

# CHRONOS 1.4

High-Speed Camera

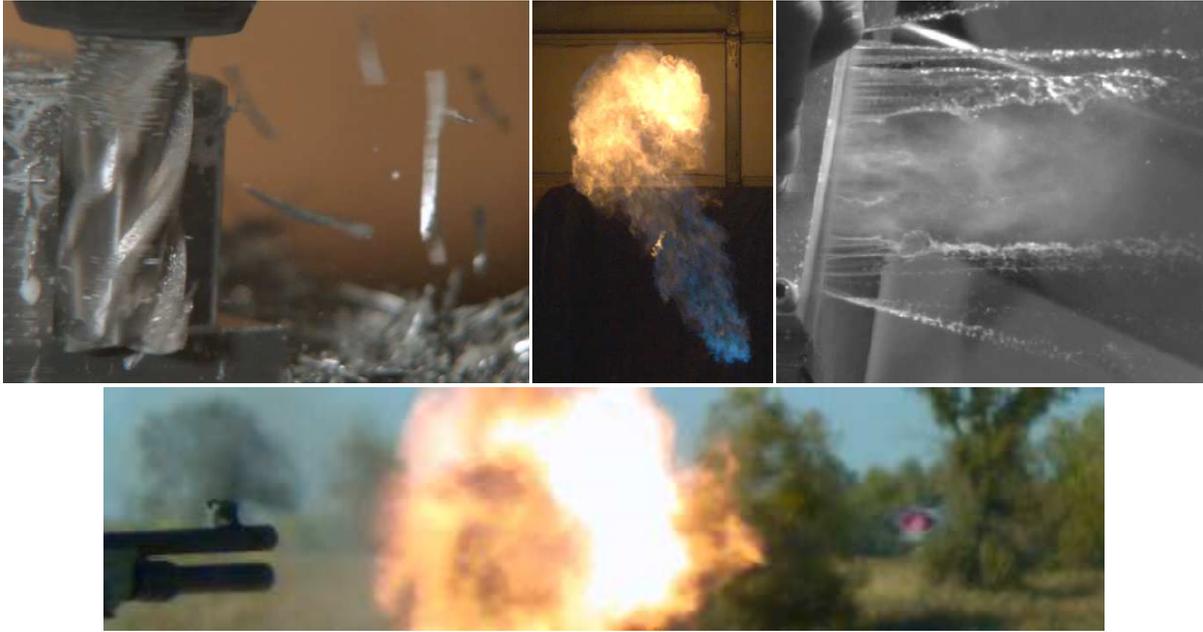


## User Manual

for

## Software v0.2

Document Rev 3



Thank you for choosing the Chronos 1.4 High Speed camera! For whatever your intended use, this guide is designed to aid you in operation and troubleshooting of the camera. Kron Technologies also advises you to read and review the Terms of Sale and Warranty in addition to reading this document. This document is not considered the Terms of Sale or Warranty. This manual's purpose is to be instruction for the proper use of the Chronos 1.4 and its accessories. If there are any questions about this document, Terms of Sale, or Warranty, please contact [info@krontech.ca](mailto:info@krontech.ca). If there are any concerns about hardware, software or special instruction for the Chronos 1.4 and its accessories, please contact [support@krontech.ca](mailto:support@krontech.ca).

The team here at Kron Technologies wishes you all the best of luck in your research, experimentation or just plain fun with the Chronos 1.4. This camera was designed with the intent to be accessible to everyone. We encourage you to share a hacking night with some friends and please, send us a video. Kron Technologies founder David Kronstein started the company in the spirit of "If I can't buy it, I'll make it". And we here are excited to see what you and the rest of the Chronos community can create. Go forth and capture every second possible on the Chronos 1.4!

A special thanks to all of our (very patient) Kickstarter backers and preorder customers! Without you, this camera would never have been possible. Also thanks to Loial, Jax, Foobar and Oak for making sure everything is ready for production, and Joel and Jack for making an awesome Kickstarter video.

*David Kronstein*

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## Getting Support

You can contact Kron Technologies for support setting up and using your Chronos 1.4 camera.

The User Forum is a great way to share questions with other Chronos users, as well as get support directly from Kron Technologies staff. The answer to your question may already be there, use the search function on the forum to search for keywords relating to your question or issue.

User Forum: [forum.krontech.ca](http://forum.krontech.ca)  
Email: [support@krontech.ca](mailto:support@krontech.ca)

## Quick Start

So you just got a cool new high-speed camera. Now what? This Quick Start guide gives you a crash course to get you up and running with your new camera.

**IMPORTANT** - The camera ships with a CS-C adapter ring installed, as well as a dust cap. Be sure not to accidentally remove the CS-C adapter when removing the cap. The CS-C ring is shown below.



Figure 1 - CS-C adapter

## Unboxing

Unpack the camera and accessories, and check that all ordered accessories are included. Notify Kron Technologies immediately if anything is missing or damaged.

### What's included?

The following items are included as standard with all cameras:

- Chronos 1.4 camera
- EN-EL4a battery
- 19V 40W AC adapter
- AC power cord (plug depends on region)
- CS-C adapter ring (installed on camera)
- C mount body cap (installed on camera)
- 2mm Allen wrench
- User Manual

Lenses and other accessories may also be included if ordered. Check your invoice or sales receipt to know exactly what should be included.

## Set up

- Insert the battery into the camera's battery compartment. To open the door, push the latch towards the back of the camera (LCD side) with your fingernail, and pull up.
- Close the battery door, ensuring the latch is pushed back while closing. Release the latch when the door is nearly flat against the case, and firmly push the door closed until the latch clicks in fully
- Remove the body cap and install the lens by screwing it onto the mount. For the Computar 12.5-75mm zoom lens, the CS-C adapter needs to be left on. If you're using another lens, check which type it is to determine whether or not the CS-C adapter is needed
- Store the lens and body caps in a safe place. Make sure not to forget where you left them

## Powering up, charging, and powering down

It's recommended to fully charge a new battery before running the camera on battery power. Let the battery charge at least until 80% (LED flashes green/orange). This should take less than 2 hours.

- Plug the AC adapter into mains power and into the camera. The LED on the top of the camera should illuminate to indicate external power is present.
- The camera behaves just like your laptop, it charges whenever plugged in, and you can use it while charging. The battery does not need to be installed to run the camera on external power.
- Press and release the power button to power up the camera. It will take approximately 30 seconds to boot up and show the menu and image
- To power down the camera, press the power button for one second, then release. A minimum press of 0.5 seconds is required to avoid accidental shut down. Do not continue to hold the button; holding it for four seconds or more forces a hard power down. Just like your computer, the camera needs to shut down properly to avoid potential problems with the operating system. **Don't force a hard power down unless the camera is unresponsive and will not power down normally.**

## Taking Shots

1. Power up the camera
2. Set resolution in Record Settings - Camera powers up at 1280x1024  
*Tip - Don't be afraid to turn the resolution down to get a higher frame rate. Frame rate is resolution too - temporal resolution. Horizontal resolution below 336 pixels does not increase speed.*
3. (Optional) - For best quality, do a Black Calibration (Black Cal). Close the iris or cap the lens, then tap Black Cal. Only required once after changing resolutions.
4. (Optional, for color cameras) - Set white balance. Place a white card at the center of the frame and tap White Balance.
5. Frame and focus. For best sharpness, use an iris of F/2 or above on the Computar 12.5-75mm lens.
6. Press record or click the red record button to start recording
7. Stop the camera after the event occurs, using either the red button on the camera, the Stop button on the menu, or the optional remote trigger switch.

## Playback

1. Tap Play to go to playback mode
2. Use the slider, jog wheel or forward/backwards play buttons to review the video. Click in and hold the jog wheel clicked while turning to go fast (40x faster than non-clicked).

## Saving

1. Ensure an SD card is in the camera. **You MUST use a Class 10 or faster SD card from a reputable manufacturer, otherwise frames may be dropped during save.** The card must be formatted FAT32.
2. (*Optional, highly recommended*) - Use Mark In and Mark Out to select a region to save. Position playback where you'd like saving to start and tap Mark In. Repeat using Mark Out for the location you'd like saving to end. Saving the entire buffer can take a long time, especially at low resolutions.
3. Press Save and wait for save to complete
4. If the video is extremely valuable (unable or expensive to recreate the shot), remove the SD card and use a PC to check that the video saved properly without dropped frames. This is especially important when using a new brand of SD card for the first time.

## Hardware Reference

### Hardware Overview

#### Back/Top

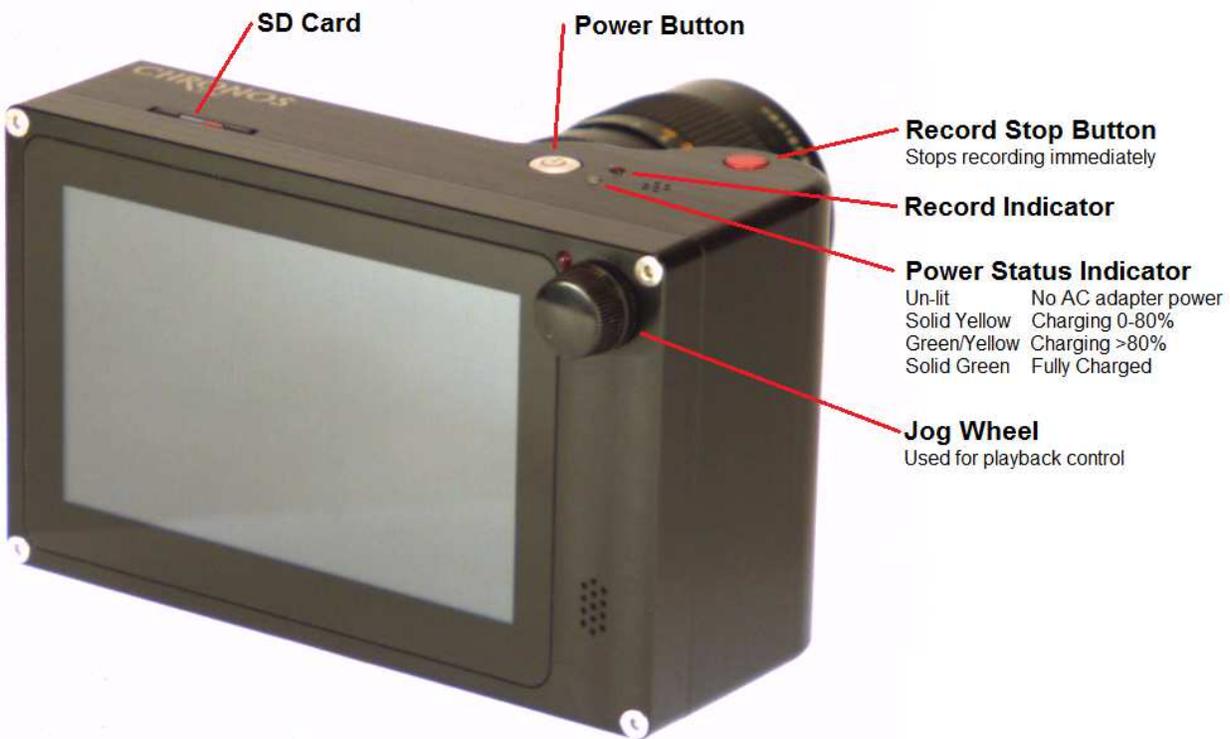


Figure 2 - Overview of camera (Back)

