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USER MANUAL

ISC-178x

Monochrome/Color Smart Camera

This document contains detailed electrical and mechanical information for the National Instruments ISC-178x.
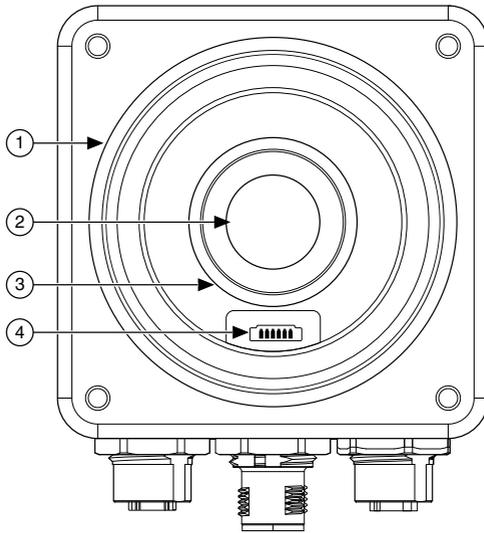
Contents

Hardware Overview

ISC-178x smart cameras incorporate a 1.58 GHz dual-core Intel Celeron processor, image sensor, and digital I/O in a compact, IP67-rated housing.

Figure 1. ISC-178x Front

1.	Lens cover mount	3.	C-mount lens mount
2.	Image sensor	4.	Varioptic liquid lens connector

Figure 2. ISC-178x Connectors
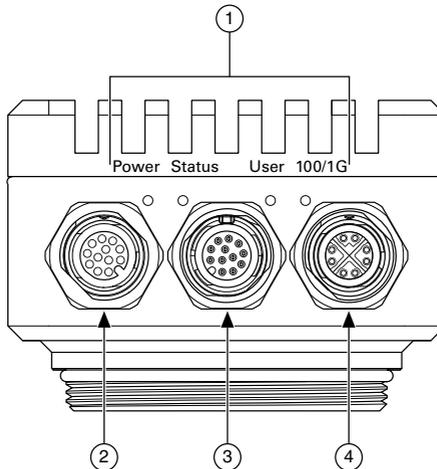
1.	LED indicators	3.	VGA and USB connector
2.	Digital I/O and Power connector	4.	Network connector

Connector Pinouts

The ISC-178x provides the following connectors.

Power and I/O Connector

The Power and I/O connector is a 12-pin female M12 connector that provides power to the camera and transmits digital I/O signals.

In addition, the connector has a specialized analog dimmer output intended to be used with Advanced Illumination lighting devices.

Related Information

ISC-178x Power and I/O Connector Pinout
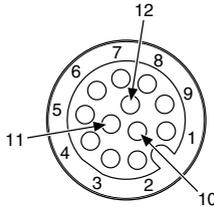
Table 1. ISC-178x Power and I/O Connector Signal Descriptions

Pin	Signal	Description
1	C OUT	Common reference (negative) for isolated outputs
2	Analog Out	Analog reference output for lighting controller
3	Iso Out 2+	General-purpose isolated output (positive)
4	V	System power voltage (24 VDC ± 10%)
5	Iso In 0	General-purpose isolated input
6	C IN	Common reference (positive or negative) for isolated inputs
7	Iso In 2	General-purpose isolated input
8	Iso In 3	**(NI Linux Real-Time)** Reserved for safe mode **(Windows)** General-purpose isolated input
9	Iso In 1	General-purpose isolated input

Table 1. ISC-178x Power and I/O Connector Signal Descriptions (Continued)

Pin	Signal	Description
10	Iso Out 0+	General-purpose isolated output (positive)
11	C	System power and analog reference common
12	Iso Out 1+	General-purpose isolated output (positive)

The following NI power and I/O cables are available for the ISC-178x.

Table 2. Power and I/O Cables

Cables	Length	Part Number
A-Code M12 to A-Code M12 Power and I/O Cable	3 m	145232-03
A-Code M12 to Pigtail Power and I/O Cable	3 m	145233-03

A-Code M12 to Pigtail Power and I/O Cable

The A-Code M12 to Pigtail Power and I/O Cable (NI part number 145233-03) provides power to the NI ISC-178x smart camera and transmits digital I/O signals.

Figure 3. A-Code M12 to Pigtail Power and I/O Cable Pinout
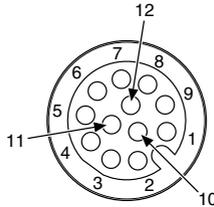
Table 3. A-Code M12 to Pigtail Power and I/O Cable Wire Designations

Pin	Signal	Color
1	C_{OUT}	Brown
2	Analog Out	Blue
3	Iso Out 2+	White
4	V	Green
5	Iso In 0	Pink

Pin	Signal	Color
6	C_{IN}	Yellow
7	Iso In 2	Black
8	Iso In 3	Gray
9	Iso In 1	Red
10	Iso Out 0+	Violet
11	C	Gray/pink
12	Iso Out 1+	Red/blue

VGA and USB Connector

The VGA and USB connector is a 12-pin male M12 connector that provides connectivity between the ISC-178x, a display device, and USB 2.0 devices like a keyboard or a mouse.

ISC-178x VGA and USB Connector Pinout
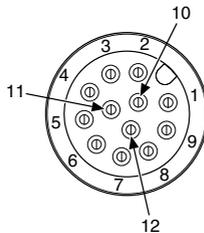
Table 4. ISC-178x USB and VGA Connector Signal Descriptions

Pin	Signal	Description
1	VBUS	USB power (+5 VDC)
2	D+	USB Data +
3	D-	USB Data -
4	GND	Ground for USB power
5	RED	Red analog video signal
6	BLUE	Blue analog video signal

Table 4. ISC-178x USB and VGA Connector Signal Descriptions (Continued)

Pin	Signal	Description
7	VSYNC	Vertical synchronization signal
8	HSYNC	Horizontal synchronization signal
9	GREEN	Green analog video signal
10	GND	VGA ground reference
11	GND	VGA ground reference
12	GND	VGA ground reference

The following NI USB and VGA cable is available for the ISC-178x.

Table 5. USB and VGA Cable

Cables	Length	Part Number
M12 to VGA/USB Splitter Cable	1 m	782022-01

Network Connector

The network connector is an 8-pin M12 X-coded connector that provides connectivity between the ISC-178x and a computer or network.

ISC-178x Network Connector Pinout

Table 6. ISC-178x Network Connector Signal Descriptions

Pin	Fast Ethernet (100 Mbps)	Gigabit Ethernet	
		MDI	MDI-X
1	TX+	BI_DA+	BI_DB+
2	TX-	BI_DA-	BI_DB-
3	RX+	BI_DB+	BI_DA+

Table 6. ISC-178x Network Connector Signal Descriptions (Continued)

Pin	Fast Ethernet (100 Mbps)	Gigabit Ethernet	
		MDI	MDI-X
4	RX-	BI_DB-	BI_DA-
5	No Connect	BI_DD+	BI_DC+
6	No Connect	BI_DD-	BI_DC-
7	No Connect	BI_DC-	BI_DD-
8	No Connect	BI_DC+	BI_DD+

The following NI network cables are available for the ISC-178x.

