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NI Vision

NI 17xx Smart Camera User Manual

For NI 1722/1742/1744/1762/1764 Smart Cameras

September 2013
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If this hardware does cause interference with licensed radio communications services or other nearby electronics, which can be determined by turning the hardware off and on, you are encouraged to try to correct the interference by one or more of the following measures:

- Reorient the antenna of the receiver (the device suffering interference).
- Relocate the transmitter (the device generating interference) with respect to the receiver.
- Plug the transmitter into a different outlet so that the transmitter and the receiver are on different branch circuits.

Some hardware may require the use of a metal, shielded enclosure (windowless version) to meet the EMC requirements for special EMC environments such as, for marine use or in heavy industrial areas. Refer to the hardware's user documentation and the DoC[1] for product installation requirements.

When the hardware is connected to a test object or to test leads, the system may become more sensitive to disturbances or may cause interference in the local electromagnetic environment.

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Changes or modifications not expressly approved by National Instruments could void the user's right to operate the hardware under the local regulatory rules.

[1] The Declaration of Conformity (DoC) contains important EMC compliance information and instructions for the user or installer. To obtain the DoC for this product, visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

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About This Manual

This manual describes the electrical and mechanical aspects of the National Instruments 17xx Smart Camera. Refer to *Getting Started with the NI 17xx Smart Camera* for smart camera and accessory installation information.

Related Documentation

The following documents contain information that you may find helpful as you read this manual:

Hardware Documents

- *Getting Started with the NI 17xx Smart Camera*—Contains important safety information and information about installing and configuring NI Smart Cameras and accessories. You can access this manual by navigating to **Start»All Programs»National Instruments» Vision»Documentation»NI-IMAQ**.
- NI Developer Zone—Contains example programs, tutorials, technical presentations, the Instrument Driver Network, a measurement glossary, an online magazine, a product advisor, and a community area where you can share ideas, questions, and source code with developers around the world. The NI Developer Zone is located on the National Instruments Web site at `ni.com/zone`. You can find the following documents in the NI Developer Zone:
  - *Using the NI 17xx Smart Camera Direct Drive Lighting Controller*—Demonstrates how to utilize the Direct Drive lighting controller feature on the NI 17xx Smart Camera with LabVIEW or Vision Builder for Automated Inspection.
  - *A Practical Guide to Machine Vision Lighting*—Explains machine vision lighting concepts and theories.

NI Vision Builder for Automated Inspection Documents

- *NI Vision Builder for Automated Inspection Tutorial*—Describes Vision Builder for Automated Inspection and provides step-by-step instructions for solving common visual inspection tasks, such as inspection, gauging, part presence, guidance, and counting.
- *NI Vision Builder for Automated Inspection: Configuration Help*—Contains information about using the Vision Builder for Automated Inspection Configuration Interface to create a machine vision application.
- *NI Vision Builder for Automated Inspection: Inspection Help*—Contains information about running applications created with Vision Builder for Automated Inspection in the Vision Builder Automated Inspection Interface.

LabVIEW and NI Vision Development Module Documents

- *LabVIEW Help*—Includes information about LabVIEW programming concepts, step-by-step instructions for using LabVIEW, and reference information about LabVIEW VIs, functions, palettes, menus, and tools.
- *Getting Started with LabVIEW*—Use this manual as a tutorial to familiarize yourself with the LabVIEW graphical programming environment and the basic LabVIEW features you use to build data acquisition and instrument control applications.
- *Getting Started with the LabVIEW Real-Time Module*—Use this manual as a tutorial to familiarize yourself with the LabVIEW Real-Time Module and the basic Real-Time Module features you use to build real-time applications.
- *NI Vision Concepts Manual*—Describes the basic concepts of image analysis, image processing, and machine vision. This document also contains in-depth discussions about imaging functions for advanced users.
- *NI Vision for LabVIEW Help*—Describes how to create machine vision and image processing applications in LabVIEW using the Vision Development Module. The help file guides you through tasks beginning with setting up your imaging system to taking measurements. It also describes how to create a real-time vision application using NI Vision with the LabVIEW Real-Time Module and contains reference information about NI Vision for LabVIEW palettes and VIs.

NI Vision Acquisition Software Documents

- *NI-IMAQ VI Reference Help*—Contains reference information about the LabVIEW VIs and properties for NI-IMAQ driver software.
- *Measurement & Automation Explorer Help for NI-IMAQ*—Describes how to configure NI-IMAQ driver software, NI image acquisition devices, and NI Smart Cameras using Measurement & Automation Explorer.

1

NI Smart Camera Overview

This chapter provides an overview of the features and components of the National Instruments Smart Camera. Refer to *Getting Started with the NI 17xx Smart Camera* for smart camera and accessory installation information.

Hardware Overview

The NI Smart Camera is available in several different configurations. When a feature pertains only to specific smart camera models, a list at the beginning of the section shows which smart camera models support the feature.

All smart camera models incorporate an image sensor, processor, and digital I/O in a compact, rugged housing.

Table 1-1 shows the differentiating features for each smart camera model.

Table 1-1. NI Smart Camera Models

NI Smart Camera Model	Processor	Image Sensor	Direct Drive Lighting Controller	Quadrature Encoder Support
NI 1722	400 MHz PowerPC	1/3 inch Sony ICX424AL CCD Monochrome 640 × 480 pixels (VGA)	No	No
NI 1742	533 MHz PowerPC	1/3 inch Sony ICX424AL CCD Monochrome 640 × 480 pixels (VGA)	Yes	Yes
NI 1744	533 MHz PowerPC	1/2 inch Sony ICX205AL CCD Monochrome 1,280 × 1,024 pixels (SXGA)	Yes	Yes
NI 1762	533 MHz PowerPC and 720 MHz DSP	1/3 inch Sony ICX424AL CCD Monochrome 640 × 480 pixels (VGA)	Yes	Yes
NI 1764	533 MHz PowerPC and 720 MHz DSP	1/2 inch Sony ICX205AL CCD Monochrome 1,280 × 1,024 pixels (SXGA)	Yes	Yes

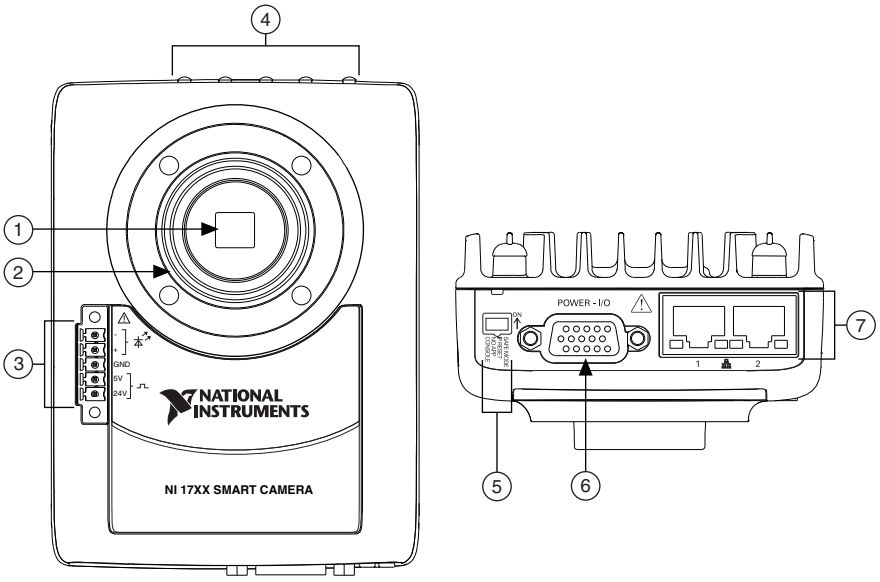
For more information about the image sensors, refer to Chapter 3, *NI Smart Camera Image Sensor*. For complete smart camera specifications, refer to Appendix A, *Specifications*.

All smart cameras have an RS-232 serial port, Gigabit Ethernet ports, and use a standard C-mount lens. Some smart camera models also include the Direct Drive lighting controller and support for quadrature encoders. The Direct Drive lighting controller is an integrated controller to directly power a variety of third-party current-controlled lights. Refer to Chapter 4, *Lighting*, for more information about the Direct Drive lighting controller. The smart camera also has one 5 V TTL strobe output and one unregulated 24 V strobe output for lighting control.

The smart camera also includes LEDs for communicating system status, four DIP switches to specify startup options, isolated inputs, and isolated outputs for connecting to external devices. Refer to Chapter 6, *LEDs and DIP Switches*, for more information about the LEDs and DIP switches. Refer to Chapter 2, *Power and I/O*, for more information about the digital I/O capabilities of the smart camera.

Figure 1-1 shows the smart camera.

Figure 1-1. NI Smart Camera



1	Image Sensor	5	DIP Switches
2	Standard C Lens Mount	6	POWER-I/O Connector
3	Lighting Connector	7	Ethernet Ports
4	LEDs		

Software Overview

Developing applications with the NI Smart Camera requires one of the following software options:



Vision Builder
for
Automated Inspection

or



LabVIEW
LabVIEW Real-Time Module
NI Vision Development Module
NI Vision Acquisition Software

The installation and configuration process for each development environment is different. Refer to *Getting Started with the NI 17xx Smart Camera* for installation and configuration instructions.

The following sections describe the software options. For detailed information about individual software packages, refer to the documentation specific to the package.

Note Vision Builder for Automated Inspection and NI Vision Acquisition Software are included with the smart camera. LabVIEW, the LabVIEW Real-Time Module, and the NI Vision Development Module are sold separately.

NI Vision Builder for Automated Inspection

Vision Builder for Automated Inspection (Vision Builder AI) is configurable machine vision software you can use to configure the NI Smart Camera and prototype, benchmark, and deploy machine vision applications.

Creating applications in Vision Builder AI does not require programming. 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 can also migrate your configured inspection to LabVIEW, extending the capabilities of your applications if necessary.

LabVIEW

LabVIEW is a graphical programming environment for developing flexible and scalable applications. To develop machine vision applications with the NI Smart Camera and LabVIEW, you must have the following add-on modules: LabVIEW Real-Time Module, NI Vision Development Module, and Vision Acquisition Software.

LabVIEW Real-Time Module

The LabVIEW Real-Time Module combines LabVIEW graphical programming with the power of Real-Time (RT) hardware, enabling you to build deterministic, real-time systems. You develop VIs in LabVIEW and embed the VIs on RT targets, such as the NI Smart Camera. The RT target runs VIs without a user interface and offers a stable platform for real-time VIs. For more information about the LabVIEW Real-Time Module, refer to the *LabVIEW Help*.

NI Vision Development Module

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

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

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

For information about how to use the NI Vision Development Module with the LabVIEW Real-Time Module, refer to the *NI Vision for LabVIEW Help*.

NI Vision Acquisition Software

The NI Vision Acquisition Software CD contains Measurement & Automation Explorer (MAX) configuration software and NI-IMAQ driver software.

Use MAX to configure the NI Smart Camera. You can set the IP address, update software on the smart camera, configure triggering, and set up the lighting features. For more information about MAX, refer to the *Measurement & Automation Explorer Help for NI-IMAQ*

NI-IMAQ is the interface path between the application software and the smart camera. NI-IMAQ also controls the I/O and image acquisition on the smart camera.

NI-IMAQ includes an extensive library of VIs you can call from LabVIEW. These VIs include routines for video configuration, continuous and single-shot image acquisition, and trigger control.

The NI-IMAQ driver software performs all functions necessary for acquiring and saving images but does not perform image analysis. NI-IMAQ features both high-level and low-level functions. A function that acquires images in single-shot or continuous mode is an example of a high-level function. A function that requires advanced understanding of image acquisition, such as configuring an image sequence, is an example of a low-level function.

For information about using NI-IMAQ to configure an acquisition, refer to the *NI-IMAQ VI Reference Help*.

2

Power and I/O

This chapter provides information about the NI Smart Camera POWER-I/O connector, connecting isolated inputs and isolated outputs, and connecting to serial devices and to quadrature encoders.

POWER-I/O Connector

The POWER-I/O connector provides signal connections for power and I/O, including isolated inputs and outputs, quadrature encoders, and serial devices. The POWER-I/O connector is a standard female high-density 15-pin D-SUB connector. Table 2-1 shows the pin organization for the POWER-I/O connector. The two pins used to connect to a power supply, pin 15 and pin 5, are also shown in the table. Refer to *Getting Started with the NI 17xx Smart Camera* for information about connecting a power supply to the NI Smart Camera.

Table 2-1 lists the signal names and pin numbers for the 15-pin POWER-I/O connector. The table also lists the wire colors for the 15-pin D-SUB pigtail cable (part number 197818-05), sold separately by National Instruments. Cables sold by other manufacturers could have different wire colors.

Table 2-1. POWER-I/O Connector Signal Descriptions

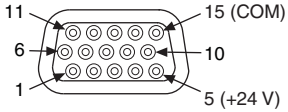
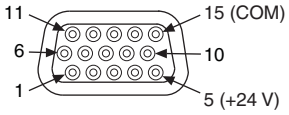
Connector Diagram	Signal Name	Pin Number	Wire Color
	+24 V	5	Red
	COM	15	Black
	RS232_TXD	10	Pink
	RS232_RXD	14	Black/White
	TrigIn+ IsoIn(0)+	2	Brown
	IsoIn(1)+	8	Orange

Table 2-1. POWER-I/O Connector Signal Descriptions (Continued)

Connector Diagram	Signal Name	Pin Number	Wire Color
	TrigIn- IsoIn(0)- IsoIn(1)-	12	Light Green
	IsoOut(0)+	6	Yellow
	IsoOut(0)-	1	Green
	IsoOut(1)+	11	Light Blue
	IsoOut(1)-	7	Gray
	PhaseA+	3	Blue
	PhaseA-	13	Brown/White
	PhaseB+	9	Purple
	PhaseB-	4	White

NI Smart Camera Power Requirements

Caution Use the NI Smart Camera only with a 24 VDC, UL listed, limited power source (LPS) supply. The power supply should bear the UL listed mark, LPS. The power supply *must* meet any safety and compliance requirements for the country of use.

