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NI Vision

NI PXI/PCI-1409 User Manual

High-Quality Monochrome Image Acquisition Device

February 2007
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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.

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 marking 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 NI could void the user's authority to operate the equipment under the FCC Rules.

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Federal Communications Commission

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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:

<>	Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, AO <3..0>.
»	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.
	This icon denotes a note, which alerts you to important information.
	This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.
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.
NI 1409	NI 1409 refers to the NI PXI/PCI-1409 image acquisition device.

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1 Introduction

This chapter describes the NI PXI/PCI-1409 (NI 1409) device and your software programming choices.

About the NI 1409

The NI 1409 is a high-accuracy, monochrome image acquisition device for PXI, PCI, or CompactPCI chassis that support RS-170, CCIR, NTSC, and PAL video standards, as well as some nonstandard cameras from any of four input sources. The NI 1409 features a 10-bit analog-to-digital converter (ADC) that converts video signals to digital formats. The NI 1409 device acquires images in real time and stores them in onboard frame memory or transfers them directly to system memory.

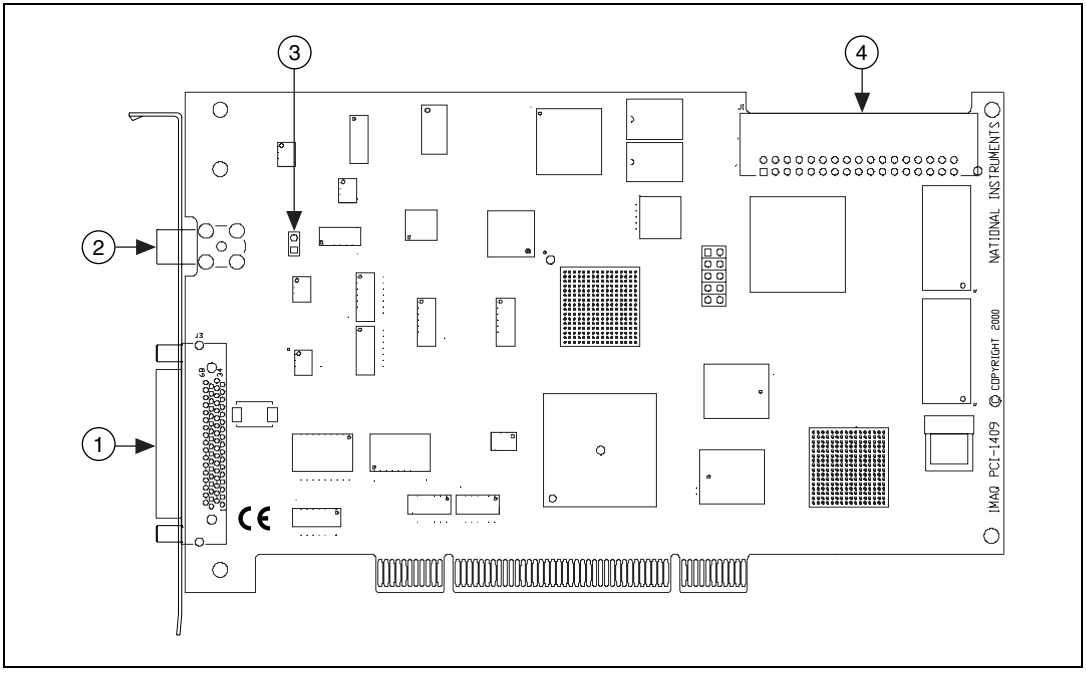
The NI 1409 is easy to install and configure. The NI 1409 ships with NI Vision Acquisition Software, which includes NI-IMAQ, the National Instruments driver software you can use to directly control the NI 1409 and other National Instruments image acquisition devices. With NI-IMAQ, you can quickly and easily start your applications without having to program the device at the register level.

As a standalone device, the NI 1409 supports four general-purpose control lines that are configurable to generate precise timing signals for controlling camera acquisition. The NI 1409 also supports four video sources and four external I/O lines to use as triggers or digital I/O lines.

Easily synchronizing several functions to a common trigger or timing event is a common challenge with image acquisition devices. The NI 1409 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 NI 1409 and up to four National Instruments data acquisition (DAQ), Motion Control, or image acquisition devices. The RTSI bus can even synchronize multiple image acquisition device hardware captures.

For detailed NI 1409 specifications, refer to *Getting Started with the NI PXI/PCI-1409*.

Refer to Figure 1-1 for the location of the NI 1409 W1 jumper and the connectors discussed in this manual.



