

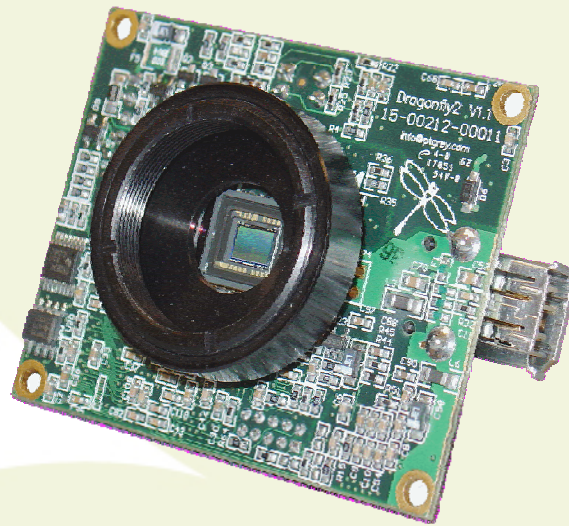


POINT GREY  
RESEARCH

# Dragonfly<sup>®</sup>2

## Technical Reference Manual

Revision 2.4



**Point Grey Research<sup>®</sup> Inc.**

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## For customers in the U.S.A.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. 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. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

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

The shielded interface cable recommended in this manual must be used with this equipment in order to comply with the limits for a computing device pursuant to Subpart J of Part 15 of FCC Rules.

## Hardware Warranty

Point Grey Research<sup>®</sup>, 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.



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# 1 Introduction

## 1.1. Dragonfly2 Overview

The *Dragonfly2* is the next generation of OEM-style IEEE-1394 board level camera specifically designed for imaging product development. It was developed for easy design transition from the original *Dragonfly* camera. The *Dragonfly2* was created to provide maximum control and flexibility for digital imaging applications.

Users are encouraged to download TAN2006001 from [www.ptgrey.com/support/downloads](http://www.ptgrey.com/support/downloads) for detailed information on how to transition applications from the *Dragonfly* to the *Dragonfly2*.



*All model-specific information presented in this manual reflects functionality available in the following camera firmware version:*

### **0.9 Beta 46**

*To check the camera firmware version, consult our knowledge base: [www.ptgrey.com/support/kb/index.asp?a=4&q=9](http://www.ptgrey.com/support/kb/index.asp?a=4&q=9).*

## 1.2. Using This Manual

This manual attempts to provide the user with a detailed specification of the *Dragonfly2* 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.

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 user manuals, technical references and application notes, which can be downloaded from our website at [www.ptgrey.com/support/downloads/](http://www.ptgrey.com/support/downloads/):

- *PGR IEEE-1394 Digital Camera Register Reference*
- *PGR FlyCapture User Manual*
- *TAN2004004: Synchronizing to an external signal using DCAM 1.31 Trigger Mode\_0*
- *TAN2004001: Configuring and testing the RS-232 serial port*
- *TAN2005002: Setting a GPIO pin to strobe using DCAM 1.31 Strobe Signal Output*
- *TAN2005003: Setting a GPIO pin to output a strobe signal pulse pattern*
- *TAN2005004: Buffering a GPIO pin output signal to drive an external device*
- *TAN2006001: Transitioning from the Dragonfly® to the Dragonfly®2: A How-To Guide*

## 1.3. Camera Specifications

Specification	03S2	08S2	13S2
Overview	OEM board-level camera (anodized aluminum case available)		
Imaging Sensor	Sony 1/3" progressive scan CCD		
Sensor Model	ICX424 (640x480)	ICX204 (1024x768)	ICX445 (1280x960)
Sensor Pixel Size	7.4µm x 7.4µm	4.65µm x 4.65µm	3.75µm x 3.75µm
A/D Converter	Analog Devices AD9949 12-bit		AD9971 12-bit
Video Data Output	8, 16 and 24-bit digital data (see <i>Supported Data Formats</i> )		
Resolutions and FPS	See the <i>Standard Data Formats</i> section		
Partial Image Modes	Pixel binning and region of interest modes available via Format_7		
Interfaces	6-pin IEEE-1394 for camera control and video data transmission 4 general-purpose digital input/output (GPIO) pins.		
Power Requirements	8-30V, < 2W	8-30V, < 2W	8-30V, < 2.1W
Gain	Automatic/Manual/One-Push Gain modes 0dB to 24dB		
Shutter	Automatic/Manual/One-Push Shutter modes		
	0.01ms to 66.63ms @ 15 FPS		
	Extended Shutter modes		
	Greater than 5 seconds @ 15 FPS		
Gamma	0.50 to 4.00		
Trigger Modes	DCAM v1.31 Modes 0, 1, 3, 4, 5 and 14		Modes 0, 1, 3, 14
Signal To Noise Ratio	Greater than 60dB @ 15 FPS		
Dimensions	63.5mm x 50.8mm x 13.15mm (bare board w/o case or lens holder)		
Mass	25 grams (bare board w/o case or optics) 45 grams (includes lens holder and C-mount adapter)		
Lens Mount	C/CS-mount or M12 microlens		C/CS-mount <sup>1</sup>
Camera Specification	IIDC 1394-based Digital Camera Specification v1.31		
Emissions Compliance	Complies with CE rules and Part 15 Class A of FCC Rules		
Operating Temperature	Commercial grade electronics rated from 0° to 45°C		
Storage Temperature	-30° to 60°C		
Operating Relative Humidity	20 to 80% (no condensation)		
Storage Relative Humidity	20 to 95% (no condensation)		

### 1.3.1. Spectral Response



*All **color models** are 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](#).*

For spectral response curves, see [Appendix A: Spectral Response Curves](#).

<sup>1</sup> Not compatible with M12 microlens holder.

## 1.4. Camera Features

### 1.4.1. Image Acquisition

Feature	Description
<b>Automatic Synchronization</b>	Multiple Dragonfly2's on the same 1394 bus automatically sync
<b>Fast Frame Rates</b>	Faster standard frame rates plus pixel binning and ROI support
<b>Multiple Trigger Modes</b>	Bulb-trigger mode, multiple triggered exposures before readout
<b>Trigger at Full Frame Rate</b>	Overlapped trigger input, image acquisition and transfer

### 1.4.2. Image Processing

Feature	Description
<b>Color Conversion</b>	On-camera conversion to YUV411, YUV422 and RGB formats
<b>Image Processing</b>	On-camera control of sharpness, hue, saturation, gamma, LUT
<b>Image Flip / Mirror</b>	Horizontal image flip (mirror image)
<b>Embedded Image Info</b>	Pixels contain frame-specific info (e.g. shutter, 1394 cycle time)
<b>Test Pattern</b>	Continuous static image for testing and development

### 1.4.3. Camera and Device Control

Feature	Description
<b>Broadcast Properties</b>	Apply settings (e.g. shutter, gain) to all cameras on the same bus
<b>Auto Iris</b>	On-board DC output for use by an auto iris lens
<b>Auto White Balance</b>	Auto and one-push white balance for easy color balancing
<b>Temperature Sensor</b>	Reports the temperature near the imaging sensor
<b>Voltage Sensor</b>	Monitors sensor voltages to ensure optimal image quality
<b>Frame Rate Control</b>	Fine-tune frame rates for video conversion (e.g. PAL @ 24 FPS)
<b>Improved Strobe Output</b>	Increased drive strength, configurable strobe pattern output
<b>RS-232 Serial Port</b>	Provides serial communication via GPIO TTL digital logic levels
<b>Data Storage</b>	Non-volatile storage of camera default settings and user data
<b>Camera Upgrades</b>	Firmware upgradeable in field via IEEE-1394 interface.

## 1.5. System Requirements

- Processor  
Recommended – Intel Pentium® 4 2.0 GHz or compatible processor  
Minimum – Intel Pentium® III 800 MHz or compatible processor
- Memory  
Recommended – 512 MB RAM, Minimum - 64 MB RAM
- AGP video card with 64 MB video memory (128 MB recommended)
- 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)



### 1.5.1. Laptop / Notebook Considerations

Some 1394 PCMCIA cards for laptop / notebook computers require a 4-pin cable. A 4-pin cable does not provide power and will therefore not work with Point Grey cameras, which require a 6-pin connector (the additional two pins provide power). For suggestions on how to provide power in these circumstances, consult the following knowledge base article:

KB Article 93: [www.ptgrey.com/support/kb/index.asp?a=4&q=93](http://www.ptgrey.com/support/kb/index.asp?a=4&q=93)

### 1.5.2. Macintosh and Linux OS Support

Users wishing to operate their Point Grey camera on the Macintosh OS/X or Linux operating systems should consult the following knowledge base articles:

Macintosh support: [www.ptgrey.com/support/kb/index.asp?a=4&q=173](http://www.ptgrey.com/support/kb/index.asp?a=4&q=173)  
Linux support: [www.ptgrey.com/support/kb/index.asp?a=4&q=17](http://www.ptgrey.com/support/kb/index.asp?a=4&q=17)

## 1.6. Controlling the Camera

The *Dragonfly2* can be controlled by the following types of applications:

### 1.6.1. FlyCapture SDK FlyCap Demo Program

The FlyCap application is a generic streaming image viewer included with the FlyCapture<sup>®</sup> 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.

### 1.6.2. Custom Applications Built with the PGR 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.

### 1.6.3. Third-Party Software Applications

The following knowledge base article provides information on Point Grey IEEE-1394 camera compatibility with third-party software development kits, applications, camera drivers, and integrated development environments (IDEs):

KB Article 152: [www.ptgrey.com/support/kb/index.asp?a=4&q=152](http://www.ptgrey.com/support/kb/index.asp?a=4&q=152)

## 1.7. 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/](http://www.ptgrey.com/support/downloads/).

## 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](http://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](http://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.

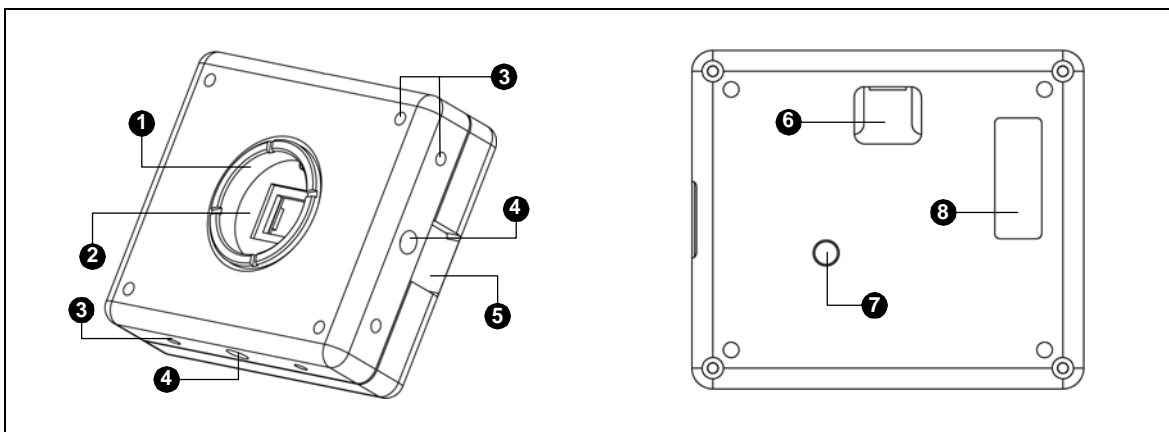
## 1.9. Camera Accessories

Accessories such as tripod mounts and lens holders are available from PGR – contact our Sales team at [sales@ptgrey.com](mailto:sales@ptgrey.com) for additional information. Links to FireWire/IEEE-1394 and 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](http://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. Glass / IR filter system**

Refer to the *Dust Protection* and the *Infrared Cut-Off Filters* section for more information.

**3. M3 mounting holes**

**4. 1/4-20 mounting holes**

Refer to the *Mounting* section for full details.

**5. IEEE-1394 connector**

The camera uses a standard 6-pin 1394 connector. See the *IEEE-1394 Connector* section for full connector details.

