Pyrocam™ IIIHR User Guide

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Table of Contents

CHAPTER 1 – GENERAL INFORMATION

1.1 Introduction

The Pyrocam IIIHR is a high performance, solid-state, pyroelectric camera that features a 12mm imager (160 x 160 pixels) and 16-bit A/D converter. This enables reliable measurement and analysis of both large signals and low-level signals in the wings of the laser beam. The uniform infrared response and large dynamic range makes the camera suitable for real-time thermal imaging of hot sources. 16-bit digitizing also enables accurate signal summing and averaging to pull weak signals out of noise. The Pyrocam employs an IEEE 802.3ab Gigabit Ethernet interface that is compliant with the GigE Vision standard. The camera ships with an USB 3.0 to Ethernet adaptor and a 10′ (3m) Ethernet cable. If a longer or shorter cable is required, Spiricon recommends using a shielded Cat6A cable.

The Pyrocam ships with BeamGage Standard software. The Pyrocam is also compatible with National Instruments Vision Image Acquisition Software and any GenICam standard client (CHAPTER 4).

1.2 Models

Spiricon offers the Pyrocam IIIHR in one model which includes BeamGage Standard Edition. Upgrades to BeamGage Professional can be purchased separately.

Model	Description
PY-III-HR-C	Pyrocam IIIHR, CW and Pulsed operation*

* Specify window type, one standard removable window included at no additional charge.

1.3 Included Items

The standard Pyrocam IIIHR comes with the following included items:

- USB 3.0 to Ethernet adaptor
- Shielded Cat6A Ethernet cable, 10′ (3m)
- Wall mount universal power supply with international AC mains adapters
- SMA to BNC trigger cable, 36″ (0.9m)
- Protective dust cover
- User specified A/R coated window, installed in the camera
- DVD with BeamGage software
- Getting Started with GigE User Guide
- This User Guide

1.4 Accessories

Spiricon offers a complete line of accessory equipment to support the Pyrocam in your application. These range from Ge lenses to beam attenuation optics and beam expanders/reducers. Spiricon provides custom accessories to match your specifications.

Consult Spiricon or your local Spiricon representative for current accessory availability and pricing.

Pyrocam IIIHR Accessories

Lenses	Many different lenses and adapters. See APPENDIX E for a complete list

1.5 How To Use This Manual

WARNING:

It is STRONGLY advised that you read through this manual before setting up your Pyrocam. The Pyrocam imager is very costly to replace and is not covered for damage under Spiricon's standard warranty.

After this first chapter containing general information, Chapter 2 introduces the controls, connections, and displays, Chapter 3 explains about setup and operation, Chapter 4 explains how to design your own GenICam interface to the Pyrocam, Appendix A contains all specifications and dimensions for the Pyrocam, Appendix B describes the detector window removal/installation process, Appendix C explains the optional bad pixel correction procedure, Appendix D explains the optional gain correction procedure, Appendix E contains a complete list of all Pyrocam models and accessories, and Appendix F contains a table of features included in the Pyrocam.

NOTICE: It is essential to understand and apply a proper trigger pulse to the Pyrocam. Therefore, it is strongly recommend that you read and familiarize yourself with the sections in CHAPTER 2 and CHAPTER 3 that are applicable to pulsed modes of operation. Also, pay close attention to the damage threshold limits described in APPENDIX A.

1.6 Safety

The Pyrocam does not present the operator with any electrical safety hazards. However, it is intended for use with laser systems, therefore the operator should be protected from any hazards that the laser system may present. The major hazards associated with laser systems are damage to the eyes and skin due to laser radiation.

1.6.1 Optical Radiation Hazards

With most cameras, the optical radiation at the sensor is low enough to be considered relatively harmless. This is not necessarily true with the Pyrocam using a pyroelectric imager. The Pyrocam's chopper and imager window will reflect laser radiation from the input laser beam. Take this reflection into consideration when directing a laser into the camera.

Usage of this instrument may require the operator to work in the optical path of high power lasers. Exposure to the radiation from these lasers may be sufficient to warrant the use of protective equipment.

Unless the optical path is enclosed, the operator should be protected against accidental exposure. Exposure to personnel other than the operator must also be considered. Exposure hazards include reflected radiation as well as the direct beam. When working in an unenclosed beam path, it is advisable to do so with the laser not operating, or operating at reduced power levels. Whenever there is risk of dangerous exposure, protective eye shields and clothing should be used.

1.6.2 Electrical Hazards

The Pyrocam universal power supply is intended to operate from a power source that applies less than 240 Volts AC, 50/60Hz between the supply terminals. The supply output is a regulated 12Vdc that presents no electrical shock hazard. The power supply has no user serviceable parts and should not be tampered with.

To avoid explosion, do not operate the Pyrocam in an explosive atmosphere.

WARNING:

To prevent electrical shock, do not remove covers. No user serviceable parts are inside. Refer servicing to qualified service personnel.

1.7 Maintenance and Cleaning

Any internal maintenance or repair of the Pyrocam must be done by the factory. The exterior of the camera may be cleaned with a soft, damp cloth and non-abrasive liquid. Use filtered compressed air to remove dust particles from the surface of the window.

CHAPTER 2 – CONNECTIONS, CONTROLS AND DISPLAYS

2.1 System Installation

A Pyrocam system consists of the following:

- Pyrocam camera with power supply
- USB 3.0 to Ethernet adaptor
- PC computer running Windows 7 (32 or 64 bit) and BeamGage
- Cat6A cable
- Trigger cable with TTL trigger source (for pulsed lasers only)

2.1.1 BeamGage Setup

Before connecting the Pyrocam to the PC, install the edition of BeamGage that is supplied with the Pyrocam. Follow the instructions on the DVD jacket. BeamGage is supplied with an electronic User Guide in multiple languages. BeamGage also has a **What's This** help feature that can be used to quickly discover what the various controls do and how to manage the display features. If not familiar with BeamGage's operation, it is recommended that some time is spent learning how to use it with the Pyrocam before applying a laser beam. Read through the BeamGage User Guide before connecting and attempting to run the Pyrocam.

2.1.2 Connections

Either two or three connections are needed:

- the Ethernet cable
- the power supply
- a TTL trigger source (if required)

See **Figure 2.1**. An external trigger source is always required when operating with a low rep-rate pulsed laser. An external trigger is not required if the internal chopper is being used with a CW laser.

2.1.2.1 Gigabit Ethernet

Connect the Ethernet cable between the Pyrocam and the host computer. An Ethernet to USB 3.0 adaptor is provided if there is not an available Ethernet port on the host computer.

2.1.2.2 Power

The Pyrocam is provided with a 12Vdc/24W AC to DC universal power supply. The power connection is made by plugging the output power cable into the camera and connecting the power supply to a proper AC source.

2.1.2.3 Trigger

For pulsed operations, connect the trigger source to this SMA connector. An SMA to BNC adapter cable is supplied. A TTL trigger pulse can trigger the Pyrocam. The trigger is rising edge sensitive.

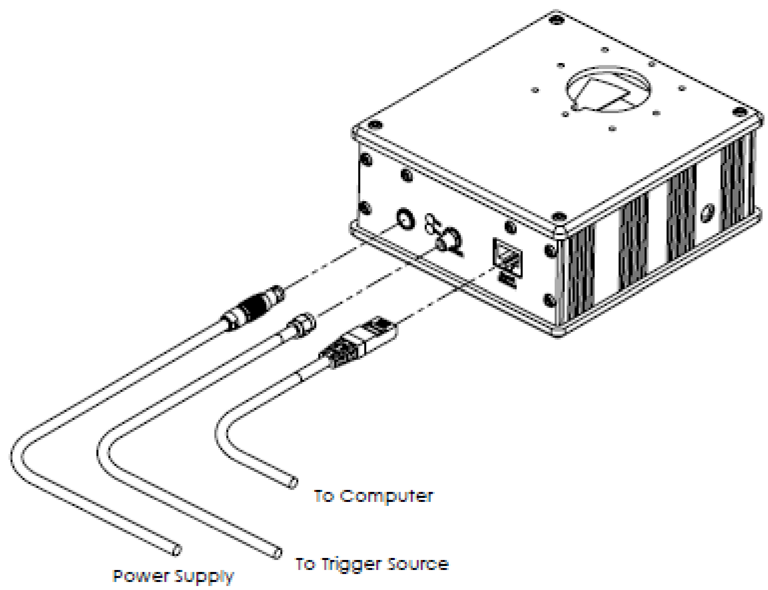


Figure 2.1: Typical Cabling Diagram

2.1.3 Driver Installation

The eBus Universal Pro driver required to run the Pyrocam is included with BeamGage. The Spiricon Camera Driver Manager is launched at the end of the BeamGage installation. Select the **Pyrocam IIIHR** then click the **Install** button. You can close the Spiricon Camera Driver Manager when finished. BeamGage will now automatically connect to the Pyrocam when powered and connected to the computer.

For more information, consult the Getting Started with Gig-E Camera in BeamGage User Notes included with the Pyrocam.

CHAPTER 3 – SETUP AND OPERATION

3.1 Introduction

The Pyrocam can analyze both CW and Pulsed style lasers. Fitted with an appropriate lens, the Pyrocam can continuously image high temperature thermal objects, or can capture short-pulsed thermal events. The Pyrocam requires different setups depending on the specific application.

NOTE: *This manual describes the operation of the Pyrocam IIIHR with BeamGage. For other methods of operation, please refer to CHAPTER 4.*

3.2 Overview of Pyrocam Controls

All of the features for the Pyrocam IIIHR are found in the BeamGage software. The panels that are unique to the Pyrocam IIIHR are shown and described below.

Chopped (CW) vs. Pulsed

To operate in Chopped (CW) mode, the Pyrocam employs a rotating chopper that can operate at one of two different chopping rates, **25Hz** and **50Hz**. We recommend that you always use the **50Hz** rate in order to obtain a linear response. The **25Hz** rate should only be used in combination with higher gain and frame averaging to extract the very weakest of images.

When operating in pulsed mode, the Pyrocam must be externally triggered. The **Delay** setting should be set to **0µs** (default) if the laser fires a few microseconds after the trigger's rising edge and if the pulse is at least tens of µs in length.

If the laser pulse is very short and/or occurs either simultaneous with the trigger's rising edge or before the trigger pulse's rising edge, set the Delay to a negative value that will insure the capture of the laser pulse prior to receiving the trigger.

The **Rate** value will indicate either the current chopper frequency or the input trigger pulse rate in Hz.

Exposure Control

When operating in **Pulsed** mode, the Pyrocam must be externally triggered and the **Exposure** control must be set to a value slightly larger (10-15%) than the laser's pulse width. (Not the trigger pulse length.) The exposure range is from 1 to 40,000µs.

