

# **IMAQ™**

---

## **IMAQ PCI-1428 User Manual**

**High-Quality Camera Link Image  
Acquisition Board for PCI**

## **Worldwide Technical Support and Product Information**

ni.com

### **National Instruments Corporate Headquarters**

11500 North Mopac Expressway Austin, Texas 78759-3504 USA Tel: 512 794 0100

### **Worldwide Offices**

Australia 03 9879 5166, Austria 0662 45 79 90 0, Belgium 02 757 00 20, Brazil 011 284 5011,  
Canada (Calgary) 403 274 9391, Canada (Ottawa) 613 233 5949, Canada (Québec) 514 694 8521,  
China (Shanghai) 021 6555 7838, China (ShenZhen) 0755 3904939, Denmark 45 76 26 00,  
Finland 09 725 725 11, France 01 48 14 24 24, Germany 089 741 31 30, Greece 30 1 42 96 427,  
Hong Kong 2645 3186, India 91805275406, Israel 03 6120092, Italy 02 413091, Japan 03 5472 2970,  
Korea 02 596 7456, Mexico 5 280 7625, Netherlands 0348 433466, New Zealand 09 914 0488,  
Norway 32 27 73 00, Poland 0 22 528 94 06, Portugal 351 1 726 9011, Singapore 2265886, Spain 91 640 0085,  
Sweden 08 587 895 00, Switzerland 056 200 51 51, Taiwan 02 2528 7227, United Kingdom 01635 523545

For further support information, see the *Technical Support Resources* appendix. To comment on the documentation, send e-mail to [techpubs@ni.com](mailto:techpubs@ni.com)

© Copyright 2001 National Instruments Corporation. All rights reserved.

# Important Information

---

## Warranty

The IMAQ PCI-1428 is warranted against defects in materials and workmanship for a period of one year from the date of shipment, as evidenced by receipts or other documentation. National Instruments will, at its option, repair or replace equipment that proves to be defective during the warranty period. This warranty includes parts and labor.

The media on which you receive National Instruments software are warranted not to fail to execute programming instructions, due to defects in materials and workmanship, for a period of 90 days from date of shipment, as evidenced by receipts or other documentation. National Instruments will, at its option, repair or replace software media that do not execute programming instructions if National Instruments receives notice of such defects during the warranty period. National Instruments does not warrant that the operation of the software shall be uninterrupted or error free.

A Return Material Authorization (RMA) number must be obtained from the factory and clearly marked on the outside of the package before any equipment will be accepted for warranty work. National Instruments will pay the shipping costs of returning to the owner parts which are covered by warranty.

National Instruments believes that the information in this document is accurate. The document has been carefully reviewed for technical accuracy. In the event that technical or typographical errors exist, National Instruments reserves the right to make changes to subsequent editions of this document without prior notice to holders of this edition. The reader should consult National Instruments if errors are suspected. In no event shall National Instruments be liable for any damages arising out of or related to this document or the information contained in it.

EXCEPT AS SPECIFIED HEREIN, NATIONAL INSTRUMENTS MAKES NO WARRANTIES, EXPRESS OR IMPLIED, AND SPECIFICALLY DISCLAIMS ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. CUSTOMER'S RIGHT TO RECOVER DAMAGES CAUSED BY FAULT OR NEGLIGENCE ON THE PART OF NATIONAL INSTRUMENTS SHALL BE LIMITED TO THE AMOUNT THEREFORE PAID BY THE CUSTOMER. NATIONAL INSTRUMENTS WILL NOT BE LIABLE FOR DAMAGES RESULTING FROM LOSS OF DATA, PROFITS, USE OF PRODUCTS, OR INCIDENTAL OR CONSEQUENTIAL DAMAGES, EVEN IF ADVISED OF THE POSSIBILITY THEREOF. This limitation of the liability of National Instruments will apply regardless of the form of action, whether in contract or tort, including negligence. Any action against National Instruments must be brought within one year after the cause of action accrues. National Instruments shall not be liable for any delay in performance due to causes beyond its reasonable control. The warranty provided herein does not cover damages, defects, malfunctions, or service failures caused by owner's failure to follow the National Instruments installation, operation, or maintenance instructions; owner's modification of the product; owner's abuse, misuse, or negligent acts; and power failure or surges, fire, flood, accident, actions of third parties, or other events outside reasonable control.

## Copyright

Under the copyright laws, this publication may not be reproduced or transmitted in any form, electronic or mechanical, including photocopying, recording, storing in an information retrieval system, or translating, in whole or in part, without the prior written consent of National Instruments Corporation.

## Trademarks

CVI™, IMAQ™, LabVIEW™, National Instruments™, and ni.com™ are trademarks of National Instruments Corporation.

Product and company names mentioned herein are trademarks or trade names of their respective companies.

## WARNING REGARDING USE OF NATIONAL INSTRUMENTS PRODUCTS

(1) NATIONAL INSTRUMENTS PRODUCTS ARE NOT DESIGNED WITH COMPONENTS AND TESTING FOR A LEVEL OF RELIABILITY SUITABLE FOR USE IN OR IN CONNECTION WITH SURGICAL IMPLANTS OR AS CRITICAL COMPONENTS IN ANY LIFE SUPPORT SYSTEMS WHOSE FAILURE TO PERFORM CAN REASONABLY BE EXPECTED TO CAUSE SIGNIFICANT INJURY TO A HUMAN.