Table 7. Network Cables

Cables	Length	Part Number
X-Code M12 to RJ45 Network Cable	5 m	145230-05
X-Code M12 to X-Code M12 Network Cable	5 m	145231-05

Varioptic Liquid Lens Connector

The ISC-178x supports the following models of Varioptic liquid lenses.

- Caspian C-39N0-160-I2C
- Caspian C-39N0-250-I2C

Refer to the *ISC-178x Getting Started Guide* for installation instructions.

ISC-178x Varioptic Liquid Lens Connector Pinout

Table 8. ISC-178x Varioptic Liquid Lens Connector Signal Descriptions

Pin	Signal	Description
1	Power	Power supply (+5 V)
2	Ground	Ground
3	SDA	Serial data line

Table 8. ISC-178x Varioptic Liquid Lens Connector Signal Descriptions (Continued)

Pin	Signal	Description
4	SCL	Serial data clock
5	Unused	Unused
6	Unused	Unused

LED Indications

The ISC-178x indicates specific error conditions by flashing the Power, Status, and User LEDs.

Table 9. LED Indications

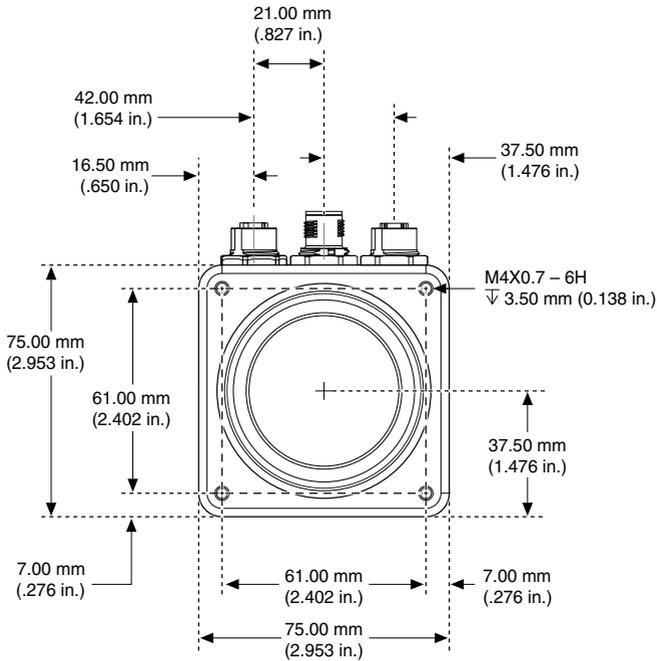| Power LED	Status LED	User LED	Indication
Off	Off	Off	The ISC-178x does not have power.
Red	Red	Red	The ISC-178x is powered, but is not responding.
Red	—	Orange	Initialization error.
Orange	—	Orange/Red blink	Temperature limit exceeded.
Orange	Orange/Red blink	Orange	System firmware initializing.
Orange	Orange/Red blink	Green	System firmware initialization completed.
Green	Orange/Red blink	Off	Sensor driver not loaded. Possible reasons: • Operating system loading • ISC-178x is booted in safe mode (NI Linux Real-Time only) • NI-IMAQdx Smart Camera Support is not installed
Green	Orange	User defined (default is Off)	The ISC-178x is ready to use. The sensor driver is idle.
Green	Green	User defined (default is Off)	The ISC-178x is ready to use. The sensor driver is in use.

Mounting the ISC-178x

The ISC-178x must be mounted to a support using the provided mounting holes before operating.

Note The acceptable bend radius for all connected cables is ten times (10x) the cable diameter.

The following figures provide dimensional drawings for the ISC-178x.

Figure 4. Front View with Dimensions

Figure 5. Back View with Dimensions

61.00 mm
(2.402 in.)

7.00 mm
(.276 in.)

M4X0.7 – 6H
▽ 4.00 mm (0.157 in.)

87.55 mm
(3.447 in.)

46.50 mm
(1.831 in.)

91.00 mm
(3.583 in.)

7.00 mm
(.276 in.)
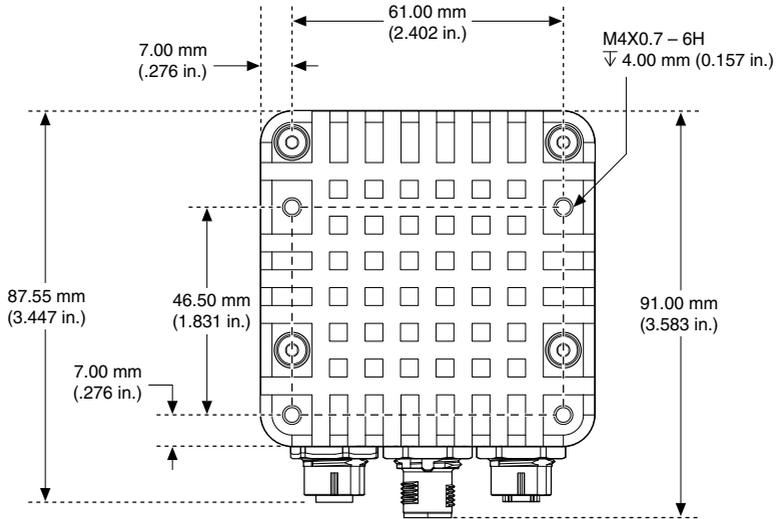
Figure 6. Side View with Dimensions

46.00 mm
(1.811 in.)

72.00 mm
(2.834 in.)
REF.
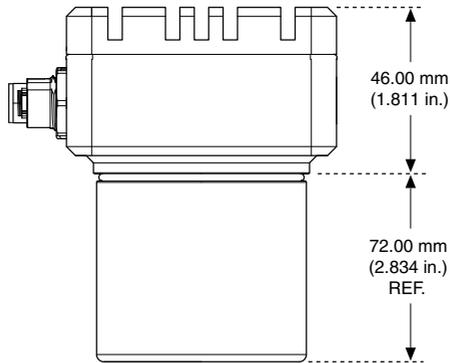
Figure 7. Side View with Dimensions

41.00 mm
(1.614 in.)

26.50 mm
(1.043 in.)

118.00 mm
(4.646 in.)
REF.
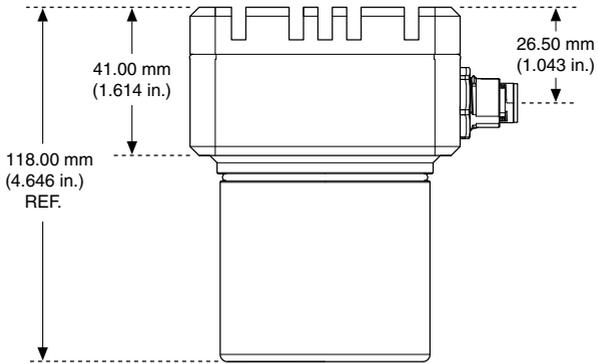
Figure 8. Bottom View with Dimensions

24.00 mm
(.945 in.)

