NI Vision

NI PCI-1424 User Manual

High-Quality Digital Image Acquisition Device

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Depending on where it is operated, this Class A product could be subject to restrictions in the FCC rules. (In Canada, the Department of Communications (DOC), of Industry Canada, regulates wireless interference in much the same way.) Digital electronics emit weak signals during normal operation that can affect radio, television, or other wireless products.

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.

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Federal Communications Commission

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Canadian Department of Communications

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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.**bold**
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 1424	NI 1424 refers to the NI PCI-1424 image acquisition device.

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Glossary

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1

Introduction

This chapter describes the NI PCI-1424 (NI 1424) image acquisition device and describes your software programming choices.

About the NI 1424

The NI 1424 is a monochrome and color, PCI-based image acquisition device that supports a diverse range of digital cameras from many camera companies. The NI 1424 acquires digital images in real time and can store these images in onboard frame memory, or transfer these images directly to system memory. The device can capture up to 32 bits of data at a time at clock speeds up to 50 MHz.[1]

The NI 1424 is simple to configure so that you can easily install the device and begin acquiring images. The NI 1424 ships with NI Vision Acquisition Software, which includes NI-IMAQ, the National Instruments driver software you can use to directly control the NI 1424 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.

Featuring a high-speed data flow path, the NI 1424 is ideal for both industrial and scientific environments. As a standalone device, the NI 1424 supports up to 32 bits of differential or TTL level video data, four general purpose control lines that can be configured to generate precise timing signals to control digital camera acquisition, and four external input/output (I/O) lines that you can use as triggers or as high-speed digital I/O lines. If you require more advanced triggering or digital I/O lines (either digital or analog), you can use the NI 1424 and NI-IMAQ with the National Instruments data acquisition (DAQ) product line.

Refer to *Getting Started with the NI PCI-1424* for detailed specifications of the NI 1424.

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[1] Early versions of the NI 1424 may not support acquisitions at 50 MHz. For the exact maximum acquisition clock rate of your NI 1424, refer to the **Maximum Clock Rate** indicator in Measurement & Automation Explorer.

Software Overview

Programming the NI 1424 requires the NI-IMAQ driver software for controlling the hardware and one of the following application software packages for image processing:

- **Vision Builder for Automated Inspection (AI)**—for configuring solutions to common inspection tasks
- **National Instruments Vision Development Module**—for more 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 the package.

NI-IMAQ Driver Software

The NI-IMAQ driver software ships with the NI 1424. NI-IMAQ has an extensive library of functions you can call from your application programming environment, such as routines for video configuration, image acquisition (continuous and single-shot), memory buffer allocation, trigger control, and device configuration.

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

For maximum flexibility and performance, 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.

NI-IMAQ handles many of the complex issues between the computer and the image acquisition device, such as programming interrupts and camera control.

National Instruments Application Software

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. With Vision Builder AI, you can migrate your configured inspection to LabVIEW, extending the capabilities of your applications if necessary.

Vision Builder AI is available for LabVIEW, LabWindows/CVI, and Measurement Studio, which includes support for Visual Basic.

Vision Development Module

The Vision Development Module is an image acquisition, processing, and analysis library of more than 270 functions for grayscale, color, and binary image display, image processing, pattern matching, particle analysis, gauging, and measurement.

For unique image processing, you can use the Vision Development Module functions individually or in combination. With the Vision Development Module you can acquire, display, manipulate, and store images, as well as perform image analysis, processing, and interpretation. 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 into any development environment, 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 diagrams that perform the prototype you created in Vision Assistant. Using LabVIEW, you can add functionality to this 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 presents an overview of the hardware functions on the NI 1424 and explains the operation of each functional unit making up the NI 1424.

Functional Overview

The NI 1424 features a high-speed data path optimized for the reception and formatting of video data from digital monochrome and color cameras.