#### SD Card Slot

Use a **Class 10 or faster** card only

#### Power button

Click to turn on camera.

To shut down the camera, press the button for 1 second then release. Presses less than 0.5s will be ignored to reduce the chance of accidentally turning off the camera.

Holding for 4 seconds forces a hard power down. **Do this only if the camera software has crashed and won't respond.** Like a PC, the camera needs to shut down properly or file system damage may occur, requiring a reflash of the OS SD card.

#### Shutter Button

Starts and stops recording

#### Record Indicator

Illuminates to indicate the camera is currently recording

## Power Status Indicator

Indicates the presences of AC power and charge status of the battery

LED	Indication
Un-lit	No AC power connected
Solid Yellow	Charging, state of charge 0-80%
Green/Yellow alternating	Charging, state of charge > 80%
Green	AC connected, charge complete or no battery present

## Jog Wheel

Used for playback control. Moves playback 1 frame per detent (rotational click). Press and hold dial clicked in to move fast (40 frames per detent)

## Front/Side Connectors

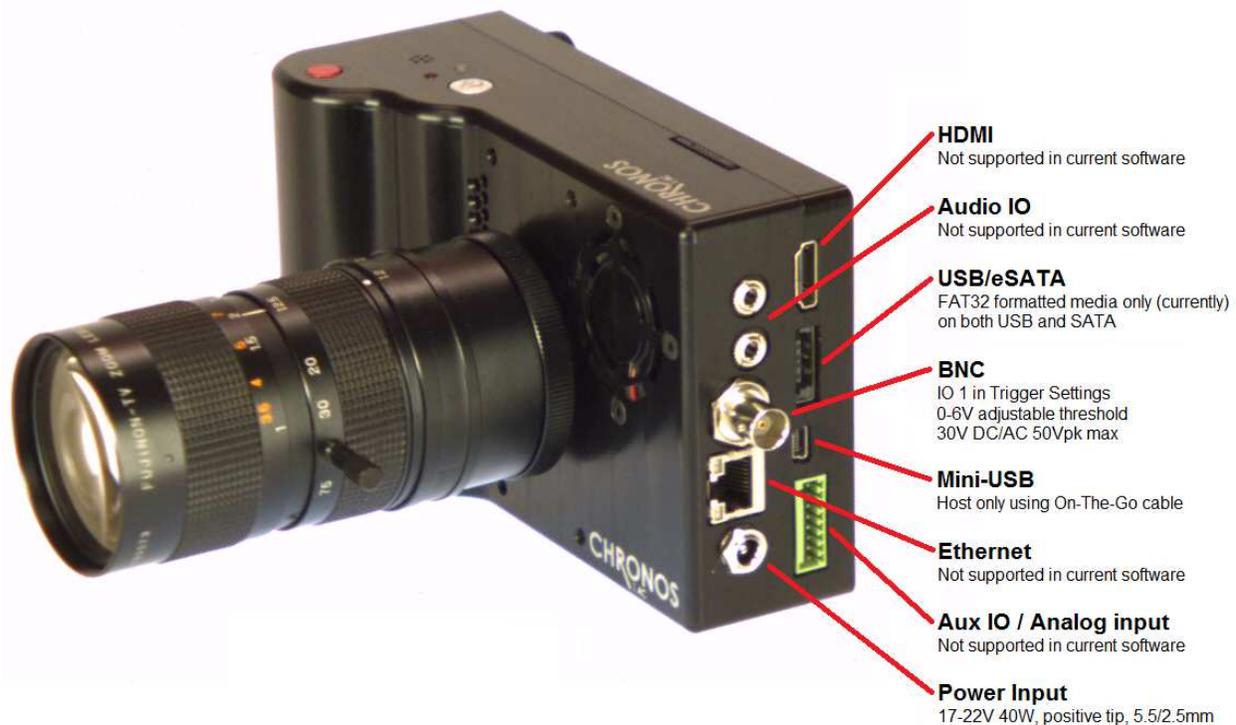


Figure 3 - Overview of camera (Front)

### Power Input

17-20V DC 40W, 5.5/2.5mm barrel jack, positive tip

### USB/eSATA

This port accepts both USB type A and eSATA devices. USB mass storage devices such as flash drives and hard drives can be connected to this port.

### Mini USB OTG

USB mass storage devices such as flash drives and hard drives can be connected using a Mini-B OTG cable.

**Aux IO**

Trigger and Analog inputs. Only trigger inputs are supported in the current software. The mating plug is Phoenix Contact part number 1881383.

Pinout:

Pin	Function
1	Analog In 1
2	Common
3	Analog In 2
4	Common
5	Trigger IO 2
6	Common
7	Isolated Trigger Input 3 (+)
8	Isolated Trigger Input 3 (-)

All Common pins are internally connected together and to the camera's power input ground and chassis ground. The included AC adapter internally connects common to mains earth ground as well.

**Ethernet**

Not supported in current software but the hardware is present in all production cameras. Please check back with Kron Technologies shortly for the latest software update for Ethernet support.

**HDMI**

Not supported in current software but the hardware is present in all production cameras. Please check back with Kron Technologies shortly for the latest software update for HDMI support.

**Audio IO**

Not supported in current software but the hardware is present in all production cameras. Please check back with Kron Technologies shortly for the latest software update for audio support.

**Lenses****Lens Mount**

Chronos 1.4 is natively a CS-mount camera. C-mount lenses can be used with the included adapter. Other lens types such as F, EF, and PL can be used with an appropriate adapter to convert them to C mount.

Common lenses available for the camera are listed below, along with the adapter required to use them

Lens	Lens mount	Adapter required
Computar 12.5-75mm f/1.2 Zoom	C	CS - C
Computar 12mm f/1.4 Prime	C	CS - C
6-60mm f/1.7 Zoom	CS	None
2.8-12mm f/1.4 Zoom	CS	None
Fujian 25mm f/1.4	C	CS - C
Fujian 35mm f/1.7	C	CS - C
Microscope lens	C	CS - C

Table 1 - Lenses, mounts and adapter requirements

## Lens Selection

Lenses vary in their image circle, that is, how large an image sensor they can cover. Chronos 1.4 uses a 2/3" image sensor (actual sensor dimensions are 8.45 x 6.76mm). Lenses designed for smaller sensors can be used, however the image will not cover the entire sensor. This is called vignetting and is visible as a black ring around the outside of the image frame.

## Backfocus

Backfocus controls how lenses focus, and must be set correctly for your lenses to focus properly. The camera is set from the factory for the Computar 12.5-75mm zoom lens, and this setting is generally correct for most other lenses, but if you are experiencing problems with focus, this is the first thing to check.

Backfocus itself is the distance between the lens mount flange and the image sensor.

## Backfocus Adjustment

To correctly set backfocus for your particular lens, follow these steps:

### Prime lenses (non-zoom)

1. Use a lens that has graduated focus (markings showing the focal distance). You cannot properly adjust backfocus on non-graduated-focus lenses
2. Set the lens to infinity focus
3. Loosen the backfocus lock screw on the bottom of the camera by about 1 turn using the included 2mm Allen key
4. Aim the camera at an object very far away, such as out a window at a distant tree
5. Rotate the entire lens allowing the CS ring to screw in or out. Do not adjust the focus ring on the lens. Adjust the rotation until best focus on a distant object is obtained
6. Tighten the backfocus lock screw finger tight.

### Zoom lenses (parfocal lenses only)

1. Zoom the lens into maximum zoom
2. Adjust for best focus on an object within the lenses normal focus range, perhaps a few meters away
3. Zoom the lens out
4. Loosen the backfocus lock screw on the bottom of the camera by about 1 turn using the included 2mm Allen key
5. Rotate the entire lens allowing the CS ring to screw in or out. Do not adjust the focus ring on the lens or any other lens controls. Adjust the rotation until best focus on the same object is obtained
6. Tighten the backfocus lock screw finger tight.
7. Repeat steps 1 to 6 until the lens is in focus both when zoomed in and when zoomed out, without adjusting the focus control while zooming.

## IR Filter

The color version of the camera comes with an IR cut filter for proper color reproduction. The monochrome version can also be ordered with the IR filter if desired. All the color pixels (red, green and blue) have some parasitic sensitivity to IR light, which will result in a washed out image, especially under daylight or incandescent lamps. The IR filter removes the invisible light that would cause the image to become washed out.

The Monochrome version benefits from the IR filter if recording objects that emit large amounts of IR light, such as glowing objects like sparks. The IR light will focus differently than visible light in most lenses, resulting in these objects being blurry. The IR filter removes the light that would cause this blurriness, resulting in sharper images at the penalty of reduced sensitivity.