2X 6.00 mm (.236 in.)

17.10 mm
(.673 in.)

Power Status   User 100/1G

54.00 mm
(2.126 in.)
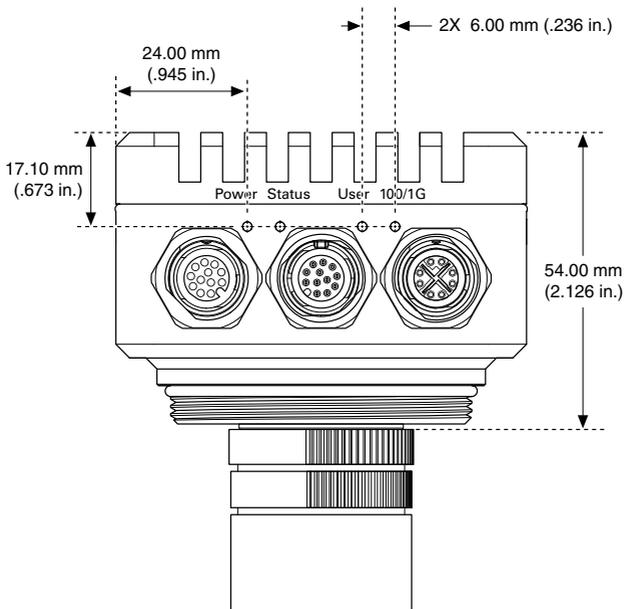
Connecting to Lighting Devices

The Power and I/O connector has a specialized analog dimmer output intended to be used with the Advanced Illumination Inline Control System 3 (ICS 3) or ICS 3S for continuous or strobed lighting operations.

Related Information

Triggering on page 20

External Trigger on page 21

Power and I/O Connector on page 3

Wiring a Lighting Device for Continuous Mode

The following figure shows how to wire the ISC-178x and an Advanced Illumination ICS 3 lighting controller without a trigger. Use this configuration to run a light in continuous mode.

Figure 9. Wiring a Lighting Controller Without a Trigger
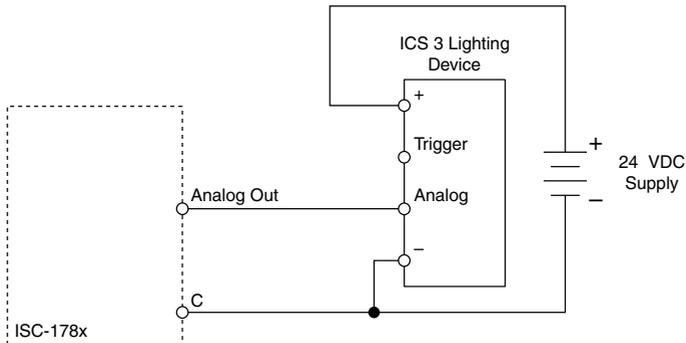
Wiring a Lighting Device for Strobe Mode

The following figure shows how to wire the ISC-178x and an Advanced Illumination ISC 3 lighting controller using an isolated output as a trigger. Use this configuration to run a light in strobe mode. This configuration requires that the isolated outputs and system power share the same ground.

Note A different pull-up resistor may be used, as long as the isolated output sink current specification is not exceeded and the resistor is appropriately rated for the expected power dissipation.
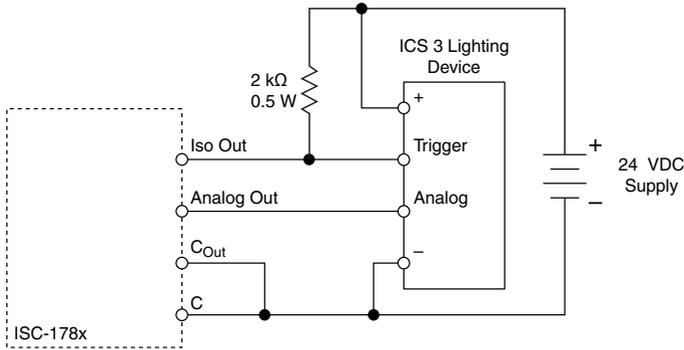
Related Information

Choosing a Pull-up Resistor on page 16

Wiring the Isolated Inputs

The isolated inputs can be configured as current sinking or current sourcing. The configuration depends on whether the common input signal is tied to ground (sinking input) or +V (sourcing input). The isolated inputs cannot be configured individually. The isolated inputs must all be sinking or must all be sourcing.

Related Information

Power and I/O Connector on page 3

Wiring an Isolated Input to a Sinking Output

The following figure shows how to wire the isolated inputs with a sourcing configuration to a sinking output. The isolated inputs on the ISC-178x have a built-in current-limiting circuit. The isolated inputs do not require a current-limiting resistor. Refer to the specifications of the connected output device to determine if a resistor is needed to limit the output current.

Figure 11. Wiring an Isolated Input to a Sinking Output

Wiring an Isolated Input to a Sourcing Output

The following figure shows how to wire the isolated inputs with a sinking configuration to a sourcing output.

Figure 12. Wiring an Isolated Input to a Sourcing Output
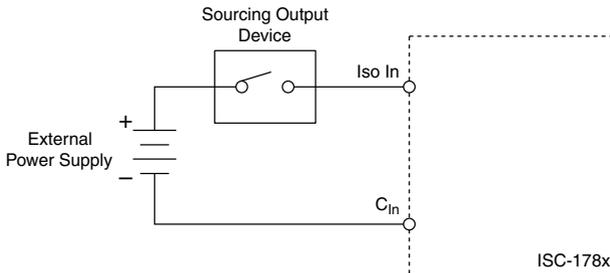
Wiring the Isolated Outputs

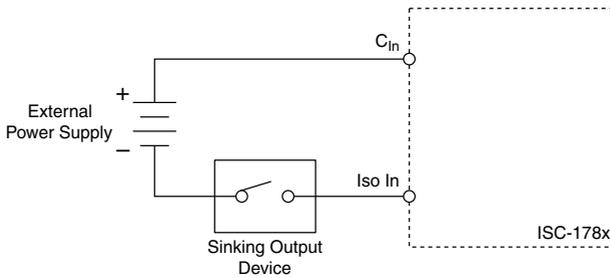The isolated outputs can be wired to a sourcing input or sinking input.

Related Information

Power and I/O Connector on page 3

Wiring an Isolated Output to a Sinking Input

The following figure shows how to wire an isolated output to a sinking input.