1	68-Pin VHDCI Connector	3	W1 Jumper
2	BNC Connector	4	RTSI Bus Connector

Figure 1-1. NI PCI-1409 Parts Locator Diagram

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. For example, the RTSI bus on the NI PXI-1409 is available in a PXI chassis, but not in a CompactPCI chassis.

The CompactPCI specification enables vendors to develop sub-buses that coexist with the basic PCI interface on the CompactPCI bus. Compatible operation is not guaranteed between CompactPCI devices with different sub-buses or between CompactPCI devices with sub-buses and PXI. The standard implementation for CompactPCI does not include these

sub-buses. The NI PXI-1409 works in any standard CompactPCI chassis adhering to the *PICMG 2.0 R2.1 CompactPCI* core specification using the 64-bit definition for J2.

PXI-specific features are implemented on the J2 connector of the CompactPCI bus. Table 1-1 lists the J2 pins the NI PXI-1409 uses. The NI PXI-1409 is compatible with any CompactPCI chassis with a sub-bus that does not drive these lines.

Caution Even if the sub-bus is capable of driving these lines, the NI PXI-1409 is still compatible as long as those pins on the sub-bus are disabled by default and are never enabled. Damage may result if these lines are driven by the sub-bus.

Table 1-1. Pins Used by the NI PXI-1409

PXI-1409 Signal	PXI Pin Name	PXI J2 Pin Number
RTSI Trigger <0..6>	PXI Trigger <0..6>	B16, A16, A17, A18, B18, C18, E18

Software Overview

Programming the NI 1409 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 for common inspection tasks.
- **Vision Development Module**—Provides customized control over hardware and algorithms.

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

NI-IMAQ Driver Software

The NI 1409 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 your 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 is also the interface path between the NI 1409 and LabVIEW, LabWindows™/CVI™, or a text-based programming environment. The NI-IMAQ software kit includes a series of image acquisition libraries 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, which requires advanced understanding of the image acquisition device and image acquisition.

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 1409.

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 for use in LabVIEW, LabWindows/CVI, and Measurement Studio. Vision Builder AI does not require programming, but it 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. With Vision Builder AI, you can migrate the configured inspection to LabVIEW, extending the capabilities of your applications if necessary.

Vision Development Module

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

- 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.

NI Vision Assistant is included with the Vision Development Module. 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 can then 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 for integration between image acquisition devices and DAQ devices.

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 describes the features of the NI 409 device and includes information about acquisition modes, analog front-end considerations, and clamping.

Functional Overview

The NI 1409 features a high-speed data path optimized for the acquisition and formatting of video data from analog cameras. The NI 1409 can acquire from RS-170/NTSC, CCIR/PAL, VGA, and progressive scan cameras, as well as from non-standard cameras such as line scan cameras. The NI 1409 digitizes analog video signals to 8 or 10 bits of resolution at sampling frequencies up to 40 MHz.

The NI 1409 has a factory-calibrated gain circuit to improve measurement accuracy and board-to-board consistency. It uses a PCI interface for high-speed data transfer, 16 MB of SDRAM for data buffering, and region-of-interest control circuitry for optimizing the data transfer. The 16 MB of SDRAM also allows you to acquire entire images into onboard memory when necessary. The NI 1409 includes four external triggers, four camera control signals, seven RTSI bus triggers, and six video synchronization signals.

The block diagram in Figure 2-1 illustrates the key functional units of the NI 1409.