## Removing/installing the IR filter

You can remove the IR filter for cleaning, and for special applications that require IR sensitivity. You can also add your own filter of any desired wavelength. The camera accepts 15x15mm square filters, of 1.1mm thickness.

To remove the filter:

1. Loosen the backfocus adjustment screw on the bottom of the camera about 1 turn using the included 2mm allen key.
2. Unscrew the CS ring from the camera
3. Using a 1.5mm Allen key (not included), remove the two screws that hold in the IR filter holder
4. Remove the IR filter holder using tweezers
5. Remove the IR filter. A vacuum pickup tool is best to avoid damage to the filter, but tweezers can be used if you are careful not to damage the filter. It is important that you remember which face of the filter faces out of the camera, as the filter has an optimum direction for light travel.
6. Reinstall the filter holder using the two screws
7. Store the IR in a manner that will avoid scratches, such as in a folded piece of paper
8. Reinstall the CS ring
9. Tighten the backfocus adjustment screw finger tight
10. Perform a backfocus adjustment. Reinstalling the CS ring to the same position it was originally in will not work, as the effective backfocus is changed by refraction in the IR filter glass.

The same steps above can be used to reinstall the IR filter.

## Trigger IO

Two trigger IO and one isolated trigger input are available on the camera.

### Trigger IO 1/2

These non-isolated IOs are referenced to the camera's power and chassis ground, and can provide either input functionality with selectable threshold (0-6.6V) or 5V TTL level output. These IOs are protected against damage when connected to voltages of 30V DC/AC RMS and +/- 50V peak.

The 20mA output drive is suitable to directly drive terminated coaxial cable, and will produce 1V into 50Ω, with rise and fall times time of (typically) 10ns or faster. Unterminated operation will result in a much slower fall time.

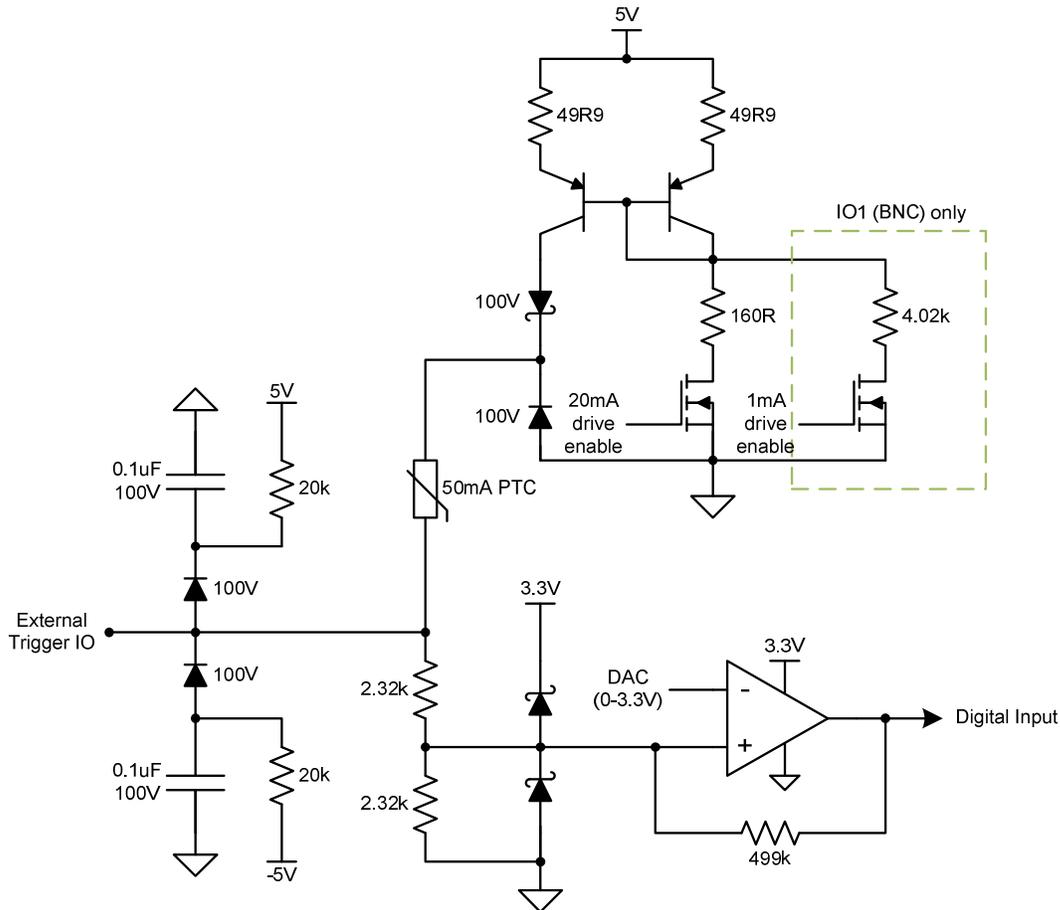


Figure 4 - Schematic of Trigger IO 1 and 2

### Trigger In 3

This input is isolated input via an optocoupler. A logic low input is a voltage from -30 to 1V, and a high level input is a voltage of 3 to 30V. Voltages between these ranges (1 to 3V) are undefined. This input has built-in resistors to correctly drive the optocoupler, and is protected from differential voltages up to 30V DC/RMS AC and +/- 50V peak.

Trigger In 3 is rated for SELV (safety extra low voltage) circuits only, up to a maximum common mode voltage of 60V above ground.

**DANGER:** The isolated input is not rated for safety isolation. Never use any of these inputs to connect directly to mains-referenced circuits. If triggering from AC mains is needed, external safety isolation (such as a transformer) is required.

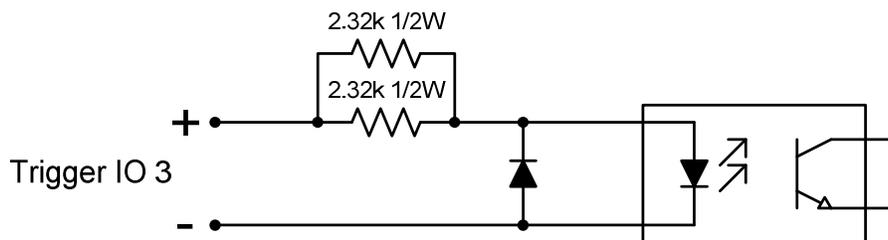


Figure 5 - Trigger IO 3 Schematic

## Storage devices

All storage devices must be formatted FAT32. No other filesystems have been tested, but EXT2, EXT3 and EXT4 may work. NTFS and exFAT support are planned for release in future software updates.

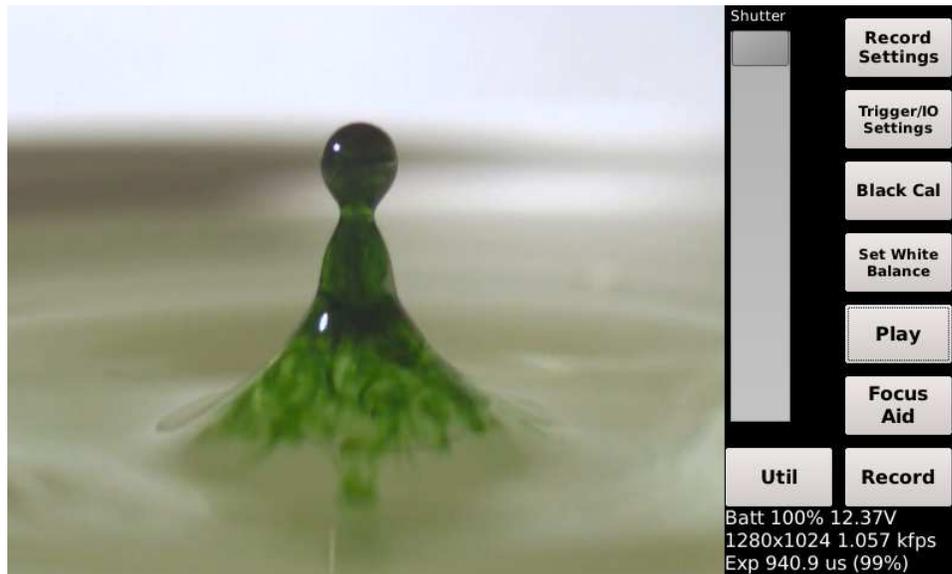
SD cards are recommended as storage devices rather than USB drives. Use only Class 10 or faster SD cards to ensure successful saving without dropped frames. Saving to USB is functional, however **many USB flash drives are not fast enough to save video without dropping frames**. USB external hard drives typically work well.

**When using a new storage device, always test it by making and saving a recording then playing it back on a PC. Problems typically show up as jumpiness or dropped frames.**

## Software Reference

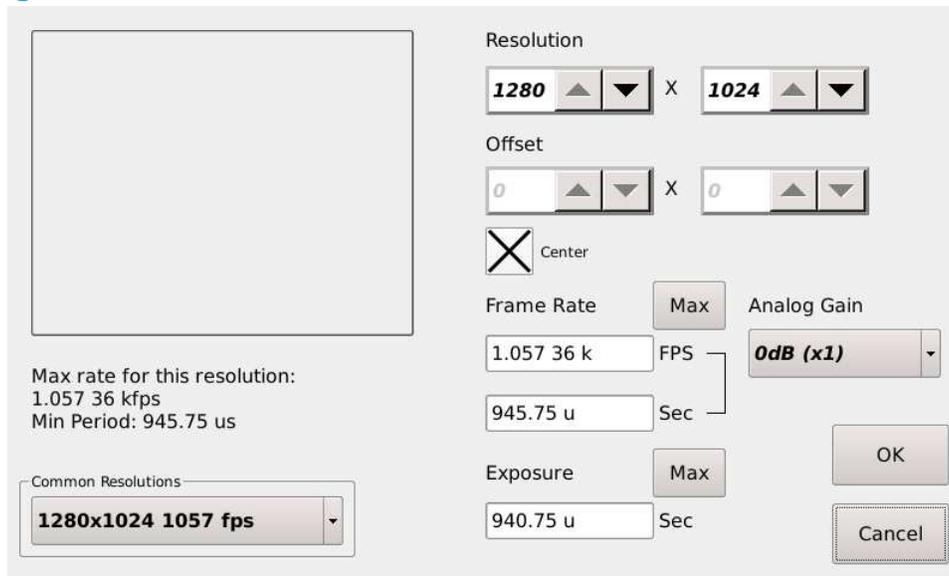
### Menu/screen overview

#### Main window



Button	Function
Record Settings	Shows the record settings window, which allows adjustment of resolution, frame rate, analog gain (ISO), and exposure.
Trigger Settings	Shows the Trigger Settings window, which allows selection of trigger/sync IO signals and trigger delay.
Black Cal	Performs a black level calibration. This increases image quality by ensuring that blacks appear black on the image. Each resolution has a separate black calibration. No light must hit the image sensor while this button is tapped.
White Balance (color cameras only)	Sets the white balance reference. The camera will sample the center of the image and adjust the white balance so that center point is white. You must place a white card covering the center of the image before activating White Balance.
Focus Aid	Enables/disables focus peaking, which highlights sharp edges with a (by default) Cyan color. This is used to make adjusting focus very easy. The sensitivity is adjustable from the Util menu.
Record (or Stop)	Starts and stops recording. Same as pressing the red Shutter Button.
Util	Shows the utility menu, which contains various functions such as clock, software update, and focus peaking/zebra controls.