NOTE: *The **Exposure** control has no effect in chopped mode and there is no Auto setup or Auto-X features for the Pyrocam.*

Hint: Always remember to re-**Ultracal** after changing the **Trigger Mode** or the **Exposure** setting.

Gain Control

The Pyrocam has a video gain control to help with viewing lower intensity lasers. The number in the slide control does not correspond to the actual gain in V/V. The corresponding gain for each setting is shown in Table 1.

Gain Setting	Gain (V/V)
1	1.00
2	1.14
3	1.33
4	1.60
5	2.00
6	2.66
7	4.00
8	8.00

Table 1 - Gain Control Settings

Hint: Always remember to re-**Ultracal** after changing the **Gain** setting.

Bad Pixel Correction

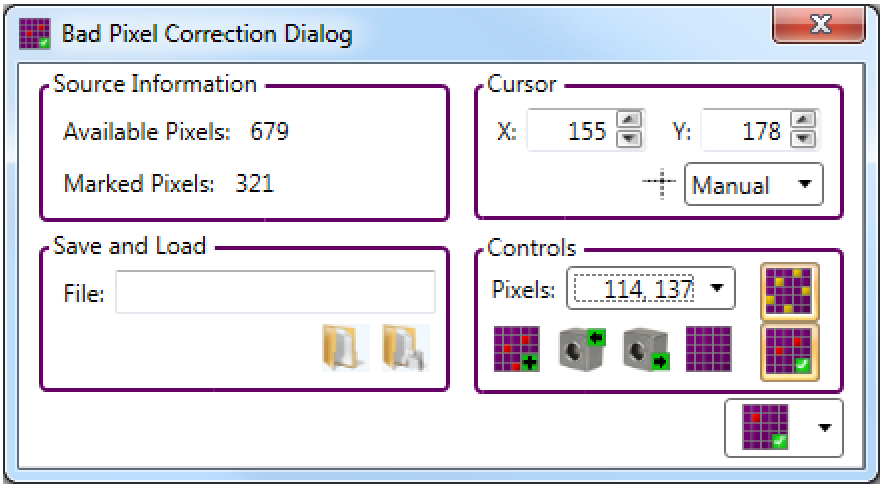
Click this control to enable/disable bad pixel (BP) correction in the Pyrocam. Bad pixel correction will default in the ON state and should always be enabled except when looking for defective pixels. If this control is deactivated, it indicates that the Pyrocam does not have a Bad Pixel map programmed. The procedure for finding and correcting bad pixels is described in APPENDIX C.

Note: The Pyrocam has separate Bad Pixel Correction maps programmed for pulsed and chopped operation. Two BP maps are created at the factory and are flashed into the Pyrocam's EEPROM memory. The factory BP maps are also supplied as two files that can be reloaded in the event that the internal maps are accidentally deleted or corrupted. BP maps can also be read from the Pyrocam and saved into a BP map file.

Click on the expansion button to modify or create a BP correction map. This is done by working with a *List* that contains the coordinates of the pixels to be BP mapped. This *List* is an intermediate device that is employed to transfer the BP map to/from the Pyrocam or to/from a BP text file. The **Bad Pixel Correction Dialog** tools can:

- Read a BP *List* from the Pyrocam
- Write a BP *List* into the Pyrocam
- Add (mark) a single BP to the BP *List*
- Remove (unmark) a single BP from the BP *List*
- Add (mark) a row of BP's to the BP *List*
- Remove (unmark) a row of BP's from the BP *List*

- Add (mark) a column of BP's to the BP *List*
- Remove (unmark) a column of BP's from the BP *List*
- Clear a BP *List*
- Save a BP *List* into a BP text file
- Load a BP *List* from a BP text file
- Show/Hide the marked pixels in the *List*
- Turn on/off BP correction, demonstrates the current impact of the mapped BP's

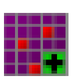


The **Source Information** group shows how many more pixels you can mark as bad and how many pixels have already been BP marked.

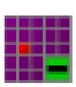
The **Save and Load** group allows you to save or load a Bad Pixel map file for use by the Pyrocam.

The **Cursor** group sets the BeamGage Cursor mode to select a BP location using either a **Manual** or **Peak** detection mode. The X and Y values indicate the pixel coordinate of the currently selected pixel location. The **Manual** mode is used to select dark, dim, or bright pixels one at a time. The **Peak** mode is used to find pixels that indicate too bright.

Note: Pixel coordinates are mapped from the lower left corner starting at location 0,0.

 **Add Pixel to List**

Click to add the pixel at the current cursor location to the BP correction *List*.

 **Remove Pixel from List**

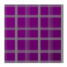
Click to remove a pixel selected from the **Pixels** dropdown from the pixel correction *List*.

 **Write Pixel List**

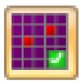
Click to write the current pixel *List* to the camera.

 **Read Pixel List**

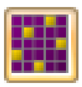
Click to read the current pixel *List* from the camera.

 **Clear Pixel List**

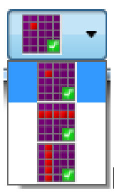
Clears all marked pixels from the correction *List.*

 **Software Bad Pixel Correction**

Enable/Disable the bad pixel correction simulation built into the BeamGage software. This allows the operator to preview the effect of the current BP *List* before writing it into the Pyrocam's EEPROM.

 **Bad Pixel Correction Map**

Toggle control to show/hide the marked pixels currently entered in the correction *List*.

 **Pixel Selection Type**

Select either a single pixel, row of pixels, or column of pixels when adding/removing pixels from the correction *List*.

Pixel List

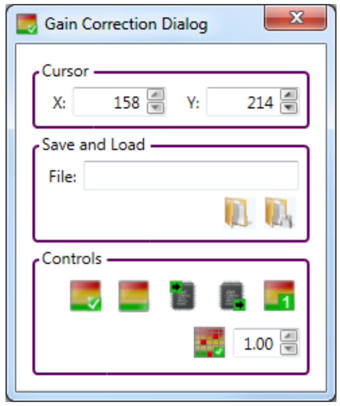
You can view and select a pixel to edit in the pixel *List* using this dropdown control. It contains all pixel coordinates currently entered in the *List.*

Gain Correction

Click this control to enable/disable gain correction in the Pyrocam. Gain Correction (GC) will default to the ON state whenever a GC table is loaded into the Pyrocam. If this control is deactivated, it indicates that the Pyrocam does not have a gain correction table programmed in its EEPROM. The procedure for creating a Gain Table is described in APPENDIX D.

Note: The Pyrocam has separate gain correction tables programmable for pulsed and chopped operation. Many of the Pyrocams will ship with a valid 50Hz chopped gain correction table installed at the factory. Pyrocams will almost never ship with a pulsed gain correction table. Factory generated GC files are supplied with the Pyrocam in case the programmed table is accidentally deleted or corrupted.

Click on the expansion button to enter the Gain Correction Dialog. In order to use the automatic GC creation method, a uniform collimated illumination must be applied over the entire imager. Clicking on the **Create Gain Table** button will then compute a normalization factor for each pixel. To GC a single pixel, a manual method is provided for setting the correction factor of only one pixel at a time.

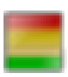


The X and Y values show the current pixel location of the cursor. This setting selects which pixel can be adjusted using the manual method.

The **Save and Load** group allows you to save and retrieve a GC table text file.

Software Gain Correction

Enable/disable the built in software gain correction. Defaults enabled when a gain table is present.

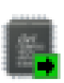


Create Gain Table

Click to automatically create the table of gain correction values. Uniform collimated illumination of the imager is required to successfully perform this operation. **Note:** The gain correction factor values are limited to the range 0.50 to 2.00. This applies to both manually entered and automatically calculated factors. Since bad pixels cannot normally be corrected within this range it is necessary to map the bad pixels before attempting to run the automatic create gain correction utility described above.

Write Flash

Click to write the gain correction values to the camera. Gain correction changes will not take effect until the revised value is written into the flash EEPROM of the Pyrocam.



Read Flash

Click to read the gain correction values from the flash.

 **Set Gain Frame to Default**

Click to set the gain frame to the default value of 1.0 for each pixel.

Pixel Gain Value

This is a dual operation control. It will display the current GC factor at the cursor selected location, and can be used to enter a new value by editing its content and then clicking on the adjacent button. Acceptable CG values are between 0.50 and 2.00.

3.3 Pulsed Operation

To operate with pulsed lasers, an external trigger must be supplied to the Pyrocam **TRIGGER** connector. The relationship between the trigger pulse and the pulsed event must meet certain timing and electrical requirements for correct operation. These requirements are detailed in the following sections.

NOTE: Pulsed operation is the default operating mode for the Pyrocam on power up*. This is important to consider since users may start BeamGage with no trigger pulses present. This results in the camera sitting idle and not collecting frames, which could be confused with the camera not operating correctly.*

3.3.1 Pulse Modes

Pulsed operation falls into three categories based on laser (trigger) pulse repetition rate. One requires special external timing between the TRIGGER input pulse and the firing of the laser. The three timing modes are designated as Pulse Modes 1, 2, and 3 and are described in **Figure 3.1** thru **Figure 3.4**.

Mode 1 describes operation when the laser fires at a trigger rate less than 3Hz. This includes non-repetitive or Single Shot events. Trigger rate stability is not critical in this mode. Positive **Delay** values can be programmed but not negative ones. Negative values default to 0µs.

Mode 2 describes operations where the laser fires at a stable periodic rate of 3Hz to 125Hz. Mode 2 can also be used to split out a single pulse from a periodic burst of laser pulses. When the trigger frequency exceeds 125Hz the Pyrocam will automatically switch into Mode 3 timing.

Mode 3 is the high speed mode. This mode can operate up to about 1000Hz, but will divide out trigger pulses to achieve a lower overall sample rate.

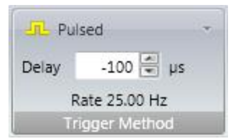
In all of the above modes, the **Exposure and Delay** times must be adjusted so that the resulting exposure time will contain the entire laser pulse. If these settings are not correct, the Pyrocam may not capture the laser pulse, may capture only a portion of the laser pulse, or may capture multiple laser pulses. **Exposure** time is adjustable from 1µs to 40,000µs in 1µs increments. **Delay** times can be programmed from -3000µs to +3,000µs in 1µs increments.