The smart camera uses a nominal 24 VDC power source. The smart camera accepts power within the range of the industry standard IEC 1311 input power specification (24 V +20%/-15% with an additional allowance for an AC peak of +5%). Refer to Appendix A, *Specifications*, for complete power requirement specifications.

Caution The 24 V external lighting strobe is an unregulated output dependent on the range of the power supply provided to the smart camera. If the power provided to the smart camera is +20%/-15% with +5% AC ripple, the external lighting strobe output could be as high as 30 V. If the provided power exceeds the input voltage specifications of the third-party lighting controller, do *not* connect the 24 V lighting strobe output to the controller to prevent damage to the controller. Use a power supply with tolerances that meet the requirements of the controller, or use the 5 V external lighting strobe.

If you are using the Direct Drive lighting controller, the power supply wattage must be sufficient to power both the camera and the light. The power required by the light can be significantly more than the power required by the smart camera.

Note The NI Smart Camera will revert to the default timestamp if power is interrupted and the device is not connected to a network. Ensure your power supply is not interrupted, or the device is connected to a networked or local SMTP server, to maintain accurate timestamps.

Isolated Inputs

Caution Do *not* apply a voltage greater than 30 VDC to the isolated inputs. Voltages greater than 30 VDC may damage the NI Smart Camera.

Caution The isolated inputs and outputs on the smart camera provide an easy means for preventing ground loops that could degrade signal integrity. The isolation on the smart camera is *not* safety isolation.

You can wire an isolated input to both sourcing and sinking output devices. Refer to Figures 2-1 and 2-2 for wiring examples by output type. Refer to Appendix A, *Specifications*, for current requirements.

Isolated inputs are not compatible with 5 V logic.

Figure 2-1. Connecting External Sourcing Output Sensors to Isolated Inputs

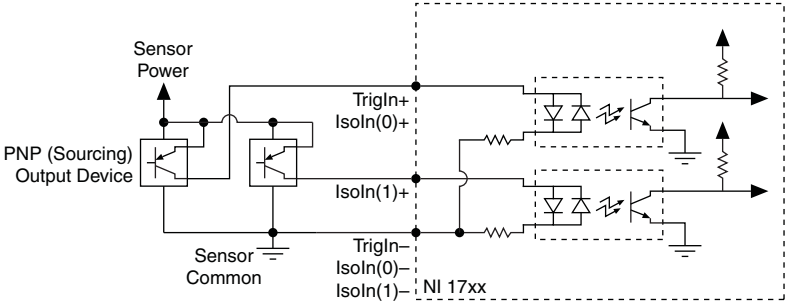
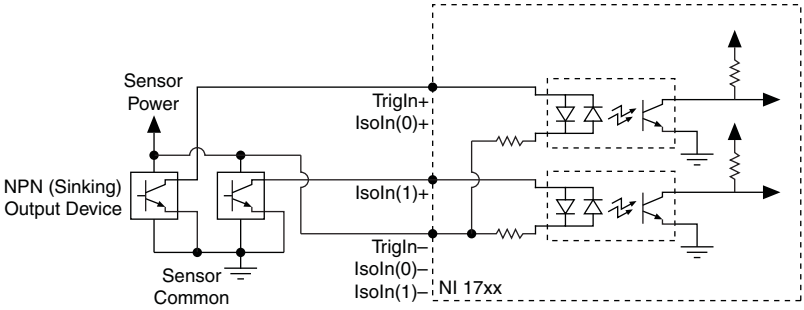


Figure 2-2. Connecting External Sinking Output Sensors to Isolated Inputs



Isolated Outputs

Caution Do *not* power the load connected to the isolated outputs with any external power supply greater than 30 VDC. Voltages greater than 30 VDC may damage the NI Smart Camera.

Caution The isolated inputs and outputs on the smart camera provide an easy means for preventing ground loops that could degrade signal integrity. The isolation on the smart camera is *not* safety isolation.

The isolated outputs can be used to drive external loads, as shown in Figures 2-3 and 2-4.

Figure 2-3. Connecting an Isolated Output to a Sourcing External Load

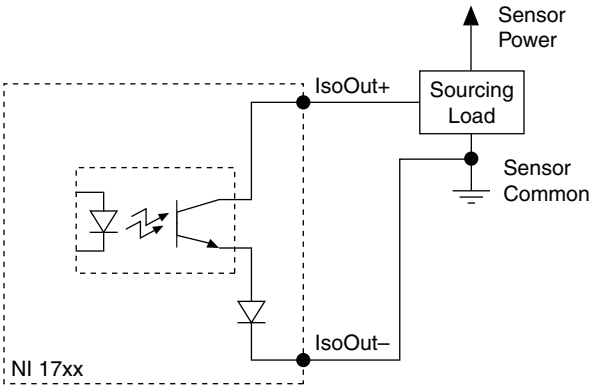
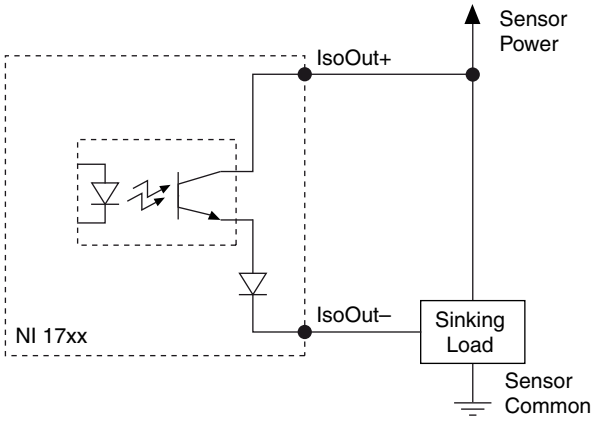


Figure 2-4. Connecting an Isolated Output to a Sinking External Load



Protecting Against Inductive Loads

When an inductive load, such as a relay or solenoid, is connected to an output, a large counter-electromotive force may occur at switching time due to energy stored in the inductive load. This flyback voltage can damage the outputs and the power supply.

To limit flyback voltages at the inductive load, install a flyback diode across the load. Mount the flyback diode as close to the load as possible. Use this protection method if you connect any of the isolated outputs to an inductive load.

Connecting to Serial Devices

Use the RS232_RXD and RS232_TXD signals on the POWER-I/O connector for serial communication. Connect the RS232_RXD signal on the NI Smart Camera to the Tx signal on your serial device. Connect the RS232_TXD signal on the smart camera to the Rx signal on your serial device. Connect COM on the smart camera to the ground of your serial device.

When the CONSOLE DIP switch is in the OFF position, you can use the NI-Serial driver for serial communication. You must install the NI-Serial software on the smart camera; it is not installed by default. Refer to the *Serial Hardware and Software Help* for information about installing the NI-Serial software on LabVIEW Real-Time targets, such as the smart camera. To open this document, navigate to **Start»All Programs» National Instruments»NI-Serial» NI-Serial Help**.

Communicating with the Console

When the CONSOLE DIP switch is in the ON position, you can read device information from the NI Smart Camera during startup, such as the IP address and firmware version, through a serial port terminal program. Ensure that the serial port terminal program is configured to the following settings:

- 9,600 bits per second
- Eight data bits
- No parity
- One stop bit
- No flow control

Connecting to a Quadrature Encoder

This section applies only to the following NI Smart Cameras:

- NI 1742
- NI 1744
- NI 1762
- NI 1764

Connect RS-422 compatible differential quadrature encoders to the NI 17xx Smart Camera to provide positional information. A quadrature encoder uses two output channels, Phase A and Phase B, to track the position of a rotary shaft. Generally, the shaft is coupled to a motor drive that controls the movement of an object. By providing Phase A and Phase B signals to the smart camera, you can obtain a precise measurement of the object position. Using a quadrature encoder gives you the ability to specify your trigger delay in terms of positional units—such as inches or centimeters, after applying the resolution information of your encoder—rather than time.

National Instruments does *not* recommend the use of single-ended encoders with the smart camera. This configuration would require the ground for a single-ended encoder to be connected to the COM pin of the smart camera, and the PhaseA- and PhaseB- signals would be left unconnected. In this configuration, the system is susceptible to significant noise that would be eliminated by using a differential encoder.

Shielded encoder cables are recommended for all applications. Unshielded cables are more susceptible to noise and can corrupt the encoder signals.

Refer to the *External Trigger* section of Chapter 5, *Image Acquisition*, for information about using a quadrature encoder to delay a trigger.

Figure 2-5 shows an example of connecting the quadrature encoder differential line drivers.

Figure 2-5. Connecting Differential Line Drivers

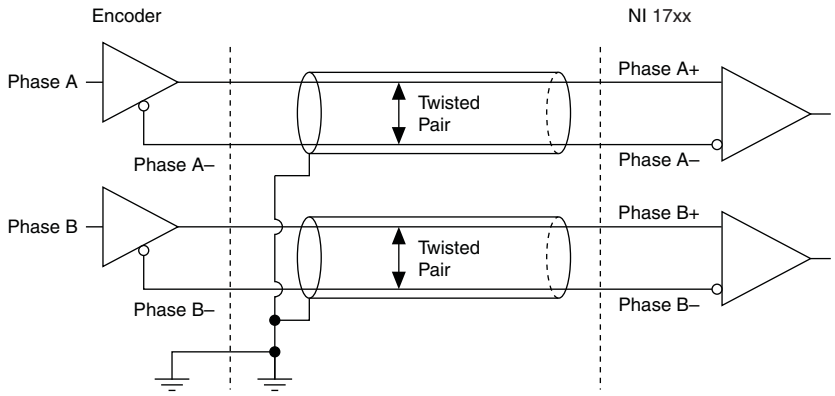
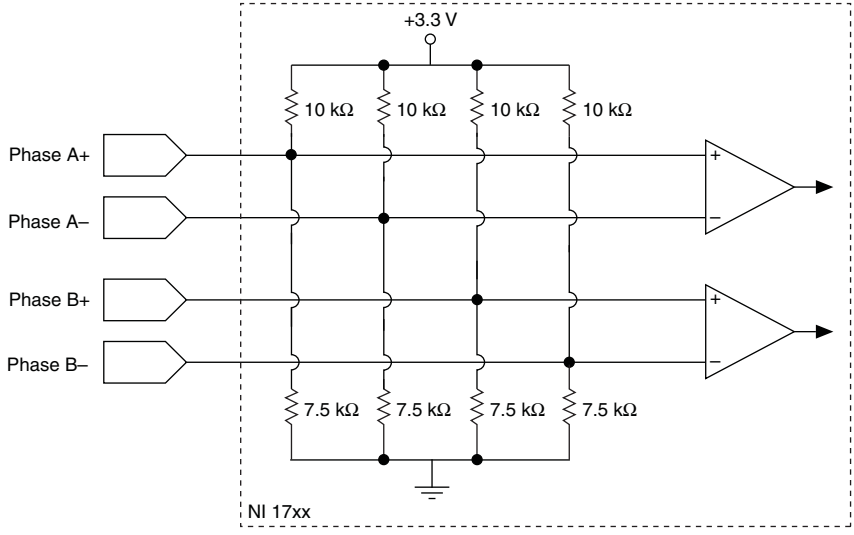


Figure 2-6 shows the internal quadrature encoder/RS-422 input circuit.

Figure 2-6. NI Smart Camera Quadrature Encoder Input Circuit



3

NI Smart Camera Image Sensor

This chapter provides an overview of the NI Smart Camera image sensors, field of view, spectral response, partial scan mode, binning, gain, and hardware binarization. NI 1722/1742/1762 Smart Cameras use a VGA sensor. NI 1744/1764 Smart Cameras use an SXGA sensor. Refer to Appendix A, *Specifications*, for information about your smart camera image sensor.

Field of View

The field of view is the area under inspection that will be imaged by the NI Smart Camera. It is critical to ensure that the field of view of your system includes the object you want to inspect.

To calculate the horizontal and vertical field of view (FOV) of your imaging system, use Equation 3-1 and the specifications for the image sensor of your smart camera, as listed in Appendix A, *Specifications*.

$$FOV = \frac{Pixel\ Pitch \times Active\ Pixels \times Working\ Distance}{Focal\ Length} \quad (3\text{-}1)$$

where *FOV* is the field of view in either the horizontal or vertical direction,

Pixel Pitch measures the distance between the centers of adjacent pixels in either the horizontal or vertical direction,

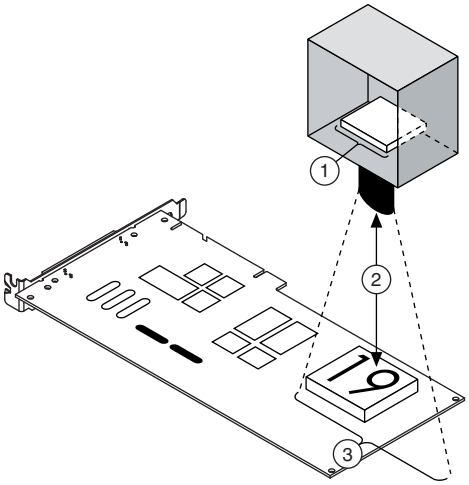
Active Pixels is the number of pixels in either the horizontal or vertical direction,

Working Distance is the distance from the front element (external glass) of the lens to the object under inspection, and

Focal Length measures how strongly a lens converges (focuses) or diverges (diffuses) light.

Figure 3-1 illustrates horizontal field of view and working distance.

Figure 3-1. Parameters of an Imaging System



1	Horizontal Imaging Width	2	Working Distance	3	Horizontal Field of View

For example, if the working distance of your imaging setup is 100 mm, and the focal length of the lens is 8 mm, then the field of view in the horizontal direction of a smart camera using the VGA sensor in full scan mode is

$$FOV_{horizontal} = \frac{0.0074\ \text{mm} \times 640 \times 100\ \text{mm}}{8\ \text{mm}} = 59.2\ \text{mm} \quad (3\text{-}2)$$

Similarly, the field of view in the vertical direction is

$$FOV_{vertical} = \frac{0.0074\ \text{mm} \times 480 \times 100\ \text{mm}}{8\ \text{mm}} = 44.4\ \text{mm} \quad (3\text{-}3)$$

Based on the result of Equations 3-2 and/or 3-3, you can see that you might need to adjust the various parameters in the FOV equation until you achieve the right combination of components that match your inspection needs. This might include increasing your working distance, choosing a lens with a shorter focal length, or changing to a high resolution camera.