Record Settings page



Control Function

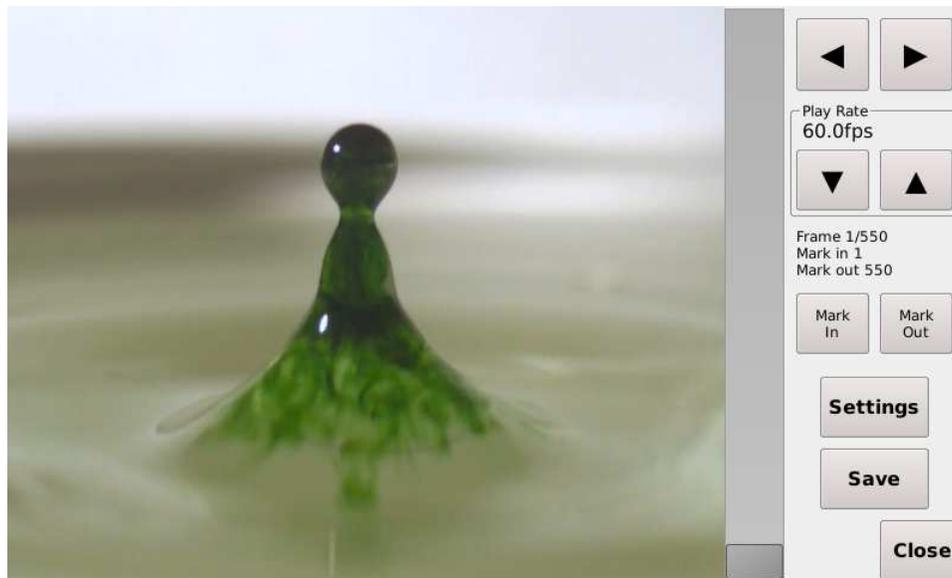
Resolution	Sets the record resolution, or ROI (Region of Interest) on the camera's image sensor. Adjustable in multiples of 16 pixels horizontally, 2 pixels vertically.																		
Offset	Adjusts the position of the top left of the ROI as an offset from the top left of the image sensor. When Center is checked, Offset is set automatically and cannot be adjusted. Adjustable in multiples of 16 pixels horizontally, 2 pixels vertically.																		
Center	When checked, the ROI is centered in the sensor full resolution.																		
Frame Rate	Sets the frame rate. Can be set as frame rate (FPS) or period (Sec) which is 1/FPS. Setting one will automatically update the other. Can be set to maximum by pressing Max.																		
Exposure	Sets the exposure (shutter speed) in seconds. Range is 1us up to slightly less than 1/FPS. Can be set to maximum by pressing Max.																		
Analog Gain	Adjusts the analog gain (ISO setting). A higher gain results in increased sensitivity (less lighting required), but increased image noise. For the best image quality, use the lowest gain possible and increase light level or aperture if more light is required.																		
	<table border="1"> <thead> <tr> <th>Gain</th> <th>Color ISO</th> <th>Mono ISO</th> </tr> </thead> <tbody> <tr> <td>0dB (1x)</td> <td>320</td> <td>740</td> </tr> <tr> <td>6dB (2x)</td> <td>640</td> <td>1480</td> </tr> <tr> <td>12dB (4x)</td> <td>1280</td> <td>2960</td> </tr> <tr> <td>18dB (8x)</td> <td>2560</td> <td>5920</td> </tr> <tr> <td>24dB (16x)</td> <td>5120</td> <td>11840</td> </tr> </tbody> </table>	Gain	Color ISO	Mono ISO	0dB (1x)	320	740	6dB (2x)	640	1480	12dB (4x)	1280	2960	18dB (8x)	2560	5920	24dB (16x)	5120	11840
Gain	Color ISO	Mono ISO																	
0dB (1x)	320	740																	
6dB (2x)	640	1480																	
12dB (4x)	1280	2960																	
18dB (8x)	2560	5920																	
24dB (16x)	5120	11840																	
Common Resolutions	Allows selection of commonly used resolutions from a list.																		
ROI Display	Shows the size and position of the ROI in relation to the sensor's full resolution. The outer box represents the sensor's 1280x1024 resolution, and the inner box represents the ROI.																		
Max Rate display	Shows the maximum frame rate and minimum period for the current resolution setting.																		
OK button	Applies changes and closes window.																		
Cancel button	Discards changes and closes window.																		

## Trigger/IO Settings page

## Control Function

Record End Trigger radio button	Sets function of IO to trigger input, allowing that input to be used to trigger the camera to stop recording.
Exposure Trigger radio button	Sets function of IO to triggered exposure input, allowing start of exposure to be controlled by the input. See Synchronizing to external sources.
Shutter Gating radio button	Sets function of IO to shutter gating input allowing image sensor shutter to be directly controlled by the input. See Synchronizing to external sources.
Frame Sync Output radio button	Sets IO function as frame sync output. Output will be active when shutter is open. Can be inverted with Invert checkbox under Frame Sync Output radio button.
Invert (Trigger Input)	Inverts the input level, trigger input will be sensitive to low level instead of high when checked.
Debounce	Enables a 10ms debounce on the input. The input is sampled at a period of 10ms, and an input is not taken as active unless measured active on two simultaneous samples. This is recommended when using a button or switch on the input to avoid glitches due to contact bounce.
Pullup checkboxes	Enables 1 or 20mA pullup on trigger input when checked.
None radio button	Disables the associated IO.
Threshold	Sets the input threshold voltage (in volts) for the IO. Range is 0 to 6.6V.
Trigger In (Input 3) checkbox	Enables input 3 for trigger input.
Input Status	Shows the current level of the 3 inputs after optional inversions are applied.
Trigger Delay	Specifies the delay in frames from trigger input becoming active to record stop.
Apply button	Applies IO settings but leaves window open.
OK button	Applies IO settings and closes window.
Cancel button	Discards changes and closes window.

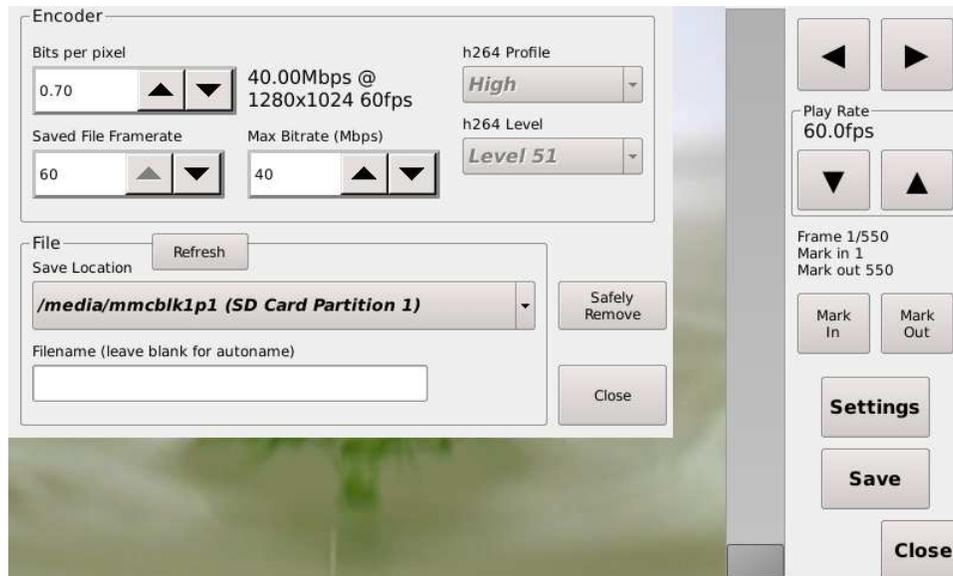
## Playback Mode



### Control Function

Control	Function
Playback Slider	Scroll bar controls playback position over the entire recording. <b>The bottom is the beginning of the buffer, the top is the end.</b>
Jogwheel (physical dial)	Turn to control playback. Clockwise moves playback forward one frame per detent, or 40 frames per detent when clicked down and held while turning.
Play forward/reverse	Plays back video in forward or reverse, at speed specified by Play Rate control.
Play Rate	Up/down arrow buttons increase or decrease playback rate when play buttons are pressed. Range: 4.6 to 960fps. This control does <b>NOT</b> affect the playback rate of saved video.
Frame/Mark indicators	Shows the current frame, number of frames recorded, and the current mark in and mark out frame positions.
Mark In/Mark Out buttons	Sets the mark in or mark out position to the current frame.
Settings button	Shows the Save Settings window.
Save button	Starts saving the video between the mark in and mark out points.
Close button	Returns to live video mode. This does not erase the recording; it will remain until a new recording is started.