NOTE: *When operating in pulsed mode, try to avoid periodic rates that border the transitions between the three timing modes. This avoids erratic acquisition* *problems. There is some built-in hysteresis between the trigger mode thresholds, so approach the boundary points from the side most desirable.*

NOTE: *An Ultracal MUST be performed for all pulsed trigger modes.*

NOTE*: Unstable periodic trigger pulses will result in timing jitter from one pulse to the next. When negative Delay settings are required to insure capture of very short pulses, excessive jitter can cause the pulse to miss being captured. Therefore high trigger pulse frequency stability is most needed for very short laser pulses.*

3.3.2 Pulse Mode Setup Procedure



Pulse mode is enabled by selecting **Pulsed** in the **Trigger Method** panel. Connect a trigger source to the TRIGGER connector. See APPENDIX A for trigger pulse electrical requirements. The GREEN **Trigger** LED will illuminate when trigger pulses are applied to the Pyrocam. The RED LED will blink once when power is applied. It will not blink again unless an error has occurred in the firmware.

NOTE: Pulsed operation is the default operating mode for the Pyrocam on power up*. This is important to consider since users may start BeamGage with no trigger pulses present. This results in the camera sitting idle and not collecting frames, which could be confused with the camera not operating correctly.*

The **Delay** setting is adjusted based on the selected operating mode and is described in the following Mode descriptions.

3.3.2.1 Trigger Rate Stability

Trigger rate stability is required for pulsed modes 2 and 3. For best results, the trigger pulse repetition rate should be stable to within ±200µs. The Pyrocam will monitor the current trigger rate and compare it to the rate recorded during the last **Ultracal** cycle.

The **Ultracal** status bar indicator 

will change from GREEN to RED 

if the trigger rate changes significantly from the rate used during the **Ultracal** cycle. This change to RED will revert to GREEN if the previous trigger rate is restored.

The following notations are used in the timing diagrams and equations:

$$f_{trig} = trigger\ pulse\ frequency\ (Hz)$$

$$f_{pul} = laser\ pulse\ frequency\ (Hz)$$

$$f_{bur} = laser\ pulse\ burst\ frequency\ (Hz)$$

$$f_{psr} = laser\ pulse\ sample\ rate\ (Hz)$$

$$f_{max} = max\ pulse\ capture\ rate\ (Hz)$$

$T_D = Delay$ (program in Trigger Method)

$T_E = Exposure$ (program in Exposure|Gain)

$$T_{tw} = trigger\ pulse\ width$$

$$T_{tp} = trigger\ period$$

$$T_{tj} = trigger\ jitter$$

$$T_{lw} = Laser\ pulse\ width$$
$$\Delta T = Laser\ pulse\ period$$
$$T_r = response\ delay$$

(All times are in µsec unless noted otherwise)

3.3.3 Mode 1, Single-Shot Operation

Mode 1 describes operation when the laser fires at a trigger rate of <3Hz, including non-repetitive or Single-Shot triggers. **Figure 3.1** diagrams the trigger timing requirements for this mode of operation. In this mode, the laser must fire within an exposure time window that begins 10µs after the rising edge of the applied trigger. The entire laser pulse duration must be contained within the programmed **Exposure** time. In general, you should program the **Exposure** time to extend 10-15% longer than the actual laser pulse width.

To remain in mode 1, you must restrict your trigger rates to be <3Hz. The Pyrocam automatically switches from Mode 1 to Mode 2 if the trigger rate meets or exceeds 3Hz.

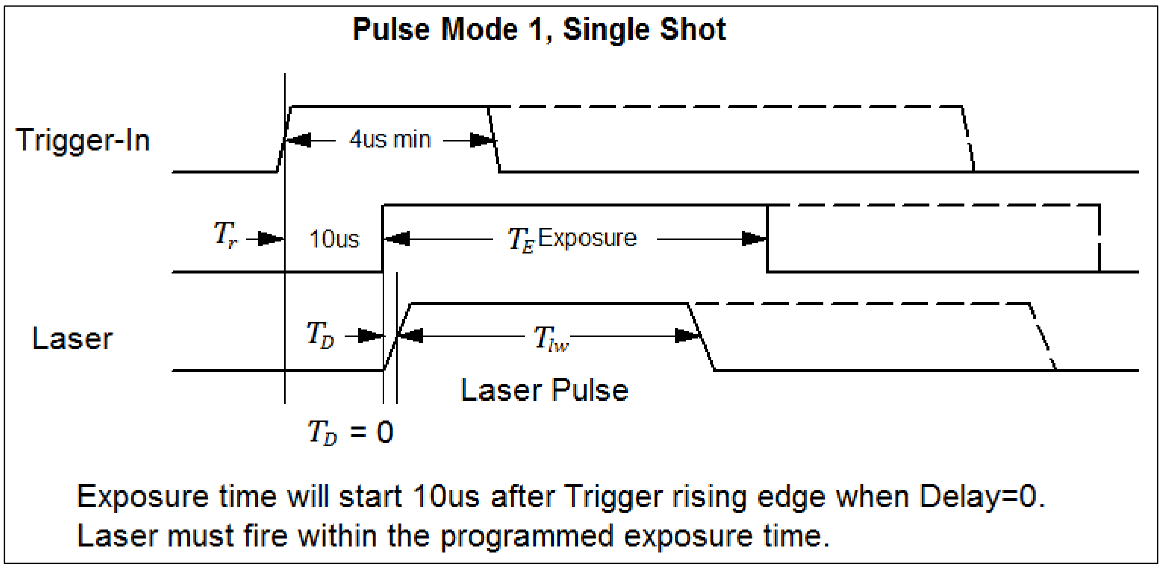


Figure 3.1 : Mode 1, Single Shot, $f_{trig} < 3Hz$

$$T_E = T_{lw} + 20 \quad \text{for} \quad T_{lw} < 100$$
$$T_E = 1.15\,T_{lw} \quad \text{for} \quad T_{lw} \geq 100$$

3.3.4 Mode 2, Periodic Operation

In Mode 2 trigger pulses must arrive at a periodic rate. Refer to **Figure 3.2**. The **Exposure** time should be set to contain just the pulsed event to be captured. If the exposure time is set too long (after the pulse) it will result in a loss of signal due to array cooling before detector readout.

If the trigger source is unstable or turns on and off, some loss of uniformity shot to shot will likely result. For best operation, calibrate the Pyrocam at the trigger rate being used and recalibrate if the rate changes.

In mode 2 and 3 the Pyrocam firmware measures the trigger pulse period and predicts when the next pulse will occur. Based on the predicted trigger time, the exposure start time can be advanced (made early). When a negative **Delay** is entered, the exposure time will start early based on the negative **Delay** value. This early exposure start time will compensate for lasers that fire at or before the trigger pulse's arrival at the Pyrocam. It can also compensate for pulse to pulse jitter when the pulse rate is less stable.

For lasers with very short pulse times (10µs or less) that start at the triggers rising edge, some amount of negative **Delay** is required to capture the pulse. Without it, the pulse will occur prior to the exposure window being able to open.

Hint: For laser pulses that occur simultaneous with the trigger rising edge and are shorter than 100µs, set the **Delay** time to -50µs and set the **Exposure** time to the pulse width plus 70µs.

NOTE: *Calibrating the Pyrocam with a slow pulse rate in mode 2 will take a while to complete, so be patient.*

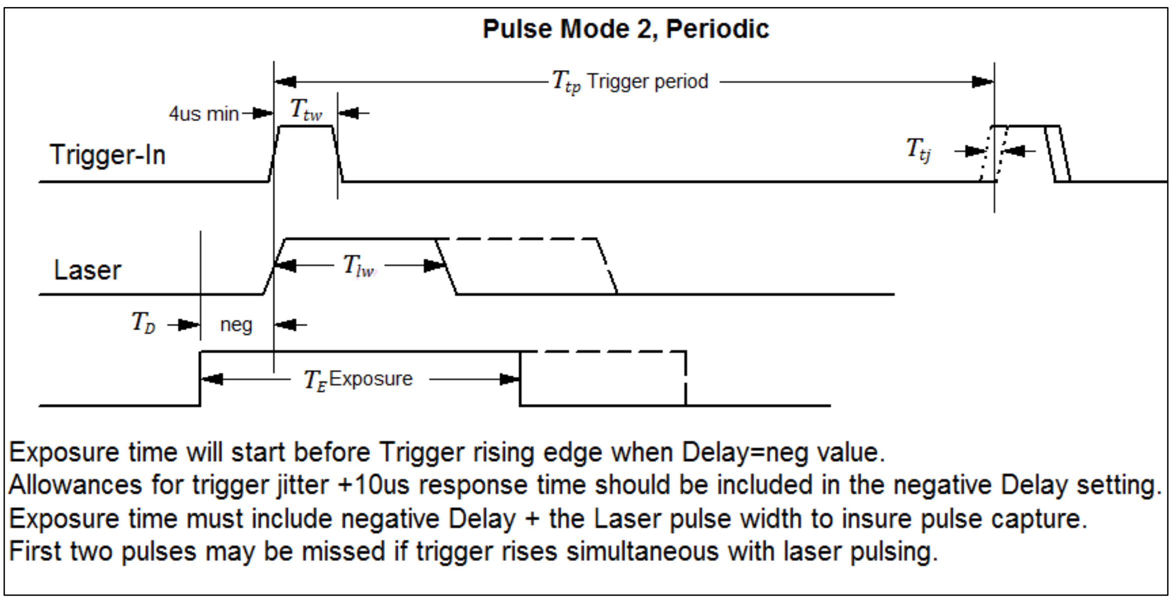


Figure 3.2 : Mode 2, Periodic, $3Hz < f_{trig} < f_{max}$

$$f_{max} = (8.705ms + T_E)^{-1}$$

$$\boldsymbol{T_D = -(T_{tj} + 10)}$$

$$T_E = |T_D| + T_{lw} + 20 \quad \text{for} \quad T_{lw} < 100$$
$$T_E = T_{tj} + 1.15\, T_{lw} \quad \text{for} \quad T_{lw} \geq 100$$

3.3.5 Mode 2, Periodic-Burst Operation

The **Delay** timer can be used to capture (split-out) a single laser pulse from a burst of pulses. **Figure 3.3** demonstrates this timing for a periodic burst event; however this same scheme can be used for a single shot burst event. The **Delay** time needs to expire just a few tens of µs before the pulse to be captured, and the **Exposure** time to end slightly longer than the pulse width. Observe that the **Trigger** pulse must only occur once per burst.

