POINT GREY
Innovation in Imaging

Gazelle

Technical Reference Manual

Version 1.4

Revised 10/1/2012

Point Grey Research® Inc.

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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.

Hardware Warranty

Point Grey Research®, Inc. (Point Grey) warrants to the Original Purchaser that the Camera Module provided with this package is guaranteed to be free from material and manufacturing defects for a period of Two years. Should a unit fail during this period, Point Grey will, at its option, repair or replace the damaged unit. Repaired or replaced units will be covered for the remainder of the original equipment warranty period. This warranty does not apply to units that, after being examined by Point Grey, have been found to have failed due to customer abuse, mishandling, alteration, improper installation or negligence. If the original camera module is housed within a case, removing the case for any purpose other than to remove the protective glass or filter over the sensor voids this warranty. This warranty does not apply to damage to any part of the optical path resulting from removal or replacement of the protective glass or filter over the camera, such as scratched glass or sensor damage.

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About This Manual

This manual provides the user with a detailed specification of the Gazelle camera system. The user should be aware that the camera system is complex and dynamic – if any errors or omissions are found during experimentation, please contact us. (See Contacting Point Grey Research on page 58.)

This document is subject to change without notice.

All model-specific information presented in this manual reflects functionality available in the model's firmware version.

For more information see Camera Firmware on page 22.

Where to Find Information

Chapter	What You Will Find
1. Welcome	General camera specifications and specific model specifications (page 1) Imaging Performance specifications and Quantum Efficiency graphs Camera properties, including diagrams (page 6)
2. Getting Started	Preparation for installing the camera (page 15) Installation instructions (page 16) Introduction to camera controls (page 17)
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Document Conventions

This manual uses the following to provide you with additional information:

A note that contains information that is distinct from the main body of text. For example, drawing attention to a difference between models; or a reminder of a limitation.

A note that contains a warning to proceed with caution and care, or to indicate that the information is meant for an advanced user. For example, indicating that an action may void the camera's warranty.

If further information can be found in our Knowledge Base, a list of articles is provided.

Related Knowledge Base Articles

Title	Article
Title of the Article	Link to the article on the Point Grey website

If there are further resources available, a link is provided either to an external website, or to the FlyCapture2 SDK.

Related Resources

Title	Link
Title of the resource	Link to the resource

1 Welcome to Gazelle

The Gazelle series of cameras feature high-resolution, high-frame rate CMOS image sensors, compact case, and Camera Link interface in Base (2-tap) and Full (8-tap) configurations.

1.1 Gazelle Specifications

MODEL	VERSION	MP	IMAGING SENSOR
GZL-CL-22C5M-C	Mono	2.2 MP	▪ CMOSIS CMV2000 CMOS, 2/3", 5.5 µm ▪ Global Shutter ▪ 2048 x 1088 at 280 FPS
GZL-CL-41C6M-C	Mono	4.1 MP	▪ CMOSIS CMV4000 CMOS, 1", 5.5 µm ▪ Global Shutter ▪ 2048 x 2048 at 150 FPS

	All Gazelle Models
A/D Converter	10-bit
Video Data Output	8-bit (Full 8-tap mode) or 10-bit (Base 2-tap mode)
Image Data Formats	Mono8, Mono10
Partial Image Modes	Single or multiple region of interest modes
Image Processing	Gain, Black Level, Pixel Defect Correction
Gain	Analog and digital programmable via software
	32-64 dB (analog); 1-63 dB (digital)
Digital Interface	Camera Link LVDS for camera control and video data transmission; Base (2-tap) and Full (8-tap) configurations
Transfer Rates	2.38 Gbits/s
GPIO	8-pin Hirose HR25 GPIO connector; opto-isolated pins for trigger and strobe
External Trigger Modes	Single-shot, bulb shutter trigger mode
Synchronization	Via external trigger or software trigger
Shutter	Global Shutter
	Manual
	74.175 µs - 54 s (Full 8-tap mode)
Memory Channels	2 memory channels for custom camera settings
Flash Memory	4 MB
Dimensions	44 mm x 29 mm x 59.5 mm excluding lens holder, without optics (metal case)
Mass	90 grams (without optics or tripod mounting bracket)

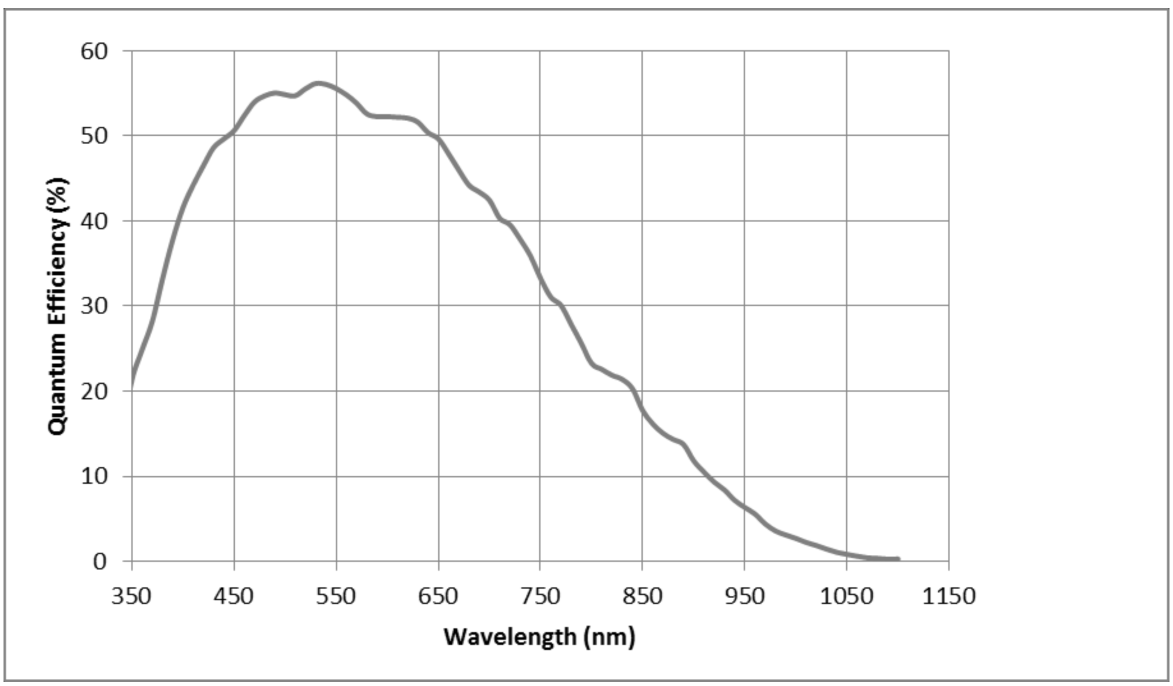
	All Gazelle Models
Power Consumption	12 V +/- 10%, 6 W
Camera Specification	Camera Link
Camera Control	Via software instruction set
Camera Updates	In-field firmware updates
Lens Mount	C-mount
Operating Temperature	-10° to 50°C
Storage Temperature	-30° to 60°C
Emissions Compliance	CE, FCC, RoHS
Operating System	XP, Vista, Windows 7
Warranty	Two years

1.1.1 GZL-CL-22C5M (Mono) Imaging Performance

Specification	Mode 0
Full Well Depth	12900 e- at zero gain
Dynamic Range	57 dB
Read Noise	18.8 e- at zero gain
Measurements taken at maximum resolution	

Quantum Efficiency	
Peak QE Wavelength	530 nm
Peak QE Value	56%

Figure 1.1: GZL-CL-22C5 Quantum Efficiency

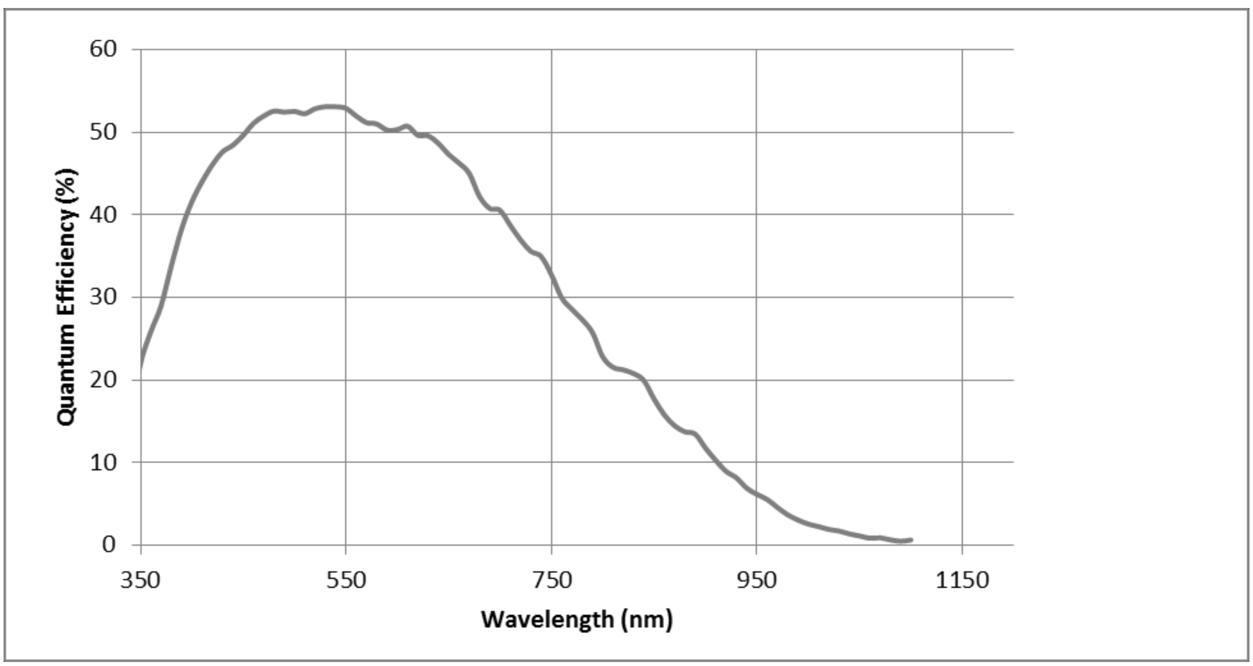


1.1.2 GZL-CL-41C6M (Mono) Imaging Performance

Specification	Mode 0
Full Well Depth	11900 e- at zero gain
Dynamic Range	56 dB
Read Noise	18.8 e- at zero gain
Measurements taken at maximum resolution	

Quantum Efficiency	
Peak QE Wavelength	530 nm
Peak QE Value	53%

Figure 1.2: GZL-CL-41C6 Quantum Efficiency



1.1.3 Gazelle Comparison

Figure 1.3: GZL-CL Mono Quantum Efficiency

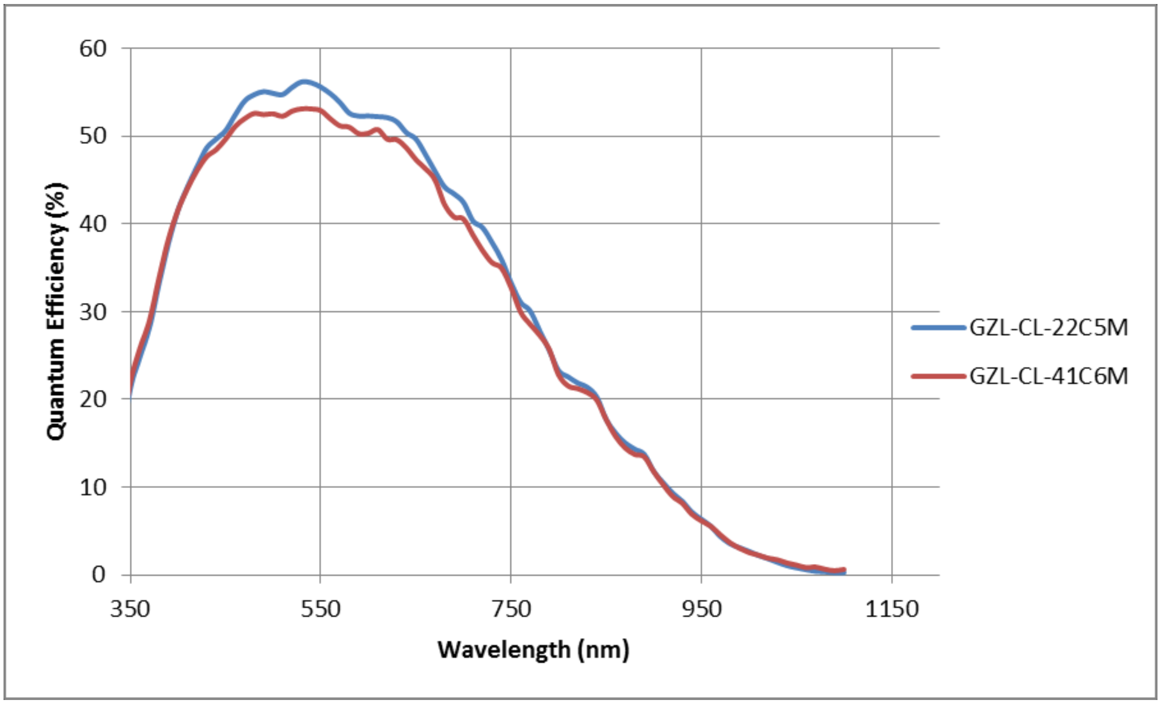
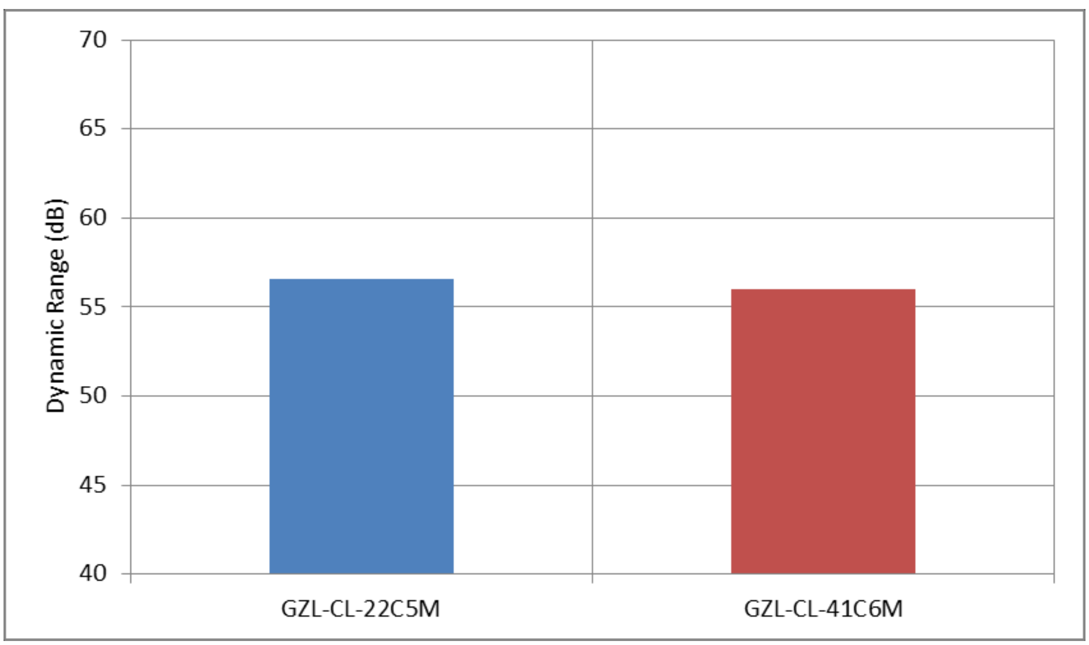
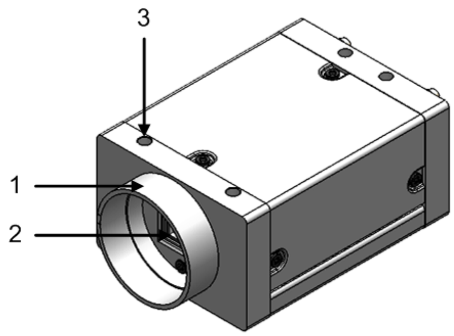