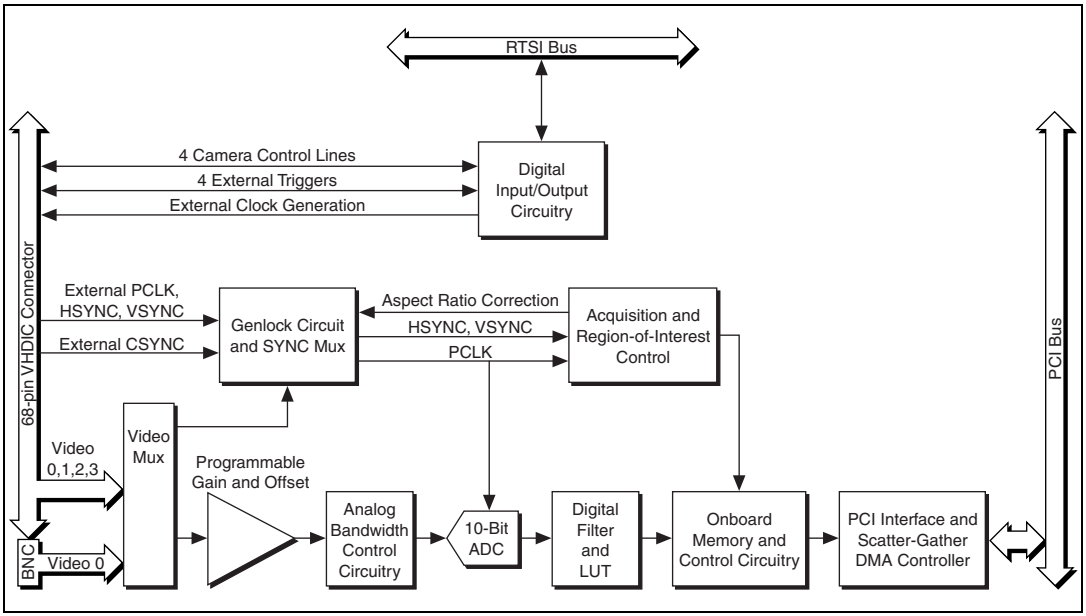


Figure 2-1. NI 1409 Block Diagram

Video Multiplexer

The video multiplexer routes one of the four AC-coupled video inputs to the 10-bit ADC circuitry. The input impedance at the input to the board is 75 Ω.

Programmable Gain and Offset

The NI 1409 uses programmable gain and offset circuitry to optimize the input signal range.

Analog Bandwidth Control Circuitry

You can select either the full bandwidth of 30 MHz or a reduced bandwidth of 9 MHz. The 9 MHz bandwidth setting is available using a 5th order Butterworth lowpass filter.

10-Bit ADC

The 10-bit ADC digitizes the conditioned video signal.

Digital Filter and LUT

The digital filter removes chrominance from a composite color video signal that conforms to either PAL or NTSC. The output of the digital filter passes through the 1,024 × 10-bit lookup table (LUT). You can configure the LUT to implement simple imaging operations such as contrast enhancement, data inversion, gamma correction, or other user-defined transfer functions.

Onboard Memory

The NI 1409 has 16 MB of SDRAM for temporarily storing image data being transferred to the system memory through the PCI bus. The memory can store multiple image buffers.

Scatter-Gather DMA Controllers

The NI 1409 uses three independent onboard direct memory access (DMA) controllers. The DMA controllers transfer data between the onboard SDRAM memory buffer and the PCI bus. Each of these controllers supports scatter-gather DMA, which allows the controllers to reconfigure on the fly. This functionality enables the NI 1409 to perform continuous image transfers directly to either contiguous or fragmented memory buffers.

PCI Interface

The NI PCI-1409 implements the PCI interface with a National Instruments custom application-specific integrated circuit (ASIC), the PCI MITE. The PCI interface can transfer data at a maximum rate of 132 MB/s in bus master mode.

Genlock Circuit and SYNC Mux

The genlock circuit receives the incoming video signal and generates PCLK, HSYNC, and VSYNC signals for use by the acquisition and control circuitry. The NI 1409 device can lock to the standard RS-170/NTSC and CCIR/PAL video signals as well as progressive scan and VGA (640 × 480 resolution) signals. The genlock circuit on the NI 1409 can also lock to external HSYNC and VSYNC or CSYNC signals.

Acquisition and Region-of-Interest (ROI) Control

The acquisition and region-of-interest control circuitry routes the active pixels from the 10-bit ADC to the onboard memory. The NI 1409 can perform ROI and scaling on all video lines. Pixel and line scaling transfers certain multiples (two, four, or eight) of pixels and lines to onboard memory.

RTSI Bus

The seven trigger lines on the RTSI bus provide a flexible interconnection scheme between multiple image acquisition devices, as well as between National Instruments DAQ or Motion Control devices.

Digital Input/Output Circuitry

The digital input/output (I/O) circuitry routes, monitors, and drives the external trigger lines, RTSI bus lines, and camera control lines. You can use the trigger lines to start or stop an acquisition on a rising or falling edge. You also can map onboard signals such as HSYNC, VSYNC, ACQUISTION_IN_PROGRESS, and ACQUISITION_DONE to these lines. The camera control lines provide a means to generate deterministic signals for triggering cameras, strobe lights, or other timing-critical applications. This module also contains an external clock generation circuit you can use as the source clock for a line scan camera.

Note The NI 1409 does not support pixel clock output on the trigger lines.

Acquisition Modes

The NI 1409 supports the following five video acquisition modes:

- **Standard Mode**—In standard mode, the NI 1409 receives an incoming composite video signal from the external BNC or 68-pin VHDCI connector and generates CSYNC, HSYNC, VSYNC, and PCLK signals. The VHDCI connector outputs the generated CSYNC signal to synchronize other image acquisition devices or cameras.
- **CSYNC External Mode**—In CYSNC external mode, the NI 1409 receives an incoming video signal (composite or luminance) and an external CSYNC signal from the external connector and generates HSYNC, VSYNC, and PCLK signals.
- **External Lock Mode**—In external lock mode, the NI 1409 receives HSYNC, VSYNC, and PCLK signals from the camera and uses these

signals to acquire the video signals directly. You can use this mode to acquire from a line scan camera.