Image Sensor Spectral Response

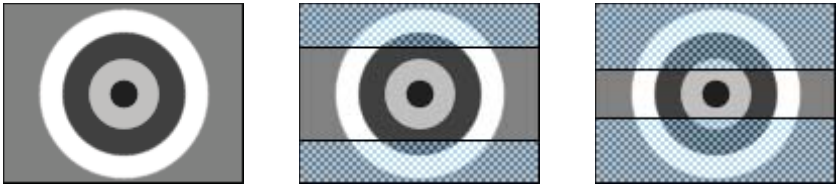
The spectral response curve describes the relative sensitivity of the sensor to different wavelengths of light. The peak responsiveness of the VGA and SXGA sensors is to light with a wavelength of approximately 500 nm. If you are imaging a dim scene, this information can be useful when selecting a light source to use in your application as the camera is most sensitive at its peak responsiveness. It also helps determine what, if any, filters your application might require to remove undesired wavelengths of light from the scene.

Refer to Appendix A, *Specifications*, to find the normalized spectral response curves for the VGA and SXGA sensors.

Partial Scan Mode

Partial scan mode is a method of obtaining higher frame rates by reading out only a portion of the image from the sensor. Partial scan is frequently used when an application requires higher speed but less resolution than the sensor offers in full scan mode. The NI Smart Camera supports 1/2 scan and 1/4 scan. In 1/2 scan, shown in Figure 3-2b, one half of the image is read out from the center of the sensor and the rest of the image is discarded to enable a faster start of the next frame. In 1/4 scan, only one quarter of the image is read out. Figure 3-2 illustrates the portion of the sensor exposed during partial scanning.

Figure 3-2. Partial Scan Modes



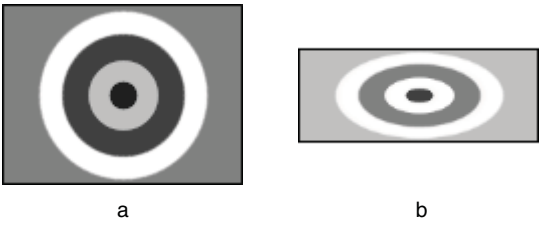
a b c

a Full Scan b 1/2 Scan c 1/4 Scan

Binning

Binning can improve the light sensitivity of the sensor by treating adjacent pixels as a single pixel. Binning allows the image sensor to collect more electrons per pixel, which reduces the amount of required light and exposure time. Binning results in higher frame rates and lower spatial resolution in the vertical direction. The NI Smart Camera supports 1 × 2 binning. Figure 3-3 illustrates what happens to the sensor output during binning.

Figure 3-3. Binning



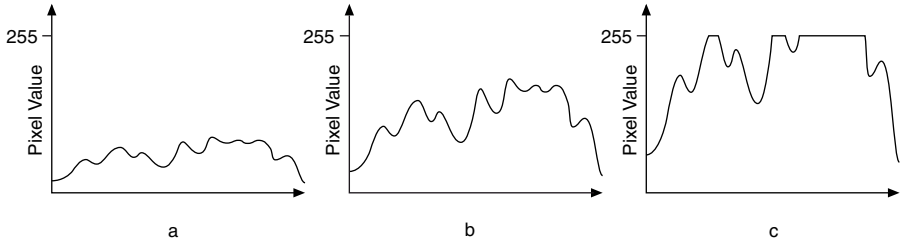
a No Binning b Binning

Gain

Gain is a multiplier applied to the analog signal prior to digitization. Increasing the gain increases the amplitude of the signal. Gain allows you to trade off between making smaller signals more visible at the cost of increased noise and no longer being able to differentiate between larger signals. For most applications, the NI Smart Camera default gain setting optimizes the balance between small signals and large signals.

Figure 3-4 shows what happens when gain is applied to a signal.

Figure 3-4. Effect of Gain on the Video Signal



a Low Gain b Medium Gain c High Gain

In Figure 3-4a, low gain has been applied to the signal. The pixel values in the image are grouped close together. In Figure 3-4b, medium gain has been applied to the signal; there are now more notable differences in pixel value within the image. In Figure 3-4c, high gain has been applied to the signal; at high gain, mid-range and bright portions of the image are now both represented

as white, the highest pixel value. In Figure 3-4c, several bright areas of the image have been clipped to the maximum pixel value, and you can no longer distinguish subtle shading in the brightest areas of the image.

Gain can be useful when there is not enough available light and you need to increase the brightness of your images. However, increasing gain multiplies both the signal and noise. When possible, it is preferable to add additional lighting.

Hardware Binarization

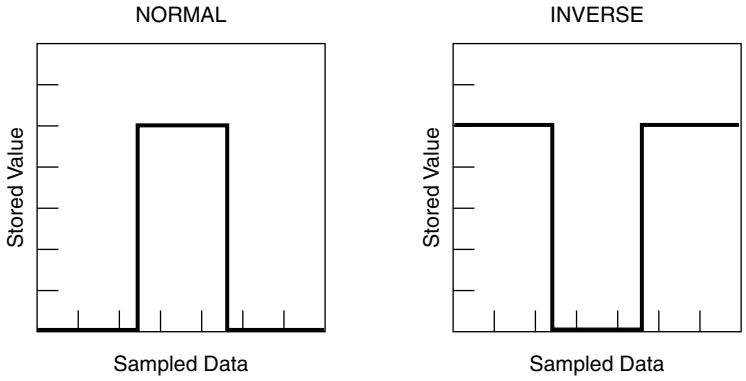
The NI Smart Camera supports binarization and inverse binarization of acquired images. Binarization and inverse binarization segment an image into two regions—a particle region and a background region. Use binarization and inverse binarization to isolate objects of interest in an image.

To separate objects under consideration from the background, select a pixel value range. This pixel value range is known as the gray-level interval, or the threshold interval. When enabled, binarization sets all image pixels that fall within the threshold interval to the image white value and sets all other image pixels to black. Pixels inside the threshold interval are considered part of the particle region. Pixels outside the threshold interval are considered part of the background region.

Inverse binarization reverses the assigned bit numbers of the particle region and the background region. All pixels that belong in the threshold interval, or the particle region, are set to black, and all pixels outside the threshold interval, or the background region, are set to the image white value.

Figure 3-5 illustrates binarization and inverse binarization.

Figure 3-5. Binarization and Inverse Binarization



You can enable hardware binarization in the following ways:

- In Vision Builder AI, configure the **Lookup Table** attribute on the **Advanced** tab of the **Acquire Image (Smart Camera)** step. Refer to the *NI Vision Builder for Automated Inspection: Configuration Help* for more information.
- In MAX, use the **Lookup Table** drop-down box on the **LUT** tab of the smart camera configuration page to enable hardware binarization. Refer to the *Measurement & Automation Explorer Help for NI-IMAQ* for more information.

4

Lighting

One of the most important aspects of setting up your imaging environment is proper illumination. Images acquired under proper lighting conditions make your image processing software development easier and overall processing time faster. The following sections describe how to use the Direct Drive lighting controller and the strobe outputs of the NI Smart Camera to control a light.

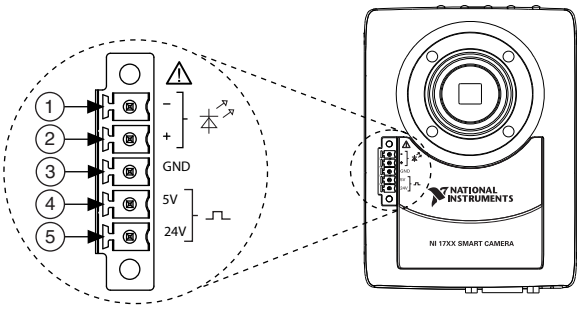
Lighting Connector

Figure 4-1 shows the lighting connector on the NI Smart Camera.

Caution All signals on the lighting connector are outputs from the smart camera. Do *not* connect any external voltage or current source to any pin on the lighting connector.

Note The NI 1722 does not offer the Direct Drive lighting controller. Do *not* connect to the LED+ and LED- connectors on the NI 1722.

Figure 4-1. NI Smart Camera Lighting Connector



1 LED- Output (Not Available on the NI 1722)
2 LED+ Output (Not Available on the NI 1722)
3 Ground Output
4 5 V TTL Strobe Output
5 24 V Strobe Output

Note Additional/replacement plugs for use with the lighting connector, part number 780260-01, are available from NI.

Direct Drive Lighting Controller

This section applies only to the following NI Smart Cameras:

- NI 1742
- NI 1744
- NI 1762
- NI 1764

The NI Smart Camera offers an innovative lighting controller that directly powers third-party current controlled lights. With other smart cameras, a lighting controller that drives a light must be purchased separately. The Direct Drive lighting controller is capable of powering a variety of third-party lights.

For a current controlled light, higher current produces more light, up to the maximum current rating of the light. The maximum current rating of the light is specified by the manufacturer and based on the average amount of power that can be safely dissipated by the light.

The Direct Drive controller can operate in continuous or strobed mode. When operating in strobed mode, the controller can provide more current to the light than in continuous mode. The average power dissipated while strobing the light for a short period of time at a higher current can be comparable to the average power dissipated while running the light continuously at a lower current. Table 4-1 shows the maximum allowed current for continuous mode and strobed mode.

Table 4-1. Maximum Allowed Current for Direct Drive Lighting Controller

Maximum Strobed Current	Maximum Continuous Current
1 A	500 mA

For applications with a pause between exposures while new parts move into position, you can strobe the light, which allows the use of higher current and produces more light; thus you can reduce the exposure time. A shorter exposure time decreases the time it takes to acquire an image and potentially increases the total throughput of the system. Refer to the *Exposure* section of Chapter 5, *Image Acquisition*, for more information about exposure control.

The smart camera automatically synchronizes the lighting strobe with the image sensor exposure. The smart camera always turns the light on before an exposure starts and turns the light off once the exposure completes. The duration of the light strobe is dictated by the exposure time. Refer to Chapter 5, *Image Acquisition*, for more information.

When operating in strobed mode, it is important that the strobe duty cycle and strobe duration are within the specified limits of both the light and the Direct Drive lighting controller. The strobe duration is the amount of time that the light remains on. The strobe duration limit is the maximum amount of time that the light can remain on when being driven at the maximum

current. The duty cycle is the ratio of the strobe duration to the frame period, expressed as a percentage. Refer to the *Maximum Frame Rate* section of Chapter 5, *Image Acquisition*, for more information about the frame period.

By default, you can set the exposure time to any setting within the range supported by your smart camera. However, if the smart camera is configured to use the Direct Drive lighting controller in strobed mode, care must be taken to ensure that the resulting strobe duty cycle and strobe duration do not violate the limits of the Direct Drive lighting controller or the limits of the light. For your convenience, the software calculates the resulting strobe duration and duty cycle for your configured frame rate and exposure time. It then compares them to the limits of the Direct Drive lighting controller and the limits specified in the associated lighting file. Refer to the *Lighting Files* section of this chapter or the *Maximum Frame Rate* section of Chapter 5, *Image Acquisition*, for more information.

If the requested exposure time violates the limits of the Direct Drive lighting controller or the limits for your light as specified in the associated lighting file, the smart camera can use the requested exposure time, but requires the configured current to be at or below the maximum *continuous* current.



Caution If you are using the 5 V strobe output or the 24 V strobe output, the software does not impose any limits on the duration or the duty cycle of the strobe output. You must ensure that your requested exposure time and the frame rate result in duration and duty cycle that do not violate the limits of the external controller and/or light(s). Refer to the *Maximum Frame Rate* section of Chapter 5, *Image Acquisition*, for more information.

Lighting Files

A lighting file is a text file that contains information about a light, such as the type and color of the light, maximum current limit, and maximum strobe duty cycle. Lighting files have the extension `.ild`. MAX and Vision Builder AI use lighting files to ensure that the current limits and duty cycle of your light are not exceeded when the light is used with the Direct Drive lighting controller. Lighting files exist in four levels of certification:

- **Digitally Signed by National Instruments**—The information contained within the lighting file has been verified as correct and safe by National Instruments. Contact National Instruments for support regarding this lighting data file or the light to which it refers.
- **Digitally Signed by a Third-Party Company**—The information contained within the lighting file has been verified as correct and safe by the specified third-party company. Contact the third-party company for support regarding this lighting data file or the light to which it refers.

- **Not Digitally Signed**—The information contained within the lighting file meets the requirements of Direct Drive lighting; however, it has not been verified that the information is safe to use with the specified light. Use this file at your own risk.
- **Invalid**—The information contained within the lighting file is unusable because the data does not meet the requirements of Direct Drive lighting, the data describing the light is not in the proper syntax, or the digital signature has been altered.

In digitally signed lighting files, the current limit and duty cycle limit are encoded as part of the signing process. The limits in signed lighting files are not human-readable. Modifying a signed lighting file will invalidate the signature and render the file unusable.

To use a light that has a lighting file, you can select the lighting data in MAX or Vision Builder AI:

- **In MAX**—Select the **Lighting** tab of the NI Smart Camera configuration page. Click **Configure Light**, and select **Select Light**.
- **In Vision Builder AI**—Select the **Lighting** tab of the **Acquire Image (Smart Camera)** step. Click **Configure Light Source**, and select **Select Light**.

To use a light that does not have a lighting file, you can enter the lighting data manually in MAX or Vision Builder AI:

- **In MAX**—Select the **Lighting** tab of the NI Smart Camera configuration page. Click **Configure Light**, and select **Enter Lighting Data Manually**.
- **In Vision Builder AI**—Select the **Lighting** tab of the **Acquire Image (Smart Camera)** step. Click **Configure Light Source**, and select **Enter Lighting Data Manually**.

