IMAQ™

IMAQ PCI/PXI™-1411 User Manual

Single-Channel Color Image Acquisition Board for PCI, PXI, and CompactPCI Chassis

NATIONAL INSTRUMENTS™

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Worldwide Technical Support and Product Information

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FCC/DOC Radio Frequency Interference Class A Compliance

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

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

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

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

Canadian Department of Communications

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

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

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About This Manual

The *IMAQ PCI/PXI-1411 User Manual* describes the features, functions, and operation of the IMAQ PCI-1411 and PXI-1411 devices.

The IMAQ PCI/PXI-1411 is a color analog camera image acquisition (IMAQ) board designed to acquire color and grayscale images. The *IMAQ PCI/PXI-1411 User Manual* is intended for users with a basic knowledge of color image acquisition.

Conventions

The following conventions appear 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 warning, which advises you of precautions to take to avoid being electrically shocked.
1411 device	The term 1411 device refers to both the PCI-1411 and the PXI-1411.
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.

Related Documentation

The *IMAQ PCI/PXI-1411 User Manual* is one piece of the documentation set for your image acquisition system. You could have any of several types of manuals, depending on the hardware and software in your system. Use the different types of manuals you have as follows:

- Software documentation—You may have both application software and NI-IMAQ software documentation. National Instruments application software includes LabVIEW, BridgeVIEW, ComponentWorks, and LabWindows/CVI. After you set up your hardware system, use either the application software documentation or the NI-IMAQ documentation to help you write your application. If you have a large and complicated system, it is worthwhile to look through the software documentation before you configure your hardware.
- Accessory installation guides or manuals—If you are using accessory products, read the terminal block and cable assembly installation guides or accessory board user manuals. They explain how to physically connect the relevant pieces of the system. Consult these guides when you are making your connections.

1 Introduction

This chapter describes the PCI/PXI-1411; lists what you need to get started; describes software programming choices; and explains how to unpack and set up the PCI/PXI-1411.

About the PCI/PXI-1411

The PCI/PXI-1411 is a highly flexible monochrome and color IMAQ board for PCI, PXI, or CompactPCI chassis that supports a diverse range of analog cameras from many camera companies. The PCI/PXI-1411 acquires images in real time and can store these images in onboard frame memory, or transfer these images directly to system memory.

The PCI/PXI-1411 is simple to configure and is factory calibrated so that you can easily install the board and begin acquiring images. The PCI/PXI-1411 ships with NI-IMAQ, the National Instruments complete IMAQ driver software you can use to directly control the PCI/PXI-1411 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.

The PCI/PXI-1411 features a precision color analog video decoder ideal for both industrial and scientific environments. The 1411 device supports both NTSC and PAL color standards as well as the RS-170 and CCIR monochrome standards. The 1411 also provides one external I/O line that you can use as a trigger or as a digital input/output (I/O) line. If you require more advanced triggering or digital I/O lines, you can use the PCI/PXI-1411 and NI-IMAQ with the National Instruments data acquisition (DAQ) product line.

Detailed specifications of the PCI/PXI-1411 are in Appendix A, *Specifications*.

Using PXI with CompactPCI

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

The CompactPCI specification permits vendors to develop sub-buses that coexist with the basic PCI interface on the CompactPCI bus. Compatible operation is not guaranteed between CompactPCI devices with different sub-buses nor between CompactPCI devices with sub-buses and PXI. The standard implementation for CompactPCI does not include these sub-buses. Your PXI-1411 device will work in any standard CompactPCI chassis adhering to the *PICMG 2.0 R2.1 CompactPCI* core specification.

What You Need to Get Started

To set up and use your PCI/PXI-1411, you will need the following:

- ❑ One of the following IMAQ devices:
  - PCI-1411
  - PXI-1411
- ❑ *Getting Started with Your IMAQ System*
- ❑ *IMAQ PCI/PXI-1411 User Manual*
- ❑ *NI-IMAQ for Windows NT/98/95 Release Notes*
- ❑ NI-IMAQ for Windows NT/98/95 and documentation
- ❑ Optional software packages and documentation:
  - LabVIEW
  - BridgeVIEW
  - LabWindows/CVI
  - IMAQ Vision for G
  - IMAQ Vision for LabWindows/CVI
  - ComponentWorks IMAQ Vision
  - IMAQ Vision Builder

- ❑ BNC cable (included with your PCI/PXI-1411)
- ❑ S-Video cable (optional)
- ❑ Your Pentium-based PCI computer, PXI chassis, or CompactPCI chassis running Windows NT, Windows 98, or Windows 95.
- ❑ An analog video camera (composite or S-Video)

Software Programming Choices

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

National Instruments Application Software

LabVIEW and BridgeVIEW feature interactive graphics, a state-of-the-art user interface, and a powerful graphical programming language, G. The NI-IMAQ VI Library for G, a series of virtual instruments (VIs) for using LabVIEW and BridgeVIEW with the PCI/PXI-1411, is included with the NI-IMAQ software kit. The NI-IMAQ VI Library for G is functionally equivalent to the NI-IMAQ software.

LabWindows/CVI features interactive graphics, a state-of-the-art user interface, and uses the ANSI standard C programming language. The LabWindows/CVI IMAQ Library, a series of functions for using LabWindows/CVI with the PCI/PXI-1411, is included with the NI-IMAQ software kit. The LabWindows/CVI IMAQ Library is functionally equivalent to the NI-IMAQ software.

