POINT GREY
RESEARCH

Chameleon

Technical Reference Manual

Version 1.6
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Point Grey Research® Inc.
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FCC Compliance Information

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off or on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

You are cautioned that any changes or modifications not expressly approved in this manual could void your authority to operate this equipment.

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 one (1) year. 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 voids this warranty.

Point Grey Research, Inc. expressly disclaims and excludes all other warranties, express, implied and statutory, including, but without limitation, warranty of merchantability and fitness for a particular application or purpose. In no event shall Point Grey Research, Inc. be liable to the Original Purchaser or any third party for direct, indirect, incidental, consequential, special or accidental damages, including without limitation damages for business interruption, loss of profits, revenue, data or bodily injury or death.

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 Point Grey Research.

Trademarks

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1 Introduction

1.1. Chameleon Overview

The ultra-compact and versatile *Chameleon* is designed as a cost-effective USB solution for high-quality imaging applications such as eye tracking, security and biometrics, augmented reality, multitouch displays, robot guidance and semiconductor inspection.

All model-specific information presented in this manual reflects functionality available in firmware version **1.5.3**

To check the camera firmware version, consult our knowledge base: www.ptgrey.com/support/kb/index.asp?a=4&q=94.

1.1.1. Image Acquisition and Processing

Feature	Description
USB 2.0 Bandwidth	480 Mb/s interface
Programmable Exposure	User-programmable shutter and gain settings via software
Fast Frame Rates	Faster standard frame rates plus pixel binning and ROI support
Multiple Trigger Modes	Bulb-trigger mode, multiple triggered exposures before readout
Trigger at Full Frame Rate	Overlapped trigger input, image acquisition and transfer
Embedded Image Info	Pixels contain frame-specific info

1.1.2. Camera and Device Control

Feature	Description
Frame Rate Control	Fine-tuned frame rates for video conversion
Improved Strobe Output	Increased drive strength, configurable strobe pattern output
Memory Channels	Non-volatile storage of camera default power-up settings
Camera Upgrades	Firmware upgradeable in field via USB 2.0 interface.

1.1.3. Mechanics and Form Factor

Feature	Description
Ultra-Compact Design	Small (44mm x 41mm x 25.5mm) and light (37g)
Industry Standard Mechanics	ASA/ISO-compliant tripod adapter and CS-mount lens holder

1.2. Using This Manual

This manual attempts to provide the user with a detailed specification of the *Chameleon* camera system. The reader should be aware that the camera system is a complex and dynamic system – if any errors or omissions are found during experimentation, please contact us.

This document is subject to change without notice.

Many of the operational descriptions included in this manual are intended as general overviews, and may not present the detailed information required for developing specific applications. For additional details and operational descriptions, refer to the following resources that can be downloaded from our website at www.ptgrey.com/support/downloads/:

- *Point Grey Digital Camera Register Reference*
- *PGR FlyCapture User Manual*
- *TAN2005003: Setting a GPIO pin to output a strobe signal pulse pattern*
- *TAN2005004: Buffering a GPIO pin output signal to drive an external device*

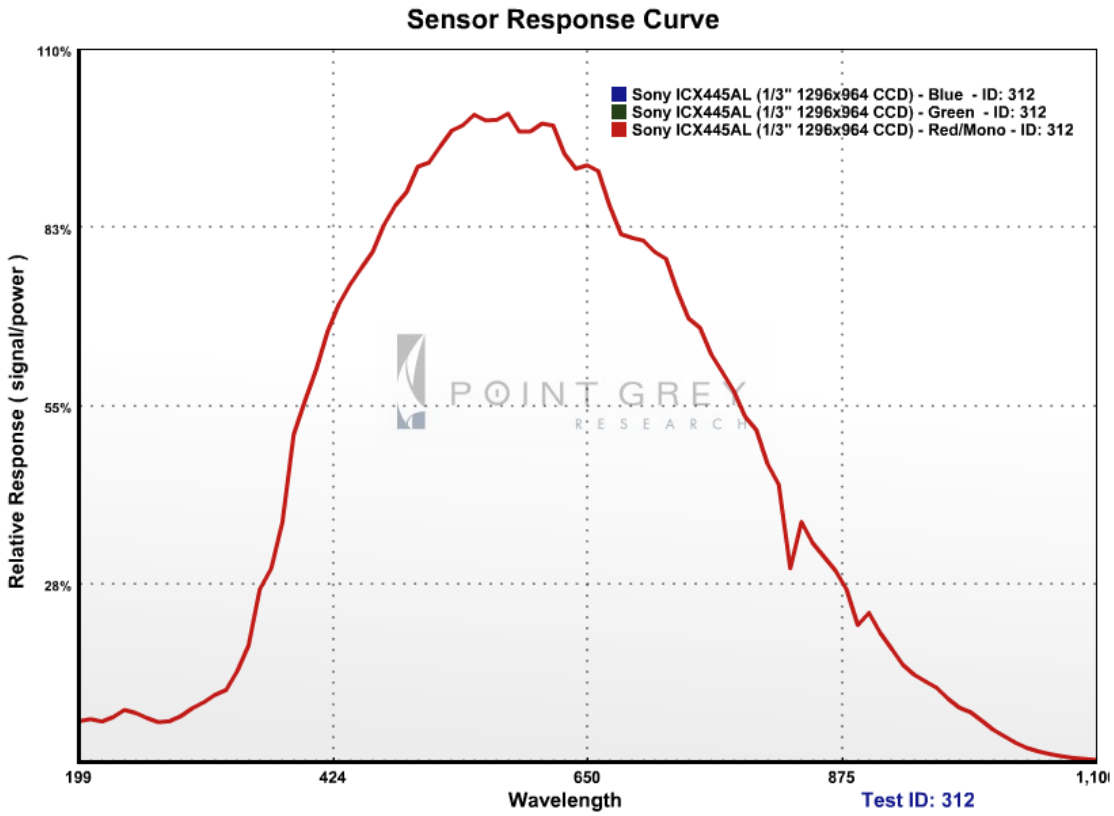
1.3. Camera Specifications

Specification	13S2
Imaging Sensor Type	Sony progressive scan interline transfer CCD with square pixels and global shutter
Image Sensor Model	ICX445 1/3" EXview HAD CCD™
Maximum Resolution	1296(H) x 964(V)
Pixel Size	3.75µm(H) x 3.75µm(V)
Effective Imager Size	6.26mm(H) x 5.01mm(V)
A/D Converter	Analog Devices 12-bit ADC
Video Data Output	8 and 16-bit digital data (see *Supported Data Formats* below)
Image Data Formats	Y8, Y16 (monochrome), 8-bit and 16-bit raw Bayer data (color)
Digital Interfaces	5-pin Mini-B USB 2.0 for camera control, video data transmission and power
Data Transfer Rate	480 Mbit/s
Maximum Frame Rate	1296 X 964 Y8 at 18 FPS (Format 7)
Partial Image Modes	Pixel binning and region of interest modes via Format_7
General Purpose I/O ports	7-pin JST GPIO connector, 4 pins for trigger and strobe, 1 pin +3.3 V, 1 V_{EXT} pin for external power
Gain	Automatic/Manual/One-Push Gain modes, programmable via software, 0 dB to 24 dB in 0.04 dB increments
Shutter	Automatic/Manual/One-Push modes, programmable via software, 0.01ms to greater than 10 s (extended shutter model)
Synchronization	Via external hardware trigger
External Trigger Modes	IIDC v1.31 Trigger Modes 0, 1 (bulb trigger) , 3 and 14 (overlapped trigger and transfer)
Memory Storage	3 memory channels for custom camera settings
Power Requirements	4.75 to 5.25 V via the Mini-B USB 2.0 cable or JST 7-pin GPIO connector
Power Consumption	2.0W (max) at 5V
Gamma	0.5 – 4.0
Signal To Noise Ratio	61dB at 0dB gain
Camera Housing	Black plastic with 8 M2 x 3.5 mounting holes
Dimensions (L x W x H)	25.5mm x 44mm x 41mm (case-enclosed, excluding optics)
Mass	37 grams (including tripod adapter)
Lens Mount	CS-mount (5mm C-mount adapter included)
Camera Specification	IIDC 1394-based Digital Camera Specification v1.31
Emissions Compliance	Complies with CE rules and Part 15 Class B of FCC Rules.
Operating Temperature	Commercial grade electronics rated from 0° - 45°C
Storage Temperature	-30° - 60°C
Operating Relative Humidity	20 to 80% (no condensation)
Storage Relative Humidity	20 to 95% (no condensation)
Current Firmware Version	0.9 Release Candidate 5
Warranty	1 year