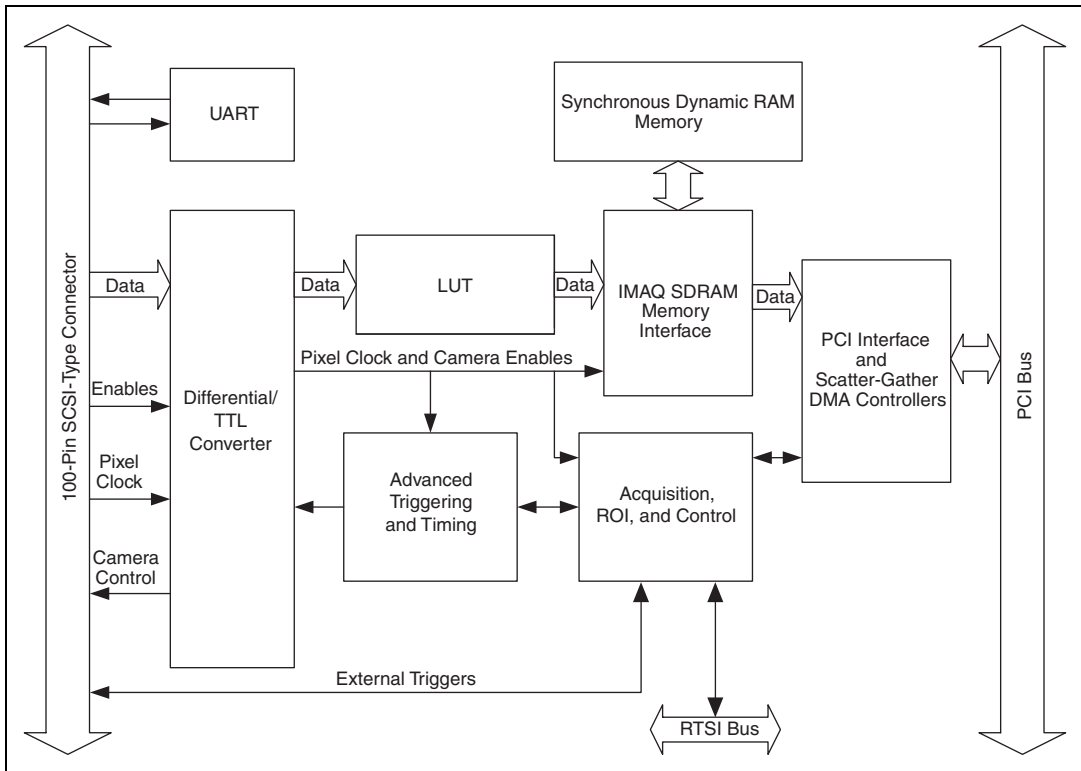The block diagram in Figure 2-1 illustrates the key functional components of the NI 1424.

Figure 2-1. NI 1424 Block Diagram

Signaling

The NI 1424 is available in two different versions. The RS-422/TTL version can drive and receive RS-422 and TTL-level signals. NI-IMAQ can control these signals independently for data, control, and enable lines on the 100-pin connector. The LVDS/TTL version, also known as EIA-644, can drive and receive LVDS- and TTL-level signals. Benefits of LVDS include less power consumption, longer cable lengths, less noise, and higher clock rates.

LUTs

You can configure the NI 1424 to use either four 8-bit or two 10-bit to 16-bit lookup tables (LUTs) to perform LUT operations such as contrast enhancement, data inversion, gamma manipulation, or other nonlinear transfer functions.

Multiple-Tap Data Formatter

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

The multiple tap data formatting circuitry on the NI 1424 can reorder the data from up to four 8-bit taps. The data from each tap can be independently scanned either from left-to-right or right-to-left and top-to-bottom or bottom-to-top.

SDRAM

The NI 1424 comes with 16 MB of onboard high-speed synchronous dynamic RAM (SDRAM). You can purchase additional SO-DIMM memory upgrades from National Instruments. SO-DIMM upgrades are available in 64 MB and 128 MB densities.

The NI 1424 can also use the onboard RAM as a first-in first-out (FIFO) buffer so that in some instances, the NI 1424 can capture images larger than the amount of RAM on the device.

RS-232 Serial Interface

You can use the RS-232 serial interface on the 100-pin SCSI-type connector to control digital cameras that also have a serial interface for camera control and configuration. The serial interface is configurable, allowing you to customize it to your camera requirements.

Trigger Control and Mapping Circuitry

The trigger control and mapping circuity routes, monitors, and drives the external and RTSI bus trigger lines. You can configure each of these lines to start an acquisition on a rising or falling edge. In addition, you can drive each line asserted or unasserted, similar to a digital I/O line. You can also map pulses from the high-speed timing circuitry or many of the NI 1424 status signals to these trigger lines. There are four external and seven RTSI bus triggers. You can program each of these triggers in polarity and direction.