Lighting files are installed to the following locations when you install NI-IMAQ. *X* represents the letter of the CD drive:

- **Windows Vista**—*X*:\Users\Public\Documents\National Instruments\NI-IMAQ\Data
- **Windows XP/2000**—*X*:\Documents and Settings\All Users\Documents\National Instruments\NI-IMAQ\Data

Selecting a Light

This section applies only to the following NI Smart Cameras:

- NI 1742
- NI 1744
- NI 1762
- NI 1764

National Instruments software provides support for a variety of lights from major machine vision lighting companies. However, if your light is not in the list of supported lights, you may still be able to use your light with the Direct Drive lighting controller.

To determine if your light is compatible with the NI Smart Camera, verify the following:

- The light is current controlled and not voltage controlled.
- The smart camera can provide enough current to obtain the desired illumination from the light.
- The maximum voltage drop specified for the light does not exceed the specified range of the smart camera. Under some circumstances, some LEDs, particularly certain lights with white and blue LEDs, require a higher voltage drop than usual to turn on or reach full brightness. Such lights may be incompatible with the smart camera. These lights may need to be reconfigured by the manufacturer to bring the voltage drop within the specified range of the smart camera.
- The minimum voltage drop specified for the light does not fall below the specified range of the smart camera. Under some circumstances some LEDs, particularly certain lights with infrared LEDs and lights with only one LED per string, present a lower voltage drop than usual and may be incompatible with the smart camera. These lights may need to be reconfigured by the manufacturer to bring the voltage drop within the specified range of the smart camera.



Note The voltage drop of a light can vary significantly with environmental conditions, such as ambient temperature, current supplied, and strobe time.

Refer to Appendix A, *Specifications*, for complete specifications for the Direct Drive lighting controller.

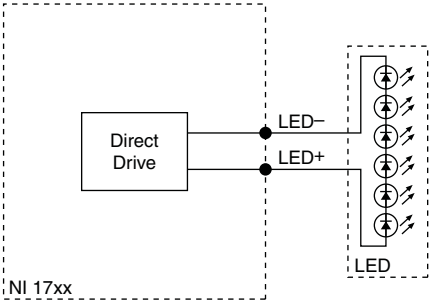
Connecting a Light to the Direct Drive Lighting Controller

This section applies only to the following NI Smart Cameras:

- NI 1742
- NI 1744
- NI 1762
- NI 1764

Figure 4-2 illustrates how to connect a light to the Direct Drive lighting controller. Do *not* use the GND signal when connecting a light to the Direct Drive lighting controller.

Figure 4-2. Connecting a Light to the Direct Drive Lighting Controller



The Direct Drive controller performs an initialization sequence to achieve the requested current output prior to acquiring the first image. You may notice a sequence of short flashes from the light when the application initializes or shuts down.

External Lighting Controllers

While the Direct Drive lighting controller is designed to handle common machine vision lighting requirements, some applications require the use of a light with current or voltage requirements beyond those supported by the Direct Drive. Other applications require more than one light. All NI Smart Cameras support connections to third-party lighting controllers to solve these applications.

The smart camera provides two types of external lighting outputs for synchronizing third-party controllers to the exposure of the smart camera: a 5 V TTL strobe output and a 24 V strobe output. The 5 V TTL strobe output is available for connecting to devices that require a 5 V signal. The 24 V strobe output is powered by the voltage from the smart camera power supply and is available for controllers that require higher voltage inputs. The 24 V strobe output is nominally a 24 V output if 24 V power is supplied to the smart camera.

Caution The 24 V external lighting strobe is an unregulated output dependent on the range of the power supply provided to the smart camera. If the power provided to the smart camera is +20%/-15% with +5% AC ripple, the output could be as high as 30 V. If the provided power exceeds the input voltage specifications of the third-party lighting controller, do *not* connect the 24 V lighting strobe output to the controller to prevent damage to the controller. Use a power supply with tolerances that meet the requirements of the controller, or use the 5 V external lighting strobe.

When enabled, the 5 V and 24 V external strobe outputs create a strobe pulse that can be used as a level-sensitive signal by third-party controllers to strobe the light simultaneously with the image exposure. Alternatively, if the third-party lighting controller supports a programmable

strobe time, the controller can be programmed for any arbitrary strobe duration, and the assertion edge of the smart camera output can start the strobe timer in the controller.

Caution If you are using the 5 V strobe output or the 24 V strobe output, the software does not impose any limits on the duration or the duty cycle of the strobe output. You must ensure that your requested exposure time and the frame rate result in duration and duty cycle that do not violate the limits of the external controller and/or light(s). Refer to the *Maximum Frame Rate* section of Chapter 5, *Image Acquisition*, for more information.

Enable the 5 V and 24 V lighting outputs as follows:

- In Vision Builder AI, enable the **5 V TTL Strobe** and/or **24 V Strobe** controls on the **Lighting** tab of the **Acquire Image (Smart Camera)** step. Refer to the *NI Vision Builder for Automated Inspection: Configuration Help* for more information about configuring the 5 V TTL and 24 V strobe outputs.
- In LabVIEW, configure the **24V Strobe** and **5V Strobe** lighting properties. Refer to the *NI-IMAQ VI Reference Help* for more information about configuring the 5 V TTL and 24 V strobe outputs.
- In MAX, select the **5 V TTL Strobe** and/or **24 V Strobe** checkboxes on the **Lighting** tab of the smart camera configuration page. Refer to the *Measurement & Automation Explorer Help for NI-IMAQ* for more information about configuring the 5 V TTL and 24 V strobe outputs.

Connecting an External Lighting Controller to the NI Smart Camera

Figure 4-3 illustrates how to connect an external lighting controller to the 5 V TTL output on the NI Smart Camera.

Figure 4-3. Connecting an External Lighting Controller to the 5 V TTL Strobe Output

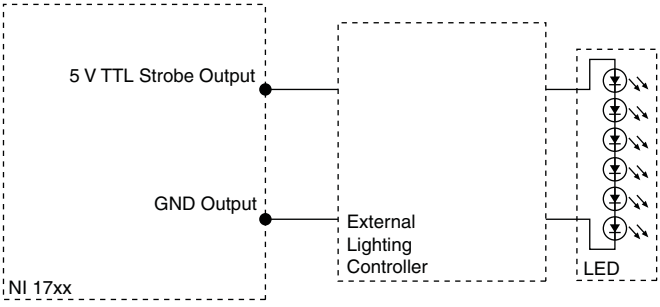
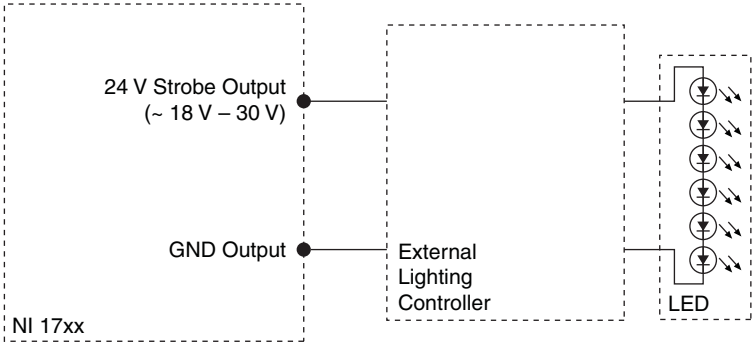


Figure 4-4 illustrates how to connect an external lighting controller to the 24 V output on the NI Smart Camera.

Figure 4-4. Connecting an External Lighting Controller to the 24 V Strobe Output



5

Image Acquisition

This chapter contains information about acquiring images with the NI Smart Camera and explains the relationships between triggering, lighting, and exposure.

Exposure

The NI Smart Camera provides control of the image sensor exposure time through software. The exposure time is the amount of time that light is allowed to strike the sensor to produce an image. When light strikes the surface of the sensor, it dislodges electrons. As more light strikes the sensor, more electrons are freed, creating a charge on the sensor.

For a given amount of light, the sensor collects more charge during a longer exposure time than a shorter exposure time. Because the charge is what is read out to produce the image, it is important to have an optimal amount of light and exposure time for your application.

Exposing the image sensor for too short of a time relative to the amount of light in the environment results in a dark, low contrast image. Exposing the image sensor for too long of a time relative to the amount of light in the environment results in a bright, low contrast image. When the image sensor is exposed for an appropriate amount of time relative to the light in the environment, acquired images will exhibit appropriate contrast to easily distinguish both dark and light features. Contrast is a key factor in obtaining good results from image processing algorithms.

In applications where the object under inspection is moving, the exposure time must be carefully considered. If the object moves significantly during the exposure, the resulting image is blurry and unsuitable for processing.

The maximum exposure time for imaging a moving object without blurring depends on the per pixel spatial resolution and the rate of motion of the object. The per pixel spatial resolution is the field of view, calculated in the *Field of View* section of Chapter 3, *NI Smart Camera Image Sensor*, divided by the number of pixels in the sensor. Together, this information can be used to calculate the maximum exposure. Assuming the object is moving horizontally across the field of view, use Equation 5-1 to calculate the maximum exposure time.

$$E_{max} = \frac{R_{Horizontal} \times 2}{(FOV_{Horizontal})/(N_{Horizontal})} \quad (5\text{-}1)$$

where E_{max} is the maximum exposure time without blurring,

R is the rate of motion of the object either horizontally or vertically,

FOV is the field of view in the direction of motion, and

N is the number of sensor pixels in the direction of motion

For many applications that include moving objects, additional lighting is necessary to achieve good image contrast due to the short exposure time required to avoid motion blur.

Additionally, in many environments, the ambient light conditions vary too significantly to obtain consistent results without adding dedicated lighting. For example, in a building with windows, the ambient light can vary significantly with weather. Also, standard fluorescent lighting flickers at a rate that is perceivable by the smart camera. In these situations, the ambient light must be overridden with a dedicated light source to ensure reproducible results.

Acquiring Images

You can configure the NI Smart Camera to acquire images based on internal timing or an external trigger signal. In both cases, the smart camera can acquire full frame images at the camera's maximum frame rate. If partial scanning or binning are enabled, the smart camera can acquire images faster than the full frame maximum frame rate. Refer to the *Maximum Frame Rate* section for information about factors that affect the maximum frame rate.

Internal Timing

The NI Smart Camera features two types of internally-timed modes: free-run mode and fixed-frame-rate mode.

In free-run mode, the smart camera acquires images at the maximum frame rate allowed by the configuration.

In fixed-frame-rate mode, you can specify a frame rate that is less than or equal to the maximum frame rate by setting the **Frame Rate** property in LabVIEW. Setting the **Frame Rate** property will implicitly take you out of free-run mode and into fixed-frame-rate mode. To return to free-run mode, set the **Fixed-Frame-Rate Mode** property in LabVIEW to FALSE.

Note Vision Builder AI and MAX do not support fixed-frame-rate mode.

External Trigger

Use the trigger input to synchronize the NI Smart Camera with an external event, such as the assertion of a signal generated by a proximity sensor. You can trigger the smart camera at rates up the maximum frame rate. Refer to the *Maximum Frame Rate* section for information about factors that affect the maximum frame rate.

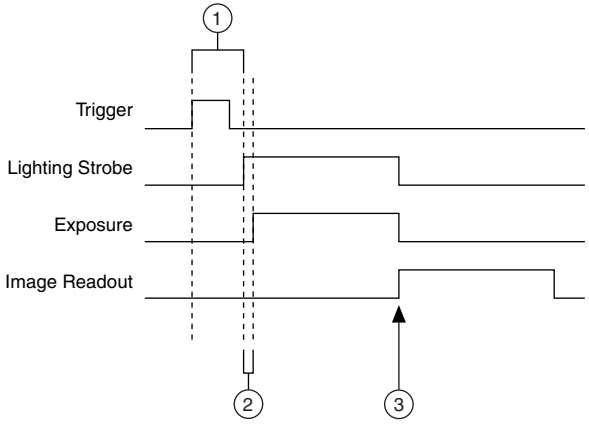
To use an external trigger, the trigger signal must be provided on the TrigIn/IsoIn(0)+ and TrigIn/IsoIn(0)- inputs to the camera and triggering must be enabled in the software. Refer to the *Isolated Inputs* section of Chapter 2, *Power and I/O*, for information about connecting external signals.

You can enable triggering in the following software programs:

- **Vision Builder AI**—Select the **Triggered Acquisition** checkbox on the **Trigger** tab of the **Acquire Image (Smart Camera)** step.
- **LabVIEW**—Use the IMAQ Configure Trigger 3 VI.
- **MAX**—Select the **Enable Trigger** checkbox on the **Triggering** tab of the smart camera configuration page.

Figure 5-1 illustrates the relationship between an external trigger, a lighting strobe, and the exposure time.

Figure 5-1. Externally Triggered Mode



1 User-Configurable Trigger Delay
2 Lighting Turn-On Time
3 Beginning of Image Readout

The trigger shown in Figure 5-1 represents an external trigger, configured to use the rising edge as the active edge. The time between the active edge of the trigger and the assertion of the lighting strobe is a user-configurable trigger delay. The trigger delay can be configured in either milliseconds or quadrature encoder counts. The NI 1722 does not support quadrature encoders.

The incoming trigger is synchronized to the line rate of the smart camera. This adds an additional delay that can vary on a frame by frame basis. The maximum variability is shown in Table 5-1.

Table 5-1. Trigger Synchronization Variability

Smart Camera Model	Trigger Synchronization Variability
NI 1722 NI 1742 NI 1762	31.2 µs
NI 1744 NI 1764	71.6 µs

The amount of time required from the assertion of a trigger to the start of the light strobe and image exposure varies by application. For example, if a sensor that detects the presence of a part is positioned before the smart camera on a conveyor belt, a trigger delay will be necessary so that the smart camera waits to expose the image until the part to be inspected passes in front of the smart camera. In this case, specifying the trigger delay in terms of quadrature encoder counts allows the smart camera to expose the image when the part is positioned in front of the smart camera regardless of changes in speed of the conveyor belt. For other applications, a delay specified in milliseconds is sufficient.

If you are strobing a light, there is a short delay while the lighting controller turns on the light. This delay is represented by the lighting turn-on time in Figure 5-1. Table 5-2 lists the lighting turn-on times.