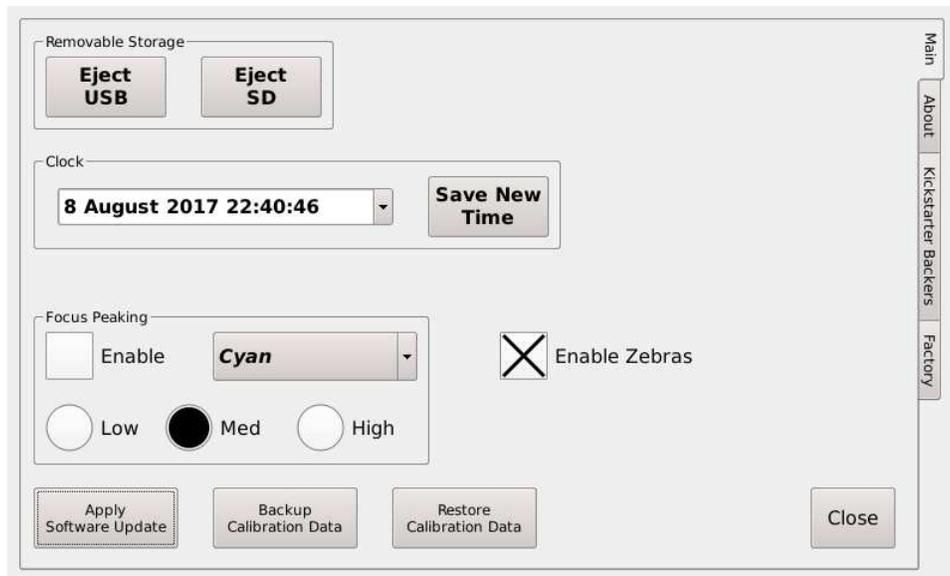
## Save Settings



### Control Function

Control	Function
Bits per pixel	Primary quality control for saved video. Resolution- and Frame rate-independent control of video bitrate. This sets the number of bits per pixel of encoded output video.
Max Bitrate	Sets a limit to the bitrate used by the encoder
Resultant bitrate	Shows the bitrate and frame rate calculated from the bits per pixel setting.
Saved File Framerate	Sets the frame rate for saved video files. This is currently limited to integers (whole numbers), so rates such as 59.94fps are not currently supported. These rates can be achieved by reinterpreting the frame rate in your video editor.
h264 profile	Sets the h264 encoding level. Disabled as some levels cause encoder to crash.
h264 Level	Sets the H264 encoding Level. Disabled as some levels cause encoder to crash.
Save Location	Selects the storage device for saved video. This list automatically refreshes, it may take several seconds for newly inserted devices to appear.
Filename	Sets the filename for saved video, on the device selected in Save Location. If this field is left blank the files will be autonamed vid_<date and time>.mp4
Safely Remove	Ejects the selected storage device, allowing you to safely remove it from the system.
Close button	Returns to Playback window (Settings are applied automatically as they are changed).

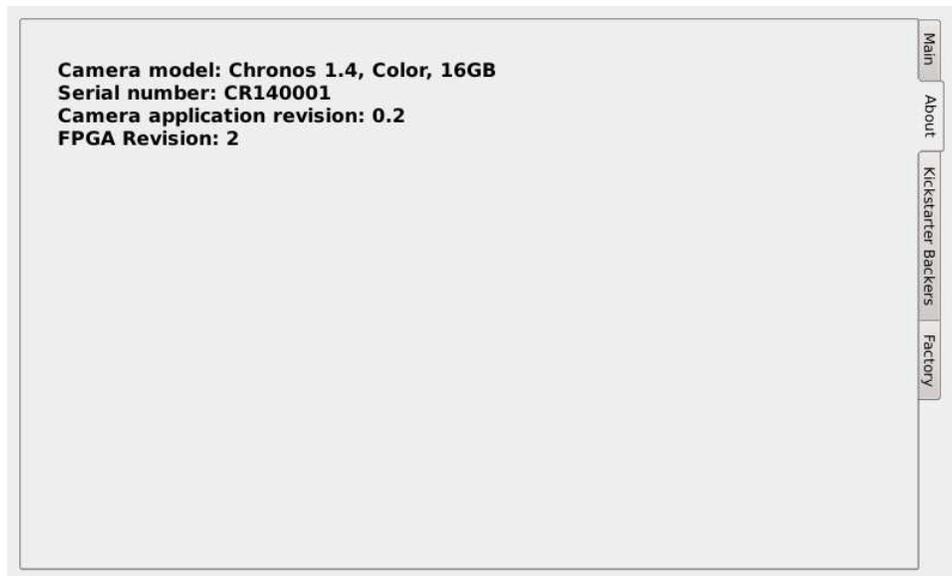
## Util page



## Control Function

Control	Function
Eject buttons	Ejects the selected storage device, allowing you to safely remove it from the system. Wait for the confirmation dialog to appear before removing the device.
Clock Setting	Allows you to adjust the camera's date and clock. Tap on the box until a cursor is visible, then you can use the arrow keys to select and adjust values, or type in numerical values.
Set New Time button	Applies the current time in the clock adjustment box to the camera's clock.
Focus Peaking Enable checkbox	Enables or disables focus peaking function which highlights sharp edges.
Focus peaking sensitivity radio buttons	These radio buttons select how sensitive the focus peaking algorithm is. Increased sensitivity will lead to more noise, but will pick up dark edges better. Lower sensitivity will allow more accurate focusing on bright edges.
Focus peaking color dropdown	Selects the color used to highlight edges.
Enable Zebras checkbox	Enables or disables the overexposure indicator which shows a rolling zebra line pattern on areas of the image that are clipped.
Apply Software Update button	Applies a software update from a USB drive. Follow instructions provided with the software update.
Backup Calibration Data button	Saves the camera's factory calibration data to a USB drive. It is recommended to do this and keep a copy in case the camera's OS SD card becomes corrupt and needs to be reflashed.
Restore Calibration data button	Restores the camera's factory calibration data from a USB drive.
About tab	Shows information about camera such as serial number and software version.
Kickstarter Backers tab	Lists all of the Chronos 1.4 Kickstarter project backers.
Close button	Returns to the Main window (Settings are applied automatically as they are changed).

## About Tab



Shows information about camera, such as model, serial number, and software version.

## Setting resolution and frame rate

Chronos 1.4 allows you to trade image resolution for frame rate. In many applications, temporal resolution (frame rate) is far more important than spatial resolution (image resolution). Don't be afraid to turn the resolution down!

Frame rates can be set on the record settings page. This page is shown below:

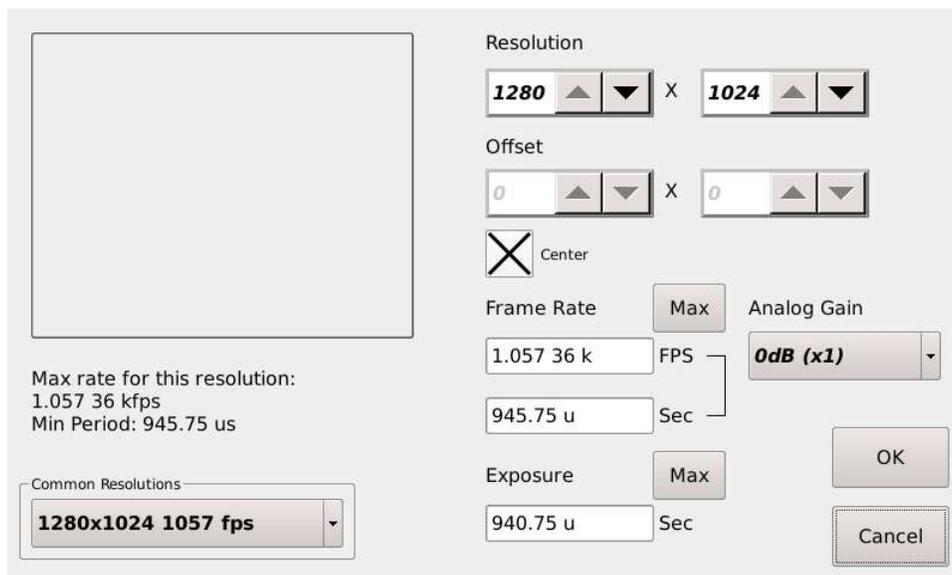


Figure 6 - Record Settings page

The image resolution can be adjusted in two ways. Common preset resolutions are available from the drop down menu on the bottom left. There are also direct controls of resolution at the top right. Resolution can be adjusted in increments of 16 pixels horizontally and 2 pixels vertically. Tap on the text box to enter a resolution using the keyboard, or use the up/down buttons to adjust in minimum increments. As the resolution is changed, the Region of Interest (ROI) display shows the resulting image size within the full 1280x1024 image sensor resolution. The maximum frame rate and minimum frame period is displayed under the ROI display.

Once the desired resolution is set, the frame rate can be adjusted anywhere from 0.025fps up to the maximum displayed under the ROI display. The Max buttons will set the resolution and exposure to their respective maximum values for the current resolution.

### Custom resolution calibration

When using resolutions other than those shown in the Common Resolutions dropdown box, it is very important to do a black calibration, as only the Common Resolutions are black calibrated at the factory. When a new (never before used on this camera) resolution is selected, a basic black calibration is done with the shutter at minimum. This allows a reasonable image display for immediate use, but a full black calibration is required for best quality.

### Black Calibration

For best image quality, the camera automatically subtracts a black reference image from all normal images during operation. This corrects for pixel offsets that occur on the camera's image sensor. This black reference is updated by doing a black calibration.

Black calibration is separate for each resolution and gain setting, ie. a black calibration done at 1280x1024 0dB gain does not apply to 1280x1024 6dB gain.

For best image quality, perform a black calibration:

- After changing the resolution, frame rate or shutter speed
- After the camera's temperature has changed significantly
- After the camera has reached a stable temperature

It is recommended to let the camera reach normal operating temperature before performing a black cal. Let the camera run for about 15 minutes to reach normal operating temperature.