(2) IN ANY APPLICATION, INCLUDING THE ABOVE, RELIABILITY OF OPERATION OF THE SOFTWARE PRODUCTS CAN BE IMPAIRED BY ADVERSE FACTORS, INCLUDING BUT NOT LIMITED TO FLUCTUATIONS IN ELECTRICAL POWER SUPPLY, COMPUTER HARDWARE MALFUNCTIONS, COMPUTER OPERATING SYSTEM SOFTWARE FITNESS, FITNESS OF COMPILERS AND DEVELOPMENT SOFTWARE USED TO DEVELOP AN APPLICATION, INSTALLATION ERRORS, SOFTWARE AND HARDWARE COMPATIBILITY PROBLEMS, MALFUNCTIONS OR FAILURES OF ELECTRONIC MONITORING OR CONTROL DEVICES, TRANSIENT FAILURES OF ELECTRONIC SYSTEMS (HARDWARE AND/OR SOFTWARE), UNANTICIPATED USES OR MISUSES, OR ERRORS ON THE PART OF THE USER OR APPLICATIONS DESIGNER (ADVERSE FACTORS SUCH AS THESE ARE HEREAFTER COLLECTIVELY TERMED "SYSTEM FAILURES"). ANY APPLICATION WHERE A SYSTEM FAILURE WOULD CREATE A RISK OF HARM TO PROPERTY OR PERSONS (INCLUDING THE RISK OF BODILY INJURY AND DEATH) SHOULD NOT BE RELIANT SOLELY UPON ONE FORM OF ELECTRONIC SYSTEM DUE TO THE RISK OF SYSTEM FAILURE. TO AVOID DAMAGE, INJURY, OR DEATH, THE USER OR APPLICATION DESIGNER MUST TAKE REASONABLY PRUDENT STEPS TO PROTECT AGAINST SYSTEM FAILURES, INCLUDING BUT NOT LIMITED TO BACK-UP OR SHUT DOWN MECHANISMS. BECAUSE EACH END-USER SYSTEM IS CUSTOMIZED AND DIFFERS FROM NATIONAL INSTRUMENTS' TESTING PLATFORMS AND BECAUSE A USER OR APPLICATION DESIGNER MAY USE NATIONAL INSTRUMENTS PRODUCTS IN COMBINATION WITH OTHER PRODUCTS IN A MANNER NOT EVALUATED OR CONTEMPLATED BY NATIONAL INSTRUMENTS, THE USER OR APPLICATION DESIGNER IS ULTIMATELY RESPONSIBLE FOR VERIFYING AND VALIDATING THE SUITABILITY OF NATIONAL INSTRUMENTS PRODUCTS WHENEVER NATIONAL INSTRUMENTS PRODUCTS ARE INCORPORATED IN A SYSTEM OR APPLICATION, INCLUDING, WITHOUT LIMITATION, THE APPROPRIATE DESIGN, PROCESS AND SAFETY LEVEL OF SUCH SYSTEM OR APPLICATION.

# Compliance

---

## FCC/Canada Radio Frequency Interference Compliance\*

### Determining FCC Class

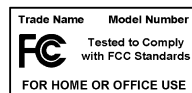
The Federal Communications Commission (FCC) has rules to protect wireless communications from interference. The FCC places digital electronics into two classes. These classes are known as Class A (for use in industrial-commercial locations only) or Class B (for use in residential or commercial locations). 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.

## **European Union - Compliance to EEC Directives**

Readers in the EU/EEC/EEA 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.

\* 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:



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



This icon denotes a warning, which advises you of precautions to take to avoid being electrically shocked.

*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.

# Contents

---

## Chapter 1

### Introduction

About the PCI-1428 .....	1-1
About Camera Link .....	1-2
Software Programming Choices .....	1-2
NI-IMAQ Driver Software .....	1-3
National Instruments IMAQ Vision .....	1-5
IMAQ Vision Builder .....	1-5
Integration with DAQ .....	1-6
Vision and Motion .....	1-6

## Chapter 2

### Installation

What You Need to Get Started .....	2-1
Optional Equipment .....	2-2
How to Set up Your IMAQ System .....	2-2
Unpacking .....	2-4
Installation .....	2-4

## Chapter 3

### Hardware Overview

Functional Overview .....	3-1
LUTs .....	3-2
Multiple-Tap Data Formatter .....	3-3
SDRAM .....	3-3
Serial Interface .....	3-3
Trigger Control and Mapping Circuitry .....	3-3
High-Speed Timing .....	3-3
Acquisition, Scaling, ROI .....	3-4
Scatter-Gather DMA Controllers .....	3-4
Bus Master PCI Interface .....	3-4
Board Configuration NVRAM .....	3-4
Video Acquisition .....	3-4
Start Conditions .....	3-5
Acquisition Window Control .....	3-5

**Appendix A  
Specifications**

**Appendix B  
Technical Support Resources**

**Glossary**

**Index**



---

# Introduction

This chapter describes the PCI-1428 and the Camera Link standard, and also describes your software programming choices.

## About the PCI-1428

---

The PCI-1428 is a highly flexible IMAQ board for PCI chassis that supports a diverse range of Camera Link-compatible cameras from many camera companies. The PCI-1428 acquires digital images in real time and can store these images in onboard frame memory or transfer these images directly to system memory. The board can support the Medium configuration of the Camera Link standard at clock speeds up to 50 MHz.