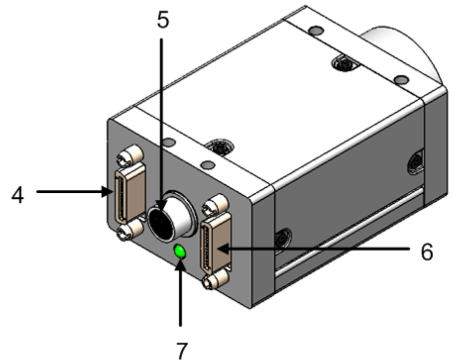
Figure 1.4: GZL-CL Mono Dynamic Range



1.2 Gazelle Mechanical Properties

1.2.1 Physical Description





1. **Lens holder (C-mount)**
   Attach any C-mount lens or other optical equipment. See Lens Mounting on next page.

2. **Glass/IR filter system**
   See Dust Protection on page 8 .

3. **M3 mounting holes**
   Configuration of M3 mounting holes is the same on the top and bottom of the camera case. See Mounting (page 9).

4. **FULL Camera Link connector**
   The camera uses a standard 26-pin SDR connector. M2 screwholes are located on either side of the connector for secure connection to the 26-pin locking Camera Link cable. Use this connector for the full configuration (with BASE connector). See Camera Link Connectors (page 10).

5. **General purpose I/O connector**
   The 8-pin GPIO connector is used for power, external triggering, and strobe output. See General Purpose Input/Output (GPIO) on page 13.

6. **BASE Camera Link connector**
   Use this connector for the base configuration (page 10).

7. **Status LED**
   This light indicates the current state of the camera operation. See Status Indicator LED (page 19).

1.2.2 Camera Dimensions

To obtain 3D models, contact support@ptgrey.com.

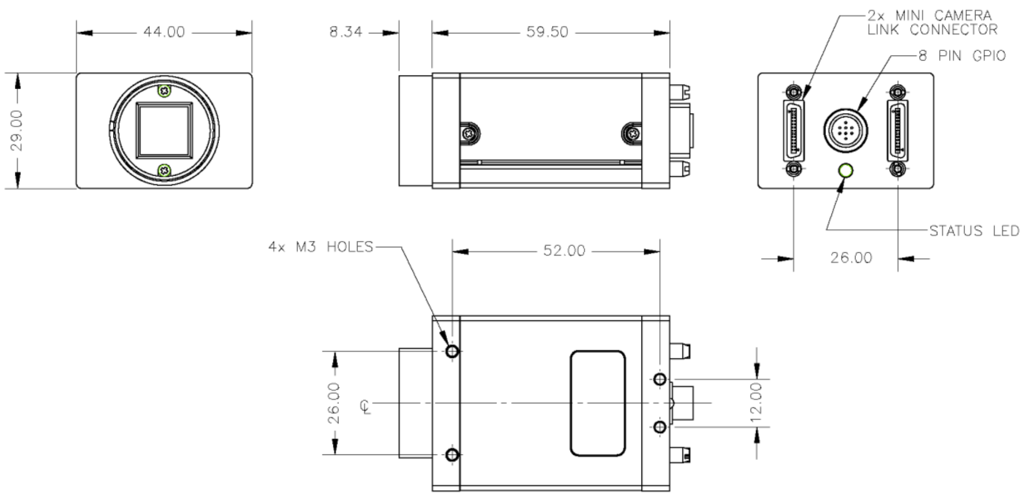


Figure 1.5: Camera Dimensional Diagram

1.2.3 Tripod Adapter Dimensions

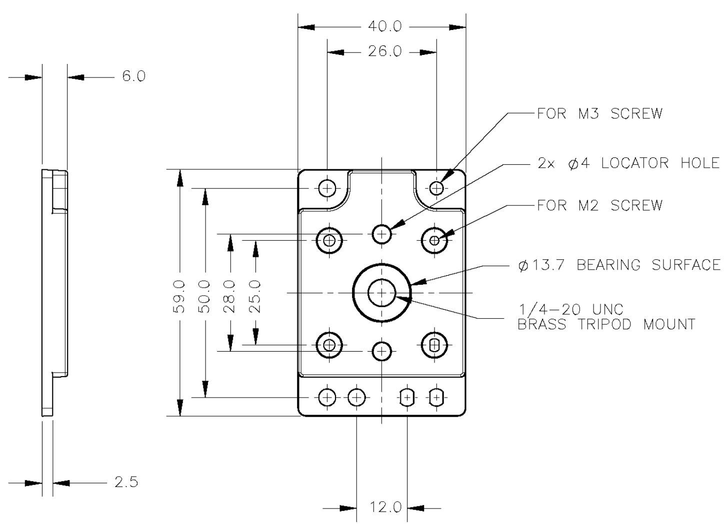


Figure 1.6: Tripod Adapter Dimensional Diagram

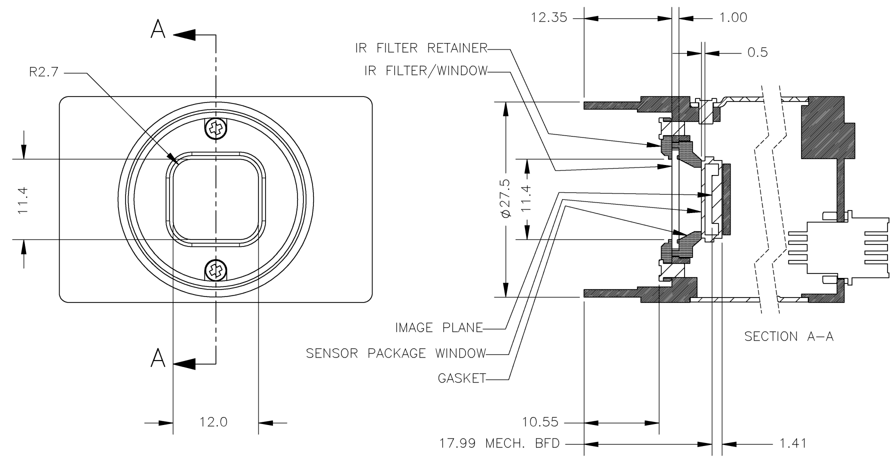
1.2.4 Lens Mounting

Lenses are not included with individual cameras.

Related Knowledge Base Articles

Title	Article
Selecting a lens for your camera	Knowledge Base Article 345

The lens mount is compatible with C-mount lenses. Correct focus cannot be achieved using a CS-mount lens on a C-mount camera.



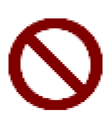
1.2.4.1 Back Flange Distance

The Back Flange Distance (BFD) is offset due to the presence of both a 1 mm infrared cutoff (IRC) filter and a 0.55 mm sensor package window. These two pieces of glass fit between the lens and the sensor image plane. The IRC filter is installed on color cameras. In monochrome cameras, it is a transparent piece of glass. The sensor package window is installed by the sensor manufacturer. Both components cause refraction, which requires some offset in flange back distance to correct.

The resulting BFD is 18.01 mm.

1.2.5 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 piece of clear glass (monochrome camera models) or an IR cut-off filter (color models) that sits above the surface of the sensor's glass. A removable plastic retainer keeps this glass/filter system in place. By increasing the distance between the imaging surface and the location of the potential dust particles, the likelihood of interference from the dust (assuming non-collimated light) and the possibility of damage to the sensor during cleaning is reduced.



- *Cameras are sealed when they are shipped. To avoid contamination, seals should not be broken until cameras are ready for assembly at customer's site.*
- *Use caution when removing the protective glass or filter. Damage to any component of the optical path voids the Hardware Warranty.*
- *Removing the protective glass or filter alters the optical path of the camera, and may result in problems obtaining proper focus with your lens.*

Related Knowledge Base Articles

Title	Article
Removing the IR filter from a color camera	Knowledge Base Article 215
Selecting a lens for your camera	Knowledge Base Article 345

1.2.6 Mounting with the Case or Mounting Bracket

Using the Case

The case is equipped with the following mounting holes:

- Four (4) M3x0.5mm mounting holes on the top of the case
- Four (4) M3x0.5mm mounting holes on the bottom of the case that can be used to attach the camera directly to a custom mount or to the tripod mounting bracket.

Using the Mounting Bracket

The tripod mounting bracket is equipped with four (4) M3 mounting holes. For more information, see Tripod Adapter Dimensions on page 7.

1.3 Analog-to-Digital Conversion

The camera sensor incorporates an on-chip analog to digital converter, configurable to 10-bit output. 10-bit conversion produces 1,024 possible values between 0 and 65,472. Image data is left-aligned across a 2-byte format. The least significant bits are always zero.

1.4 Handling Precautions and Camera Care

Do not open the camera housing. Doing so voids the Hardware Warranty described at the beginning of this manual.

Your Point Grey digital 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.

Related Knowledge Base Articles

Title	Article
Solving problems with static electricity	Knowledge Base Article 42
Cleaning the imaging surface of your camera	Knowledge Base Article 66

1.4.1 Case 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. This feature can be accessed using the Device Temperature command (page 20).

Table 1.1: Temperature Sensor Specifications

Accuracy	0.5°C
Range	-25°C to +85°C
Resolution	12 bits

As a result of packing the camera electronics into a small space, the outer case of the camera can become very warm to the touch when running in some high data rate video modes. This is expected behavior and will not damage the camera electronics.

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 case 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.

1.5 Camera Interface and Connectors

1.5.1 Camera Link Connectors

The camera is equipped with two 26-pin female 0.05 inch SDR connectors for video data and camera control and configuration. Pin assignments conform to the Camera Link specification. For reference, pin assignments for both connectors are provided below. For more information about RS-644 Serial Communication, see Serial Communication on page 38.