Figure 13. Wiring an Isolated Output to a Sinking Input
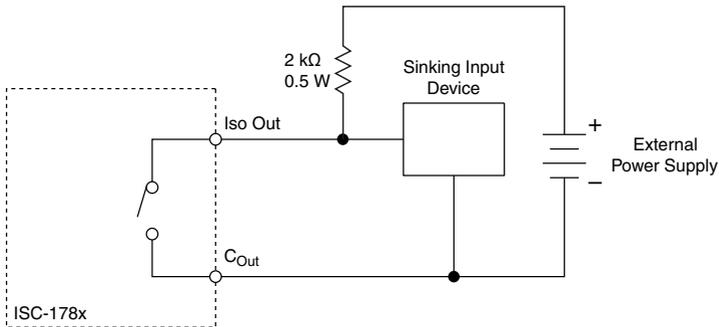
Note A different pull-up resistor may be used, as long as the isolated output sink current specification is not exceeded, the sinking input device specifications are met, and the resistor is appropriately rated for the expected power dissipation. Refer to the documentation for the sinking input device for additional requirements.

Related Information
Choosing a Pull-up Resistor on page 16

Wiring an Isolated Output to a Sourcing Input

The following figure shows how to wire an isolated output to a sourcing input.

Figure 14. Wiring an Isolated Output to a Sourcing Input
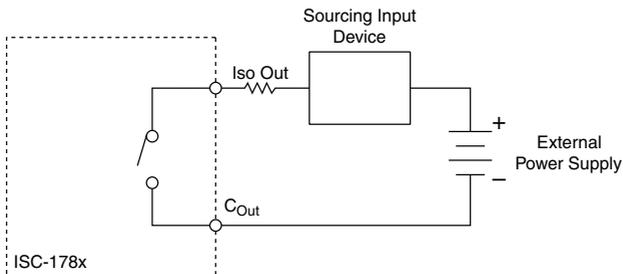
Note Choose a resistor value that does not exceed the output sink current specification of the isolated output. The value of the resistor depends on the current-limiting characteristics of the sourcing input device. A resistor may not be needed if the current is sufficiently limited by the input device.

Related Information
Choosing a Pull-up Resistor on page 16

Choosing a Pull-up Resistor

Choose a pull-up resistor that does not exceed the maximum current sink rating of the isolated outputs. The pull-up resistor must have a power rating that will not cause it to overheat.

For example, with a 24 V output, a 2 kΩ resistor will cause a current sink of 24 V / 2 kΩ = 12 mA. This leads to a power consumption in the resistor of 12 mA × 24 V = 0.288 W. In this example, a 0.5 W resistor would be recommended. Because 12 mA is less than the current sink rating, a 2 kΩ, 0.5 W resistor would be acceptable.

The resistor value also affects the rise time of the output. For example, a 1 kΩ resistor will rise more quickly than a 2 kΩ resistor, but the 1 kΩ resistor will consume more power and require a resistor with a higher power rating.

Related Information

Safe Mode (NI Linux Real-Time)

When you boot the ISC-178x into safe mode, it launches only the services necessary for updating its configuration and installing software. Connect the Iso In 3 and C_{IN} signals of the ISC-178x as shown in the following figure, then apply power to boot into safe mode.

Figure 15. Booting into Safe Mode
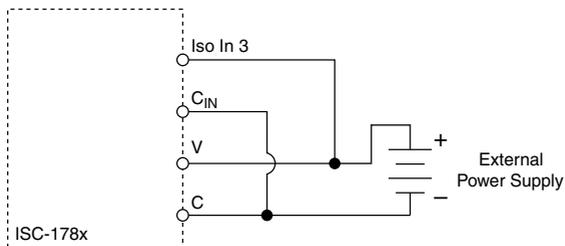
Image Sensor

This section provides an overview of the ISC-178x image sensors, field of view, and imaging settings.

All models of the ISC-178x use ON Semiconductor Python NOIP1SN or NOIP1SE sensors.

ISC-178x are available with the following resolution configurations.

Table 10. ISC-178x Resolution Configurations

Model	Resolution
ISC-1780	640 x 480
ISC-1781	1280 x 1024
ISC-1782	1920 x 1200
ISC-1783	2592 x 2048

Field of View

The field of view is the area under inspection that will be imaged by the ISC-178x. 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 the following equation. All models of the ISC-178x have square pixels that are 4.8 μm on each side. Use that value for the Pixel Pitch. The Active Pixels can be obtained from the image sensor configuration table or the specifications for each model.

$$FOV = \frac{Pixel\ Pitch \times Active\ Pixels \times Working\ Distance}{Focal\ Length}$$

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.

The following figure illustrates horizontal field of view and working distance.

Figure 16. Parameters of an Imaging System
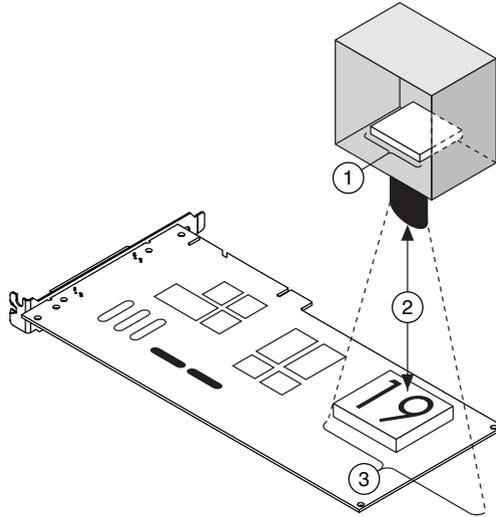
1. Horizontal Imaging Width
2. Working Distance
3. Horizontal Field of View

For example, if the working distance of the 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 an ISC-1780 is

$$FOV_{horizontal} = \frac{0.0048\,mm \times 640 \times 100mm}{8\,mm} = 38.4\,mm$$

The field of view in the vertical direction is

$$FOV_{horizontal} = \frac{0.0048\,mm \times 480 \times 100mm}{8\,mm} = 28.8\,mm$$

Based on the results of these two equations, you can adjust the various parameters until you achieve the right combination of components that match your inspection needs. This might include increasing the working distance, choosing a lens with a shorter focal length, or changing to a higher resolution camera.

Related Information

Exposure and Lighting on page 24
Image Readout on page 25

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 ISC-178x default gain setting optimizes the balance between small signals and large signals.

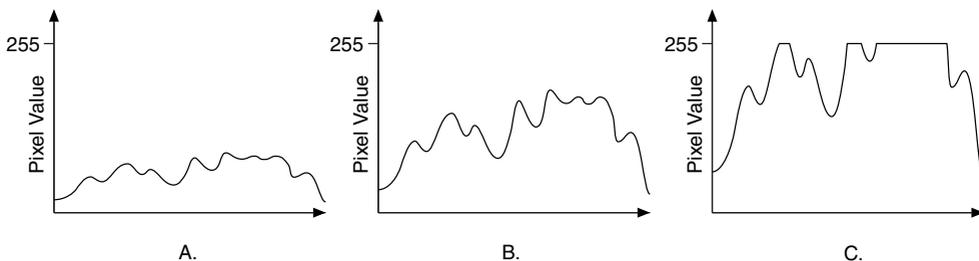**Figure 17.** Effect of Gain on the Video Signal

1. Low Gain
2. Medium Gain
3. High Gain

In figure A, low gain has been applied to the signal. The pixel values in the image are grouped close together. In figure B, medium gain has been applied to the signal. There are now more notable differences in pixel value within the image. In figure C, 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 C, 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 images. However, increasing gain multiplies both the signal and noise. When possible, it is preferable to add additional lighting.