### Performing Black Cal

Perform the black cal by either closing the iris fully, or, if the lens doesn't have an iris that can be fully closed, putting the lens cap on. Once all light is completely blocked from entering the image sensor, tap the black cal button on the main screen. The record LED will flash for a short period as the camera records the black reference frames. The black reference will then be calculated by averaging 16 frames. This process takes some time, up to about 25 seconds depending on resolution. This will be sped up greatly in a future software update.

Once the record light has flashed and is out, you can safely open the iris or remove the lens cap, as the black reference frames are fully captured. You can continue setting up your shot (such as focus) while the black cal is being computed.

Once the black cal is done, the message will go away and the camera is ready to use. The black cal is persistent across restarts and will be remembered the next time you use the same resolution.

### Recording

Chronos 1.4 records in a ring buffer in internal high-speed RAM. The camera records continuously until stopped either by the shutter button, on-screen record/stop button, or external trigger source.

## Ring Buffer

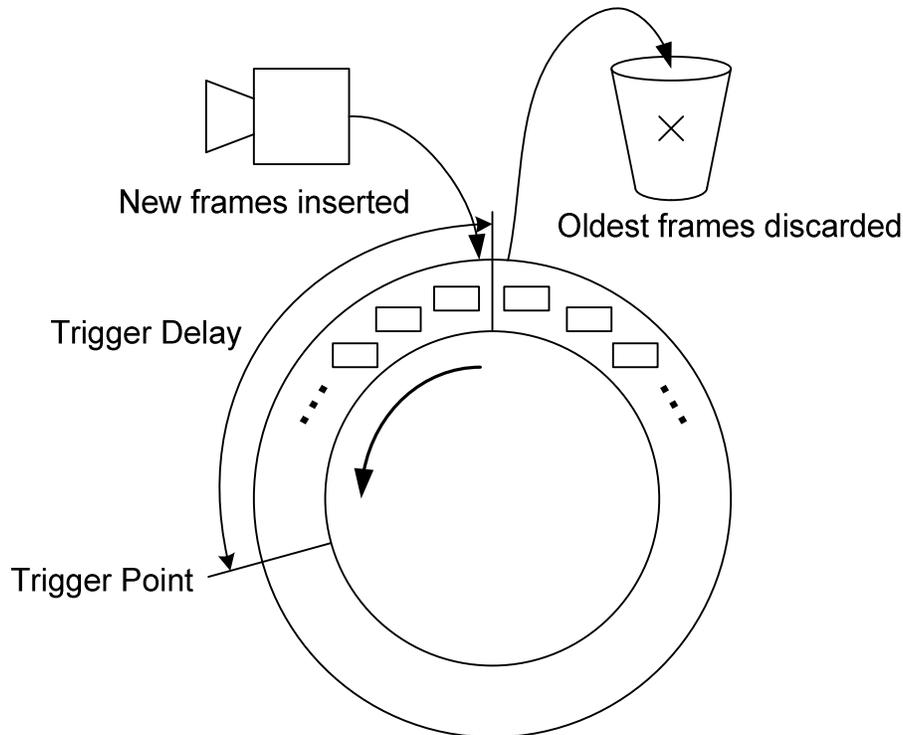


Figure 7 - Ring Buffer

The ring buffer stores recorded frames until full. Once full, the oldest frames are overwritten with new frames. This allows the camera to record for an unlimited period, however only the most recent frames are kept. The length of the buffer depends on the record settings. At maximum frame rate, the record length is as specified in Record rates and times. Reducing the frame rate below maximum will increase the record time proportionally. For example, if the maximum frame rate for your resolution is 3000fps, setting the frame rate to 1000fps will result in 3x the record time available at maximum frame rate.

## Playback

The playback functionality is accessed through the Play button on the main screen. The latest recording can be reviewed on-camera from the playback page.

The left/right buttons at the top will play back video forward or backward when held down, at the frame rate specified below. The up/down buttons will cycle through the available playback rates, from 4.6 up to 960fps. This frame rate is for local playback only, it does not affect the frame rate of the saved video.

Quick navigation is achieved with the vertical slider, the top of the slider is the most forward in time (newest frames).

Precise and quick playback control is available with the jog wheel. Turning the wheel moves playback by one frame per detent (rotational click), or 24 frames per turn. Pushing the jogwheel in while turning moves playback by 40 frames per detent, or 960 frames per turn

The other controls on this window are described in Saving below

## Saving

Video can currently be saved in compressed H264 format to removable storage such as SD cards, USB drives, etc. Other saving modes such as RAW/DNG or uncompressed will be added in a future software update.

To save a video:

1. From the Play page, use the navigation controls and mark in/mark out buttons to select the range of video you want to save. Mark in at the beginning and out at the end of the desired save region.
2. (optional) adjust save settings such as save location, bitrate, saved file frame rate, etc in the Save Settings window
3. Tap Save and wait for saving to complete

Saving occurs at 60fps at all resolutions, due to current encoder limitations, but the frame rate will still be as specified during playback.

Save location, file name and encoder bitrate settings are adjustable under Save Settings.

### Save Settings

The primary adjustment of encoded file bitrate is the Bits per Pixel control. This is a resolution- and frame-rate-independent control of quality. Higher Bits per Pixel values will result in higher quality video. This value is converted into a bitrate in bits per second based on the resolution and save frame rate as set in Save Settings, and displayed for reference.

The playback frame rate of the saved file can be set with the Saved File Framerate control. This is adjustable from 1 to 60fps in 1fps increments. Due to encoder limitations, only integer framerates are currently supported.

The maximum ultimate bitrate is 60Mbps at a 60fps save speed, and is limited by the hardware H264 encoder on the camera's CPU. If the saved file frame rate is set less than 60fps, the maximum bitrate will be lower than 60Mbps.

H264 profile and level controls are shown but currently disabled as some settings cause the encoder to crash. They are currently fixed to the highest quality settings.

The filename field can be used to set custom file names. You don't need to append ".mp4" to the end, the camera does this automatically. Leaving this field blank will result in automatic naming of saved files, in the format vid\_<date and time>.mp4

## Record start/stop and Triggering

Recordings can be started and stopped in several different ways, as detailed below.

### Shutter button

The red shutter button on top of the camera will toggle between recording and stopped. **Trigger delays do not apply to the shutter button, pressing the button while recording will stop the recording immediately regardless of any trigger delay that has been set.**

### External trigger sources

Three external trigger inputs are available, Trigger IOs 1 and 2, and Trigger input 3. Details on the electrical specifications of these inputs are available the Trigger IO section

Any or all of the trigger inputs can be selected as the trigger source in the trigger settings page. If multiple sources are selected, they are logic OR'd together internally (after any invert or debounce operations are applied), any one becoming active will trigger the recording to stop.

### Debounce

Selecting the debounce option in trigger settings causes the inputs to be sampled every 10ms, to avoid spurious triggers due to switch contact bounce. Use debounce whenever you are using a physical switch as the trigger source.

### Trigger Delay

The delay from trigger received to record stop can be set in the Trigger Settings page on the bottom left. This delay is specified in frames. Record will stop this many frames after the trigger occurs.

## Synchronizing to external sources

Frame capture can be precisely controlled by external sources. Two modes are supported, triggered exposure and shutter gating.

### Triggered Exposure

In this mode, an external trigger source connected to either Trigger IO 1 or 2 controls the start of exposure, and the exposure duration is controlled by the camera.

To use this mode, first select the desired resolution and maximum frame rate in Record Settings. The exposure time is limited to  $1/\text{frame rate}$ , if longer exposures are desired, you must reduce the frame. Once frame rate is set, select Triggered Exposure for the desired input on the Trigger/IO settings page. Ensure debounce is disabled for proper operation, and select invert and pullups as required. For TTL input, no pullups are generally required. With Invert unchecked, exposure will start on the rising edge of the input.

**The frequency of the external signal must not be higher than the frame rate specified in Record Settings. Frames will be dropped if this requirement is not followed.**

In this mode, black cal can only be performed when a stable repetitive trigger is received by the camera. If a stable trigger source isn't available, set the mode to None in Trigger/IO settings, perform a black cal, then set the mode back to Triggered Exposure.

### Shutter Gating

In this mode, the shutter is directly controlled by either Trigger IO 1 or 2. Exposure occurs when the signal is active.

To use this mode, first select the desired resolution in Record Settings, and set to maximum frame rate. At lower resolutions, if you select a frame rate lower than maximum, the sensor's configuration may be optimized for this lower frame rate, limiting the maximum achievable frame rate. Once frame rate is set, select Shutter Gating on the desired input on the Trigger/IO settings page. Ensure debounce is disabled for proper operation, and select invert and pullups as required. For TTL input, no pullups are generally required. With Invert unchecked, exposure will occur when the input is at a logic high level.

In this mode, black cal can only be performed when a stable repetitive trigger is received by the camera. If a stable trigger source isn't available, set the mode to None in Trigger/IO settings, perform a black cal, then set the mode back to Shutter Gating.

### Timing requirements

Shutter gating has some limitations on the input signal.

1. Minimum exposure duration of 1 $\mu$ s must be maintained, undefined operation may occur with a pulse width below 1 $\mu$ s.
2. Exposure start must occur at least 2 $\mu$ s after the end of the previous exposure.
3. Exposure end must occur at least one frame period ( $1 / (\text{frame rate})$ ) after the previous exposure end to allow time for sensor readout. An example is shown in Figure 8 below. Frame period can be determined for your current resolution in the Record Settings window, under the ROI display.