1.3.1. Spectral Response

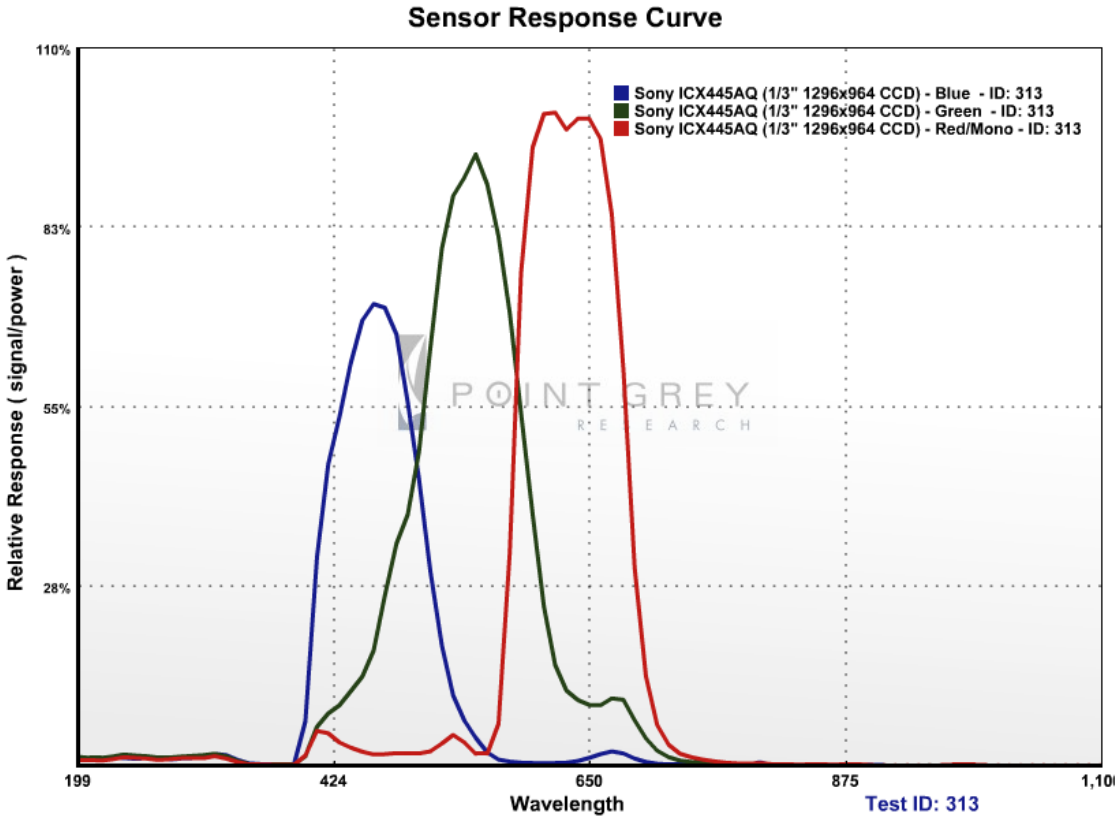
The graphs below present the spectral response curve of the Sony ICX445 CCD image sensor used in the *Chameleon*.

1.3.1.1. Monochrome Model



1.3.1.2. Color Model

*The **color model** is equipped with an optical filter that prevents infrared light from reaching the image sensor. This filter is discussed in the section on **Infrared Cut-Off Filters**.*



1.3.2. Analog-to-Digital Converter

The *Chameleon* incorporates an Analog Devices AD9971AKCPZ A/D converter in order to digitize the images produced by the CCD. The 12-bit conversion produces 4,096 possible image values between 0 and 65,520, left-aligned across a 2-byte data format. The four right-most bits are always zero. The following table illustrates the most important aspects of the processor. For more information, please refer to the Analog Devices website at www.analog.com.

Resolution	12-bit, 50MHz
Pixel Gain Amplifier	0dB to 18dB
Variable Gain Amplifier	6dB to 42dB 10-bit
Black Level Clamp	0 LSB to 255 LSB

1.4. System Requirements

- Processor
  Recommended – Intel Pentium® 4 2.0 GHz or compatible processor
  Minimum – Intel Pentium III 800 MHz or compatible processor
- Memory
  Recommended – 2GB
  Minimum - 256MB
- AGP video card with 64 MB video memory (128 MB recommended)
- Bus Configuration
  Recommended – PCI Express (PCI-e card not included) or 64-bit PCI slot
  Minimum – 32-bit standard PCI slot for the IEEE-1394 card
- Microsoft Windows XP Service Pack 1
- Microsoft Visual C++ 6.0 (to compile and run example code)

1.5. Controlling the Camera

The FlyCapture® Software Development Kit (SDK) that accompanies your *Chameleon* provides the following tools and interfaces for controlling the camera:

1.5.1. FlyCap Demo Program

The FlyCap application is a generic streaming image viewer included with the FlyCapture® SDK that can be used to test many of the capabilities of your compatible PGR IEEE-1394 camera. It allows you to view a live video stream from the camera, save individual images or .avi movie clips, adjust the various video formats, frame rates, properties and settings of the camera, and access camera registers. It is an easy-to-use program that can be used to test many of the capabilities of your PGR IEEE-1394 camera system. Consult the *PGR FlyCapture User Manual* for more information.

1.5.2. Custom Applications Built with the FlyCapture API

PGR FlyCapture includes a full Application Programming Interface that allows customers to create custom applications to control Point Grey Imaging Products. The SDK provides a number of sample programs and source code that is meant to help the advanced programmer get started using the FlyCapture API. Examples range from simple console programs that demonstrate the basic functionality of the API, such as PGRFlyCaptureTest, to more complex examples such as the MFC application FlyCap.

1.5.3. Custom Applications Built with other APIs

The FlyCapture SDK supports custom applications built with DirectShow, TWAIN and ActiveX components. An ActiveX Programming Reference is installed by default in the Start menu at Point Grey Research → PGR FlyCapture → Documentation.

1.6. Camera Control Command Registers

For a complete description of the Camera Control Command Registers implemented on the camera, please refer to the *Point Grey Research Digital Camera Register Reference*, included with the FlyCapture SDK and downloadable from www.ptgrey.com/support/downloads/.

1.7. Description of the Data Flow

The diagram below depicts the flow of image data on the Chameleon from capture, through manipulation, to output. The table that follows describes the steps in more detail.

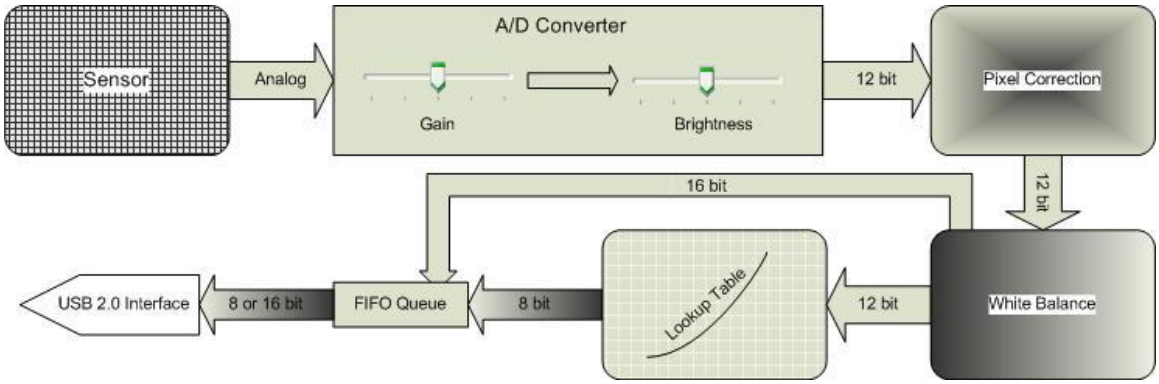


Figure 1: Data Flow Diagram for CMLN-13S2

Image Flow Step	Description
Sensor	Depending on the image size being captured, the Sony® ICX445 CCD sensor produces voltage signals in each pixel from the optical input.
Analog to Digital (A/D) Converter	The sensor's A/D Converter transforms pixel voltage into a 12-bit value, adjusting for gain and brightness in the process. The Chameleon supports automatic, manual and one-push gain control, and manual brightness control. Gain and brightness cannot be turned off.
Defect Correction	The camera firmware corrects any blemish pixels identified during manufacturing quality assurance by applying the average value of neighboring pixels. For more information, see Knowledge Base Article 314.
White Balance	In color models, color intensities can be adjusted manually to achieve more correct balance. White Balance is ON by default. If not ON, no white balance correction occurs.
Gamma/Lookup Table	Gamma correction can be applied manually, which results in adjustments to an 11-bit to 8-bit lookup table. By default, gamma adjustment is OFF, and no correction occurs. Gamma adjustment is not available if the camera is in a 16-bit image format.
FIFO Queue	The final output of image data is controlled in a first in, first-out (FIFO) queue.
USB 2.0 Interface	The camera's 5-pin Mini-B USB 2.0 port transfers data at a rate of 480 Mbit/s.

1.8. Handling Precautions and Camera Care

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

Your Point Grey digital camera module 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. Please consult the following knowledge base article for more details: www.ptgrey.com/support/kb/index.asp?a=4&q=42.
- Users who have purchased a bare board camera should take the following additional protective measures:
    - Either handle bare handed or use non-chargeable gloves, clothes or material. Also, use conductive shoes.
    - Install a conductive mat on the floor or working table to prevent the generation of static electricity.
- 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.
- To clean the imaging surface of your CCD, follow the steps outlined in www.ptgrey.com/support/kb/index.asp?a=4&q=66.
- Our cameras are designed for an office environment or laboratory use. 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.

1.8.1. Heat Dissipation

The plastic case of the *Chameleon* does not get hot. Nevertheless, the camera can generate significant heat, especially when running in some high data rate video modes. A high-quality lens with a metal housing, in conjunction with the lens mount, can act as an effective heat sink. As such, the lens and lens mount may become very warm to the touch. This is expected behaviour and will not cause damage. If reducing heat is a concern, use a cooling fan to set up a positive air flow around the camera, while ensuring there is enough open space around the camera to facilitate the free flow of air.

The *Chameleon* is equipped with an on-board temperature sensor. It allows you to obtain the temperature of the camera board-level components. If the camera is case-enclosed, the sensor measures the ambient temperature within the case. This feature can be accessed using the FlyCap Demo program, or the TEMPERATURE register 0x82C, described in detail in the *Point Grey Digital Camera Register Reference*. Looking at the front of the camera, the temperature

sensor is on the left edge of the printed circuit board, roughly one-third of the distance down from the top edge.

1.9. Common CCD Artifacts

The following section describes issues typical of CCD sensors and possible solutions.

- **Bright Pixels**
  Cosmic rays have the ability to cause images to have artifacts which look like hot pixels which are randomly distributed throughout the image. This is most apparent when the camera is running at a high temperature or the gain is set to a high amount. It is impossible to prevent cosmic rays from reaching the CCD.

- **Dead / Hot Pixels**
  It is possible for one or more pixels in the CCD sensor array to stop responding. This will result in a situation where the pixel will always appear black (dead), or white (hot/stuck). This is generally not an issue except in very rare cases.