Auto White Level (Color Models Only)

Color models of the ISC-178x allow you to adjust the gain for each color plane in the RGB color space. The white level specifies the point at which values in the red, green, and blue color planes converge to produce white. To obtain an accurate white level, either adjust each gain value manually or use automatic white level adjustment with a test image. For best results the image should contain a neutral reference, such as a gray piece of paper or a reference card.

There are multiple ways to adjust gain values or enable automatic white balance adjustment:
- MAX—Use the settings on the Color tab of the device configuration page to adjust gain levels or enable automatic white level adjustment.
- Vision Builder AI—Use the settings on the Color tab of the Acquire Image (Smart Camera) step to adjust gain levels or enable automatic white level adjustment.

Black Level

The black level specifies the image brightness. Set the black level to the pixel value which corresponds to true black. If the black level is inaccurate, near-black pixels may be displayed as black or black objects may appear gray in the output image.

There are multiple ways to adjust the black level:

- MAX—Use the settings on the Camera Attributes tab of the device configuration page.
- Vision Builder AI—Use the settings on the Advanced tab of the Acquire Image (Smart Camera) step.

Look-up Table

A look-up table (LUT) transformation maps pixel values in the source image into other values in the transformed image. For example, you can use a LUT transformation to improve the contrast and brightness of an image. Color models of the ISC-178x allow you to define a LUT for each color plane in the RGB color space.

To enable a LUT in MAX, use the LUT Controls on the Camera Attributes tab of the device configuration page. Vision Builder AI does not support LUT editing for the ISC-178x.

Image Sensor Maintenance

Do not touch the image 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 sensor, 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.

Acquiring Images

This section contains information about the main components of acquiring images with the ISC-178x—triggering, exposure and lighting, and image readout—and explains the relationships between them.

Triggering

You can configure the ISC-178x to acquire images based on internal timing or an external trigger signal. When using internal timing, the ISC-178x will trigger the acquisition using an on-board clock that runs at a constant rate. Once the acquisition is started, images will be acquired without any external stimulus. When using external triggering, the acquisition of each frame is tied to the occurrence of the configured external event. The rate of the acquisition is determined by the rate of the external event. In both cases, the ISC-178x can acquire images at up to the maximum frame rate.

Related Information

Connecting to Lighting Devices on page 12
Determining the Maximum Frame Rate on page 22

Internal Timing

The ISC-178x features two types of internally-timed modes: free-run mode and fixed-frame-rate mode.

In free-run mode, the device acquires images at the maximum frame rate allowed by the configuration. To operate in free-run mode, the Trigger Mode must be set to Off.

In fixed-frame-rate mode, you can specify a frame rate that is less than or equal to the maximum frame rate. To operate in fixed-frame-rate mode, the Trigger Source must be set to Fixed Rate and the Trigger Mode must be set to On. The rate is determined by the minimum of the specified Acquisition Frame Rate and the Acquisition Frame Rate Limit attributes.

External Trigger

Use a trigger input to synchronize the ISC-178x with an external event, such as the assertion of a signal generated by a proximity sensor. You can trigger the ISC-178x at rates up to the maximum frame rate. You can configure external triggering with any of the Input lines or the software as the trigger source.

Enable triggering with the Input lines as the trigger source in the following software programs:
- In Vision Builder AI, select the **Enable Trigger** checkbox on the Trigger tab of the Acquire Image (Smart Camera) step. Then select one of the **Input** lines from the Source drop-down control.
- In LabVIEW, set the value of the **Trigger Mode** to ON and the value of the **Trigger Source** attribute to one of the available Input lines.
- In MAX, select the **Enable Trigger** checkbox on the Triggering tab of the device configuration page. Then select one of the **Input** lines from the Source drop-down control.

Enable triggering with the software as the trigger source in the following software programs:
- In Vision Builder AI, select the **Enable Trigger** checkbox on the Trigger tab of the Acquire Image (Smart Camera) step. Then select **Software** from the Source drop-down control. Use Send Software Trigger to trigger the smart camera.
- In LabVIEW, set the value of the **Trigger Mode** to ON and the value of the **Trigger Source** attribute to **Software**.
- In MAX, select the **Enable Trigger** checkbox on the Triggering tab of the device configuration page. Then select **Software** from the Source drop-down control. Use Send Software Trigger to trigger the smart camera.

Related Information
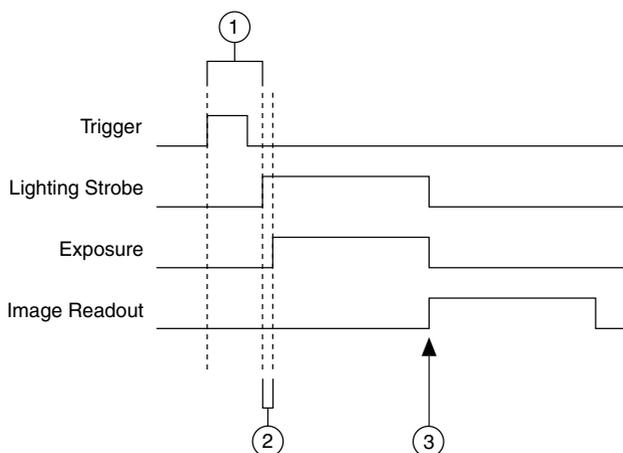
Connecting to Lighting Devices on page 12
Determining the Maximum Frame Rate on page 22

Delay and Activation

The following figure illustrates the relationship between an external trigger, a lightning strobe, and the exposure time.

Figure 18. Acquisition Timing Diagram

1. User-configurable Trigger Delay
2. User-configurable Exposure Delay
3. Beginning of Image Readout

The trigger shown in the figure 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 specified as a duration of time or as a number of edges on an input line.

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 ISC-178x on a conveyor belt, a trigger delay is required to ensure that the image is not exposed until the part to be inspected passes in front of the ISC-178x. In this case, specifying the trigger delay in terms of edge counts allows the ISC-178x to expose the image when the part is in position regardless of changes in conveyor belt speed.

When using an Input line as the trigger source, you must specify the desired activation for your trigger. The activation can be edge-based - rising, falling, or any - or level-based - high or low. When using a level-based activation mode, the ISC-178x only acquires images while the Input line is in the active state. The frame rate in this case is determined by the Acquisition Frame Rate attribute. This is a special case where external and internal timing are blended. When using a level-based activation mode, the trigger delay is ignored.

When using an internally timed acquisition, the activation mode and trigger delay do not apply. When using a software trigger, the activation mode will also be ignored, but the trigger delay is always applied.