The PCI-1428 is simple to configure; you can easily install the board and begin acquiring images. The PCI-1428 ships with NI-IMAQ, the National Instruments complete IMAQ driver software which you can use to directly control the PCI-1428 and other National Instruments IMAQ hardware products. Using NI-IMAQ, you can quickly and easily start your applications without having to program the board at the register level.

Featuring a high-speed data flow path, the PCI-1428 is ideal for both industrial and scientific environments. As a stand-alone board, the PCI-1428 supports the Camera Link Base configuration, which includes four general-purpose control lines that can be configured to generate precise timing signals to control digital camera acquisition. An additional cable allows the PCI-1428 to support the Medium configuration. Four external input/output (I/O) lines that you can use as triggers or as high-speed digital I/O lines are available on the VHDCI 68-pin connector. If you require more advanced triggering or digital I/O lines (either digital or analog), use the PCI-1428 and NI-IMAQ with the National Instruments data acquisition (DAQ) product line.

A common problem with other image acquisition boards is that you cannot easily synchronize several functions to a common trigger or timing event. The PCI-1428 uses its Real-Time System Integration (RTSI) bus to solve this problem. The RTSI bus uses the National Instruments RTSI bus interface and ribbon cable to route additional timing and trigger signals

between the PCI-1428 and up to four National Instruments DAQ or IMAQ boards in your computer. The RTSI bus can even synchronize multiple IMAQ hardware captures.

Detailed specifications of the PCI-1428 are in Appendix A, [Specifications](#).

## About Camera Link

---

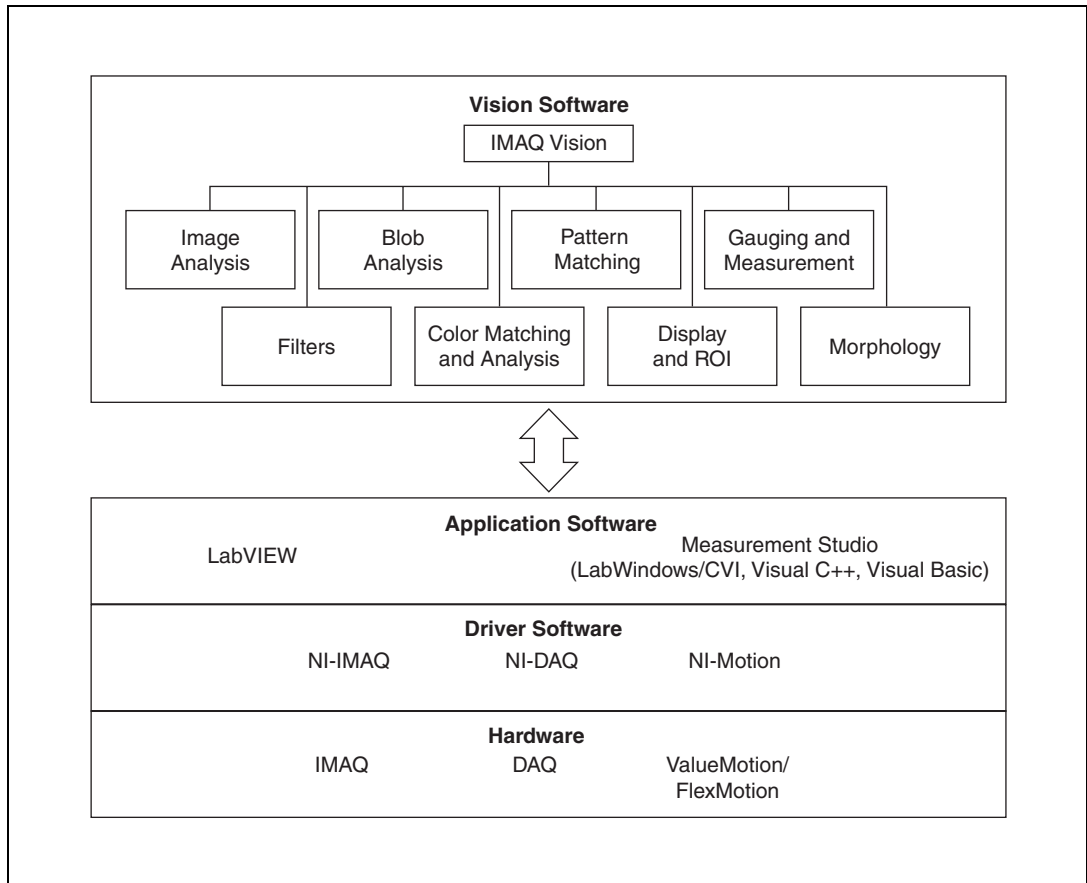
Camera Link is an informal standard for a digital camera interface that was created by a consortium of camera and frame grabber manufacturers. The National Semiconductor Channel Link chipset, a general purpose transmitter/receiver pair, is the basis for the standard. The Channel Link driver takes 28 bits of parallel digital data and a clock and serializes the stream to four LVDS data streams and an LVDS clock, providing high speed data transmission across 10 wires over distances of up to 10 meters.

The Camera Link Base configuration places 24 data bits as well as Frame Valid, Line Valid, and Data Valid signals on a single Channel Link part and cable. The Base configuration also bundles wires for four digital camera control lines and asynchronous serial transmission. For cameras generating more than 24 bits of data, the standard allows the use of two or three Channel Link parts; these are the Medium and Full configurations, respectively.