High-Speed Timing

The high-speed timing circuitry on the NI 1424, built from high-speed counters, allows you to specify or generate precise, real-time control signals. You can map the output of this circuitry to a trigger line to provide accurate pulses and pulse trains.

Acquisition and ROI

The acquisition and region-of-interest (ROI) circuitry monitors the incoming video signals and routes the active pixels to the multiple-tap data formatter and SDRAM memory. In an ROI acquisition, you select an area within the acquisition window to transfer to the PCI bus.

Scatter-Gather DMA Controllers

The NI 1424 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 1424 can perform continuous image transfers directly to either contiguous or fragmented memory buffers.

Device Configuration NVRAM

The NI 1424 contains onboard nonvolatile RAM (NVRAM) that configures all registers on power-up.

Start Conditions

The NI 1424 can start acquisitions in a variety of conditions:

- **Software control**—The NI 1424 supports software control of acquisition start. You can configure the NI 1424 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 external or RTSI bus trigger lines. Each of these inputs can start a video acquisition on a rising or falling edge.

- **Delayed acquisition**—You can use either software or triggers to start acquisitions instantaneously or after skipping a specific period of time. You can use delayed acquisition for posttrigger applications.

- **Frame/field selection**—With an interlaced camera and the NI 1424 in frame mode, you can program the NI 1424 to start an acquisition on any odd or even field.

Acquisition Window Control

You can configure numerous parameters on the NI 1424 to control the video acquisition window. A brief description of each parameter follows:

- **Acquisition window**—The NI 1424 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 NI 1424 uses a second level of active pixel and active line regions for selecting a region of interest. When you disable the region-of-interest circuitry, the device stores the entire acquisition window in onboard or system memory. However, when you enable the region-of-interest circuitry, the device acquires only a selected subset of the image frame.

- **Interlaced video**—The NI 1424 supports both interlaced and non-interlaced, or progressive scan, digital video signals. In interlaced mode, the NI 1424 combines the odd and even fields into one contiguous frame for analysis. In non-interlaced mode, each field is treated as an independent frame.

3

Signal Connections

This chapter describes cable connections for the NI 1424.

I/O Connector

The NI 1424 100-pin SCSI-type connector connects to all digital video data inputs, digital enable inputs, camera control outputs, RS-232 serial interface, and the external trigger signals. To access these connections, you can build your own custom cable or use one of the optional cables from National Instruments.

Note Refer to the National Instruments Web site, ni.com/vision, for the latest information on optional cables and the cameras they support.

Figure 3-1 shows the pinout of the 100-pin SCSI-type connector.

Data0+	1	51	Data16+
Data0–	2	52	Data16–
Data1+	3	53	Data17+
Data1–	4	54	Data17–
Data2+	5	55	Data18+
Data2–	6	56	Data18–
Data3+	7	57	Data19+
Data3–	8	58	Data19–
Data4+	9	59	Data20+
Data4–	10	60	Data20–
Data5+	11	61	Data21+
Data5–	12	62	Data21–
Data6+	13	63	Data22+
Data6–	14	64	Data22–
Data7+	15	65	Data23+
Data7–	16	66	Data23–
Data8+	17	67	Data24+
Data8–	18	68	Data24–
Data9+	19	69	Data25+
Data9–	20	70	Data25–
Data10+	21	71	Data26+
Data10–	22	72	Data26–
Data11+	23	73	Data27+
Data11–	24	74	Data27–
Data12+	25	75	Data28+
Data12–	26	76	Data28–
Data13+	27	77	Data29+
Data13–	28	78	Data29–
Data14+	29	79	Data30+
Data14–	30	80	Data30–
Data15+	31	81	Data31+
Data15–	32	82	Data31–
Control0+	33	83	RI (RS-232)
Control0–	34	84	DTR (RS-232)
Control1+	35	85	DSR (RS-232)
Control1–	36	86	RTS (RS-232)
Control2+	37	87	CTS (RS-232)
Control2–	38	88	DCD (RS-232)
Control3+	39	89	Reserved
Control3–	40	90	Reserved
EnableA+	41	91	Reserved
EnableA–	42	92	Reserved
EnableB+	43	93	SOUT (RS-232)
EnableB–	44	94	SIN (RS-232)
EnableC+	45	95	External Trigger0
EnableC–	46	96	External Trigger1
EnableD+	47	97	External Trigger2
EnableD–	48	98	External Trigger3
Pixel Clock +	49	99	GND
Pixel Clock –	50	100	GND

Figure 3-1. NI 1424 Pin Assignments

Signal Description

Table 3-1 describes each signal connection on the 100-pin SCSI connector.