**6. Auto-iris connector**

Standard DC auto-iris connector for camera control of lens aperture. See the section *Connecting the Auto-Iris Lens*.

**7. Status LED**

This light indicates the current state of the *Dragonfly2* operation. Refer to the section *Status Indicator LED*.

**8. General purpose I/O connector**

The 8-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

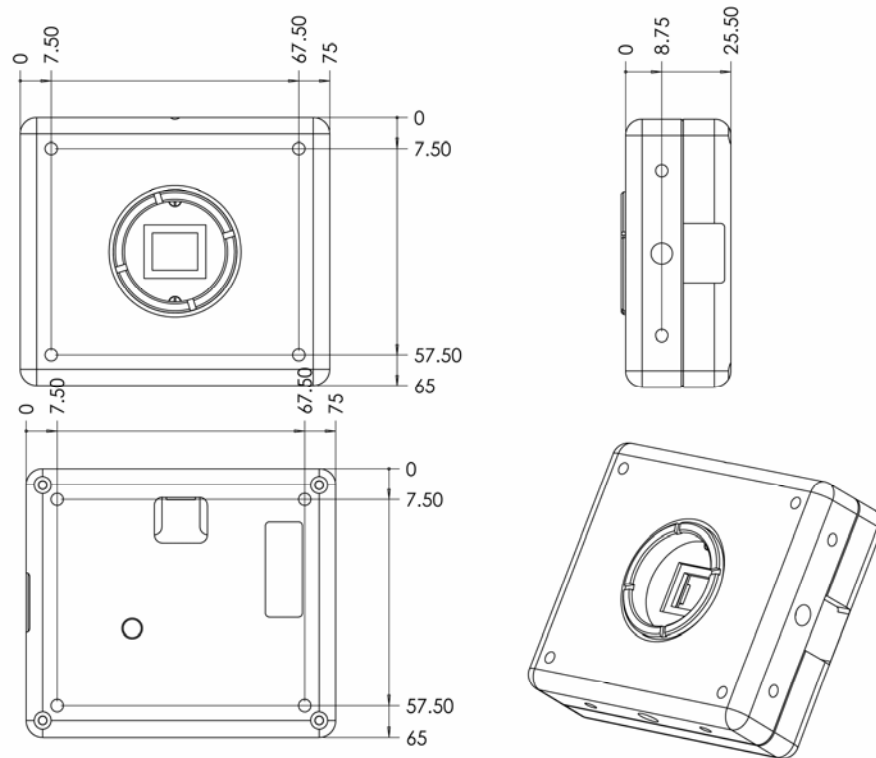


Figure 1: Dimensional drawing: DR2-xxx-CSBOX (aluminum enclosure)

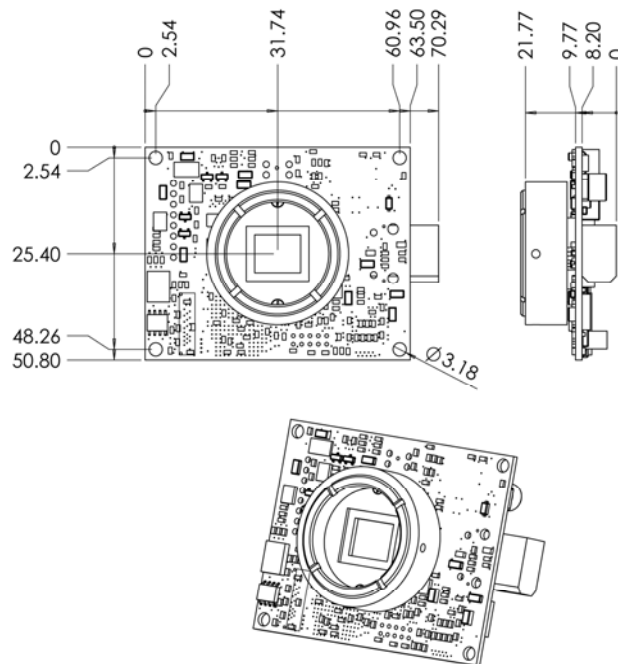


Figure 2: Dimensional drawing: DR2-xxx-CS (board level with CS-mount lens holder)

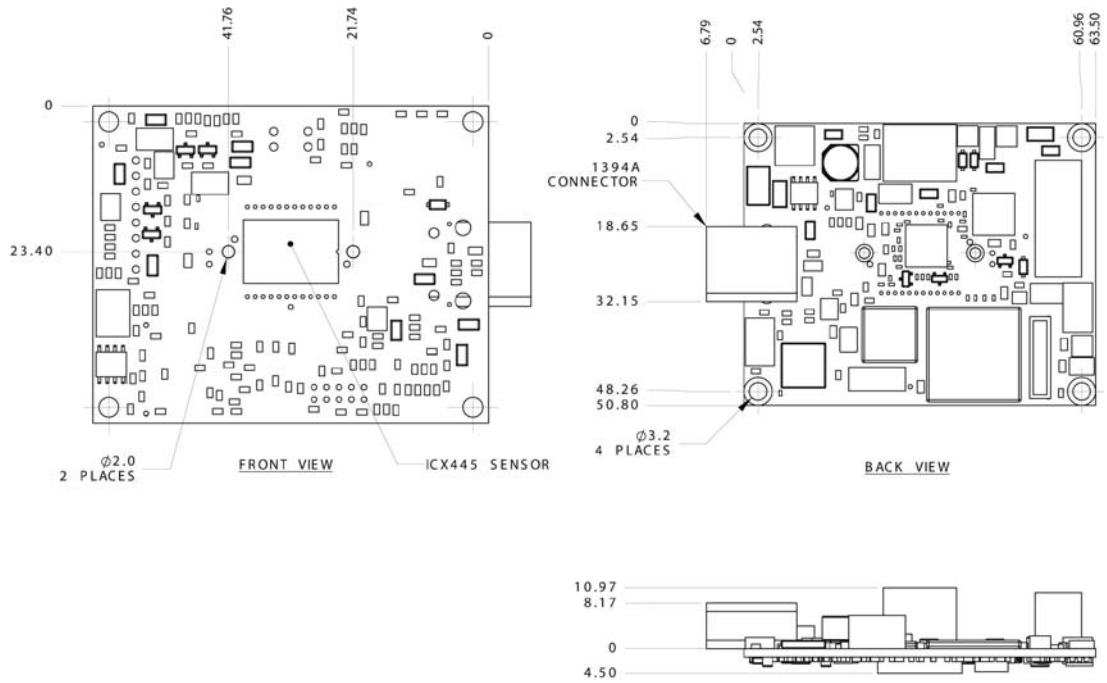


Figure 3: Dimensional drawing: DR2-13S2M/C-CS (board level without lens holder)

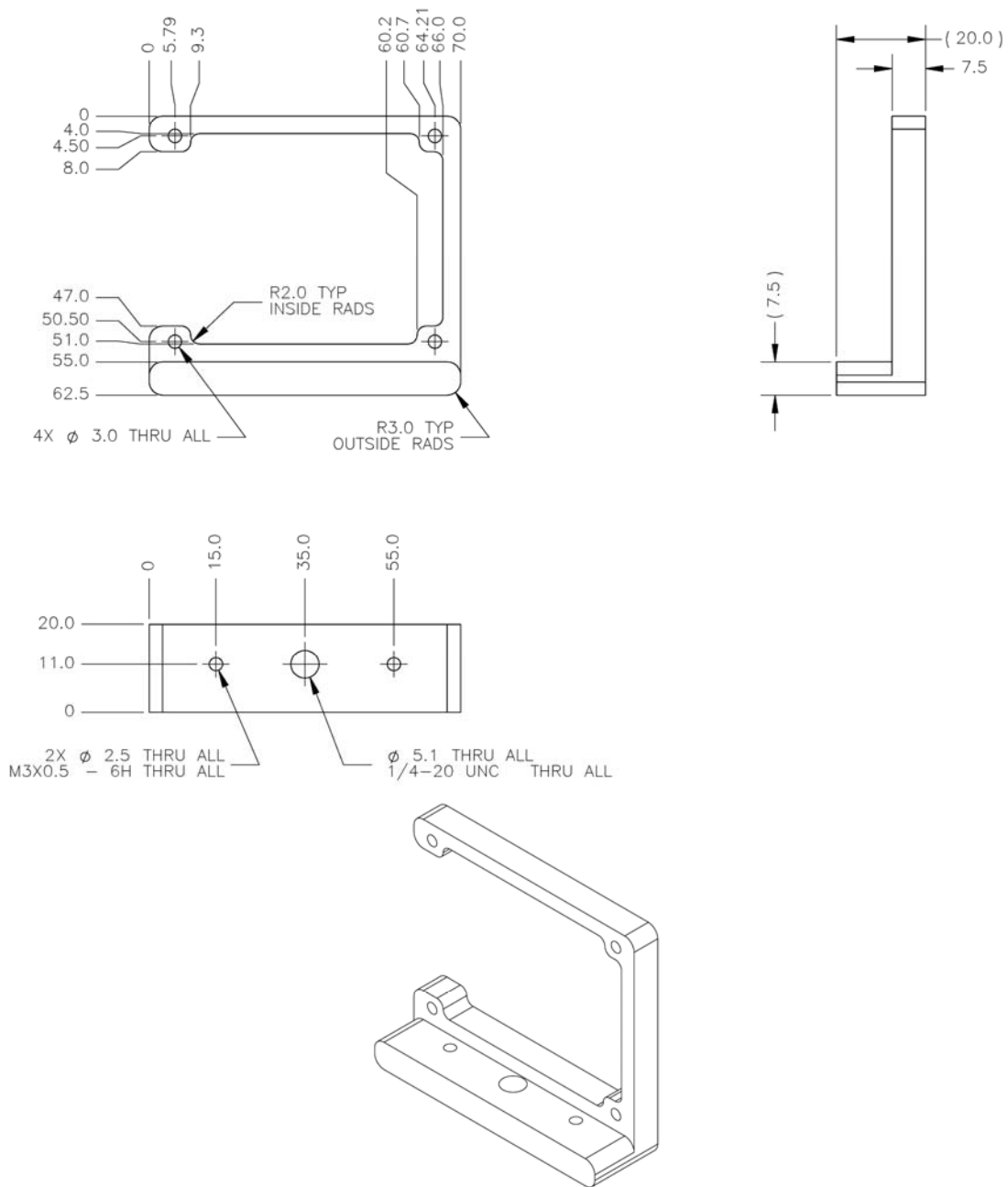


Figure 4: Tripod adapter dimensional drawing

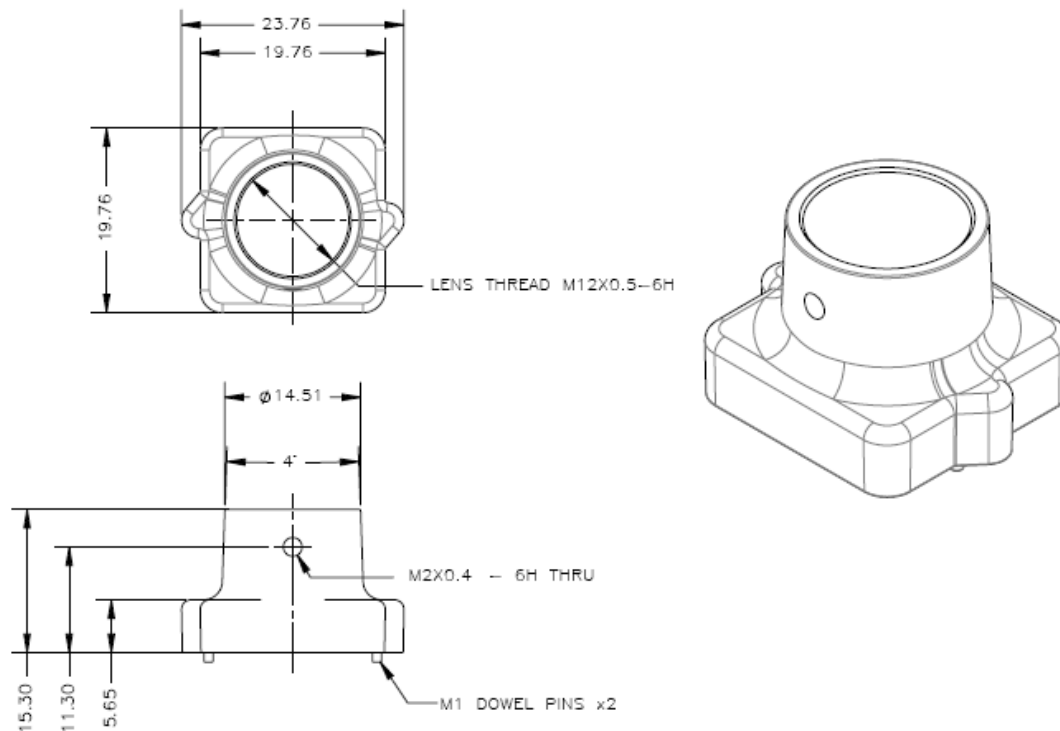


Figure 5: M12 Microlens Mount Dimensional Drawing (available separately for board-level camera models)

## 2.3. Lens Setup and Compatibility

The lens holder is compatible with CS-mount lenses. A 5mm adapter (included) can be used to accommodate C-mount lenses. Lenses are not included with individual cameras (except DR2-xxxx-KIT). To differentiate between C- and CS-mount lenses, consult the following article:

KB Article 98: [ptgrey.com/support/kb/index.asp?a=4&q=98](http://ptgrey.com/support/kb/index.asp?a=4&q=98)

Refer to the *Iris* section for information on auto iris lens properties and installation.