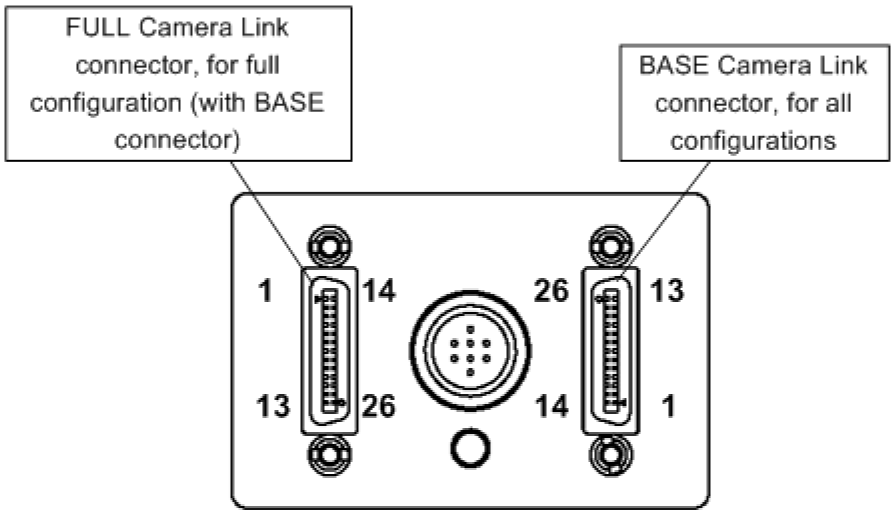


Figure 1.7: Camera Link connector pin numbering

Table 1.2: BASE Camera Link connector pin assignments

Pin Number	Signal	Direction	Level	Description
1	GND	In	Ground	Ground for inner shield of cable
2	XO-	Out	Camera Link LVDS	Data from Camera Link transmitter
3	X1-	Out	Camera Link LVDS	Data from Camera Link transmitter
4	X2-	Out	Camera Link LVDS	Data from Camera Link transmitter
5	XClk-	Out	Camera Link LVDS	Transmit clock from Camera Link transmitter
6	X3-	Out	Camera Link LVDS	Data from Camera Link transmitter
7	SerTC+	In	RS-644 LVDS	Serial to camera
8	SerTFG-	Out	RS-644-LVDS	Serial to frame grabber
9	CC1-	In	RS-644-LVDS	External trigger
10	CC2+	In	RS-644 LVDS	External clock (not supported)
11	CC3-	In	RS-644 LVDS	External flash
12	CC4+	In	RS-644 LVDS	Reserved
13	GND	In	Ground	Ground for inner shield of cable
14	GND	In	Ground	Ground for inner shield of cable
15	XO+	Out	Camera Link LVDS	Data from Camera Link transmitter
16	X1+	Out	Camera Link LVDS	Data from Camera Link transmitter
17	X2+	Out	Camera Link LVDS	Data from Camera Link transmitter
18	XClk+	Out	Camera Link LVDS	Transmit clock from Camera Link transmitter
19	X3+	Out	Camera Link LVDS	Data from Camera Link transmitter
20	SerTC-	In	RS-644 LVDS	Serial to camera
21	SerTFG+	Out	RS-644 LVDS	Serial to frame grabber
22	CC1+	In	RS-644 LVDS	External trigger

Pin Number	Signal	Direction	Level	Description
23	CC2-	In	RS-644 LVDS	External clock (not supported)
24	CC3+	In	RS-644 LVDS	External flash
25	CC4-	In	RS-644 LVDS	Reserved
26	GND	In	Ground	Ground for inner shield of cable

Table 1.3: FULL Camera Link connector pin assignments

Pin Number	Signal	Direction	Level	Description
1	GND	In	Ground	Ground for inner shield of cable
2	YO-	Out	Camera Link LVDS	Data from Camera Link transmitter
3	Y1-	Out	Camera Link LVDS	Data from Camera Link transmitter
4	Y2-	Out	Camera Link LVDS	Data from Camera Link transmitter
5	YClk-	Out	Camera Link LVDS	Transmit clock from Camera Link transmitter
6	Y3-	Out	Camera Link LVDS	Data from Camera Link transmitter
7	T+			Connected to T-; not used
8	Z0-	Out	Camera Link LVDS	Data from Camera Link transmitter
9	Z1-	Out	Camera Link LVDS	Data from Camera Link transmitter
10	Z2-	Out	Camera Link LVDS	Data from Camera Link transmitter
11	ZClk-	Out	Camera Link LVDS	Transmit clock from Camera Link transmitter
12	Z3-	Out	Camera Link LVDS	Data from Camera Link transmitter
13	GND	In	Ground	Ground for inner shield of cable
14	GND	In	Ground	Ground for inner shield of cable
15	YO+	Out	Camera Link LVDS	Data from Camera Link transmitter
16	Y1+	Out	Camera Link LVDS	Data from Camera Link transmitter
17	Y2+	Out	Camera Link LVDS	Data from Camera Link transmitter
18	YClk+	Out	Camera Link LVDS	Transmit clock from Camera Link transmitter
19	Y3+	Out	Camera Link LVDS	Data from Camera Link transmitter
20	T-			Connected to T+; not used
21	Z0+	Out	Camera Link LVDS	Data from Camera Link transmitter
22	Z1+	Out	Camera Link LVDS	Data from Camera Link transmitter
23	Z2+	Out	Camera Link LVDS	Data from Camera Link transmitter
24	ZClk+	Out	Camera Link LVDS	Transmit clock from Camera Link transmitter
25	Z3+	Out	Camera Link LVDS	Data from Camera Link transmitter
26	GND	In	Ground	Ground for inner shield of cable

1.5.2 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).

To purchase a compatible card from Point Grey, visit the Point Grey Webstore or the Products Accessories page.

1.5.3 Interface Cables

85 MHz-certified cables are required for the Camera Link connection between the camera and the host system. The maximum supported cable length is 5 meters.

Related Knowledge Base Articles

Title	Link
Which frame grabbers and cables can I use with my Camera Link camera?	Knowledge Base Article 359

To purchase a recommended cable from Point Grey, visit the Point Grey Webstore or the Products Accessories page.

1.5.4 Frame Grabbers

Point Grey provides camera configuration files (CCFs) for using the following Camera Link frame grabbers with Gazelle cameras:

- Aval Data APX-3318
- Dalsa Xcelera-CL PX4 Full
- BitFlow Karbon-CL

Related Resources

To find...	Go to...
CCFs for download	Point Grey downloads page

Related Knowledge Base Articles

Title	Article
Which frame grabbers and cables can I use with my Camera Link camera?	Knowledge Base Article 359

1.5.5 General Purpose Input/Output (GPIO)

The camera has an 8-pin GPIO connector on the back of the case; refer to the diagram below for wire color-coding. The connector is a Hirose HR25 8 pin connector (Mfg P/N: HR25-7TR-8SA). Male connectors (Mfg P/N: HR25-7TP-8P) can be purchased from Digikey (P/N: HR702-ND).

Table 1.4: GPIO pin assignments (as shown looking at rear of camera)

Diagram	Pin	Function	Description
	1	I0	Opto-isolated input (default Trigger in)
	2	O1	Opto-isolated output
	3	IO2	Input/Output/serial transmit (TX)
	4	IO3	Input/Output/serial receive (RX)
	5	GND	Ground for bi-directional IO, V_{EXT}, +3.3 V pins
	6	OPTO_GND	Ground for opto-isolated IO pins
	7	V_{EXT}	Allows the camera to be powered externally
	8	+3.3 V	Power external circuitry up to 150 mA

Power must be provided through the GPIO interface.

Point Grey sells a 12 V wall-mount power supply equipped with a HR25 8-pin GPIO wiring harness for connecting to the camera (**Part No. ACC-01-9006**). For more information, see the miscellaneous product accessories page on the Point Grey website.

For details on GPIO circuits, see GPIO Electrical Characteristics on page 56.

1.5.5.1 GPIO Modes

GPIO Mode 0: Input

When a GPIO pin is put into GPIO Mode 0 it is configured to accept external trigger signals. See Serial Communication on page 38.

GPIO Mode 1: Output

When a GPIO pin is put into GPIO Mode 1 it is configured to send output signals.

*Do **not** connect power to a pin configured as an output (effectively connecting two outputs to each other). Doing so can cause damage to camera electronics.*

GPIO Mode 2: Asynchronous (External) Trigger

When a GPIO pin is put into GPIO Mode 2, and an external trigger mode is enabled (which disables isochronous data transmission), the camera can be asynchronously triggered to grab an image by sending a voltage transition to the pin. See Asynchronous Triggering on page 30.

GPIO Mode 3: Strobe

A GPIO pin in GPIO Mode 3 will output a voltage pulse of fixed delay, either relative to the start of integration (default) or relative to the time of an asynchronous trigger. A GPIO pin in this mode can be configured to output a variable strobe pattern. See Programmable Strobe Output on page 36.

2 Getting Started with Gazelle

2.1 Before You Install

2.1.1 Will your system configuration support the camera?

Recommended System Configuration

Operating System	CPU	RAM	Video	Ports
XP, Vista, Windows 7	2.4 GHz (or equivalent)	512 MB	NVIDIAGeForce6 or later; 128 MB RAM or more	Camera Link PCIe card with Full CL interface

2.1.2 Do you have all the parts you need?

To install your camera you will need the following components:

- Camera Link cable (on page 13)
- 8-pin GPIO connector (on page 13)
- C-mount Lens (on page 7)
- Interface card (on page 13)

Point Grey sells a number of the additional parts required for installation. To purchase, visit the Point Grey Webstore or the Products Accessories page.

2.1.3 Do you have a downloads account?

The Point Grey downloads page has many resources to help you operate your camera effectively, including:

- Software, including CCFs (required for installation)
- Firmware updates and release notes
- Dimensional drawings and CAD models
- Documentation

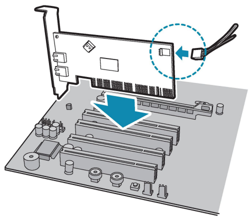
To access the downloads resources you must have a downloads account.

1. Go to the Point Grey downloads page.
2. Under **Register (New Users)**, complete the form, then click **Submit**.

After you submit your registration, you will receive an email with instructions on how to activate your account.

2.2 Installing Your Interface Card and Software

1. Install your Interface Card



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

Open the Windows Device Manager. Ensure the card is properly installed under the manufacturer's name or, in some cases, **Multifunction Adaptors**. An exclamation point (!) next to the card indicates the driver has not yet been installed.

2. Enable the driver for the card

If not already done so as part of the card installation, enable the driver for the card as per the manufacturer's instructions.

3. Install the Camera Configuration File for your Frame Grabber

a. Login to the Point Grey downloads page.

b. Select your **Gazelle** from the drop-down lists and click the **Search** button.

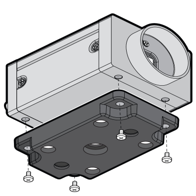
c. Click on the **Software** search results to expand the list.

d. Click on **Gazelle Camera Configuration Files** to begin the download.

e. From the download location, extract the zip files to a directory location of your choice.

2.3 Installing Your Camera

1. Install the Tripod Mounting Bracket

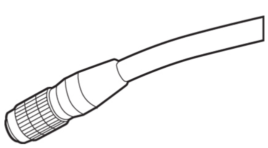


The ASA and ISO-compliant tripod mounting bracket attaches to the camera using the included screws.

2. Attach a Lens

Unscrew the dust cap from the C-mount lens holder to install a lens.

3. Plug in the GPIO connector

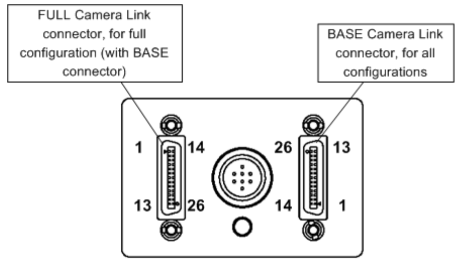


GPIO is used for power, trigger, serial input output, and strobe.

The wiring harness must be compatible with a Hirose HR25 8-pin female GPIO connector.

4. Connect the interface Card and Cable to the Camera

Plug the interface cable into the host controller card and the camera. The cable jack screws can be used for a secure connection.



For Base 2-tap configuration, use base connector. For Full 8-tap configuration, use both base and full connectors (two cables are required). Connectors are labelled on the camera.

5. Confirm Successful Installation

To operate the camera, start the serial interface tool for your frame grabber and reference the configuration files downloaded in Step 3 of Installing your Interface Card and Software. Control the camera using the software instruction set described in the Technical Reference Manual.

2.4 Controlling the Camera

The user can monitor or control features of the camera using a command set developed by Point Grey. These commands are used with the serial interface tool provided by your Camera Link frame grabber, and control the camera via a frame grabber-specific camera configuration file (CCF) that is downloaded during the camera installation process. For more information about CCFs, see Frame Grabbers on page 13.

Commands are introduced in this manual with the features they control. In some cases, examples of common usage are also provided. A complete list of commands is provided in Software Instruction Set on page 49.

Commands return an error when parameters are outside of allowable values. All errors begin with the string `Err:`

2.4.1 User Configuration Sets

The camera can save and restore settings and imaging parameters via on-board configuration sets, also known as memory channels. This is useful for saving default power-up settings, such as gain, shutter, video format and frame rate, and others that are different from the factory defaults.

Configuration set 0 stores the factory default settings. Two additional sets are provided for custom default settings.

The following property settings are saved in configuration sets:

Table 2.1: User configuration set properties

Number of taps (page 24)	Strobe delay (page 37)
Sensor input clock speed (page 42)	Strobe activation (page 37)
Gain (analog and digital) (page 41)	Chunk data and checksum embedding (page 43)
Exposure (page 40)	Pixel correction on/off (page 47)

Black level (page 42)	Test pattern mode (page 46)
Trigger source (page 31)	Height and vertical offset of all ROIs (page 28)
Trigger mode (page 31)	Width and horizontal offset of ROIs (page 28)
Trigger delay (page 33)	Sensor mode (page 25)
Trigger activation phase (page 33)	Reverse imaging (page 42)
Strobe mode (page 37)	

User Configuration Sets

Name	Description	Write
User Set Save	Saves the camera's current configuration to one of the three available user-configuration sets	memsave *value* *value* is 1 or 2
User Set Load	Loads a configuration set	memload *value* *value* is 0 (default), 1, or 2
User Set Current	Gets the currently-loaded configuration set	memcurr

3 General Camera Operation

3.1 Powering the Camera

The power consumption specification is: 12 V +/- 10%, 6 W.

Power must be provided through the GPIO interface. For more information, see General Purpose Input/Output (GPIO) on page 13.

Point Grey sells a 12 V wall-mount power supply equipped with a HR25 8-pin GPIO wiring harness for connecting to the camera (**Part No. ACC-01-9006**). For more information, see the miscellaneous product accessories page on the Point Grey website.

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 (n) images to get a satisfactory image, where n is undefined.

When the camera is power cycled (power disengaged then re-engaged), the camera will revert to its default factory settings, or if applicable, the last saved memory channel. For more information, see User Configuration Sets on page 17.

3.2 Camera Error and Status Monitoring

3.2.1 Status Indicator LED

The user can turn off the camera's status LED. LEDs are re-enabled the next time the camera is power cycled.