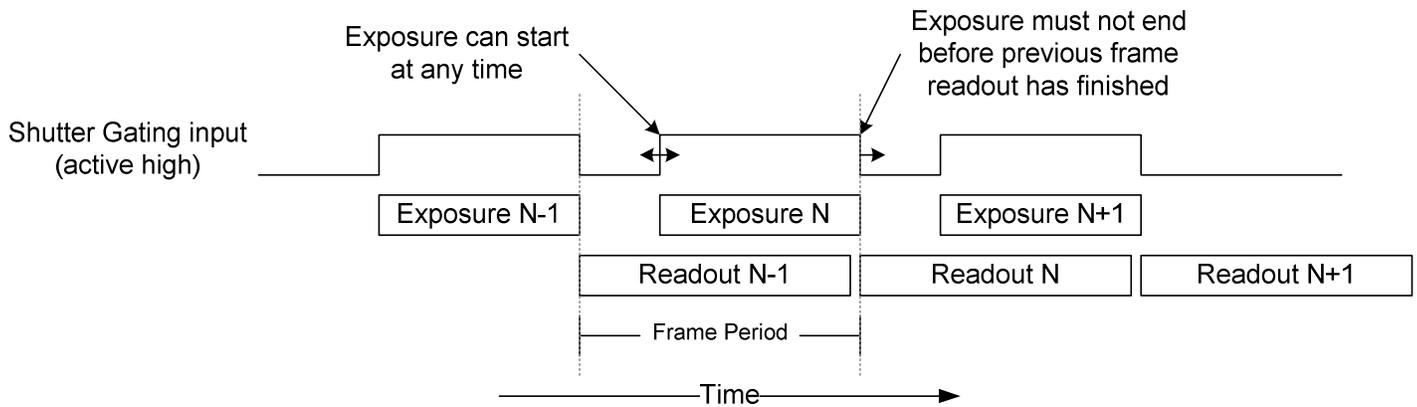


Figure 8 - Shutter gating timing

## Maintenance and care

### Optics

- Keep the optical area clean when changing lenses by keeping the body and lens mount caps on when the lens is separated from the camera
- If the lens or sensor/IR filter is dusty, remove the dust with air using clean, dry compressed air, dusting gas, or a dusting squeeze bulb.
- If the above is not able to remove the dust, use a brush or lens pen.
- If there is dust under the IR filter, you can remove the filter for cleaning. See *Removing/installing the IR filter*.

### Camera body

- Do not expose the camera to moisture, rain, or excessively dusty environments, contamination may enter the camera and cause damage.
- Do not expose the camera to molten metal.
- The camera body can be cleaned with a lint-free cloth, and optionally a small amount of rubbing alcohol. Do not use excessive liquids as they may enter the camera body.

### Screen

The touchscreen surface is glass. **Don't strike it with hard objects or put excessive pressure on the screen, or the glass may break.**

- The screen should be cleaned with a soft lint-free or microfiber cloth.
- A small amount of glass cleaner or rubbing alcohol may be applied to the cloth if required. Don't use excessive amounts, and don't spray glass cleaner directly on the camera.

### Storage/Shipping

- Store the camera in a cool, dry, and clean location.
- When shipping the camera, it's recommended to put it in a plastic bag with desiccant to avoid problems with condensation during temperature changes.
- If the camera will be stored for more than a few weeks, charge or discharge the battery to approximately 40% charge, then turn off the camera and remove the battery. This will minimize battery capacity degradation during storage
- **Always** remove the battery from the camera for shipping to avoid the possibility of the camera turning on in-transit.

## Troubleshooting

Symptom	Possible problem	Solution
Camera won't power on	No power	Insert battery or connect to mains power.
	Crash	Remove battery and AC adapter for 10 seconds, then reconnect and power on.
	AC Adapter voltage wrong	Ensure that AC adapter is providing between 17 and 20V DC, positive tip.
Battery won't charge	Battery inserted after AC connected	Unplug AC adapter from camera then replug.
	AC Adapter voltage wrong	Ensure that AC adapter is providing between 17 and 20V DC, positive tip.
Battery indicator drops very fast	Low quality or failing battery	Replace battery.
Power status indicator flashes red/green continuously	Power controller in recovery mode	Turn camera off, then remove the battery and disconnect AC adapter for 10 seconds. When reconnecting power or inserting battery, ensure power button is not pressed until after the LED flashing stops.
	Power controller firmware corrupt	If the above does not fix the problem, contact Kron Technologies for assistance. A power controller recovery update may need to be applied.
Horizontal line shows up in video	Black cal not done after changing shutter speed (especially at resolutions below 1280 pixels horizontal)	Perform black cal after every shutter speed or resolution change.
Extremely blurry image, can't get close to proper focus. Except possibly when lens zoomed in	Incorrect lens adapter installed	Check if lens is CS or C mount to determine proper adapter to use.
Focus slightly wrong, proper focus out of range	Backfocus misadjusted	Readjust backfocus, see Backfocus Adjustment.
	Lens limitation	The Computar 12.5-75mm lens as well as some others are slightly soft at fully wide aperture. Close aperture slightly and retry. Try f/2 or smaller.
Lens doesn't maintain consistent focus while zooming	Backfocus misadjusted	Readjust backfocus, see Backfocus Adjustment.
	Lens is not parfocal	Some lenses, especially lower end lenses such as the 6-60mm and 2.8-12mm lenses, do not maintain focus during zoom, Focus needs to be adjusted after zooming.
Black ring around image	Lens too small for sensor	Some lenses (such as the 6-60mm and 2.8-12mm lenses) don't cover the full image sensor. The black ring around the outside is called Vignetting. Change to a different lens to eliminate.
Saved video skips	Storage device too slow	Use a Class 10 or faster SD card, or use a faster USB drive. USB drives are often very slow.
	Bitrate set too high	Turn bitrate down.

## Reference Information

### Specifications

<b>Camera</b>	<i>Imaging</i>	1280x1024 1057fps, see resolution table for details
	<i>Memory</i>	8GB or 16GB
	<i>Record time</i>	4 seconds (8GB), 8 seconds (16GB)
	<i>Lens mount</i>	CS mount, C mount with included adapter
	<i>Backfocus</i>	Field adjustable
	<i>IR Filter</i>	650nm, user removable, 15 x 15 x 1.1mm
	<i>Display</i>	5" 800x480 capacitive touchscreen
	<i>Enclosure</i>	Anodized CNC machined aluminum
	<i>Cooling</i>	Active cooling, variable-speed fan
	<i>Dimensions</i>	155mm x 96mm x 67.3mm (6.11" x 3.78" x 2.65") without lens
<i>Weight</i>	1.06kg (2.34 lbs) without lens	
<b>Video formats</b>	<i>H.264</i>	Industry-standard mp4 files at bitrates up to 60Mbps
	<i>cinemaDNG Raw*</i>	Standard Adobe cinemaDNG raw files
<b>Image Sensor</b>	<i>Resolution</i>	1280x1024 @ 1057fps
	<i>Speed</i>	1.4Gpx/s - Full throughput down to 336 pixel image width
	<i>Dimensions</i>	8.45 x 6.76mm
	<i>Pixel pitch</i>	6.6um
	<i>Sensitivity (ISO)</i>	Color - ISO 320 to 5 120
		Mono - ISO 740 to 11 840
	<i>Shutter</i>	Electronic global shutter, 1/fps to 2us (1/500 000 s)
	<i>Dynamic range</i>	56.7 dB
<i>Bit depth</i>	12-bit	
<b>Battery</b>	<i>Type</i>	EN-EL4a
	<i>Runtime</i>	1.5 hours recording (typical)
	<i>Charge time</i>	2 hours (0-80%) with in-camera charger
<b>IO</b>	<i>Power Input</i>	17-20V 40W
		5.5/2.5mm barrel jack, positive tip
	<i>Network*</i>	Gigabit Ethernet
	<i>Trigger</i>	Two Trigger inputs/frame strobe outputs (BNC and Aux)
		Adjustable input threshold 0 to 6.6V
		Electrically isolated trigger input (Aux connector)
	<i>Audio*</i>	Microphone/Line input, headphone output
	<i>Video*</i>	HDMI output, video or video+menus
	<i>USB</i>	Two USB host ports (one on mini-B via USB OTG cable)
	<i>SATA</i>	eSATA 3G
<i>Analog input*</i>	1MSa/s 12-bit, 200kHz bandwidth, +/- 1V full scale	
<b>Trigger modes</b>	<i>Normal triggered</i>	Camera records until a defined delay after a trigger
	<i>Triggered start</i>	Camera starts recording a defined delay after a trigger
<b>Trigger Sources</b>	<i>Electrical</i>	0-6.6V threshold, optional button debounce and pullup
	<i>Audio*</i>	Trigger on loud sounds
	<i>Acceleration*</i>	Trigger on camera motion, tilt or shock

	<i>Image*</i>	Trigger on image changes
<b>Recording modes</b>	<i>Normal</i>	Records into the circular buffer. Once a trigger occurs, video can be reviewed and saved
	<i>Segmented*</i>	RAM is divided into segments, each recording as in the Normal mode above. Number of segments is user selectable.
	<i>Continuous*</i>	Video is saved continuously at up to 60fps to mp4 files on removable storage. Operates like a normal video camera.
	<i>Run-n-Gun*</i>	Bursts of video are saved to RAM while holding down the shutter button. Video is saved to storage devices automatically. More bursts can be captured simultaneously while video is saving.
	<i>Gated burst*</i> <i>Normal + continuous*</i>	Frames are captured while trigger is active High-speed video is recorded to the RAM buffer while simultaneously 60fps videos is saved to removable storage
<b>Shutter timing</b>	<i>Normal</i>	Frame rate and exposure time are controlled by the camera
	<i>Edge triggered</i>	A single frame is captured on each rising or falling edge of an external input. Exposure is controlled by camera
	<i>Shutter gating</i>	Image sensor shutter is directly controlled by an external input, exposing while the input is active
<b>Assistive</b>	<i>Focus Peaking</i>	Highlights sharp edges to aid focusing
	<i>Zebras</i>	Rolling diagonal lines indicate clipped (overexposed) areas
	<i>Focus Aid</i>	Zooms in to allow easier focusing