Table 5-2. Lighting Turn-On Time

Smart Camera Model	Lighting Turn-On Time
NI 1722 NI 1742 NI 1762	156 µs
NI 1744 NI 1764	143.2 µs

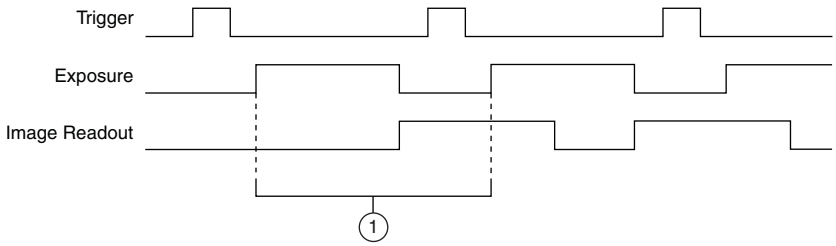
After the lighting turn-on time, the exposure begins. The width of the exposure pulse determines how long the sensor is exposed. The exposure time can be adjusted by setting the **Exposure Time** control in Vision Builder AI, setting the **Exposure Time** property in LabVIEW, or by setting the **Exposure Time** control in MAX. The lighting strobe deasserts at the end of the exposure pulse. The end of an exposure starts the image readout from the sensor.

The maximum trigger rate is determined by the maximum frame rate for your configuration. Refer to the *Maximum Frame Rate* section for information about the factors that affect the maximum frame rate.

Maximum Frame Rate

Frame rate is the inverse of the frame period. The frame period is the time from the start of exposure on one frame to the start of exposure on the next frame, as shown in Figure 5-2.

Figure 5-2. Frame Period



1 Frame Period

The frame period is affected by the following factors:

- Partial scan mode, as described in the *Partial Scan Mode* section of Chapter 3, *NI Smart Camera Image Sensor*
- Binning mode, as described in the *Binning* section of Chapter 3, *NI Smart Camera Image Sensor*
- Exposure time, as described in the *Exposure* section of this chapter
- Lighting mode, as described in Chapter 4, *Lighting*
- Trigger delay, as described in the *External Trigger* section of this chapter

Determining the Maximum Frame Rate

You can determine the maximum frame rate for your configuration in software by reading the **Max Frame Rate** indicator in Vision Builder AI, reading the **Max Frame Rate** property in LabVIEW, or reading the **Max Frame Rate** indicator in MAX. When external triggering is enabled, do not trigger faster than the maximum frame rate.

Note Sending a trigger faster than the maximum frame rate will result in a missed trigger.

Use Equation 5-2 to understand how software determines the maximum frame rate:

$$\textit{max frame rate} = \min(\ \textit{max frame rate for selected scan mode},\ \frac{1}{\textit{min frame period}}\ ) \qquad (5\text{-}2)$$

where *max frame rate for selected scan mode* is determined by the partial scan mode and binning mode, as described in the *Determining the Scan Mode* section, and

min frame period is the minimum amount of time for the strobe and trigger mode, as described in the *Calculating the Minimum Frame Period* section.

Determining the Scan Mode

The *maximum frame rate for selected scan mode* is determined by the partial scan mode and binning mode. Because the amount of data read out of the sensor is less in 1/2 or 1/4 scan mode, the readout takes less time, and you can achieve faster frame rates. The same is true of binning. When binning is enabled, the readout takes less time, and you can achieve faster frame rates. Refer to the *Partial Scan Mode* and *Binning* sections of Chapter 3, *Image Acquisition*, for more information about partial scanning and binning.

Use the maximum frame rate specifications for your smart camera in your scan mode in Appendix A, *Specifications*, to determine the *maximum frame rate for selected scan mode*.

Determining the Exposure Time

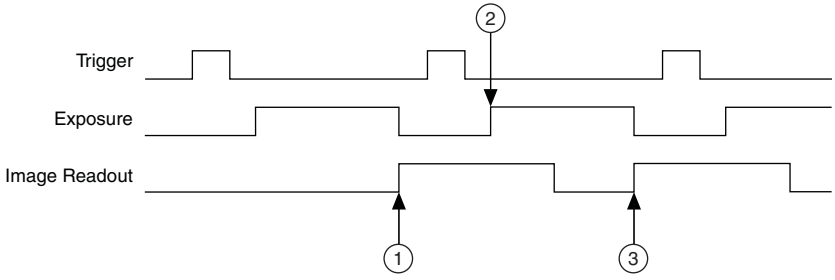
The minimum frame period depends on exposure time, lighting mode, and trigger delay.

A longer exposure time results in a longer frame period, and a slower maximum frame rate.

Determining the Lighting Mode

If you are not strobing a light using the Direct Drive or the external strobe outputs of the smart camera, the smart camera can expose one image while it is reading out the previous image, allowing for the highest possible frame rates. Figure 5-3 illustrates this relationship. The smart camera receives the trigger for the second image while it is still reading out the first image. The first image readout finishes before the second image readout begins.

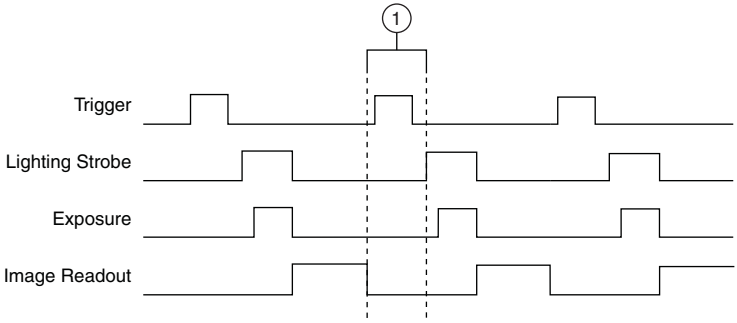
Figure 5-3. Image Acquisition Without Strobing



1 Beginning of First Image Readout
2 Beginning of Second Image Exposure
3 Beginning of Second Image Readout

When strobing is enabled, the smart camera waits until the image readout is complete before turning on the light for the next frame, as shown in Figure 5-4.

Figure 5-4. Image Acquisition With Strobing



1 Image Readout Completes Before Lighting Strobe Asserts for Next Image

Determining the Trigger Delay

If the trigger delay is set longer than the untriggered minimum frame period, the trigger delay value further limits the *min frame period*. When the trigger delay is specified in milliseconds, the software includes this in the calculation of the maximum frame rate indicator.

Calculating the Minimum Frame Period

Refer to Equations 5-3 and 5-4 to calculate the minimum frame period for untriggered acquisitions with and without strobing.

$$min\ frame\ period_{NoStrobeNoTrigger} = T + L + E \tag{5-3}$$

$$min\ frame\ period_{WithStrobeNoTrigger} = T + L + E + R \tag{5-4}$$

Refer to Equations 5-5 and 5-6 to calculate the minimum frame period for triggered acquisitions with and without strobing.

$$min\ frame\ period_{NoStrobeWithTrigger} = max\ (T + L + E, \text{Trigger Delay}) \tag{5-5}$$

$$min\ frame\ period_{WithStrobeWithTrigger} = max\ (T + L + E + R, \text{Trigger Delay}) \tag{5-6}$$

where T is the trigger synchronization variability,

L is the lighting turn-on time,

E is the exposure time, and

R is the image readout duration.

Tables 5-1 and 5-2 list the values for the trigger synchronization variability and the lighting turn-on time, respectively.

The image readout duration varies depending on the smart camera configuration, as shown in Table 5-3.

Table 5-3. Image Readout Duration

Smart Camera Model	Full Scan	1/2 Scan	1/4 Scan	Binning
NI 1722 NI 1742 NI 1762	16.38 ms	8.86 ms	5.49 ms	8.17 ms
NI 1744 NI 1764	76.47 ms	41.38 ms	24.70 ms	38.23 ms

6

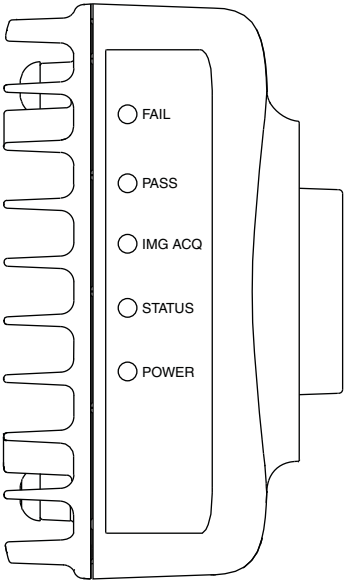
LEDs and DIP Switches

This chapter provides information about the location and functionality of the LED indicators and DIP switches on the NI Smart Camera.

Understanding the LED Indicators

Figure 6-1 shows the location of the LEDs on the NI Smart Camera.

Figure 6-1. NI Smart Camera LEDs



Device Initialization

While the NI Smart Camera initializes, the POWER LED lights solid green and the STATUS, IMG ACQ, PASS, and FAIL LEDs exhibit a scrolling pattern. When the smart camera finishes initializing, the STATUS LED lights solid green. If the system does not initialize within the expected period of time, the STATUS LED flashes a status code. Refer to the *STATUS LED* section for information about the status codes.

The initialization scrolling pattern will last longer than usual if the smart camera is configured to acquire an IP address from a DHCP server but no DHCP server is available on the network. When acquiring an IP address from a DHCP server, the smart camera waits up to 60 seconds to acquire an IP address. If the smart camera does not receive an IP address within 60 seconds, the device automatically restarts and tries again. The smart camera attempts to acquire an IP address from a DHCP server three times. If after the third time the smart camera has not been assigned an IP address, the smart camera reverts to the unconfigured state and the IP address resets to `0.0.0.0`. The STATUS LED flashes to indicate that the smart camera is in an unconfigured state.

POWER LED

The POWER LED indicates whether the power supplied to the camera is adequate. The POWER LED is green while the camera is properly powered on. When no power is being supplied to the NI Smart Camera, the POWER LED is unlit. When power is first applied to the smart camera, the POWER LED flashes red for one second while internal systems power up. If the POWER LED stays red for longer than one second, it indicates that the voltage is out of range.

STATUS LED

The STATUS LED is green during normal operation. The NI Smart Camera indicates specific conditions by flashing the STATUS LED, as shown in Table 6-1.

Table 6-1. STATUS LED Indications

LED Behavior	LED Color	Indication
Solid	Green	The smart camera initialized successfully and is ready for use.
1 Flash	Green	The smart camera IP address or software is unconfigured. The smart camera ships from the factory unconfigured. The smart camera also enters the unconfigured state if it is configured for DHCP and no DHCP server is available. Use MAX or Vision Builder AI to configure the smart camera. Refer to *Getting Started with the NI 17xx Smart Camera* for information about configuring the smart camera.
2 Flashes	Green	The smart camera detects an error in the software configuration. The camera has automatically started up into safe mode, regardless of the SAFE MODE DIP switch position. This usually occurs when an attempt to upgrade the software is interrupted or if system files are deleted from the smart camera. Reinstall software on the smart camera. Refer to *Getting Started with the NI 17xx Smart Camera* for information about installing software on the smart camera.

Table 6-1. STATUS LED Indications (Continued)

LED Behavior	LED Color	Indication
3 Flashes	Green	The smart camera is in safe mode because the SAFE MODE DIP switch is in the ON position. Refer to the *Configuring DIP Switches* section for information about the SAFE MODE DIP switch.
4 Flashes	Green	The smart camera has experienced two consecutive software exceptions. The smart camera automatically restarts after an exception. After the second exception, the smart camera remains in the exception state, alerting you to resolve the problem. Reinstall software on the smart camera or contact National Instruments for assistance. Refer to *Getting Started with the NI 17xx Smart Camera* for information about installing software on the smart camera.
5 Flashes	Green	The smart camera detects a critical error. Reinstall software on the smart camera or contact National Instruments for assistance. Refer to *Getting Started with the NI 17xx Smart Camera* for information about installing software on the smart camera.
Flashing	Red	The smart camera detects a software crash or hang. Contact National Instruments for assistance.
Solid	Red	The smart camera detects a critical firmware error. Contact National Instruments for assistance.

IMG ACQ LED

The IMG ACQ LED briefly lights green when an image is captured and ready for analysis. Fast frame rates can give this LED the appearance of being continuously lit.

If the IMG ACQ LED and the FAIL LED both flash red, it indicates that the NI Smart Camera has shut down because the maximum internal temperature was exceeded. Refer to the *Thermal Considerations* section of Chapter 8, *Thermal Considerations and Mounting*, for information about measuring the temperature of the smart camera. Refer to Appendix A, *Specifications*, for complete specifications.

PASS LED

The PASS LED is a green LED that is user-configurable through the IMAQ property node in LabVIEW or the **Read/Write I/O** step in Vision Builder AI.

FAIL LED

The FAIL LED is a red LED that is user-configurable through the IMAQ property node in LabVIEW or the **Read/Write I/O** step in Vision Builder AI.

If the IMG ACQ LED and the FAIL LED both flash red, it indicates that the NI Smart Camera has shut down because the maximum internal temperature was exceeded. Refer to the *Thermal Considerations* section of Chapter 8, *Thermal Considerations and Mounting*, for information about measuring the temperature of the smart camera. Refer to Appendix A, *Specifications*, for complete temperature specifications.

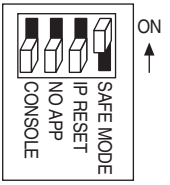
Configuring DIP Switches

This section describes the SAFE MODE, IP RESET, NO APP, and CONSOLE DIP switches on the NI Smart Camera. To turn on a DIP switch, lift the DIP switch cover and move the switch to the ON position.

Caution To avoid potential damage to your device, use care when configuring DIP switches. Do not use blunt tools or excessive force when changing the switch position.

SAFE MODE Switch

To start the NI Smart Camera in safe mode, move the SAFE MODE switch to the ON position and reapply power or restart the smart camera. If the switch is in the ON position when the smart camera starts, the smart camera launches only the essential services required for updating configuration information and installing software. The LabVIEW Real-Time engine does not launch. Use safe mode to reconfigure the smart camera TCP/IP settings, update firmware, and to install or update the software on the smart camera.