Table 3.1: LED During Camera Power-up and Operation

LED Status	Description
Off	Not receiving power
Orange	Initialization
Steady green	Receiving power and successful camera initialization
Slow flashing green	Streaming images or performing internal operation
Alternating red/green flashing	Firmware update in progress
Solid red	Input voltage is out of tolerance
Slow flashing red	Firmware initialization problem - contact technical support
Fast flashing red	General error - contact technical support

3.2.2 Camera Initialization

For information about power-up default settings, refer to the specifications tables (page 3). For information about powering-up to a user-defined configuration set, see Gets the currently-loaded configuration set on page 18.

Device Reset

Name	Description	Read	Write
Device Reset	Resets Device to Power Up State		dr
Initialization	Indicates if initialization is complete 0=Still in initialization 1=Complete	init	

3.2.3 General Status Monitoring

Use the following parameters to monitor the status of the camera.

Uptime Status—This reports the time, in seconds, since the camera was initialized during a hard power-up. This is different from powering up the camera, which will not reset this time.

Voltage—This allows the user to access and monitor the input as well as several of the internal voltages of the cameras.

Current—This allows the user to access and monitor the current consumption of the camera.

Temperature—Allows the user to get the temperature of the camera board-level components. For cameras housed in a case, it is the ambient temperature within the case. For more information about camera temperature, see Case Temperature and Heat Dissipation on page 10.

Status Monitoring

Name	Description	Read	Write
Voltage Status	Returns the internal and external voltage, in volts	vstat	
Current Status	Returns the electrical current, in amperes	cstat	
Uptime Status	Returns the time since the camera was last initialized, in hours:minutes:seconds	ustat	
Device Clock Frequency	Returns the frequency of the sensor input Clock, in hertz	dcf	dcf *value* *value* can be 40, 35, 30, 20, or 10MHz for 8-tap mode 10 MHz for 2-tap mode
Device Temperature	Returns the ambient temperature inside the camera case, in degrees Celsius	dt	

3.2.4 Device Information

Use the following to obtain information about the camera.

Device Information

Name	Description	Read
Device Vendor Name	Returns the Vendor Name	dvn
Device Model Name	Returns the Model Name	dvm
Device Firmware Version	Returns the Firmware Version	dfv
Device Firmware Build Date	Returns the Firmware build date	dbd
Device Hardware Version	Returns the hardware versions of the PCBs in the camera	dhv
Sensor Hardware Version	Returns the sensor model of the camera 0170FFFEh = CMOSIS CMV4000 0180FFFEh = CMOSIS CMV2000	shv
Device ID	Returns the Serial Number	did
Device Information	Gets the following camera information: Camera Model Camera Serial Number Firmware Version Firmware Build Date Baud Rate Analog Gain Digital Gain Trigger source Trigger Polarity Trigger Mode Trigger Delay Strobe width Strobe Mode Strobe Delay Strobe Activation ROIs Reverse Image Status Defect Pixel Correction status Current User Set Voltage Status Current Status Uptime Status Width Height OffsetX OffsetY Number of Taps Input Clock Exposure Black Level	dump

3.3 Non-Volatile Flash Memory

The camera has 4 MB of non-volatile memory for users to store data. Data must be written to individual pages in 528-byte data chunks.

Related Knowledge Base Articles

Title	Article
Storing data in on-camera flash memory	Knowledge Base Article 341

Non-Volatile Flash Memory

Name	Description	Read	Write
Flash Memory Size	Returns the following in order: Total size of flash memory Number of pages Page size	dfi	
Flash Memory Write	Writes a page to the flash memory		dfw *page_number num_bytes ASCII_string* *page_number* can be from 0 to 8191 *num_bytes* can e from 0 to 527 If the size of *ASCII_string* is more than 528 bytes, it is cut to 528 to fit the page size
Flash Memory Read	Reads a page from the flash memory	dfr page_number page_number can be from 0 to 8191	
Flash Memory Clear Page	Clears a page of the flash memory		dfw *page_number* 0 0 *page_number* can be from 0 to 8191
Flash Memory Clear All	Clears all the flash memory		dfclear

3.4 Camera Firmware

Firmware is programming that is inserted into the programmable read-only memory (programmable ROM) of most Point Grey 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.

Related Knowledge Base Articles

Title	Article
PGR software and firmware version numbering scheme/standards	Knowledge Base Article 96
Determining the firmware version used by a PGR camera	Knowledge Base Article 94
Should I upgrade my camera firmware or software?	Knowledge Base Article 225

3.4.1 Upgrading Camera Firmware

Camera firmware can be upgraded or downgraded to later or earlier versions using the UpdatorGUI program that is bundled with the FlyCapture SDK available from the Point Grey downloads site.

Before upgrading firmware:

- Install the SDK, downloadable from the Point Grey downloads site.
- Download the firmware file from the Point Grey downloads site.

Firmware Information

Name	Description	Read	Write
Device Firmware Version	Returns the Firmware Version	dfv	
Device Firmware Build Date	Returns the Firmware build date	dbd	
Update Mode	Puts the camera into firmware update mode		update

3 Video Data Output

3.1 GZL-CL-22C5 Video Data Output

# Taps	Bit Depth	Max Size (HxV)	Maximum Frame Rate at				
			Max Size	1280 x 960	640 x 480	320 x 240	160 x 120
8	8	2048x1088	281	319	630	1231	2347
2	10	2048x1088	71	80	160	319	630

3.2 GZL-CL-41C6 Video Data Output

# Taps	Bit Depth	Max Size (HxV)	Maximum Frame Rate at					
			Max Size	1600 x 1200	1280 x 960	640 x 480	320 x 240	160 x 120
8	8	2048x2048	149	253	315	618	1183	2183
2	10	2048x2048	37	64	80	160	318	630

3.3 Setting the Video Format and Frame Rate

The number of Camera Link taps for video output dictates the data format and frame rate in which the camera operates, per the tables above. The number of Camera Link taps can be changed dynamically without power-cycling the camera.

Setting Video Format

Name	Description	Read	Write
Video Format	Gets or sets the video format. Can be set to 2-tap, 8-tap, 8-tap 10-bit, or bin2x2. (2x binning is only available in base 2-tap mode)	smod	smod *value* *value* is 2tap, 8tap, 8tap10bit, bin2x2

3.3.1 Sensor Mode Pixel Binning

When operating in base 2-tap mode, the camera can implement 2x2 pixel binning, which occurs digitally after sensor readout, on the FPGA of the camera. In this configuration, the values of two adjacent pixels are aggregated and averaged, both vertically and horizontally, resulting in a resolution that is both half in width and half in height of the original video output. Pixel binning can be implemented in conjunction with regions of interest (page 25).

The primary benefit of pixel binning is an increase in frame rate in 2-tap mode. When binning is implemented, the sensor input clock can run up to twice as fast as in non-binning mode, resulting in a frame rate also up to twice as fast. Because pixel values are averaged after aggregation, there is no significant increase in image intensity.

Sensor Mode Pixel Binning

Name	Description	Read	Write
Sensor Mode (Pixel Binning mode)	Gets or sets the sensor mode to 2x binning (only available in base 2-tap mode)	smod	smod bin2x2

3.3.2 Specifying 8-Tap 10-Bit Output

Unless identified as 8-tap 10-bit, references to 8-tap throughout this document mean 8-tap 8-bit.

The camera can output 10 bits/pixel in full 8-tap configuration. This mode is not supported by the Camera Link standard and requires users to implement custom software to decode data on the PC for outputting images.

In this mode, four contiguous horizontal pixels contain the eight most significant bits (MSB) of their respective pixels. Every fifth pixel contains the two least significant bits (LSB) of the previous four pixels, effectively increasing image output width by 25%. The bit format of every fifth pixel is as follows:

Bits of every 5th pixel	Description
0 - 1	LSBs of 4th pixel
2 - 3	LSBs of 3rd pixel
4 - 5	LSBs of 2nd pixel
6 - 7	LSBs of 1st pixel

To output 8-tap 10-bit data, you must increase image width on the frame grabber by 25%. Assuming no ROI is specified, width should be increased to 2560. Frame grabber output will appear corrupted unless user-defined post-processing is performed on the PC. After processing, image width at full resolution should be 2048.

Video Format 8-tap 10-bit

Name	Description	Read	Write
Video Format (8-tap 10-bit mode)	Gets or sets the video format to 8-tap 10-bit	smod	smod 8tap10bit

3.4 Specifying Regions of Interest

You can specify subsets of the sensor pixel array, or 'regions of interest (ROIs),' for transmitting images. Regions of interest allow you to limit the amount of image data that is sampled and transmitted, and may increase frame rate.

When specifying regions of interest, keep in mind the following:

- Vertical offset and height are configurable in increments of one pixel row. Horizontal offset and width are configurable in multiples of eight pixel columns.

- Reducing the number of rows is performed on the image sensor, prior to image readout. Reducing image width is performed on the FPGA of the camera. As a result, a frame rate increase may be achieved by reducing image height. No frame rate increase is achieved by reducing image width.
- Vertical and horizontal offsets are measured from pixel (0,0) in the image array.
- Dynamically setting or changing ROI configuration does not require stopping and re-starting image acquisition, or produce any latency in frame rate.
- To maximize frame rate, exposure adjusts dynamically when ROIs are set or changed. For more information about exposure, see (page 40).
- ROI settings are saved in user configuration sets. For more information, see (page 18).
- ROI information can be saved in chunk data. For more information, see (page 43).

3.4.1 Specifying Multiple ROIs

The camera supports up to eight ROIs within the larger pixel array. Multiple ROIs have different vertical offsets, but only one width and horizontal offset can be set for all ROIs. The camera joins multiple ROIs to form a single image, which is transmitted to the frame grabber in a single frame readout cycle. Imaging parameters, such as exposure, gain and black level, are applied equally to all ROIs.

3.4.2 Calculating Frame Rate

Using the following formulas, you can calculate frames per second based on sensor input clock speed (page 42) and image height.

Due to the Camera Link standard for processing Frame Valid and Line Valid bits of LVDS data channels,actual frame rates may be slower than calculated frame rates.

The formula for calculating frame rate is:

Frame Rate = 1 / (Frame Overhead Time + Readout Time)

GZL-CL-41C6

Sensor Input Clock (MHz)	FOT (µs)	Readout Time (µs)
40	70.95	(129 / 40) x height
35	81.08	(129 / 35) x height
30	94.60	(129 / 30) x height
20	141.90	(129 / 20) x height
10	38.70	(129 / 10) x height

GZL-CL-41C6 Example:

For a camera operating at 40 MHz with an image size of 2048 x 2048, the frame rate would be:

Frame rate = 1 / (FOT + Readout Time)
= 1 / [70.95 + ((129/40) x 2048)]
= 1 / [70.95 + (3.225 x 2048)]
= 1 / [70.95 + 6604.8]
= 1 / 6675.75µs

= 1 / 0.00667575 seconds
= 149.79 FPS

GZL-CL-22C5

Sensor Input Clock (MHz)	FOT (µs)	Readout Time (µs)
40	38.70	(129 / 40) x height
35	44.23	(129 / 35) x height
30	51.60	(129 / 30) x height
20	77.40	(129 / 20) x height
10	38.70	(129 / 10) x height

GZL-CL-22C5 Example:

For a camera operating at 40 MHz with an image size of 2048 x 1088, the frame rate would be:

Frame rate = 1 / (FOT + Readout Time)
= 1 / [38.70 + ((129/40) x 1088)]
= 1 / [38.70 + (3.225 x 1088)]
= 1 / [38.70 + 3508.8]
= 1 / 3547.5µs
= 1 / 0.0035475 seconds
= 281.89 FPS

3.4.3 Creating ROIs

Use the following commands when creating ROIs.

Regions of Interest (ROI)

Name	Description	Read	Write
Width	Gets or sets the image width (Returns zero if no ROIs are present) Width must be specified before horizontal offset.	w	w *value* *value* is in pixel columns and is measured from the specified horizontal offset; it must be a multiple of 8
OffsetY, Height	Gets or sets the vertical offset and height of current ROIs. (Returns zero if no ROIs are present) To specify more than one ROI, use multiple *setroi* commands. *ROI_number* and *y-offset* must vary between ROIs	getroi	setroi *ROI_number y_offset height* *ROI_number* can be from 0 to 7, specifying one of eight allowable ROIs *y_offset* is the starting row of the ROI on the y-axis, measure from pixel row 0 at the top of the image *height* specifies how many rows of pixels are sampled, beginning from the *y-offset*

Name	Description	Read	Write
OffsetX	Gets or sets the horizontal offset of the image from the left side of the pixel array. (Returns zero if no ROIs are present) The combination of horizontal offset and width must not exceed sensor width.	ox	ox *offset* *offset* is the starting column of the ROI on the x-axis, measured from pixel column 0 at the left of the image; it must be a multiple of 8
Sensor Width	Returns the total width of the sensor, in pixels	sw	
Sensor Height	Returns the total height of the sensor, in pixels	sh	
Remove ROI	Removes an ROI or returns the camera to non-ROI operation. Removing a subset of ROIs results in the camera sampling and transmitting any remaining ROIs. If all ROIs are removed, the camera stops using ROIs and returns to sampling and transmitting the entire pixel array		rstroi *ROI_number* *ROI_number* is a previously set ROI using the *setroi* command. Removing an ROI does not affect the *ROI_number* value of any remaining ROIs

Regions of interest must be removed, then re-created, when changing video output format, including number of taps (page 24) or between binning and non-binning (page 24), or when changing ROI height.

Best practice: If creating a single ROI, specify `ROI_number` = 0. If creating multiple ROIs, number them sequentially from the top-most ROI, beginning with `ROI_number` =0.