- **Dark Current Accumulation**
  Dark current refers to charge that accumulates in pixel wells in complete darkness. This effect may be especially noticeable when the camera is operating at higher temperatures (see Section 1.8.1). Dark current may be minimized by reducing gain, or enabling the Min_Dark_Noise bit (bit [6]) of AUTO_SHUTTER_RANGE register 1098h. This feature can be enabled only when the camera is operating in free-running mode or trigger Mode_0. For more information, refer to the Point Grey Digital Camera Register Reference.

- **Vertical Smear**
  When a strong light source is shot on the camera, there may be a vertical smear above and below the position of the actual light source. This is a byproduct of the interline transfer system used to extract data from the CCD.

Related Knowledge Base Articles

ID	Title	URL
314	How Point Grey tests for white blemish pixels	www.ptgrey.com/support/kb/index.asp?a=4&q=314
88	Vertical bleeding or smearing from a saturated portion of an image	http://www.ptgrey.com/support/kb/index.asp?a=4&q=88

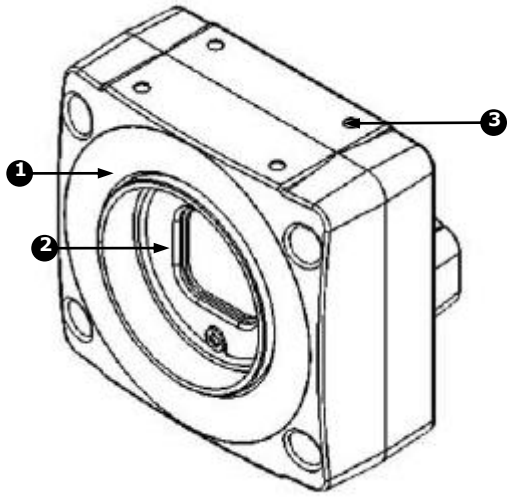
1.10. Camera Accessories

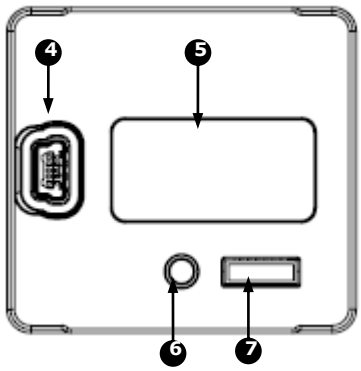
Accessories such as tripod mounts and lens holders are available from PGR – contact our Sales team at sales@ptgrey.com for additional information. Links to digital camera accessories can be found in the following knowledge base article:

KB Article 131: www.ptgrey.com/support/kb/index.asp?a=4&q=131.

2 Camera Physical Properties

2.1. Physical Description





1. **Lens holder (CS-mount)**
   Attach any CS-mount lens or other optical equipment. Consult the section *Lens Setup and Compatibility* for full details.
2. **Window / IR filter system**
   Refer to the *Dust Protection* and the *Infrared Cut-Off Filters* section for more information.
3. **M2x3.5 mounting holes**
   Refer to the *Mounting* section for full details.
4. **USB 2.0 Mini-B vertical connector**
   The camera uses a USB 2.0 Mini-B vertical connector. See the *USB Connector* section for full connector details.
5. **Camera label**
   Contains camera information such as model name, serial number and required compliance information.
6. **Status LED**
   This light indicates the current state of the *Chameleon* operation. Refer to the section *Status Indicator LED*.
7. **General purpose I/O connector**
   The 7-pin GPIO connector is used for external triggering, strobe output or digital I/O. Refer to the *General Purpose Input/Output* section for more information.