IMAQ Vision for G is an image acquisition, processing, and analysis library that consists of more than 400 VIs for using the PCI/PXI-1411 with LabVIEW and BridgeVIEW. You can use IMAQ Vision for G functions directly or in combination for unique image processing. There are two versions of IMAQ Vision for G. The Base version gives you the ability to acquire, display, manipulate, and store images. The Advanced version is a complete set of functions for image analysis, processing, and interpretation. Using IMAQ Vision for G, an imaging novice or expert can perform graphical programming of the most basic or complicated image applications without knowledge of any algorithm implementations.

IMAQ Vision for LabWindows/CVI is an image acquisition and analysis library consisting of a series of routines for using the PCI/PXI-1411 with LabWindows/CVI. IMAQ Vision for LabWindows/CVI brings the same functionality to LabWindows/CVI as IMAQ Vision for G does for LabVIEW and BridgeVIEW.

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

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 1-1, IMAQ Vision Builder generates a text description—a recipe of the machine vision and image processing functions. This description file provides a guide for developing applications with IMAQ Vision in LabVIEW, BridgeVIEW, LabWindows/CVI, and ComponentWorks.

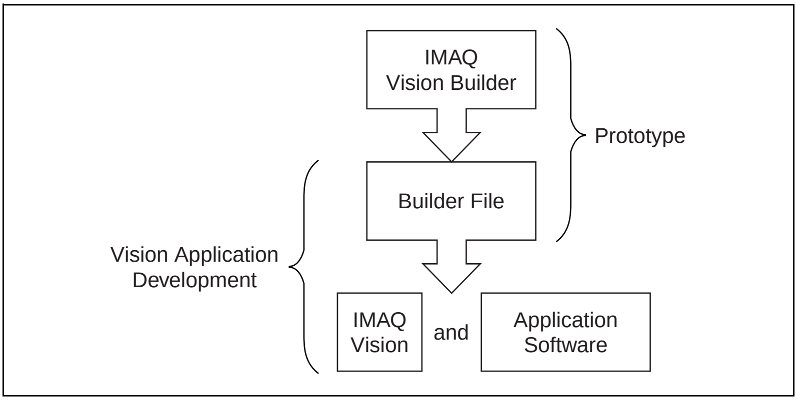

Figure 1-1. IMAQ Vision Builder and Application Development Tools

NI-IMAQ Driver Software

The NI-IMAQ driver software is included at no charge with the PCI/PXI-1411. 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.

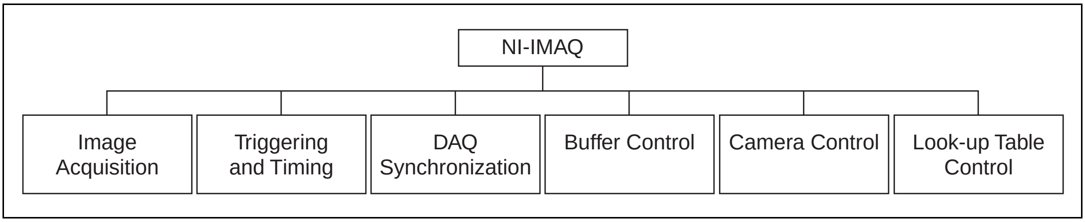

Figure 1-2. NI-IMAQ Functions

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

NI-IMAQ has both high-level and low-level functions for maximum flexibility and performance. Examples of high-level functions include the functions to acquire images in single-shot or continuous mode. An example of a low-level function is configuring an image sequence since it requires advanced understanding of the PCI/PXI-1411 and image acquisition.

NI-IMAQ also internally resolves many of the complex issues between the computer and the PCI/PXI-1411, such as programming interrupts and DMA controllers. NI-IMAQ is the interface path between LabVIEW, BridgeVIEW, LabWindows/CVI, or a conventional programming environment and the PCI/PXI-1411.

Any platform that supports NI-IMAQ also supports NI-DAQ and a variety of National Instruments DAQ boards, so your PCI/PXI-1411 and NI-IMAQ development can integrate with National Instruments DAQ products.

Whether you are using conventional programming languages or National Instruments software, your application uses the NI-IMAQ driver software, as illustrated in Figure 1-3.

