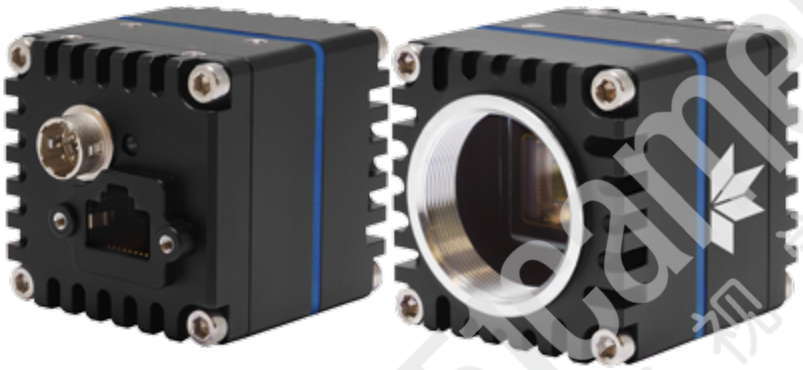
# INSTALLATION GUIDE

# FORGE® 1GIGE

## *SWIR SERIES INDUSTRIAL MACHINE VISION CAMERAS*



**Version 1.1**

**Revised 11/5/2024**



11/5/2024



TELEDYNE

## FCC Compliance

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesirable operation.

## Korean EMC Certification

The KCC symbol indicates that this product complies with Korea's Electrical Communication Basic Law regarding EMC testing for electromagnetic interference (EMI) and susceptibility (EMS).

This equipment is classified as Class A industrial equipment.

This equipment has received a conformity assessment for use in a business environment, and it may cause radio frequency interference if it is used in a home environment.

주의사항

A급 기기(업무용 방송통신기자재)

이 기기는 업무용 환경에서 사용할 목적으로 적합성평가를 받은 기기로서 가정용 환경에서 사용하는 경우 전파 간섭의 우려가 있습니다.

## Hardware Warranty

The warranty for the Forge 1GigE SWIR camera is 3 years. For detailed information on how to repair or replace your camera, please see the terms and conditions on our website.

## Export Control

The ECCN for this product is US ECCN 6A003.b.4.a / Canadian ECL 1-6.A.3.b.4.a.

## WEEE

The symbol indicates that this product may not be treated as household waste. Please ensure this product is properly disposed as inappropriate waste handling of this product may cause potential hazards to the environment and human health. For more detailed information about recycling of this product, please contact us.

## Trademarks

Names and marks appearing on the products herein are either registered trademarks or trademarks of Teledyne FLIR, LLC and/or its subsidiaries.

## Licensing

To view the licenses of open source packages used in this product please see What open source packages are in Teledyne FLIR IIS products?

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# Table of Contents

# 1 Forge 1GigE SWIR Camera Installation Guide

Welcome to the Forge 1GigE SWIR camera. We offer a number of resources to assist you with your camera.

- **Spinnaker SDK**—software development kit that provides GenICam-compliant controls to create applications for the camera. Spinnaker is available for download. Each installation includes API documentation for C, C++, and C#.
- **Release Notes**—information about the current firmware release including feature additions or changes, bug fixes, and known issues.
- **Specifications**—information about the camera model as it performs with the current firmware.
- **Getting Started**—quick start guide for installing the camera and software.
- **Installation Guide**—information about installing the camera and SDK, the physical interface and mechanical properties, troubleshooting and how to get help. This document is available as a PDF for download or as a webpage included in the firmware release package.
- **Technical Reference**—information about the features supported by the camera model with the current firmware, including: image format control, acquisition control, sequencing, binning/decimation, and others. This document is available as a PDF for download or as a webpage included in the firmware release package.
- **Firmware**—programming inserted into the programmable ROM of the camera that can be updated in-field. New firmware packages are available for download and include both the firmware file and documentation.

These resources as well as knowledge base articles and application notes can be found on the Support page for the product.

Forge 1GigE SWIR Camera Resources and Support

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# 2 Handling Precautions and Camera Care

**Warning!** Do not open the camera housing. Doing so voids the Hardware Warranty described in the Terms and Conditions on our website.

Your Teledyne FLIR IIS machine vision camera is a precisely manufactured device and should be handled with care. Here are some tips on how to care for the device.

- Avoid electrostatic charging.
- When handling the camera unit, avoid touching the lenses. Fingerprints will affect the quality of the image produced by the device.
- To clean the lenses, use a standard camera lens cleaning kit or a clean dry cotton cloth. Do not apply excessive force.
- Extended exposure to bright sunlight, rain, dusty environments, etc. may cause problems with the electronics and the optics of the system.
- Avoid excessive shaking, dropping or any kind of mishandling of the device.

# 3 Forge 1GigE SWIR Camera Installation

## 3.1 Preparing for Installation

### Will your system support your camera?

Recommended System Configuration:

- **OS, CPU, RAM**—dependent on SDK requirements
- **Ports**—GigE network adapter
- **Software**—Microsoft Visual Studio to run/compile example code

### Have you visited our website?

A downloads account is required to download software and firmware.

1. Go to the Teledyne Vision Solutions website.
2. Enter your email address and click Continue.
3. Complete the Create an account form and click Continue.
4. You will receive an email with a link to activate your account.
5. Once activated, you can login using your credentials.

The Forge SWIR camera resources page has many links to help you operate your camera effectively, including:

- Knowledge Base articles
- Spinnaker® SDK software, including drivers and Firmware updates and release notes (login required)
- Documentation and dimensional drawings / CAD models

### Do you have all the parts you need?

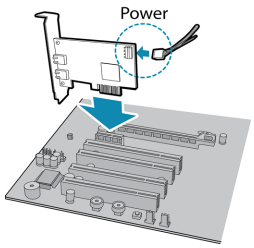
To install your camera you need the following components:

- Ethernet cable (see Data Interface Cables)
- Powered Ethernet switch or Ethernet power injector (if using PoE)
- GPIO cable (see General Purpose Input/Output (GPIO))
- Lens—a SWIR lens is required to capture the SWIR wavelength (see Lens Mounting)
- Interface card (see Data Interface Card)
- Tripod adapter (optional) (see Mounting your Forge 1GigE SWIR Camera)
- Lighting (application dependent)

Teledyne FLIR IIS sells a number of the additional parts required for installation. Visit the Teledyne FLIR IIS Accessories page.

# 3.2 Installing your Interface Card and Software

**1. Install your Interface Card**




Ensure the card is installed per the manufacturer's instructions.

Connect the internal IDE or SATA power connector on the card to the computer power supply.

Alternatively, use your PC's built-in host controller, if equipped.