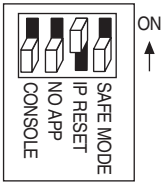


If the software on the smart camera is corrupted, start the smart camera in safe mode and update the software. To resume normal operations, move the SAFE MODE switch to the OFF position and reapply power or restart the smart camera. Refer to *Getting Started with the NI 17xx Smart Camera* for information about updating the software on the smart camera.

The STATUS LED flashes green three times when the smart camera is in safe mode. Keep the SAFE MODE switch in the OFF position during normal operation.

IP RESET Switch

To clear the NI Smart Camera IP settings, move the IP RESET switch to the ON position and reapply power or restart the smart camera. Use the IP RESET switch to reset the TCP/IP settings when moving the camera from one subnet to another or when the current TCP/IP settings are otherwise invalid.

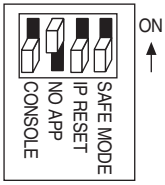


Starting the smart camera with the IP RESET switch in the ON position resets the IP address to `0.0.0.0`. Once you have reset the IP address, you can set up a new network configuration for the smart camera from a development machine on the same subnet, or you can use an Ethernet cable to connect the smart camera directly to the development computer. Refer to *Getting Started with the NI 17xx Smart Camera* for information about assigning an IP address to the smart camera.

To resume normal operations, move the IP RESET switch to the OFF position and reapply power or restart the smart camera. Keep the IP RESET switch in the OFF position during normal operation.

NO APP Switch

Move the NO APP switch to the ON position to prevent a startup application from running when the NI Smart Camera powers on. If you want to permanently disable the application from running when the smart camera powers on, you can disable the startup application in software.

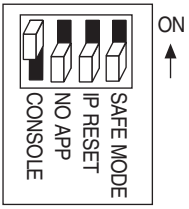


To automatically run an application when the smart camera powers on, keep the NO APP switch in the OFF position. You must configure the application in software to automatically run when the smart camera powers on. Refer to the *LabVIEW Real-Time Module Help* for more information about automatically launching VIs when the smart camera powers on. Refer to the *NI Vision Builder for Automated Inspection: Configuration Help* for more information about configuring remote target options.

Keep the NO APP switch in the OFF position during normal operation.

CONSOLE Switch

With a serial port terminal program, you can use the CONSOLE switch to read device information from the NI Smart Camera during startup, such as the IP address and firmware version. When the CONSOLE switch is in the ON position, the serial port outputs device information and is not available for applications. The smart camera reads this switch only when powering up or restarting and will only display device information during startup.



When the CONSOLE switch is in the OFF position, you can use the smart camera serial port and NI-Serial driver software to send and receive serial data. The NI-Serial software is installed when you install NI-IMAQ. When using the NI-Serial driver, keep the CONSOLE switch in the OFF position during normal operation.

Refer to the *Connecting to Serial Devices* section of Chapter 2, *Power and I/O*, for more information about using serial communication with the smart camera.

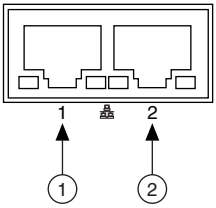
7

Ethernet Ports

This chapter provides information about the Ethernet ports and Ethernet LEDs on the NI Smart Camera and considerations for assigning an IP address.

The Ethernet ports on the smart camera provide a connection between the smart camera and the development computer or other network devices. The smart camera provides two 10/100/1,000 Mbps Ethernet ports. Figure 7-2 shows the Ethernet ports on the smart camera.

Figure 7-1. NI Smart Camera Ethernet Ports



1 Port 1 2 Port 2

Port 1 is the primary port and port 2 is the secondary port. The primary port can be configured to acquire an IP address from a DHCP server. The secondary port can only be configured for a static IP address.

Both Ethernet ports of the smart camera can connect to a 10, 100, or 1,000 Mbps (1 Gbps) Ethernet network at either full or half duplex. The smart camera automatically detects the speed and duplex capabilities of its link partner and configures for the fastest common interface. The smart camera can also perform auto-crossover, allowing the use of straight or crossover Ethernet cables, independent of the connection configuration.

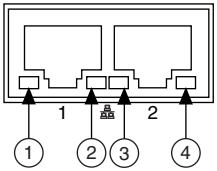
When shielded Ethernet cables are being used, ensure that the shields on the Ethernet cables and the POWER-I/O cable do not contact each other to maintain full Ethernet signal integrity.

Note A CAT 5e or CAT 6 1000Base-T Ethernet cable is required to achieve maximum 1,000 Mbps (Gigabit) Ethernet performance. CAT 5e and CAT 6 Ethernet cables adhere to higher electrical standards required for Gigabit Ethernet communication. CAT 5 cables are not guaranteed to meet necessary electrical requirements. While CAT 5 cables may appear to work in some installations at 1,000 Mbps, CAT 5 cables are likely to cause increased bit errors resulting in degraded or unreliable network performance.

Ethernet LEDs

Figure 7-2 shows the Ethernet LEDs on the NI Smart Camera.

Figure 7-2. NI Smart Camera Ethernet LEDs



1	Port 1 ACTIVITY/LINK LED	3	Port 2 ACTIVITY/LINK LED
2	Port 1 SPEED LED	4	Port 2 SPEED LED

ACTIVITY/LINK LED

The ACTIVITY/LINK LED indicates whether a link is established between the NI Smart Camera and the device connected at the other end of the Ethernet cable. The LED is unlit when no cable is connected or if the smart camera or the device connected at the other end of the cable are powered down. The LED is solid green when a link is established, but there is no traffic activity on the link. The LED will flash green when there is traffic activity on the link. If the smart camera is connected to a corporate network, traffic that is not related to the smart camera traffic will often be present on the link. In dedicated links between a computer and the smart camera, typically the only traffic on the link will be the communication between the computer and the smart camera.

SPEED LED

The SPEED LED indicates the speed of the negotiated link. The NI Smart Camera supports 10 Mbps, 100 Mbps, and 1,000 Mbps (1 Gbps) links, and will automatically select the highest speed shared by the smart camera and the device it is connected to. The SPEED LED follows the behavior specified in Table 7-1.

Table 7-1. SPEED LED Behavior

SPEED LED Behavior	Indication
Off	No link or a 10 Mbps link is negotiated
Solid Green	A 100 Mbps link is negotiated
Solid Amber	A 1,000 Mbps link is negotiated

DHCP and Static IP Address Assignment

You must configure the IP settings for the NI Smart Camera prior to use. You can assign a static IP address or, if your network has a DHCP server, you can use a DHCP server to assign an IP address. If you do not know whether you should assign a static IP address or use a DHCP server to assign an IP address, assign a static IP address or contact your network administrator.

DCHP IP address assignment is only available for port 1. Static IP address assignment is available on both ports.

For information about assigning an IP address to the smart camera, refer to *Getting Started with the NI 17xx Smart Camera*.

The advantage of using a DHCP server to assign an IP address is that the DHCP server manages the IP addresses of the network. You do not need to know the IP address of the smart camera. Also, the DHCP server does not allow other devices to use the IP address that is already assigned to your smart camera.

Although using a DHCP server makes configuring an IP address easy, configuring a static IP address can be more reliable. Consider the following potential issues before using a DHCP server to assign an IP address to the smart camera:

- If the network has both static IP addresses and IP addresses managed by a DHCP server, the DHCP server must be configured to not use reserved static IP addresses. If the DHCP server is not configured this way, the DHCP server can assign a reserved IP address to another device, causing address conflicts on the network, which results in some devices being unreachable.
- When a smart camera configured for DHCP starts, it must be able to connect to the DHCP server. If a smart camera was previously configured to use a DHCP server and the smart camera cannot connect to the DHCP server, the smart camera does not appear in MAX or Vision Builder AI. The IP address must to be reconfigured before you can use the smart camera.

Firewall Considerations

If you are having difficulty detecting the system and setting up the NI Smart Camera on your network, you must configure the firewall to open the TCP/UDP ports used by the smart camera and the host machine. The smart camera uses the ports listed in Table 7-2.

Table 7-2. TCP/UDP Ports Used by the NI Smart Camera

Port	Type	Details
3580	TCP/UDP	Reserved as nati-svrloc (NAT-ServiceLocator). Used by Measurement & Automation Explorer (MAX) to locate remote targets.
7749	TCP	Used for remote image display (not reserved).

Table 7-2. TCP/UDP Ports Used by the NI Smart Camera (Continued)

Port	Type	Details
7750	TCP	Used for NI-IMAQ remote configuration (not reserved).
3363	TCP/UDP	Reserved as nati-vi-server (NATI VI Server). Used by Vision Builder for Automated Inspection to configure a remote NI Smart Camera.

Subnet Considerations

To configure the NI Smart Camera, it must reside on the same subnet as the development computer. If you want to use the smart camera on a subnet other than the one the development computer is on, first connect and configure the smart camera on the same subnet as the host computer.

The first time you configure the smart camera, you must also install software on it. After configuring the smart camera, use DHCP to assign an IP address or reassign a static IP address for the subnet where you want the smart camera to reside, then physically move the smart camera to the other subnet. Refer to *Getting Started with the NI 17xx Smart Camera* for more information about configuring the smart camera.

Contact your network administrator if you need assistance configuring the host computer and smart camera on the same subnet.

8

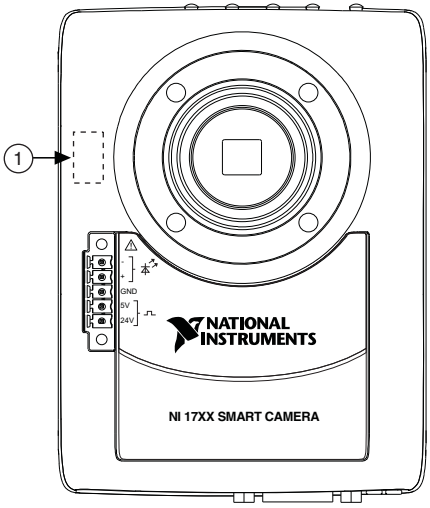
Thermal Considerations and Mounting

This chapter contains information about the operating temperature of the NI Smart Camera and provides the information necessary to create a custom mount for the smart camera.

Thermal Considerations

The NI Smart Camera can operate in environments with ambient temperatures ranging from 0 to 45 °C. The maximum housing temperature of the smart camera is 65 °C. Refer to Appendix A, *Specifications*, for complete specifications. Figure 8-1 shows the location to take temperature measurements on the smart camera.

Figure 8-1. Measuring the NI Smart Camera Housing Temperature



1 Region to Measure NI Smart Camera Housing Temperature

Operating the smart camera above the specified ambient temperature or above the specified case temperature will degrade image quality and can cause permanent damage to the device.

The smart camera also has a internal temperature sensor that provides an internal temperature measurement. You can monitor the temperature sensor from LabVIEW using the **Status Information»Temperature** property from the IMAQ property node.

If the internal temperature sensor reads 70 °C or more, the smart camera immediately halts operation and becomes unresponsive. The IMG ACQ LED and the FAIL LED flash red. You must remove and reapply power to the smart camera to recover from this condition.

To maximize the cooling efficiency of the smart camera, mount it to a thermally conductive structure, as specified in the *Mounting the NI Smart Camera* section.

Mounting the NI Smart Camera

Caution If you choose not to mount the NI Smart Camera to a thermally conductive structure, do not position the smart camera with the heat sinks resting on any surface. Doing so may violate the thermal requirements of the smart camera and cause the smart camera to overheat. Refer to Appendix A, *Specifications*, for temperature specifications.

Figures 8-2 through 8-5 provide the dimensional drawings necessary to create a custom mount for the smart camera.

Figure 8-2. Back View of the NI Smart Camera with Dimensions

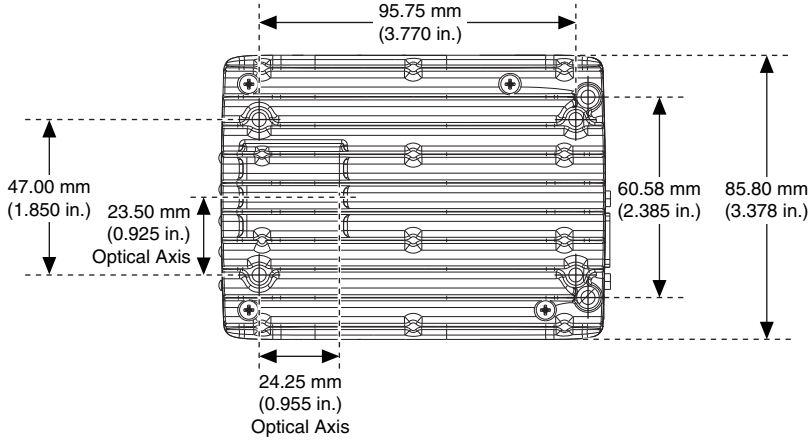


Figure 8-3. Front View of the NI Smart Camera with Dimensions

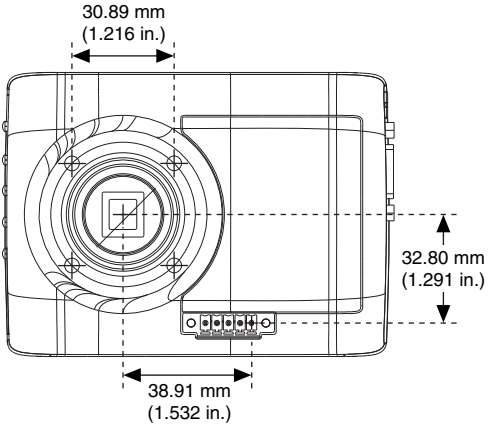


Figure 8-4. Side View of the NI Smart Camera with Dimensions

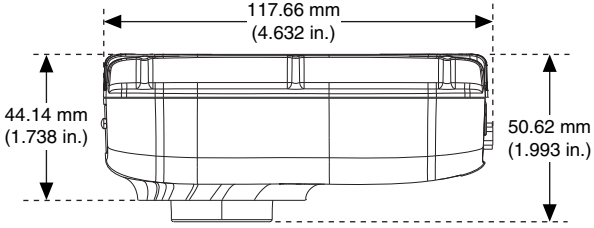
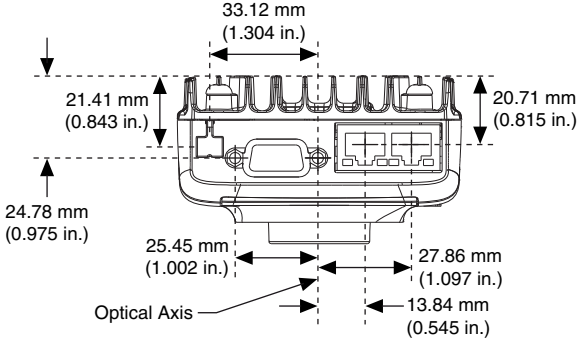


Figure 8-5. Bottom View of the NI Smart Camera with Dimensions



A

Specifications

The following specifications apply to the NI 1722/1742/1744/1762/1764 Smart Camera. These specifications are typical at 25 °C, unless otherwise stated.