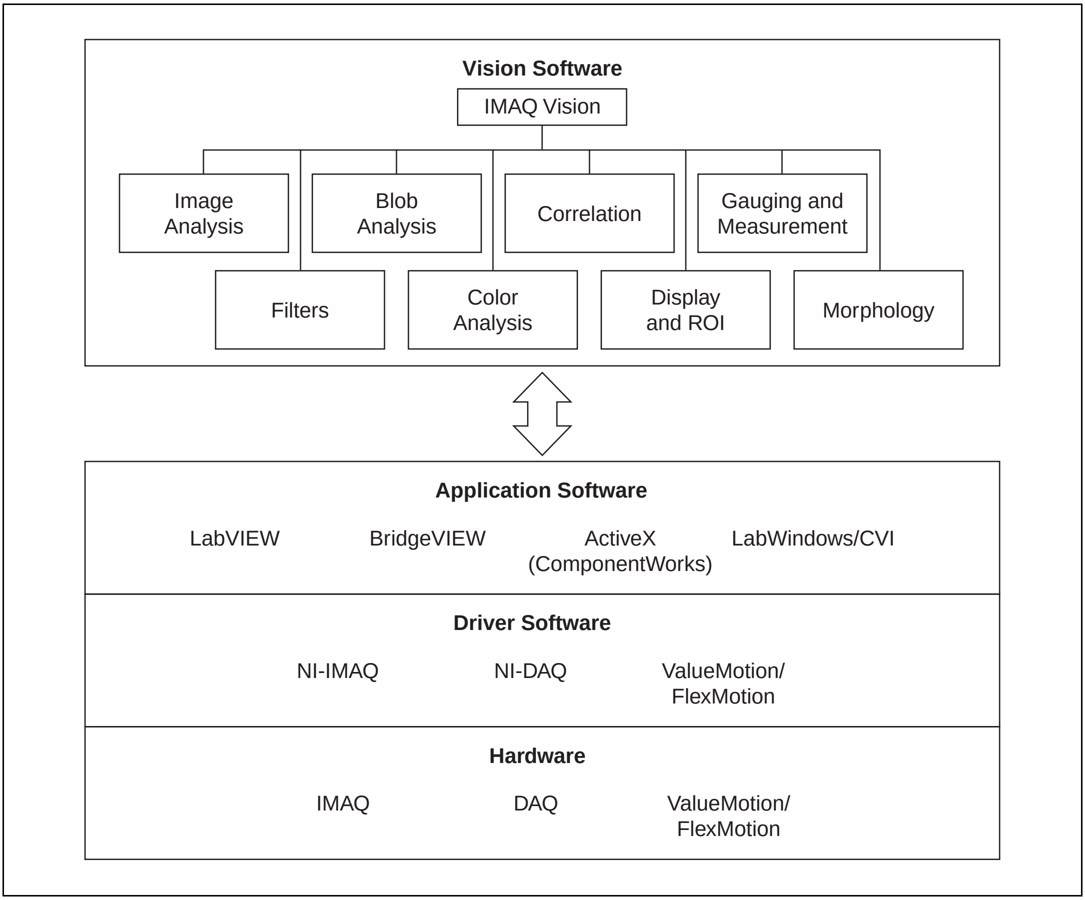

Figure 1-3. The Relationship between the Programming Environment, NI-IMAQ, and Your Hardware

Optional Equipment

National Instruments offers a variety of products for use with your PCI/PXI-1411, including other National Instruments DAQ devices for enhanced triggering, timing, or input/output.

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

Unpacking

Your PCI/PXI-1411 is shipped in an antistatic package to prevent electrostatic damage to the board. Electrostatic discharge can damage several components on the board. To avoid such damage in handling the board, take the following precautions:

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

How to Set up Your IMAQ System

Use Figure 1-4 to 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 or BridgeVIEW, you should read the NI-IMAQ release notes and the *NI-IMAQ VI Reference Manual* to help you get started.