Table 3-1. I/O Connector Signals

Signal Name	Description
Data<31..0>±	Data<31..0>± allows you to connect data up to 32 bits wide in either TTL or differential format to the NI 1424.
Control<3..0>±	You can use the control lines on the NI 1424 to control digital camera features and timing information. Either TTL or differential signals can be generated on these lines to perform such functions as generating integration or shutter pulses to the digital cameras.
Enable<D..A>±	The NI 1424 can receive any combination of up to four enable signals. These signals can be either TTL or differential. Examples of camera signals which might be connected to these pins are frame enable, line enable, even enable and odd enable. If your camera has a separate field signal, that line should be connected to Enable C.
SOUT	Serial Data Out is used for RS-232 connections.
SIN	Serial Data In is used for RS-232 connections.
RI	Ring Indicator is used for RS-232 connections.
DTR	Data Terminal Ready is used for RS-232 connections.
DSR	Data Set Ready is used for RS-232 connections.
RTS	Request to Send is used for RS-232 connections.
CTS	Clear to Send is used for RS-232 connections.
DCD	Data Carrier Detect is used for RS-232 connections.
External Trigger<3..0>	External Trigger<3..0> are TTL I/O lines used to start an acquisition or output to control external events. You can program the triggers to be rising or falling edge sensitive. You can also program the triggers to be programmatically asserted or unasserted similar to the function of a digital I/O line or to contain internal status signals (by using the onboard events) or specific pulse widths.
Pixel Clock±	The NI 1424 uses the Pixel Clock input as a reference clock to latch the incoming video data in either TTL or differential format.
GND	GND is a direct connection to digital ground on the NI 1424.

A

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Glossary

A

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.
ASIC	Application-Specific Integrated Circuit. A proprietary semiconductor component designed and manufactured to perform a set of specific functions for specific customer needs.

B

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.

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 devices plugged into a computer, and possibly generating control signals with D/A and/or DIO devices in the same computer.

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.

driver   Software that controls a specific hardware device, such as an image
                        acquisition device.

E

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.

I

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.

L

LUT	Look-up table. Table containing values used to transform the gray-level values of an image. For each gray-level value in the image, the corresponding new value is obtained from the look-up table.

M

memory buffer	*See* buffer.

N

NI-IMAQ	Driver software for National Instruments image acquisition hardware.
NVRAM	Nonvolatile RAM. RAM that is not erased when a device loses power or is turned off.

P

PCI	Peripheral Component Interconnect. A high-performance expansion bus architecture originally developed by Intel to replace ISA and EISA. PCI offers a theoretical maximum transfer rate of 133 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.

R

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.
ribbon cable	A flat cable in which the conductors are side by side.
ROI	Region of interest. An area of the image from a window displaying the image.

S

scatter-gather DMA	A type of DMA that allows the DMA controller to reconfigure on-the-fly.
SDRAM	Synchronous dynamic RAM.
SO-DIMM	Small outline dual inline memory module.

T

tap	A stream of pixels from a camera. Some cameras send multiple streams, or taps, of data over a cable simultaneously to increase transfer rate.
transfer rate	The rate, measured in bytes/s, at which data is moved from source to destination after software initialization and set up operations. The maximum rate at which the hardware can operate.
trigger	Any event that causes or starts some form of data capture.
trigger control and mapping circuitry	Circuitry that routes, monitors, and drives external and RTSI bus trigger lines. You can configure each of these lines to start or stop acquisition on a rising or falling edge.
TTL	Transistor-transistor logic.

V

VI	Virtual Instrument. (1) A combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument. (2) A LabVIEW software module (VI), which consists of a front panel user interface and a block diagram program.

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