Open the Windows Device Manager. Ensure the card is properly installed. Ethernet cards appear under **Network Adapters**. An exclamation point (!) next to the card indicates the driver has not yet been installed.

**2. Install the Spinnaker® SDK Software**

> **Note:** For existing users who already have Spinnaker installed, we recommend ensuring you have the latest version for optimal performance of your camera. If you do not need to install Spinnaker, use SpinView to install and enable drivers for your card.

a. Go to the Spinnaker SDK Download page. If you are not already logged in, you are prompted to login.

b. Click the Download Now button.

c. Select your operating system and version.

d. After download is complete, open the file to start the Spinnaker setup wizard.

e. Follow the steps in each setup dialog.

**3. Optimize the settings of your Ethernet card**

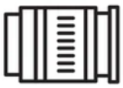
a. In **Start→Teledyne Spinnaker SDK→SpinView**, right click on the Network Adapter and select Adapter Configuration. The Adapter Config Utility lists your network adapters and allows you to access the following:

- Adapter IP address
- Subnet mask
- Default gateway
- Receive buffers
- Transmit buffers
- Jumbo packets
- RSS
- Media optimization
- CPU affinity

> **Note:** See How to Optimize GigE Network Adapter Settings for more information on configuring for best performance.

# 3.3 Installing your Forge 1GigE SWIR Camera

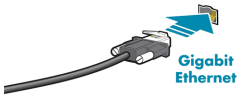
**1. Attach a Lens**



Unscrew the dust cap from the lens holder to install a lens.

A SWIR lens is required to capture images in the SWIR wavelength.

**2. Connect the interface Card and Cable to the Camera**




Plug the interface cable into the host adapter card and the camera. The cable jack screws can be used for a secure connection. If using PoE, connect a powered Ethernet switch or Ethernet power injector in between the card and the camera.

When the camera is first connected, the operating system automatically installs the camera driver. Camera drivers are available with the Spinnaker SDK installation.

**3. Plug in the GPIO connector**


GPIO is used for power, trigger, serial input output, and strobe.

**4. Confirm Successful Installation**

Run the SpinView application: **Start→Teledyne Spinnaker SDK→SpinView**
The SpinView application can be used to test the camera's image acquisition capabilities and make changes to the camera's installation configuration.

**5. Configure IP Settings if necessary**

By default, a dynamic IP address is assigned to the camera according to the DHCP protocol. If DHCP addressing fails, a link-local address is assigned. If necessary, in SpinView change the IP address of the camera to be on the same subnet as the NIC.

# 3.4 Powering your Forge 1GigE SWIR Camera

Power can be provided over the Ethernet interface (PoE). To use PoE, you must also have a powered Ethernet card, a powered Ethernet switch, or an Ethernet power injector.

Power can also be provided externally through the GPIO interface: 12 V nominal (8 - 24 V). Power consumption is ~3.2 W at 30°C ambient temperature.

If both power sources are connected the camera always uses external power over the GPIO connector.

The camera does not transmit images for the first 100 ms after power-up. The auto-exposure and auto-white balance algorithms do not run while the camera is powered down. It may therefore take several images to get a satisfactory image.

When the camera is power cycled (power disengaged then re-engaged), the camera reverts to its default factory settings, or if applicable, a saved user set.

# 4 Tools to Control your Forge 1GigE SWIR Camera

The Forge 1GigE SWIR camera's features can be accessed using various controls, including:

- Spinnaker SDK including API examples
- SpinView camera evaluation application, included in the Spinnaker SDK installation
- Third-party GenICam applications

## 4.1 Using the Spinnaker® SDK

You can monitor or control features of the camera through Spinnaker API examples provided in the Spinnaker SDK, or through the SpinView camera evaluation application. A *Programmer's Guide and API Reference* is included in the installation.

The Spinnaker SDK is available for download from the Spinnaker page.

### 4.1.1 SpinView Camera Evaluation Application

The SpinView application is a generic, easy-to-use streaming image viewer included with the Spinnaker SDK that can be used to test many of the capabilities of your camera. It allows you to view a live video stream from the camera, save individual images, adjust the various attributes, frame rates, features and settings of the camera. It includes tools for updating firmware, managing drivers, IP addressing, and activity logging.

### 4.1.2 Custom Applications Built with the Spinnaker API

The Spinnaker SDK includes a full Application Programming Interface that allows you to create custom applications to control your camera. Included with the SDK are a number of source code examples to help you get started.

Spinnaker API examples are provided for C, C++, C#, and VB.NET languages. These examples are precompiled for your convenience.

# 4.2 Using GenICam Applications

GigE Vision is an interface standard that allows for fast image transfer over Ethernet networks. All cameras supporting GigE Vision interact the same way with software also supporting GigE Vision.

For more information on the standard, visit visiononline.org.

The standard defines required elements for camera identification, control, and output. It uses GenICam, a programming interface for camera attribute control. GenICam allows camera vendors to define features and attributes in an XML file stored inside the camera. The file is parsed by the host application when the camera is initially discovered. One of the key benefits of GenICam is the ability for camera vendors to introduce new camera-specific features without needing to update the host application.

Each camera attribute, such as exposure time, is controlled by a specific GenICam feature. The camera includes an XML device description file for interfacing with third-party GenICam-compliant APIs.

For more information on GenICam, visit emva.org.

**Getting Started with Third-Party Applications Resources**

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|---|
| Getting Started with OpenCV |
| Getting Started with MATLAB |
| Getting Started with MVTec HALCON |
| Getting Started with Cognex VisionPro |
| Getting Started with Adaptive Vision |
| Getting Started with Matrox Imaging Library |
| Getting Started with Matrox Design Assistant |
| Getting Started with NI-MAX and LabVIEW |
| Getting Started with NI Vision Builder for Automatic Inspection |

# 5 Configuring the Forge 1GigE SWIR Camera Setup

After successful installation of your camera and interface card, you can make changes to the setup. Use the tools described below to change the IP Address, bandwidth, Ethernet settings, or the driver for your interface card.

For information on updating your camera's firmware post installation, see Forge 1GigE SWIR Camera Firmware.

## 5.1 Configuring the Camera Driver

The driver is installed automatically by the Spinnaker SDK installer for Camera Evaluation or for Application Development if the Drivers checkbox is selected (default). A restart is required.

> **Note:** For optimal driver performance, install Spinnaker version 4.0 or later.

Alternatively, you can manually install the driver. The driver files are located in:

**GigE**—C:\Program Files\Teledyne\GigE Vision Interface\x64

To manage and update drivers use the SpinView application:

1. Start SpinView:
   ***Start Menu→Teledyne Spinnaker SDK→SpinView***
2. From the Devices list, select the camera and click the Switch Driver button.