2.2. Camera Dimensions

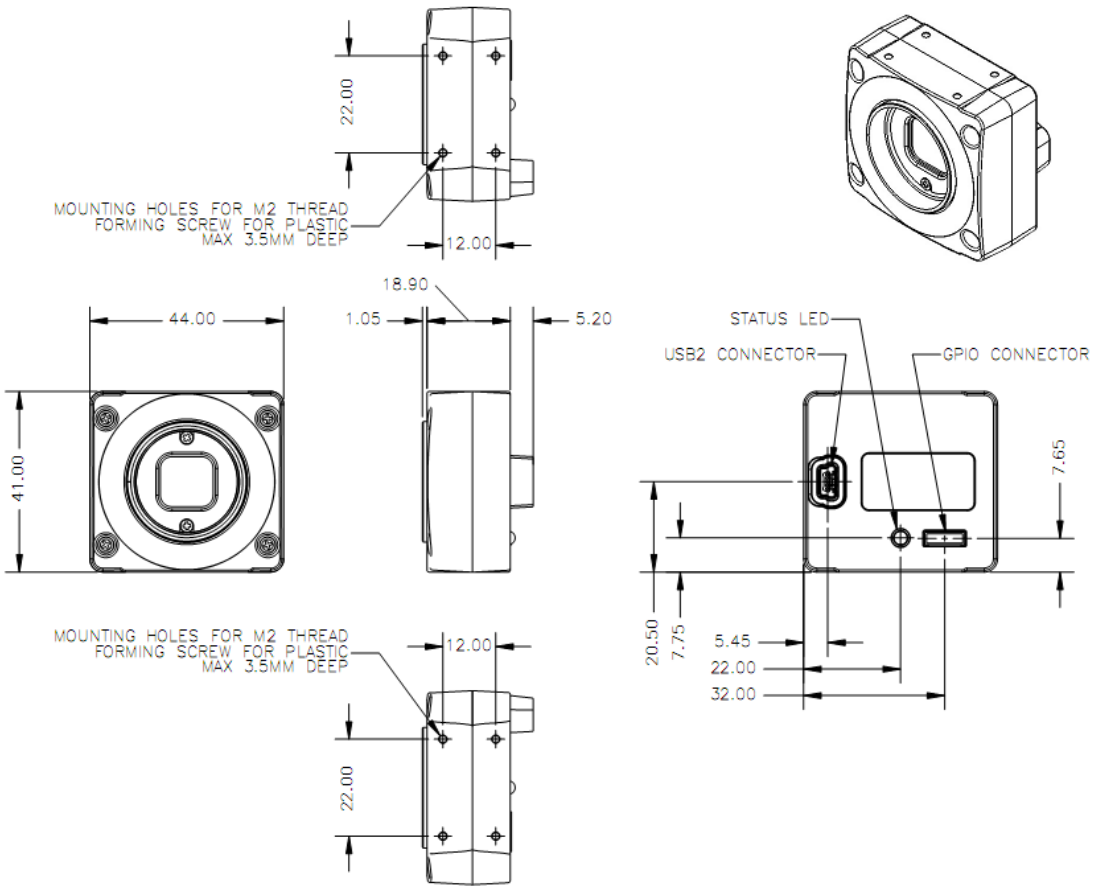


Figure 2: Case-enclosed dimensional drawing

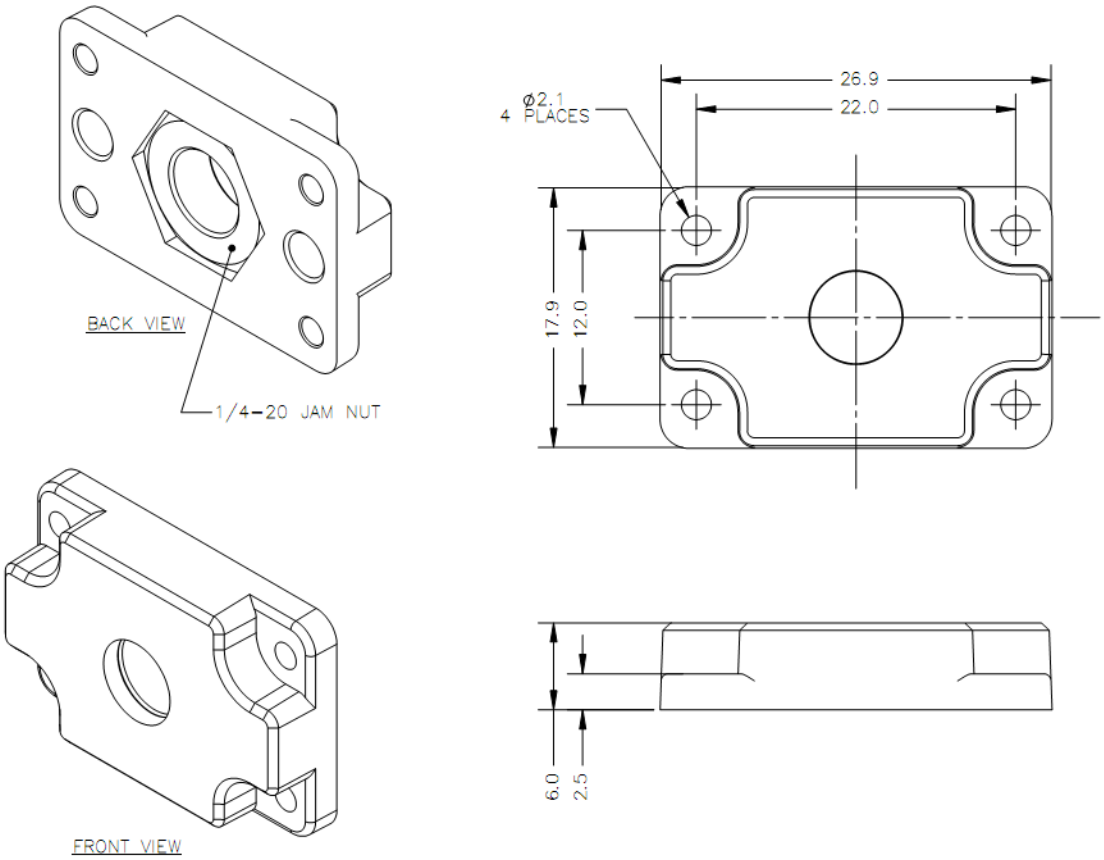


Figure 3: Tripod Adapter Dimensional Drawing

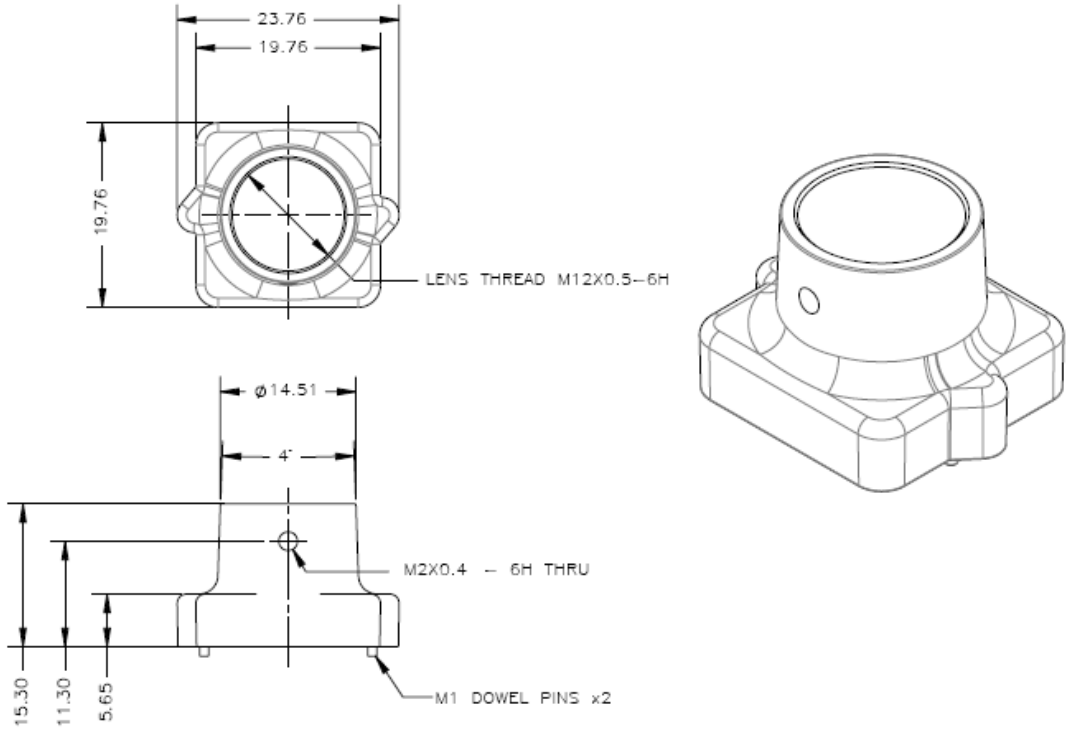


Figure 4: M12 Microlens Mount Dimensional Drawing (available separately for board-level camera models)

2.3. Lens Setup and Compatibility

The lens holder is compatible with CS-mount lenses. A 5mm C-mount adapter is included. Lenses are not included with individual cameras. To differentiate between C- and CS-mount lenses, consult the following article:

KB Article 98: www.ptgrey.com/support/kb/index.asp?a=4&q=98

An M12 microlens holder can be obtained for use with board-level camera models. For dimensions, see Figure 4.

2.4. Dust Protection

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.

Do not remove the protective glass. Doing so can void the Hardware Warranty *described at the beginning of this reference manual.*

The case is designed to prevent dust from falling directly onto the CCD's protective glass surface. This is achieved by placing a piece of clear glass (monochrome camera models) or IR cut-off filter (color models) that sits above the surface of the CCD'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.

2.5. Mounting

2.5.1. Using the Case

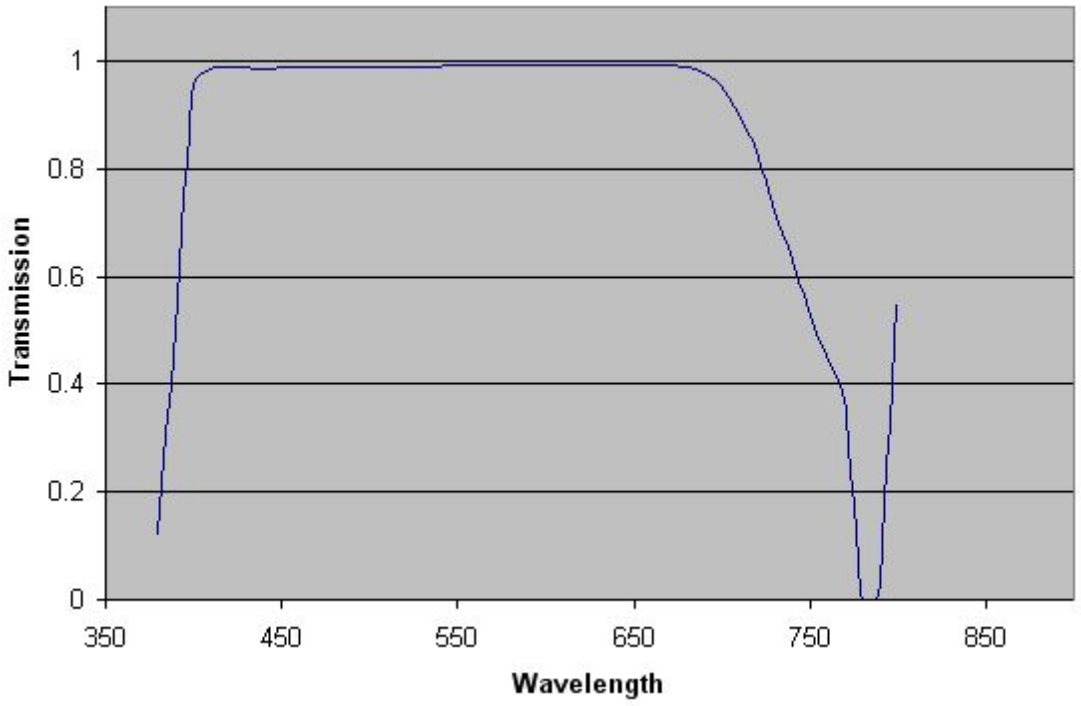
The case is equipped with four (4) M2x3.5mm mounting holes on the top and bottom of the case that can be used to attach the camera directly to a custom mount or to the *Chameleon* tripod mounting bracket

2.5.2. Using the Tripod Adapter

The *Chameleon* tripod adapter comes with the Development Kit, or can be purchased separately by contacting sales@ptgrey.com.

2.6. Infrared Cut-Off Filter

Point Grey Research color camera models are equipped with an additional infrared (IR) cut-off filter. This filter can reduce sensitivity in the visible spectrum. The properties of this filter are illustrated in the results below, which were obtained by Point Grey Research independent of camera model.



In monochrome models, the IR filter is replaced with a transparent piece of glass.

The following are the properties of the IR filter/protective glass[1]:

Type	Reflective
Material	Schott D 263 T or BK7 equivalent for coating filters
Physical Filter Size	14 mm x 14 mm
Glass Thickness	1.0 mm
Dimensional Tolerance	+/-0.1 mm`
Coating Filters	Scott D 263 T

[1] These properties apply to all imaging cameras except GRAS 14S5.

Related Knowledge Base Articles

ID	Title	URL
98	Understanding flange back distance on C-mount and CS-mount cameras	www.ptgrey.com/support/kb/index.asp?a=4&q=98

3 Camera Interface

3.1. USB Connector

The *Chameleon* has a USB 2.0 Mini-B vertical connector that is used for data transmission, camera control and powering the camera. For more detailed information, consult the USB 2.0 specification available from http://www.usb.org/developers/docs/.

The Chameleon is not backward compatible with a USB 1.1 interface. If the computer on which you want to operate a Point Grey USB camera does not have a built-in USB 2.0 host controller, you can install a USB 2.0 PCI host adapter card. For more information, refer to Knowledge Base Article 309: Using USB PCI 2.0 host adapter cards with USB cameras.

3.2. Cables

The maximum cable length between any USB node (e.g. camera to USB, USB to hub, etc.) is 5.0m, as indicated by the USB specification. Standard, shielded twisted pair copper cables must be used. For more information, refer to the following FAQ on the usb.org website.

3.3. Camera Power

The 5-pin USB 2.0 Mini-B vertical connector provides a power connection between the camera and the host computer. The ideal input voltage is 5V DC; however, the camera is designed to handle voltages between 4.75V and 5.25V DC according to the USB 2.0 standard. The power consumption is outlined in the *Camera Specifications* section.

Some PGR cameras allow the user to power-up or power-down components of the camera using the CAMERA_POWER register 0x610. The exact components, e.g. image sensor, A/D converter, other board electronics, will vary between camera models. Consult the *Point Grey Digital Camera Register Reference* for more information.

When a 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.

Related Knowledge Base Articles

ID	Title	URL
295	Providing Power to Point Grey Cameras	www.ptgrey.com/support/kb/index.asp?a=4&q=295

3.4. General Purpose Input/Output (GPIO)

The *Chameleon* has a 7-pin GPIO connector on the back of the case. The connector is made by JST (Mfg P/N: BM07B-SRSS-TB). The Development Kit contents include a pre-wired female connector; refer to the diagram below for wire color-coding. Additional female connectors (Mfg P/N: SHR-07V-S-B) can be purchased from Digikey (P/N: 455-1382-ND).

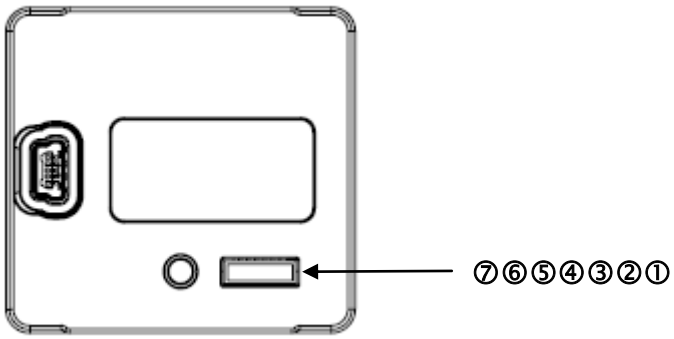


Figure 5: GPIO pin layout

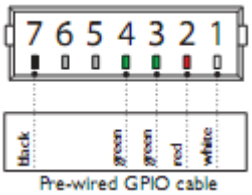
Diagram	Pin	GPIO	Function
 Pre-wired GPIO cable	1	V_{EXT}	Power camera externally. Voltage limit: 4.75 to 5.25V
	2	+3.3V	Power external circuitry up to a total of 150mA
	3	IO0	Input / Output (default Trigger_Src)
	4	IO1	Input / Output
	5	IO2	
	6	IO3	
	7	GND	

Table 1: GPIO pin assignments

Inputs can be configured to accept external trigger signals. **Outputs** can be configured to send an output signal, strobe, or PWM signal.