## Software Programming Choices

---

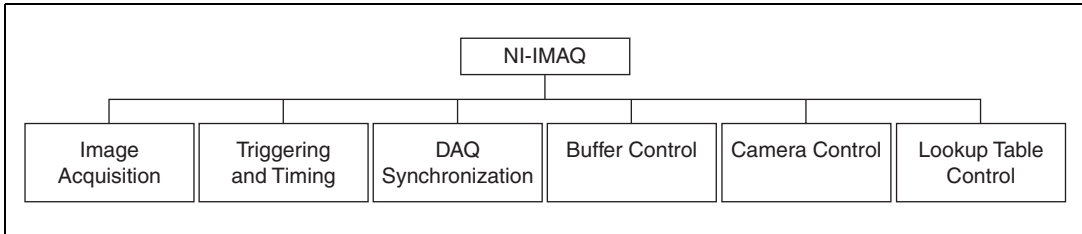
Using NI-IMAQ, the National Instruments image acquisition driver software, you can program your IMAQ board to acquire and save images. You can use NI-IMAQ with other National Instruments software for a complete image acquisition and analysis solution, as shown in Figure 1-1. NI-IMAQ works with LabVIEW and LabWindows/CVI, as well as 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. The NI-IMAQ software does not perform any image analysis. For image analysis functionality, refer to the [National Instruments IMAQ Vision](#) section 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 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 your 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.

## National Instruments IMAQ Vision

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.

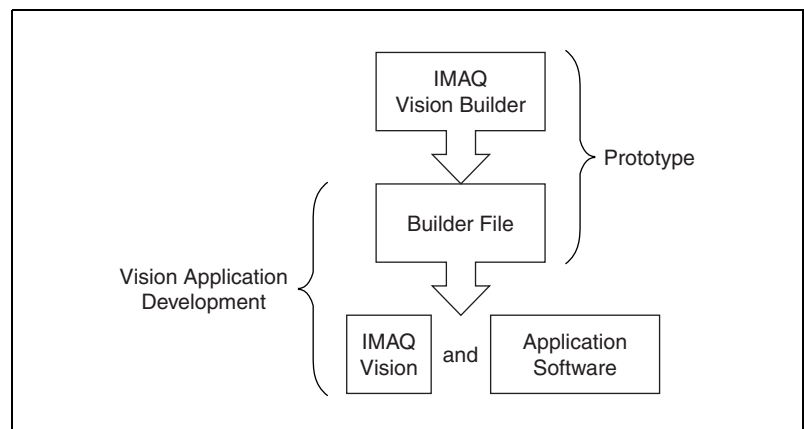
You can use IMAQ Vision functions directly or in combination for unique image processing. With IMAQ Vision you can acquire, display, manipulate, and store images as well as perform image analysis, processing, and interpretation. Using IMAQ Vision, an imaging novice or expert can perform graphical programming 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

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 for developing applications with IMAQ Vision in LabVIEW or Measurement Studio.



**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 boards, 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 where 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 for inspection and guidance applications such as locating alignment markers on semiconductor wafers, guiding robotic arms, inspecting the quality of manufactured parts, and locating cells.

---

# Installation

This chapter lists what you need to get started acquiring images with your IMAQ device; 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 and use your PCI-1428, you will need the following:

- Your PCI-1428
- Getting Started with Your IMAQ System*
- IMAQ PCI-1428 User Manual*
- NI-IMAQ release notes
- NI-IMAQ for Windows 2000/NT/Me/9x and 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)
- Your Pentium-based PCI computer running Windows 2000, Windows NT, Windows Me, or Windows 9x.
- A Camera Link camera
- 3M MDR 26-pin Camera Link cable

## Optional Equipment

---

National Instruments offers a variety of products for use with your PCI-1428, including the following cables and other National Instruments products:

- A breakout cable for triggering. Use one of the following IMAQ cables:
  - IMAQ D682604-1 breakout cable for triggering and Medium Configuration (with an MDR 26-pin connector on a second Camera Link cable)
  - IMAQ D6804 breakout cable for all other triggering
- RTSI bus cables for connecting the PCI-1428 to other IMAQ or DAQ hardware
- 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.

## How to Set up Your IMAQ System

---

Use Figure 2-1 as a guide while you install your software and hardware, configure your hardware, and begin using NI-IMAQ in your application programs.

Follow the instructions in the *Getting Started with Your IMAQ System* document to install your NI-IMAQ software and IMAQ hardware.