3.4.4 Example: Specifying Regions of Interest

The figure below shows three regions of interest specified within the 2048 x 2048 pixel array of the GZL-CL-41C6: ROI_0, ROI_1 and ROI_2. ROI_0 is offset vertically by 300 pixels, and is 374 pixels in height. ROI_1 is offset vertically by 874 pixels and is 300 pixels in height. ROI_2 is offset vertically by 1374 pixels and is 374 pixels in height. The ROIs are offset horizontally by 648 pixels, and are 752 pixels wide.

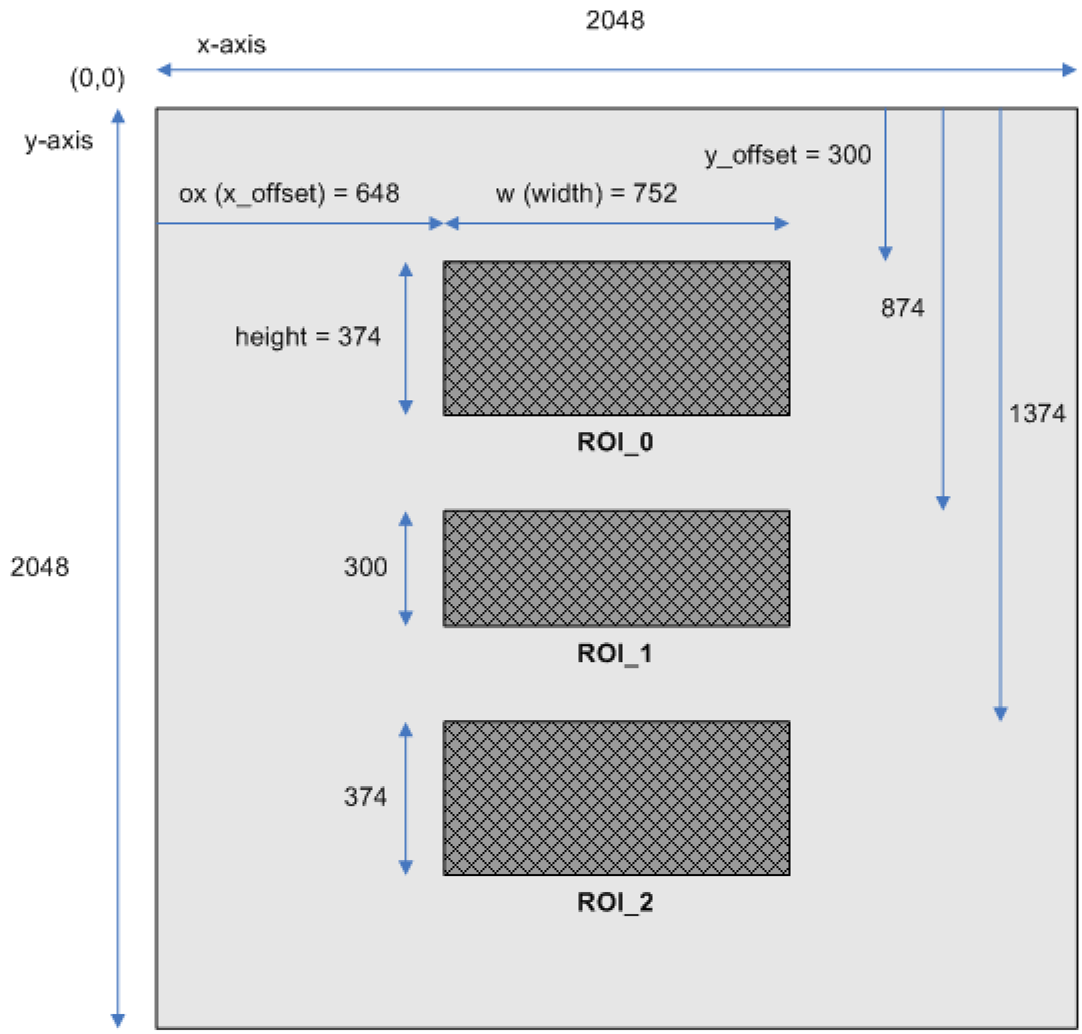


Figure 3.1: Example ROI configuration on GZL-CL-41C6

The following are the commands for achieving this ROI configuration:

```
setroi 0 300 374
setroi 1 874 300
setroi 2 1374 374
w 752
ox 648
```

4 Image Acquisition

4.1 Free-Running Acquisition

When image capture is not controlled by a triggering mechanism, the camera captures and transmits image data continuously, based on the specified frame rate. For information, see Setting the Video Format and Frame Rate on page 24. When exposure is increased beyond what the specified frame rate can sustain, the frame rate is lowered dynamically. For information about exposure, see Exposure on page 40.

Image Acquisition

Name	Description	Read	Write
Acquisition Start	Starts Image Acquisition		astart
Acquisition Stop	Stops Image Acquisition		astop

4.2 Asynchronous Triggering

The camera supports asynchronous triggering, which allows the start of exposure (shutter) to be initiated by an external electrical source (hardware trigger) or from an internal software mechanism (software trigger).

External triggers can be sourced through one of the RS-644 LVDS Camera Control (CC) signals on the Camera Link connectors, or a GPIO pin. For information about the Camera Link connectors, see Camera Link Connectors on page 10. For information about the GPIO interface, see General Purpose Input/Output (GPIO) on page 13.

Gazelle Supported Trigger Modes		
Model	**Mode**	**More Information**
All	Single Shot	page 33
All	Bulb Shutter	page 34

GZL-CL-22C5 and GZL-CL-41C6 models implement different exposure timing mechanisms between free-running and asynchronous trigger modes. As a result, images may appear over-exposed when switching to trigger mode. To fix, lower the gain or exposure settings. For more information, see Gain on page 41 or Exposure on page 40. Additionally, achievable frame rates may decrease. To fix, lower the exposure setting. To maximize frame rate when operating these models in trigger mode, we recommend raw exposure values of 100 or less.

Triggering

Name	Description	Read	Write
Trigger Source	Gets or sets the source from which to accept an incoming trigger	trsrc	trsrc *source* *source* may be: soft—Software trigger line1—Camera Control 1 (CC1) line2—Camera Control 2 (CC2) line3—Camera Control 3 (CC3) line4—Camera Control 4 (CC4) GPIO0—Opto-isolated GPIO input pin
Trigger Mode	Gets or sets the trigger acquisition mode	trm	trm *mode* *mode* is single, bulb, freerun, or none. (Both *freerun* and *none* put the camera in a free running state, but *freerun* may limit maximum frame rate. See Horizontal Line Artifact on page 47 for more information.)
Trigger Software	Fires a software trigger		trgsoft

4.2.1 Triggering off the GPIO

This example puts the camera into synchronized exposure mode by starting exposure from the falling edge of a trigger that originates from the camera's opto-isolated GPIO pin (GPIO0). Single-shot mode is specified, which means exposure lasts for the duration to which it is set, in this case a raw value of 10, or 10.32 µs (Full 8-tap configuration, 40 MHz input clock):

```
trsrc GPIO0
eraw 10
tra fe
trm single
```

4.2.2 Software triggering

This example puts the camera into synchronized exposure mode by starting exposure from a software trigger. Single-shot mode is specified, with a raw exposure value of 100, or 393.45 µs (full configuration, 40 MHz input clock). The example finishes by invoking a software trigger, which results in one frame capture.

```
trsrc soft
eraw 100
trm single
trgsoft
```

4.2.3 Maximum Frame Rates When Triggering

The following are the camera's maximum achievable frame rates in asynchronous trigger mode, full 8-tap configuration, and exposure set to the minimum allowable value when triggering (eraw = 5).

Table 4.1: Maximum Frame Rates in Trigger Mode

Camera	Trigger Mode	Maximum Frames per Second
GZL-CL-22C5	Single shot	265
	Bulb shutter	266
GZL-CL-41C6	Single shot	142
	Bulb shutter	142

If exposure is set to higher than image readout rate * image height, frame rate decreases dynamically. To determine readout rate, see Trigger Modes on next page. For information about setting exposure, see Exposure on page 40.

4.2.4 Trigger Delay

You can specify a delay from when a trigger signal is detected by the camera to when the trigger actually fires and initiates image acquisition.

To convert from raw values to seconds, use one of the following formulas, depending on current number of taps for output (page 24) and sensor input clock speed (page 42).

- *Full 8-tap configuration*:

40 MHz (default)

((2^12 * *raw_value*) / 40e6) + 0.00007095

30 MHz

((2^12 * *raw_value*) / 30e6) + 0.0000946

20 MHz

((2^12 * *raw_value*) / 20e6) + 0.0001419

10 MHz

((2^12 * *raw_value*) / 10e6) + 0.0002838

- *Base 2-tap configuration*:

((2^12 * *raw_value*) / 10e6) + 0.0000903

Trigger Delay

Name	Description	Read	Write
Trigger Delay Raw	Gets or sets the delay from when the trigger signal is detected to when the trigger fires and initiates image acquisition	trdraw	trdraw *value* *value* is in raw (non-absolute) terms
Trigger Delay Minimum	Gets the minimum image acquisition delay available in the current video mode	trdraw gmin	
Trigger Delay Maximum	Gets the maximum image acquisition delay available in the current video mode	trdraw gmax	

4.2.5 Trigger Polarity

You can specify the rising or falling edge of the trigger phase that activates image acquisition.

Trigger Polarity

Name	Description	Read	Write
Trigger Activation	Gets or sets the trigger phase that activates image acquisition	tra	tra *phase* *phase* is re (rising edge) or fe (falling edge)

4.2.6 Trigger Modes

4.2.6.1 Single-Shot Trigger Mode

In single-shot trigger mode, the camera starts exposure of the incoming light from external trigger input falling/rising edge. Exposure time is user-configurable (see Exposure on page 40.) The camera can be triggered in this mode using the Camera Link camera control lines, the opto-isolated GPIO pin, or internally (software trigger). For information about maximum frame rates while triggering, see Maximum Frame Rates When Triggering on previous page.

To configure trigger delay, see Trigger Delay on previous page. If no additional delay is explicitly configured, the delay between the trigger signal and exposure is 45 ns.

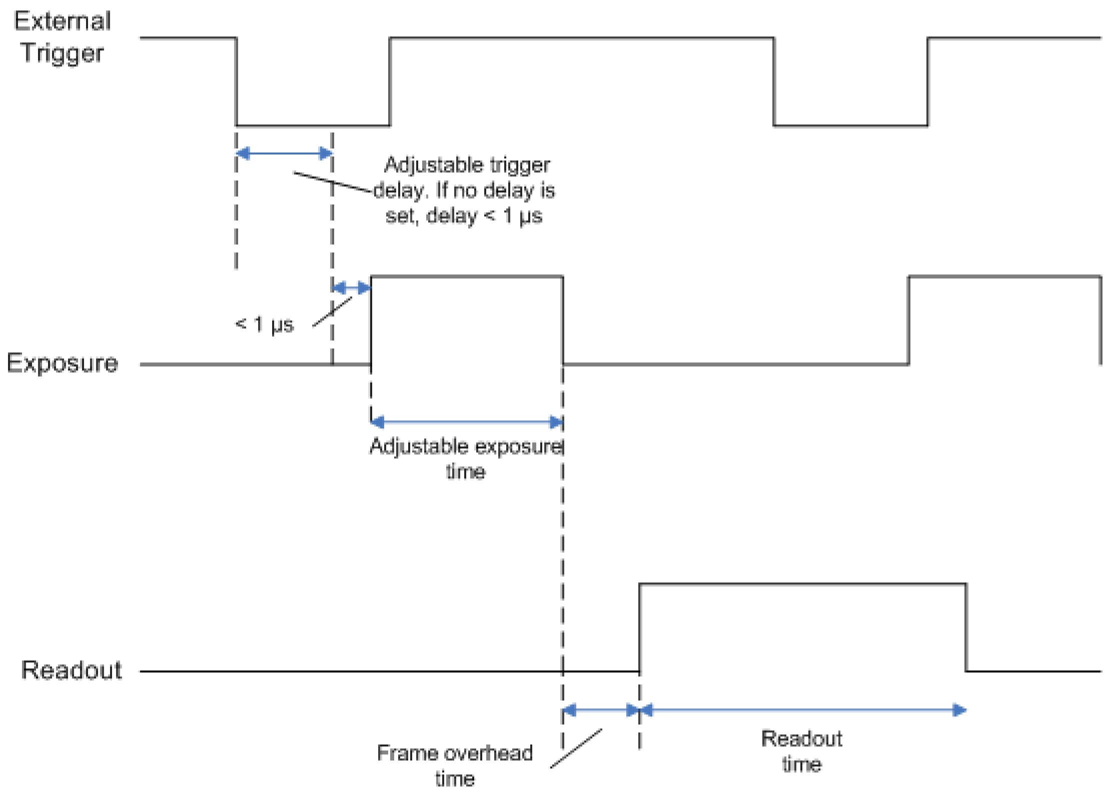


Figure 4.1: Single-Shot Trigger Timing

Values for Frame Overhead Time and Readout Rate vary by current sensor input clock speed (page 42) and video data output mode (page 24), as follows:

Full 8-tap configuration

Sensor Input Clock Speed (MHz)	Frame Overhead Time (µs)	Readout Rate (µs/line)
40	70.95	3.2
30	94.60	4.27
20	141.9	6.4
10	38.7	12.8

Base 2-tap configuration

Sensor Input Clock Speed (MHz)	Frame Overhead Time (µs)	Readout Rate (µs/line)
20 (binning mode)	141.9	6.4
10 (non-binning mode)	38.7	12.8

4.2.6.2 Bulb Shutter Trigger Mode

In bulb shutter mode, the camera starts exposure from the external trigger edge. Exposure time is equal to the low state time of the external trigger input. For information about maximum frame rates while triggering, see Maximum Frame Rates When Triggering on page 32.