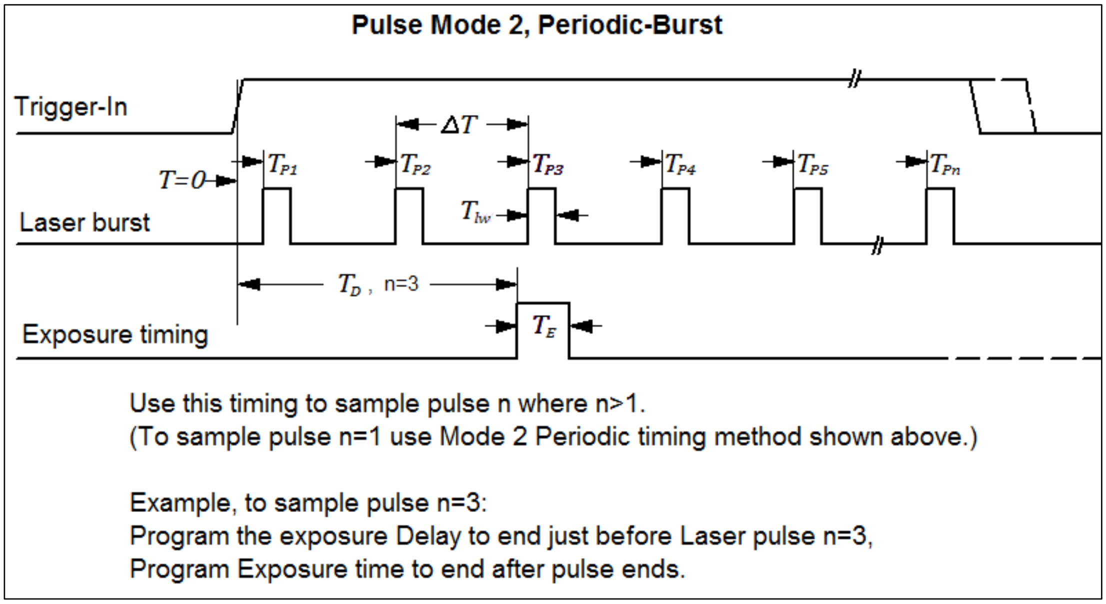


Figure 3.3 : Mode 2, Periodic–Burst, $3Hz < f_{trig} < f_{max}$ **,** $10 f_{trig} < f_{bur} < 1000Hz$

$$f_{max} = (8.705ms + T_E)^{-1}$$

$$\Delta T = T_{pn} - T_{pn-1}$$

$$T_D = T_{pn} - .1\Delta T + 10 \quad \text{for} \quad n > 1$$

$$\text{for} \quad n = 1 \text{ use Mode 2, Periodic}$$

$$T_E = .1\Delta T + T_{lw} + 20 \quad \text{for} \quad T_{lw} < 100$$

$$T_E = .1\Delta T + 1.15 T_{lw} \quad \text{for} \quad T_{lw} \geq 100$$

3.3.6 Mode 3, High-Speed Operation

If the laser pulse rate is greater than the maximum rate supported in pulse mode 2, the Pyrocam will automatically switch into mode 3, the high-speed mode. If the setup is optimized for short pulses in Mode 2, Periodic timing, then the transition to Mode 3 will occur without the need to change any settings. The only thing needed is a new **Ultracal** for the new pulse rate.

WARNING:

Special care should be exercised when operating at high-speed pulsed rates to avoid damage to the Pyrocam's detector. High pulse rates with large ON-time duty cycles can cause a significant amount of power to be dissipated in the detector, even though small signal outputs may be observed. Be sure to limit the total incident power to levels below ½ the CW laser damage thresholds specified in APPENDIX A. As an added precaution, it is recommended that duty cycles greater than 10% should be avoided.

In pulse mode 3, the Pyrocam is receiving trigger pulses at a rate faster than the pyroelectric detector can read out. See **Figure 3.4**. Thus, trigger inputs are automatically divided down to a range that the Pyrocam can keep up with. The dividing factor will be the least integer value that will reduce the effective rate to a value that falls just within a rate supported in pulse mode 2.

For example, a pulse rate of 150Hz will be divided by 2, yielding a capture rate of 75Hz. A pulse rate of 1000Hz will be divided by 9, yielding a rate of 111Hz. Note that this does not mean that the Pyrocam will output data frames at a rate of 75 or 111Hz. The actual frame rate output from the Pyrocam is limited by equipment bandwidths that are not accurately predictable.

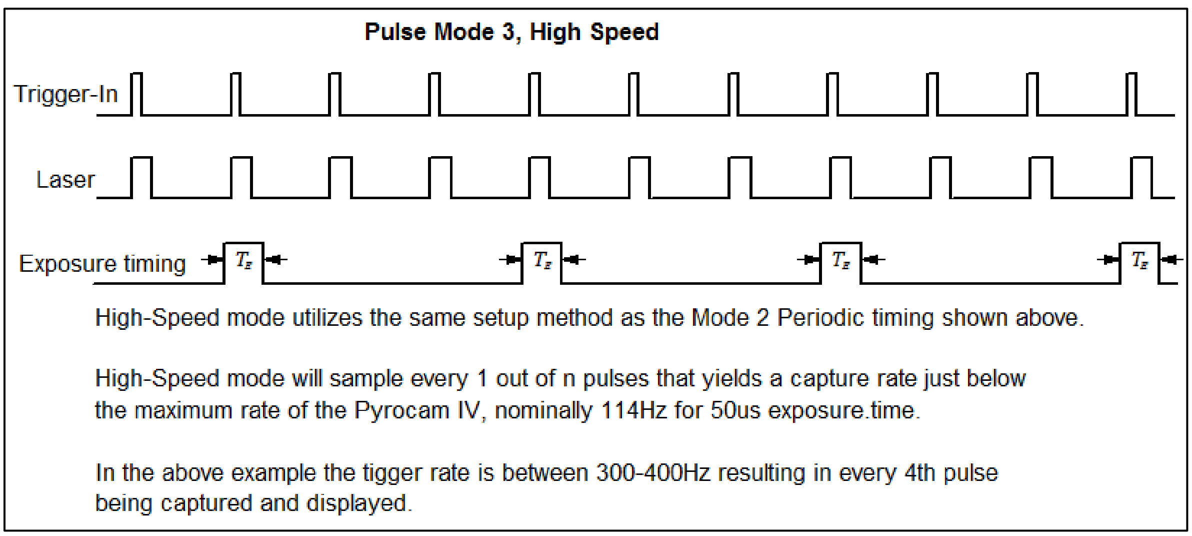


Figure 3.4 : Mode 3, High Speed, $f_{max} < f_{trig} < 1000Hz$

$$f_{max} = (8.705ms + T_E)^{-1}$$

Use Mode 2, Periodic timing.

$$f_{psr} = \frac{f_{pul}}{\left\lceil f_{pul}/f_{max} \right\rceil}$$

Example: Laser pulse rate is 350Hz, Exposure 50us, Delay 0us

Solution: $f_{psr} = \frac{350}{\lceil 350/_{114.22} \rceil} = \frac{350}{4} = 87.5Hz$

3.4 Chopped (CW) Operation

The Pyrocam chopped models contain an internal chopper for use with CW lasers or to do thermal imaging when fitted with a specialized lens. The operation of the chopper is managed by the camera's firmware and no external trigger is required when in chopped mode. The chop rate can be reduced to increase responsivity, but with some loss in response linearity.

WARNING:

Before exposing the Pyrocam detector to a CW Laser, be sure that you will not exceed the safe operating levels of the array. Refer to APPENDIX A for damage threshold limits. Permanent damage to the array may result if these limits are exceeded.

Proper operation of the chopper requires that the readout of the array be performed synchronous with the motion of the chopper across the array. More specifically, the scan is synchronized with the leading edges of the chopper as it just covers or uncovers a row of pixels. If the chopper is running erratically, or is mechanically rubbing on a surface within the Pyrocam, scan timing may not be properly sync'd and service of the Pyrocam may be needed.

CAUTION:

DO NOT MOVE THE PYROCAM WHEN RUNNING IN CHOPPED MODE

DAMAGE to the Pyrocam could result.

The Pyrocam chopper blade is an etched metallic disk made from laminated layers of thin blackened metal that rotates at a high rate of speed. The rotation and mass of the disk creates a gyroscopic effect. Movement of the camera while the chopper is rotating will cause the blade to deflect against the direction of the camera's movement. This deflection can bring the rotating blade into contact with the position encoder and/or the imager's protective bezel risking costly damage to the chopper and the imager's bezel.

When repositioning the Pyrocam it is best to turn off the chopper by placing it into **Pulsed** mode. If you must move the Pyrocam with the chopper running, move it very slowing and do not jar or bump the camera into another object.

3.4.1 Chopped (CW) Setup Procedure

With the Pyrocam set to **Pulsed** trigger mode, align the Pyrocam imager with the beam path of the laser. Next place the Pyrocam into **Chopped** (CW) trigger mode and wait for the chopper to spin up to the selected **Chop Rate.**

Hint: In general, it is best to start with the 50Hz chop rate.

While in CW mode, no external **TRIGGER** source is required, and any source connected to the **TRIGGER** input will have no effect so long as the Pyrocam is in **Chopped** mode.

The GREEN trigger LED will be lit in a solid state when in chopped mode. The RED LED will blink once when power is applied. It will not blink again unless an error has occurred in the firmware.

3.4.1.1 Internal Chopper

The internal chopper in the Pyrocam utilizes a closed-loop PID control system to keep it running at a constant speed. When in **Pulsed** mode, the controller is still active, maintaining the position of the chopper blade so that it doesn't cover the detector. Occasionally, the blade will jitter or make a little noise as the control loop makes slight periodic adjustments to the chopper's position.

The internal chopper is placed very close to the detector's focal plane. Thus diffraction effects are reduced and a sharper image is possible when an optional lens is fitted.

3.4.1.2 Beam Alignment

Chopped imaging is most accurate when the input laser beam is perpendicular to the plane of the chopper/imager. Beams coming in at oblique angles will be chopped somewhat out of phase. This can contribute to some loss in responsivity and/or response linearity.

3.4.1.3 Damage Concerns

In Chopped mode, with the gain set to minimum (or near the minimum setting), the output signal from the detector will saturate at about 5 W/cm². This is very near the Pyrocam's damage threshold of 8 W/cm².

WARNING

With a low GAIN setting, it is easy to inadvertently exceed the Pyrocam detector's damage threshold. For example: A one (1) Watt input beam, with a TEM_{00} Gaussian beam width of 5mm will have a peak power density of 10 W/cm^2. If left on the detector for a significant amount of time, the detector will sustain damage in and around the region of peak power density. Pyrocam detectors are very costly to replace, but if treated with care they can last nearly as long as most other semiconductor devices.