3. Select the driver from the drop-down list.
4. Click Install Driver.

## 5.2 Configuring the IP Address—GigE

When a new GigE camera is first powered and initialized, a dynamic IP address is assigned to the camera according to the DHCP protocol. If DHCP addressing fails, a link-local address is assigned. You can configure the IP address using the GenICam Features Transport Layer Control.

Alternatively, SpinView is a tool included with the Spinnaker SDK that allows you to set the internet protocol (IP) configuration for any GigE interface cards or Teledyne FLIR IIS GigE Vision cameras connected to your system. Using SpinView, you can:

- Set the IP address for the current connection.
- Program a persistent IP address for the camera.
- Configure the default IP addressing behavior of the camera on startup using a persistent IP, DHCP or LLA.
- Enable Jumbo Frames on the GigE NIC.

Both your camera and host adapter must have an IP address on the same subnet. This can be assigned in three ways:

- **Persistent**—The camera has a fixed IP address that does not change. Generally the address is within a closed network range of 192.168.X.X.
- **Dynamic (DHCP)**—The camera is set to automatically obtain an IP address. This means that the IP address may change (within a range) every time the camera or computer is restarted. It may take up to one minute for the IP address to resolve and the camera to enumerate.
- **Default (LLA)**—The camera uses an IP address from the link-local address block 169.254.x.x.

The camera assigns its current IP address in the following sequence:

1. **Persistent**—Uses the defined IP address. If not available, then;
2. **DHCP**—Attempts to find a dynamic IP address. If not available, then;
3. **LLA**—Uses an LLA IP address.

SpinView can automatically force an IP address refresh. This detects the IP address of the Network Interface card and automatically sets the camera's IP address relative to the card.

To open SpinView:

**Start→Teledyne Spinnaker SDK→SpinView**

# 5.3 Allocating Bandwidth—GigE

The User Datagram Protocol (UDP) used by the GigE Vision standard provides no guaranteed transmission or fixed timing mechanism. Therefore, bandwidth must be managed by the Device Throughput Limit, based on desired resolution and frame rate.

## 5.3.1 Determining Bandwidth Requirements

The maximum bandwidth available is 125 MB/s. This includes image data, control data and image resends, which occur when frames are being dropped. Each image and each packet has a certain amount of overhead that will use some bandwidth. Therefore, when calculating your bandwidth requirements, you should not attempt to use the full maximum of 125 MB/s.

To calculate your bandwidth requirements:

Determine your required resolution, frame rate, and pixel format (bytes per pixel)

(Height x Width x Frame Rate x Bytes per Pixel)/1000000 = Bandwidth in MB/s

For example, for an image that is VGA, 82 FPS, Mono8:

640 (H) x 480 (W) x 82 (FPS) x 1 (BPP) = ~25 MB/s

Once you have calculated your required bandwidth, you can allocate an amount to each camera by adjusting the Device Throughput Limit. Allocating a specific amount to each camera helps to avoid dropped packets due to a data burst. You would do this in a set up with multiple cameras, or in a situation where the system bandwidth might be limited or shared due to hardware architecture.

### Bandwidth Requirements for Multiple Cameras

Multiple cameras can be set up in two ways: 1) Each camera is connected directly to a single Ethernet port; or, 2) multiple cameras are connected to a single port through an Ethernet switch.

If using the first method, each camera has the full bandwidth allocation available to it. If using the second method, the combination of all cameras on a switch cannot exceed the available bandwidth.

**Related Knowledge Base Articles**

Setting Up Multiple GigE Cameras

# 5.4 Configuring Other Ethernet Settings—GigE

## 5.4.1 Stream Channel Destination Address

The stream channel destination address (SCDA) register is used to specify the streaming destination IP address. The default SCDA is the IP address of the network or computer to which the camera is connected. It can be set within a range so that the camera sends data as a multicast. As long as switches in the path between the sender and receivers support and are configured for multicasting, multiple receivers can listen to the data stream from the camera.

Multicast addresses are between 224.0.0.0 and 239.255.255.255.

> **Note:** For more information on multicast address assignments, see http://tools.ietf.org/html/rfc3171

To control SCDA use:

- GenICam—GevSCDA in the Transport Layer Control

## 5.4.2 Heartbeat

The heartbeat is a mandatory GigE Vision feature to monitor the connection between an application and the camera. The application must continually reset the heartbeat timer, or the camera assumes an error has occurred and shuts down the connection.

In general, the Spinnaker API manages the heartbeat at a low level; however the following two features are controllable: Heartbeat Timeout and Heartbeat Disable.

### Heartbeat Timeout

Heartbeat timeout is the time, in milliseconds, that the camera waits before closing the connection. Heartbeat timeout can be set between 500 ms and 10 seconds. The default setting is 3000 ms (3 seconds). If there is no communication between the camera and the application for longer than the timeout value, the connection is shut down.

To control Heartbeat Timeout use:

- GenICam—Under Transport Layer Control, GevHeartbeatTimeout.
- Spinnaker API—The Spinnaker SDK supports configuring heartbeat timeout.

### Heartbeat Disable

The heartbeat is enabled by default.

To disable Heartbeat use:

- GenICam—Under Transport Layer Control GevGVCPHeartbeatDisable.
- Spinnaker API—The Spinnaker SDK supports disabling heartbeat.

# 5.5 Forge 1GigE SWIR Camera Firmware

Firmware is programming that is inserted into the programmable read-only memory (programmable ROM) of most Teledyne FLIR IIS cameras. Firmware is created and tested like software. When ready, it can be distributed like other software and installed in the programmable read-only memory by the user.

The latest firmware versions often include significant bug fixes and feature enhancements. To determine the changes made in a specific firmware version, consult the Release Notes.

Firmware is identified by a version number, a build date, and a description. As well, the Device Version shows the progression of firmware versions for a product, starting with 1.0.

## 5.5.1 Determining Firmware Version

To determine the firmware version number of your camera:

- Query the GenICam Device Control feature DeviceFirmwareVersion.

  or

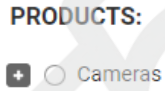
- In SpinView, click the Information tab to view camera information including Device Firmware Version and Device Version.

## 5.5.2 Upgrading Firmware

Firmware can be upgraded or downgraded to later or earlier versions using SpinView, part of the Spinnaker SDK.

Before upgrading firmware:

- Install the **Spinnaker SDK**, available from the Spinnaker page.
- Download the firmware from the website:
  - Go to the Software & Firmware Downloads page.
  - Click the + symbol to expand the Cameras tree to find your model.

  - Click Download next to the file.