3.4.1. GPIO Electrical Characteristics

The *Chameleon* GPIO pins are bi-directional. When configured as outputs, they operate as open collector transistor logic. As inputs, the lines are internally pulled up to 3.3V.

When configured as **inputs**, the pins are internally pulled high using weak pull-up resistors to allow easy triggering of the camera by simply shorting the pin to ground (GND). Inputs can also be directly driven from a 3.3V or 5V logic output. The inputs are protected from both over and under voltage. It is recommended, however, that they only be connected to 5V or 3.3V digital logic signals. When configured as **outputs**, each line can sink 10mA of current. To drive external devices that require more, consult the following article for information on buffering an output signal using an optocoupler:

KB Article 200: www.ptgrey.com/support/kb/index.asp?a=4&q=200

The $\mathbf{V_{EXT}}$ pin (Pin 1) allows the camera to be powered externally. The voltage limit is 4.75-5.25V.

The **+3.3V** pin (Pin 2) is fused at 200mA. External devices connected to Pin 1 should not attempt to pull anything greater than that.

3.5. Status Indicator LED

LED Status	Description
Off	Not receiving power
Steady on	Receiving power and successful camera initialization
Steady on and very bright	Acquiring / transmitting images
Flashing bright, then brighter	Camera registers being accessed (no image acquisition)
Steady flashing on and off	Indicates possible camera problem
Slow flashing on and off	Indicates possible camera problem

Table 2: Status indicator LED descriptions

4 Camera Operations and Features

Although designed with a USB 2.0 interface, the *Chameleon* camera complies with the *IIDC 1394-based Digital Camera Specification Version v1.31*.

To determine the specific IIDC v1.31 features implemented in a particular *Chameleon* model, consult the following sections of the *Point Grey Digital Camera Register Reference* included with the PGR FlyCapture SDK and downloadable from www.ptgrey.com/support/downloads/..

- Inquiry Registers for Basic Functions
- Inquiry Registers for Feature Presence
- Inquiry Registers for Feature Elements

You can query the registers described in these sections to identify whether specific features have been implemented. The *Point Grey Digital Camera Register Reference* can also be referenced for a complete description of the Camera Control Command Registers implemented on the *Chameleon.*

4.1. General Camera Properties

The following section provides an overview of the camera properties implemented by the *Chameleon*. Descriptions of some of the following properties and how they are implemented can be found in this *Technical Reference*. Refer to the *Point Grey Digital Camera Register Reference* for additional definitions and descriptions of:

- "Auto", "On/Off" and "One Push" - *Control and Status Registers for Features* section
- "Absolute Mode" - *Absolute Value CSR Registers* section

The following property ranges apply to a *Chameleon* CMLN-13S2C running at 15 FPS, and can change depending on the camera resolution and frame rate:

- Shutter / Extended Shutter: maximum values increase as frame rate decreases
- Pan / Tilt: maximum values increase with smaller non-Format_7 resolutions
- Frame Rate: range changes according to the current frame rate

Property	Units	Min	Max	Auto	On/Off	One Push	Absolute Mode
Brightness	%	0	6.24	N	N	N	Y
Auto Exposure	EV	-7.58	2.41	Y	Y	Y	Y
White Balance	1	0	1023	N	Y	N	
Gamma		0.5	4	N	Y	N	Y
Pan		0	16	Y	Y	N	Y
Tilt		0	4	Y	Y	N	Y
Shutter	ms	0	66.64	Y	N	Y	Y
Gain	dB	-5.63	24	Y	N	Y	Y
Trigger Delay	s	0	0.07	N	Y	N	Y
Frame Rate	fps	0.13	16.29	Y	Y	N	Y
Extended Shutter	ms	0.01	63312.04	N	N	N	Y

4.2. Standard Data Formats, Modes and Frame Rates

This section lists the different video formats, modes and frame rates that are supported by the *Chameleon*. Refer to the *Customizable Formats and Modes* for a list of supported partial image (Format_7) modes. These standard modes are controlled using the following IIDC registers:

- CURRENT_VIDEO_FORMAT register 0x608
- CURRENT_VIDEO_MODE register 0x604
- CURRENT_FRAME_RATE register 0x600

Models: ● 13S2M/C

Modes	1.875fps	3.75fps	7.5fps	15fps	30fps*
640x480 Y8	●	●	●	●	●
640x480 Y16	●	●	●	●	●
1280x960 Y8	●	●	●	●	
1280x960 Y16	●	●	●		

*B/W output only. Color data is removed due to pixel binning.

Table 3: Supported video formats, modes and frame rates

4.3. Frame Rates and Camera Bandwidth

This section is recommended for advanced users only, and is not meant to address all possible applications of the Chameleon *camera.*

4.3.1. Maximum Number of Cameras on a Single Bus

A single USB port generally constitutes a single “bus”. The USB standard allows for 127 devices (including up to five levels of hub devices) to be connected to a single bus. In practice, however, this limit may be further defined by the following considerations:

- Adequate power supply. The Chameleon requires 5 volts (V) of power to operate effectively. While a standard, non-powered bus provides 500 milliamps (mA) of power at 5V, an internal, bus-powered hub provides only 400mA. Externally-powered hubs provide 500mA per port.
- Adequate bandwidth. The USB 2.0 bandwidth capacity is 480 megabits per second (Mbit/s). Depending on the operating configuration of the cameras and other devices, this bandwidth must be shared on the system.

Point Grey does not support the use of multiple USB 2.0 cameras streaming simultaneously on the same computer. There has been no rigorous qualification of the ability of various hardware platforms, operating systems, software, and drivers to handle multiple USB 2.0 image streams. Therefore, questions or troubleshooting of these issues cannot be addressed. Wherever possible, Point Grey FireWire cameras should be used for applications that require multiple cameras running simultaneously on the same computer.

4.4. Customizable Data Formats and Modes

The table below outlines the Format_7 custom image modes that are supported by the *Chameleon*. The implementation of these modes and the frame rates that are possible are not specified by the IIDC, and are subject to change across firmware versions.

Mode_0, Mode_1 and Mode_2 are region of interest (sub-window) modes that allow the user to only transmit a selected area of the image. Mode_1 and Mode_2 are also pixel binning (subsampling) modes. Refer to the *Pixel Binning and Region of Interest Modes* section for information on mode implementation.

Moving the position of region of interest to a different location does not require the camera to be stopped (isochronous transmission disabled) and restarted (iso enabled), unless the change is illegal (e.g. moving the ROI outside the imaging area) or would affect the isochronous packet size. Changing the size of the image or the pixel encoding format does require the stop/start procedure. Ignoring the time required to do this in software (tearing down, then reallocating, image buffers, write times to the camera, etc.), the maximum amount of time required for the stop/start procedure is slightly more than one frame time.

The sizes and frame rates supported by monochrome (BW) models are identical to the color models specified below, with the exception that only Mono8 and Mono16 are supported.

CMLN-13S2C

Mode	Pixel Format	Unit Size (H,V)	Min BPP	Max BPP	1280 x 960 FPS	640x480 FPS	320 x 240 FPS	160 x 120 FPS
0	Raw8	8,2	244	2928	18	24	29	31
0	Raw16	8,2	488	3904	12	24	29	32
1	Mono8	4,2	124	1240	-	33	33	32
1	Mono16	4,2	244	2684	-	33	33	33
2	Mono8	8,2	244	2684	-	33	33	32
2	Mono16	8,2	488	3904	-	33	33	33

Table 4: Partial image (Format 7) video formats, modes and frame rates for CMLN-13S2C

When outputting in Raw8 or Raw16 format, the camera outputs color data only in 1280x960 resolution. In lower resolutions, the camera performs pixel binning, which destroys the Bayer tile pattern.

4.4.1. Calculating Format_7 Frame Rates

The theoretical frame rate (FPS) that can be achieved given the number of packets per frame (PPF) can be calculated as follows:

$$FPS = \frac{1}{\text{Packets per Frame} * 125us}$$

An estimate for the number of packets per frame can be determined according to the following:

$$PPF = \frac{Image\_Size * Bytes\_Per\_Pixel}{Bytes\_Per\_Packet}$$

For the exact number of packets per frame, query the PACKET_PER_FRAME_INQ register. For the number of bytes per packet, query the BYTE_PER_PACKET register.

For example, assuming an image size of 1032x776, pixel format of Mono16 (2 bytes per pixel), and 3880 bytes per packet, the calculation would be as follows:

FPS = 1 / ((1032*776*2 / 3880) * 0.000125)
FPS = 1 / (412.8 * 0.000125)
FPS = 19.38

4.5. Image Acquisition

4.5.1. Camera Power

The *Chameleon* allows the user to power-up or power-down components of the camera using the CAMERA_POWER register 0x610. The exact components, e.g. image sensor, A/D converter, other board electronics, will vary between camera models. By default, power is OFF both at startup and reinitialization.

If isochronous transmit (ISO_EN / ONE_SHOT / MULTI_SHOT) is enabled while the camera is powered down, the camera will automatically write *Cam_Pwr_Ctrl* = 1 to power itself up. However, disabling isochronous transmit does not automatically power-down the camera.

The camera will typically not send the first two images acquired after power-up unless the camera is in asynchronous trigger mode. The auto-exposure algorithm does not run while the camera is powered down. It may therefore take several (*n*) images to get a satisfactory image, where *n* is undefined.