- **External HSYNC/VSYNC Mode**—In external HSYNC/VSYNC mode, the NI 1409 receives the external HSYNC and VSYNC from the connector and internally generates the PCLK signal. The NI 1409 genlock circuitry locks to the external HSYNC and VSYNC signals. You can use this mode to acquire from VGA monitors (640×480 resolution).
- **External HSYNC/VSYNC (HLOCK only) Mode**—In external HSYNC/VSYNC (HLOCK only) mode, the NI 1409 receives the external HSYNC and VSYNC signals and internally generates the PCLK signal. In this mode, the NI 1409 genlock circuitry uses only the HSYNC signal for locking. You can use this mode to acquire from asynchronously reset cameras that output a continuous HSYNC.

Analog Front End Considerations

The analog front end of the NI 1409 features a calibrated gain circuit, programmable DC-restore circuit, and 10-bit ADC as shown in Figure 2-2.

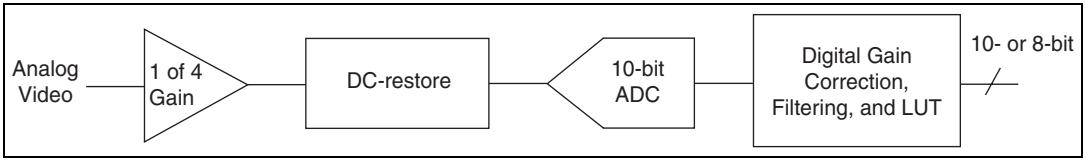


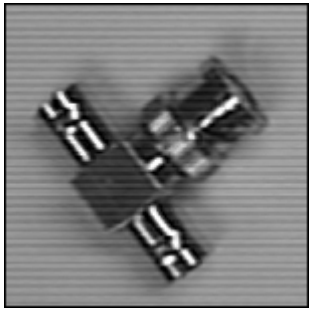
Figure 2-2. NI 1409 Analog Front End

10-Bit/8-Bit Mode

The NI 1409 always digitizes the incoming video signal to 10 bits of resolution. In 10-bit mode, the NI 1409 has four fixed, full-scale ranges for calibrating the gain for each range. Because the nominal full-scale ranges are 0.20, 0.35, 0.70, and 1.40 V, the gain is not continuously variable in this mode. To maintain compatibility with other analog image acquisition devices, the NI 1409 has an 8-bit mode that converts the 10-bit data from the ADC to 8-bit data in the lookup table (LUT) after gain correction and any digital filtering has occurred.

Clamping

The NTSC camera file sets the default values of Clamp Start and Clamp Stop to 106 and 116, respectively. These settings place the clamp pulse, which restores the DC level of the video signal, between the color burst signal and the beginning of active video. Because some cameras deviate from the exact timing required by the NTSC standard, the clamping pulse may intersect either the color burst or the active video portions of the signal. If this occurs, an acquired image may appear to have dark and light bands, as in the following image:



To prevent this problem, open Measurement & Automation Explorer (MAX) and navigate to the Advanced page of the camera file property page. Use the following guidelines to adjust the Clamp Start and Clamp Stop values until the image is corrected:

- Minimum Clamp Start is 100
- Maximum Clamp Stop is 120
- Difference between Clamp Start and Clamp Stop is at least 10