To upgrade the firmware:

1. **Start→Teledyne Spinnaker SDK→SpinView**
2. From the Device list, right click the camera and select Update Device Firmware.
   If you get a Device is Active warning, close the Display pane or click the Disconnect button and right click the camera again.
3. Browse to select the firmware file and click Open.
4. Click Yes to continue.

**Warning!** Do not disconnect the camera during the firmware update process.

**Related Knowledge Base Articles**

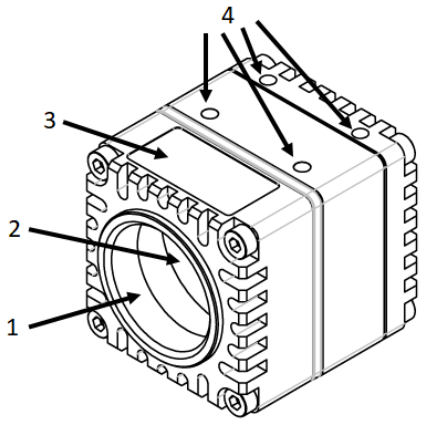
Teledyne FLIR machine vision software and firmware version numbering systems

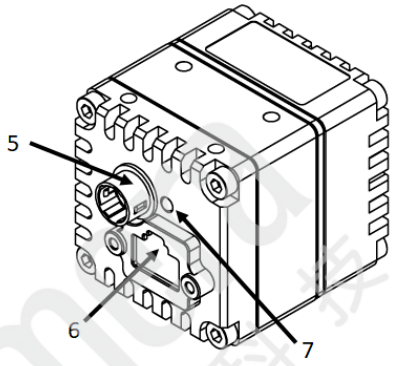
Determining my camera's firmware version

Should I upgrade my camera firmware or software?

# 6 Forge 1GigE SWIR Camera Physical Interface

## 6.1 Forge 1GigE SWIR Camera Physical Description



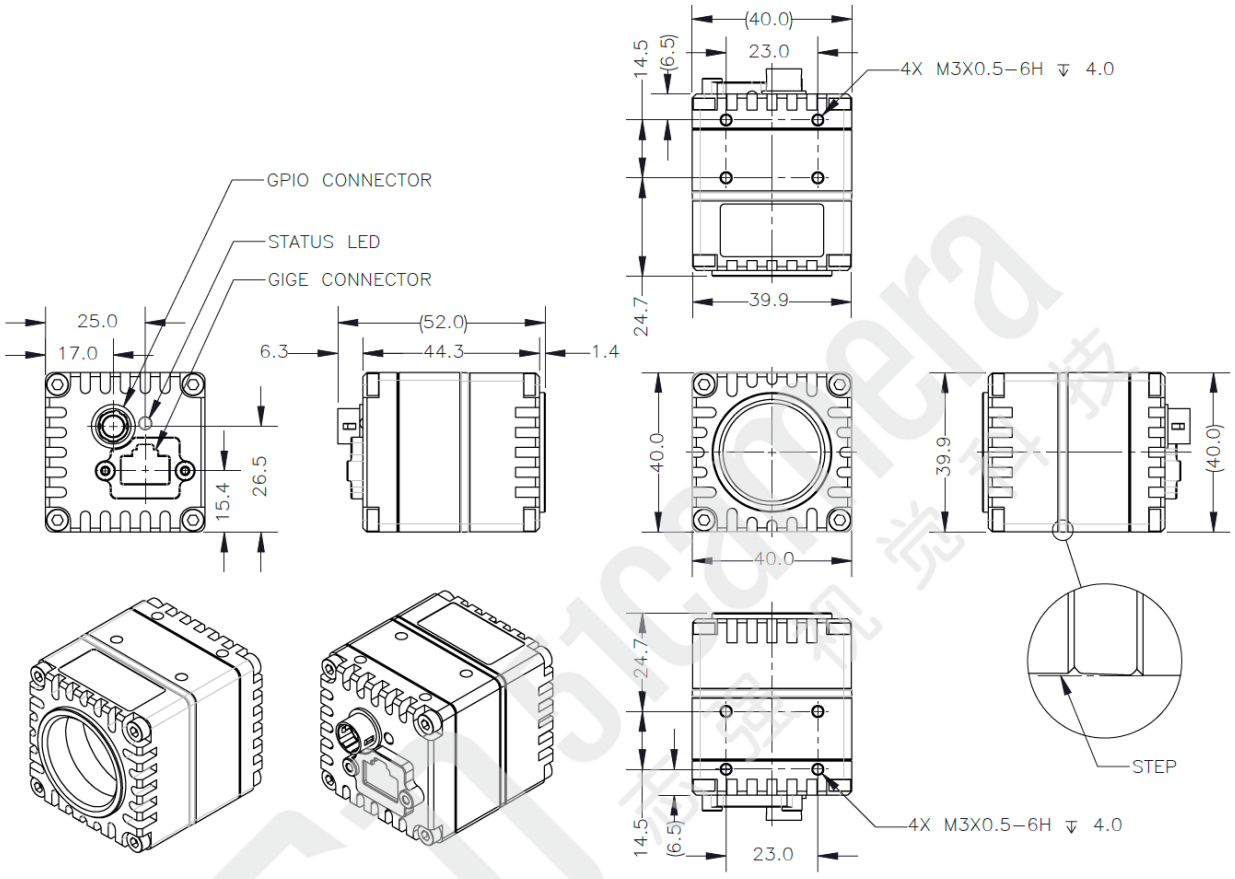




1. **Lens holder**
   See Lens Mounting
2. **Sensor package**
   See Dust Protection
3. **Camera Label**
   Contains camera information such as model name, serial number and required compliance.
4. **Mounting Holes**
   M3X0.5 holes 4 mm deep—4 on the top and 4 on the bottom
   See Mounting your Forge 1GigE SWIR Camera.
5. **GPIO connector—Hirose 6-pin**
   See General Purpose Input/Output (GPIO)
6. **Interface connector—Ethernet RJ45**
   See Data Interface Connector
7. **LED Status Indicator**
   See Status Indicator LED

# 6.2 Forge 1GigE SWIR Camera Dimensions

Download 3D CAD Models / Drawings from our website: CAD Models

**Forge 1GigE SWIR Camera Dimensional Drawing**



# 6.3 Data Interface Connector

## 6.3.1 Ethernet Connector

The 8-pin RJ-45 Ethernet jack is equipped with two (2) M2 screwholes for secure connection. Pin assignments conform to the Ethernet standard.

# 6.4 Data Interface Cables

To purchase a recommended cable from Teledyne FLIR IIS, visit the Accessories→Cables page.

Category 5e or 6 cables up to 100 meters in length should be used for connecting the camera to the network interface card on the host system.

> **Note:** For optimal ESD protection, we recommend using a shielded Ethernet cable or connecting the camera housing to chassis ground (earth).