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



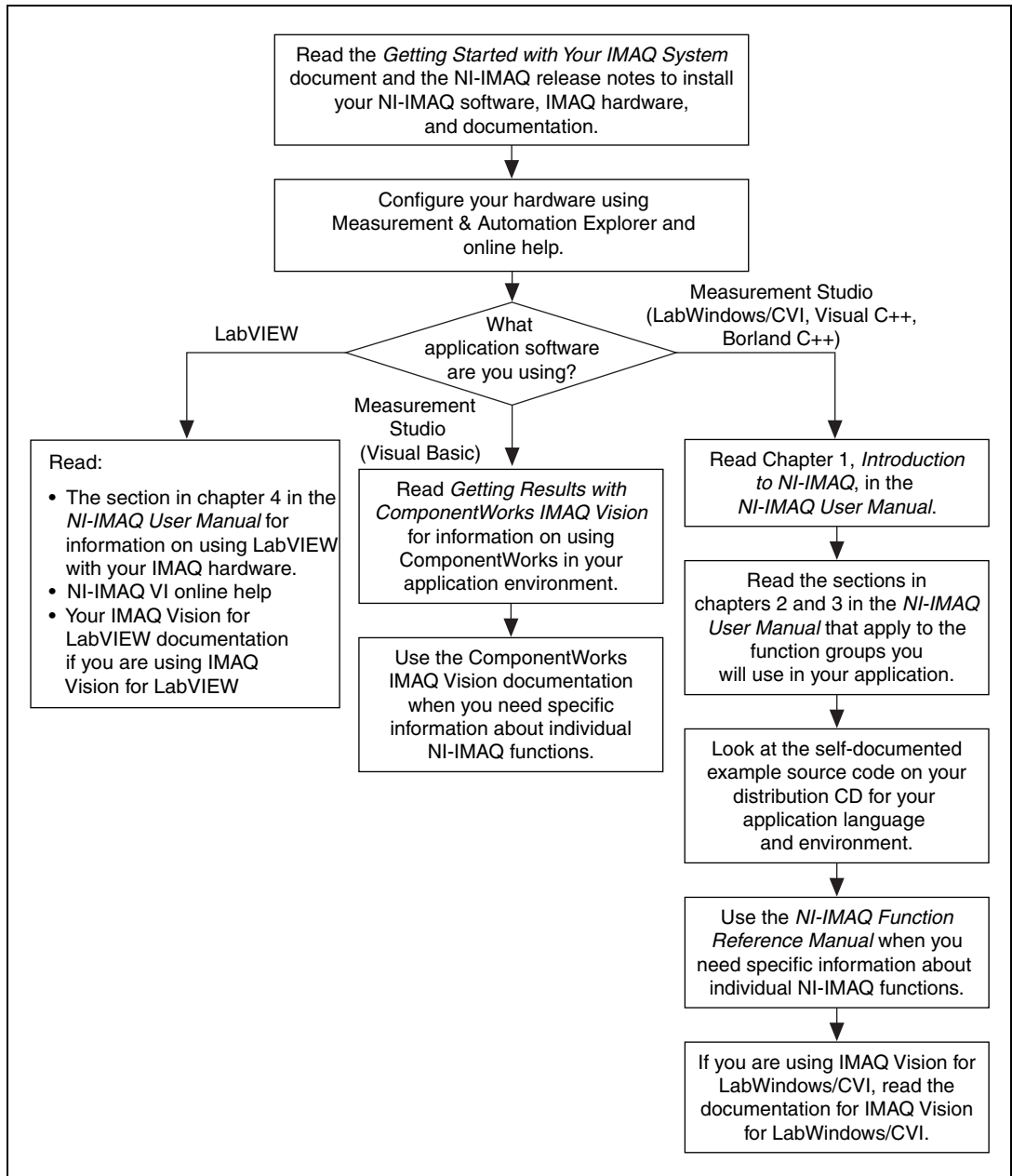


Figure 2-1. How to Set up Your IMAQ System

# Unpacking

---

Your PCI-1428 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.

# Installation

---



**Note** You must install the NI-IMAQ driver software before installing your 1428 device. For information on how to install NI-IMAQ, please see the *Getting Started with Your IMAQ System* document and your NI-IMAQ release notes.

You can install the PCI-1428 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-1428 and other boards and hardware.



**Note** Follow the guidelines in your computer documentation for installing plug-in hardware.

1. Turn off and unplug your computer.



**Warning** To protect both yourself and the computer from electrical hazards, the computer should remain off until you finish installing the PCI-1428.

2. Follow the electrostatic discharge guidelines in the *Unpacking* section of this chapter.
3. Remove the cover of your computer.
4. Make sure there are no lighted 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. 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.
7. Line up the PCI-1428 with the MDR 26-pin connector near the cut-out on the back panel. Slowly push down on the top of the PCI-1428 until its card-edge connector is resting on the expansion slot receptacle. Using slow, evenly distributed pressure, press the PCI-1428 straight down until it seats in the expansion slot.
8. Reinstall the bracket-retaining screw to secure the PCI-1428 to the back panel rail.
9. Visually verify the installation.
10. Replace the computer cover.

Your PCI-1428 is now installed.

---

# Hardware Overview

This chapter presents an overview of the hardware functions on your PCI-1428 board and explains the operation of each functional unit making up the PCI-1428.

## Functional Overview

---

The PCI-1428 features a flexible, high-speed data path optimized for the reception and formatting of video data from Camera Link cameras.

The block diagram in Figure 3-1 illustrates the key functional components of the PCI-1428.