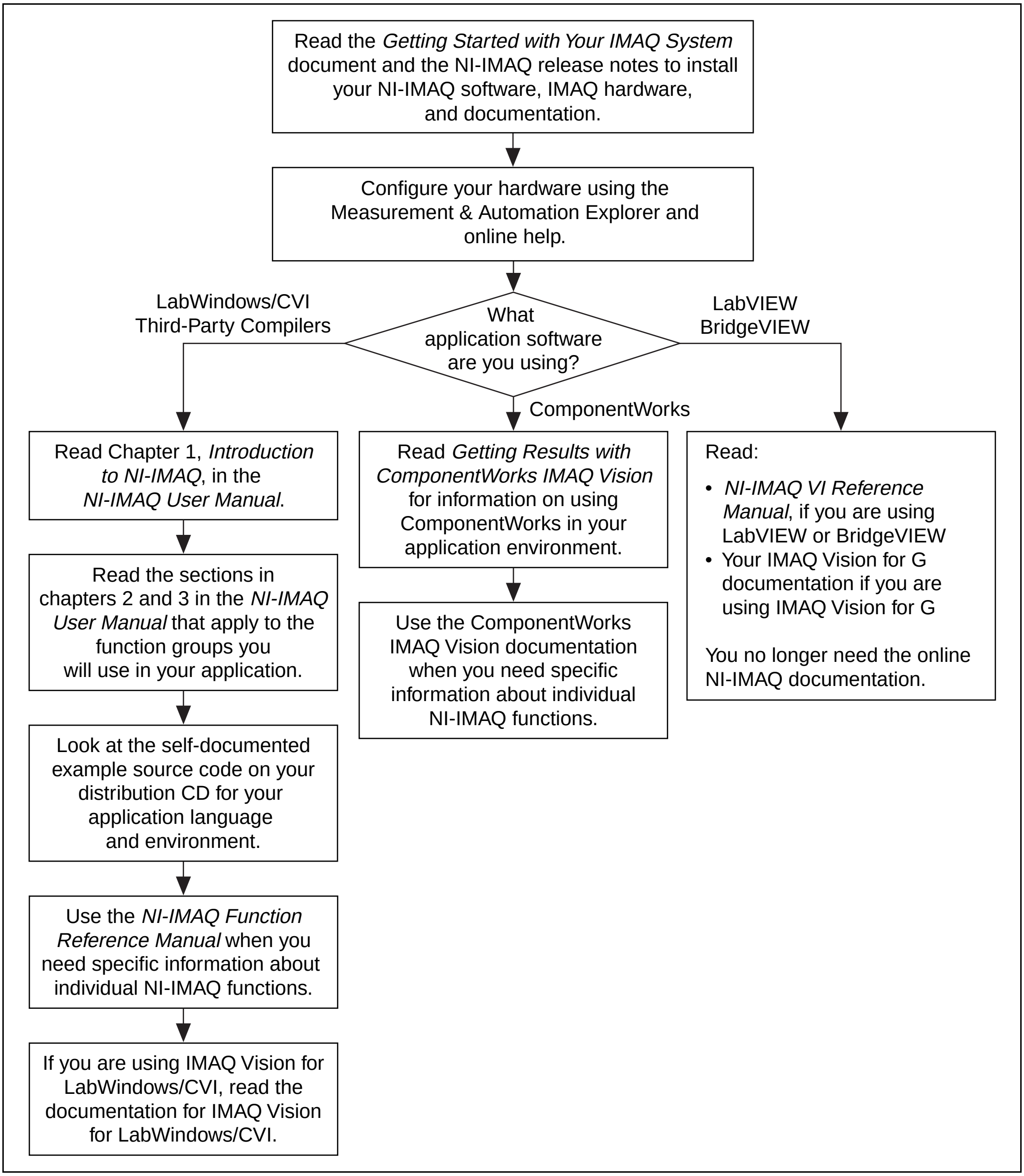

Figure 1-4. How to Set up Your IMAQ System

2

Installation

This chapter explains how to install and configure your PCI/PXI-1411 board.

Installation

Note You must install the NI-IMAQ driver software before installing your 1411 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.

- PCI-1411

You can install the PCI-1411 in any available PCI expansion slot in your computer. However, to achieve the best noise performance, you should leave as much room as possible between the PCI-1411 and other boards and hardware. The following are general instructions, but consult your computer user manual or technical reference manual for specific instructions and warnings.

1. Plug in but do not turn on your computer before installing the PCI-1411 device. The power cord grounds the computer and protects it from electrical damage while you are installing the module.

Warning To protect both yourself and the computer from electrical hazards, the computer should remain off until you finish installing the PCI-1411.

2. Remove the top cover or access port to the PCI bus.
3. Select any available PCI expansion slot.
4. Locate the metal bracket that covers the cut-out in the back panel of the chassis for the slot you have selected. Remove and save the bracket-retaining screw and the bracket cover.
5. Touch the metal part of the power supply case inside the computer to discharge any static electricity that might be on your clothes or body.
6. Line up the PCI-1411 with the BNC connectors near the cut-out on the back panel. Slowly push down on the top of the PCI-1411 until its card-edge connector is resting on the expansion slot receptacle. Using

slow, evenly distributed pressure, press the PCI-1411 straight down until it seats in the expansion slot.

7. Reinstall the bracket-retaining screw to secure the PCI-1411 to the back panel rail.
8. Check the installation.
9. Replace the computer cover.

Your PCI-1411 is now installed.

- PXI-1411

You can install a PXI-1411 in any available 5 V peripheral slot in your PXI or CompactPCI chassis.

1. Turn off and unplug your PXI or CompactPCI chassis.
2. Choose an unused PXI or CompactPCI 5 V peripheral slot. Install the PXI-1411 in a slot that supports bus arbitration or bus-master cards. PXI-compliant chassis must have bus arbitration for all slots.
3. Remove the filler panel for the peripheral slot you have chosen.
4. Touch a metal part on your chassis to discharge any static electricity that might be on your clothes or body.
5. Insert the PXI-1411 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-1411 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-1411 is now installed.

3

Hardware Overview

This chapter presents an overview of the hardware functions on your PCI/PXI-1411 board and explains the operation of each functional unit making up the PCI/PXI-1411.

Functional Overview

The PCI/PXI-1411 features a flexible, high-speed data path optimized for the acquisition and formatting of video data from analog monochrome and color cameras.

The block diagram in Figure 3-1 illustrates the key functional components of the PCI/PXI-1411.

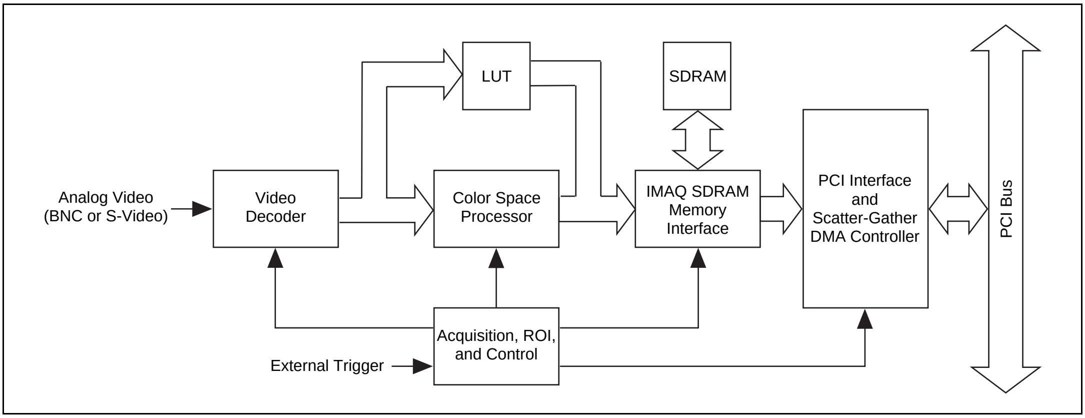

Figure 3-1. PCI/PXI-1411 Block Diagram

Video Acquisition

The PCI/PXI-1411 can acquire analog color video in a variety of modes and store the images in the onboard SDRAM memory or transfer the images directly to PCI system memory.

Video Decoder

The PCI/PXI-1411 supports NTSC and PAL video standards in either composite or S-Video format. The onboard video decoder converts the incoming video signal to Red, Green, and Blue (RGB) data and passes this data to the color-space processor for further processing.