# 6.5 General Purpose Input/Output (GPIO)

The camera is equipped with a 6-pin GPIO connector on the back of the case. The connector is a Hirose HR10A-7R-6PB, the mating connector is a Hirose HR10A-7P-6S(73).

See Input/Output Control for details on pin assignments and electrical characteristics.

# 6.6 Data Interface Card

The camera must connect to an interface card. This is sometimes called a host adapter, a bus controller, or a network interface card (NIC).

> **Note:** For optimal video streaming and camera control performance, we recommend an Intel Pro chipset on a PCIe interface.

A 1000 BASE-T NIC is recommended for streaming images on the Ethernet network between the camera and host system.

See How to Optimize GigE Network Adapter Settings for more information on configuring for best performance.

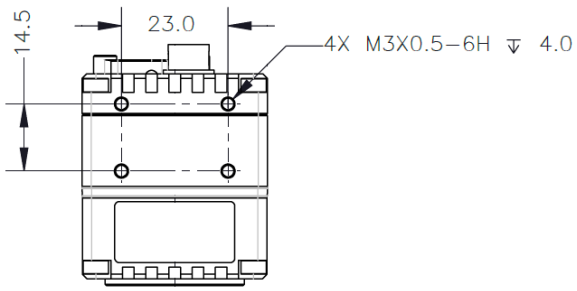
To purchase a compatible card from Teledyne FLIR IIS, visit the Accessories→Host Adapter Cards page.

# 6.7 Mounting your Forge 1GigE SWIR Camera

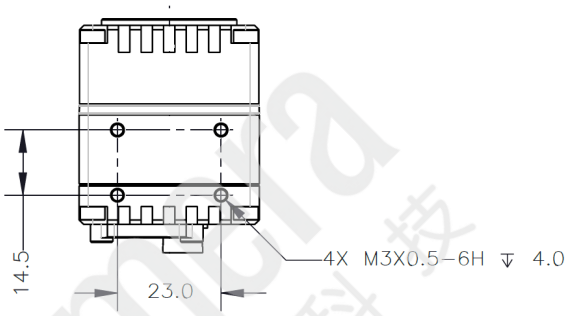
### Using the Case

The case is equipped with:

- Four (4) M3x0.5 mounting holes on the top of the case
- Four (4) M3x0.5 mounting holes on the bottom of the case




**Camera Top**




**Camera Bottom**

# 6.8 Camera Temperature and Heat Dissipation

You must provide sufficient heat dissipation to control the internal operating temperature of the camera.

The camera is equipped with an on-board temperature sensor. It allows you to obtain the temperature of the camera board-level components. The sensor measures the ambient temperature within the case.

To access temperature information query the GenICam Device Control feature DeviceTemperature.

*As a result of packing the camera electronics into a small space, the camera can become hot when running. This is expected behavior and will not damage the camera electronics.*

**Warning!** *To avoid possible burns do not touch the camera while in operation. Wait at least 15 minutes after powering off before touching.*

To reduce heat, use a cooling fan to set up a positive air flow around the camera, taking into consideration the following precautions:

- Mount the camera on a heat sink, such as a camera mounting bracket, made out of a heat-conductive material like aluminum.

- Make sure the flow of heat from the camera to the bracket is not blocked by a non-conductive material like plastic.
- Make sure the camera has enough open space around it to facilitate the free flow of air.

# 6.9 Lens Mounting

The Forge 1GigE SWIR camera is capable of capturing images from visible light to SWIR (400 nm to 1700 nm). The wavelength captured is dependent on the lighting used and the lens. A SWIR lens is required to capture images in the SWIR wavelength. Depending on the lighting of the scene, an additional filter applied to the lens may further narrow the wavelength.

Lenses are not included with cameras. Teledyne FLIR IIS sells a number of lenses compatible with our cameras from our Accessories →Lenses page. There is also a Lens Calculator to help choose an appropriate lens.

Correct focus cannot be achieved using a CS-mount lens on a C-mount camera.

**Related Knowledge Base Articles**

Selecting a lens for your camera

## 6.9.1 Back Flange Distance

The Back Flange Distance (BFD) is offset due to the presence of a 0.5 mm sensor package window. This glass fits between the lens and the sensor image plane and is installed by the sensor manufacturer. This component causes refraction, which requires some offset in flange back distance to correct.

# 6.10 Non-Volatile Flash Memory

The Forge 1GigE SWIR camera has 1 MB of non-volatile flash memory for users to store data.

**Related Knowledge Base Articles**

Storing data in on-camera flash memory

# 6.11 Dust Protection

The camera housing is designed to prevent dust from falling directly onto the sensor's protective glass surface. This is achieved by placing a lens mount cover that sits above the surface of the sensor's glass.

**Warning!** Cameras are sealed when they are shipped. To avoid contamination, seals should not be broken until cameras are ready for assembly on site.