To configure trigger delay, see Trigger Delay on page 32. If no additional delay is explicitly configured, the delay between the trigger signal and exposure is 45 ns.

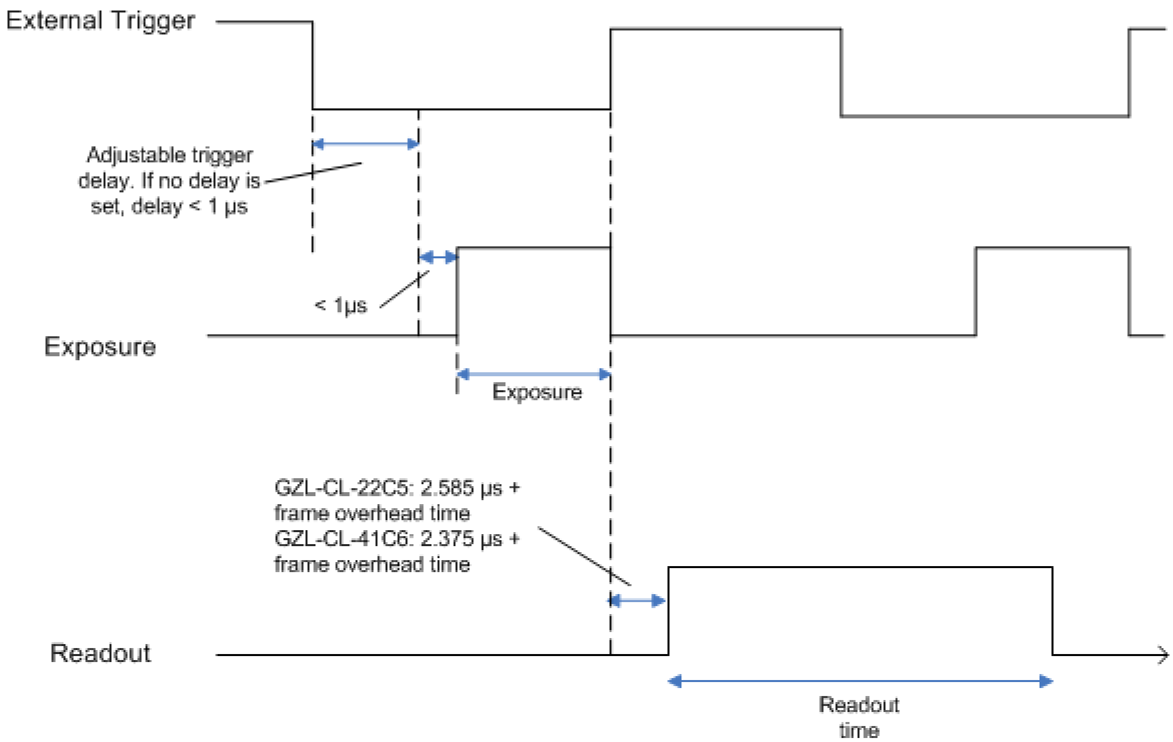


Figure 4.2: Bulb Shutter Trigger Timing

Values for Frame Overhead Time and Readout Rate vary by current sensor input clock speed (page 42) and video data output mode (page 24), as follows:

Full 8-tap configuration

Sensor Input Clock Speed (MHz)	Frame Overhead Time (µs)	Readout Rate (µs/line)
40	70.95	3.2
30	94.60	4.27
20	141.9	6.4
10	38.7	12.8

Base 2-tap configuration

Sensor Input Clock Speed (MHz)	Frame Overhead Time (µs)	Readout Rate (µs/line)
20 (binning mode)	141.9	6.4
10 (non-binning mode)	38.7	12.8

4.2.7 Minimum Trigger Pulse Length

A digital signal debouncer helps to ensure that the camera does not respond to spurious electrical signals that are shorter than 16 ticks of the current sensor input clock setting (page 42). This safeguard results in a minimum 16-tick delay before the camera responds to a trigger signal.

4.3 Programmable Strobe Output

The camera is capable of outputting a strobe pulse off select GPIO pins that are configured as outputs. The start of the strobe can be offset from either the start of exposure (free-running mode) or time of incoming trigger (external trigger mode). By default, a pin that is configured as a strobe output will output a pulse each time the camera begins integration of an image.

The duration of the strobe can also be controlled. Setting a strobe duration value of zero produces a strobe pulse with duration equal to the exposure (shutter) time.

Multiple GPIO pins, configured as outputs, can strobe simultaneously.

Connecting two strobe pins directly together is not supported. Instead, place a diode on each strobe pin.

The camera can also be configured to output a variable strobe pulse pattern. The strobe pattern functionality allows users to define the frames for which the camera will output a strobe. For example, this is useful in situations where a strobe should only fire:

- Every Nth frame (e.g. odd frames from one camera and even frames from another); or
- N frames in a row out of T (e.g. the last 3 frames in a set of 6); or
- Specific frames within a defined period (e.g. frames 1, 5 and 7 in a set of 8)

On GZL-CL-41C6 models, strobe output is not available when raw exposure value is set to 35 or lower. To adjust exposure, see *Exposure on page 40**.*

Related Knowledge Base Articles

Title	Article
Buffering a GPIO pin strobe output signal using an optocoupler to drive external devices	Knowledge Base Article 200
GPIO strobe signal continues after isochronous image transfer stops	Knowledge Base Article 212
Setting a GPIO pin to output a strobe signal pulse pattern	Knowledge Base Article 207

Programmable Strobe Output

Name	Description	Read	Write
Strobe Activation	Specifies whether the strobe active state is low or high, or if no signal is output at all	sta	sta *mode* *mode* is high, low, or off (default)
Strobe Source	Specifies the strobe output type	stsrc	stsrc *source* *source* may be: high—The strobe signal is always high low—The strobe signal is always low duration—The strobe signal lasts for the duration of exposure. Signal polarity depends on the setting of the sta command trigger—The strobe signal lasts for the duration of a high input trigger signal. The trigger input can be from either the GPIO or a Camera Control (CC) Camera Link line. Signal polarity depends on the setting of the sta command. user—The strobe signal duration is defined using the stw command below. Signal polarity depends on the setting of the sta command.
Strobe Width	Specifies a user-defined duration for the strobe signal. Note that the stsrc command must be set to user.		stw *value* *value* is in raw (non-absolute) terms. To convert the raw value to microseconds, multiply by 0.12
Strobe Delay	Specifies that the strobe output signal be delayed by a period of time.		std *value* *value* is in raw (non-absolute) terms. To convert the raw value to microseconds, multiply by 0.12

Strobe Source 'duration' cannot be specified if the camera is operating in bulb shutter trigger mode (page 34). To synchronize the strobe signal with exposure in bulb shutter trigger mode, use 'trigger'.

4.3.1 Strobe Output Examples

4.3.1.1 Outputting a continuous strobe

This example puts the camera into an active high strobe state, and outputs a continuous high strobe signal:

```
sta high
stsrc high
```

4.3.1.2 Outputting a strobe for duration of exposure

This example puts the camera into an active high strobe state, and outputs a high strobe signal for the duration of exposure:

```
sta high
stsrc duration
```

4.3.1.3 Outputting a strobe for duration of trigger signal

This example puts the camera into active high strobe state, and outputs a high strobe signal for the duration of the trigger signal:

```
sta high
stsrc trigger
trsrc GPIO0
trm single
```

4.3.1.4 Outputting a strobe for a specified duration, after a specified delay

This example puts the camera into active high strobe state, and outputs a high strobe signal at the start of a trigger signal plus a specified delay period, and lasts for a specified duration. The delay period is specified as a raw value of 10, or 10.32 µs (full configuration, 40 MHz input clock). The duration is specified as a raw value of 100, or 393.45 µs (full configuration, 40 MHz input clock):

```
sta high
stsrc trigger
stw 100
std 10
trsrc GPIO0
trm single
```

4.4 Serial Communication

The camera supports RS-644 serial communication via the serial connection (SerTC/SerTFG) signals in the Camera Link interface. The default baud rate of the serial port is 9600 bit/s. For more information about the Camera Link interface, see Camera Link Connectors on page 10.

Related Knowledge Base Articles

Title	Article
Configuring and testing the RS-232 serial port	Knowledge Base Article 151

SIO Buffers

Both the transmit and receive buffers are implemented as circular buffers that may exceed the 255 byte maximum.

- The transmit buffer size is 512 B.
- The receive buffer size is 8 KB.

Block reads and writes are both supported. Neither their length nor their address have to be 32-bit aligned or divisible by 4.

Serial Communication: Device Baud Rate

Name	Description	Read	Write
Device Baud Rate	Gets or sets the speed (baud rate) of the serial communications port, in bit/s	dbr	dbr *value* *value* can be 9600, 19200, 57600, 115200, or 230400

5 Imaging Parameters and Control

5.1 Exposure

Exposure, or integration, refers to the amount of time the shutter stays open. The shutter is the camera mechanism that controls exposure to light on the sensor for each frame.

The exposure range is a 24-bit register. The range of values is from 1h - FFFFFFh. For factory default settings, refer to the specifications tables for each model (page 3).

If the exposure time is changed after placing the camera in asynchronous trigger mode, the exposure time will automatically revert to its previous value after the camera is taken out of trigger mode. For more information about trigger mode, see Asynchronous Triggering on page 30.

When operating in trigger mode, the minimum allowable exposure value is 5. For more information about trigger modes, see Asynchronous Triggering on page 30.

Exposure (Shutter)

Name	Description	Read	Write
Exposure Time Raw	Gets or sets the exposure time	eraw	eraw *value* *value* is in raw (non-absolute) terms
Exposure Time Minimum	Gets the minimum exposure time available in the current video mode	eraw gmin	
Exposure Time Maximum	Gets the maximum exposure time available in the current video mode	eraw gmax	

To convert from raw values to seconds, use one of the following formulas, depending on current image acquisition mode (either free-running or synchronized exposure (page 30)), number of taps for output and sensor input clock speed:

Free-running mode:

- *Full 8-tap configuration*:

40 MHz (default)

((*raw_value* * 129) / 40e6) + 0.00007095

30 MHz

((*raw_value* * 129) / 30e6) + 0.0000946

20 MHz

((*raw_value* * 129) / 20e6) + 0.0001419

10 MHz

Synchronized Exposure (Trigger) mode:

- *Full 8-tap configuration*:

40 MHz (default)

((2^12 * *raw_value*) / 40e6) + 0.00007095

30 MHz

((2^12 * *raw_value*) / 30e6) + 0.0000946

20 MHz

((2^12 * *raw_value*) / 20e6) + 0.0001419

10 MHz

((*raw_value* * 129) / 10e6) + 0.0002838

- *Base 2-tap configuration*:
((*raw_value* * 129) / 10e6) + 0.0000903

((2^12 * *raw_value*) / 10e6) + 0.0002838

- *Base 2-tap configuration*:
((2^12 * *raw_value*) / 10e6) + 0.0000903

5.2 Gain

Gain refers to the amount of amplification applied to the image pixels. The camera supports configuring both analog and digital gain. In the imaging data path, analog gain is applied before digital gain. Both analog and digital gain values are saved in user configuration sets (page 18).

5.2.1 Analog Gain

Analog gain is configurable in raw values between 32 and 64. A formula for converting raw values to dB is not available. The default analog gain setting is factory-calibrated for each camera based on the default exposure setting.

The combination of analog gain and exposure time (page 40) impact imaging performance. In general, longer exposure times require a higher analog gain for the sensor to achieve full saturation.

5.2.2 Digital Gain

Digital gain multiplies pixel values. The allowable range of multipliers is 1 to 63.

Gain

Name	Description	Read	Write
Analog Gain Raw	Gets or sets the sensor analog gain	agraw	agraw *value* *value* is in raw (non-absolute) terms, between 32-64
Analog Gain Minimum	Gets the minimum sensor analog gain	agraw gmin	
Analog Gain Maximum	Gets the maximum sensor analog gain	agraw gmax	
Digital Gain Raw	Gets or sets the sensor digital gain	graw	graw *value* *value* is in raw (non-absolute) terms, between 1-64
Digital Gain Minimum	Gets the minimum sensor digital gain	graw gmin	
Digital Gain Maximum	Gets the maximum sensor digital gain	graw gmax	

5.3 Black Level

Brightness, also known as offset or black level, controls the level of black in an image.

Black level is a digital value added to the existing pixel value after analog to digital conversion.

Black Level (Brightness)

Name	Description	Read	Write
Black Level	Gets or sets the sensor black level	blraw	blraw *value* *value* is in raw (non-absolute) terms, between 0-950 The default setting is 10.
Black Level Minimum	Gets the minimum sensor black level	blraw gmin	
Black Level Maximum	Gets the maximum sensor black level	blraw gmax	

5.4 Sensor Input Clock

The sensor input clock controls the rate at which pixel data is acquired by the imaging sensor. In full 8-tap configuration, the input clock runs at a default rate of 40 MHz. You can configure the sensor input clock to run at 35 MHz, 30 MHz, 20 MHz, or 10 MHz. Configuring the sensor input clock at any other setting is not supported. Exposure and frame rate are affected by the pixel clock, so slowing the pixel clock is an alternative way to regulate these properties.

In base 2-tap configuration, the input clock runs at a default rate of 10 MHz, and 20 MHz in pixel binning mode (page 24). Setting the pixel clock speed at any other rate in base configuration is not supported.