3

Signal Connections

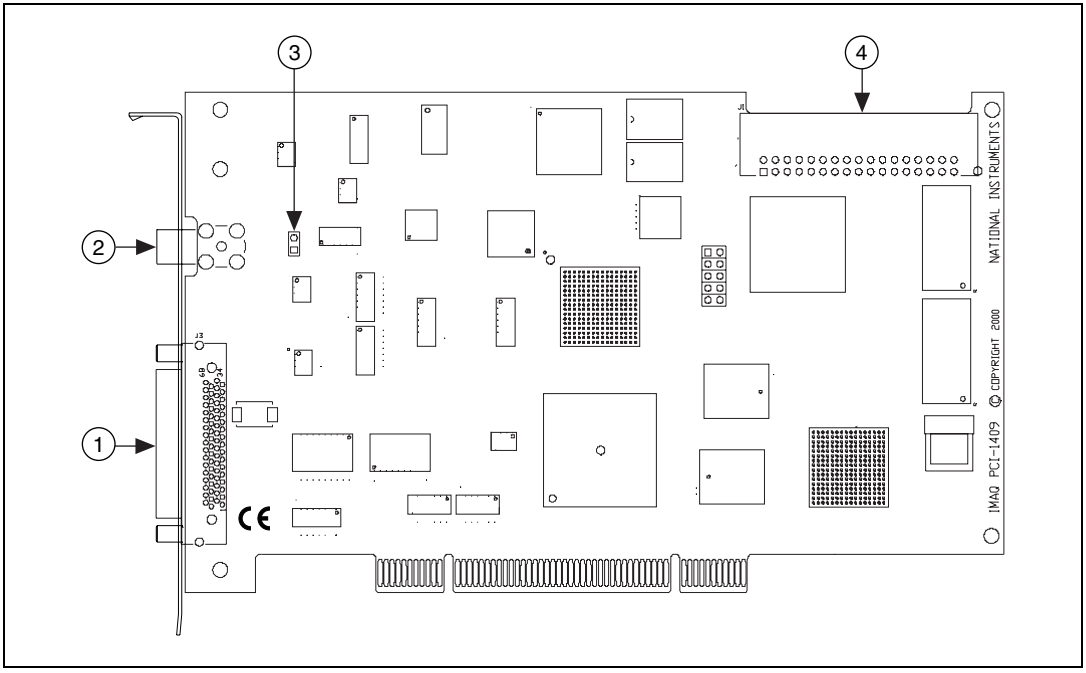
This chapter describes cable connections for the NI 1409 devices.

BNC Connector

The BNC external connector supplies an immediate connection (RSE mode only) to the 1409 device VIDEO0 input. To use the VIDEO0 connection on the 68-pin VHDCI I/O connector, you must connect VIDEO0+ to the signal and VIDEO0– to ground.

To connect a camera to VIDEO0, first verify that the W1 jumper is intact. Next, use the 2 m BNC cable shipped with the NI 409 to connect to the BNC connector.

Refer to Figure 3-1 for the location of the NI 1409 W1 jumper and the connectors discussed in this chapter.



1	68-Pin VHDCI Connector	3	W1 Jumper
2	BNC Connector	4	RTSI Bus Connector

Figure 3-1. NI PCI-1409 Parts Locator Diagram

Figure 3-2 shows the BNC connector pin assignments.

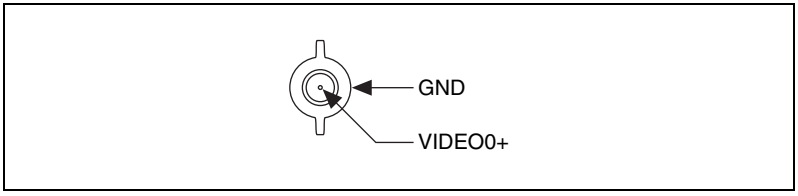


Figure 3-2. BNC Connector Pin Assignment

Digital I/O Connector

The 68-pin VHDCI connector connects to all video signals (VIDEO0, VIDEO1, VIDEO2, and VIDEO3), the external digital I/O lines, triggers, and external signals. To access these connections, you can build your own custom cable or use one of the optional National Instruments cables.

Note If you are using the VIDEO0 connection on the 68-pin VHDCI connector, you must unplug the BNC cable.

Figure 3-3 shows the pinout of the 68-pin VHDCI connector.

