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# NI Vision

## NI PXI/PCI-1411 User Manual

*Single-Channel Color Image Acquisition Device*

February 2007
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## Compliance with FCC/Canada Radio Frequency Interference Regulations

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

Consult the FCC Web site at `www.fcc.gov` for more information.

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Changes or modifications not expressly approved by NI 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 is required to correct the interference at their own expense.

#### Canadian Department of Communications

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

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* The CE marking Declaration of Conformity contains important supplementary information and instructions for the user or installer.

# Conventions

The following conventions are used in this manual:

| | |
|---|---|
| » | The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box. |
| ♦ | 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. |
|  | When symbol is marked on a product, it denotes a warning advising you to take precautions to avoid electrical shock. |
| **bold** | Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names. |
| *italic* | Italic text denotes variables, emphasis, a cross-reference, or an introduction to a key concept. Italic text also denotes text that is a placeholder for a word or value that you must supply. |
| `monospace` | Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames, and extensions. |

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# 1

# Introduction

This chapter describes the NI PXI/PCI-1411 (NI 1411) and describes your software programming choices.

## About the NI 1411

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

The NI 1411 is simple to configure so that you can easily install the device and begin acquiring images. The NI 1411 ships with NI Vision Acquisition Software, which includes NI-IMAQ, the National Instruments driver software you can use to directly control the NI 1411 and other National Instruments image acquisition devices. Using NI-IMAQ, you can quickly and easily start your applications without having to program the device at the register level.

The NI 1411 features a precision color analog video decoder ideal for both industrial and scientific environments. The NI 1411 device supports both NTSC and PAL color standards as well as the RS-170 and CCIR monochrome standards. The NI 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 NI 1411 and NI-IMAQ with the National Instruments data acquisition (DAQ) product line.

For detailed specifications of the NI 1411, refer to the *Specifications* section of *Getting Started with the NI PXI/PCI-1411*.

# 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 cannot 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. The NI 1411 device will work in any standard CompactPCI chassis adhering to the *PICMG 2.0 R2.1 CompactPCI* core specification.

# Software Overview

Programming the NI 1411 requires the NI-IMAQ driver software for controlling the hardware. National Instruments also offers the following application software packages for analyzing and processing your acquired images.

- **Vision Builder for Automated Inspection (AI)**—Allows you to configure solutions to common inspection tasks.
- **National Instruments Vision Development Module**—Provides customized control over hardware and algorithms.

The following sections provide an overview of the driver software and the application software. For detailed information about individual software packages, refer to the documentation specific to each package.

## NI-IMAQ Driver Software

The NI 1411 ships with NI Vision Acquisition Software, which includes the NI-IMAQ driver software. NI-IMAQ has an extensive library of functions—such as routines for video configuration, continuous and single shot image acquisition, memory buffer allocation, trigger control, and device configuration—you can call from the application development environment (ADE). NI-IMAQ handles many of the complex issues between the computer and the image acquisition device, such as programming interrupts and camera control.

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

NI-IMAQ also provides the interface path between the NI 1411 and LabVIEW, LabWindows™/CVI™, or a text-based programming environment. The NI-IMAQ software kit includes a series of libraries for image acquisition for LabVIEW, LabWindows/CVI, and Measurement Studio, which contains libraries for Microsoft Visual Basic.

NI-IMAQ features both high-level and low-level functions. Examples of high-level functions include the sequences to acquire images in multi-buffer, single-shot, or continuous mode. An example of a low-level function is configuring an image sequence, since it requires advanced understanding of the image acquisition device and image acquisition principles.

## National Instruments Application Software

This section describes the National Instruments application software packages you can use to analyze and process the images you acquire with the NI 1411.

### Vision Builder for Automated Inspection

NI Vision Builder for Automated Inspection (AI) is configurable machine vision software that you can use to prototype, benchmark, and deploy applications. Vision Builder AI does not require programming, but is scalable to powerful programming environments.

Vision Builder AI allows you to easily configure and benchmark a sequence of visual inspection steps, as well as deploy the visual inspection system for automated inspection. With Vision Builder AI, you can perform powerful visual inspection tasks and make decisions based on the results of individual tasks. You also can migrate the configured inspection to LabVIEW, extending the capabilities of the applications if necessary.