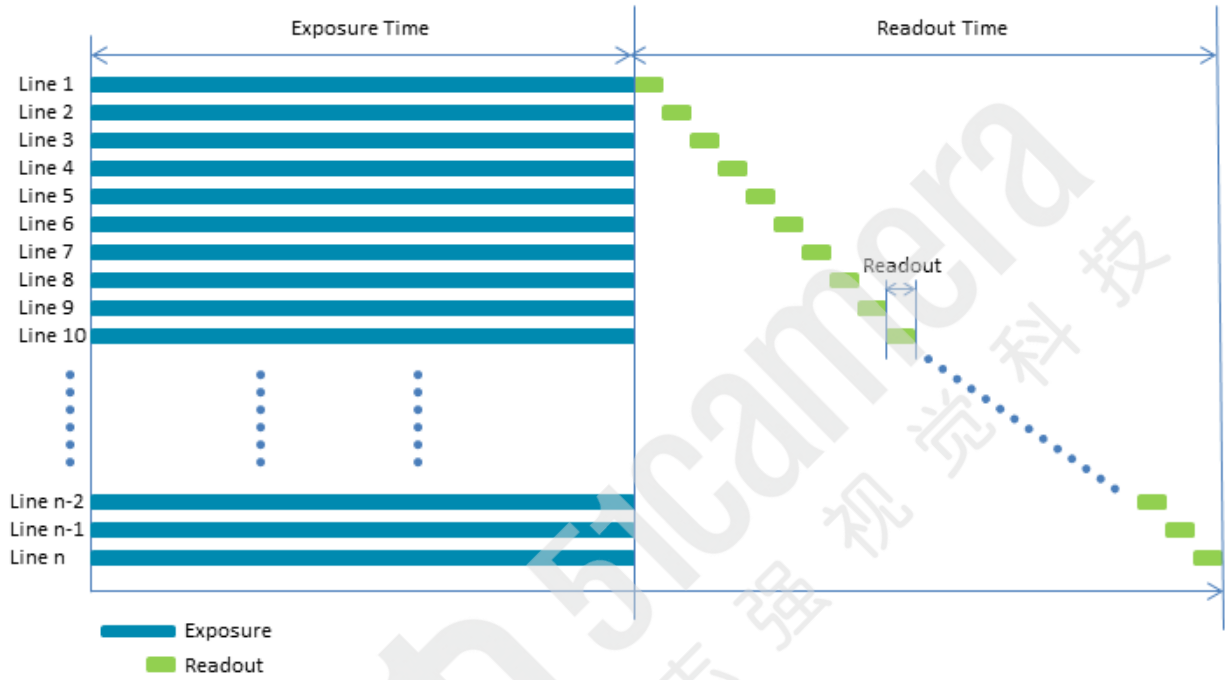
**Related Knowledge Base Articles**

Selecting a lens for your camera

# 6.12 Sensor Shutter Type

## 6.12.1 Global Shutter

For cameras with a global shutter sensor, for each frame all of the lines start and stop exposure at the same time. The exposure time for each line is the same. Following exposure, data readout begins. The readout time for each line is the same but the start and end times are staggered. Readout time for a line is equal to 1/Horizontal Line Frequency.

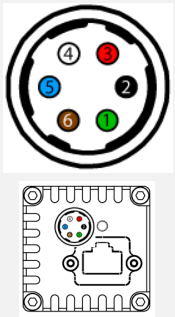



Some advantages of global shutter are more uniform brightness and minimal motion blur.

# 7 Input/Output Control

## 7.1 General Purpose Input/Output (GPIO)

The camera is equipped with a 6-pin GPIO connector on the back of the case. The connector is a Hirose HR10A-7R-6PB, the mating connector is a Hirose HR10A-7P-6S(73).



| Color[1] | Pin | Line | Function | Description | Parameter | Value |
|---|---|---|---|---|---|---|
| Green | 1[2] | 3 | $V_{AUX}$ | Auxiliary Input Voltage (DC) | Input Voltage Range | 8 - 24 V |
| | | | GPI | Non-isolated Input | Input Low Level | 0 - 1.4 V |
| | | | | | Input High Level | 2.6 - 3.6 V |
| | | | | | Propagation Delay | 1 µs |
| Black | 2 | 0 | OPTOIN | Opto-isolated Input | Input Low Level | 0 - 1.4 V |
| | | | | | Input High Level | 2.6 - 30 V |
| | | | | | Input Current | 3.5 - 7 mA |
| | | | | | Propagation Delay Low to High | 18 µs |
| | | | | | Propagation Delay High to Low | 9 µs |
| Red | 3[2] | 2 | VOUT | Camera Power Output | Output Voltage | 3.05 - 3.35 V |
| | | | | | Output Current | 120 mA |
| | | | GPIO[3] | Non-isolated Input/Output | Input Low Level | 0 - 1.4 V |
| | | | | | Input High Level | 2.6 - 24 V |
| | | | | | Propagation Delay | 1 µs |
| | | | | | Output Low Current | 25 mA |
| | | | | | Output High Level | 0 - 24 V |
| White | 4 | 1 | OPTOOUT[3] | Opto-isolated Output | Output Low Current[4] | 25 mA |
| | | | | | Output High Level | 0 - 7 V |
| | | | | | Propagation Delay Low to High | 36 µs |
| | | | | | Propagation Delay High to Low | 18 µs |
| Blue | 5 | N/A | Opto GND | Opto-isolated Ground | | |
| Brown | 6 | N/A | GND | Camera Power Ground | | |

Measurement conditions: Opto-Isolated I/O VCC=5 V, Rext=1 KOhm, Non-Isolated Output: VCC=5 V, Rext=330 Ohm, Non-Isolated Input: VCC=3.3 V. Measured over operating temperature range (-20℃ to +50℃ ambient temperature), unless otherwise noted.

1—GPIO cable assembly wire colors
2—Dual function pin
3—Open drain output, requires pullup resistor
4—Output low level depends on the output voltage / pullup resistor combination

# 7.2 GPIO Electrical Characteristics

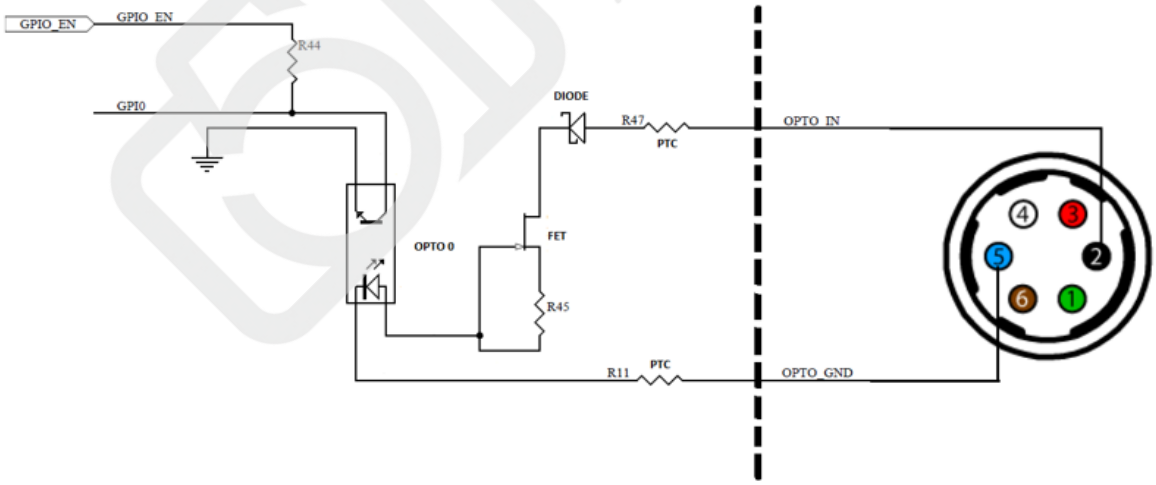
The output is open collector and thus requires a pull-up resistor to operate. The rise time and bias current is determined by the resistor value chosen. If the camera is generating an output signal that approaches the rise time plus the fall time of the circuit, care must be taken to optimize the pull-up resistor chosen to minimize the rise time while still remaining within the current limits of the output circuit.