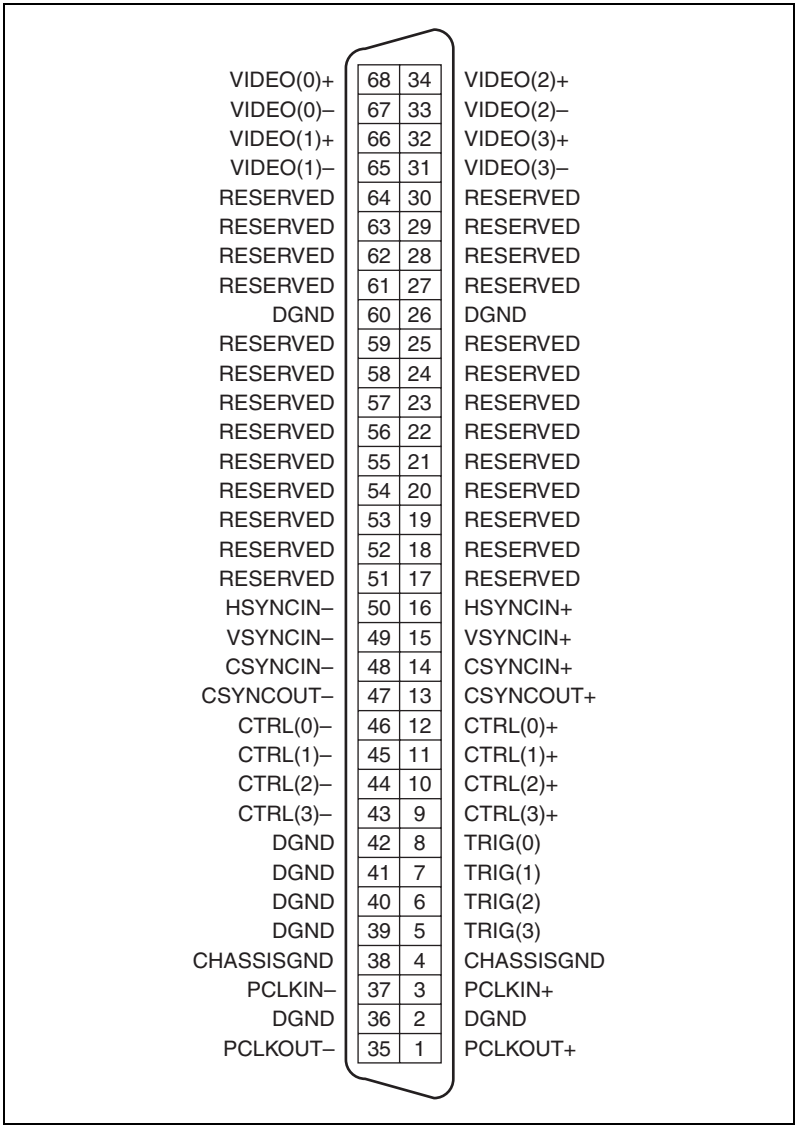


Figure 3-3. I/O Connector Pin Assignments

Digital I/O Connector Signal Connection Descriptions

Table 3-1 describes each signal connection on the 68-pin VHDCI connector.

Table 3-1. I/O Connector Signals

Signal Name	Description
VIDEO0±	VIDEO0± supports RSE connection only. To operate in RSE mode, you must connect VIDEO0– to DGND. When you use VIDEO0+ or VIDEO0–, you must disconnect the BNC connector.
VIDEO<3..1>±	VIDEO<3..1>± allows for a DIFF or RSE connection to video channels 1, 2, and 3. To operate in RSE mode, connect VIDEO<3..1>– to DGND.
PCLKIN±	Use PCLKIN± when the NI 1409 is in external lock mode. In this mode, PCLKIN represents the A/D sampling clock. You can select PCLKIN to be either TTL or RS-422 mode and program its polarity through software. In RS-422 mode, both PCLKIN+ and PCLKIN– receive the PCLK signal.
PCLKOUT±	Use PCLKOUT± when your camera requires an external pixel clock source. The NI 1409 can generate variable pixel clock frequencies between 11 MHz and 40 MHz. You can set PCLKOUT± through your software in TTL and RS-422 modes.
HSYNCIN±	Use HSYNCIN± when the NI 1409 is in external lock mode. HSYNC is a synchronization pulse produced at the beginning of each video scan line that keeps the video monitor horizontal scan rate in step with the transmission of each new line. You can set HSYNCIN for either TTL or RS-422 mode and program its polarity through software. In RS-422 mode, both HSYNCIN+ and HSYNCIN– receive the HSYNC signal.
VSYNCIN±	Use VSYNCIN± when the NI 1409 is in external lock mode. VSYNC is a synchronization pulse generated at the beginning of each video frame that tells the video monitor when to start a new field. You can set VSYNCIN to be either TTL or RS-422 mode and program its polarity through software. In RS-422 mode, both VSYNCIN+ and VSYNCIN– receive the VSYNC signal.
CSYNCIN±	Use CSYNCIN± when the NI 1409 is in CSYNC external mode. CSYNC is a signal consisting of horizontal sync pulses, vertical sync pulses, and equalizing pulses only. You can set CSYNCIN to be either TTL or RS-422 mode and program its polarity through software. In RS-422 mode, both CSYNCIN+ and CSYNCIN– receive the CSYNC signal.
CSYNCOUT	CSYNCOUT is a TTL output of the internal CSYNC signal. In CSYNC external mode, CSYNCOUT maps directly to CSYNCIN. In standard mode, the synchronization circuitry of the NI 1409 generates CSYNCOUT.