The video decoder also allows you to control numerous parameters to optimize an acquisition. You can independently adjust parameters such as analog input range, brightness, contrast, saturation, or frequency range (controlled by different filters). See the Measurement & Automation Explorer online help for a complete description of the PCI/PXI-1411 video parameters.

Furthermore, the video decoder strips out all necessary clock and synchronization signals included in the video signal and controls the acquisition conditions automatically. High-quality circuitry regenerates even bad timing signals allowing acquisitions from, for example, a video cassette recorder (VCR).

Color-Space Processor and LUTs

The color-space processor receives the RGB data from the video decoder and performs several different (optional) operations on the data before passing them to the memory controller. Processing functions include the following:

- Adjusting independent gain of the three signals (R, G, and B). You can use independent gain to perform, for example, white balancing on the acquired image.
- Applying three independent look-up tables (LUTs) to the R, G, and B data.
- Converting the RGB data into Hue, Saturation, and Luminance (HSL).
- Processing the hue plane to clear pixels where the saturation falls below a predefined threshold value. This function is called *post-decoding coring*. You can use this function to remove part of the image without color information (monochrome) that otherwise would introduce noise on the hue plane.

The color-space processor can export the video data in 32-bit RGB or HSL formats or in individual 8-bit hue, saturation, or luminance planes. For more information on these image types, see the *Image Representations* section in Appendix B, *Introduction to Color*.

SDRAM

The PCI/PXI-1411 comes with 16 MB of onboard high-speed synchronous dynamic RAM (SDRAM). The PCI/PXI-1411 can use the onboard RAM as a first-in first-out (FIFO) buffer, transferring the image data as it is acquired or acquiring the image data into SDRAM and holding it for later transfer to main memory.

Trigger Control and Mapping Circuitry

The trigger control monitors and drives the external trigger line. You can configure this line to start an acquisition on a rising or falling edge and drive the line asserted or unasserted, similar to a digital I/O line. You can also map many of the PCI/PXI-1411 status signals to this trigger line and program the trigger line in polarity and direction. For a list of mappable status signals, see Chapter 3, *Programming with NI-IMAQ*, of the *NI-IMAQ User Manual*.

Acquisition, Scaling, ROI

The acquisition, scaling, and region-of-interest (ROI) circuitry monitors the incoming video signals and routes the active pixels to the SDRAM memory. The PCI/PXI-1411 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 to the PCI bus.

Scatter-Gather DMA Controllers

The PCI/PXI-1411 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. Thus, the PCI/PXI-1411 can perform continuous image transfers directly to either contiguous or fragmented memory buffers.

Bus Master PCI Interface

The PCI/PXI-1411 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/PXI-1411 can generate 8-, 16-, and 32-bit memory read and write cycles, both single and multiple. In slave mode, the PCI/PXI-1411 is a medium-speed decoder that accepts both memory and configuration cycles. The interface logic ensures that the PCI/PXI-1411 can meet PCI loading, driving, and timing requirements.

Board Configuration NVRAM

The PCI/PXI-1411 contains onboard nonvolatile RAM (NVRAM) that configures all registers on power-up.

Start Conditions

The PCI/PXI-1411 can start acquisitions in a variety of conditions:

- Software control—The PCI/PXI-1411 supports software control of acquisition start. You can configure the PCI/PXI-1411 to capture a fixed number of fields or frames. This configuration is useful for capturing a single frame or a sequence of frames.
- Trigger control—You can start an acquisition by enabling the external trigger line. This input can start a video acquisition on a rising or falling edge.
- Frame/field selection—With an interlaced camera and the PCI/PXI-1411 in frame mode, you can program the PCI/PXI-1411 to start an acquisition on any odd or even field.

Acquisition Window Control

You can configure numerous parameters on the PCI/PXI-1411 to control the video acquisition window. A brief description of each parameter follows:

- *Acquisition window*—The PCI/PXI-1411 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/PXI-1411 uses a second level of active pixel and active line regions for selecting a region of interest. When you disable the region-of-interest circuitry, the board stores the entire acquisition window into with onboard or system memory. However, when you enable the region-of-interest circuitry, the board acquires only a selected subset of the image frame.

- *Scaling down*—The scaling down circuitry also controls the active acquisition region. The PCI/PXI-1411 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/PXI-1411 can select every pixel, every other pixel, every fourth pixel, or every eighth pixel. For active line selection, the PCI/PXI-1411 can select 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.

4

Signal Connections

This chapter describes cable connections for the PCI/PXI-1411.

I/O Connector

The PCI/PXI-1411 uses one S-Video and two BNC connectors on the front panel to connect to video data inputs and the external trigger signal. Figure 4-1 shows the position of the three connectors.