## Vision Development Module

The Vision Development Module is an image acquisition, processing, and analysis library of more than 270 functions for the following common machine vision tasks:

- Pattern matching
- Particle analysis
- Gauging
- Taking measurements
- Grayscale, color, and binary image display

You can use the Vision Development Module functions individually or in combination. With the Vision Development Module, you can acquire, display, and store images, as well as perform image analysis, and processing. Using the Vision Development Module, imaging novices and experts can program the most basic or complicated image applications without knowledge of particular algorithm implementations.

As a part of the Vision Development Module, NI Vision Assistant is an interactive prototyping tool for machine vision and scientific imaging developers. With Vision Assistant, you can prototype vision applications quickly and test how various vision image processing functions work.

Vision Assistant generates a Builder file, which is a text description containing a recipe of the machine vision and image processing functions. This Builder file provides a guide you can use for developing applications in any ADE, such as LabWindows/CVI or Visual Basic, using the Vision Assistant machine vision and image processing libraries. Using the LabVIEW VI creation wizard, Vision Assistant can create LabVIEW VI block diagrams that perform the prototype you created in Vision Assistant. You then can use LabVIEW to add functionality to the generated VI.

# Integration with DAQ and Motion Control

Platforms that support NI-IMAQ also support NI-DAQ and a variety of National Instruments DAQ devices. This allows integration between image acquisition devices and National Instruments DAQ products.

Use National Instruments high-performance stepper and servo motion control products with pattern matching software in inspection and guidance applications, such as locating alignment markers on semiconductor wafers, guiding robotic arms, inspecting the quality of manufactured parts, and locating cells.

# 2

# Hardware Overview

This chapter presents an overview of the hardware functions on the NI 1411 and explains the operation of each functional unit making up the NI 1411.

## Functional Overview

The NI 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 2-1 illustrates the key functional components of the NI 1411.

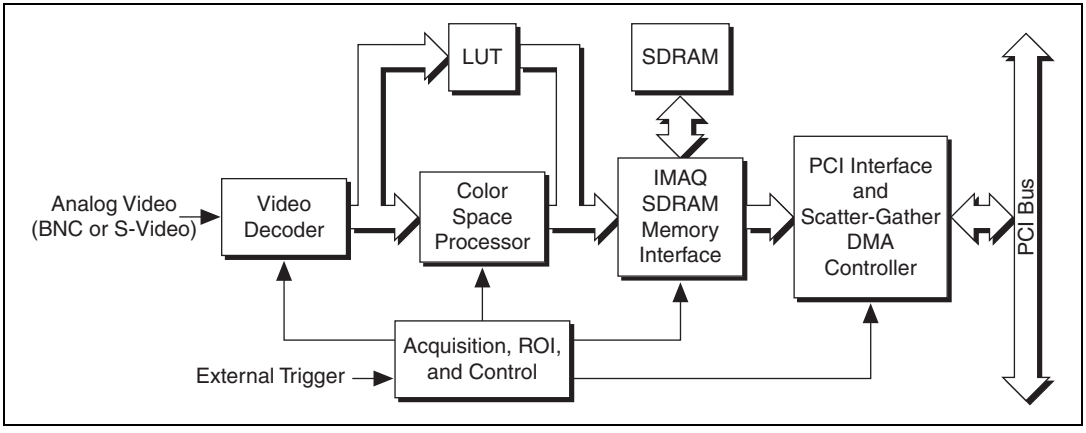



**Figure 2-1.** NI 1411 Block Diagram

### Video Acquisition

The NI 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 NI 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). Refer to the *Measurement & Automation Explorer Help for NI-IMAQ* for a complete description of the NI 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).



**Note** The NI PCI-1411 revision C, NI PXI-1411 revision A, and all later revisions are factory calibrated to improve measurement accuracy and board-to-board consistency. Specifically, the luma gain and chroma gain have been calibrated. For detailed specifications of the NI 1411, refer to the *Specifications* section of *Getting Started with the NI PXI/PCI-1411*.

## 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 lookup 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 A, *Introduction to Color*.

## SDRAM

The NI 1411 comes with 16 MB of onboard high-speed synchronous dynamic RAM (SDRAM). The NI 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 NI 1411 status signals to this trigger line and program the trigger line in polarity and direction.

## 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 NI 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 NI 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 NI 1411 can perform continuous image transfers directly to either contiguous or fragmented memory buffers.