Table 3-1. I/O Connector Signals (Continued)

Signal Name	Description
TRIG<3..0>	Triggers<3..0> are TTL I/O lines used to start or stop an acquisition or output an acquisition status. You can program the triggers to be rising- or falling-edge sensitive. You can also program the triggers to be programmatically asserted or unasserted, which is similar in function to a digital I/O line, or to contain specific pulse widths or internal status signals by using the onboard events.
CTRL<3..0>±	Use the control lines on the NI PCI-1409 to control camera features and timing information, such as generating integration or shutter pulses. You can generate either static or dynamic signals and either TTL or differential signals on these lines.
DGND	DGND is a direct connection to a digital ground on the NI 1409.
CHASSIS_GND	CHASSIS_GND is a direct connection to the computer's chassis, which is grounded through the power cord.

A

Custom Cables

This appendix lists specifications for building custom cables to use with the NI 1409 device.

Cable Specification

National Instruments offers cables and accessories for you to connect to video sources, trigger sources, or synchronization sources. Use the following guidelines when developing your own cables:

- For the video inputs, use a 75 Ω shielded coaxial cable.
- For the digital triggers and synchronization signals, use twisted pairs for each signal.

For information about connector pin assignments, refer to the *Digital I/O Connector* section of Chapter 3, *Signal Connections*.

Connector Specifications

- Video and sync signals—75 Ω impedance
- Trigger signals—TTL
- Type—75 Ω BNC or 68-pin VHDCI receptacle

B

Technical Support and Professional Services

Visit the following sections of the National Instruments Web site at ni.com for technical support and professional services:

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- **Calibration Certificate**—If your product supports calibration, you can obtain the calibration certificate for your product at ni.com/calibration.

If you searched ni.com and could not find the answers you need, contact your local office or NI corporate headquarters. Phone numbers for our worldwide offices are listed at the front of this manual. You also can visit the Worldwide Offices section of ni.com/niglobal to access the branch office Web sites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.

Glossary

A

A	Amperes.
A/D	Analog-to-digital.
AC	Alternating current.
acquisition window	The image size specific to a video standard or camera resolution.
active line region	The region of lines actively being stored. Defined by a line start (relative to the vertical synchronization signal (VSYNC)) 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 (HSYNC)) and a pixel count.
ADC	Analog-to-digital converter. An electronic device, often an integrated circuit, that converts an analog voltage to a digital value.
address	Value that identifies a specific location (or series of locations) in memory.
ANSI	American National Standards Institute.
antichrominance filter	Removes the color information from the video signal.
API	Application programming interface.
area	A rectangular portion of an acquisition window or frame that is controlled and defined by software.
array	Ordered, indexed set of data elements of the same type.
ASIC	Application-Specific Integrated Circuit. A proprietary semiconductor component designed and manufactured to perform a set of specific functions for specific customer needs.
aspect ratio	The ratio of a picture or image's width to its height.

B

b	Bit. One binary digit, either 0 or 1.
B	Byte. Eight related bits of data, an 8-bit binary number. Also denotes the amount of memory required to store one byte of data.
back porch	The area of the video signal between the rising edge of the horizontal synchronization signal (HSYNC) and the active video information.
black reference level	The level that represents the darkest an image can get. *See also* white reference level.
buffer	Temporary storage for acquired data.
bus	A group of conductors that interconnect individual circuitry in a computer, such as the PCI bus; typically the expansion vehicle to which I/O or other devices are connected.

C

C	Celsius.
cache	High-speed processor memory that buffers commonly used instructions or data to increase processing throughput.
CCIR	Comite Consultatif International des Radiocommunications. A committee that developed standards for video signals. Also used to describe signals, boards, and cameras that adhere to the CCIR standards.
chroma	The color information in a video signal.
chrominance	*See* chroma.
CMOS	Complementary metal-oxide semiconductor.
CompactPCI	Refers to the core specification defined by the PCI Industrial Computer Manufacturer's Group (PICMG).
conversion device	Device that transforms a signal from one form to another. For example, analog-to-digital converters (ADCs) for analog input and digital-to-analog converters (DACs) for analog output.

CPU	Central processing unit.
CSYNC	Composite synchronization signal. Signals in a color video system that multiplex all picture information into a single signal, such as NTSC, PAL, or SECAM.