NOTE: *If the Pyrocam is placed into* ***Pulsed*** *operating mode, the internal chopper will set itself to an open position. If you are illuminating the detector with a CW laser and have placed the Pyrocam into* ***Pulsed*** *mode, the total power falling on the detector will effectively double, thus increasing the damage risk described above by a factor of 2.*

3.5 Calibrate and Ultracal Cycles

Calibrate and Ultracal are two different operations but they are applied together when an **Ultracal** operation is initiated in BeamGage. Both operations must be performed without a laser on the imager and under subdued room lighting if fitted with a window that transmits room light. Here's how they differ:

3.5.1 Calibrate Cycle

The Calibrate operation is performed in the Pyrocam when a **Calibrate** command (see APPENDIX F) is sent to the Pyrocam firmware. This process establishes a zero set-point within the Pyrocam that corrects for circuit and ADC offset errors. It also sign adjusts for the pyroelectric crystal's polarity and dynamic range.

A Calibrate cycle is initiated in the Pyrocam each time an **Ultracal** cycle is initiated in BeamGage.

3.5.2 Ultracal Cycle

An **Ultracal** cycle begins after the above Calibrate cycle is completed. The **Ultracal** operation is performed completely in BeamGage. **Ultracal** will average 64 dark frames to establish a new baseline that is accurate to fractional count precision. This extra precision allows beam width and centroid calculations to be as precise as possible.

Ultracal operations should be performed whenever any of the following conditions are changed:

1. A change of the Pulsed/Chopped mode selector
2. A change in pulse trigger repetition rate
3. A change of Chopper frequency
4. A change of Exposure time
5. A change of the Gain setting
6. A change in background radiation (including room temperature or changes caused by varying the optical path)
7. A change in the Pyrocam operating temperature

3.5.3 Performing an Ultracal

After setting up the Pyrocam, in either **Pulsed** or **Chopped** mode, an **Ultracal** cycle can be performed. It is recommended to wait approximately 30 minutes after powering up the Pyrocam so that it reaches thermal equilibrium. If a warm up period is not possible, the **Ultracal** cycle should be rerun every 5 minutes or so during the warm-up phase.

To execute an **Ultracal** cycle, do the following:

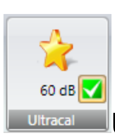
STEP 1. In **Pulsed** mode, provide stable periodic trigger pulses to the Pyrocam at the rate for which operation is required. Note: if you are operating below 3Hz in single shot mode, an external trigger is not required during the **Ultracal** cycle. Adjust the **Exposure**, **Delay**, and **Gain** values as needed.

In **Chopped** mode, external trigger pulses are not required. Adjust the **Chop Rate** and **Gain** values as needed.

STEP 2. Block the laser beam, from the Pyrocam's detector. If you are using a lens, cover it with an opaque material or close its iris. If the imager's window can transmit visible light, all operations should be performed under subdued room lighting conditions.

STEP 3. 

Click on the **Ultracal** button on the **Source** tab or **Quick Access Toolbar** to initiate the Ultracal cycle.

STEP 4. 

Upon completion, the Ultracal checkbox will turn ON, a measured signal to noise ratio of the camera in RMS dB will be computed and displayed and a Green 

will illuminate in the status bar. Be patient… this can take more than a minute if the trigger rate is slow or if you are using pulse mode 1 (single-shot mode).

3.5.4 Ultracal Status Indicator

The Pyrocam powers up in an un-calibrated state. Each time it is powered down all previous calibration data is lost. BeamGage indicates that an **Ultracal** cycle has not been performed by displaying a GRAY  in the **Status** bar.

When a valid calibration cycle has been performed and is in effect, the status indicator will appear GREEN . As long as you do not disturb the Pyrocam set up or trigger timing, the indicator will remain GREEN.

A RED  status bar indicator is a warning to the operator than trigger conditions may be affecting the quality of the collected data. If the rate change is slight then the data may still be useful. The operator must use their own judgment in evaluating and accepting the results under this condition.

The only conditions that will cause the button to turn RED are listed above in section 3.5.2 as items 1, 2, 3, 4, and 5. Items 6 and 7 are not detectable by the camera and are left for the operator to monitor.

CHAPTER 4 – GenICam COMPATIBILITY

The Pyrocam is compliant with GenICam v2.0. The Pyrocam should work with any GenICam client.

4.1 Features

The Pyrocam contains hundreds of settings which are called Features in the GenICam standard. All of the features, except for those identified as read-only, can be changed by any program that communicates with a GenICam compliant camera. However, only a very small subset of Pyrocam features should be changed by the normal user. APPENDIX F shows a list of features that should be changed by, and read-only features that could be useful to, any user. Ophir-Spiricon can provide support only for the features in this list. Changing any other feature will cause the Pyrocam to misbehave and may cause the camera to stop working.

A table of features is shown in APPENDIX F.

4.2 National Instruments Vision Acquisition Software

The Pyrocam has been tested with and is compatible with National Instruments Vision Image Acquisition Software.

National Instruments Vision Acquisition Software, 778413-35, can be used alone or with LabVIEW to control and capture images from the Pyrocam.

Follow these steps to capture images and control the Pyrocam with National Instruments Vision Acquisition Software:

1. Launch the "Measurement & Automation Explorer"
2. Open "Devices and Interfaces"
3. If the Pyrocam is powered and properly connected, you should see "NI-IMAQdx Devices".
4. Open "NI-IMAQdx Devices"
5. Click on "cam0: Spiricon Pyrocam_III_HR"
6. Click the Snap button to capture one frame.
7. You can view and change NI-IMAQdx and Pyrocam features in the window below the image. We suggest you use the default NI-IMAQdx settings.
8. Pyrocam features can be viewed and changed in the Camera Attributes group. Be careful to change only those features listed in the table in APPENDIX F.

LabVIEW can be used in conjunction with the Vision Acquisition Software to capture images and control the Pyrocam.

Most of the LabVIEW IMAQdx examples will work "as is" with the Pyrocam. To find IMAQdx examples in LabVIEW 2012, select Help | Find Examples… In the Browse window, open "Hardware Input and Output" then open "IMAQdx". Here you will find High-Level and Low-Level IMAQdx examples.

The Pyrocam has been tested with the following examples:

- Grab and Attributes Setup.vi
- Grab and Basic Attributes.vi
- Grab and Detect Skipped Buffers.vi
- Grab and Reconfigure.vi
- Grab and Select Interface.vi
- Grab.vi
- Sequence.vi
- Snap.vi
- Low-Level Grab Async.vi
- Low-Level Grab Raw Data.vi
- Low-Level Grab.vi
- Low-Level SDequence.vi
- Low-Level Snap.vi

The following examples do not work "as-is" with the Pyrocam:

- Grab (177x Smart Camera).vi
    - "NI-IMAQdx (Hex 0xBFF6900F) Attribute not supported by the camera."
- Grab and Bayer Decoding.vi
    - Times out after changing any of the Red, Green, or Blue sliders
- Grab and Scalable Format.vi
    - "NI-IMAQdx (Hex 0xBFF6900F) Attribute not supported by the camera."

APPENDIX A – SPECIFICATIONS

Pyrocam IIIHR Specifications

ENVIRONMENTAL	
Operating Temperature	+5°C to +50°C
Storage Temperature	-30°C to +85°C
Humidity	95% max non-condensing
POWER REQUIREMENTS	
Line Voltage	100-240 Vac
Line Frequency	47-63Hz
Power Consumption	10 W
WEIGHT	
Pyrocam (w/o power supply)	0.85kg (1.88 lbs.)
DIMENSIONS	
See page 30	
GENERAL	
Wavelength range	157nm to 355nm
	1.06µm to >1000µm
Detector Array Details	
# Elements	25,600… 160 x 160
Active Area	12.8mm x 12.8mm
Element Spacing	80µm x 80µm
Pixel Size	75µm x 75µm
Detector Material	$LiTaO_3$
Interchangeable Windows	See APPENDIX E
ADC	16 bit
Memory	64MB RAM, 4MB Flash
Interface	IEEE 802.3ab Gigabit Ethernet, GigE Vision compliant
Electronic Gain	x1, x1.14, x1.33, x1.6, x2, x2.66, x4, x8
Chopper	8-blade, 4” dia. PID controlled
Mounting	3 ¼”-20 threaded inserts

Firmware	Field upgradeable via Ethernet port
Software	BeamGage™
	GenICam controls provided for 3rd party interfacing

CHOPPED / CW OPERATION

Chopping Frequencies	25Hz, 50Hz
Sensitivity (RMS noise limit)	64 nW/pixel (25Hz)
	96 nW/pixel (50Hz)
	1.0 mW/cm^2 (25Hz)
	1.5 mW/cm^2 (50Hz)
Noise Equivalent Pwr (NEP)	12.8 nW/Hz$^{1/2}$/pixel (1Hz)
(Chopped at 25Hz and averaging 25 frames to 1Hz)	
Saturation Power	3.0 W/cm^2 (25Hz)
	4.5 W/cm^2 (50Hz)
Damage Threshold Power	
Over entire array	2 W
Peak Power Density	8 W/cm^2 Chopped mode
	4 W/cm^2 CW in Pulsed mode

PULSED OPERATION

Laser Pulse Rate	Single-shot to 1000Hz
Pulse Width	1fs to 12.8ms
Sensitivity (Peak noise limit)	0.5nJ/Pixel
	8µJ/cm^2
Saturation Energy	15mJ/cm^2
Damage Threshold	20mJ/cm^2 (1ns pulse)
	600mJ/cm^2 (1ms pulse)