**Warning!** To avoid damage, connect the OPTO_GND pin first before applying voltage to the GPIO line.

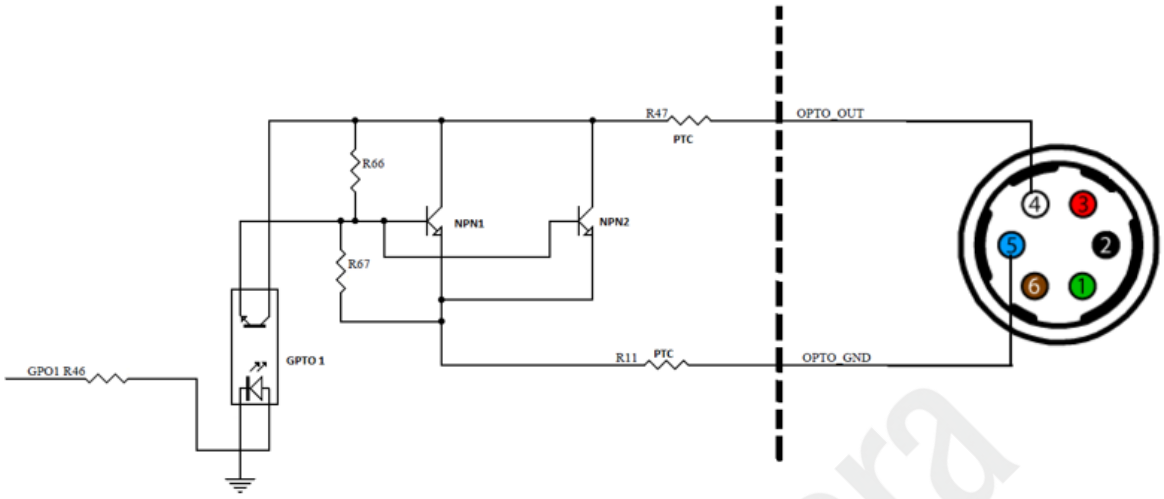
**Warning!** Prolonged use of the camera outside of the Operating Range described below may lead to unexpected behavior and should be avoided.

**Operating Range**

| Description | Minimum | Maximum |
|---|---|---|
| Opto-isolated Input Voltage | 0 V | 30 V |
| Opto-isolated Output Voltage | 0 V | 7 V |
| Opto-isolated Output Current | | 25 mA |
| 3.3 V Output Current | | 120 mA |




**Opto-isolated input circuit**

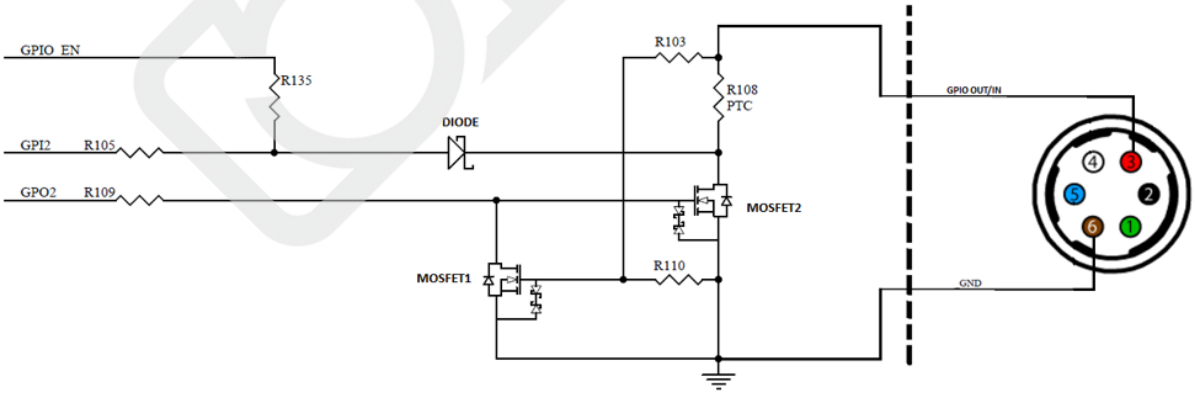



**Opto-isolated output circuit**

**Non-isolated External Voltage Resistor Combinations**

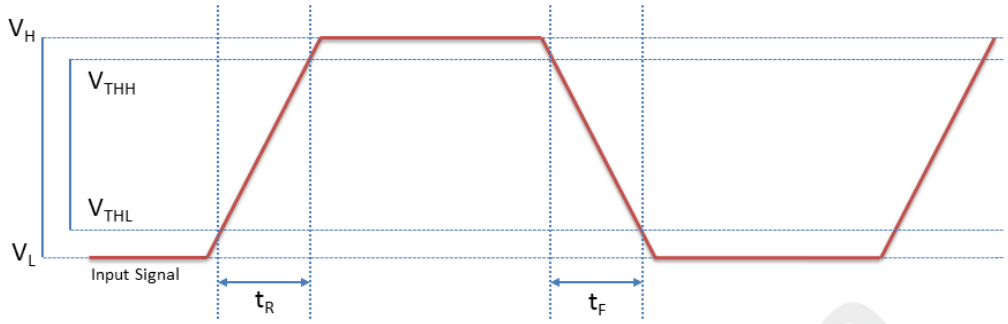
| External Voltage | External Resistor | Current |
|---|---|---|
| 3.3 V | 1.0 kΩ | 3.1 mA |
| 5 V | 1.0 kΩ | 4.8 mA |
| 12 V | 2.0 kΩ | 6 mA |
| 12 V | 2.4 kΩ | 5 mA |
| 24 V | 4.7 kΩ | 5.2 mA |