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 AcquisitionFrameRateLimit attribute in LabVIEW, or reading the Max Frame Rate indicator in MAX.

Do not trigger faster than the maximum frame rate. If a trigger occurs faster than the maximum frame rate, such as the time between triggers being less than the minimum frame period, the incoming trigger is ignored.

Software determines the maximum frame rate using the following equation:

$$\text{max frame rate} = \frac{1}{\text{min frame period}}$$

where `min frame period` is the minimum amount of time for the current camera configuration

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 the following figure.

Figure 19. Frame Period
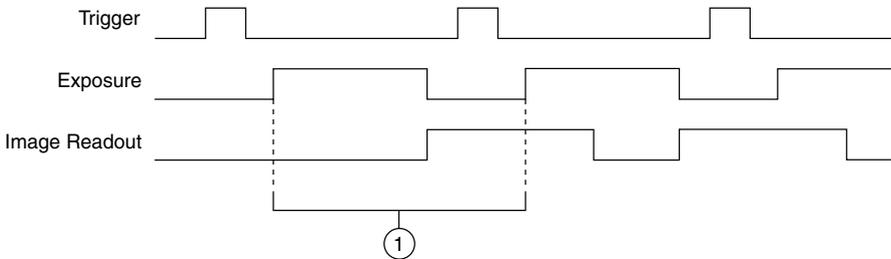
1. Frame Period

The frame period is affected by the following factors:
*   Exposure Time and Exposure Delay attributes
*   Trigger Delay attribute
*   Image size, determined by the Width and Height attributes
*   Image decimation, determined by the Decimation Vertical and Decimation Horizontal attributes
*   Image format, determined by the Pixel Format and Pixel Coding attributes
*   Trigger Overlap attribute

Related Information
Exposure and Lighting on page 24
Image Readout on page 25
Triggering on page 20
External Trigger on page 21

Determining the Exposure Time
In general, a longer exposure time or exposure delay results in a longer frame period, and a slower maximum frame rate, provided the trigger delay is not longer than the untriggered minimum frame period.

Determining the Trigger Delay

If the trigger delay is set longer than the untriggered minimum frame period, the trigger delay value further limits the minimum frame period. When the trigger delay is specified in time units, the software includes this in the calculation of the maximum frame rate indicator. Otherwise, the expected rate of the edges for the delay is not known, and you must determine the duration of the trigger delay.

Exposure and Lighting

The ISC-178x 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 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 the following equation to calculate the maximum exposure time.

$$E_{\max} = \frac{R_{Horizontal} \times 2}{(FOV_{Horizontal})/N_{Horizontal}}$$

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 ISC-178x. In these situations, the ambient light must be overridden with a dedicated light source to ensure reproducible results.

The Lighting Strobe starts after the Trigger Delay is satisfied. Use the Exposure Delay if your lighting source requires time to reach a stable intensity so that your images are consistent and your lighting does not fluctuate. The Exposure Delay can only be specified in units of time, and defaults to a value of 0. The Exposure Delay can be adjusted by setting the Exposure Delay control in Vision Builder AI, setting the Exposure Delay attribute in LabVIEW, or by setting the Exposure Delay in the attribute tree in MAX. The exposure begins once the Exposure Delay is satisfied. Both the Lighting Strobe and the Exposure signals end once the Exposure Time is satisfied.

Related Information

Field of View on page 17
Determining the Maximum Frame Rate on page 22

Image Readout

The image readout phase begins immediately following the completion of the image exposure time. During image readout, the sensor transfers the acquired image data to the CPU of the ISC-178x.

The image readout duration is primarily dependent upon the image size and the image decimation because these settings directly influence the amount of data that must be transferred. The length of time required for the image readout directly affects the maximum frame rate that can be achieved because only one image can be transferred at a time. There can never be an exposure that ends during the image readout for the previous image. The relationship between the triggering, exposure, and readout of the image is determined by the Trigger Overlap feature.

Related Information

Field of View on page 17
Determining the Maximum Frame Rate on page 22

Trigger Overlap

The Trigger Overlap feature determines whether to allow the exposure phase of a triggered image acquisition to occur while the previous image is still being transferred to the host. If Trigger Overlap is disabled, the exposure phase and the image transfer phase will occur sequentially. If the exposure phase ends before the previously acquired image is transferred to the host, enabling Trigger Overlap can lead to dropped frames. If, however, the exposure phase ends after the previously acquired image is transferred to the host, enabling Trigger Overlap can increase the speed of your application.

When Trigger Overlap is disabled, the start of the exposure phase is highly deterministic because the exposure and image readout occur sequentially. When Trigger Overlap is enabled and the exposure begins during the readout of the previous image, the exposure signal must be synchronized with the sensor. This introduces additional offset and jitter to the start of the exposure.

The Trigger Overlap feature defaults to **Readout**, which means Trigger Overlap is enabled, and allows an exposure to occur during the image readout of the previous frame. Change the Trigger Overlap behavior by setting the Trigger Overlap control in Vision Builder AI, setting the Trigger Overlap attribute in LabVIEW, or by setting the Trigger Overlap in the attribute tree in MAX.

Reconfiguring During an Acquisition

Many attributes can be reconfigured while an acquisition is in progress. Some of these attributes, including all of the Analog Controls and the Exposure attributes, directly affect the content of the image. The attribute values are latched when an image is placed into the acquisition queue. Image queuing is managed by the driver without direct interaction from the user.

If any of these values are changed while the ISC-178x is waiting on a trigger, the settings will not be applied to the currently queued image. The first image acquired after changing the settings will still use the old configuration, and the new configuration will begin with the subsequent image. These conditions only apply when changing the configuration during an acquisition. When the camera is configured prior to starting the acquisition, all images will be acquired using the current settings.

ISC-178x Software Attributes

The following table provides a list of the available ISC-178x attributes for use in LabVIEW applications.

Attribute Name	Data Type	Range	Unit	Description
AcquisitionFrameRate	DBL	Model dependent	—	Determines the frame rate of the camera when the Trigger Source is set to Fixed Rate
AcquisitionFrameRateLimit	DBL	Model dependent	—	Indicates the maximum frame rate possible in the current configuration
AutoWhiteBalance	Command	—	—	Starts an automatic white balance (color models only)

Attribute Name	Data Type	Range	Unit	Description
BalanceRatio	DBL	0 to 3.999	—	Controls the balance ratio of the selected component (color models only)
BalanceRatioSelector	Enum	Red, Green, Blue	—	Selects the balance ratio to control (color models only)
BlackLevelRaw	U32	0 to 255	—	Determines the black level of the camera
CounterEventActivation	Enum	Rising Edge, Falling Edge, Any Edge	—	Gets/sets the activation for the selected counter
CounterEventSource	Enum	Counter dependent	—	Gets/sets the source for the selected counter
CounterReset	Command	—	—	Resets the selected counter
CounterSelector	Enum	Counter 0, Counter 1, Counter 2, Counter 3 (Windows only)	—	Selects the counter to configure
CounterValue	U32	0 to 4294967295	Counts	Indicates the value of the selected counter
DecimationHorizontal	U32	1 to 2	—	Gets/sets the horizontal decimation of the image
DecimationVertical	U32	1 to 2	—	Gets/sets the vertical decimation of the image