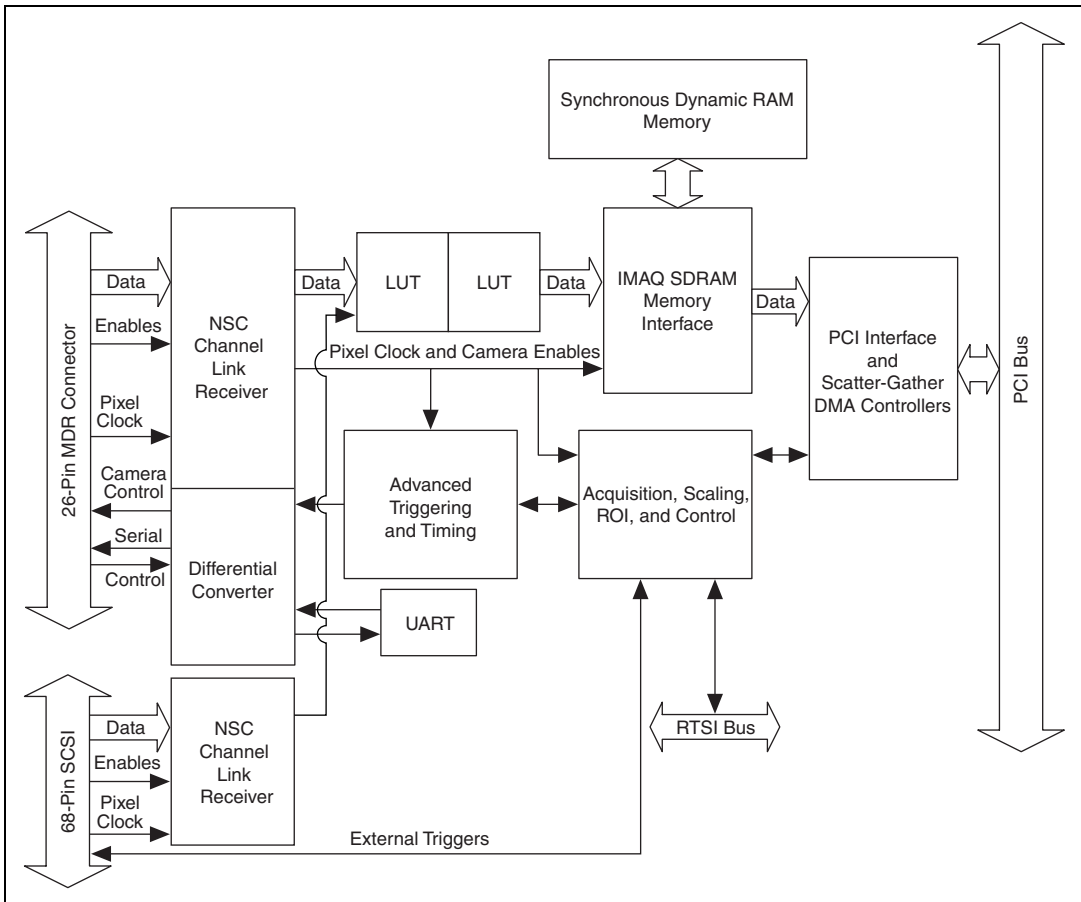


Figure 3-1. PCI-1428 Block Diagram

## LUTs

The PCI-1428 uses two 64 KB × 16 bit lookup tables (LUTs) that can also be used to do up to four 256 B × 8 bit LUT operations such as contrast enhancement, data inversion, gamma manipulation, or other nonlinear transfer functions.

## Multiple-Tap Data Formatter

Many digital cameras transfer multiple channels, or taps, of data simultaneously to increase the frame rate of the camera. However, the data in each tap may not be transferred in the traditional top-left to bottom-right direction. Also, the taps may not transfer data in similar directions.

The multiple-tap data formatting circuitry on the PCI-1428 can reorder the data from up to four 8-bit taps. The data from each tap can be independently scanned either from left-to-right or right-to-left and top-to-bottom or bottom-to-top.

## SDRAM

The PCI-1428 comes with 16 MB of onboard high-speed synchronous dynamic RAM (SDRAM). The PCI-1428 uses the onboard RAM as a FIFO buffer to ensure acquisition. Even when the data rate from the camera exceeds PCI throughput, you can acquire without interruption until the onboard RAM is full.

## Serial Interface

Use the asynchronous serial interface on the MDR 26-pin connector to control Camera Link cameras that also have a serial interface for camera control and configuration.

## Trigger Control and Mapping Circuitry

The trigger control and mapping circuitry routes, monitors, and drives the external and RTSI bus trigger lines. You can configure each of these lines to start an acquisition on a rising or falling edge. In addition, you can drive each line asserted or unasserted, similar to a digital I/O line. You can also map pulses from the high-speed timing circuitry or many of the PCI-1428 status signals to these trigger lines. There are four external and four RTSI bus triggers. You can program each of these triggers in polarity and direction.

## High-Speed Timing

The high-speed timing circuitry on the PCI-1428, built from high-speed counters, allows you to specify or generate precise, real-time control signals. Map the output of this circuitry to a trigger line to provide accurate pulses and pulse trains.

## Acquisition, Scaling, ROI

The acquisition, scaling, and region-of-interest (ROI) circuitry monitors the incoming video signals and routes the active pixels to the multiple-tap data formatter and SDRAM memory. The PCI-1428 can perform ROI and scaling on all video lines and frames. Pixel and line scaling transfers certain multiples (two, four, or eight) of pixels and lines to onboard memory. In an ROI acquisition, you select an area within the acquisition window to transfer across the PCI bus to system memory.

## Scatter-Gather DMA Controllers

The PCI-1428 uses three independent onboard direct memory access (DMA) controllers. The DMA controllers transfer data between the onboard SDRAM memory buffers and the PCI bus. Each of these controllers supports scatter-gather DMA, which allows the DMA controller to reconfigure on-the-fly. The PCI-1428 can perform continuous image transfers directly to either contiguous or fragmented memory buffers.