D

D/A	Digital-to-analog.
DAC	Digital-to-analog converter. An electronic device, often an integrated circuit, that converts a digital number into a corresponding analog voltage or current.
DAQ	Data acquisition. (1) Collecting and measuring electrical signals from sensors, transducers, and test probes or fixtures and inputting them to a computer for processing. (2) Collecting and measuring the same kinds of electrical signals with A/D or DIO boards plugged into a computer, and possibly generating control signals with D/A and/or DIO boards in the same computer.
dB	Decibel. The unit for expressing a logarithmic measure of the ratio of two signal levels: $dB = 20\log_{10} V1/V2$, for signals in volts.
DC	Direct current.
default setting	A default parameter value recorded in the driver. In many cases, the default input of a control is a certain value (often 0).
DMA	Direct memory access. A method by which data can be transferred between computer memory and 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.
driver	Software that controls a specific hardware device, such as an image or data acquisition 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 image acquisition devices to temporarily store incoming data until that data can be retrieved.
flash ADC	An ADC whose output code is determined in a single step by a bank of comparators and encoding logic.
frame	A complete image. In interlaced formats, a frame is composed of two fields.
front porch	The area of a video signal between the start of the horizontal blank and the start of the horizontal synchronization signal (HSYNC).
ft	Feet.
function	A set of software instructions executed by a single line of code that may have input and/or output parameters and returns a value when executed.

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	The process of synchronizing a video source to the signal from a separate video source. The circuitry aligns the video timing signals by locking together the horizontal, vertical, and color subcarrier frequencies and phases and generates a pixel clock that clocks pixel data into memory for display or into another circuit for processing.

H

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.
Hz	Hertz. Frequency in units of 1/second.

I

IC	Integrated circuit.
in.	Inches.
INL	Integral nonlinearity. A measure of LSB of the worst-case deviation from the ideal A/D or D/A transfer characteristic of the analog I/O circuitry.
instrument driver	A set of high-level software functions, such as NI-IMAQ, that control specific plug-in computer boards. Instrument drivers are available in several forms, ranging from a function callable from a programming language to a virtual instrument (VI) in LabVIEW.
interlaced	A video frame composed of two interleaved fields. The number of lines in a field are half the number of lines in an interlaced frame.
interpreter	A software utility that executes source code from a high-level language such as Basic, C, or Pascal by reading one line at a time and executing the specified operation.
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.

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.
number of planes (in an image)	The number of arrays of pixels that compose the image. A gray-level or pseudo-color image is composed of one plane, while an RGB image is composed of three planes (one for the red component, one for the blue, and one for the green).
NVRAM	Nonvolatile RAM. RAM that is not erased when a device loses power or is turned off.

P

PAL	Phase Alternation Line. One of the European video color standards. PAL 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.
PCLK	Pixel clock signal. Times the sampling of pixels on a video line.
picture aspect ratio	The ratio of the active pixel region to the active line region. For standard video signals like RS-170 or CCIR, the full-size picture aspect ratio normally is 4/3 (1.33).
pixel aspect ratio	The ratio between the physical horizontal size and the vertical size of the region covered by the pixel. An acquired pixel should optimally be square, thus the optimal value is 1.0, but typically it falls between 0.95 and 1.05, depending on camera quality.

pixel clock	Divides the incoming horizontal video line into pixels.
pixel count	The total number of pixels between two horizontal synchronization signals (HSYNCs). 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, such as an incoming horizontal synchronization signal (HSYNC).
PXI	PCI eXtensions for Instrumentation. An open specification that builds on the CompactPCI specification by adding instrumentation-specific features.

R

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	(1) The number of rows and columns of pixels. An image composed of *m* rows and *n* columns has a resolution of $m \times n$. This image has *n* pixels along its horizontal axis and *m* pixels along its vertical axis. (2) The smallest signal increment that can be detected by a measurement system. Resolution can be expressed in bits, proportions, or a percentage 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. (1) An area of the image that is graphically selected from a window displaying the image. This area can be used focus further processing. (2) A hardware-programmable rectangular portion of the acquisition window.
RSE	Referenced single-ended. All measurements are made with respect to a common reference measurement system or a ground. Also called a grounded measurement system.

RTSI bus	Real-Time System Integration Bus. The National Instruments timing bus that connects image and data acquisition boards directly by means of connectors on top of the boards for precise synchronization of functions.

S

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.
SRAM	Static RAM.
StillColor	A post-processing algorithm that allows the acquisition of high-quality color images generated either by an RGB or composite (NTSC or PAL) camera using a monochrome video acquisition board.
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.

U

UV plane	*See* YUV.

V

V	Volts.
value	The grayscale intensity of a color pixel computed as the average of the maximum and minimum red, green, and blue values of that pixel.
VCO	Voltage-controlled oscillator. An oscillator that changes frequency depending on a control signal. Use VCO in a phase-locked loop 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.
video line	A video line consists of a horizontal synchronization signal, back porch, active pixel region, and a front porch.
VSYNC	Vertical synchronization signal. The synchronization pulse generated at the beginning of each video field that tells the video monitor when to start a new field.

W

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

Y

YUV	A representation of a color image used for the coding of NTSC or PAL video signals. The luma information is called Y, while the chroma information is represented by two components, U and V representing the coordinates in a color plane.

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