Attribute Name	Data Type	Range	Unit	Description
ExposureDelay	DBL	0 to 4200000	μs	Determines the time between the start of the lighting strobe and the start of the exposure pulse. This allows for the lighting strobe signal to be asserted prior to the start of the exposure.
ExposureMode	Enum	Timed	—	Sets the operation mode of the exposure
ExposureTime	DBL	50 to 4200000	μs	Determines the exposure time of the camera
Gain	U32	0 to 255	—	Determines the input gain of the camera
Height	U32	Model dependent	Pixels	Gets/sets the height of the image.
LensFocalPositionRaw	U32	0 to 1023	—	Controls the focal position of the liquid lens (Varioptic Caspian I2C lenses only)
LensPresent	Bool	—	—	Indicates if the attached liquid lens supports the proper control protocol for programmatically setting the focal position (Varioptic Caspian I2C lenses only)

Attribute Name	Data Type	Range	Unit	Description
LightingIntensityRaw	U32	0 to 255	—	Controls the voltage level of the analog output signal that is used to adjust the intensity of the light
LineDebouncerTime	DBL	0.25 to 25000	—	Gets/sets the debounce time for the selected line
LineInverter	Bool	—	—	Controls the inversion of the signal on the selected line
LineMode	Enum	Input, Output	—	Indicates the mode of the selected line
LineSelector	Enum	Input 0, Input 1, Input 2, Input 3 (Windows only), Output 0, Output 1, Output 2,	—	Selects the digital I/O line to configure
LineSource	Enum	User Output, Pulse Generator, Exposure Active, Lighting Strobe	—	Indicates the source of the selected line
LineStatus	Bool	—	—	Indicates the status of the selected line
LineStatusAll	U32	0 to 4294967295	—	Indicates the status of the all available line signals

Attribute Name	Data Type	Range	Unit	Description
LUTEnable	Bool	—	—	Gets/sets if the lookup table is enabled
LUTIndex	U32	0 to 255	—	Selects the LUT element to access
LUTSelector	Enum	Red, Green, Blue	—	Selects the LUT to control
LUTValue	U32	0 to 255	—	Gets/sets the value of the selected LUT element
OffsetX	U32	Model dependent	Pixels	Gets/sets the left offset of the image.
OffsetY	U32	Model dependent	Pixels	Gets/sets the top offset of the image.
PayloadSize	U32	0 to 4294967295	Bytes	Gets the frame size in bytes.
PixelCoding	Enum	Raw, Mono, BGRAPacked (color models only)	—	Controls the coding of the pixels in the image. Raw outputs the data in the native format of the sensor
PixelFormat	Enum	Mono8, BGRA8Packed (color models only)	—	Gets/sets the pixel format of the source sensor.
PulseGeneratorDelay	DBL	0 to 1374389534.4	μs	Specifies the delay in microseconds of the pulse generator

Attribute Name	Data Type	Range	Unit	Description
PulseGeneratorDelayEdgeActivation	Enum	Rising Edge, Falling Edge, Any Edge	—	Specifies the activation for the pulse generator delay when configured for a delay in edge counts
PulseGeneratorDelayEdgeCounts	U32	0 to 4294967295	μs	Specifies the delay in edge counts of the pulse generator
PulseGeneratorDelaySource	Enum	Internal Clock, Input 0 Edges, Input 1 Edges, Input 2 Edges, Input 3 Edges (Windows only)	—	Specifies the counter source for the pulse generator delay
PulseGeneratorDuration	DBL	0 to 1374389534.4	μs	Specifies the duration in microseconds of the pulse generator
PulseGeneratorEnable	Bool	—	—	Enables the specified pulse generator
PulseGeneratorMode	Enum	Single Pulse, Rearmed Pulse, Pulse Train	—	Gets/sets the mode of the selected pulse generator
PulseGeneratorSelector	Enum	Pulse Generator 0, Pulse Generator 1, Pulse Generator 2	—	Selects pulse generator to configure

Attribute Name	Data Type	Range	Unit	Description
PulseGeneratorTriggerActivation	Enum	Rising Edge, Falling Edge, Any Edge, High Level, Low Level	—	Gets/sets the trigger activation of the selected pulse generator
PulseGeneratorTriggerSoftware	Command	—	—	Sends a software trigger to the pulse generator
PulseGeneratorTriggerSource	Enum	Immediate, Software, Input 0, Input 1, Input 2, Input 3 (Windows only)	—	Gets/sets the trigger source of the selected pulse generator
ReverseX	Bool	—	—	Determines if the image is flipped horizontally
ReverseY	Bool	—	—	Determines if the image is flipped vertically
SensorHeight	U32	Model dependent	Pixels	Indicates the height of the sensor
SensorType	Enum	Monochrome, Color	—	Indicates the type of the sensor (Monochrome or Color)
SensorWidth	U32	Model dependent	Pixels	Indicates the width of the sensor
TriggerActivation	Enum	Rising Edge, Falling Edge, Any Edge, High Level, Low Level	—	Specifies the activation mode of the selected trigger. Ignored when TriggerSource is set to Software.

Attribute Name	Data Type	Range	Unit	Description
TriggerDelay	DBL	0 to 1374389534.4	μs	Specifies the delay in microseconds to apply after the trigger reception before activating it for the selected trigger. Applies when TriggerDelaySource is InternalClock. Applies when TriggerSource is Software or when TriggerSource is an input line and TriggerActivation is edge-based.
TriggerDelayEdgeActivation	Enum	Rising Edge, Falling Edge, Any Edge	—	Specifies the activation for the trigger delay when configured for a delay in edge counts for the selected trigger

Attribute Name	Data Type	Range	Unit	Description
TriggerDelayEdgeCounts	U32	0 to 268435455	Counts	Specifies the delay in edge counts to apply after the trigger reception before activating it for the selected trigger. Applies when TriggerDelaySource is set to input edges. Applies when TriggerSource is Software or when TriggerSource is an input line and TriggerActivation is edge-based.
TriggerDelaySource	Enum	Internal Clock, Input 0 Edges, Input 1 Edges, Input 2 Edges, Input 3 Edges (Windows only)	—	Specifies the counter source for the trigger delay for the selected trigger
TriggerMode	Enum	Off, On	—	Selects the mode of the selected trigger
TriggerOverlap	Enum	Readout, Off	—	Specifies the type of overlap permitted with the previous frame
TriggerSelector	Enum	Frame Start	—	Selects the type of trigger to configure
TriggerSoftware	Command	—	—	Sends a software trigger to the selected trigger

Attribute Name	Data Type	Range	Unit	Description
TriggerSource	Enum	Input 0, Input 1, Input 2, Input 3 (Windows only), Fixed Rate, Software	—	Determines the source of the selected trigger
UserLEDState	Enum	Off, Green, Red, Orange	—	Gets/sets the value of the User LED
UserOutputSelector	Enum	User Output 0, User Output 1, User Output 2	—	Selects which bit of the User Output register will be set
UserOutputValue	Bool	—	—	Gets/sets the status of the selected user output
UserOutputValueAll	U32	0 to 7	—	Gets/sets the value of all bits in the User Output register
Width	U32	Model dependent	Pixels	Gets/sets the width of the image.