Sensor Input Clock

Name	Description	Read	Write
Device Clock Frequency	Gets or sets the frequency of the sensor input Clock, in hertz	dcf	dcf *value* *value* can be 40, 35, 30, 20, or 10MHz for 8-tap mode 10 MHz for 2-tap mode

5.5 Image Flip/Mirror

The camera supports reverse imaging, otherwise known as image mirroring or image flipping. When images are reversed, pixel values are flipped along the x (horizontal) center axis of the image, y (vertical) center axis, or both. Reverse imaging is compatible with regions of interest (ROIs) (page 25).

Image Flipping

Name	Description	Read	Write
Reverse Image	Flips the image horizontally, vertically, or both	ri	ri *value* *value* is one of the following: 0—Images are vertically reflected along the y center axis 1—Images are vertically and horizontally reflected along both the x and y axes 2—Original image orientation (default) 3—Images are horizontally reflected along the x center axis

5.6 Chunk Data

The camera provides a feature that allows image information and camera settings, such as checksum, frame counter, region of interest (ROI) and other settings, to be embedded in images. When this feature is enabled, the last pixels of the last line in an image are replaced with 'chunk data' that contain binary values for the information requested. The size of each chunk depends on the data item. Refer to the table below for a list of items in the order they are embedded and the number of pixels each item comprises. In 10-bit per pixel mode, the two left-most bits of the pixel are padded with zeros.

Table 5.1: Chunk data information types, order and size

Value (Information Item)	Pixels	Description
`htroi3`	2	The vertical offset (stroi) and height (htroi) of regions of interest (ROI) 0, 1, 2 and 3 (if configured) of the image. For more information, see Specifying Regions of Interest on page 25. Only data on the first four ROIs can be embedded in chunk data.
`stroi3`	2	
`htroi2`	2	
`stroi2`	2	
`htroi1`	2	
`stroi1`	2	
`htroi0`	2	
`stroi0`	2	
`width`	2	The width and horizontal offset of all regions of interest (ROIs)of the image. See Specifying Regions of Interest on page 25.
`offsetx`	2	
`blacklevel`	2	See Black Level on page 41
`gain`	1	See Gain on page 41.
`exposure`	3	See Exposure on page 40.
`horizline`	2	The line number of the horizontal line artifact. For more information, see Horizontal Line Artifact on page 47.
`framecounter`	2	The frame number since the onset of free-running or synchronized exposure. For more information, see Image Acquisition on page 30
checksum	8	A checksum computed as the sum of all previous bytes in the image. This value can be compared with a user-generated checksum on the transmitted image to determine if the image was corrupted during transmission. *Checksum is specified using separate syntax (see below).*

Chunk Data

Name	Description	Write
Chunk Enable	Enables or disables chunk data embedding	chnken *value* *value* is 0 (disabled) or 1 (enabled)
Chunk Selector	Specifies the chunk data items to embed images	chnksel *value* For more information see Chunk Data on previous page Multiple values cannot be specified in a single command; to embed multiple items, issue separate commands for each one. Information items are presented in the order in which they appear in the last pixels of the last line in an image. If images are offset by ROIs, the location of chunk data is adjusted to fit within the last ROI.
	Removes all currently embedded data items from being embedded. It is not possible to unembed a subset of currently embedded items	chnksel *none*
Checksum	Embeds a checksum in images	icsum *value* *value* is 0 (disabled) or 1 (enabled) When icsum=1, a checksum is embedded in the last bytes of the last line of an image. A total of 8 bytes are used. The first 7 bytes are programmed 0 (black). The last bytes is the checksum value. In 2-tap mode, the checksum is a 10-bit value. All remaining bits are padded with 0's.

6 Support

Point Grey Research endeavors to provide the highest level of technical support possible to our customers. Most support resources can be accessed through the Point Grey Product Support page.

Creating a Customer Login Account

The first step in accessing our technical support resources is to obtain a Customer Login Account. This requires a valid name and e-mail address. To apply for a Customer Login Account go to the Product Downloads page.

Knowledge Base

Our Knowledge Base contains answers to some of the most common support questions. It is constantly updated, expanded, and refined to ensure that our customers have access to the latest information.

Product Downloads

Customers with a Customer Login Account can access the latest software and firmware for their cameras from our Product Downloads page. We encourage our customers to keep their software and firmware up-to-date by downloading and installing the latest versions.

Contacting Technical Support

Before contacting Technical Support, have you:

1. Read the product documentation and user manual?
2. Searched the Knowledge Base?
3. Downloaded and installed the latest version of software and/or firmware?

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

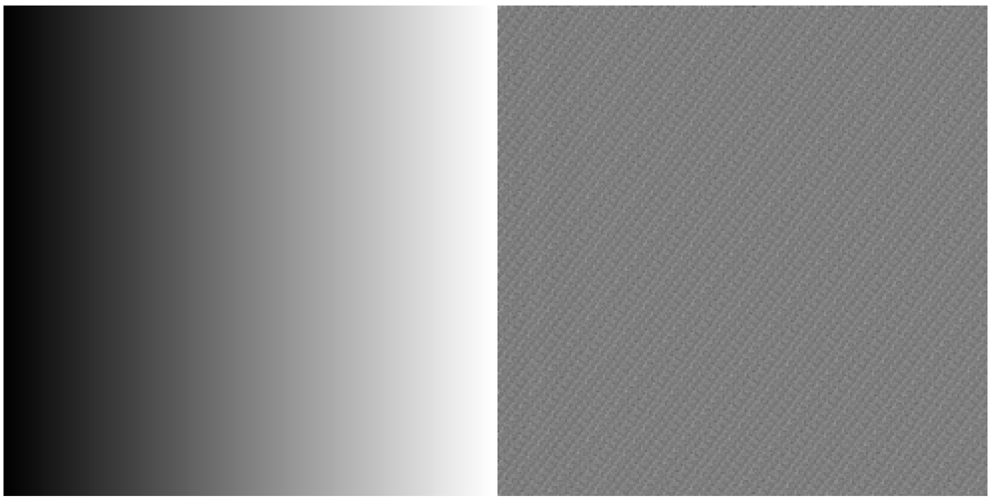
6.1 Status Indicator LED

LED Status	Description
Off	Not receiving power
Orange	Initialization
Steady green	Receiving power and successful camera initialization
Slow flashing green	Streaming images or performing internal operation
Alternating red/green flashing	Firmware update in progress
Solid red	Input voltage is out of tolerance
Slow flashing red	Firmware initialization problem - contact technical support
Fast flashing red	General error - contact technical support

6.2 Test Pattern

The camera is capable of outputting continuous static images for testing and development purposes. The test pattern image is inserted into the imaging pipeline immediately prior to the transfer to the on-board FIFO, and is therefore not subject to changes in imaging parameters.

Supported outputs include a fixed pattern or a pseudorandom pattern. The pseudorandom pattern uses a linear feedback shift register to generate pixel values for each frame, with different starting values for each pixel.



Fixed Pattern **Pseudorandom Pattern**

Figure 6.1: Test Pattern Sample Image

Test Pattern

Name	Description	Read	Write
Test Pattern	Specifies the type of test image to transmit	tp	tp *value* *value* is 0 (live image—no test pattern), 1 (fixed pattern), or 2 (pseudorandom pattern).

6.3 Blemish Pixel Artifacts

Cosmic radiation may cause random pixels to generate a permanently high charge, resulting in a permanently lit, or 'glowing,' appearance. Point Grey tests for and programs white blemish pixel correction into the camera firmware.

In very rare cases, one or more pixels in the sensor array may stop responding and appear black (dead) or white (hot/stuck).

6.3.1 Pixel Defect Correction

Point Grey tests for both dead (black) pixels and hot (white) pixels on each camera. The mechanism to correct pixel defects is hard-coded into the camera firmware, and is enabled by default. Pixels are corrected if they are 20 grayscale levels different than a neighboring pixel average in a gray (mid-level) image. The correction algorithm involves applying the average grayscale values of horizontal neighbor pixels to the defective pixel. The maximum number of pixels corrected is 253.

Pixel correction is not done in any of the binning modes (page 24).

Related Knowledge Base Articles

Title	Article
How Point Grey tests for white blemish pixels	Knowledge Base Article 314

Defect Pixel Correction

Name	Description	Read	Write
Defect Pixel Correction	Turns defect pixel correction on or off		dpc *value* *value* is 0 (disabled) or 1 (enabled)
Defect Pixel Dump	Returns the x,y coordinates of all pixels being corrected, from top left to bottom right	dpdump	
Defect Pixel Information	Returns the number of pixels corrected, or the x,y coordinates of a corrected pixel	dpinfo *value* *value* is the defect pixel number. Defect pixels are numbered (zero-based) from top left to bottom right in the image array. For example, to get the x,y coordinates of the third defect pixel, specify dpinfo 2	
Defect Pixel Test Mode	Displays all corrected pixels of an image in white		dpt *value* *value* is 0 (disabled) or 1 (enabled). This feature is disabled by default.

6.4 Horizontal Line Artifact

One artifact described by CMOSIS is a horizontal line artifact. This artifact can be handled using one of the following methods:

- When the camera operates in free-running acquisition mode (page 30), issue the `trm freerun` command. When issued, the horizontal line artifact is auto-corrected and virtually disappears. However, maximum achievable frame rates in 8-tap mode are slightly slower than when running in standard 8-tap free-running mode, per the following table. To return to standard free-running mode, issue the `trm none` command.

Table 6.1: Maximum frame rates in `trm freerun` mode versus standard free-running mode

Model	#Taps	Max FPS at max resolution (with `trm freerun` command)	Max FPS at max resolution (standard free-running mode)
GZL-CL-22C5	8-tap	265	281
	2-tap	71	71
GZL-CL-41C6	8-tap	142	149
	2-tap	37	37

- In both free-running (page 30)and triggered acquisition (page 30) modes, the horizontal line number of the artifact can be obtained for performing user-defined correction of the artifact.To obtain the horizontal line number of the artifact, specify the `horizline` chunk data item. For more information about working with chunk data, see Chunk Data on page 43.

6.5 CMOSIS Sensor Artifacts

Certain image effects have been identified by the sensor manufacturer as known artifacts, and may manifest themselves depending on your application. These include:

- Horizontal Line effect
- Black Sun effect
- Black Level offset

For more information about these artifacts, see this CMOSIS application note.

Appendix A: Software Instruction Set

A.1 Device Control

Name	Description	Read	Write
Device Vendor Name	Returns the Vendor Name	dvn	
Device Model Name	Returns the Model Name	dvm	
Device Firmware Version	Returns the Firmware Version	dfv	
Device Firmware Build Date	Returns the Firmware build date	dbd	
Device Hardware Version	Returns the hardware versions of the PCBs in the camera	dhv	
Sensor Hardware Version	Returns the sensor model of the camera 0170FFFEh = CMOSIS CMV4000 0180FFFEh = CMOSIS CMV2000	shv	
Device ID	Returns the Serial Number	did	
Update Mode	Puts the camera into firmware update mode		update
Device Reset	Resets Device to Power Up State		dr
Initialization	Indicates if initialization is complete 0=Still in initialization 1=Complete	init	

Name	Description	Read	Write
Device Information	Gets the following camera information: Camera Model Camera Serial Number Firmware Version Firmware Build Date Baud Rate Analog Gain Digital Gain Trigger source Trigger Polarity Trigger Mode Trigger Delay Strobe width Strobe Mode Strobe Delay Strobe Activation ROIs Reverse Image Status Defect Pixel Correction status Current User Set Voltage Status Current Status Uptime Status Width Height OffsetX OffsetY Number of Taps Input Clock Exposure Black Level	dump	

A.2 Image Format Control

Name	Description	Read	Write
Width	Gets or sets the image width (Returns zero if no ROIs are present) Width must be specified before horizontal offset.	w	w *value* *value* is in pixel columns and is measured from the specified horizontal offset; it must be a value of 8
OffsetY, Height	Gets or sets the vertical offset and height of current ROIs. (Returns zero if no ROIs are present) To specify more than one ROI, use multiple *setroi* commands. *ROI_ number* and *y-offset* must vary between ROIs	getroi	setroi *ROI_number y_offset height* *ROI_number* can be from 0 to 7, specifying one of eight allowable ROIs *y_offset* is the starting row of the ROI on the y-axis, measure from pixel row 0 at the top of the image *height* specifies how many rows of pixels are sampled, beginning from the *y-offset*

Name	Description	Read	Write
OffsetX	Gets or sets the horizontal offset of the image from the left side of the pixel array. (Returns zero if no ROIs are present) The combination of horizontal offset and width must not exceed sensor width.	ox	ox *offset* *offset* is the starting column of the ROI on the x-axis, measured from pixel column 0 at the left of the image; it must be a value of 8
Sensor Width	Returns the total width of the sensor, in pixels	sw	
Sensor Height	Returns the total height of the sensor, in pixels	sh	
Remove ROI	Removes an ROI or returns the camera to non-ROI operation. Removing a subset of ROIs results in the camera sampling and transmitting any remaining ROIs. If all ROIs are removed, the camera stops using ROIs and returns to sampling and transmitting the entire pixel array		rstroi *ROI_number* *ROI_number* is a previously set ROI using the *setroi* command. Removing an ROI does not affect the *ROI_number* value of any remaining ROIs
Sensor Mode	Gets or sets the sensor mode. Can be set to 2-tap, 8-tap, 8-tap 10-bit, or bin2x2. (2x binning is only available in base 2-tap mode)	smod	smod *value* *value* is 2tap, 8tap, 8tap10bit, bin2x2
Test Pattern	Specifies the type of test image to transmit	tp	tp *value* *value* is 0 (live image—no test pattern), 1 (fixed pattern), or 2 (pseudorandom pattern).