## Bus Master PCI Interface

The NI 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 NI 1411 can generate 8-, 16-, and 32-bit memory

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

## Board Configuration NVRAM

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

## Start Conditions

The NI 1411 can start acquisitions in a variety of conditions:

- **Software control**—The NI 1411 supports software control of acquisition start. You can configure the NI 1411 to capture a fixed number of fields or frames. Use this configuration 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 NI 1411 in frame mode, you can program the NI 1411 to start an acquisition on any odd or even field.

## Acquisition Window Control

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

- **Acquisition window**—The NI 1411 allows you 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 NI 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 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 NI 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 NI 1411 can select every pixel, every other pixel, every fourth pixel, or every eighth pixel. For active line selection, the NI 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.

# 3

# Signal Connections

This chapter describes cable connections for the NI 1411.

## I/O Connector

The NI 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 3-1 shows the position of the three connectors.

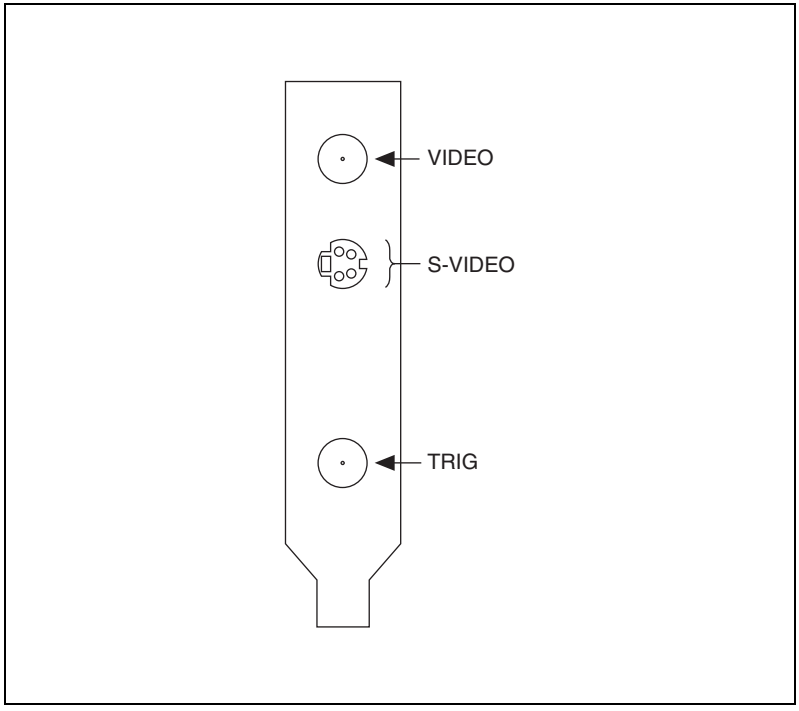



**Figure 3-1.** NI 1411 Connectors

# Signal Description

Table 3-1 describes each signal connection on the NI 1411 device connectors:

**Table 3-1.** 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:<br>Y—The Y signal of the S-Video connection contains the luma and synchronization information of the video signal.<br>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). |
| GND | Ground—A direct connection to digital ground on the NI 1411. |

# Custom Cables

If you plan to make your own cables, refer to Figure 3-2 for the pin-out of the S-Video connector, as seen from the front of the NI 1411.