Restoring the NI Linux Real-Time Operating System

Complete the following steps to restore the NI Linux Real-Time operating system to its factory default condition. These steps do not restore the BIOS settings to factory default. Use the **Load Optimal Defaults** option in the *Exit Menu* of the BIOS setup utility to restore the BIOS settings.

⚠️ **Caution**   Restoring the operating system erases the contents of the onboard storage. Back up any files you want to keep before restoring the onboard storage.

1. Start the ISC-178x in safe mode.
2. Launch NI MAX on the development computer.
3. In the MAX configuration tree, expand **Remote Systems**.
4. Right-click the name of the ISC-178x you want to restore and select **Format Disk**.
5. Enter the username and password for the device. By default, the username is admin and the password field is blank.

6. Click **Format**.
7. After formatting is complete, a confirmation dialog window appears. Click **Close**.
8. Refer to the *ISC-178x Getting Started Guide* for information about installing software and configuring the device.

Related Information

Safe Mode (NI Linux Real-Time) on page 16

Restoring the Windows Operating System

You can restore the Windows operating system on the onboard storage of the ISC-178x. This erases the contents of the onboard storage. Back up any files you want to keep before restoring the onboard storage.

Note Restore the Windows operating system from the included recovery DVD or a bootable USB flash drive with the recovery DVD contents loaded onto it. Installing your own copy of the Windows operating system is not supported.

Creating a Bootable USB Flash Drive

You can create a bootable USB flash drive from the reinstallation DVD if you do not have an external USB DVD drive to connect to the ISC-178x.

Note If you have an external USB DVD drive, you can use the reinstallation DVD to restore Windows without creating a bootable USB flash drive. Proceed to the next section if you are using an external DVD drive.

What to Use

- USB flash drive, at least 8 GB but no more than 32 GB
- Windows reinstallation DVD
- Windows computer with a DVD drive

What to Do

Complete the following steps to prepare the USB flash drive for recovery.

1. Insert the USB flash drive into the USB port on the computer and wait for the flash drive to be recognized.

    Note Ensure the USB flash drive appears as a Removable Drive in Windows. Avoid using drives that appear as Fixed Disk drives.

2. Open a command prompt as an administrator.
3. Type diskpart.exe and press <Enter>.
4. Type list disk and press <Enter>.
5. Identify the drive number that corresponds to the USB flash drive.
6. Type select disk *x*, where *x* is the drive number of the USB flash drive, and press <Enter>. For example, in the following image, the USB flash drive is disk number 5. The command is select disk 5.

```
 ▪                       C:\Windows\system32\diskpart.exe              –  □   ×

DISKPART> List Disk

  Disk ###  Status          Size     Free     Dyn  Gpt
  --------  -------------   -------  -------   ---  ---
  Disk 0    Online          465 GB   1024 KB
  Disk 1    Online          465 GB   4096 KB
  Disk 2    Online          465 GB   4096 KB
  Disk 3    Online          465 GB   1024 KB
  Disk 5    Online           14 GB      0 B

DISKPART> Select Disk 5

Disk 5 is now the selected disk.

DISKPART> List Disk

  Disk ###  Status          Size     Free     Dyn  Gpt
  --------  -------------   -------  -------   ---  ---
  Disk 0    Online          465 GB   1024 KB
  Disk 1    Online          465 GB   4096 KB
  Disk 2    Online          465 GB   4096 KB
  Disk 3    Online          465 GB   1024 KB
* Disk 5    Online           14 GB      0 B

DISKPART>
```

⚠ **Caution**   Following this process will delete all data on the USB flash drive.

7. Type clean and press <Enter>. This command deletes all data from the USB flash drive.
8. Type create partition primary and press <Enter>.
9. Type active and press <Enter>
10. Type format fs=FAT32 quick and press <Enter> to format the USB flash drive.
11. Type assign letter *free volume letter*, where *free volume letter* is a letter not currently associated with any disk drives. For example, assign letter K.
12. Copy the contents of the reinstallation DVD to the root of the USB flash drive.

    The USB flash drive is now bootable and will install Windows.

Reinstalling Windows

What to Use
- •   ISC-178x Smart Camera
- •   Bootable USB flash drive or external USB DVD drive with recovery DVD inserted
- •   M12 to VGA/USB splitter cable (1 m), NI part number 153064-01
- •   USB hub
- •   USB keyboard
- •   USB mouse
- •   Monitor with VGA connection

What to Do
Complete the following steps to use the recovery media to install Windows.
1. Connect the M12 splitter cable to the VGA and USB connector on the ISC-178x.
2. Connect the USB hub to the USB port on the M12 splitter cable.
3. Connect the keyboard and mouse to the USB hub.

4. Connect the bootable USB flash drive or the external USB DVD drive to the USB hub.

5. Connect a monitor to the VGA port on the M12 splitter cable.

6. Power on the ISC-178x.

7. Press the <Esc> key on the keyboard to enter the setup utility.

8. Select **Boot Manager** in the setup utility.

9. Select the bootable USB flash drive or the DVD drive.

10. Press any key to boot from the recovery media.

11. Follow the on-screen instructions to format the onboard storage and install the operating system.

Note After restoring the operating system, reinstall any software and drivers onto the ISC-178x.

Where to Go Next

The following documents and resources contain information you may find helpful as you use the ISC-178x in an application. Refer to the National Instruments Product Manuals Library at *ni.com/manuals* for the most recent versions of product documentation.

- *Power and I/O Accessory for ISC-178x Smart Cameras User Manual*—Contains installation and operation instructions for the Power and I/O Accessory for ISC-178x Smart Cameras.
- *ISC-178x Getting Started Guide*—Explains how to install and configure the software necessary to use the ISC-178x, and how to get started using the hardware.
- *ISC-1780 Specifications*—Contains detailed specifications for the ISC-1780.
- *ISC-1781 Specifications*—Contains detailed specifications for the ISC-1781.
- *ISC-1782 Specifications*—Contains detailed specifications for the ISC-1782.
- *ISC-1783 Specifications*—Contains detailed specifications for the ISC-1783.

Worldwide Support and Services

The NI website is your complete resource for technical support. At *ni.com/support*, you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

Visit *ni.com/services* for NI Factory Installation Services, repairs, extended warranty, and other services.

Visit *ni.com/register* to register your NI product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

A Declaration of Conformity (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*. If your product supports calibration, you can obtain the calibration certificate for your product at *ni.com/calibration*.

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