A.3 Acquisition Control

Name	Description	Read	Write
Acquisition Start	Starts Image Acquisition		astart
Acquisition Stop	Stops Image Acquisition		astop
Trigger Source	Gets or sets the source from which to accept an incoming trigger	trsrc	trsrc *source* *source* may be: soft—Software trigger line1—Camera Control 1 (CC1) line2—Camera Control 2 (CC2) line3—Camera Control 3 (CC3) line4—Camera Control 4 (CC4) GPIO0—Opto-isolated GPIO input pin

Name	Description	Read	Write
Trigger Mode	Gets or sets the trigger acquisition mode	trm	trm *mode* *mode* is single, bulb, freerun, or none. (Both *freerun* and *none* put the camera in a free running state, but *freerun* may limit maximum frame rate. See Horizontal Line Artifact on page 47 for more information.)
Trigger Activation	Gets or sets the trigger phase that activates image acquisition	tra	tra *phase* *phase* is re (rising edge) or fe (falling edge)
Trigger Software	Fires a software trigger		trgsoft
Trigger Delay Raw	Gets or sets the delay from when the trigger signal is detected to when the trigger fires and initiates image acquisition	trdraw	trdraw *value* *value* is in raw (non-absolute) terms
Trigger Delay Minimum	Gets the minimum image acquisition delay available in the current video mode	trdraw gmin	
Trigger Delay Maximum	Gets the maximum image acquisition delay available in the current video mode	trdraw gmax	
Exposure Time Raw	Gets or sets the exposure time	eraw	eraw *value* *value* is in raw (non-absolute) terms
Exposure Time Minimum	Gets the minimum exposure time available in the current video mode	eraw gmin	
Exposure Time Maximum	Gets the maximum exposure time available in the current video mode	eraw gmax	

A.4 Strobe Control

Name	Description	Read	Write
Strobe Activation	Specifies whether the strobe active state is low or high, or if no signal is output at all	sta	sta *mode* *mode* is high, low, or off (default)
Strobe Source	Specifies the strobe output type	stsrc	stsrc *source* *source* may be: high—The strobe signal is always high low—The strobe signal is always low duration—The strobe signal lasts for the duration of exposure. Signal polarity depends on the setting of the sta command trigger—The strobe signal lasts for the duration of a high input trigger signal. The trigger input can be from either the GPIO or a Camera Control (CC) Camera Link line. Signal polarity depends on the setting of the sta command. user—The strobe signal duration is defined using the stw command below. Signal polarity depends on the setting of the sta command.

Name	Description	Read	Write
Strobe Width	Specifies a user-defined duration for the strobe signal. Note that the stsrc command must be set to user.		stw *value* *value* is in raw (non-absolute) terms. To convert the raw value to microseconds, multiply by 0.12
Strobe Delay	Specifies that the strobe output signal be delayed by a period of time.		std *value* *value* is in raw (non-absolute) terms. To convert the raw value to microseconds, multiply by 0.12

A.5 Imaging Parameters Control

Name	Description	Read	Write
Analog Gain Raw	Gets or sets the sensor analog gain	agraw	agraw *value* *value* is in raw (non-absolute) terms, between 32-64
Analog Gain Minimum	Gets the minimum sensor analog gain	agraw gmin	
Analog Gain Maximum	Gets the maximum sensor analog gain	agraw gmax	
Digital Gain Raw	Gets or sets the sensor digital gain	graw	graw *value* *value* is in raw (non-absolute) terms, between 1-64
Digital Gain Minimum	Gets the minimum sensor digital gain	graw gmin	
Digital Gain Maximum	Gets the maximum sensor digital gain	graw gmax	
Black Level	Gets or sets the sensor black level	blraw	blraw *value* *value* is in raw (non-absolute) terms, between 0-950
Black Level Minimum	Gets the minimum sensor black level	blraw gmin	
Black Level Maximum	Gets the maximum sensor black level	blraw gmax	
Reverse Image	Flips the image horizontally, vertically, or both	ri	ri *value* *value* is one of the following: 0—Images are vertically reflected along the y center axis 1—Images are vertically and horizontally reflected along both the x and y axes 2—Original image orientation (default) 3—Images are horizontally reflected along the x center axis

Name	Description	Read	Write
Defect Pixel Correction	Turns defect pixel correction on or off		dpc *value* *value* is 0 (disabled) or 1 (enabled)
Defect Pixel Dump	Returns the x,y coordinates of all pixels being corrected, from top left to bottom right	dpdump	
Defect Pixel Information	Returns the number of pixels corrected, or the x,y coordinates of a corrected pixel	dpinfo *value* *value* is the defect pixel number. Defect pixels are numbered (zero-based) from top left to bottom right in the image array. For example, to get the x,y coordinates of the third defect pixel, specify dpinfo 2	
Defect Pixel Test Mode	Displays all corrected pixels of an image in white		dpt *value* *value* is 0 (disabled) or 1 (enabled). This feature is disabled by default.

A.6 User Set Control

Name	Description	Write
User Set Save	Saves the camera's current configuration to one of the three available user-configuration sets	memsave *value* *value* is 1 or 2
User Set Load	Loads a configuration set	memload *value* *value* is 0 (default), 1, or 2
User Set Current	Gets the currently-loaded configuration set	memcurr

A.7 Status Monitoring

Name	Description	Read	Write
Voltage Status	Returns the internal and external voltage, in hertz	vstat	
Current Status	Returns the electrical current, in amperes	cstat	
Uptime Status	Returns the time since the camera was last initialized, in hours:minutes:seconds	ustat	
Device Clock Frequency	Returns the frequency of the sensor input Clock, in hertz	dcf	dcf *value* *value* can be 40, 35, 30, 20, or 10MHz for 8-tap mode 10 MHz for 2-tap mode
Device Temperature	Returns the ambient temperature inside the camera case, in degrees Celsius	dt	

A.8 Flash Memory Control

Name	Description	Read	Write
Flash Memory Size	Returns the following in order: Total size of flash memory Number of pages Page size	dfi	
Flash Memory Write	Writes a page to the flash memory		dfw *page_number num_bytes ASCII_string* *page_number* can be from 0 to 8191 *num_bytes* can e from 0 to 527 If the size of *ASCII_string* is more than 528 bytes, it is cut to 528 to fit the page size
Flash Memory Read	Reads a page from the flash memory	dfr page_number page_number can be from 0 to 8191	
Flash Memory Clear Page	Clears a page of the flash memory		dfw *page_number* 0 0 *page_number* can be from 0 to 8191
Flash Memory Clear All	Clears all the flash memory		dfclear

A.9 Chunk Data Control

Name	Description	Write
Chunk Enable	Enables or disables chunk data embedding	chnken *value* *value* is on or off
Chunk Selector	Specifies the chunk data items to embed images	chnksel *value* For more information see Chunk Data on page 43
	Removes all currently embedded data items from being embedded. It is not possible to unembed a subset of currently embedded items	chnksel *none*
Checksum	Embeds a checksum in images	icsum *value* *value* is 0 (disabled) or 1 (enabled) When icsum=1, a checksum is embedded in the last bytes of the last line of an image. A total of 8 bytes are used. The first 7 bytes are programmed 0 (black). The last bytes is the checksum value.

Appendix B: GPIO Electrical Characteristics

Opto-isolated **input** pins require an external pull up resistor to allow triggering of the camera by shorting the pin to the corresponding opto ground (OPTO_GND). Non opto-isolated input pins are internally pulled high using weak pull-up resistors to allow triggering by shorting the pin to GND. Inputs can also be directly driven from a 3.3 V or 5 V logic output.

The inputs are protected from over voltage.

When configured as **outputs**, each line can sink 10 mA of current. To drive external devices that require more, consult Knowledge Base Article 200 for information on buffering an output signal using an optocoupler.

The **+3.3V** pin is fused at 150 mA. External devices connected to Pin 8 should not attempt to pull anything greater than that.

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

B.1 GPIO0 (Opto-Isolated Input) Circuit

The figure below shows the schematic for the opto-isolated input circuit.

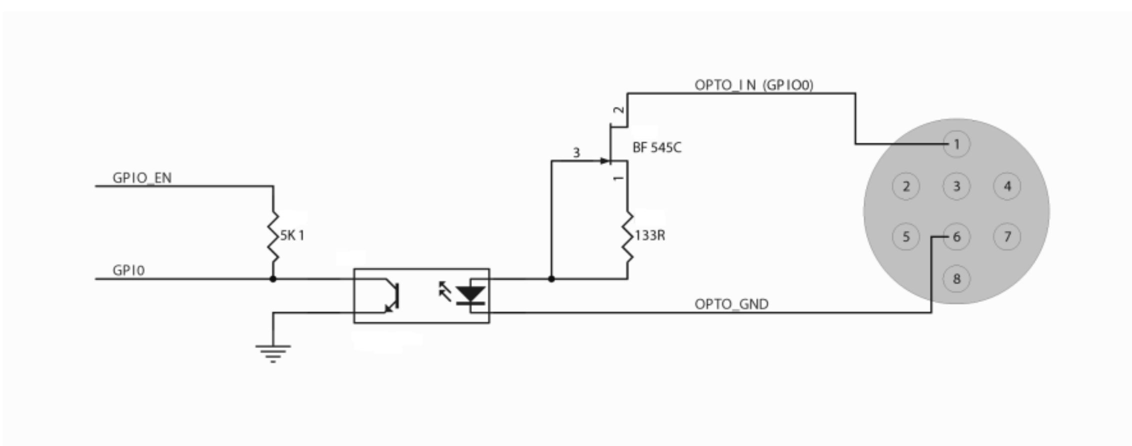


Figure B.1: Optical input circuit

- Logical 0 input voltage: 0 VDC to +1 VDC (voltage at OPTO_IN)
- Logical 1 input voltage: +1.5 VDC to +30 VDC (voltage at OPTO_IN)
- Maximum input current: 8.3 mA
- Behavior between 1 VDC and 1.5 VDC is undefined and input voltages between those values should be avoided
- Input delay time: 4 µs

B.2 GPIO1 (Opto-Isolated Output) Circuit

The figure below shows the schematic for the opto-isolated output circuit. The maximum current allowed through the opto-isolated output circuit is 25 mA.

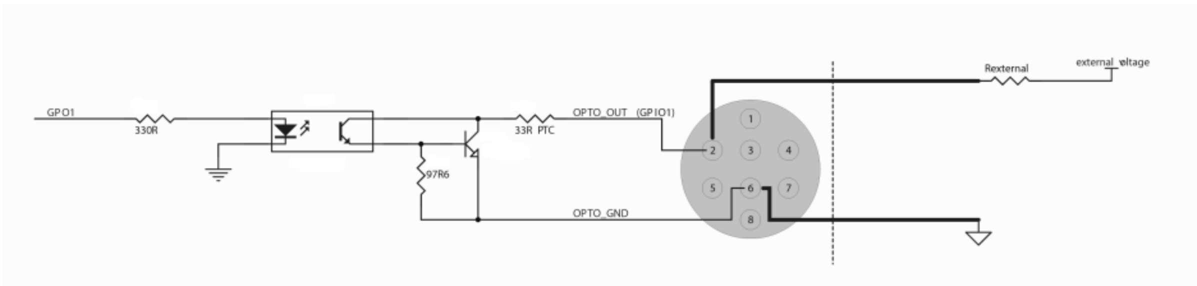


Figure B.2: Optical output circuit

The following table lists the switching times for the opto-isolator in the output pin, assuming an output VCC of 5 V and a 1 kΩ resistor.

Parameter	Value
Delay Time	9 µs
Rise Time	16.8 µs
Storage Time	0.52 µs
Fall Time	2.92 µs

The following table lists several external voltage and resistor combinations that have been tested to work with the opto-isolated output.

External Voltage	External Resistor	OPTO_OUT Voltage	OPTO_OUT Current
3.3 V	1 kΩ	0.56 V	2.7 mA
5 V	1 kΩ	0.84 V	4.2 mA
12 V	2.4 kΩ	0.91 V	4.6 mA
24 V	4.7 kΩ	1.07 V	5.1 mA

Contacting Point Grey Research

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Taiwan	Apo Star Co., Ltd.	www.apostar.com.tw
United Kingdom	ClearView Imaging Ltd.	www.clearviewimaging.co.uk

Revision History

Revision	Date	Notes
1.0	January 18, 2011	■ Initial version
1.1	May 16, 2011	■ Updated formula for converting raw strobe duration and delay values to absolute values. ■ Revised frame rate values per testing on latest firmware. ■ Added `trm freerun` command for troubleshooting horizontal line artifact. ■ Added chunk data item for troubleshooting horizontal line artifact. ■ Updated timing diagram with new value for delay between end of integration and readout. ■ Added that checksum cannot be embedded when pixel defect correction is enabled.
1.2	February 7, 2012	■ Revised chunk data implementation. ■ New options for troubleshooting. ■ Added that ROI parameters must be specified according to pixel configuration on the sensor, even if the camera is operating in binning mode. ■ Added that ROIs must be re-configured if changing video output format. ■ Digital gain range changed from 0-64 to 1-64. ■ Updated dimensional diagram. ■ Added missing instructions for *stsrc* command. ■ Revised frame rate formulas. ■ Updated the Software Instruction Set ■ Standardized format for presentation of software instruction set commands ■ New specifications format ■ Added commands: *dump, blraw gmin, blraw gmax, graw gmin, graw gmax, agraw gmin, agraw gmax*
1.3	June 1, 2012	■ Digital gain range changed to 1-63. ■ Added note that changing ROI height requires removal and redefinition. ■ Corrected vstat unit of measure to be volts. ■ Clarified ROI offset to be multiple of 8. ■ Clarified image flipping commands. ■ Added note that strobe duration cannot be used in Bulb trigger mode.
1.4	October 1, 2012	■ Added revised imaging performance specifications and quantum efficiency graphs ■ Clarified *trm freerun* and *trm none* commands

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