An M12 microlens holder can be obtained for use with board-level camera models. For dimensions, see **Error! Reference source not found..**

### 2.3.1. Adjusting Lens Focus

A lens M2 set screw is located on the top and side of the *Dragonfly2* CS-mount lens holder<sup>2</sup>, and on the top of the *Dragonfly2* CS aluminum case. The set screw is used to hold the adjustable C/CS lens holder ring (see the *Physical Description* section) in place once the lens is focused. The *Dragonfly2* comes pre-focused to the standard CS-mount lens focal length (12.52mm). If you need to adjust the back focal length, loosen the set screw with the 0.035" (inch) hex driver provided with the camera before adjusting the focal length.

For more information on lens focusing, consult the following knowledge base article:

<sup>2</sup> Except DR2-13S2M/C-CS models

KB Article 122: [ptgrey.com/support/kb/index.asp?a=4&q=122](http://ptgrey.com/support/kb/index.asp?a=4&q=122)

## 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 Aluminum Case<sup>3</sup>

The *Dragonfly2* anodized aluminum case comes with the Development Kit, or can be purchased separately by contacting [sales@ptgrey.com](mailto:sales@ptgrey.com).

#### **Top, Bottom and Side Mounts**

The case is equipped with two (2) M3 and one (1) ¼-20 mounting holes on each of the top, bottom and side faces of the case (12 holes total). These holes can be used to attach the camera directly to a custom mount or standard tripod.

#### **Front Mount**

The *Dragonfly2* anodized aluminum case is equipped with four M3 mounting holes on the front (sensor) face that can be used to attach the camera directly to a custom fixture.

### 2.5.2. Using the Tripod Mounting Bracket

The *Dragonfly2* tripod mounting bracket comes with the OEM Development Kit, or can be purchased separately by contacting [sales@ptgrey.com](mailto:sales@ptgrey.com). The bracket is equipped with two (2) M3 and one (1) ¼-20 mounting hole. For a dimensional diagram, see [Camera Dimensions](#).

## 2.6. Infrared Cut-Off Filters

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<sup>3</sup> Not compatible with DR2-13S2M/C-CS camera models



PGR cameras equipped with color sensors have an additional infrared cut-off filter included. The approximate properties of this filter are illustrated by the IRC30 curve in the graph below.

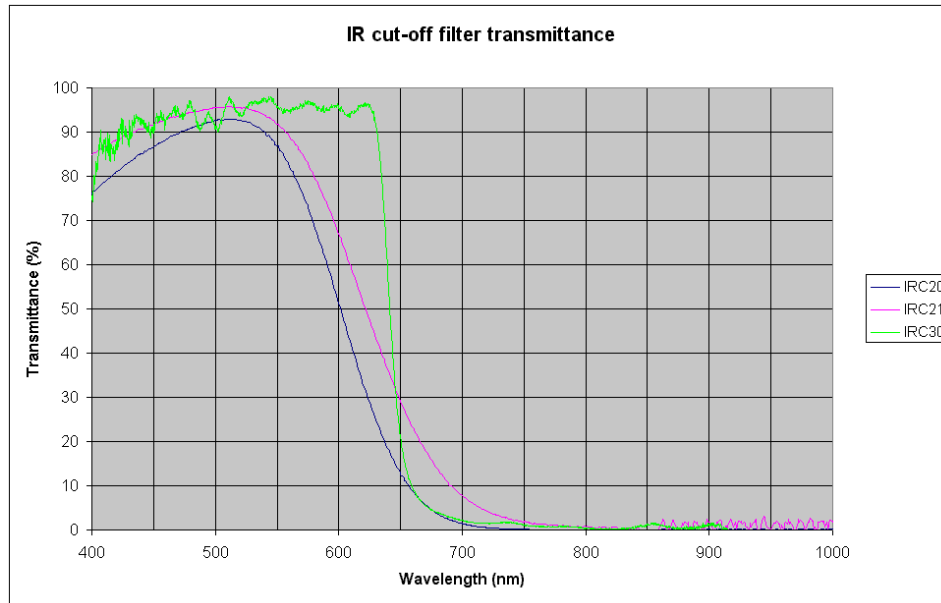


Figure 6: IR filter transmittance graph

## 3 Camera Interface

### 3.1. IEEE-1394 Connector

The camera has a standard 6-pin IEEE-1394 connector (pin configuration shown below) that is used for data transmission, camera control and powering the camera.

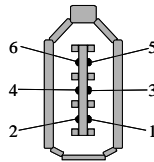


Figure 7: IEEE-1394 connector pin configuration

Pin	Function
1	Power Input (+8 to +32 VDC)
2	DC GND
3	TPB-
4	TPB+
5	TPA-
6	TPA+

Table 1: IEEE-1394 connector pin configuration

The signal on the Twisted Pair A is 1.0V DC. This voltage is then detected on the Twisted Pair B signal line; levels of 0.6 to 1.0V DC are used to determine when a device has been removed or added i.e. device attached  $\geq 1.0V$ , device not attached  $\leq 0.6V$ .

### 3.2. Cables

The maximum 1394 cable length between any 1394 node (e.g. camera to PCI card, PCI card to hub, etc.) is 4.5m, as specified by the IEEE-1394 standard. Standard, shielded twisted pair copper cables must be used. Consult the following knowledge base article for information on how to extend the physical distance between the camera and the controlling host system:

KB Article 197: [www.ptgrey.com/support/kb/index.asp?a=4&q=197](http://www.ptgrey.com/support/kb/index.asp?a=4&q=197)

### 3.3. Host Adapter Card

All camera KITs (e.g. part numbers ending with "KIT") come with a 3-port IEEE-1394 PCI host adapter card. For more information regarding the differences between various 1394 host adapters, consult the following knowledge base article:

KB Article 146: [www.ptgrey.com/support/kb/index.asp?a=4&q=146](http://www.ptgrey.com/support/kb/index.asp?a=4&q=146)

### 3.4. Camera Power

The 6-pin 1394 connector (9-pin for 1394b cameras) connects to a standard IEEE-1394 (FireWire) 6-pin (9-pin) cable and provides a power connection between the camera and the host computer. The ideal input voltage is 12V DC; however, the camera is designed to handle voltages between 8V and 30V DC. The power consumption is outlined in the *Camera Specifications* section.

Some systems - such as laptop computers or those with several FireWire devices connected - require an external power supply to power the camera. For suggestions on how to provide power in these circumstances, consult the following knowledge base article:

KB Article 93: [www.ptgrey.com/support/kb/index.asp?a=4&q=93](http://www.ptgrey.com/support/kb/index.asp?a=4&q=93)

Some PGR cameras allow the user to power-up or power-down components of the camera using the DCAM CAMERA\_POWER register 0x610. The exact components, e.g. image sensor, A/D converter, other board electronics, will vary between camera models. Consult the *PGR IEEE-1394 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.

### 3.5. General Purpose Input/Output (GPIO)

The *Dragonfly2* has an 8-pin GPIO connector on the back of the case. Cameras housed in the aluminum case use a Phoenix Contact (<http://www.phoenixcon.com/>) connector (Mfg P/N: 1881613). The male counterpart (Mfg P/N: 1881383) can be purchased from Digi-Key (P/N: 277-1436-ND) at <http://www.digikey.com>. Bare-board models use a JST (<http://www.jst-mfg.com/>) connector (Mfg P/N: B8B-EH-A). The male counterpart (P/N: EHR-8) can be purchased from Digi-Key (P/N: 455-1006-ND), and requires crimping pins (Digi-Key P/N: 455-1042-1-ND).

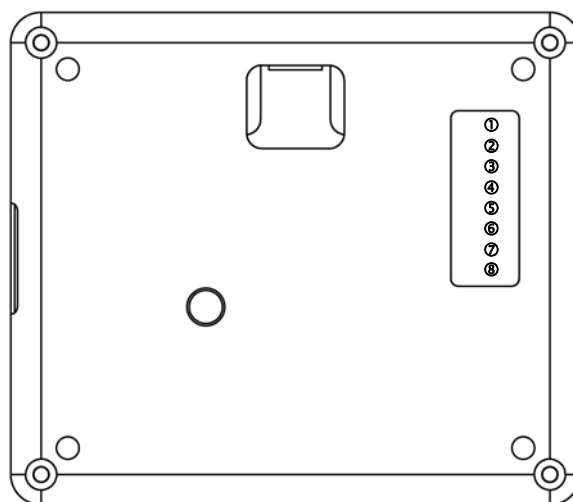


Figure 8: GPIO pin layout

Pin	GPIO	Function	Abbreviation
1	+3.3V	Provides +3.3V, current limited to 150mA	
2	GND		
3	IO0	Input / Output (default Trigger_Src)	

4	IO1	Input / Output	
5	IO2	Input / Output / RS232 Transmit (Output)	TD or TX or TXD
6	IO3	Input / Output / RS232 Receive (Input)	RD or RX or RXD
7	GND		
8	V <sub>EXT</sub>	Power camera externally	

Table 2: 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. To use the **RS232** functionality, a level converter must be used to convert the TTL digital logic levels to RS232 voltage levels. B&B Electronics (<http://www.bb-elec.com/>) part number 232LPTTL can be used for this conversion.

For more information on using the RS232 serial port, download Technical Application Note TAN2004001 from [www.ptgrey.com/support/downloads/](http://www.ptgrey.com/support/downloads/).

### 3.5.1. GPIO Electrical Characteristics

The *Dragonfly2* GPIO pins are TTL 3.3V pins. 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](http://www.ptgrey.com/support/kb/index.asp?a=4&q=200)

The **+3.3V** pin is fused at 150mA. External devices connected to Pin 1 should not attempt to pull anything greater than that.

The **V<sub>EXT</sub>** pin (Pin 8) allows the camera to be powered externally. The voltage limit is 8-30V, and current is limited to 1A.

## 3.6. Status Indicator LED

The LED on the back of the *Dragonfly2* module provides the following general status messages:

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 3: Status indicator LED descriptions

## 4 Camera Operations and Features

The *Dragonfly2* line of IEEE-1394 cameras complies with the *IIDC 1394-based Digital Camera (DCAM) Specification Version v1.31*.

To determine the specific DCAM v1.31 features implemented in a particular *Dragonfly2* model, consult the following sections of the *PGR IEEE-1394 Digital Camera Register Reference*.