4.5.2. Shutter

The *Chameleon* supports automatic, manual and one-push control of the CCD shutter time. Refer to the *General Specifications* section for detailed information on supported shutter time ranges. Shutter times are scaled by the divider of the basic frame rate. For example, dividing the frame rate by two (e.g. 15 FPS to 7.5 FPS) causes the maximum shutter time to double (e.g. 66ms to 133ms).

Formulas for converting the fixed point (relative) shutter values reported by SHUTTER register 0x81C to floating point (absolute) values are not provided. Users wishing to work with real-world values should refer to the *Absolute Value CSR Registers* section of the *Point Grey Digital Camera Register Reference*.

The terms "integration" and "exposure" are often used interchangeably with "shutter".

The time between the end of shutter for consecutive frames will always be constant. However, if the shutter time is continually changing (e.g. shutter is in Auto mode being controlled by Auto Exposure), the time between the beginning of consecutive integrations will change. If the shutter time is constant, the time between integrations will also be constant.

The *Chameleon* will continually expose and read image data off of the sensor under the following conditions:

1. The camera is powered up (see *Camera Power* above); **and**
2. The camera is not in asynchronous trigger mode. When in async trigger mode, the camera simply clears the sensor and does not read the data off the sensor.

It is important to note that the camera will continue exposing images even when isochronous data transfer is disabled and images are not being streamed to the PC. The camera continues

exposing images even when ISO is off in order to keep things such as the auto exposure algorithm (if enabled) running. This is done to ensure that when a user starts requesting images (ISO turned on), the first image they receive will be properly exposed.

4.5.3. Gain

The *Chameleon* supports automatic, manual and one-push gain modes. The A/D converter provides field-programmable gate array (FPGA) gain stage (white balance / preamp) and VGA gain stage (GAIN register 0x820). The main VGA gain stage is available to the user, and is variable from -5.63 to 24dB in steps of 0.046db.

Formulas for converting the fixed point (relative) gain values reported by GAIN register 0x820 to floating point (absolute) values are not provided. Users wishing to work with real-world values should refer to the *Absolute Value CSR Registers* section of the *Point Grey Digital Camera Register Reference*.

Increasing gain also increases image noise, which can affect image quality. To increase image intensity, try adjusting the lens aperture (iris) and shutter time first.

4.5.4. Auto Exposure

Auto exposure (AE) allows the camera to automatically control shutter and/or gain in order to achieve a specific average image intensity, and is controlled using the AUTO_EXPOSURE register 0x804. There are three AE states:

State	Description
Off	Control of the exposure is achieved via setting shutter and/or gain.
On Manual AE	The camera automatically modifies shutter and/or gain to try and match the average image intensity to one-quarter of the specified AE value.
On Auto AE	The camera modifies the AE value in order to produce an image that is visually pleasing.

If only one of shutter and gain is in auto mode, the auto exposure controller attempts to control the image intensity using that one parameter. If both of these parameters are in auto mode, the auto exposure controller uses a shutter-before-gain heuristic to try and maximize the signal-to-noise ratio by favoring a longer shutter time over a larger gain value.

The auto exposure algorithm is only applied to the active region of interest, and not the entire array of active pixels.

4.5.5. Extended Shutter Times

The maximum shutter time for the *Chameleon* can be extended beyond the normal shutter range by setting the *ON_OFF* bit [6] of the FRAME_RATE register 0x83C to zero (OFF). Once the FRAME_RATE is turned off, you should see the *Max_Value* of the ABS_VAL_SHUTTER register increase.

The maximum extended shutter time reported by the SHUTTER_INQ register 51Ch is capped at 4095 (0xFFF), the maximum value allowed by the Max_Value *field of this register. Use the* Max_Value *of the ABS_VAL_SHUTTER register to determine the maximum shutter.*

Model	Format and FPS	Min (ms)	Max (ms)	Notes
CMLN 13S2M CMLN 13S2C	1280x960 Y8, 15 FPS	0.005	4088	
	1280x960 Y8, 7.5 FPS	0.01	8176	
	1280x960 Y8 3.75 FPS	0.01	16352	
	1280x960 Y8 1.875 FPS	0.01	32704	
	640x480 Y8, 30 FPS	0.005	4088	
	640x480 Y8, 15 FPS	0.01	8177	
	640x480 Y8, 7.5 FPS	0.01	16355	
	640x480 Y8, 3.75 FPS	0.01	32711	
	640x480 Y8, 1.875 FPS	0.01	65426	

Table 5: Extended shutter minimum and maximum times

4.5.6. Frame Rate Control

The current base frame rate is controlled using the CURRENT_FRAME_RATE register 0x600. The *Chameleon* allows users to further “fine-tune” the frame rates of their cameras using the FRAME_RATE register 0x83C, which is described in detail in the *Point Grey Digital Camera Register Reference*. This is particularly useful for capturing an image stream at a different frame rate than those outlined in the *Supported Data Formats and Modes* section, and can be useful for synchronizing to 50Hz light sources, which can cause image intensity fluctuations due to the light source oscillations being out of sync with the frame rate.

For example, users may wish to play an image stream back on a PAL-based system that displays at 25 FPS. To do this, set the CURRENT_FRAME_RATE to 30 FPS, set the *A_M_Mode* bit [7] of the FRAME_RATE register 0x83C to zero (manual), then adjust the value using the *Value* field or using the ABS_VAL_FRAME_RATE register (recommended).

4.5.7. Pixel Binning and Region of Interest Modes

The *Chameleon* implements three Format_7 customizable video modes (see the *Customizable Formats and Modes* section for camera-specific information) that allow for faster frame rates based on selecting a specific region of interest (ROI) of the image or by configuring the camera to sub-sample the image using a process known as "pixel binning". Mode 1 implements 2X vertical and 2X horizontal binning, which lowers the image resolution by a factor of 4. Mode 2 implements 2X horizontal binning only, which lowers resolution by a factor of 2.

Related Knowledge Base Articles

ID	Title	URL
163	What are the differences between pixel binning and region of interest custom image modes?	www.ptgrey.com/support/kb/index.asp?a=4&q=163

4.5.8. Y16 (16-bit Mono) Image Acquisition

The *Chameleon* can output Y16 (16 bit-per-pixel) mono images. However, the camera uses a 12-bit A/D converter (see the *Analog-to-Digital Converter* section), so only 12 bits of useable data is theoretically possible.

To determine the number of bits of useable image data, and resulting signal-to-noise ratio, that is actually being produced by the A/D converter, see www.ptgrey.com/support/kb/index.asp?a=4&q=170.

The data format for Y16 images is controlled by the *Y16_Data_Format* field of the IMAGE_DATA_FORMAT register 0x1048. Consult the *Point Grey Digital Camera Register Reference* for more information.

The PGM file format can be used to correctly save 16-bit images. However, there are very few photo manipulation/display applications that can correctly display true 16-bit images. XV in Linux and Adobe Photoshop are two possibilities.

4.5.9. Asynchronous (External) Trigger Modes

The *Chameleon* provides a number of different asynchronous trigger modes, which allows the start of exposure (shutter) to be initiated by an external electrical source (hardware trigger) or camera register write (software trigger). Supported modes include: 0, 1, 3 and 14. These modes and their operation are described in greater detail in the *Point Grey Digital Camera Register Reference*.

4.5.9.1. External Trigger Timing

The time from the external trigger going low to the start of shutter is shown below:

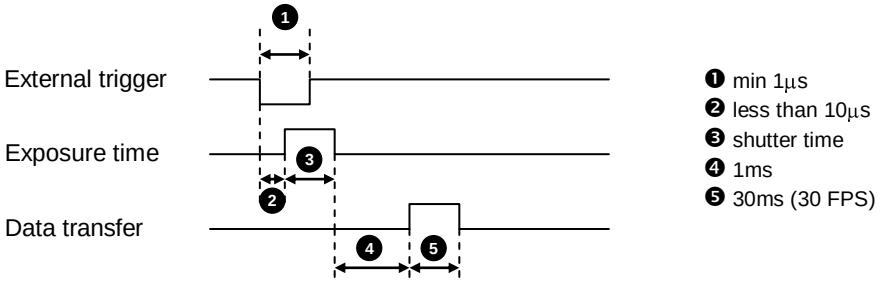


Figure 6: *Chameleon* external trigger timing characteristics

It is possible for users to measure this themselves by configuring one of the camera's GPIO pins to output a strobe pulse (see the *Programmable Strobe Output* section) and connecting an oscilliscope up to the input trigger pin and the output strobe pin. The camera will strobe each time an image acquisition is triggered; the start of the strobe pulse represents the start of exposure.

4.5.9.2. Ensuring Trigger is Armed

It is possible for the *Chameleon* to be in asynchronous trigger mode but not be ready to accept a trigger. The reason for this is that the camera may be currently exposing an image; the camera is only ready to be triggered again when this image finishes integrating and is completely read off of the CCD.

To ensure that the camera is ready to be triggered, poll the SOFTWARE_TRIGGER register 0x62C. The concept of polling to ensure the trigger is armed is demonstrated in the AsyncTriggerEx example program distributed with the *FlyCapture* SDK.

Once the trigger is reporting that it is armed, there should be no delay between when the user can enable isochronous transmission and when they can trigger the camera. In fact, it is possible to trigger the camera before iso is enabled and receive the image that was triggered, provided iso is enabled at some point during exposure. For example, assuming a 10ms shutter time, it is possible to trigger the camera, enable iso 5ms after, and still receive the triggered image.

Related Knowledge Base Articles

ID	Title	URL
169	Time between software trigger and start of integration.	www.ptgrey.com/support/kb/index.asp?a=4&q=169
177	Maximum frame rate possible in external trigger mode_0.	www.ptgrey.com/support/kb/index.asp?a=4&q=177
221	Synchronizing to an external signal using IIDC 1.31 Trigger_Mode_0	www.ptgrey.com/support/kb/index.asp?a=4&q=221

4.5.9.3. 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 pixel clock setting. This safeguard results in a minimum 16-tick delay before the camera responds to a trigger signal. The pixel clock frequency can be read from the floating point PIXEL_CLOCK_FREQ register 0x1AF0.