Power Requirements

Power consumption

- NI 1722 ..... 24 VDC, +20%/-15% (IEC 1311); 450 mA
- NI 1742/1744/1762/1764
  - Direct Drive disabled ..... 24 VDC, +20%/-15% (IEC 1311); 450 mA
  - Direct Drive enabled ..... 24 VDC, +20%/-15% (IEC 1311); 800 mA

Reverse polarity protection ..... Yes

Memory

SDRAM ..... 128 MB

Nonvolatile program/data memory ..... 128 MB

Image/data storage ..... Unlimited using FTP or an Ethernet hard drive

Processor

NI 1722 ..... Freescale PowerQUICC II Pro 400 MHz

NI 1742/1744 ..... Freescale PowerQUICC II Pro 533 MHz

NI 1762/1764 ..... Freescale PowerQUICC II Pro 533 MHz and Texas Instruments DSP 720 MHz

VGA Sensor (NI 1722/1742/1762 Only)

Sensor ..... Sony CCD ICX424AL

Active pixels (VGA)

- Full scan ..... 640 × 480
- 1/2 scan ..... 640 × 240
- 1/4 scan ..... 640 × 120
- Binning (1 × 2) ..... 640 × 240

Pixel size ..... 7.4 µm × 7.4 µm

Pixel pitch for field of view calculation

- Full scan, 1/2 scan, 1/4 scan ..... 7.4 µm horizontal, 7.4 µm vertical
- Binning (1 × 2)..... 7.4 µm horizontal, 14.8 µm vertical

Maximum frame rate[1]

- Full scan ..... Up to 60 fps
- 1/2 scan ..... Up to 109 fps
- 1/4 scan ..... Up to 175 fps
- Binning (1 × 2)..... Up to 114 fps

Optical format ..... 1/3 in.

Sensor readout..... Progressive scan

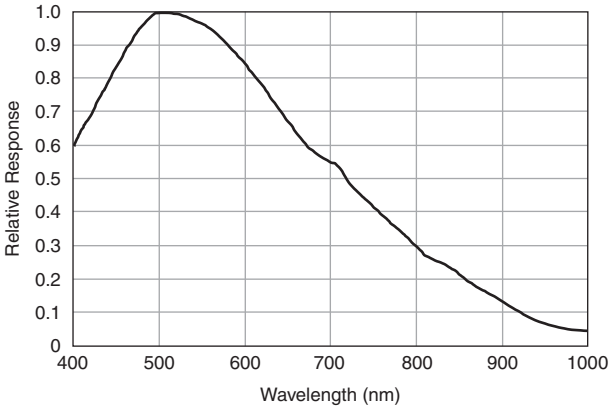
Bits per pixel ..... 8 bits; 256 gray levels

Minimum exposure time ..... 36.28 µs

Exposure time increment ..... 31.2 µs

Spectral characteristics ..... Refer to Figure A-1

Figure A-1. VGA Sensor Spectral Response Curve



Gamma..... 1.0 fixed

SXGA Sensor (NI 1744/1764 Only)

Sensor..... Sony CCD ICX205AL

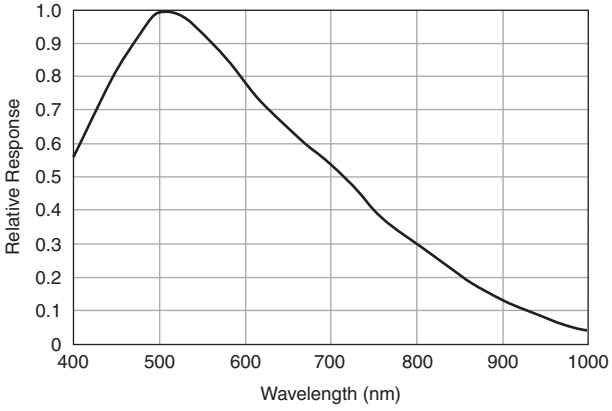
Active pixels (SXGA)

- Full scan..... 1,280 × 1,024
- 1/2 scan ..... 1,280 × 512

[1] Refer to the *Maximum Frame Rate* section of Chapter 5, *Image Acquisition*, for more information about calculating the maximum frame rate for your application.

1/4 scan ..... 1,280 × 256
Binning (1 × 2) ..... 1,280 × 512
Pixel size ..... 4.65 µm × 4.65 µm
Pixel pitch
Full scan, 1/2 scan, 1/4 scan ..... 4.65 µm horizontal, 4.65 µm vertical
Binning (1 × 2) ..... 4.65 µm horizontal, 9.3 µm vertical
Maximum frame rate[1]
Full scan ..... Up to 13 fps
1/2 scan ..... Up to 23 fps
1/4 scan ..... Up to 39 fps
Binning (1 × 2) ..... Up to 26 fps
Optical format ..... 1/2 in.
Sensor readout ..... Progressive scan
Bits per pixel ..... 8 bits; 256 gray levels
Minimum exposure time ..... 76.68 µs
Exposure time increment ..... 71.6 µs
Spectral characteristics ..... Refer to Figure A-2

Figure A-2. SXGA Sensor Spectral Response Curve



Gamma ..... 1.0 fixed

[1] Refer to the *Maximum Frame Rate* section of Chapter 5, *Image Acquisition*, for more information about calculating the maximum frame rate for your application.

Lighting

Direct Drive lighting controller (NI 1742/1744/1762/1764 Only)

- Maximum current ..... 500 mA continuous; 1 A strobed
- Minimum current ..... 50 mA
- Light requirements
  - Maximum voltage drop across LED+/LED- terminals ..... 30 V, with ±10% input power supply 25 V, with +20%/-15% input power supply
  - Minimum voltage drop across LED+/LED- terminals ..... 7 V
- Strobe frequency ..... Operating frame rate
- Maximum strobe duty cycle 45%

5 V external strobe

- Polarity ..... Programmable
- Strobe frequency ..... Operating frame rate
- V_{OH} minimum ..... 3.8 V
- V_{OL} maximum ..... 0.55 V
- I_{OH} maximum ..... -12 mA
- I_{OL} maximum ..... 12 mA

24 V external strobe

- Polarity ..... Active high
- Strobe frequency ..... Operating frame rate
- ON state
  - Voltage ..... Unregulated output drawn from the smart camera power supply
  - Current ..... 16 mA, maximum
- OFF state
  - Voltage ..... Not driven
  - Current ..... Not applicable

Network

- Network interface ..... Ethernet
- Ports 2
- Speed ..... 10; 100; 1,000 Mbps
- Duplex ..... Full, half
- Speed autodetection ..... Yes
- Duplex autodetection ..... Yes
- Auto MDI/MDI-X correction ..... Yes
- DHCP Support ..... Port 1 only

Serial

Baud rates ..... Up to 230.4 Kbps
- Default baud rate ..... 9,600 bps

Hardware flow control ..... No

Optically Isolated Inputs and Outputs

Isolated Inputs

Channels 2

Input type ..... Sinking/sourcing, both inputs must have the same configuration

Digital logic levels
- OFF state
  - Input current ..... 0 mA to 0.1 mA
  - Input voltage ..... 0 V to 1 V
- ON state
  - Input current ..... 3 mA to 5.4 mA
  - Input voltage ..... 20 V to 30 V

Minimum pulse width ..... 1 ms

Isolated Outputs

Channels 2

Output type ..... Sinking/sourcing, independently configurable

External load power supply range ..... 19 V to 30 V

Output current ..... 100 mA, maximum per channel

Quadrature Encoder (NI 1742/1744/1762/1764 Only)

Encoder type ..... Differential, RS-422; phase A/phase B, no index

Physical Characteristics

Lens mount ..... C-mount

Camera housing ..... Painted die-cast aluminium

Dimensions ..... 11.77 cm × 8.58 cm × 5.06 cm (4.63 in. × 3.38 in. × 1.99 in.)

Weight ..... 525 g (18.52 oz)

Environmental

The NI Smart Camera is intended for indoor use only.

Operating temperature

- Ambient temperature ..... 0 to 45 °C
- Maximum camera housing temperature ..... 65 °C

Storage temperature ..... -15 to 45 °C

Humidity ..... 10% to 90% RH, noncondensing

IP rating 40

Pollution degree 2

Operating shock (IEC 60068-2-27) ..... 50 g, 3 ms half sine, 18 shocks at 6 orientations; 30 g, 11 ms half sine, 18 shocks at 6 orientations

Operating vibration

- Random (IEC 60068-2-34) ..... 10 Hz to 500 Hz, 10 Grms, 100 min per axis
- Swept sine (IEC 60068-2-6) ..... 10 Hz to 500 Hz, 10 g

Approved at altitudes up to 2,000 m.

Safety

The NI Smart Camera meets the requirements of the following standards for safety and electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1

Note For UL and other safety certifications, refer to the product label or visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Electromagnetic Compatibility

The NI Smart Camera meets the following standards of EMC for electrical equipment for measurement, control, and laboratory use:

- EN 61326 EMC requirements; Minimum Immunity
- EN 55011 Emissions; Group 1, Class A
- CE, C-Tick, ICES, and FCC Part 15 Emissions; Class A

Note For full EMC compliance, operate this device with shielded cabling.

CE Compliance CE

The NI Smart Camera meets the essential requirements of applicable European Directives, as amended for CE marking, as follows:

- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EC; Electromagnetic Compatibility Directive (EMC)

Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at `ni.com/environment`. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of the product life cycle, all products *must* be sent to a WEEE recycling center. For more information about WEEE recycling centers, National Instruments WEEE initiatives, and compliance with WEEE Directive 2002/96/EC on Waste and Electronic Equipment, visit `ni.com/environment/weee`.

电子信息产品污染控制管理办法 （中国 RoHS）

中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令 (RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 `ni.com/environment/rohs_china`。 (For information about China RoHS compliance, go to `ni.com/environment/rohs_china`.)

B

Troubleshooting

This appendix provides instructions for troubleshooting the NI Smart Camera.

Configuration Problems

The NI Smart Camera Does Not Appear in MAX or Vision Builder AI

Possible causes and solutions:

- The smart camera may not be powered. Verify that there is power to the smart camera and that both the smart camera and the development computer are properly connected to the network. The POWER LED should be lit green and the ACTIVITY/LINK LED should flash green when refreshing the list of devices in MAX or Vision Builder AI.
- The smart camera may have been configured on another network subnet and then moved to the current network subnet. Reconfigure the smart camera on the current network. Refer to the *Subnet Considerations* section of Chapter 7, *Ethernet Ports*, for more information.
- Another device on the network is using the IP address assigned to the smart camera. This can happen when you assign the same static IP to two devices, you assign a static IP that is in the range of the IP address available for DHCP use on your network, or the DHCP server assigns the same IP address to another device. Either remove or reconfigure the other device, or reconfigure the smart camera to use a different IP address by moving the IP RESET DIP switch to the ON position and reapplying power or restarting the smart camera. Refer to the *IP RESET Switch* section of Chapter 6, *LEDs and DIP Switches*, for more information.
- You are experiencing firewall issues. If you are having difficulty detecting the system and setting up the NI Smart Camera on your network, you must configure the firewall to open the TCP/UDP ports used by the smart camera and the host machine. Refer to the *Firewall Considerations* section of Chapter 7, *Ethernet Ports*, for more information about TCP/UDP ports.
- The cable you are using may be inappropriate for the speed of your network, causing network communication dropout. While 1,000 Mbps communication over short cables lengths can be achieved with the CAT5 cable commonly used for 10 and 100 Mbps, CAT5e and CAT6 cables are more reliable and recommended for 1,000 Mbps links. The smart camera has the ability to perform auto-crossover, allowing the use of straight or crossover Ethernet cables, independent of the connection configuration.

The NI Smart Camera Restarts Unexpectedly

Possible causes and solutions:

- The smart camera is configured to acquire an IP address from a DHCP server, but no DHCP server is available on the network. When the smart camera is configured to acquire an IP address from a DHCP server, it waits for up to 60 seconds for the IP address to be acquired successfully. If the smart camera does not receive an IP address within 60 seconds, it restarts and attempts to acquire an IP address again. After three unsuccessful attempts to acquire an IP address from a DHCP server, the smart camera restarts and enters an unconfigured state. In the unconfigured state, the smart camera has an IP address of `0.0.0.0` and only limited software loads.

  In the unconfigured state, the smart camera has network connectivity. If the smart camera is on the same subnet as the host computer, then refreshing the list of remote devices in MAX or Vision Builder AI will cause the smart camera to appear with an IP address of `0.0.0.0`. Use MAX or Vision Builder AI to reconfigure the smart camera IP address, then restart the smart camera.