- 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. For a complete description of the Camera Control Command Registers implemented on the *Dragonfly2*, please refer to the *PGR IEEE-1394 Digital Camera Register Reference*, included with the PGR FlyCapture SDK and downloadable from [www.ptgrey.com/support/downloads/](http://www.ptgrey.com/support/downloads/).

## 4.1. General Camera Properties

The following section provides an overview of the different DCAM-compliant camera properties implemented by the *Dragonfly2*. Definitions and the effects of these properties on an image can be found in the *Glossary* section and in various sections in this *Technical Reference* and in the *PGR IEEE-1394 Digital Camera Register Reference*.



*The camera will revert to the factory default settings or last saved memory channel (if applicable) after being power cycled. To read more about this, consult [Knowledge Base Article 245](#).*

The following property ranges apply to a Dragonfly2 DR2-COL at 640x480 resolution 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



*Properties marked with a '(COL)' apply to color models only and are not implemented on cameras using a monochrome sensor.*

Property	Min	Max	Auto	On/Off	One Push	Absolute Mode	Defaults
Brightness	0.00%	6.23%	N	N	N	Y	
Exposure	-7.58EV	2.41EV	Y	Y	Y	Y	Auto, On
Sharpness	0	4095	Y	Y	N	-	Auto, On
Hue (COL)	-180.0de	179.91de	N	Y	N	Y	Off
Saturation (COL)	0.0%	399.90%	Y	Y	N	Y	Auto, On
Gamma	0.50	4.00	N	Y	N	Y	Off
Iris	0	256	Y	Y	N	N	Off
Focus	-	-	-	-	-	-	
Zoom	-	-	-	-	-	-	
Temperature	2231	4095	N	N	N	N	
Pan	0	8	Y	Y	N	N	Auto, On
Tilt	0	8	Y	Y	N	N	Auto, On
Shutter	0.04ms	66.63ms	Y	N	Y	Y	Auto, On
Extended Shutter	0.04ms	7915ms	Y	N	Y	Y	Off
Gain	0dB	24dB	Y	N	Y	Y	Auto, On
White Balance (COL)	1	1023	Y	Y	Y	N	Auto, On
Frame Rate	0.13 FPS	15.77 FPS	Y	Y	N	Y	Auto, On, 15 FPS
Broadcast	-	-	-	-	-	-	
Power	-	-	-	Y	-	-	

## 4.2. Standard Data Formats, Modes and Frame Rates

The following sections enumerate the different non-Format 7 data formats and modes contained in the IEEE-1394 specification that are supported by the *Dragonfly2* and controlled using the `CURRENT_VIDEO_FORMAT` (0x608), `CURRENT_VIDEO_MODE` (0x604), and `CURRENT_FRAME_RATE` (0x600) registers. See the *Customizable Formats and Modes* section for supported Format 7 modes.



*Images acquired by color cameras using Y8 or Y16 modes are converted to greyscale (monochrome) on-board the camera. Users interested in accessing the raw Bayer data to apply their own color conversion algorithm or one of the FlyCapture library algorithms, should acquire images 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.*

● DR2-COL	● DR2-BW	● DR2-HICOL	● DR2-HIBW	● DR2-13S2C	● DR2-13S2M
-----------	----------	-------------	------------	-------------	-------------

Mode Description	Frames Per Second					
	1.875	3.75	7.5	15	30	60
160x120 YUV444 (24bpp)			●●	●●	●●	●
320x240 YUV422 (16bpp)	●●	●●	●●	●●	●●	●
640x480 YUV411 (12bpp)	●●	●●	●●	●●	●●	●
640x480 YUV422 (16bpp)	●●	●●	●●	●●	●●	
640x480 RGB (24bpp)	●●	●●	●●	●●	●●	
640x480 Y8 (8bpp)	●●●●●●	●●●●●●	●●●●●●	●●●●●●	●●●●●●	●●
640x480 Y16 (16bpp)	●●●●●●	●●●●●●	●●●●●●	●●●●●●	●●●●●●	
800x600 YUV422 (16bpp)		●	●	●	●	
800x600 RGB (24bpp)			●	●		
800x600 Y16 (16bpp)		●●	●●	●●	●●	
800x600 Y8 (8bpp)			●●	●●	●●	
1024x768 YUV422 (16bpp)	●	●	●	●		
1024x768 RGB (24bpp)	●	●	●			
1024x768 Y16 (16bpp)	●●	●●	●●	●●		
1024x768 Y8 (8bpp)	●●	●●	●●	●●	●●	
1280x960 YUV422 (16bpp)	●	●	●			
1280x960 RGB (24bpp)	●	●	●			
1280x960 Y16 (16bpp)	●●	●●	●●			
1280x960 Y8 (8bpp)	●●	●●	●●	●●		

Table 4: Supported video formats, modes and frame rates



*Some smaller format / mode combinations (e.g. 800x600 on a hi-res, or 160x120 on a lo-res) currently run at 5/6th of the frame rate reported in the following table (e.g. 25 FPS instead of 30 FPS).*

## 4.3. Frame Rates and Camera Bandwidth

### 4.3.1. Maximum Number of Cameras on a Single Bus

The maximum frame rate allowable for each of the cameras on the bus depends on the type and resolution of the cameras being used i.e. single-lens (e.g. Dragonfly) or stereo (Bumblebee), hi-res or lo-res. The DCAM standard defines a specific number of bytes-per-pixel (Bpp) for every video format/mode/frame rate combination - a number generally higher than the minimum bandwidth that might be expected. In order to accurately determine whether or not there is enough bandwidth available for a given scenario, these numbers must be used.

For example, a single PGR Dragonfly in 640x480 Y16 mode running at 15fps is sending 640 pixels per packet. Each pixel consists of 16 bits, or 2 bytes, of data. Therefore, the camera is sending  $640 \times 2 = 1280$ Bpp of data. The maximum bandwidth of the 1394a bus for a single packet as discussed above is 4096Bpp, so it would be possible for  $4096/1280 = 3$  (rounded down) PGR Dragonfly's to run in 640x480 Y16 mode at 15fps on the same 1394a bus.

The Bpp can be found in the "Isochronous Bandwidth Requirements" table in Section 3 of the PGR IEEE-1394 Digital Camera Register Reference, available via the [Downloads section](#).

### 4.3.2. Calculating Maximum Possible Frame Rate

The maximum frame rate allowable for each of the cameras on the bus depends on the type and resolution of the cameras being used i.e. single-lens (e.g. Dragonfly) or stereo (Bumblebee), hi-res or lo-res. The DCAM standard defines a specific number of bytes-per-pixel (Bpp) for every video format/mode/frame rate combination - a number generally higher than the minimum bandwidth that might be expected. In order to accurately determine whether or not there is enough bandwidth available for a given scenario, these numbers must be used.

For example, a single PGR Dragonfly in 640x480 Y16 mode running at 15fps is sending 640 pixels per packet. Each pixel consists of 16 bits, or 2 bytes, of data. Therefore, the camera is sending  $640 \times 2 = 1280$ Bpp of data. The maximum bandwidth of the 1394a bus for a single packet as discussed above is 4096Bpp, so it would be possible for  $4096/1280 = 3$  (rounded down) PGR Dragonfly's to run in 640x480 Y16 mode at 15fps on the same 1394a bus.

The Bpp can be found in the "Isochronous Bandwidth Requirements" table in Section 3 of the PGR IEEE-1394 Digital Camera Register Reference, available via the [Downloads section](#).

### 4.3.3. Problems Maximizing Frame Rates

In some circumstances, due to 1394 bus bandwidth limitations set by the operating system, some cameras may not be able to achieve the maximum calculated frame rate.

**Example:**



According to the formula in the section *Calculating Maximum Possible Frame Rate* it is possible to run four 640x480 cameras in Y8 (8-bit) mode at 30 FPS. However, when attempting to do this via the PGR software *Format and Frame Rate* controls, starting the fourth camera at 30 FPS often results in a “bandwidth exceeded” error.

The workaround to this problem is to circumvent the Windows bandwidth restrictions by directly manipulating the camera's CURRENT\_FRAME\_RATE register 600h. In the example above, start three instances of the PGR FlyCapture demo program, FlyCap, with each camera running at 30 FPS. Start the fourth camera up at 15 FPS, then access register 600h and set the register to 0x80000000 (FrameRate\_4: 30 FPS).

## 4.4. Customizable Data Formats and Modes

The table below outlines the Format\_7 custom image modes that are supported by the *Dragonfly2*. The implementation of these modes and the frame rates that are possible are not specified by the DCAM, and are subject to change across firmware versions.

Mode\_0 is a region of interest (sub-window) mode that allows the user to only transmit a selected area of the image. Mode\_1 and Mode\_2 are pixel binned or subsampled 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.*

*Not all possible size, pixel format and byte per packet combinations are listed.*

### DR2-COL

Mode	Pixel Format	Max Size (HxV)	Unit Size (H,V)	Min BPP (Max Size)	Max BPP (Max Size)	FPS (Max BPP)	Comments
0	Mono8	648x488	8,2	40	2560	59	ROI Mode
0	Mono16	648x488	8,2	80	4080	47	ROI Mode
0	Raw8	648x488	8,2	40	2560	59	ROI Mode
0	Raw16	648x488	8,2	80	4080	47	ROI Mode
0	411YUV8	648x488	8,2	60	3840	59	ROI Mode
0	422YUV8	648x488	8,2	80	4080	47	ROI Mode
0	444YUV8	648x488	8,2	120	4080	31	ROI Mode
0	RGB8	648x488	8,2	120	4080	31	ROI Mode
1	Mono8	324x244	4,2	20	1180	100	2x2 pixel binning
1	Mono16	324x244	4,2	40	2360	100	2x2 pixel binning

1	411YUV8	324x244	4,2	16	960	59	Subsampling
1	422YUV8	324x244	4,2	20	1280	59	Subsampling
1	444YUV8	324x244	4,2	32	1920	59	Subsampling
1	RGB8	324x244	4,2	32	1920	59	Subsampling
2	Mono8	648x244	8,2	20	1280	59	1x2 pixel binning
2	Mono16	648x244	8,2	40	2560	59	1x2 pixel binning
2	411YUV8	648x244	8,2	32	1920	59	Subsampling
2	422YUV8	648x244	8,2	40	2560	59	Subsampling
2	444YUV8	648x244	8,2	60	3840	59	Subsampling
2	RGB8	648x244	8,2	60	3840	59	Subsampling

Table 5: Supported partial image (Format 7) video formats and modes for DR2-COL

**DR2-HICOL**

Mode	Pixel Format	Max Size (HxV)	Unit Size (H,V)	Min BPP (Max Size)	Max BPP (Max Size)	FPS (Max BPP)	Comments
0	Mono8	1032x776	8,2	64	3264	31	ROI Mode
0	Mono16	1032x776	8,2	128	3072	15	ROI Mode
0	Raw8	1032x776	8,2	64	3264	31	ROI Mode
0	Raw16	1032x776	8,2	128	3072	15	ROI Mode
0	411YUV8	1032x776	8,2	96	4032	26	ROI Mode
0	422YUV8	1032x776	8,2	128	3072	15	ROI Mode
0	444YUV8	1032x776	8,2	192	3456	11	ROI Mode
0	RGB8	1032x776	8,2	192	3456	11	ROI Mode
1	Mono8	516x388	4,2	32	1440	54	2x2 binning
1	Mono16	516x388	4,2	64	2880	54	2x2 inning
1	411YUV8	516x388	4,2	24	1224	31	Subsampling
1	422YUV8	516x388	4,2	32	1632	31	Subsampling
1	RGB8	516x388	4,2	48	2448	31	Subsampling
1	444YUV8	516x388	4,2	48	2448	31	Subsampling
2	Mono8	1032x388	8,2	32	1632	31	1x2 binning
2	Mono16	1032x388	8,2	64	2688	26	1x2 binning
2	411YUV8	1032x388	8,2	48	2448	31	Subsampling
2	422YUV8	1032x388	8,2	64	2688	26	Subsampling
2	RGB8	1032x388	8,2	96	2688	17	Subsampling
2	444YUV8	1032x388	8,2	96	2688	17	Subsampling