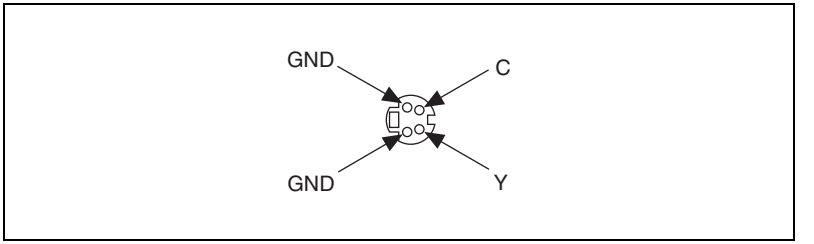



**Figure 3-2.** S-Video Connector Pin Assignments

# A

# 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 A-1.

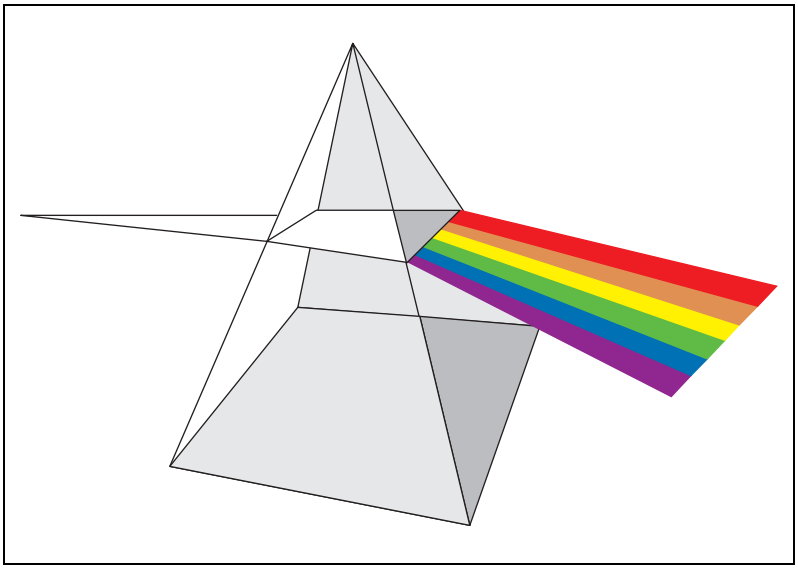


**Figure A-1.** White Light and the Visible Spectrum

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:

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

Intensity = (Red + Green + Blue) / 3

Hue = arctangent (Y, X)

where

Y = (Green – Blue) / $\sqrt{2}$ and

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

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

## 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.

# B

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# Glossary

| Symbol | Prefix | 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 | $10^{12}$ |

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

## C

| | |
|---|---|
| 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 luma; 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 luma and chroma components of a color pixel in the color decoding process.

coring — The process of eliminating 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: $dB = 20\log_{10} V1/V2$, for signals in volts.

DC — Direct current.

default setting — A default parameter value recorded in the driver; in many cases, the default input of a control is a certain value (often 0) that means *use the current default setting*.

DMA — Direct memory access. A method by which data can be transferred to and from computer memory from and to a device or memory on the bus while the processor does something else; DMA is the fastest method of transferring data to/from computer memory.

DRAM — Dynamic RAM.

drivers — Software that controls a specific hardware device, such as an image acquisition board.

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

## E

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

## F

| | |
|---|---|
| field | For an interlaced video signal, a field is half the number of horizontal lines needed to represent a frame of video. The first field of a frame contains all the odd-numbered lines, the second field contains all of the even-numbered lines. |
| FIFO | First-in first-out memory buffer. The first data stored is the first data sent to the acceptor; FIFOs are used on image acquisition 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. |

## 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

| | |
|---|---|
| HSI | Color encoding scheme in Hue, Saturation, and Intensity. |
| HSL | Color encoding scheme using Hue, Saturation, and Luma information where each image in the pixel is encoded using 32 bits: 8 bits for hue, 8 bits for saturation, 8 bits for luma, and 8 unused bits. |

| | |
|---|---|
| HSYNC | Horizontal synchronization signal. The synchronization pulse signal produced at the beginning of each video scan line that keeps a video monitor's horizontal scan rate in step with the transmission of each new line. |
| 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 | Rotates the Hue plane with a specified offset angle. The hue value of a pixel is defined as an angle in the normal color plane. You can offset this angle to move the discontinuity point (at 0 modulo 360°) to another angle value. The range is –180° to +180° with a default of 0°. |
| 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. |
| 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. *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. |
| luma | The brightness information in the video picture. The luma signal amplitude varies in proportion to the brightness of the video signal and corresponds exactly to the monochrome picture. |
| luminance | *See* luma. |
| LUT | Lookup 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 lookup table. |

## 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 | *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 image acquisition hardware. |
| noninterlaced | A video frame where all the lines are scanned sequentially, instead of divided into two frames as in an interlaced video frame. |
| NTSC | National Television Standards Committee. The committee that developed the color video standard used primarily in North America, which uses 525 lines per frame. *See also* PAL. |
| 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. *See also* NTSC. |
| 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. |
| PLL | Phase-locked loop. Circuitry that provides a very stable pixel clock that is referenced to another signal, for example, an incoming horizontal synchronization 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 | 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). |
| 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-Video | A type of color video transmission where timing and luma information are transmitted on one analog signal and chroma is transmitted on a separate analog signal. |
| 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

| | |
|---|---|
| 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

| | |
|---|---|
| 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 signal. The synchronization pulse generated at the beginning of each video field that tells the video monitor when to start a new field. |

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