  Refer to *Getting Started with the NI 17xx Smart Camera* for more information about assigning an IP address to the smart camera.
- The smart camera has detected an error in the software configuration and automatically restarted into safe mode, independent of the state of the SAFE MODE DIP switch. This usually occurs when an attempt to upgrade the software is interrupted or if system files are deleted from the smart camera by the user. Reinstall software on the smart camera. Refer to *Getting Started with the NI 17xx Smart Camera* for information about installing software on the smart camera.
- The smart camera experienced two consecutive software exceptions. The smart camera automatically restarts after an exception. After the second exception, the smart camera remains in the exception state, alerting you to resolve the problem. To correct this issue, reinstall software on the smart camera. Refer to *Getting Started with the NI 17xx Smart Camera* for information about installing software on the smart camera or contact National Instruments for assistance.
- In the event that the Direct Drive lighting controller detects an abnormal load condition, such as a short circuit on the LED+ output, the smart camera stops image acquisition and returns an error. The Direct Drive stops providing current to the light, and the smart camera may restart. Ensure that your lighting wire connections are correct and/or reconfigure your lighting settings in MAX or Vision Builder AI.
- The voltage drop of the light may have exceeded the maximum voltage or minimum voltage requirements of the smart camera. The voltage drop of a light can vary significantly with environmental conditions, such as temperature, current, and strobe time. Verify that the voltage drop across the LED+ and LED- terminals is within the specified range of the smart camera. Your light may need to be reconfigured by the manufacturer to bring the voltage drop within the specified range of the smart camera. Refer to Appendix A, *Specifications*, for more information.

- The smart camera ran out of memory. The reason may be that acquired images are still in memory. When developing applications with LabVIEW, use the IMAQ Dispose VI to destroy an image and free the space it occupied in memory. This VI is required for each image created in an application to free the memory allocated to the IMAQ Create VI. Execute the IMAQ Dispose VI only when the image is no longer needed in your application. You can configure the IMAQ Dispose VI to free memory for each call to the IMAQ Create VI or just once for all images created using the IMAQ Create VI.

Run-Time Problems

The NI Smart Camera is Unresponsive and Blinks the IMG ACQ and FAIL LEDs

The smart camera maximum internal temperature was exceeded. Complete the following steps to verify that the ambient and enclosure temperatures are within specifications.

1. Measure the ambient temperature and verify that it is within specifications.

Note If the smart camera is mounted within an enclosure, the ambient temperature of the camera is the temperature inside the enclosure, which can be notably warmer than the ambient temperature outside the enclosure.

2. Measure the smart camera housing temperature at the location indicated in Figure 8-1, *Measuring the NI Smart Camera Housing Temperature*, and verify that it is within specifications.

You must remove power, bring the temperature within specifications, and reapply power to the smart camera to recover from this condition. Refer to the *Thermal Considerations* section of Chapter 8, *Thermal Considerations and Mounting*, for information about measuring the temperature of the smart camera. Refer to Appendix A, *Specifications*, for complete temperature specifications.

Lighting Problems

The Light Does Not Illuminate When Using the Direct Drive Controller

In the event that your light does not illuminate, verify the following:

- That your NI Smart Camera supports the Direct Drive lighting controller. Refer to the *Direct Drive Lighting Controller* section of Chapter 4, *Lighting*, for a list of smart cameras that support the Direct Drive lighting controller.
- The light is wired with the correct polarity, LED+ pin to the anode and LED- pin to cathode.

- You have properly configured the maximum light settings in MAX or Vision Builder AI. For safety reasons, the default configuration of the smart camera does not enable lighting until you configure the maximum lighting current settings that are appropriate for your light.
- You have enabled the Direct Drive lighting controller in MAX or Vision Builder AI.
- The smart camera is receiving a trigger if you have configured the smart camera for triggering in MAX or Vision Builder AI. This can be verified by checking that the IMG ACQ LED on the smart camera illuminates when a trigger is provided on the TrigIn+/IsoIn(0)+ and TrigIn-/IsoIn(0)- pins. If you are not receiving a trigger, refer to the *No Trigger is Received* troubleshooting section.
- There is a short circuit wiring condition. If the smart camera detects a short circuit wiring condition, it will disable the Direct Drive until the condition is cleared and the acquisition is reinitialized.

  In the event that the Direct Drive lighting controller detects an abnormal load condition, such as a short circuit on the LED+ output, the smart camera stops image acquisition and returns an error. The Direct Drive stops providing current to the light, and the smart camera may restart. Ensure that your lighting wire connections are correct and/or reconfigure your lighting settings in MAX or Vision Builder AI.
- You have requested an amount of current within the specified range of the smart camera and within the maximum lighting current settings you configured in MAX or Vision Builder AI. If your application requests more current than either of these two options, the smart camera disables the Direct Drive until an allowable current level is requested and the acquisition is reinitialized.
- If you are strobing, the on time required to illuminate for your requested exposure time plus the lighting turn-on time does not exceed the maximum allowed strobe duration. Refer to Chapter 5, *Image Acquisition*, for more information.
- If you are strobing, the duty cycle does not exceed the maximum allowed duty cycle at your requested frame rate. Refer to Chapter 5, *Image Acquisition*, for more information.
- The on voltage of the light is within the specifications of the Direct Drive lighting controller. Refer to Appendix A, *Specifications*, for more information.
- The voltage drop of the light may have exceeded the maximum voltage or minimum voltage requirements of the smart camera. The voltage drop of a light can vary significantly with environmental conditions, such as temperature, current, and strobe time. Verify that the voltage drop across the LED+ and LED- terminals is within the specified range of the smart camera. Your light may need to be reconfigured by the manufacturer to bring the voltage drop within the specified range of the smart camera. Refer to Appendix A, *Specifications*, for more information.

There is No External Lighting Strobe

Possible causes and solutions:

- If you have configured the NI Smart Camera for triggering in MAX or Vision Builder AI, verify that the smart camera is receiving a trigger. This can be verified by checking that the IMG ACQ LED on the smart camera illuminates when a trigger is provided on the TrigIn+/IsoIn(0)+ and TrigIn-/IsoIn(0)- pins. If you are not receiving a trigger, refer to the *No Trigger is Received* troubleshooting section.
- If you are using the 24 V strobe output, verify that there is enough time between frames for the strobe output to fully turn off before being re-enabled. The required time will vary with the load conditions, but is typically a few milliseconds. If a faster response is necessary, use the 5 V strobe output.
- Make sure that you have enabled the corresponding external lighting strobe in MAX or Vision Builder AI. Complete one of the following procedures to enable the correct lighting strobe.

MAX

1. Launch MAX.
2. In the Configuration tree, expand **Devices and Interfaces**.
3. Expand **NI-IMAQ Devices**.
4. Expand the smart camera you are using.
5. Select the channel you are using.
6. Select the **Lighting** tab.
7. Select the appropriate strobe from the **External Strobe Generation** control.

Vision Builder AI

1. Launch Vision Builder AI.
2. In the **Acquire Image (Smart Camera)** step, select the **Lighting** tab.
3. Select the appropriate strobe from the **External Strobe Generation** control.

Triggering Problems

No Trigger is Received

If you are not receiving a trigger, verify the following:

- The trigger is wired to the TrigIn+/IsoIn(0)+ and TrigIn-/IsoIn(0)- signals.
- If TrigIn/IsoIn(0) and IsoIn(1) are both being used, that the devices they are connected to are either both sinking (NPN) or both sourcing (PNP).
- The trigger is connected correctly based on the type of sensor it is—sourcing or sinking. Refer to the *Isolated Inputs* section of Chapter 2, *Power and I/O*, for information about connecting isolated inputs.

- The sensor power supply is of appropriate voltage for interfacing to NI Smart Camera isolated inputs. Refer to the *Isolated Inputs* section of Chapter 2, *Power and I/O*, for information about isolated inputs. Refer to Appendix A, *Specifications*, for complete specifications.
- You configured the device in MAX or Vision Builder AI to expect a trigger. Refer to the *External Trigger* section of Chapter 5, *Image Acquisition*, for information about configuring an external trigger.

LED Error Indications

STATUS LED Error Conditions

The NI Smart Camera indicates specific error conditions by flashing the STATUS LED a specific number of times. Refer to the *STATUS LED* section of Chapter 6, *LEDs and DIP Switches*, for the STATUS LED flashing sequences and the corresponding error condition.

POWER LED is Not Lit When the NI Smart Camera is Powered On

If the power supply is properly connected to the smart camera, but the POWER LED does not light up, check that the power supply is 24 V +20%/-15% and within the specifications outlined in Appendix A, *Specifications*. Verify that the power supply can supply enough current for the smart camera model in use. Using a power supply that is not within these specifications might result in an unresponsive or unstable system and could damage the smart camera.

Caution The 24 V external lighting strobe is an unregulated output dependent on the range of the power supply provided to the smart camera. If the power provided to the smart camera is +20%/-15% with +5% AC ripple, the output could be as high as 30 V. If the provided power exceeds the input voltage specifications of the third-party lighting controller, do *not* connect the 24 V lighting strobe output to the controller to prevent damage to the controller. Use a power supply with tolerances that meet the requirements of the controller, or use the 5 V external lighting strobe.

C

Maintenance

Do not touch the CCD sensor by hand or with other objects. The sensor can be damaged by electrostatic discharge (ESD), body oils, and particulate matter.

Use a lens mount cover whenever a lens is not mounted on the camera to protect the sensor from dust and dirt.

Avoid drastic temperature changes to prevent dew condensation.

When necessary, use the following procedure to clean the sensor at a workstation equipped with anti-ESD facilities. If dust sticks to the CCD, first attempt to blow it off from the side of the sensor using ionized air. If oils are present on the sensor, clean the sensor with a cotton bud and ethyl alcohol. Be careful not to scratch the glass. Use only one pass over the glass per cotton bud to minimize the risk of recontamination and scratching.

D

Technical Support and Professional Services

Log in to your National Instruments ni.com User Profile to get personalized access to your services. Visit the following sections of ni.com for technical support and professional services:

- **Support**—Technical support at ni.com/support includes the following resources:
  - **Self-Help Technical Resources**—For answers and solutions, visit ni.com/support for software drivers and updates, a searchable KnowledgeBase, product manuals, step-by-step troubleshooting wizards, thousands of example programs, tutorials, application notes, instrument drivers, and so on. Registered users also receive access to the NI Discussion Forums at ni.com/forums. NI Applications Engineers make sure every question submitted online receives an answer.
  - **Standard Service Program Membership**—This program entitles members to direct access to NI Applications Engineers via phone and email for one-to-one technical support, as well as exclusive access to self-paced online training modules at ni.com/self-paced-training. All customers automatically receive a one-year membership in the Standard Service Program (SSP) with the purchase of most software products and bundles including NI Developer Suite. NI also offers flexible extended contract options that guarantee your SSP benefits are available without interruption for as long as you need them. Visit ni.com/ssp for more information.

    For information about other technical support options in your area, visit ni.com/services, or contact your local office at ni.com/contact.
- **Training and Certification**—Visit ni.com/training for training and certification program information. You can also register for instructor-led, hands-on courses at locations around the world.
- **System Integration**—If you have time constraints, limited in-house technical resources, or other project challenges, National Instruments Alliance Partner members can help. To learn more, call your local NI office or visit ni.com/alliance.
- **Declaration of Conformity (DoC)**—A DoC is our claim of compliance with the Council of the European Communities using the manufacturer's declaration of conformity. This system affords the user protection for electromagnetic compatibility (EMC) and product safety. You can obtain the DoC for your product by visiting ni.com/certification.
- **Calibration Certificate**—If your product supports calibration, you can obtain the calibration certificate for your product at ni.com/calibration.

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

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}

B

binary image — An image in which the pixels have only one of two intensity values. Objects in the image usually have a pixel intensity of 1 (or 255), and the background has a pixel intensity of 0.

C

CCD — Charge Coupled Device. A chip that converts light into electronic signals.

D

DIP switch — Dual Inline Package switch.

Direct Drive lighting controller — A lighting controller integrated into some models of the National Instruments smart camera that can directly power current-controlled lights.

E

Ethernet cable, standard	CAT 5, CAT 5e, or CAT 6 Ethernet cable used to connect a Real-Time target to a network port or between the development computer and the Real-Time target.
exposure time	The amount of time that light is allowed to strike the imaging sensor to produce an image.

F

falling edge	The digital signal transition from the high state to the low state.
field of view	The area of inspection that the camera can acquire.
fps	Frames per second.

G

gain	The amount of increase in signal power, voltage, or current expressed as the ratio of output to input.

I

IEC	International Electrotechnical Commission. A standard-setting body.
IEEE	Institute of Electrical and Electronics Engineers. A standard-setting body.
I/O	Input/output. The transfer of data to/from a computer system involving communications channels, operator interface devices, or data acquisition and control interfaces.

L

LED	Light-emitting diode.

M

MAC	Media access control. The MAC address uniquely identifies each unit connected to a network.
MAX	Measurement & Automation Explorer. A controlled, centralized configuration environment that allows you to configure all of your NI devices.

N

NI-IMAQ	Driver software for National Instruments image acquisition devices and smart cameras.

P

PLC	Programmable Logic Controller. An industrial computer used for factory automation, process control, and manufacturing systems.
pulse train	A signal consisting of a series of continuous pulses.

Q

quadrature encoder	An encoding technique for a rotating device where two tracks of information are placed on the device, with the signals on the tracks offset by 90 degrees from each other. The phase difference indicates the position and direction of rotation.

R

rising edge	The digital signal transition from the low state to the high state.
RS-232	Standard electrical interface for serial data communications.

S

sensor resolution	The number of columns and rows of CCD pixels in the camera sensor.
sensor size	The size of the active area of an image sensor.

subnet	A set of systems whose IP addresses are configured such that they can communicate directly with one another. Data will not flow through an intermediate router.
SXGA sensor	Super eXtended Graphics Array sensor. Image sensor that features a resolution of 1,280 × 1,024 pixels.
syntax	Set of rules to which statements must conform in a particular programming language.

T

TCP	Transmission Control Protocol. A set of standard protocols for communicating across a single network or interconnected set of networks. TCP is for high-reliability transmissions.
trigger	Any event that causes or starts some form of data capture.

V

VDC	Volts direct current.
VGA sensor	Video Graphics Array sensor. Image sensor that features a resolution of 640 × 480 pixels.
VI	Virtual Instrument. A combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument.

W

working distance	The distance from the front of the camera lens to the object under inspection.

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