Table 6: Supported partial image (Format 7) video formats and modes for DR2-HICOL

**DR2-13S2C**

Mode	Pixel Format	Max Size (HxV)	Unit Size (H,V)	Min BPP (Max Size)	Max BPP (Max Size)	FPS (Max BPP)	Comments
0	Mono8	1296x964	8,2	108	3132	20	ROI
0	Mono8	1296x482	8,2	108	3132	31	
0	Mono8	1296x240	8,2	108	3132	44	
0	Mono16	1296x964	8,2	212	4028	13	
0	Mono16	1296x482	8,2	212	4028	20	
0	Mono16	1296x240	8,2	212	4028	28	
0	Raw8	1296x964	8,2	108	3132	20	
0	Raw8	1296x482	8,2	108	3132	31	
0	Raw8	1296x240	8,2	108	3132	44	
0	Raw16	1296x964	8,2	212	4028	13	
0	Raw16	1296x482	8,2	212	4028	20	
0	Raw16	1296x240	8,2	212	4028	28	

0	YUV411	1296x964	8,2	160	4000	17	
0	YUV411	1296x482	8,2	160	4000	27	
0	YUV411	1296x240	8,2	160	4000	38	
0	YUV422	1296x964	8,2	212	4028	13	
0	YUV422	1296x482	8,2	212	4028	20	
0	YUV422	1296x240	8,2	212	4028	28	
0	YUV444	1296x964	8,2	320	3840	8	
0	YUV444	1296x482	8,2	320	3840	13	
0	YUV444	1296x240	8,2	320	3840	18	
0	RGB8	1296x964	8,2	320	3840	8	
0	RGB8	1296x482	8,2	320	3840	13	
0	RGB8	1296x240	8,2	320	3840	18	
1	Mono8	648x482	4,2	56	1456	36	2x2 binning <sup>4</sup>
1	Mono8	648x240	4,2	56	1456	36	
1	Mono8	648x120	4,2	56	1456	36	
1	Mono16	648x482	4,2	108	2916	36	
1	Mono16	648x240	4,2	108	2916	36	
1	Mono16	648x120	4,2	108	2916	36	
1	YUV411	648x482	4,2	40	1200	20	2x2 bayer binning <sup>5</sup>
1	YUV411	648x240	4,2	40	1200	32	
1	YUV411	648x120	4,2	40	1200	45	
1	YUV422	648x482	4,2	56	1568	20	
1	YUV422	648x240	4,2	56	1568	31	
1	YUV422	648x120	4,2	56	1568	44	
1	YUV444	648x482	4,2	84	2352	20	
1	YUV444	648x240	4,2	84	2352	31	
1	YUV444	648x120	4,2	84	2352	44	
1	RGB8	648x482	4,2	84	2352	20	
1	RGB8	648x240	4,2	84	2352	31	
1	RGB8	648x120	4,2	84	2352	44	
2	Mono8	1296x482	8,2	56	1568	20	1x2 binning <sup>6</sup>
2	Mono8	1296x240	8,2	56	1568	31	
2	Mono8	1296x120	8,2	56	1568	44	
2	Mono16	1296x482	8,2	108	3132	20	
2	Mono16	1296x240	8,2	108	3132	31	
2	Mono16	1296x120	8,2	108	3132	44	
2	YUV411	1296x482	8,2	80	2400	20	1x2 bayer binning <sup>7</sup>
2	YUV411	1296x240	8,2	80	2400	32	
2	YUV411	1296x120	8,2	80	2400	45	
2	YUV422	1296x482	8,2	108	3132	20	
2	YUV422	1296x240	8,2	108	3132	31	
2	YUV422	1296x120	8,2	108	3132	44	
2	YUV444	1296x482	8,2	160	2880	12	
2	YUV444	1296x240	8,2	160	2880	19	
2	YUV444	1296x120	8,2	160	2880	27	
2	RGB8	1296x482	8,2	160	2880	12	
2	RGB8	1296x240	8,2	160	2880	19	
2	RGB8	1296x120	8,2	160	2880	27	

Table 7: Supported partial image (Format 7) video formats and modes for DR2-13S2

<sup>4</sup> Subsampling is performed to reduce the number of rows<sup>5</sup> Subsampling is performed to reduce the number of rows<sup>6</sup> Subsampling is performed to reduce the number of rows<sup>7</sup> Subsampling is performed to reduce the number of rows

#### 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:

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

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

$$\text{PPF} = \frac{\text{Image Size} * \text{Bytes Per Pixel}}{\text{Bytes\_Per\_Packet}}$$

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 3072 bytes per packet, the calculation would be as follows:

$$\begin{aligned}\text{FPS} &= 1 / ( ( 1032 * 776 * 2 / 3072 ) * 0.000125 ) \\ \text{FPS} &= 1 / ( 521 / 8000 ) \\ \text{FPS} &= 15.34\end{aligned}$$

## 4.5. Image Acquisition

### 4.5.1. Camera Power

The *Dragonfly2* 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 *Dragonfly2* 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 *PGR IEEE-1394 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 *Dragonfly2* 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 *Dragonfly2* supports automatic, manual and one-push gain modes. The A/D converter provides a PxGA 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 0 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 *PGR IEEE-1394 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. Iris



*Do not connect/disconnect to/from the auto iris connector while the camera is powered. To avoid any possibility of damaging the board electronics while attaching the lens, power the camera down by unplugging the 1394 cable.*

*Dragonfly2* DR2-xxxx-CSBOX models are equipped with a DC auto-iris connector on the back of the camera. Using standard CCTV auto-iris lenses, it is possible for the user to adjust the iris value using the IRIS register 0x824 to open and close the lens aperture, which physically controls the amount of light that falls onto the CCD. This feature is particularly important in outdoor applications where the amount of light can vary greatly. Aperture can also affect the depth of field; a smaller iris value closes the aperture, which results in a greater depth of field.

#### 4.5.4.1. Auto Iris Lens Properties

Property	Specification
Focal length	Variable, 3.5mm to 8.0mm
F-stop	F1.4
Iris accuracy	+/-15% at video signal level
Sensitivity adjustment	Video signal level 0.5-1.0V P-P continuously adjustable
Iris response time	Approx. 1.5s min to max

#### 4.5.4.2. Iris Operation



*Auto iris control does not work at frame rates less than 15 FPS or while in asynchronous trigger mode.*

An iris value of 0 will drive the iris fully closed, while an iris value of 256 will force it completely open. The iris value is essentially the amount of force being applied to open or close the aperture. Going directly from a value of 0 (closed) to 256 (open) will cause the iris to open within the response time described in the *Auto Iris Lens Properties* section. Going from a value of 256 to some middle value, e.g. 140, will cause the iris to close but at a slower rate.

Refer to the *Auto Exposure* section for information on how the camera controls iris, shutter and gain together when all properties are in auto mode.

#### 4.5.5. 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, gain and/or iris.
On Manual AE	The camera automatically modifies shutter, gain and/or iris 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/gain/iris is in auto mode, the auto exposure controller attempts to control the image intensity using that one parameter. If all of these parameters are in auto mode, the auto exposure controller uses a shutter-before-gain-before-iris heuristic to try and maximize the signal-to-noise ratio by favoring a longer shutter time over a larger gain value.

Auto iris deals specifically with the input AE error term from the input image, and will only be adjusted to ensure the following:

1. The image is exposed correctly, according to the auto exposure controller requirements;
2. Gain is as low as possible (minimize noise); and
3. Shutter is at its optimal setting (not too short or long).

#### 4.5.6. Extended Shutter Times

The maximum shutter time for the *Dragonfly2* 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, the *Max\_Value* of the ABS\_VAL\_SHUTTER register will increase.



*The maximum extended shutter time reported by the SHUTTER\_INQ register 51Ch is capped at 4095 (0xFFF). Use the Max\_Value of the ABS\_VAL\_SHUTTER register to determine the maximum shutter.*



Model	Format and FPS	Min (ms)	Max (ms)	Notes
DR2-BW	640x480 Y8, 60 FPS	0.01	1978	
DR2-COL	640x480 Y8, 1.875 FPS	0.01	63312	
DR2-HIBW	1024x768 Y8, 30 FPS	0.01	2642	
DR2-HICOL	1024x768 Y8, 1.875 FPS	0.01	42282	

Table 8: Extended shutter minimum and maximum times

## Related Knowledge Base Articles

ID	Title	URL
166	Extended shutter mode operation for DCAM 1.31-compliant PGR Imaging Products.	<a href="http://www.ptgrey.com/support/kb/index.asp?a=4&amp;q=166">www.ptgrey.com/support/kb/index.asp?a=4&amp;q=166</a>

### 4.5.7. Automatic Inter-Camera Synchronization

Multiple Point Grey FireWire cameras, when they are on the same IEEE-1394 bus and running at the same frame rate, are automatically synchronized to each other at the hardware level. When using multiple cameras, the timing of one camera to another camera is as follows:

- If the cameras are on the same bus, the cameras are synchronized to within 125 $\mu$ s (microseconds) of each other (note: 125 $\mu$ s is the maximum deviation). However, the 1394 bandwidth limits the maximum number of cameras that can be on one bus. See the section *Maximum Number of Cameras on a Single 1394 Bus* for more information.
- If the cameras are on separate buses, use PointGrey's *MultiSync*<sup>™</sup> software to synchronize the cameras across buses. This can be used to synchronize cameras on different buses within the same computer or on different buses across multiple computers. The software will ensure that the cameras are synchronized to within 125 $\mu$ s. If Multisync is not running, there is no timing correlation between separate cameras on separate buses.

It is possible to offset the synchronization of individual cameras relative to other cameras using the TRIGGER\_DELAY register 0x834.

## Related Knowledge Base Articles

ID	Title	URL
112	Synchronizing PGR cameras across multiple PCs	<a href="http://www.ptgrey.com/support/kb/index.asp?a=4&amp;q=112">www.ptgrey.com/support/kb/index.asp?a=4&amp;q=112</a>

### 4.5.8. Frame Rate Control

The current base frame rate is controlled using the CURRENT\_FRAME\_RATE register 0x600. The *Dragonfly2* 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 *PGR IEEE-1394 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).

#### 4.5.9. Pixel Binning and Region of Interest Modes

The *Dragonfly2* implements several DCAM Format\_7 customizable video modes (see the *Customizable Formats and Modes* section for camera-specific information) that allows 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”.

##### Related Knowledge Base Articles

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

#### 4.5.10. Y16 (16-bit Mono) Image Acquisition

The *Dragonfly2* 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](http://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 *PGR IEEE-1394 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.

#### 4.5.11. Asynchronous (External) Trigger Modes

The *Dragonfly2* 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, 4, 5, and 14. These modes and their operation are described in greater detail in the *PGR IEEE-1394 Digital Camera Register Reference*.