## Bus Master PCI Interface

The PCI-1428 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 bus master mode. The PCI-1428 can generate 8-, 16-, and 32-bit memory read and write cycles, both single and multiple. In slave mode, the PCI-1428 is a medium-speed decoder that accepts both memory and configuration cycles. The interface logic ensures that the PCI-1428 meets PCI loading, driving, and timing requirements.

## Board Configuration NVRAM

The PCI-1428 contains onboard nonvolatile RAM (NVRAM) that configures all registers on power-up.

## Video Acquisition

The PCI-1428 can acquire digital video in a variety of modes and store the images in the onboard SDRAM memory or transfer the images directly to PCI system memory.

## Start Conditions

The PCI-1428 can start acquisitions in a variety of conditions:

- **Software control**—The PCI-1428 supports software control of acquisition start. You can configure the PCI-1428 to capture a fixed number of frames. This configuration is useful for capturing a single frame or a sequence of frames.
- **Trigger control**—You can start an acquisition by enabling external or RTSI bus trigger lines. Each of these 11 inputs can start a video acquisition on a rising or falling edge. You can use all four external triggers and up to four RTSI bus triggers simultaneously.
- **Delayed acquisition**—Use either software or triggers to start acquisitions instantaneously or after skipping a specific period of time. You can use delayed acquisition for posttrigger applications.

## Acquisition Window Control

You can configure numerous parameters on the PCI-1428 to control the video acquisition window. A brief description of each parameter follows:

- **Acquisition window**—The PCI-1428 allows the user to specify a particular region of active pixels and active lines within the incoming video data. The active pixel region selects the starting pixel and number of pixels to be acquired relative to the assertion edge of the horizontal (or line) enable signal from the camera. The active line region selects the starting line and number of lines to be acquired relative to the assertion edge of the vertical (or frame) enable signal.
- **Region of interest**—The PCI-1428 uses a second level of active pixel and active line regions for selecting a region of interest. Using the region-of-interest circuitry, the board acquires only a selected subset of the acquisition window.
- **Scaling down**—The scaling-down circuitry also controls the active acquisition region. The PCI-1428 can scale down a frame by reducing the number of pixels per line, the number of lines per frame, or both. For active pixel selection, the PCI-1428 selects every pixel, every other pixel, every fourth pixel, or every eighth pixel. For active line selection, the PCI-1428 selects every line, every other line, every fourth line, or every eighth line. You can use the scaling-down circuitry in conjunction with the region-of-interest circuitry.



# Specifications

This appendix lists the specifications of the PCI-1428. These specifications are typical at 25 °C, unless otherwise stated.

## External Connections

Trigger sense .....	TTL
Trigger level .....	Programmable (rising or falling)
Pixel clock .....	Camera Link compatible
Enables .....	Camera Link compatible
Control signal .....	Camera Link compatible
Video data .....	Camera Link compatible

## Clocks

Pixel clock frequency range .....	500 kHz–50 MHz
-----------------------------------	----------------

## PCI Interface

PCI initiator (master) capability .....	Supported
PCI target (slave) capability .....	Supported
Data path .....	32 bits
Card voltage .....	5 V, 12 V, –12 V
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
Base address registers .....	BAR0 (16 KB) BAR1 (64 KB)
Expansion ROM .....	4 KB
PCI master performance	
Ideal .....	133 Mbytes/s
Sustained.....	100 Mbytes/s

## Power Requirements

Voltage.....	+5 V <sub>DC</sub> (1.5 A <sub>DC</sub> ) +12 V <sub>AC</sub> (24 mA) -12 V <sub>DC</sub> (20 mA)
--------------	---

## Physical

Dimensions .....	10.7 by 17.5 cm (4.2 by 6.9 in.)
Weight .....	0.127 kg (0.28 lb)

## Environment

Operating temperature .....	0 to 55 °C
Storage temperature .....	-20 to 70 °C
Relative humidity .....	5–90%, noncondensing
Emissions.....	EN 55011:1991 Group 1 Class A at 10 m FCC Class A at 10 m

# 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](http://ni.com)

## NI Developer Zone

---

The NI Developer Zone at [ni.com/zone](http://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](http://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](http://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](http://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
k-	kilo-	$10^3$
M-	mega-	$10^6$

## Numbers/Symbols

%	Percent.
+	Positive of, or plus.
/	Per.
$\Omega$	Ohm.
$\pm$	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 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.
address	Value that identifies a specific location (or series of locations) in memory.
ANSI	American National Standards Institute.
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.
<b>B</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
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.
<b>C</b>	
C	Celsius.
cache	High-speed processor memory that buffers commonly used instructions or data to increase processing throughput.
Camera Link	Interface standard for digital video data and camera control based on the Channel Link chipset.
Channel Link	National Semiconductor chipset for high-speed data serialization and deserialization for transmission across cables up to 10 meters.
CMOS	Complementary metal-oxide semiconductor.
CPU	Central processing unit.

**D**

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.
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 <i>use the current default setting</i> .
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**

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.
------	---

ft Feet.

## H

h Hour.

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.

in. Inches.

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.

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**

line count	The total number of horizontal lines in the picture.
LSB	Least significant bit.
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.
LVDS	Low Voltage Differential Signaling (EIA-644).