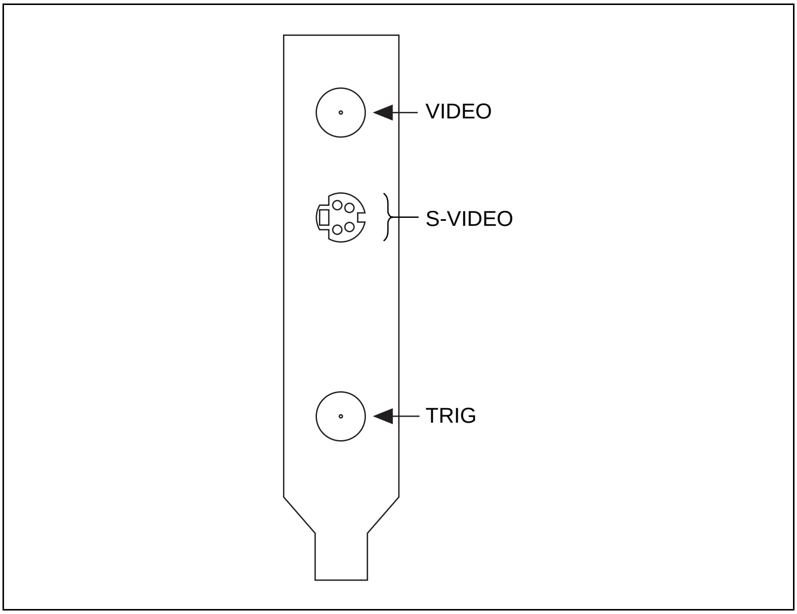

Figure 4-1. PCI/PXI-1411 Connectors

Signal Description

Table 4-1 describes each signal connection on the 1411 device connectors:

Table 4-1. I/O Connector Signals

Signal Name	Description
VIDEO	Composite Video—The signal allows you to make a referenced single-ended (RSE) connection to the video channel.
S-VIDEO	S-Video—A connector composed of two signals, as follows: Y—The Y signal of the S-Video connection contains the luma and synchronization information of the video signal. C—The C signal of the S-Video connection contains the chroma information of the video signal.
TRIG	External trigger—A TTL I/O line you can use 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). For a list of mappable status signals, see Chapter 3, *Programming with NI-IMAQ*, of the *NI-IMAQ User Manual*.
GND	Ground—A direct connection to digital ground on the PCI/PXI-1411.

Custom Cables

If you plan to make your own cables, refer to Figure 4-2 for the pin-out of the S-Video connector, as seen from the front of the PCI/PXI-1411.

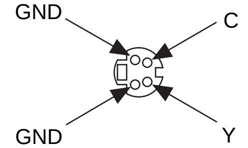

Figure 4-2. S-Video Connector Pin Assignments

A

Specifications

This appendix lists the specifications of the PCI/PXI-1411. These specifications are typical at 25 °C, unless otherwise stated.

Formats Supported

Input formats

RS-170/NTSC	29.97 frames/s
CCIR/PAL	25 frames/s

Output formats

RGB	32-bit
HSL	32-bit
R, G, B, H, S, or L	8-bit
Pixel aspect ratio	Square pixel

Video Input

Quantity	1 (VIDEO)
VIDEO	Composite video on BNC (RSE), Y/C on S-Video connector (RSE)
Input impedance	75 Ω
Input range (blank to white)	700 mV (calibrated) or 400 to 800 mV (variable gain)

Frequency response (luminance)

Full range	12 MHz (–3 dB) typ (all filters off)
Programmable	Decimation and lowpass filters

A/D Conversion

Quantity ....One 8-bit 2X oversampling for composite video
Two 8-bit 2X oversampling for Y/C (S-Video)

Dynamic range.......................................46 dB typ

Sampling Frequency

RS-170/NTSC.................................27.54 MHz (double rate of square pixel

CCIR/PAL ....29.5 MHz (double rate of square pixel)

Color Decoding

Composite video

Luma path.......................................Chroma trap filter and/or line comb

Chroma path ....Bandpass filter and/or line comb

Accuracy

Calibrated

Luma level at DC............................+/– (1% of value and 1% of white) (tentative)

Demodulated chroma level at DC ...+/– 2% (tentative)

Memory

Onboard memory ....16 MB synchronous dynamic RAM

LUTs...Three 256 × 8 (RGB only)

External Connections

Trigger sense..TTL

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

PCI Interface

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

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

Data path .... 32 bits

Board voltage .... 5 V, 12 V, –12 V

Board 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 (1.00 A)
+12 V (75 mA)

Environment

Dimensions

PCI-1411 .... 10.668 by 17.463 cm
(4.2 by 6.875 in.)

Weight
PCI-1411 ....0.136 kg (0.3 lb.)

Operating temperature .... 0–55 °C

Storage temperature ....–20–70 °C

Relative humidity ....5–90%, noncondensing

B

Introduction to Color

Color is the wavelength of the light we receive in our eye when we look at an object. In theory, the color spectrum is infinite. Humans, however, can see only a small portion of this spectrum—the portion that goes from the red edge of infrared light (the longest wavelength) to the blue edge of ultraviolet light (the shortest wavelength). This continuous spectrum is called the visible spectrum, as shown in Figure B-1.

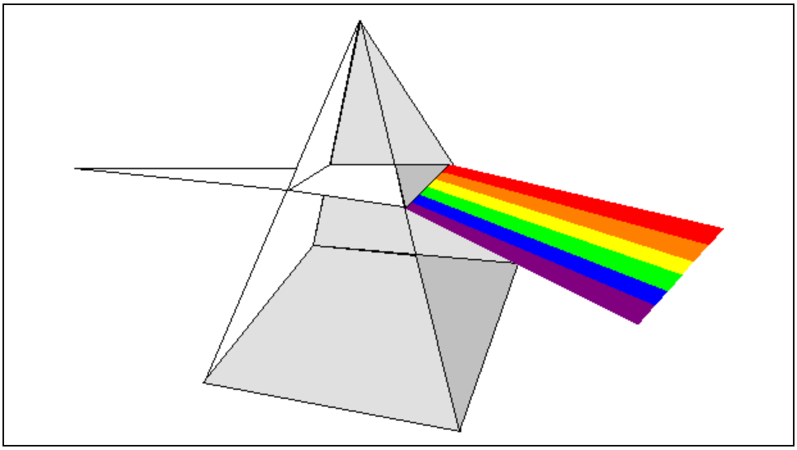

Figure B-1. White Light and the Visible Spectrum

White light is a combination of all colors at once. The spectrum of white light is continuous and goes from ultraviolet to infrared in a smooth transition. You can represent a good approximation of white light by selecting a few reference colors and weighting them appropriately. The most common way to represent white light is to use three reference components, such as red, green, and blue (R, G, and B primaries). You can simulate most colors of the visible spectrum using these primaries. For example, video projectors use red, green, and blue light generators, and an RGB camera uses red, green, and blue sensors.

