both yourself and the computer from electrical hazards, the computer should remain off and unplugged until you finish installing the 1407 device.

2. Follow the electrostatic discharge guidelines in the *Safety Information* section of this chapter.
3. Remove the cover of your computer.

4. Make sure there are no lit LEDs on your motherboard. If any are lit, wait until they go out before continuing your installation.
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. Remove the top cover or access port to the PCI bus.
7. Select any available PCI expansion slot.
8. 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 and the bracket screw.
9. Line up the PCI-1407 with the three BNC connectors near the opening 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.
10. Reinstall the bracket screw to secure the PCI-1407 to the back panel rail.
11. Check the installation.
12. 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.

Note The PXI-1407 has connections to several reserved lines on the CompactPCI J2 connector. Before installing a PXI-1407 in a CompactPCI system that uses J2 connector lines for purposes other than PXI, see the *Using PXI with CompactPCI* section in Chapter 1, *Introduction*, of this manual.

1. Turn off and unplug your PXI or CompactPCI chassis.
2. Choose an unused PXI or CompactPCI 5 V peripheral slot. Choose 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 provides 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 device 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 device also includes a trigger for controlling the image acquisition.

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

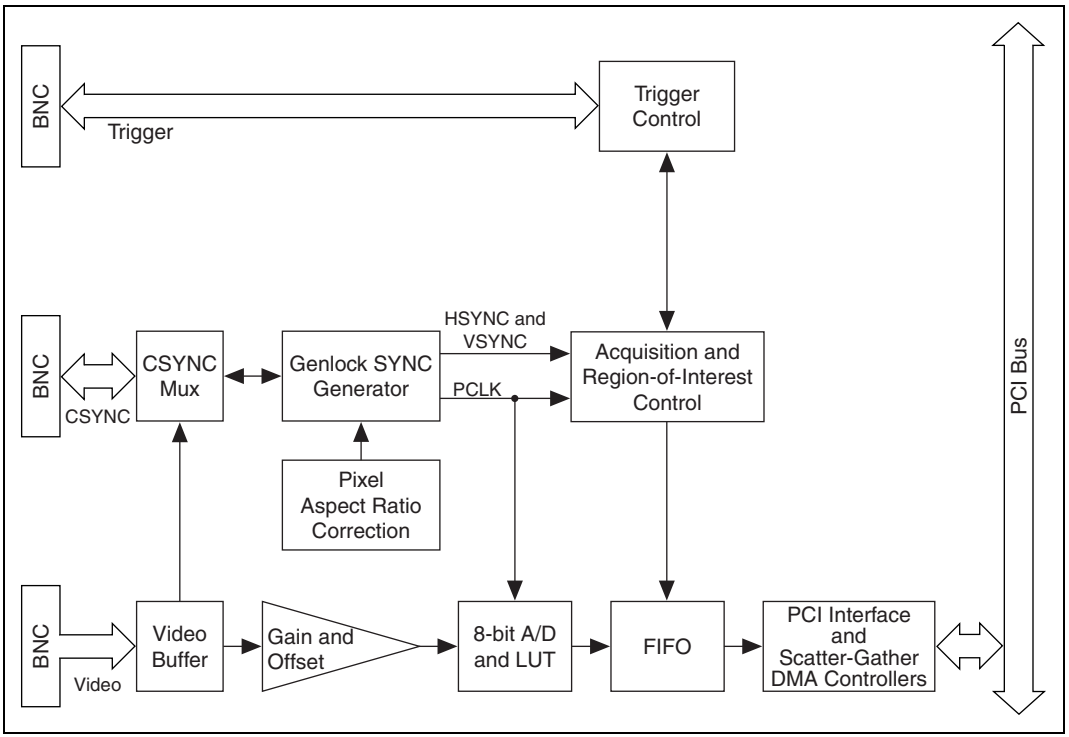


Figure 3-1. PCI/PXI-1407 Block Diagram

Video Buffer

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

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 31 MHz, which accommodate RS-170 and CCIR-601 video standards and their double-speed progressive scan counterparts.[1]

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 the PCI-1407 transfer certain multiples (2, 4, or 8) of pixels and lines 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. 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 FIFO memory buffers and the PCI bus. Each of these controllers

[1] These specifications apply only to revisions E and later of the PCI-1407, and revisions C and later of the PXI-1407.