*Asynchronous trigger modes 4 and 5 are supported only in the 03S2 and 08S2 models.*

##### 4.5.11.1. External Trigger Timing

For most *Dragonfly2* models using Trigger Mode\_0, the time from the external trigger going low to the integration time is shown below:

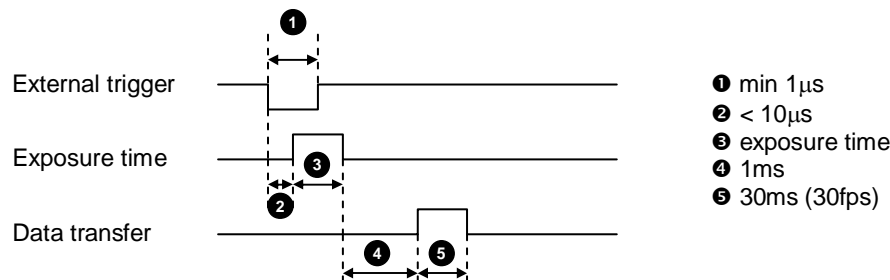


Figure 9: *Dragonfly2* external trigger timing characteristics

#### 4.5.11.2. Ensuring Trigger is Armed

It is possible for the *Dragonfly2* 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 or SOFT\_ASYNC\_TRIGGER register 0x102C. 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 isochronous transfer 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.	<a href="http://www.ptgrey.com/support/kb/index.asp?a=4&amp;q=169">www.ptgrey.com/support/kb/index.asp?a=4&amp;q=169</a>
177	Maximum frame rate possible in external trigger mode_0.	<a href="http://www.ptgrey.com/support/kb/index.asp?a=4&amp;q=177">www.ptgrey.com/support/kb/index.asp?a=4&amp;q=177</a>
221	Synchronizing to an external signal using DCAM 1.31 Trigger_Mode_0	<a href="http://www.ptgrey.com/support/kb/index.asp?a=4&amp;q=221">www.ptgrey.com/support/kb/index.asp?a=4&amp;q=221</a>

## 4.6. Image Processing

### 4.6.1. Color and Greyscale Conversion

In order to produce color (e.g. RGB, YUV) and greyscale (e.g. Y8, Y16) images, color *Dragonfly2* models perform on-board processing of the Bayer Tile Pattern output produced by the CCD. The color processing algorithm used by the *Dragonfly2* is most similar to the Edge Sensing algorithm

implemented by the PGR FlyCapture library, which weights surrounding pixels based on localized edge orientations. The primary differences are the emphasis placed on the edges and the user-configurable Sharpness filter. To convert the Bayer Tile Pattern to greyscale, the *Dragonfly2* adds the value for each of the RGB components in the color processed pixel to produce a single greyscale (Y) value for that pixel, as follows:

$$Y = R/4 + G/2 + B/4$$

#### 4.6.1.1. Accessing Raw Bayer Data

Users interested in accessing the raw Bayer data to apply their own color conversion algorithm or one of the FlyCapture library algorithms, should acquire images 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. For example, the CFA format of a Sony ICX204AK color CCD can be found in the "Block Diagram and Pin Configuration" section of its [datasheet](#). 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. In the case of a 640x480 color Flea2 that is streaming out Raw8 image data in RGBG format, if we access the image data via the pData pointer we 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.	<a href="http://www.ptgrey.com/support/kb/index.asp?a=4&amp;q=33">www.ptgrey.com/support/kb/index.asp?a=4&amp;q=33</a>
37	Writing color processing software and color interpolation algorithms.	<a href="http://www.ptgrey.com/support/kb/index.asp?a=4&amp;q=37">www.ptgrey.com/support/kb/index.asp?a=4&amp;q=37</a>
89	How is color processing performed on my camera's images?	<a href="http://www.ptgrey.com/support/kb/index.asp?a=4&amp;q=89">www.ptgrey.com/support/kb/index.asp?a=4&amp;q=89</a>

#### 4.6.2. Lookup Table and Gamma

The *Dragonfly2* supports lookup table (LUT) and gamma functionality. 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.

The *Dragonfly2* has three (3) 11-bit input lookup tables that produce 9-bit outputs. Although the camera uses a 12-bit A/D converter, the *Dragonfly2* is only able to accommodate 11-bit images. In normal color operation there is a separate LUT for red, green, and blue. The LUT therefore allows the user to map the  $2^{11}$ , or 2048, different possible pixel values to any one of 512 ( $2^9$ ) possible output values. For example, the LUT would allow the user to map any pixel with a value of 2047 (white) to any value between 0 (black) and 512 (white). For monochrome cameras, the LUT's are configured to operate as a single 11-bit input with three 9-bit outputs (mono to RGB). Color cameras in a monochrome (Y8) mode still require a three channel RGB LUT because the monochrome image comes from a weighted sum of the red, green and blue pixel values (see *Color and Greyscale Conversion*) after the LUT has been applied.

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 9 bits. By default, Gamma is OFF and has a value of 1.0, which yields a linear response. For more information regarding the LUT CSR registers, refer to the *PGR IEEE-1394 Digital Camera Register Reference*.



*Lookup table functionality is not supported on color cameras when the camera is in a raw Bayer output mode, such as Format\_7 Raw8 or Raw16 modes.*

#### 4.6.3. Saturation

The *Dragonfly2* supports saturation, which refers to color saturation, as opposed to saturation of a CCD charge. Saturation is controlled using the SATURATION register 0x814

#### 4.6.4. Sharpness

The *Dragonfly2* supports sharpness, which refers to the filtering of an image to reduce blurring at image edges. Sharpness is implemented as an average upon a 3x3 block of pixels, and is only applied to the green component of the Bayer tiled pattern. For sharpness values greater than 1000, the pixel is sharpened; for values less than 1000 it is blurred. When sharpness is in auto mode, if gain is low, then a small amount of sharpening is applied, which increases as gain decreases. If the gain is high, a small amount of blur is applied, increasing as gain increases.

#### 4.6.5. White Balance

The *Dragonfly2* 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.

The *Dragonfly2* also implements Auto and One\_Push white balance. One of the uses of one\_push / auto white balance is to obtain a similar color balance between different cameras that are slightly different from each other. Theoretically, if different cameras are pointed at the same scene, using one\_push / auto will result in a similar color balance between the cameras.

One\_push is similar identical to auto white balance, except One-Push only attempts to automatically adjust white balance for a set period of time before stopping. The white balance of the camera before using One-Push/Auto must already be relatively close, i.e. if Red is set to 0 and Blue is at maximum (two extremes), One-Push/Auto will not work. However, if the camera is already close to being color balanced, then it will work (it may only be a small change).

One\_push only attempts to automatically adjust white balance for a set period of time before stopping. It uses a “white detection” algorithm that looks for “whitish” pixels in the raw Bayer image data. One\_push adjusts the white balance for a specific number of iterations; if it cannot locate any whitish pixels, it will gradually look at the whitest objects in the scene and try to work off them. It will continue this until has completed its finite set of iterations.

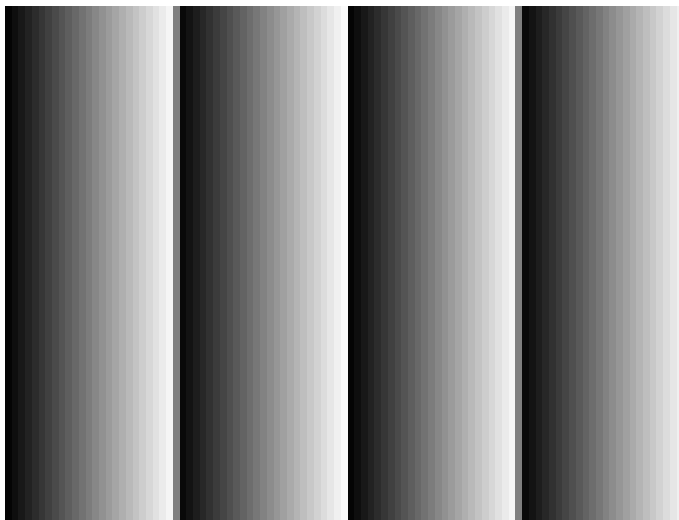
Auto is continually adjusting white balance. It differs from one\_push in that it works almost solely off the whitest objects in the scene.

#### 4.6.6. Image Flip / Mirror

The *Dragonfly2* supports horizontal image mirroring. The mirror image operation is done on the camera using the on-board frame buffer, and is controlled using the IMAGE\_DATA\_FORMAT register 0x1048, which is described in detail in the *PGR IEEE-1394 Digital Camera Register Reference*.

#### 4.6.7. Test Pattern

The *Dragonfly2* is capable of outputting a continuous static image 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 hue, saturation, sharpness, white balance or gamma. Test pattern support is available for Y8, Y16 and YUV422 video modes only. The test pattern is a simple 8 bit-per-pixel counter (the pixel intensities in each column increment from 0 to 255).



**Figure 10: Test pattern image**

The test pattern can be enabled using the TEST\_PATTERN register 0x104C, which is described in detail in the *PGR IEEE-1394 Digital Camera Register Reference*.

### 4.6.8. Embedded Image Information

The *Dragonfly2* 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 *PGR IEEE-1394 Digital Camera Register Reference*.

## 4.7. Camera and Device Control

### 4.7.1. Temperature Sensor

The *Dragonfly2* has an on-board sensor that allows the user to monitor the current temperature of the camera. This feature can be accessed using the TEMPERATURE register 0x82C, which is described in detail in the *PGR IEEE-1394 Digital Camera Register Reference*.

### 4.7.2. Voltage Sensor

The *Dragonfly2* has an on-board sensor that allows the user to monitor a variety of different voltages, including the current 1394 bus voltage. This feature can be accessed using the VOLTAGE registers 0x1A50 – 0x1A54, which are described in detail in the *PGR IEEE-1394 Digital Camera Register Reference*.

### 4.7.3. Programmable Strobe Output

The *Dragonfly2* 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 *Dragonfly2* 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 DCAM v1.31 strobe functionality	<a href="http://www.ptgrey.com/support/kb/index.asp?a=4&amp;q=179">www.ptgrey.com/support/kb/index.asp?a=4&amp;q=179</a>
207	Setting a GPIO pin to output a strobe signal pulse pattern	<a href="http://www.ptgrey.com/support/kb/index.asp?a=4&amp;q=207">www.ptgrey.com/support/kb/index.asp?a=4&amp;q=207</a>
212	GPIO strobe signal continues after isochronous image transfer stops	<a href="http://www.ptgrey.com/support/kb/index.asp?a=4&amp;q=212">www.ptgrey.com/support/kb/index.asp?a=4&amp;q=212</a>

#### 4.7.4. RS-232 Serial Port

The *Dragonfly2* is capable of serial communications at baud rates up to 115.2Kbps via the on-board logic level serial port built into the camera's GPIO connector. To use this functionality, a level converter must be used to convert the TTL digital logic levels to RS-232 voltage levels. B&B Electronics (<http://www.bb-elec.com/>) part number 232LPTTL can be used for this conversion.

##### Related Knowledge Base Articles

ID	Title	URL
151	Configuring and testing the RS-232 serial port	<a href="http://www.ptgrey.com/support/kb/index.asp?a=4&amp;q=151">www.ptgrey.com/support/kb/index.asp?a=4&amp;q=151</a>

#### 4.7.5. Memory Channel Storage of Camera Settings

The *Dragonfly2* 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 *Dragonfly2* 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 Appendix B: Memory Channel Registers, for a full listing of all registers saved.

Memory channels are configured using the following registers, which are described in detail in the *PGR IEEE-1394 Digital Camera Register Reference*: MEMORY\_SAVE 0x618; MEM\_SAVE\_CH 0x620; and CUR\_MEM\_CH 0x624.