The perception of a color depends on many factors, such as:

- *Hue*, which is the perceived dominant color. Hue depends directly on the wavelength of a color.
- *Saturation*, which is dependent on the amount of white light present in a color. Pastels typically have a low saturation while very rich colors have a high saturation. For example, pink typically has a red hue but has a low saturation.
- *Luminance*, which is the brightness information in the video picture. The luminance signal amplitude varies in proportion to the brightness of the video signal and corresponds exactly to the monochrome picture.
- *Intensity*, which is the brightness of a color and which is usually expressed as light or dark. For example, orange and brown may have the same hue and saturation; however, orange has a greater intensity than brown.

Image Representations

Color images can be represented in several different formats. These formats can contain all color information from the image or they can consist of just one aspect of the color information, such as hue or luminance. The following image representations can be produced using the PCI/PXI-1411.

RGB

The most common image representation is 32-bit RGB format. In this representation, the three 8-bit color planes—red, green and blue—are packed into an array of 32-bit integers. This representation is useful for displaying the image on your monitor. The 32-bit integer organized as:

0	RED	GREEN	BLUE

where the high-order byte is not used and blue is the low-order byte.

Color Planes

Each color plane can be returned individually. The red, green, or blue plane is extracted from the RGB image and represented as an array of 8-bit integers.

Hue, Saturation, Luminance, and Intensity Planes

The 8-bit hue, saturation, luminance, and intensity planes can also be returned individually if you want to analyze the image.

Luminance, Intensity, Hue, or Saturation are defined using the Red, Green, and Blue values in the following formulas:

$$\text{Luminance} = 0.299 \times \text{Red} + 0.587 \times \text{Green} + 0.114 \times \text{Blue}$$

$$\text{Intensity} = (\text{Red} + \text{Green} + \text{Blue}) / 3$$

$$\text{Hue} = \text{ATN2}(\text{Y}, \text{X})$$

where

$$\text{Y} = (\text{Green} - \text{Blue}) / \sqrt{2} \text{ and}$$

$$\text{X} = (2 \times \text{Red} - \text{Green} - \text{Blue}) / \sqrt{6}$$

$$\text{Saturation} = 255 \times \left(1 - \frac{3 \times \text{Min}(\text{R}, \text{G}, \text{B})}{\text{R} + \text{G} + \text{B}}\right)$$

32-Bit HSL and HSI

You can also pack the three 8-bit Hue, Saturation, and Luminance planes (HSL) or the three Hue, Saturation, and Intensity planes (HSI) in one array of 32-bit integers, which is equivalent to the 32-bit RGB representation.

C

Technical Support Resources

This appendix describes the comprehensive resources available to you in the Technical Support section of the National Instruments Web site and provides technical support telephone numbers for you to use if you have trouble connecting to our Web site or if you do not have internet access.

NI Web Support

To provide you with immediate answers and solutions 24 hours a day, 365 days a year, National Instruments maintains extensive online technical support resources. They are available to you at no cost, are updated daily, and can be found in the Technical Support section of our Web site at `www.natinst.com/support`.

Online Problem-Solving and Diagnostic Resources

- **KnowledgeBase**—A searchable database containing thousands of frequently asked questions (FAQs) and their corresponding answers or solutions, including special sections devoted to our newest products. The database is updated daily in response to new customer experiences and feedback.
- **Troubleshooting Wizards**—Step-by-step guides lead you through common problems and answer questions about our entire product line. Wizards include screen shots that illustrate the steps being described and provide detailed information ranging from simple getting started instructions to advanced topics.
- **Product Manuals**—A comprehensive, searchable library of the latest editions of National Instruments hardware and software product manuals.
- **Hardware Reference Database**—A searchable database containing brief hardware descriptions, mechanical drawings, and helpful images of jumper settings and connector pinouts.
- **Application Notes**—A library with more than 100 short papers addressing specific topics such as creating and calling DLLs, developing your own instrument driver software, and porting applications between platforms and operating systems.

Software-Related Resources

- **Instrument Driver Network**—A library with hundreds of instrument drivers for control of standalone instruments via GPIB, VXI, or serial interfaces. You also can submit a request for a particular instrument driver if it does not already appear in the library.
- **Example Programs Database**—A database with numerous, non-shipping example programs for National Instruments programming environments. You can use them to complement the example programs that are already included with National Instruments products.
- **Software Library**—A library with updates and patches to application software, links to the latest versions of driver software for National Instruments hardware products, and utility routines.