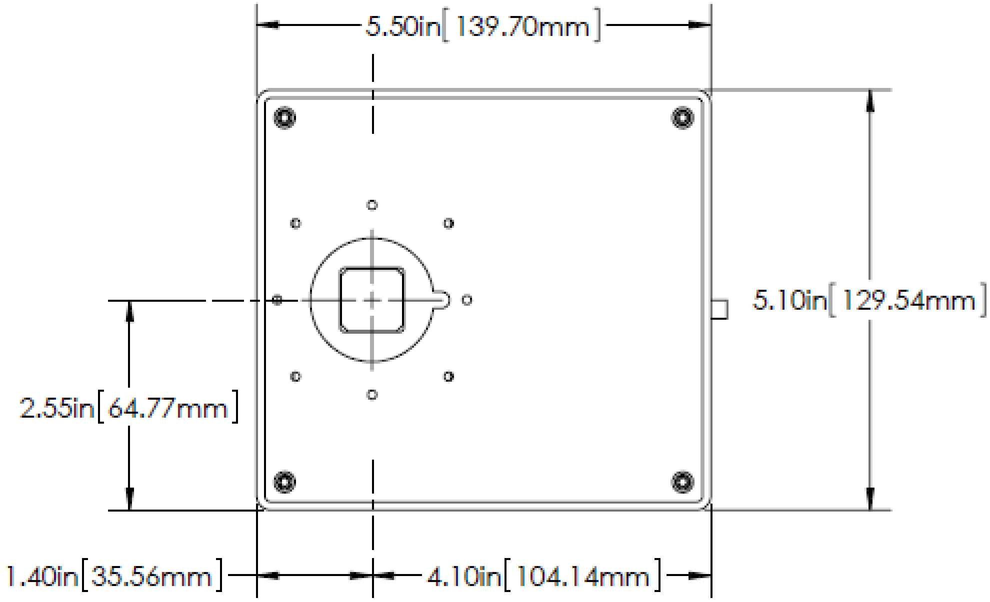
TRIGGER input: *

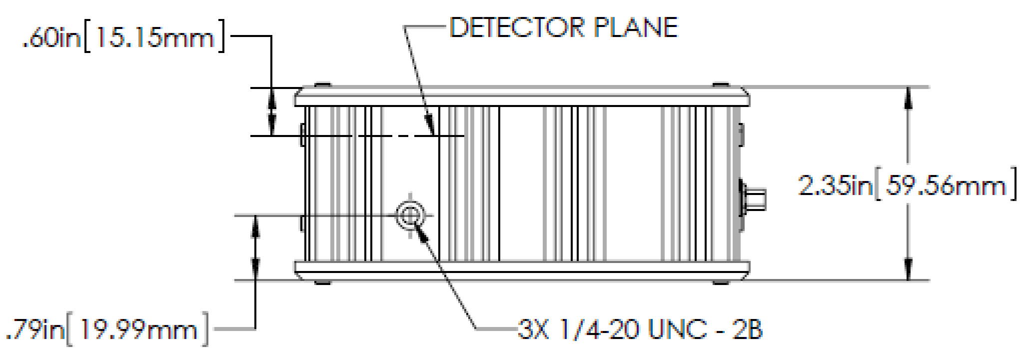
High logic level *VH	3.5 - 6.0 Vdc
Low logic level VL	0 - 0.8 Vdc
Pulse width	4µs minimum

*Trigger drive must be able to source 10ma min. Trigger input is rising edge sensitive. Refer to Figure A.1.

Pyrocam Dimensions

(w/o chopper or cables)





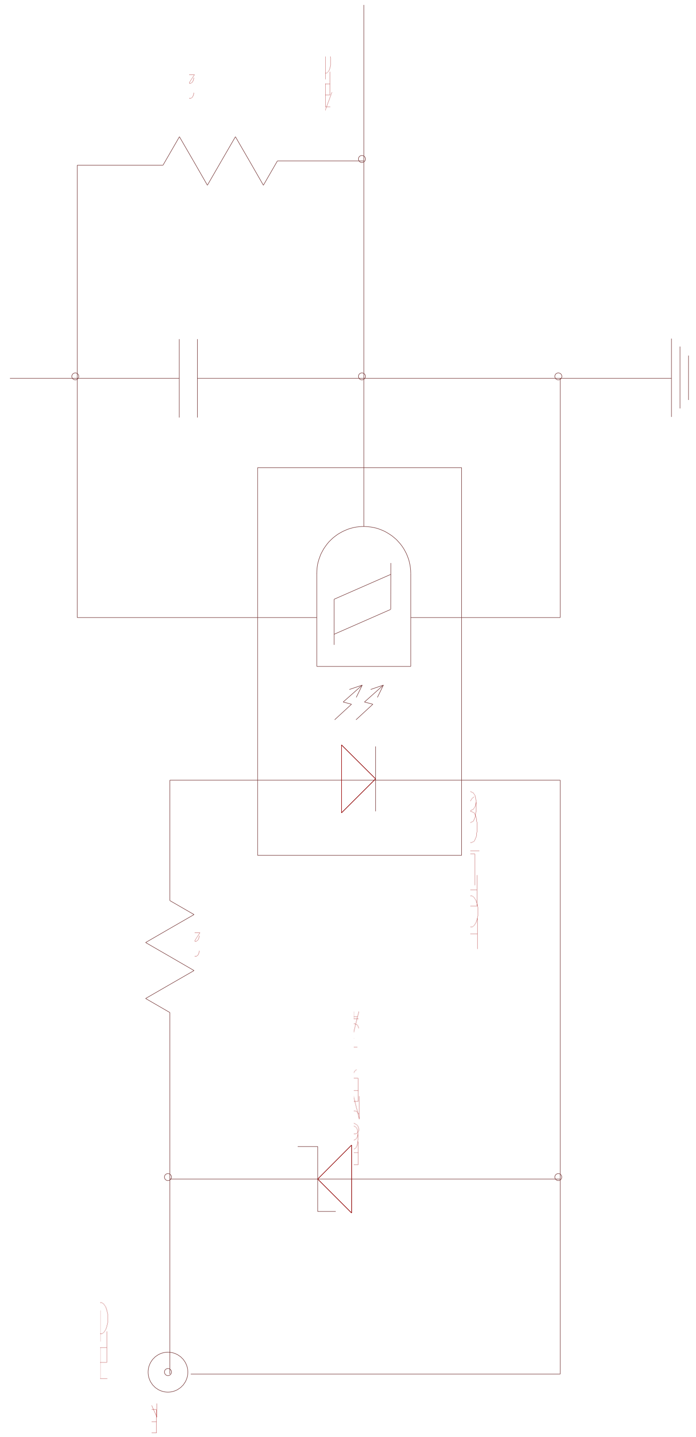


Figure A.1 Trigger Input Circuit

APPENDIX B – DETECTOR WINDOW REMOVAL AND INSTALLATION

The window on the Pyroelectric detector is removable to allow the Pyrocam to be optimized for various wavelengths of light.

Observe the following precautions:

- With the window removed, the detector is vulnerable to damage. Damage can be caused by objects striking the detector, by particles getting inside the package, or by ESD.
- Installation of a window can cause its own problems if not properly done. The clearance between the chopper blade and the window is very small. If the reinstalled window sits up higher than it should, the chopper blade may collide with the window causing considerable damage to both the window and the chopper.
- All removal and Installation of windows should be done in a clean room if possible. If one is not available, use the cleanest area possible.

CAUTION
Electrostatic Discharge can result in permanent damage to electronic equipment. Always ground yourself by touching the system cabinet before beginning the following procedure. We strongly recommend using an anti-static wrist strap attached to earth ground.

STEP 1. Remove the front cover by removing the four (4) screws as shown in Figure B.1.

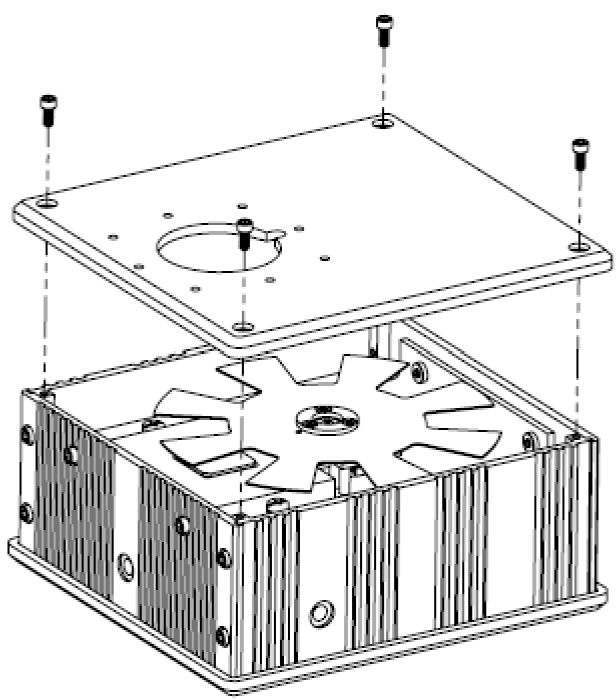


Figure B.1 Remove Front Cover

STEP 2. Remove the chopper blade by removing the three (3) screws as shown in Figure B.2. Be careful not to apply downward pressure to the screws when removing them as it could cause the chopper mount to slip out of alignment and potentially damage the window or encoder. Also be careful not to damage the chopper while removing it.

> ***CAUTION***
>
> *Do not bend or twist the chopper blade. A bent or twisted blade can cause significant damage to the window, the array, the blade itself, and various other components.*

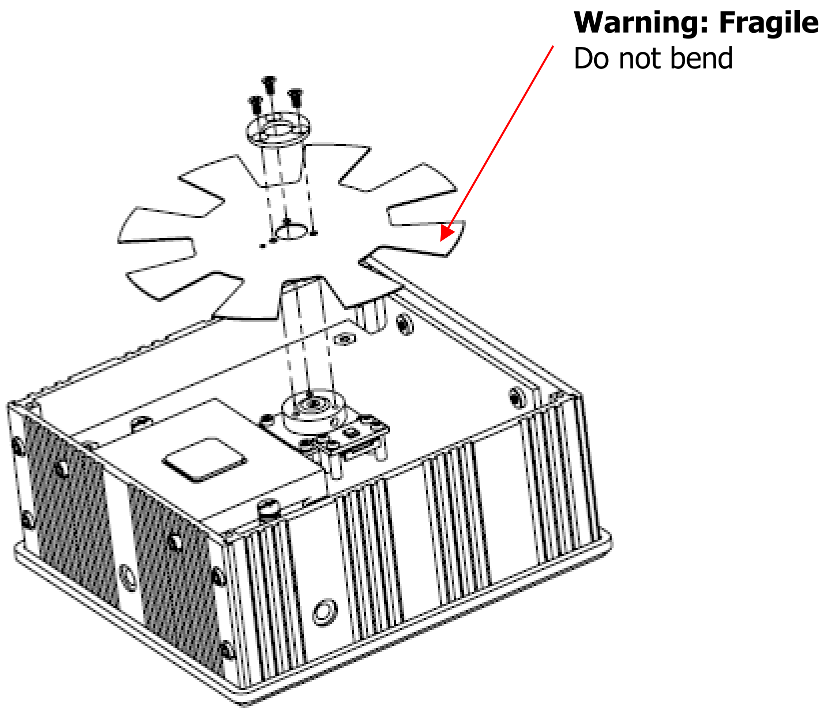


Figure B.2 Remove Chopper Blade

> **Chopper Blade reinstallation Note:**
>
> When reinstalling the chopper blade, make sure the encoder is facing down.
>
> After installing the chopper blade, give it a gentle spin to make sure that it does not come into contact with the new window, the encoder, or anything else that might impede its normal operation.
>
> The chopper blade will nominally fly 1 to 2mm above the encoder.

STEP 3. Disengage the two screws securing the window bezel to the motor plate as shown in Figure B.3.

Caution: Use great care to insure that the bezel does not slip or detach prematurely. If it contacts the sensor, damage to the sensor is very likely to occur.

STEP 4. **Carefully** lift off the window assembly. Be extremely careful not to cause damage or allow contaminates into the detector package.