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 MB/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 and 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 or 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.
- Line count—The line count is the total number of horizontal lines in the picture.
- 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.
- 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.

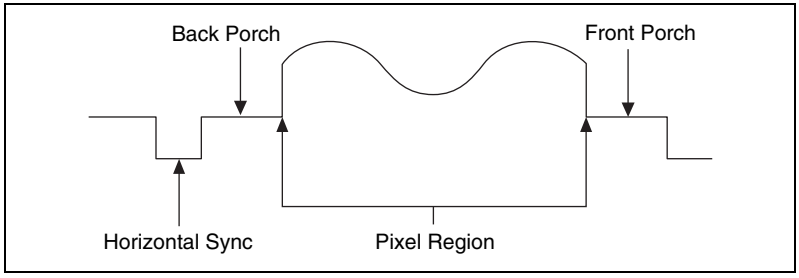


Figure 3-2. Positive Video Line

- 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.

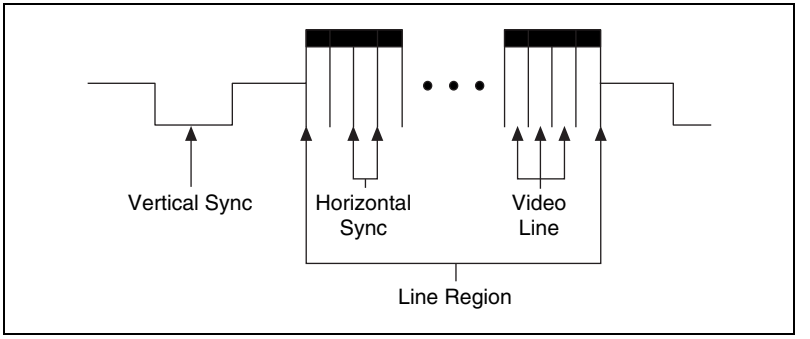


Figure 3-3. Video Field

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

Programming Video Parameters

You can program the following 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 31 MHz,[1] 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 for switching 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

[1] These specifications apply only to revisions E and later of the PCI-1407, and revisions C and later of the PXI-1407.

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 device stores the entire acquisition window in system memory. However, when you enable the region-of-interest circuitry, the device 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 devices 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.

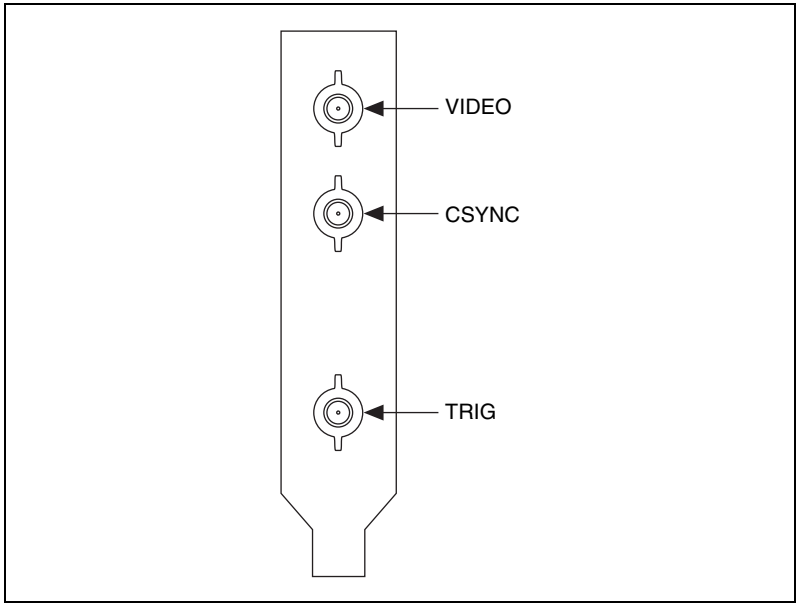


Figure 4-1. PCI/PXI-1407 BNC I/O Connectors

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, *Positive Video Line*.
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.