4.6. Image Processing

4.6.1. Color and Greyscale Conversion

The color *Chameleon* model provides raw Bayer data for users to apply their own color conversion algorithm or one of the FlyCapture library algorithms. Images should be acquired using one of the Format_7 video modes that support Raw8 or Raw16 pixel encoding. See the *Customizable Formats and Modes* section for further information on acquiring images using these modes. An alternative to this is to use the Bayer_Mono_Ctrl bit [24] of the IMAGE_DATA_FORMAT register 0x1048. Setting this bit to 1 enables raw Bayer output in non-Format_7 Y8 / Y16 modes, or Format_7 Mono8 / Mono16 modes.

The actual physical arrangement of the red, green and blue "pixels" for a given camera is determined by the arrangement of the color filter arrays on the imaging sensor itself. The format (i.e. order) in which this raw color data is streamed out, however, depends on the specific camera model and firmware version. This format can be queried using the BAYER_TILE_MAPPING register 0x1040 that is implemented on all PGR cameras.

Raw image data can be accessed programmatically via the pData pointer in the FlyCaptureImage structure (e.g. FlyCaptureImage.pData). In Raw8 modes, the first byte represents the pixel at (row 0, column 0), the second byte at (row 0, column 1), etc. Read the BAYER_TILE_MAPPING register 0x1040 to determine the current Bayer output format (e.g. RGGB, GRBG, etc.). Using a Bayer format of RGGB, for example, if we access the image data via the pData pointer we would have the following:

- pData[0] = Row 0, Column 0 = red pixel (R)
- pData[1] = Row 0, Column 1 = green pixel (G)
- pData[640] = Row 1, Column 0 = green pixel (G)
- pData[641] = Row 1, Column 1 = blue pixel (B)

Related Knowledge Base Articles

ID	Title	URL
33	Different color processing algorithms.	www.ptgrey.com/support/kb/index.asp?a=4&q=33
37	Writing color processing software and color interpolation algorithms.	www.ptgrey.com/support/kb/index.asp?a=4&q=37
89	How is color processing performed on my camera's images?	www.ptgrey.com/support/kb/index.asp?a=4&q=89

4.6.2. Lookup Table and Gamma

CCD manufacturers strive to make the transfer characteristics of CCDs inherently linear, which means that as the number of photons hitting the imaging sensor increases, the resulting image intensity increases will be linear. To augment this linearity, the *Chameleon* supports gamma functionality in conjunction with an 11-bit input lookup table (LUT) that produces 8-bit output. Although the camera uses a 12-bit A/D converter, the *Chameleon* is only able to accommodate 11-bit images.

Gamma is applied after the analog-to-digital conversion and is controlled using the GAMMA register 0x818. It can be used to apply a non-linear mapping of the resulting 11-bit image down to 8 bits. By default, Gamma is OFF and has a value of 1.0, which yields a linear response. Direct manipulation of the lookup table is not available.

4.6.3. White Balance

The *Chameleon* supports white balance, which is a name given to a system of color correction to deal with differing lighting conditions. Adjusting the white balance by modifying the relative gain of R, G and B in an image enables white areas to look "whiter". Taking some subset of the target image and looking at the relative red to green and blue to green response, the general idea is to scale the red and blue channels so that the response is 1:1:1. The white balance scheme outlined in the IIDC specification states that blue and red are adjustable and that green is not. The blue and red values can be controlled using the WHITE_BALANCE register 0x80C.

4.6.4. Embedded Image Information

The *Chameleon* has a feature that allows image timing and camera settings information to be embedded in the first several pixels of each image. This feature is controlled using the FRAME_INFO register 0x12F8, which is described in detail in the *Point Grey Digital Camera Register Reference*.

4.7. Camera and Device Control

4.7.1. Programmable Strobe Output

The *Chameleon* is capable of outputting a strobe pulse off one or all of its GPIO pins. By default, a pin that is configured to be a strobe output will output a pulse each time the camera begins integration of an image. Setting a strobe duration value of zero will produce a strobe pulse indicating the exposure (shutter) time.

The *Chameleon* 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)

Related Knowledge Base Articles

ID	Title	URL
179	Setting a GPIO pin to output a signal using IIDC v1.31 strobe functionality	www.ptgrey.com/support/kb/index.asp?a=4&q=179
207	Setting a GPIO pin to output a strobe signal pulse pattern	www.ptgrey.com/support/kb/index.asp?a=4&q=207
212	GPIO strobe signal continues after isochronous image transfer stops	www.ptgrey.com/support/kb/index.asp?a=4&q=212

4.7.2. Memory Channel Storage of Camera Settings

The *Chameleon* has the ability to save and restore camera settings and imaging parameters via on-board memory channels. This is useful for saving default power-up settings, such as gain, shutter, video format and frame rate, etc., that are different from the factory defaults.

Memory channel 0 is used for the default factory settings that users can always restore to. The *Chameleon* provides two additional memory channels for custom default settings. The camera will initialize itself at power-up, or when explicitly reinitialized, using the contents of the last saved memory channel. Attempting to save user settings to the (read-only) factory defaults channel will cause the camera to switch back to using the factory defaults during initialization.

Refer to the *Memory Channel Registers* section in the Appendix for a full listing of all registers saved.

Memory channels are configured using the following registers, which are described in detail in the *Point Grey Digital Camera Register Reference*: MEMORY_SAVE 0x618; MEM_SAVE_CH 0x620; and CUR_MEM_CH 0x624.

Related Knowledge Base Articles

ID	Title	URL
290	Using memory channels to configure default start-up settings	http://www.ptgrey.com/support/kb/index.asp?a=4&q=290

4.7.3. Flash Memory

The camera has 256 KB of on-board flash memory available for storing image data. For more information about working with the flash memory, see the following application note:

Related Knowledge Base Articles

ID	Title	URL
341	Storing data in on-camera flash memory	http://www.ptgrey.com/support/kb/index.asp?a=4&q=341

4.7.4. Camera Upgrades

The firmware on the *Chameleon* can be upgraded / downgraded to later / earlier versions using the UpdatorGUI program that is bundled with every firmware version available from

www.ptgrey.com/support/downloads/. The latest firmware versions often include significant bug fixes and feature enhancements that may benefit some users. To determine the changes made in a specific firmware version, consult the Release Notes. For more information on updating camera firmware, consult the *UpdatorGUI User Manual* available in the downloads section.

Appendix A: Memory Channel Registers

Register Name	Offset
CURRENT_FRAME_RATE	600h
CURRENT_VIDEO_MODE	604h
CURRENT_VIDEO_FORMAT	608h
CAMERA_POWER	610h
CUR_SAVE_CH	620h
BRIGHTNESS	800h
AUTO_EXPOSURE	804h
SHARPNESS	808h
WHITE_BALANCE	80Ch
HUE	810h
SATURATION	814h
GAMMA	818h
SHUTTER	81Ch
GAIN	820h
IRIS	824h
FOCUS	828h
TRIGGER_MODE	830h
TRIGGER_DELAY	834h
FRAME_RATE	83Ch
PAN	884h
TILT	888h
ABS_VAL_AUTO_EXPOSURE	908h
ABS_VAL_SHUTTER	918h
ABS_VAL_GAIN	928h
ABS_VAL_BRIGHTNESS	938h
ABS_VAL_GAMMA	948h
ABS_VAL_TRIGGER_DELAY	958h
ABS_VAL_FRAME_RATE	968h
IMAGE_DATA_FORMAT	1048h
AUTO_EXPOSURE_RANGE	1088h
AUTO_SHUTTER_RANGE	1098h
AUTO_GAIN_RANGE	10A0h
GPIO_XTRA	1104h
SHUTTER_DELAY	1108h
GPIO_STRPAT_CTRL	110Ch
GPIO_CTRL_PIN_x	1110h, 1120h, 1130h, 1140h
GPIO_XTRA_PIN_x	1114h, 1124h, 1134h, 1144h
GPIO_STRPAT_MASK_PIN_x	1118h, 1128h, 1138h, 1148h
FRAME_INFO	12F8h
FORMAT_7_IMAGE_POSITION	008h
FORMAT_7_IMAGE_SIZE	00Ch
FORMAT_7_COLOR_CODING_ID	010h
FORMAT_7_BYTE_PER_PACKET	044h