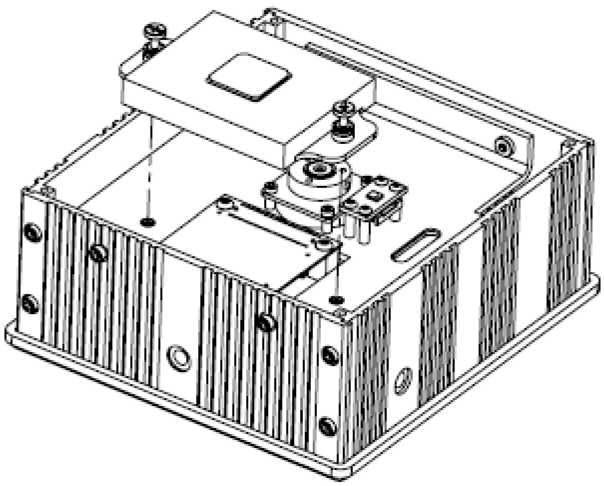


Figure B.3 Remove Window Assembly

Reverse the above procedure to install a new window assembly.

APPENDIX C – BAD PIXEL CORRECTION

Bad Pixel Correction Overview

This procedure will assume that the user is familiar with the operation of the Pyrocam. This procedure will outline how to go about locating a bad pixel, marking a pixel for correction, and downloading an updated bad pixel map to the Pyrocam. This map will be permanently stored in the Pyrocam's flash memory. How to save the map to a file is also explained.

Pulsed and Chopped

The following procedure is common for both Chopped and Pulsed operating modes. However, the Pyrocam stores separate bad pixel maps, one for Chopped mode and one for Pulsed mode. The map being loaded or saved is based on the setting of the **Chopped** / **Pulsed** selector. Only one mode can be in effect at a time.

What is a bad pixel?

A bad pixel falls primarily into 3 categories. They are:

- A pixel that under responds to radiant energy
- A pixel that over responds to radiant energy
- A pixel whose response is intermittent

Good Neighbor Policy

Bad pixels can occur singly or they can occur in groups, often referred to as clusters. Bad pixels are most successfully repaired when they have a number of good neighbors, where a neighbor is any adjacent pixel (horizontally, vertically, or diagonally) that operates normally. The more good neighbors there are, the cleaner the correction will appear. While marking pixels for repair, it is a good idea to try and keep at least one good neighbor adjacent to every marked pixel.

Factory Map Files

Every Pyrocam that is produced will have two factory installed bad pixel maps stored in its flash memory; one for Chopped mode and one for Pulsed mode. These factory stored maps form the starting point from which additional bad pixels can be added. Spiricon will also provide you with a pair of files that contain these maps upon request. These files form a backup source in case you accidentally delete or corrupt one or more of the original maps from the Flash memory. The backup files can be obtained by contacting Spiricon Service department. The backup files are named:

- ~<serial_number>.py4bpc (for chopped mode)
- ~<serial_number>.py4bpp (for pulsed mode)

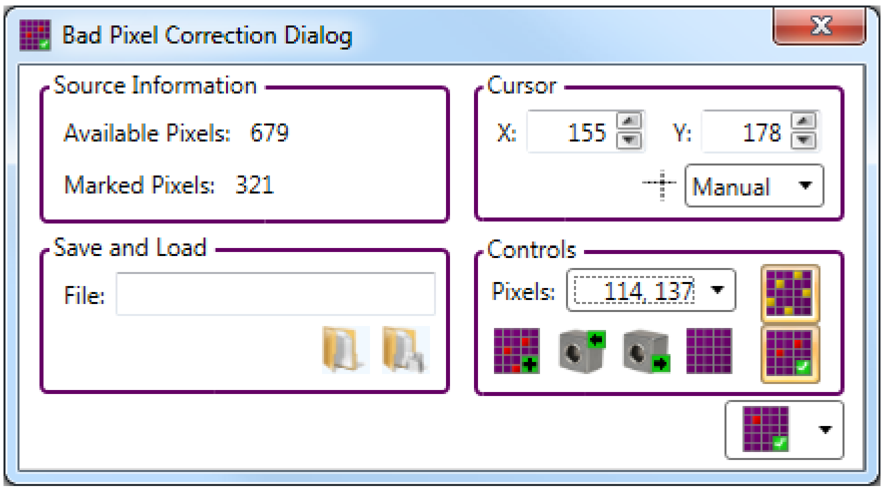
Where <serial_number> is the 5 digit serial number of the applicable Pyrocam and the ~ symbol indicates that these files are write protected to prevent accidental deletion or corruption.

Bad Pixel Correction Procedure

Before beginning a bad pixel correction process, setup the Pyrocam to operate and provide a reasonably bright source of illumination. Laser beams of the correct wavelength make good illuminators. It is also necessary to be able to translate the illuminated spot around the detector array in search of the defective pixels. Don't forget to **Calibrate/Ultracal** the Pyrocam.

Open Utilities

With the Pyrocam operating as described above, click on the **Bad Pixel Correction** expansion button to access the bad pixel correction tools as shown below.



Doing this will cause the following events to occur:

- The **Bad Pixel Correction Dialog** window will open.
- A live image will appear in the 2D BeamGage display window.

Note that a description of the Bad Pixel Correction tools is described in section 3.2.

Step by Step

STEP 1. Click **Start** in BeamGage to collect live frames of data and translate the laser spot around the detector, watching for pixels that appear to meet the bad pixel criteria.

STEP 2. When a bad pixel is found, click **Stop** to pause the live image. All of the previously marked bad pixels will be marked in YELLOW.

STEP 3. Use the mouse to center the cursor on the bad pixel. Observe the horizontal and vertical profile displays. When properly centered, the defective pixel should be clearly visible in both of the profiles. **Figure C.1** shows an example of a bad pixel centered in the cursor, with a few more nearby.

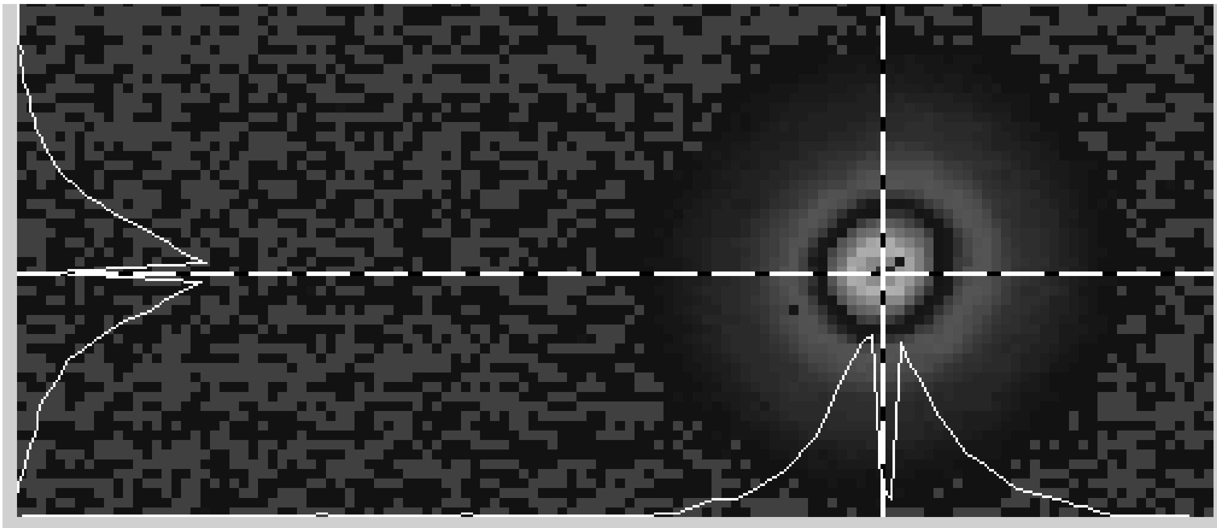


Figure C.1: A Bad Pixel Centered in the Cursors

STEP 4. Click **Add Pixel to List** to mark the newly identified bad pixel. Observe that the pixel turns YELLOW, the "Available Pixels" counter decreases by one, and the "Marked Pixels" counter will have increased by one.

NOTE: *If you accidentally mark the wrong pixel, select the unwanted pixel from the **Pixel List** and click **Remove Pixel from List**.*

If more pixels need correction, repeat Steps 1 through 4 until all bad pixels are located and marked. If not, proceed to Step 5.

STEP 5. To check the effects of the bad pixel mapping, disable the **Bad Pixel Correction Map** button and enable **Software Bad Pixel Correction**. All of the pixels marked as bad will now appear corrected. Translate the laser around the detector and check the correction effects. If additional bad pixel mapping is required, disable **Software Bad Pixel Correction** and return to Step 1. If all appears well, proceed to Step 6.

STEP 6. To send the new bad pixel map to the Pyrocam Flash memory, click on the **Write Pixel List** button. The mouse pointer will become an hourglass while the new map is programmed into the Pyrocam. When it returns to an arrow, the Flash programming has completed. Note: With small maps this happens rather quickly.

STEP 7. If you want to save your new bad pixel map to a file (highly recommended), enter a file name in the **Save and Load** section and click the **Save** button. A standard file-naming window will appear. Make sure the file name is correct, navigate to the desired save location, and click **Save**.

STEP 8. Close the **Bad Pixel Correction Dialog** window to end the bad pixel mapping and correction process.

STEP 9. To check the effects of the updated bad pixel map, turn on bad pixel correction in the Pyrocam by clicking on the **Bad Pixel Correction** button. Observe the effects of the bad pixel correction in the 2D beam display. If all went according to plan, the displayed image should show no visual indications of defective pixels.

Turn it On

In general, you will always operate the Pyrocam with bad pixel correction turned ON. The default setting of the bad pixel correction control is ON, and will remain so unless you override it in a saved setup.

APPENDIX D – GAIN CORRECTION

Gain Correction Overview

This procedure will assume that the user is familiar with the operation of the Pyrocam. This procedure will outline how to go about creating a gain correction table for downloading to the Pyrocam. This table will be permanently stored in your Pyrocam's flash memory. How to save the table to a file is also described.

Pulsed and Chopped

The following procedure is common for both Chopped and Pulsed operating modes. However, the Pyrocam can store separate gain correction tables, one for Chopped mode and one for Pulsed mode. The table being loaded or saved is based on the setting of the **Chopped** / **Pulsed** selector. Only one mode can be in effect at a time.

What is Gain Correction?