Note Specifications for items following an asterisk(*) are applicable only to revisions E and later of the PCI-1407, and revisions C and later of the PXI-1407.

Maximum Working Voltage

Channel to earth	5 V, Installation Category 1 (signal voltage plus common-mode voltage)
Channel to channel	5 V, Installation Category 1 (signal voltage plus common-mode voltage)

Formats Supported

RS-170	30 frames/s
CCIR	25 frames/s)
*Progressive scan	25, 30, 50, and 60 frames/s

Video Input

Quantity	1 monochrome
*Input impedance	75 Ω (±1%), 1 Ω (±5%)
Frequency response	15 MHz (–3 dB) typical
*Input range	700 mV (calibrated) or 60 mV to 1.26 V (variable gain)

Accuracy

*Absolute accuracy[1] .....±2.5% of reading

*Temperature drift .....< 500 ppm/°C

A/D Conversion

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

RMS noise .....< 0.5 LSB rms

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

*Sampling rate .....11.7 to 31 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

Usage .....Indoor use only

Internal Pixel Clock

*Generated frequency.....11.66 to 31 MHz

*Aspect correction for
standard video sources.....±5%

[1] Calibration conditions:
White level..... 700 mV
Black level..... 0 V
Ambient temperature..... 25°C nominal

Pixel jitter ..... < 2 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 MB/s
- Sustained ..... 100 MB/s

Power Requirements

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

Physical

Dimensions

- PCI-1407 ..... 10.7 by 17.5 cm (4.2 by 6.9 in.)
- PXI-1407 ..... 16 by 10 cm (6.3 by 3.9 in.)

Weight

PCI-1407.....0.127 kg (0.28 lb.)

PXI-1407 .....0.145 kg (0.32 lb.)

Environment

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

Storage temperature .....–20 to 70 °C

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

Maximum altitude.....2000 m

Pollution degree 2

Functional shock (PXI only).....MIL-T-28800 E Class 3 (per Section 4.5.5.4.1) Half-sine shock pulse, 11 ms duration, 30 g peak, 30 shocks per face

Operational random vibration (PXI Only) .....5 to 500 Hz, 0.31 grms, 3 axes

Nonoperational random vibration (PXI Only) .....5 to 500 Hz, 2.5 grms, 3 axes

Note Random vibration profiles were developed in accordance with MIL-T-28800E and MIL-STD-810E Method 514. Test levels exceed those recommended in MIL-STD-810E for Category 1 (Basic Transportation, Figures 514.4-1 through 514.4-3).

Electromagnetic Compatibility

EMC/EMI .....CE, C-Tick, and FCC Part 15 (Class A) Compliant

Electrical emissions .....EN 55011 Class A at 10 meters FCC Part 15A above 1 GHz

Electrical immunity .....Evaluated to EN 61326:1997/ A1:1998, Table 1

Note For full EMC compliance, you must operate this device with shielded cabling. In addition, all covers and filler panels must be installed. See the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the

DoC for this product, click **Declaration of Conformity** at `ni.com/hardref.nsf/`. This Web site lists the DoCs by product family. Select the appropriate product family, followed by your product, and a link to the DoC (in Adobe Acrobat format) appears. Click the Acrobat icon to download or read the DoC.