#### 4.7.6. User Data Storage

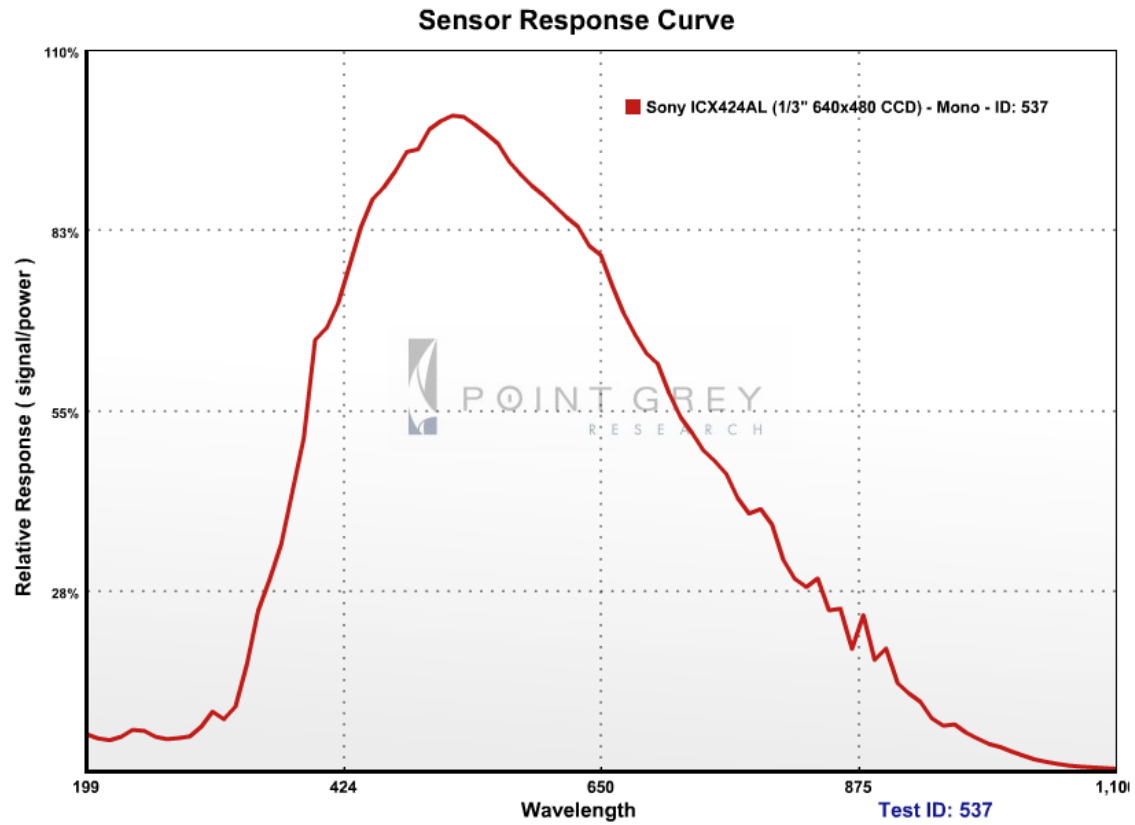
The *Dragonfly2* provides the user with 512KB of flash memory for the purposes of non-volatile data storage. This is useful for saving user data such as calibration files, software license keys, etc. The memory is divided into 2048 pages, with 256 bytes available per page. This feature is controlled using the DATA\_FLASH\_CTRL register 0x1240, which is described in detail in the *PGR IEEE-1394 Digital Camera Register Reference*.

#### 4.7.7. Camera Upgrades

The firmware on the *Dragonfly2* 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/](http://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.