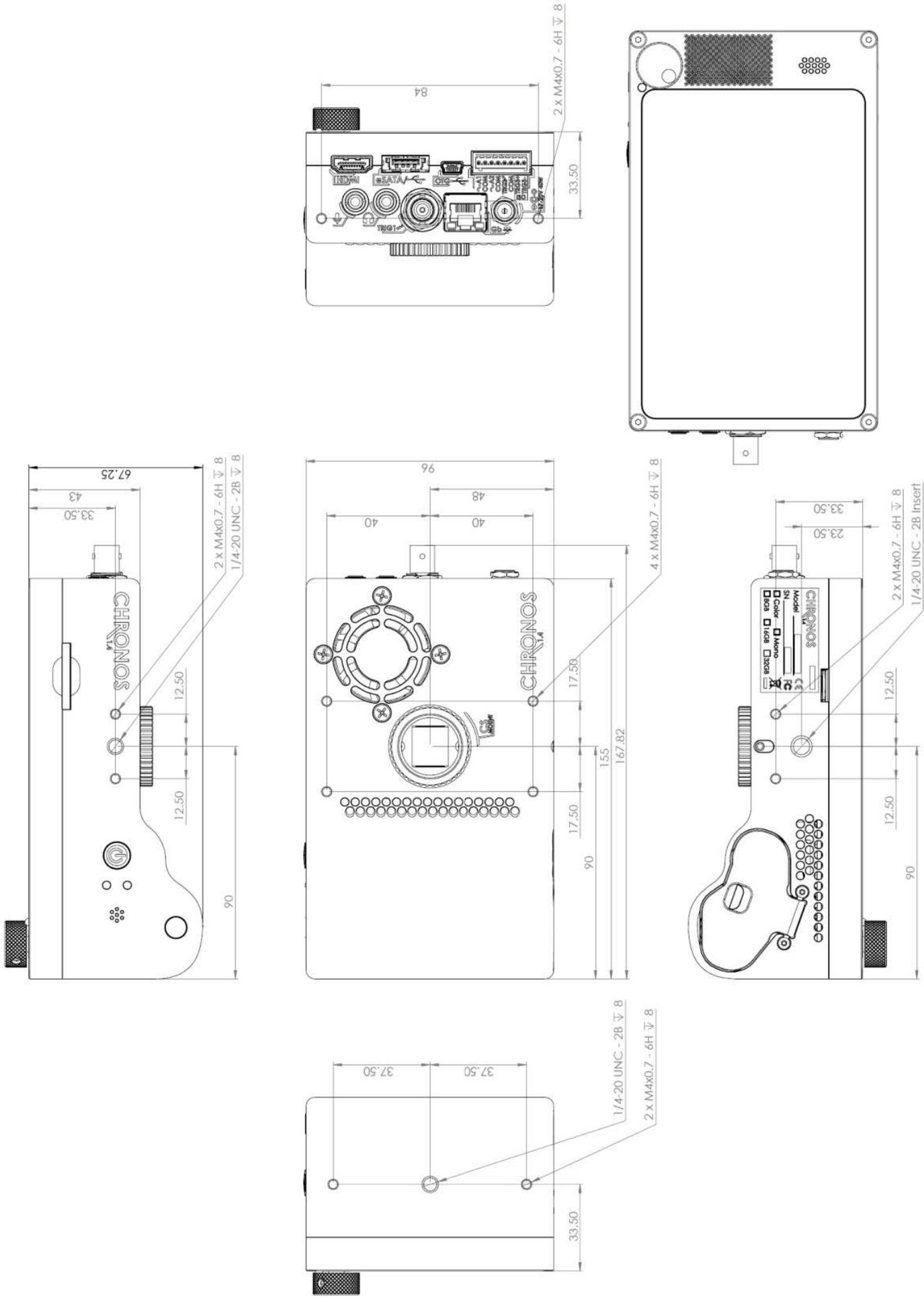
\* These features will be added in a future free software update

## Record rates and times

These are just a sample of common resolutions, resolution is adjustable in 16x2 pixel increments.

<b>Resolution</b>	<b>Max FPS</b>	<b>Record time (sec) (8GB)</b>	<b>Record time (sec) (16GB)</b>
1280 x 1024	1 057	4.13	8.26
1280 x 720	1 502	4.13	8.27
1280 x 512	2 111	4.14	8.27
1280 x 360	2 999	4.14	8.28
1280 x 240	4 489	4.15	8.30
1280 x 120	8 923	4.17	8.35
1280 x 96	11 119	4.19	8.38
1024 x 768	1 771	4.11	8.22
1024 x 576	2 359	4.11	8.23
800 x 600	2 873	4.15	8.30
800 x 480	3 587	4.15	8.31
640 x 480	4 436	4.20	8.40
640 x 360	5 903	4.21	8.42
640 x 240	8 816	4.23	8.45
640 x 120	17 424	4.28	8.56
640 x 96	21 649	4.30	8.61
336 x 252	15 200	4.43	8.87
336 x 190	20 020	4.47	8.94
336 x 120	31 192	4.53	9.07
336 x 96	38 565	4.60	9.20

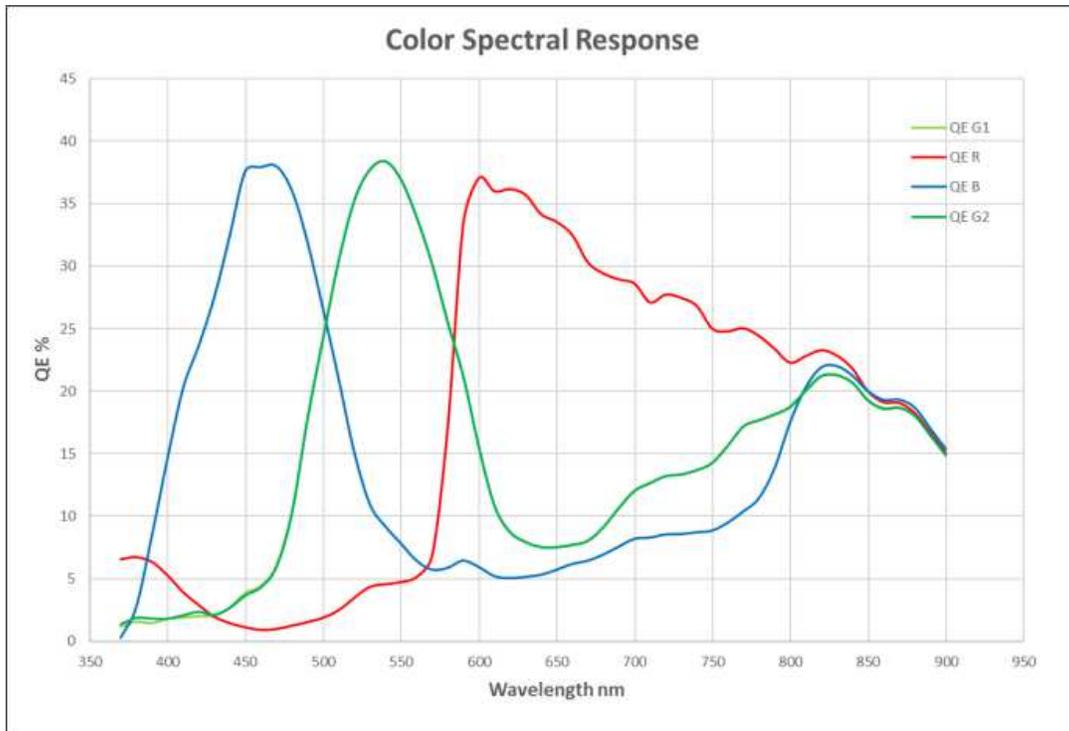
### Mechanical drawing



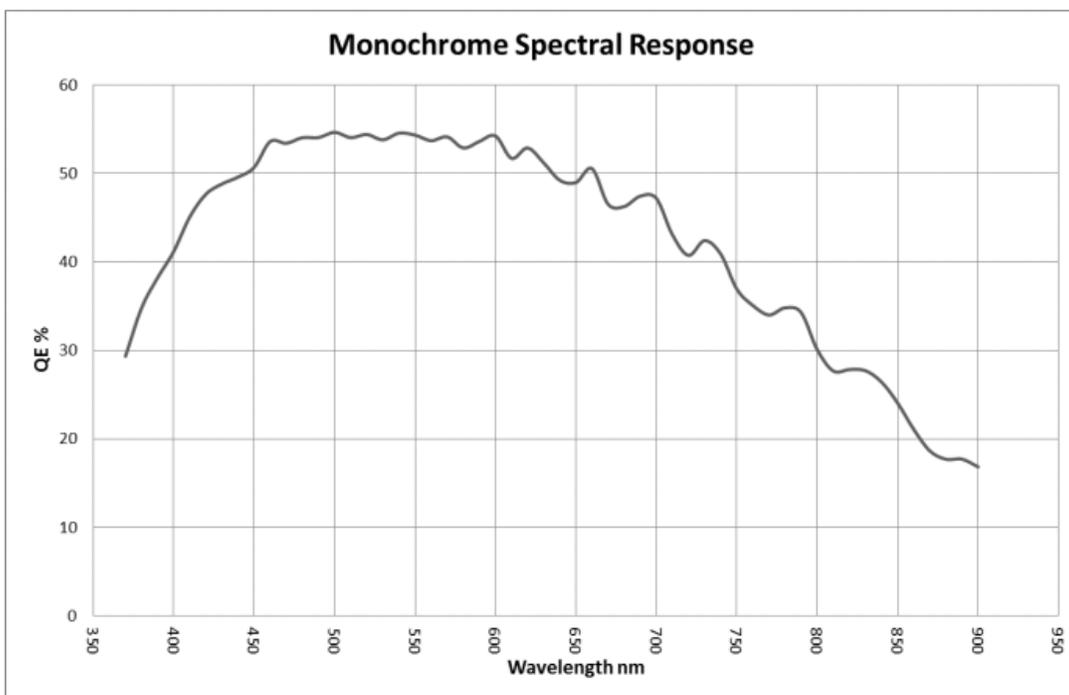
## Spectral Response

Note: These spectral response curves are in units of quantum efficiency, not the typical amperes per watt

### Color (without IR filter)



### Monochrome (without IR filter)



## Change Log

Revision	Changes
2	Initial Release
3	Added part number of Aux IO connector mating plug, updated wording in What's Included section

Notes:

**Notes:**