Worldwide Support

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For telephone support in the United States, dial 512 795 8248. For telephone support outside the United States, contact your local branch office:

Australia 03 9879 5166, Austria 0662 45 79 90 0, Belgium 02 757 00 20, Brazil 011 284 5011, Canada (Ontario) 905 785 0085, Canada (Québec) 514 694 8521, China 0755 3904939, Denmark 45 76 26 00, Finland 09 725 725 11, France 01 48 14 24 24, Germany 089 741 31 30, Hong Kong 2645 3186, India 91805275406, Israel 03 6120092, Italy 02 413091, Japan 03 5472 2970, Korea 02 596 7456, Mexico (D.F.) 5 280 7625, Mexico (Monterrey) 8 357 7695, Netherlands 0348 433466, Norway 32 27 73 00, Singapore 2265886, Spain (Madrid) 91 640 0085, Spain (Barcelona) 93 582 0251, Sweden 08 587 895 00, Switzerland 056 200 51 51, Taiwan 02 2377 1200, United Kingdom 01635 523545

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}
t-	tera-	10^{12}

Numbers/Symbols

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

A

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

active pixel region	the region of pixels actively being stored; defined by a pixel start and a pixel count
address	character code 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 a specific customer

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
brightness	a constant added to the red, green, and blue components of a color pixel during the color decoding process
buffer	temporary storage for acquired data
bus	the group of conductors that interconnect individual circuitry in a computer, such as the PCI bus; typically the expansion vehicle to which I/O or other devices are connected

C

C	Celsius
cache	high-speed processor memory that buffers commonly used instructions or data to increase processing throughput
CMOS	complementary metal-oxide semiconductor

color space	the mathematical representation for a color. For example, color can be described in terms of red, green, and blue; hue, saturation, and luminance; or hue, saturation, and intensity.
composite video	a type of color video transmission where synchronization, luma, and chroma information are transmitted on one analog signal
contrast	a constant multiplication factor applied to the luminance and chrominance components of a color pixel in the color decoding process
coring	the process of killing color information in low-color situations (if the saturation is lower than a predefined value)
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
dB	decibel—the unit for expressing a logarithmic measure of the ratio of two signal levels: dB = 20log10 V1/V2, for signals in volts
DC	direct current
default setting	a default parameter value recorded in the driver; in many cases, the default input of a control is a certain value (often 0) that means *use the current default setting*.
DMA	direct memory access—a method by which data can be transferred to and from computer memory from and to a device or memory on the bus while the processor does something else; DMA is the fastest method of transferring data to/from computer memory
DRAM	dynamic RAM
drivers	software that controls a specific hardware device such as an IMAQ or DAQ device

dynamic range	the ratio of the largest signal level a circuit can handle to the smallest signal level it can handle (usually taken to be the noise level), normally expressed in decibels

E

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

F

field	For an interlaced video signal, a field is half the number of horizontal lines needed to represent a frame of video; the first field of a frame contains all the odd-numbered lines, the second field contains all of the even-numbered lines.
FIFO	first-in first-out memory buffer—the first data stored is the first data sent to the acceptor; FIFOs are used on IMAQ devices to temporarily store incoming data until that data can be retrieved.
frame	a complete image; in interlaced formats, a frame is composed of two fields
ft	feet

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

H

h	hour
HSI	a color space where color is represented as hue, saturation, and intensity
HSL	a color space where color is represented as hue, saturation, and luminance
HSYNC	horizontal synchronization—a pulse that represents the start of a new video line
hue	represents the dominant color of a pixel. The hue function is a continuous function that covers all the possible colors generated using the R, G, and B primaries. *See also* RGB.
hue offset	an angle added to the hue calculated in the color space converter
Hz	hertz—the number of scans read or updates written per 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
ID	identification
IEEE	Institute of Electrical and Electronics Engineers
IMAQ	image acquisition
in.	inches
instrument driver	a set of high-level software functions, such as NI-IMAQ, that controls specific plug-in computer boards; instrument drivers are available in several forms, ranging from a function callable from a programming language to a virtual instrument (VI) in LabVIEW
intensity	the sum of the Red, Green, and Blue primaries divided by three: (Red + Green + Blue)/3

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

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
luma	the monochrome information of a color image, mathematically defined as $(.229 \times \text{Red}) + (.587 \times \text{Green}) + (.114 \times \text{Blue})$
luminance	*See* luma.
LUT	look-up table—a selection in the IMAQ Configuration Utility that contains formulas that let you implement simple imaging operations such as contrast enhancement, data inversion, gamma manipulation, or other nonlinear transfer functions

M

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

N

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

O

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

P

PAL	Phase Alternation Line—one of the European video color standards; uses 625 lines per frame.
PCI	Peripheral Component Interconnect—a high-performance expansion bus architecture originally developed by Intel to replace ISA and EISA; it is achieving widespread acceptance as a standard for PCs and workstations and offers a theoretical maximum transfer rate of 132 Mbytes/s
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 HYSNCs; the pixel count determines the frequency of the pixel clock
PLL	phase-locked loop—circuitry that provides a very stable pixel clock that is referenced to another signal, for example, an incoming HSYNC signal
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	red, green, and blue—the three primary colors used to represent a color picture. RGB is also a color space where color is represented as combinations of red, green, and blue.
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.

S

s	seconds
S-Video	a type of color video transmission where synchronization and luma information are transmitted on one analog signal and chroma is transmitted on a separate analog signal
saturation	the richness of a color. A saturation of zero corresponds to no color, that is, a gray pixel. 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 the 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

VCO	voltage-controlled oscillator—an oscillator that changes frequency depending on a control signal; used in a PLL to generate a stable pixel clock
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
VSYNC	vertical synchronization—a pulse that represents the start of a new field or frame

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