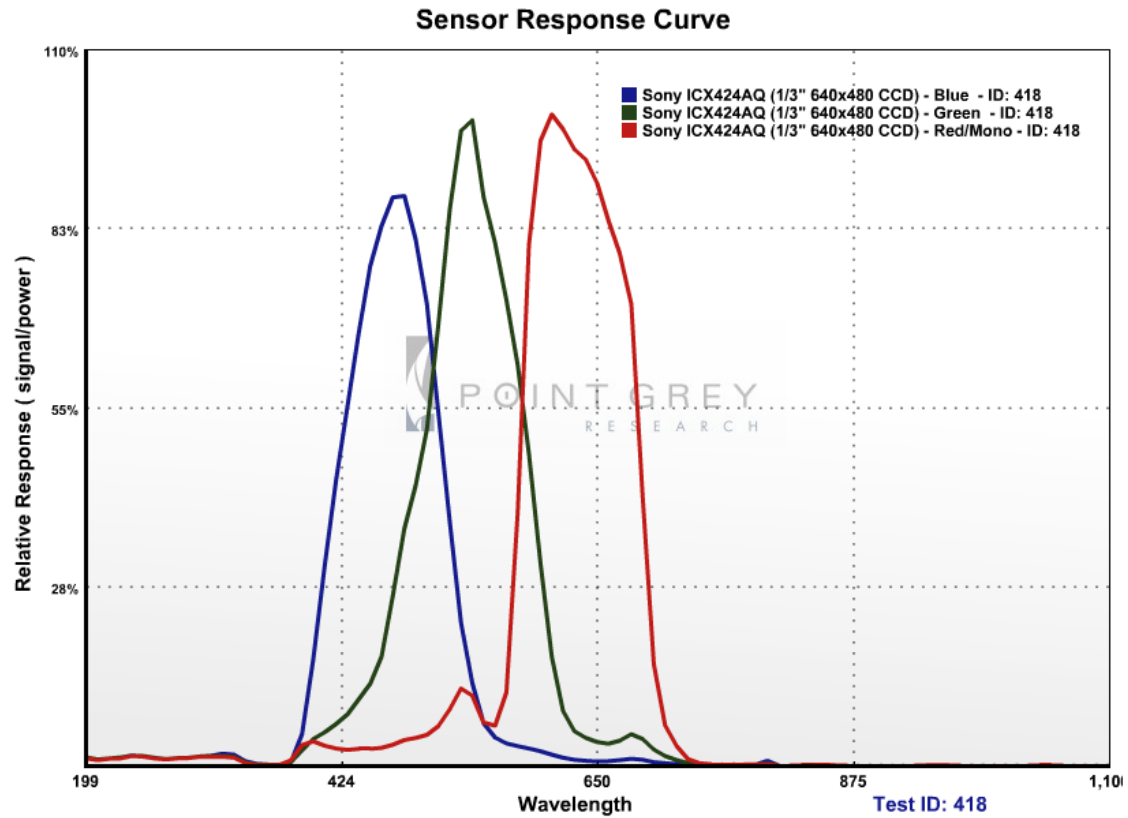
## Appendix A: Spectral Response Curves

DR2-BW

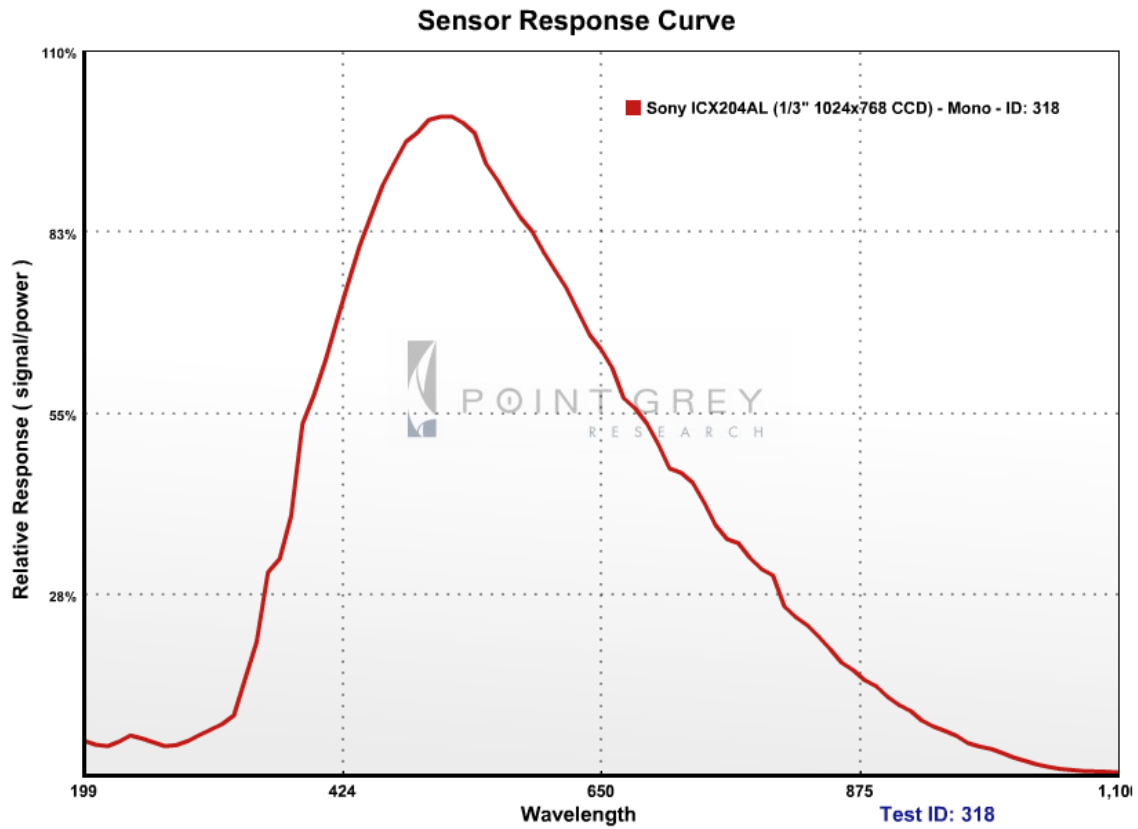




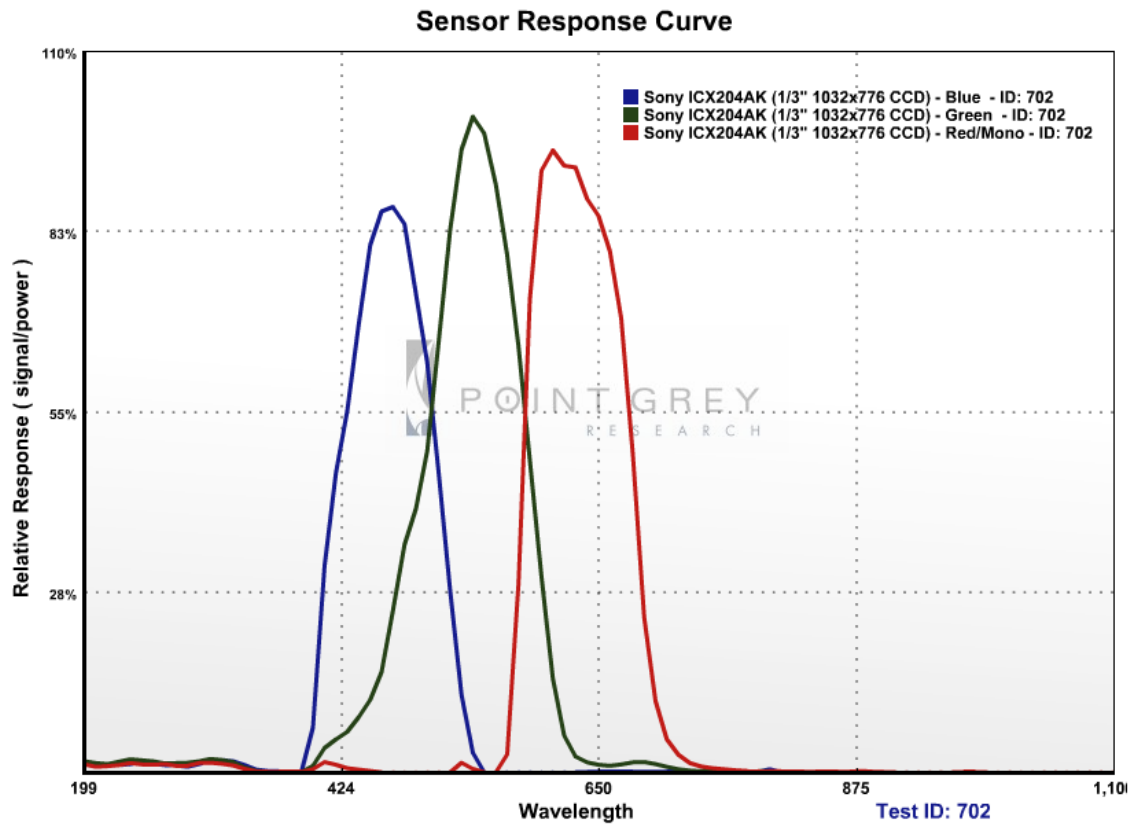
## DR2-COL



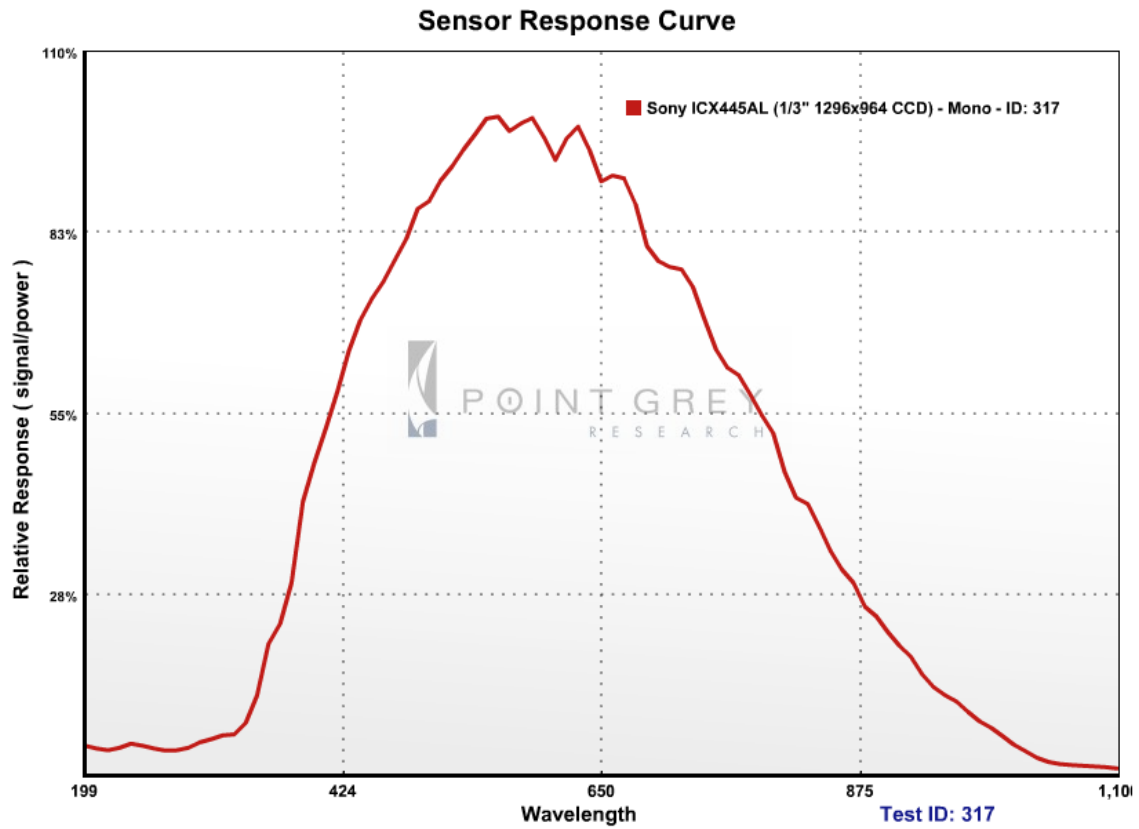
## DR2-HIBW



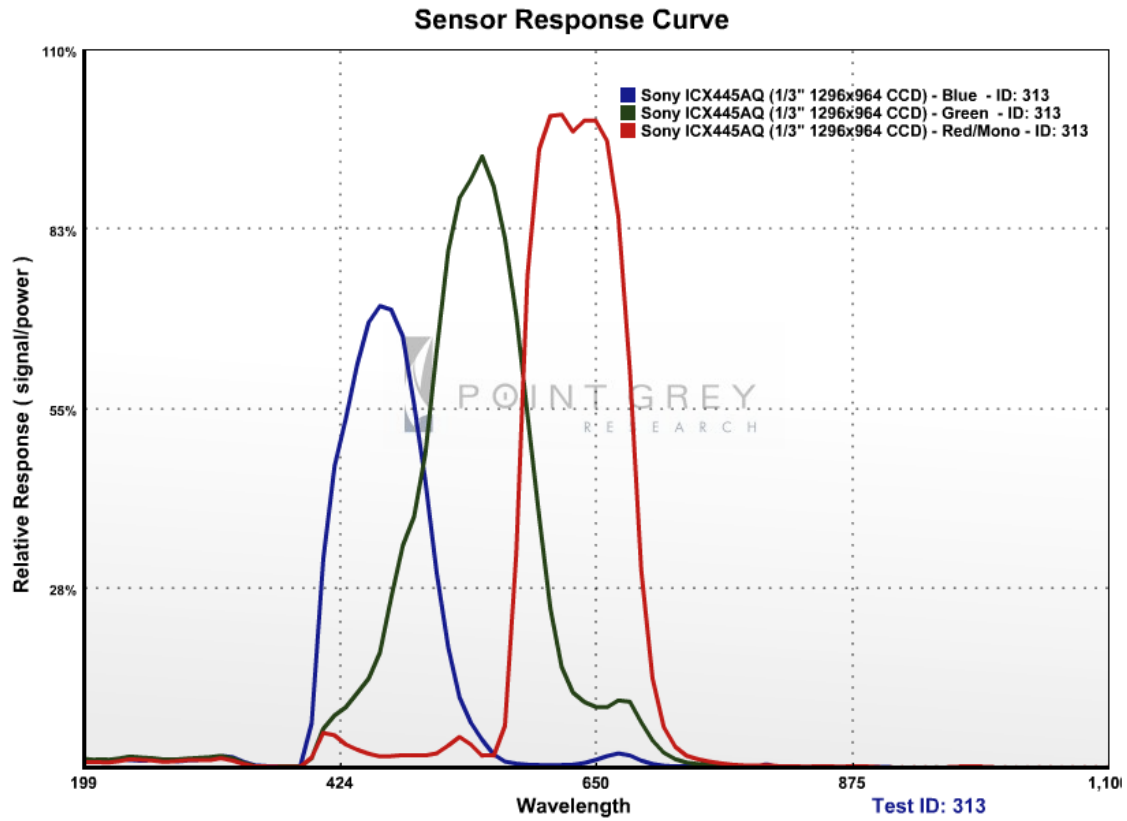
## DR2-HICOL



## DR2-13S2M



## DR2-13S2C



## Appendix B: Glossary

Term	Definition
<i>1394a</i>	An Institute of Electrical and Electronics Engineers (IEEE) interface standard capable of transferring data at a rate of 400Mbit per second.
<i>1394b</i>	An IEEE interface standard capable of transferring data at a rate of 800Mbit per second.
<i>Absolute Values</i>	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.
<i>Analog-to-Digital Converter</i>	Often abbreviated as ADC or A/D converted, it is a device that converts a voltage to a digital number.
<i>API</i>	Application Programming Interface. Essentially a library of software functions.
<i>Asynchronous Transmission</i>	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.
<i>BPP</i>	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.
<i>Brightness (%)</i>	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.
<i>Config ROM</i>	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.
<i>Color Processing</i>	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 <a href="#">Knowledge Base Article 33</a> .
<i>DCAM</i>	Abbreviation for the <i>IIDC 1394-based Digital Camera (DCAM) Specification</i> , which is the standard used for building FireWire-based cameras.
<i>Dynamic Range</i>	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).
<i>Exposure (EV)</i>	This is the average intensity of the image. It will use other available (non-manually adjustable) controls to adjust the image.
<i>Firmware</i>	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.
<i>Format_7</i>	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.
<i>FPS</i>	Frames Per Second.
<i>Frame Rate</i>	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.
<i>Gain (dB)</i>	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.
<i>Gamma</i>	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.
<i>GPIO</i>	General Purpose Input/Output.

<i>Grabbing Images</i>	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.
<i>Hz</i>	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.
<i>Isochronous Transmission</i>	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 125 $\mu$ s. Each 125 $\mu$ s 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.
<i>Lookup Table</i>	A matrix of gamma functions for each color value of the current pixel encoding format.
<i>Node</i>	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.
<i>Node ID</i>	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.
<i>One Push</i>	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.
<i>PHY</i>	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.
<i>Pan</i>	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.
<i>Pixel Clock</i>	The rate at which the sensor outputs voltage signals in each pixel from the optical input.
<i>Pixel Format</i>	The encoding scheme by which color or greyscale images are produced from raw image data.
<i>Quadlet</i>	A 4 byte (32-bit) value.
<i>Quadlet Offset</i>	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 address 0xFFFFF0F00400.
<i>Register</i>	A term used to describe quadlet-aligned addresses that may be read or written by bus transactions.
<i>Saturation</i>	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.
<i>SDK</i>	Software Development Kit
<i>Sharpness</i>	This works by filtering the image to reduce blurred edges.
<i>Shutter</i>	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 <i>exposure</i> or <i>integration</i> 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.
<i>Signal-to-Noise Ratio (dB)</i>	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-noise ratio (SNR). SNR is calculated using the general methodology outlined in <a href="#">Knowledge Base Article 142</a> .
<i>SXGA</i>	1280x1024 pixel resolution
<i>Tilt</i>	A mechanism to vertically move the current portion of the sensor that is being imaged.
<i>Trigger</i>	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).
<i>UXGA</i>	1600x1200 pixel resolution
<i>VGA</i>	640x480 pixel resolution
<i>White Balance</i>	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.
<i>XVGA</i>	1024x768 pixel resolution

## Appendix C: 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 D: 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](http://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/](http://www.ptgrey.com/support/downloads/).

### Knowledge Base

Our on-line knowledge base at [www.ptgrey.com/support/kb/](http://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](http://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/](http://www.ptgrey.com/support/contact/).

## Appendix E: 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](mailto: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/>

<b>Main Office:</b>	<b>Mailing Address:</b>	<b>Tel:</b> +1 (604) 242-9937
	Point Grey Research, Inc.	<b>Toll-free</b> (North America only):
	12051 Riverside Way	+1 (866) 765-0827
	Richmond, BC, Canada	<b>Fax:</b> +1 (604) 242-9938
	V6W 1K7	<a href="mailto:sales@ptgrey.com">sales@ptgrey.com</a>

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Europe Israel	<b>Mailing Address:</b> Point Grey Research GmbH Schwieberdinger Strasse 60 71636 Ludwigsburg Germany	<b>Tel:</b> +49 7141 488817-0 <b>Fax:</b> +49 7141 488817-99 <a href="mailto:eu-sales@ptgrey.com">eu-sales@ptgrey.com</a>
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Japan	ViewPLUS Inc. ( <a href="http://www.viewplus.co.jp/">http://www.viewplus.co.jp/</a> )
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Korea	Cylod Co. Ltd. ( <a href="http://www.cylod.com">http://www.cylod.com</a> )
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China	LUSTER LightVision Tech. Co., Ltd ( <a href="http://www.lusterlighttech.com">www.lusterlighttech.com</a> )
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Singapore Malaysia Thailand	Voltrium Systems Pte Ltd. ( <a href="http://www.voltrium.com.sg">www.voltrium.com.sg</a> )
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Taiwan	Apo Star Co., Ltd. ( <a href="http://www.apostar.com.tw">www.apostar.com.tw</a> )
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## Appendix F: Revision History

Revision	Date	Notes
2.1	11-May-07	<ul style="list-style-type: none"><li>Added Revision History to appendix</li><li>Initial updates for new DR2-13S2 model</li><li>Added section on “Accessing Raw Bayer Data”</li><li>Various other minor updates</li></ul>
	30 July 08	<ul style="list-style-type: none"><li>Updated contact information with new company address and phone numbers.</li></ul>
2.2	8 September 08	<ul style="list-style-type: none"><li>Clarified in section 4.5.11 that external trigger modes 4 and 5 are supported only in 03S2 and 08S2 models.</li></ul>
2.3	11 December 09	<ul style="list-style-type: none"><li>Power input voltage range is 8-30 volts.</li><li>Section 1.3 Camera Specifications: Added mass measurement that includes lens holder and C-mount adapter (45 g)</li><li>Added information about M12 microlens holder for board-level camera models to section <b>Error! Reference source not found.</b> <a href="#">Camera Dimensions</a> and section <b>Error! Reference source not found.</b> <a href="#">Lens Setup and Compatibility</a>.</li></ul>
2.4	15 September 2010	<ul style="list-style-type: none"><li>Added tripod mount dimensional drawing to section 2.2.</li><li>Added Appendix A: Sensor Response Curves</li></ul>

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