A gain correction table is a list of correction factors for each of the 25,600 pixels that form the Pyrocam imager array. The object of this table is to cancel out local response variations in the detector array, yielding a more uniform response overall. Gain correction table factors are limited to a range of 0.50 to 2.00. Thus pixels whose response is less than ½ of the mean response cannot be successfully gain corrected. Such pixels should be dealt with using Bad Pixel Correction. In general, pixels that deviate significantly from the mean response should be treated as bad pixels. See APPENDIX C.

NOTE: *The relationship between bad pixel correction and gain correction is important to understand. Bad pixel correction is usually turned on. Bad pixel correction has a lesser impact on overall camera throughput performance than gain correction does. This is because bad pixel correction deals with a small number of pixels, while gain correction affects every pixel. In pulsed mode (above ~35Hz) you will see a slowdown in camera frame rate output, especially at the higher pulse rates.*

Setup

Performing an accurate gain correction requires the detector to be uniformly illuminated at a relatively high level of intensity. If such a source of illumination is not available, it is best to not attempt to build a gain correction table. If this is the case, results will probably be worse than the normal detector's non-uniformity.

Factory Gain Correction Files

Most Pyrocams will come with a factory installed chopped mode gain correction table stored in its Flash memory. However, no pulsed mode gain correction table is supplied. This is because the gain correction affect is dependent on pulse width and pulse rate timing. If a pulsed gain correction file is supplied, it will be a null file, meaning it contains a gain correction table that tells the Pyrocam that it is not fitted with a gain correction table. If the null file is downloaded to the Pyrocam, the **Gain Correction** on/off button will appear disabled (gray), meaning the Pyrocam has no gain correction table loaded.

Spiricon will also provide you with a pair of files that contain these tables upon request. These files form a backup source in case you accidentally load a bad gain correction table into your Pyrocam. They can be a source of the original valid table to restore to the Flash memory. The backup files are named:

- ~<serial_number>.py4gcc (for chopped mode)
- ~<serial_number>.py4gcp (for pulsed mode)

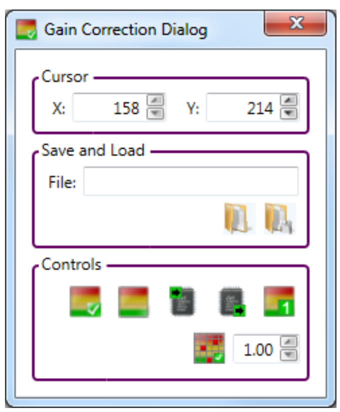
Where <serial_number> is the 5 digit serial number of the applicable Pyrocam and the ~ symbol indicates that these files are write protected to prevent accidental deletion or corruption.

Gain Correction Procedure

Before beginning a gain correction process, setup the Pyrocam to operate and provide a reasonably bright and uniform source of illumination. By "reasonably bright" we recommend a source that can drive the output intensity to at least 20% of its dynamic range with the gain set to a low setting. Don't forget to **Calibrate/Ultracal** the Pyrocam.

Open Utilities

With the Pyrocam operating as described above, click on the **Gain Correction** expansion button to access the gain correction tools as shown below.



Doing this will cause the following events to occur:

- The **Gain Correction Dialog** window will open.
- A live image will appear in the 2D BeamGage display window.
- A previously loaded gain correction table (if any) will download from the Pyrocam.

Step by Step

STEP 1. Verify that the displayed image is uniformly illuminating the detector array. Then click on the **Create Gain Table** button.

STEP 2. It can take a few seconds to compute the entire gain correction table, longer if using a very slow trigger rate to the Pyrocam. The lower status bar will indicate when the process in completed.

STEP 3. Check the effect of the gain correction operation by enabling **Software Gain Correction**. The displayed image should appear very uniformly illuminated, except for any bad pixels that may be present. Do not worry about these pixels, as the bad pixel correction map will deal with them.

NOTE: *If you want to make sure that all the bad pixels you see are marked for repair, follow the directions in APPENDIX C.*

STEP 4. To send the new gain correction table to the Pyrocam Flash memory, click on the **Write Flash** button. The mouse pointer will become an hourglass while the new table is programmed into the Pyrocam. When it returns to an arrow, the Flash programming has completed.

STEP 5. To save the new gain correction table to a file (highly recommended), enter a file name in the **Save and Load** section and click the **Save** button. A standard file-naming window will appear. Make sure the file name is correct, navigate to the desired save location, and click **Save**.

STEP 6. Close the **Gain Correction Dialog** window to end the gain correction process.

STEP 7. To check the effects of the updated gain correction table, turn on both bad pixel and gain correction in the Pyrocam by clicking on the **Bad Pixel Correction** button and the **Gain Correction** button. Observe the effects of the corrections in the 2D beam display. If all went according to plan, the displayed image should show no visual indications of defective pixels and show a uniform illumination.

APPENDIX E – PYROCAM MODEL NUMBERS AND ACCESSORIES

Pyrocam IIIHR Models

P/N	Model	Description
SP90364	PY-III-HR-C-A	Pyrocam IIIHR pulsed/chopped

Pyrocam IIIHR Windows

P/N	Model	Description
SP90365	PY-III-HR-W-BK7-1.064	Pyrocam IIIHR window assembly, BK7, A/R coated for 1.064µm
SP90366	PY-III-HR-W-SI-1.05-2.5	Pyrocam IIIHR window assembly, Si, A/R coated for 1.05 to 2.5µm
SP90367	PY-III-HR-W-SI-2.5-4	Pyrocam IIIHR window assembly, Si, A/R coated for 2.5 to 4µm
SP90368	PY-III-HR-W-GE-3-5.5	Pyrocam IIIHR window assembly, Ge, A/R coated for 3 to 5.5µm
SP90369	PY-III-HR-W-GE-10.6	Pyrocam IIIHR window assembly, Ge, A/R coated for 10.6µm
SP90370	PY-III-HR-W-GE-8-12	Pyrocam IIIHR window assembly, Ge, A/R coated for 8 to 12µm
SP90371	PY-III-HR-W-ZNSE-10.6	Pyrocam IIIHR window assembly, ZnSe, A/R coated for 10.6µm
SP90372	PY-III-HR-W-ZNSE-2-5	Pyrocam IIIHR window assembly, ZnSe, A/R coated for 2 to 5µm
SP90373	PY-III-HR-W-BAF2-Uncoated	Pyrocam IIIHR window assembly, BaF2 uncoated for 193 to 10µm
SP90374	PY-III-HR-W-POLY-THZ	Pyrocam IIIHR window assembly, LDPE, uncoated for Terahertz wavelengths

APPENDIX F – TABLE OF FEATURES

The Pyrocam contains hundreds of features. All of the features, except for those identified as read-only, can be changed by any program that communicates with a GenICam compliant camera. However, only a very small subset of Pyrocam features should be changed by the normal user. Below is a list of the only features that should be changed and read-only features that could be useful. We can provide support only for the features in this list. Changing any other feature will cause the Pyrocam to misbehave and may cause it to stop working.

Group	Feature Name	*see below	Description Value	Type	Value or Range or Default
Device Control					
	DeviceVendorName	RO	Name of the manufacturer of the device.	string[32]	Spiricon
	DeviceModelName	RO	Model of the device.	string[32]	Pyrocam_III_HR
	DeviceVersion	RO	Version of the device interface. (this is not the firmware version)	string[32]	1.00.00.01
	DeviceID	RO	Device identifier (serial number)	string[16]	
	DeviceScanType	RO	Scan type of the sensor.	enum	Linescan
	DeviceReset	WO	Resets the device to its power up state.	command	
ImageFormatControl					
	SensorWidth	RO	Effective width of the sensor in pixels.	uint	336
	SensorHeight	RO	Effective height of the sensor in pixels.	uint	328
	WidthMax	RO	Maximum width (in pixels) of the image.	uint	320
	HeightMax	RO	Maximum height (in pixels) of the image.	uint	320
	Width	RO	Width of the Image provided by the device (in pixels).	uint	320
	Height	RO	Height of the Image provided by the device (in pixels).	uint	320
	PixelFormat	RO	Format of the pixel to use for acquisition.	enum	Mono 16
Acquisition Control					
	AcquisitionMode	RO	Sets the acquisition mode of the device	enum	Continuous
	AcquisitionStart	WO	Starts the acquisition of the device	command	
	AcquisitionStop	WO	Stops the acquisition of the device	command	
	ExposureTimeRaw	RW	Sets the Exposure time (in microseconds)	uint	1 – 40000

AnalogControl					
	Gain	RW	Controls the selected gain as an absolute physical value.	float	1.0 - 8.0
	GainRaw	RW	Controls the selected gain as a raw integer value	uint	0 = 1.00 1 = 1.14 2 = 1.33 3 = 1.60 4 = 2.00 5 = 2.67 6 = 4.00 7 = 8.00
CustomFeatures					
	Calibrate	RW	Adjusts black level then collects calibrate subtraction frame. Set TRUE to initiate calibration. Set FALSE to cancel. Camera resets to FALSE when calibration is finished.	bool	False
	PixelHSize	RO	Effective horizontal pixel pitch in microns.	float	80.0
	PixelVSize	RO	Effective vertical pixel pitch in microns.	float	80.0
	CameraStatus	RO	Bit flag indicating current camera status #define STATUS_BUSY 0x0001 #define STATUS_CALIBRATE 0x0002 #define STATUS_VALID_FLASH_PULSE_BADPIX 0x1000 #define STATUS_VALID_FLASH_CHOP_BADPIX 0x2000 #define STATUS_VALID_FLASH_PULSE_GAINFRAME 0x4000 #define STATUS_VALID_FLASH_CHOP_GAINFRAME 0x8000	uint	0
	TriggerMethod	RW	Pulse or Chop	enum	Pulse
	PulseMode	RO	Pulse Mode - Single Shot or Continuous	enum	SingleShot
	PreTrigger	RW	Start array scan PreTrigger microseconds before (negative) or after (positive) the incoming trigger	uint	-3000 to 3000
	ChopperSpeed	RW	Selects the internal chopper speed	enum	ChopperSpeed50
	BadPixCorrection	RW	Enables and disables Bad Pixel Correction inside the camera.	bool	True

	GainCorrection	RW	Enables and disables Gain Correction inside the camera.	bool	False
	TriggerPeriod	RO	Number of microseconds between triggers.	uint	
	SkippedTriggers	RO	Number of triggers skipped between frame capture.	uint	
	FirmwareVersion	RO	Firmware version encoded as hex number 0xMMmmbbrr where: MM = major version mm = minor version bb = build number rr = revision	uint	0x01000001
	FPGAChecksum	RO	Simple checksum of FPGA stored in the flash	uint	
	HardwareRevision	RO	Hardware Revision	enum	A
	MaxGain	RO	Maximum allowable Gain value for this camera	float	1.0 – 8.0

* RO = Read-Only, RW = Read/Write, WO = Write-Only