**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	Megabyte of memory.
Mbytes/s	A unit for data transfer that means 1 million or $10^6$ bytes/s.
memory buffer	<i>See</i> 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.
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.

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 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.

protocol      The exact sequence of bits, characters, and control codes used to transfer data between computers and peripherals through a communications channel.

pts      Points.

## 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.

RGB	Color encoding scheme using red, green, and blue (RGB) color information where each pixel in the color image is encoded using 32 bits: 8 bits for red, 8 bits for green, 8 bits for blue, and 8 bits for the alpha value (unused).
ribbon cable	A flat cable in which the conductors are side by side.
ROI	Region of interest. A hardware-programmable rectangular portion of the acquisition window.
ROM	Read-only memory.
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.
saturation	The amount of white added to a pure color. Saturation relates to the richness of a color. A saturation of zero corresponds to a pure color with no white added. Pink is a red with low saturation.
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.
SDRAM	Synchronous dynamic RAM.
SRAM	Static RAM.
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

tap	A stream of pixels from a camera. Some cameras send multiple streams, or taps, of data over a cable simultaneously to increase transfer rate.
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.
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.

## 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.
----	--

# Index

---

## A

- acquisition, scaling, and region-of-interest (ROI) circuitry, 3-4
- acquisition start conditions, 3-5
- acquisition window control, 3-5
  - active pixel region (acquisition window), 3-5
  - region of interest, 3-5
  - scaling down circuitry, 3-5

## B

- block diagram of IMAQ PCI-1428 (figure), 3-2
- bus master PCI interface, 3-4

## C

- Camera Link, 1-1 to 1-2
- Channel Link, 1-2
- clock specifications, A-1
- configuration
  - flowchart (figure), 2-3
  - setting up IMAQ PCI-1428, 2-2

## D

- DAQ, integration with, 1-6
- data formatter, multiple-tap, 3-3
- delayed acquisition start conditions, 3-5
- DMA controllers, 3-4

## E

- environment specifications, A-2
- equipment, optional, 2-2
- external connection specifications, A-1

## F

- frame/field selection, 3-5

## H

- hardware overview, 3-1 to 3-5
  - acquisition, scaling, ROI, 3-4
  - acquisition window control, 3-5
  - block diagram (figure), 3-2
  - board configuration NVRAM, 3-4
  - bus master PCI interface, 3-4
  - high-speed timing, 3-3
  - LUTs, 3-2
  - multiple-tap data formatter, 3-3
  - RS-232 serial interface, 3-3
  - scatter-gather DMA controllers, 3-4
  - SDRAM, 3-3
  - start conditions, 3-5
  - trigger control and mapping circuitry, 3-3
  - video acquisition, 3-4
- high-speed timing circuitry, 3-3

## I

- IMAQ PCI-1428
  - optional equipment, 2-2
  - overview and features, 1-1 to 1-2
  - requirements for getting started, 2-1
  - software programming choices, 1-2 to 1-6
    - IMAQ Vision Builder, 1-5
    - IMAQ Vision, 1-5
    - NI-IMAQ driver software, 1-3 to 1-4
  - unpacking, 2-4
- IMAQ Vision Builder, 1-5
  - with application development tools (figure), 1-5
- IMAQ Vision software, 1-5

installation

- PCI-1428, 2-1 to 2-5
- procedure, 2-4 to 2-5
- unpacking IMAQ PCI-1428, 2-4

**L**

LUTs (look-up tables), 3-2

**M**

- mapping circuitry, 3-3
- memory
  - board configuration NVRAM, 3-4
  - SDRAM, 3-3
- motion control and vision, 1-6
- multiple-tap data formatter, 3-3

**N**

- National Instruments IMAQ Vision, 1-5
- National Instruments Web support, B-1 to B-2
- NI-IMAQ driver software, 1-3 to 1-4
- NI-IMAQ functions (figure), 1-4
- NVRAM, 3-4

**O**

optional equipment, 2-2

**P**

- PCI-1428 installation, 2-1 to 2-5
- PCI interface specifications, A-1 to A-2
- PCI MITE application-specific integrated circuit, 3-4
- physical specifications, A-2
- power requirements, A-2

**R**

RAM

- board configuration NVRAM, 3-4
- SDRAM, 3-3
- region of interest, in acquisition window control, 3-5
- region-of-interest (ROI) circuitry, 3-4
- requirements for getting started, 2-1

**S**

- scaling down circuitry, 3-5
- scatter-gather DMA controllers, 3-4
- SDRAM, 3-3
- serial interface, 3-3
- software controlled start conditions, 3-5
- software programming choices, 1-2 to 1-6
  - IMAQ Vision Builder, 1-5
  - IMAQ Vision, 1-5
  - NI-IMAQ driver software, 1-3
- specifications
  - clocks, A-1
  - environment, A-2
  - external connections, A-1
  - PCI interface, A-1 to A-2
  - physical, A-2
  - power requirements, A-2
- start conditions
  - delayed acquisition, 3-5
  - frame/field selection, 3-5
  - software control, 3-5
  - trigger control, 3-5

**T**

- technical support resources, B-1 to B-2
- trigger control and mapping circuitry, 3-3
- trigger controlled start conditions, 3-5

## **U**

unpacking IMAQ PCI-1428, 2-4

## **W**

Web support from National Instruments,

B-1 to B-2

    online problem-solving and diagnostic  
    resources, B-1

    software-related resources, B-2

worldwide technical support, B-2