Safety

Meets the requirements of the following standards for safety for electrical equipment for measurement, control, and laboratory use:

- EN 61010-1:1993/A2:1995, IEC 61010-1:1990/A2:1995
- UL 3101-1:1993, UL 3111-1:1994, UL 3121:1998
- CAN/CSA C22.2 no. 1010.1:1992/A2:1997

Installation category I

B

Technical Support Resources

Web Support

National Instruments Web support is your first stop for help in solving installation, configuration, and application problems and questions. Online problem-solving and diagnostic resources include frequently asked questions, knowledge bases, product-specific troubleshooting wizards, manuals, drivers, software updates, and more. Web support is available through the Technical Support section of `ni.com`.

NI Developer Zone

The NI Developer Zone at `ni.com/zone` is the essential resource for building measurement and automation systems. At the NI Developer Zone, you can easily access the latest example programs, system configurators, tutorials, technical news, as well as a community of developers ready to share their own techniques.

Customer Education

National Instruments provides a number of alternatives to satisfy your training needs, from self-paced tutorials, videos, and interactive CDs to instructor-led hands-on courses at locations around the world. Visit the Customer Education section of `ni.com` for online course schedules, syllabi, training centers, and class registration.

System Integration

If you have time constraints, limited in-house technical resources, or other dilemmas, you may prefer to employ consulting or system integration services. You can rely on the expertise available through our worldwide network of Alliance Program members. To find out more about our Alliance system integration solutions, visit the System Integration section of `ni.com`.

Worldwide Support

National Instruments has offices located around the world to help address your support needs. You can access our branch office Web sites from the Worldwide Offices section of `ni.com`. Branch office Web sites provide up-to-date contact information, support phone numbers, e-mail addresses, and current events.

If you have searched the technical support resources on our Web site and still cannot find the answers you need, contact your local office or National Instruments corporate. Phone numbers for our worldwide offices are listed at the front of this manual.

Glossary

Prefix	Meaning	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}

Symbols

%	Percent.
+	Positive of, or plus.
–	Negative of, or minus.
/	Per.
±	Plus or minus.
Ω	Ohm.

A

A	Amperes.
A/D	Analog-to-digital.
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 the vertical synchronization signal) and a line count.
active pixel region	The region of pixels actively being stored. Defined by a pixel start (relative to the horizontal synchronization signal) and a pixel count.
ADC	Analog-to-digital converter. An electronic device, often an integrated circuit, that converts an analog voltage to a digital value.
address	Value that identifies a specific location (or series of locations) in memory.
API	Application programming interface.
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 specific customer needs.
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 synchronization 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	A 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. Also used to describe signals, boards, and cameras that adhere to the CCIR standards.
CMOS	Complementary metal-oxide semiconductor.
CompactPCI	Refers to the core specification defined by the PCI Industrial Computer Manufacturer's Group (PICMG).
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 synchronization signal. A combination of the horizontal and vertical synchronization 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: $dB = 20\log_{10} V1/V2$, 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.*

display memory

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 image acquisition board.

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.
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 synchronization signal.
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

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.

H

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 synchronization 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. Frequency in units of 1/second.

I

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.
IC	Integrated circuit.
IEEE	Institute of Electrical and Electronics Engineers.
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 control 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.
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.
IRQ	Interrupt request. *See* interrupt.

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.
luma	The brightness information in the video picture. The luma signal amplitude varies in proportion to the brightness of the video signal and corresponds exactly to the monochrome picture.
luminance	*See* luma.
LUT	Look-up table. Table containing values used to transform the gray-level values of an image. For each gray-level value in the image, the corresponding new value is obtained from the look-up table.

M

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	Megabyte 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. PCI 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 horizontal synchronization signals. The pixel count determines the frequency of the pixel clock.
progressive scan	non-interlaced format video

protocol	The exact sequence of bits, characters, and control codes used to transfer data between computers and peripherals through a communications channel.
PXI	PCI eXtensions for Instrumentation. An open specification that builds on 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

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.
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 external and RTSI bus trigger lines. You can configure each of these lines to start or stop acquisition on a rising or falling edge.
TTL	Transistor-transistor logic (0 to 5 V single-ended signal).

V

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 synchronization 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.

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