Appendix B: Glossary

Term	Definition
1394a	An Institute of Electrical and Electronics Engineers (IEEE) interface standard capable of transferring data at a rate of 400Mbit per second.
1394b	An IEEE interface standard capable of transferring data at a rate of 800Mbit per second.
Absolute Values	Real-world values, such as milliseconds (ms), decibels (dB) or percent (%). Using the absolute values is easier and more efficient than applying complex conversion formulas to integer values.
Analog-to-Digital Converter	Often abbreviated as ADC or A/D converted, it is a device that converts a voltage to a digital number.
API	Application Programming Interface. Essentially a library of software functions.
Asynchronous Transmission	The transfer of image data from the camera to the PC that is regulated by an external signal, such as a trigger. Asynchronous transfers do not guarantee when data will be transferred. However, they do guarantee that data will arrive as sent. Asynchronous transfers may be used when data integrity is a higher priority than speed. An example might be an image data transfer to a printer, where speed is less critical than getting the image pixels correct. Asynchronous transfers are initiated from a single node, designated the 'requestor', to or from the address space of another node, designated the 'responder'. Asynchronous requests are packet-based. The requestor node generates a request packet that the 1394 bus sends to the responder node. The responder node is responsible for handling the request packet and creating a response packet that is sent back to the requestor node to complete a single transfer. There are three types of 1394 asynchronous transfers: Read, Write and Lock.
BPP	Bytes per packet. An image is broken into multiple packets of data, which are then streamed isochronously to the host system. Each packet is made up of multiple bytes of data.
Brightness (%)	This is essentially the level of black in an image. A high brightness will result in a low amount of black in the image. In the absence of noise, the minimum pixel value in an image acquired with a brightness setting of 1% should be 1% of the A/D converter's minimum value.
Config ROM	Configuration read-only memory. A section of memory dedicated to describing low-level device characteristics such as Model and Vendor ID, IEEE-1394 version compliance, base address quadlet offsets, etc.
Color Processing	Also known as 'interpolation,' an algorithm for converting raw Bayer-tiled image data into full color images. Depending on camera model, this process takes place either on-camera or on the PC. For more information, refer to Knowledge Base Article 33.
DCAM	Abbreviation for the *IIDC 1394-based Digital Camera (DCAM) Specification*, which is the standard used for building FireWire-based cameras.
Dynamic Range	The difference between the maximum and minimum amounts of light that a sensor can measure. This is bounded on the upper end by the maximum charge that any pixel can contain (sensor full well depth) and at the lower end by the small charge that every sensor spontaneously generates (read noise).
Exposure (EV)	This is the average intensity of the image. It will use other available (non-manually adjustable) controls to adjust the image.
Firmware	Programming that is inserted into programmable read-only memory, thus becoming a permanent part of a computing device. Firmware is created and tested like software and can be loaded onto the camera.
Format_7	Encompasses partial or custom image video formats and modes, such as region of interest of pixel binned modes. Format_7 modes and frame rates are defined by the camera manufacturer, as opposed to the DCAM specification.
FPS	Frames Per Second.
Frame Rate	Often defined in terms of number of frames per second (FPS) or frequency (Hz). This is the speed at which the camera is streaming images to the host system. It basically defines the interval between consecutive image transfers.
Gain (dB)	The amount of amplification that is applied to a pixel by the A/D converter. An increase in gain can result in a brighter image and an increase in noise.
Gamma	Gamma defines the function between incoming light level and output picture level. Gamma can also be useful in emphasizing details in the darkest and/or brightest regions of the image.
GPIO	General Purpose Input/Output.

Grabbing Images	A commonly-used phrase to refer to the process of enabling isochronous transfers on a camera, which allows image data to be streamed from the camera to the host system.
Hz	Hertz. A unit of frequency; one Hertz has a periodic interval of one second. Often used interchangeably with FPS as a measure of frame rate.
Isochronous Transmission	The transfer of image data from the camera to the PC in a continual stream that is regulated by an internal clock. Isochronous transfers on the 1394 bus guarantee timely delivery of data. Specifically, isochronous transfers are scheduled by the bus so that they occur once every 125µs. Each 125µs timeslot on the bus is called a frame. Isochronous transfers, unlike asynchronous transfers, do not guarantee the integrity of data through a transfer. No response packet is sent for an isochronous transfer. Isochronous transfers are useful for situations that require a constant data rate but not necessarily data integrity. Examples include video or audio data transfers. Isochronous transfers on the 1394 bus do not target a specific node. Isochronous transfers are broadcast transfers which use channel numbers to determine destination.
Lookup Table	A matrix of gamma functions for each color value of the current pixel encoding format.
Node	An addressable device attached to a bus. Although multiple nodes may be present within the same physical enclosure (module), each has its own bus interface and address space and may be reset independently of the others.
Node ID	A 16-bit number that uniquely differentiates a node from all other nodes within a group of interconnected buses. Although the structure of the node ID is bus-dependent, it usually consists of a bus ID portion and a local ID portion. The most significant bits of the node ID are the same for all nodes on the same bus; this is the bus ID. The least-significant bits of the node ID are unique for each node on the same bus; this is called the local ID. The local ID may be assigned as a consequence of bus initialization.
One Push	For use when a control is in manual adjust mode, One Push sets a parameter to an auto-adjusted value, then returns the control to manual adjust mode.
PHY	Physical layer. Each 1394 PHY provides the interface to the 1394 bus and performs key functions in the communications process, such as bus configuration, speed signaling and detecting transfer speed, 1394 bus control arbitration, and others.
Pan	A mechanism to horizontally move the current portion of the sensor that is being imaged. In stereo and spherical cameras, Pan controls which individual sensors transmit images.
Pixel Clock	The rate at which the sensor outputs voltage signals in each pixel from the optical input.
Pixel Format	The encoding scheme by which color or greyscale images are produced from raw image data.
Quadlet	A 4 byte (32-bit) value.
Quadlet Offset	The number of quadlets separating a base address and the desired CSR address. For example, if the base address is 0xFFFFF0F00000 and the value of the quadlet offset is 0x100, then the actual address offset is 0x400 and the actual adress 0xFFFFF0F00400.
Register	A term used to describe quadlet-aligned addresses that may be read or written by bus transactions.
Saturation	This is how far a color is from a gray image of the same intensity. For example, red is highly saturated, whereas a pale pink is not.
SDK	Software Development Kit
Sharpness	This works by filtering the image to reduce blurred edges.
Shutter	A mechanism to control the length of time the sensor is exposed to light from the image field for each frame. In milliseconds (ms), it is the amount of time that the shutter stays open, also known as the *exposure* or *integration* time. The shutter time defines the start and end point of when light falls on the imaging sensor. At the end of the exposure period, all charges are simultaneously transferred to light-shielded areas of the sensor. The charges are then shifted out of the light shielded areas of the sensor and read out.
Signal-to-Noise Ratio (dB)	The difference between the ideal signal that you expect and the real-world signal that you actually see is usually called noise. The relationship between signal and noise is called the signal-to-nose ratio (SNR). SNR is calculated using the general methodology outlined in Knowledge Base Article 142.
SXGA	1280x1024 pixel resolution
Tilt	A mechanism to vertically move the current portion of the sensor that is being imaged.
Trigger	A signal to which the acquisition of images by the camera is synchronized. Triggers can be from an outside electrical source (external) or software-generated (internal).
UXGA	1600x1200 pixel resolution
VGA	640x480 pixel resolution
White Balance	A method to enable white areas of an image to appear correctly by modifying the gain of red and blue channels relative to the green channel. White balance can be used to accommodate differing lighting conditions.
XVGA	1024x768 pixel resolution

Appendix C: Technical Support Resources

Point Grey Research Inc. endeavors to provide the highest level of technical support possible to our customers. Most support resources can be accessed through the Product Support section of our website: www.ptgrey.com/support.

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, e-mail address, and camera serial number. To apply for a Customer Login Account go to www.ptgrey.com/support/downloads/.

Knowledge Base

Our on-line knowledge base at www.ptgrey.com/support/kb/ 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 downloads site at www.ptgrey.com/support/downloads. 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 at www.ptgrey.com/support/contact/.

Appendix D: Contacting Point Grey Research

For any questions, concerns or comments please contact us via the following methods:

Email:

For all general questions about Point Grey Research please contact us at info@ptgrey.com.

For technical support (existing customers only) contact us at http://www.ptgrey.com/support/contact/.

Knowledge Base:

Find answers to commonly asked questions in our knowledge base at http://www.ptgrey.com/support/kb/.

Downloads:

Users can download the latest manuals and software from http://www.ptgrey.com/support/downloads/

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Korea

Cylod Co. Ltd. (http://www.cylod.com)

China

LUSTER LightVision Tech. Co., Ltd (www.lusterlighttech.com)

Singapore
Malaysia
Thailand

Voltrium Systems Pte Ltd. (www.voltrium.com.sg)

Taiwan

Apo Star Co., Ltd. (www.apostar.com.tw)

Appendix E: Revision History

Revision	Date	Notes
1.1	October 31, 2008	• Section 3.1: USB Connector: Added a reference to Knowledge Base Article 309: Using USB 2.0 PCI host adapter cards with USB cameras. • Section 3.4: GPIO: Clarified voltage limit of V_{EXT} pin.
1.2	January 13, 2009	• Section 3.4: GPIO. Revised Table 1 to indicate that pins 5 and 6 are supported for input/output. • Section 3.2: Cables. Added a link to usb.org website for additional information about cable lengths. • Revised Sections 1.7 and 4.6.2 to clarify that direct manipulation of the lookup table is not supported.
1.3	June 9, 2009	• Added Region of Interest (ROI) frame rates to Table 4 in Section 4.4: Customizable Data Formats and Modes. • Section 4.3.1: Clarified that Point Grey does not support the use of multiple USB 2.0 cameras streaming simultaneously on the same computer. • Section 4.3.2:-Removed this section, which discusses maximum frame rate calculations for cameras on the same bus. • Glosary: Fixed error in 1394b definition. • Clarified in Section 1.3: Specifications that the camera can synchronize to an external hardware trigger or a software trigger. • Clarified that the Chameleon complies with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules.
1.4	December 7, 2009	• Clarified camera dimensions in Section 1.3 Camera Specifications. • Added link to Knowledge Base Article 295 in Section 3.3: Camera Power. • Section 4.4 Customizable Data Formats and Modes: Removed Mono8/16 formats from Format_7 Mode 0. These formats are no longer supported. • Section 4.4.1 Calculating Format_7 Frame Rates: Updated equation.
1.5	March 17, 2011	• Added information about M12 microlens holder for board-level camera models to section 2.2 Camera Dimensions and section 2.3 Lens Setup and Compatibility. • Section 4.5.7 Pixel Binning and Region of Interest Modes Added binning information about Format_7 Mode 1 and Mode 2. • Section 4.2 Standard Data Formats, Modes and Frame Rates Clarified that 30 FPS is achieved through pixel binning, with no color output. • Section 1.8.1 Heat Dissipation Added information about location of temperature sensor. • Added Section 1.9 Common CCD Artifacts • Section 4.5.5 Extended Shutter Times: Added extended shutter times of camera in full resolution.

1.6	July 12, 2011	• Section 4.4 Customizable Data Formats and Modes: Clarified that when outputting in Raw8 or Raw16 format, the camera outputs color data only in 1280x960 resolution. In lower resolutions, the camera performs pixel binning, which destroys the Bayer tile pattern. • Section 4.5.9.3 Minimum Trigger Pulse Length: Clarified the role of the signal debouncer. • Section 4.4 Customizable Data Formats and Modes: Revised bytes per packet for Format_7 modes. • Added Section 4.7.3 Flash Memory.

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