Values are for reference only




**Non-isolated input and output circuit**

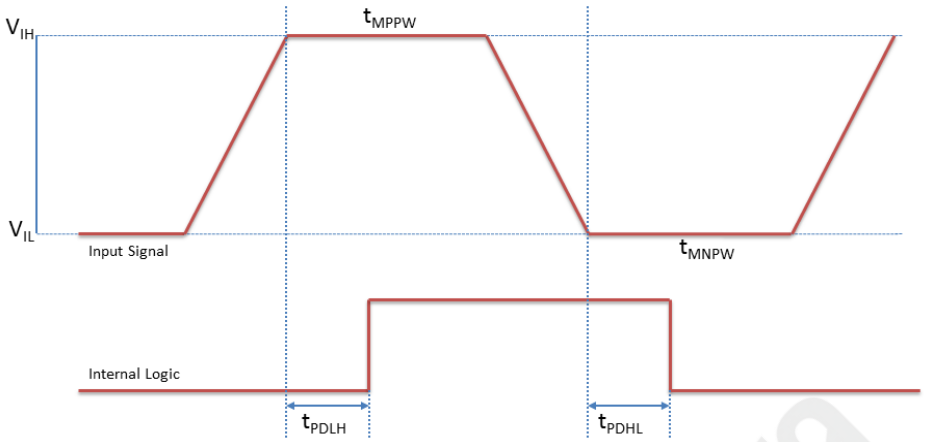
# 7.3 Input Timing Characteristics




**Input Timing Characteristics**

**Non-isolated Input Performance (measured at Vcc = 5 V, Rext = 1 kΩ)**

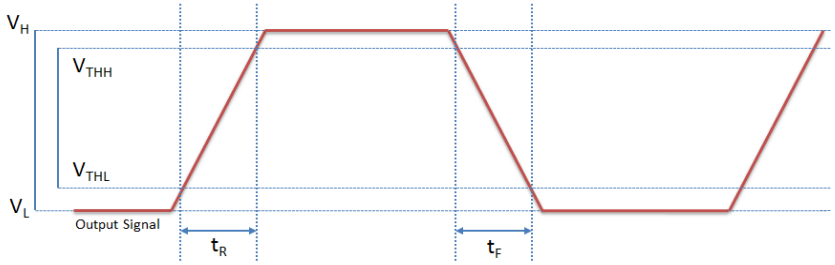
| Parameter | Symbol | Non-isolated |
|---|---|---|
| Input Low Voltage | $V_L$ | 0.85 V |
| Input High Voltage | $V_H$ | 4.94 V |
| Input Threshold High Voltage | $V_{THH}$ | 4.54 V |
| Input Threshold Low Voltage | $V_{THL}$ | 1.26 V |
| Cycle Rise Time | $t_R$ | 10.8 µs |
| Cycle Fall Time | $t_F$ | 2 µs |
| Current | | 4.1 mA |




**Opto-isolated Input Performance (Vcc = varying pk-pk)**

| Parameter | Symbol | Opto-isolated 5 V, 1 kΩ | Opto-isolated 3 V, 200 Ω |
|---|---|---|---|
| Input Low Voltage | $V_{IL}$ | ≤ 1.96 V | ≤ 2 V |
| Input High Voltage | $V_{IH}$ | ≥ 2 V | ≥ 2.05 V |
| Propagation Delay Low to High | $t_{PDLH}$ | 20.9 µs | 19.7 µs |
| Propagation Delay High to Low | $t_{PDHL}$ | 5.6 µs | 16.7 µs |
| Typical Positive Pulse Width | $t_{MPPW}$ | 12 µs | 12 µs |
| Typical Negative Pulse Width | $t_{MNPW}$ | 6 µs | 6 µs |

# 7.4 Output Timing Characteristics




**Output Timing Characteristics**

**Non-isolated Output Performance (measured at Vcc = 5 V, Rext = 1 kΩ)**

| Parameter | Symbol | Non-isolated |
|---|---|---|
| Output Low Voltage | $V_L$ | 0.23 V |
| Output High Voltage | $V_H$ | 4.95 V |
| Output Threshold High Voltage | $V_{THH}$ | 4.48 V |
| Output Threshold Low Voltage | $V_{THL}$ | 0.7 V |
| Cycle Rise Time | $t_R$ | 2.6 µs |
| Cycle Fall Time | $t_F$ | 0.23 µs |
| Opto Current | | 4.8 mA |

**Opto-isolated Output Performance (measured at Vcc = 3.3 V, Rext = 200 Ω)**

| | | Opto-isolated | |
|---|---|---|---|
| Parameter | Symbol | Load | No Load |
| Output Low Voltage | $V_L$ | 1.44 V | 1.47 V |
| Output High Voltage | $V_H$ | 2.64 V | 3.25 V |
| Output Threshold High Voltage | $V_{THH}$ | 2.52 V | 3.07 V |
| Output Threshold Low Voltage | $V_{THL}$ | 1.56 V | 1.65 V |
| Cycle Rise Time | $t_R$ | 5.2 µs | 24 µs |
| Cycle Fall Time | $t_F$ | 28 µs | 4.6 µs |
| Opto Current | | 3.08 mA | 8.4 mA |
| Opto Isolator Delay (High to Low) | | 5.3 µs | 5.5 µs |
| Opto Isolator Delay (Low to High) | | 12.7 µs | 15.2 µs |

**Opto-isolated Output Performance (measured at Vcc = 5 V, Rext = 1 kΩ)**

| | | Opto-isolated | |
|---|---|---|---|
| **Parameter** | **Symbol** | **Load** | **No Load** |
| Output Low Voltage | $V_L$ | 0.86 V | 0.92 V |
| Output High Voltage | $V_H$ | 2.29 V | 5 V |
| Output Threshold High Voltage | $V_{THH}$ | 2.15 V | 4.59 V |
| Output Threshold Low Voltage | $V_{THL}$ | 1.00 V | 1.33 V |
| Cycle Rise Time | $t_R$ | 12 µs | 10.3 µs |
| Cycle Fall Time | $t_F$ | 19.6 µs | 17.2 µs |
| Opto Current | | 2.68 mA | 3.9 mA |
| Opto Isolator Delay (High to Low) | | 3.9 µs | 4.1 µs |
| Opto Isolator Delay (Low to High) | | 26.8 µs | 25.1 µs |

# 8 Troubleshooting

## 8.1 Support

Teledyne FLIR IIS endeavors to provide the highest level of technical support possible to you. Most support resources can be accessed through your product's Support page.

Forge 1GigE SWIR Camera Resources and Support

**Contacting Technical Support**

Before contacting Technical Support, have you:

1. Read the product documentation?
2. Searched the Product Support page?
3. Downloaded and installed the latest version of software and/or firmware?
4. Checked out our support community forum?
5. Looked at our GitHub Spinnaker Examples page?

If you have done all the above and still can't find an answer to your question, contact our Technical Support team.

## 8.2 Status Indicator LED

| LED | GigE |
|---|---|
| **No Light** | No power<br>or LED is in inactive state<br>or LED is in error status state with no error |
| **Blinking Green (1 blink)** | Link-Local Address (LLA) |
| **Blinking Green (2 blinks)** | DHCP IP Address |
| **Blinking Green (3 blinks)** | Persistent IP Address |
| **Solid Green** | Acquisition Started |
| **Solid Red** | Link down |
| **Rapid Flashing Green** | Firmware update in progress |
| **Flashing Green and Red** | General Error |

# Contacting Teledyne FLIR IIS

For any questions, concerns or comments please contact us:

| | |
|---|---|
| **Email** | General questions |
| **Support Ticket** | Technical support |
| **Support Forum** | Teledyne FLIR IIS Community |
| **Website** | Find specifications, support articles, downloads on the website Teledyne FLIR IIS machine vision |

# Revision History

| Version | Date | Description |
|---|---|---|
| **1.0** | 10-17-2024 | Support for FG-PGE-13S3S-U-C |
| **1.1** | 11-05-2024 | Clarification of Class A for KCC |