

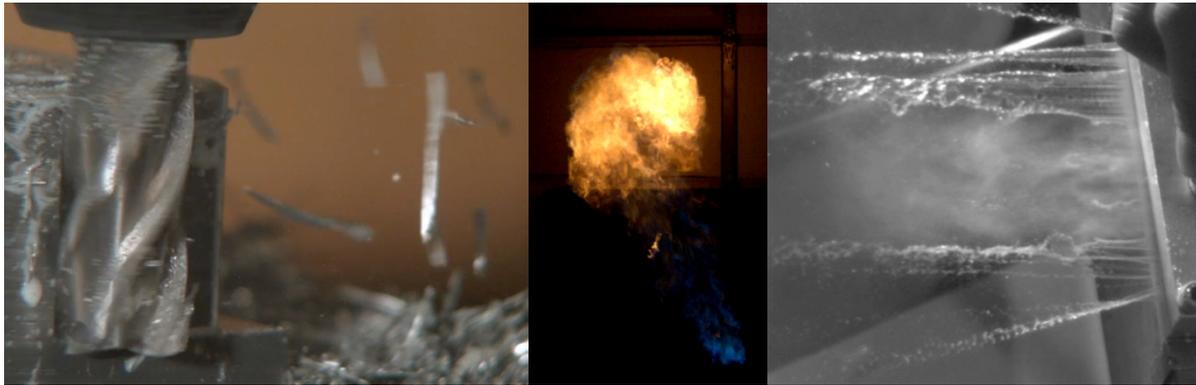
CHRONOS 1.4

High-Speed Camera



User Manual for Software v0.3.2

Document Revision 2



Thank you for choosing the Chronos 1.4 High Speed camera! 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 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 are excited to see what you and the rest of the Chronos community can create. Go forth and capture every microsecond possible on the Chronos 1.4!

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. If there are any concerns about hardware, software or special instruction for the Chronos 1.4 and its accessories, please contact support@krontech.ca.

A special thanks to all of our 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: <http://forum.krontech.ca>
Email: 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. It is required to do this when powering the camera on for the first time. The LED on the top of the camera should illuminate to indicate external power is present.
- The camera behaves just like a laptop; it charges when 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. Like a 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 defaults to 1280x1024 on first boot
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 320 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 recommended once after changing resolutions or shutter, or after camera warms up. (Black calibration issues often manifest as lines across the video.)
4. (*Optional, for color cameras*) - Set white balance. Place a white card at the center of the frame and select White Balance → Set Custom to calibrate color temperature.
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 button on top of the camera 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 while turning to go fast (40x faster than non-clicked).

Saving

1. Plug an SD card, USB drive or eSATA drive in to the camera. The device must contain a partition formatted as FAT32, EXT2 or EXT3. For fastest saving, an eSATA 2.5" SSD or HDD is recommended.
2. (*Optional, highly recommended*) - Use Mark Start and Mark End to select a region to save. Position playback where you'd like saving to start and tap Mark Start. Repeat using Mark End for the location you'd like saving to end. Saving the entire buffer can take a long time, especially at high frame rates.
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 storage device 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. (To remove the SD card, press down until a click occurs. It will then pop out.)

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:

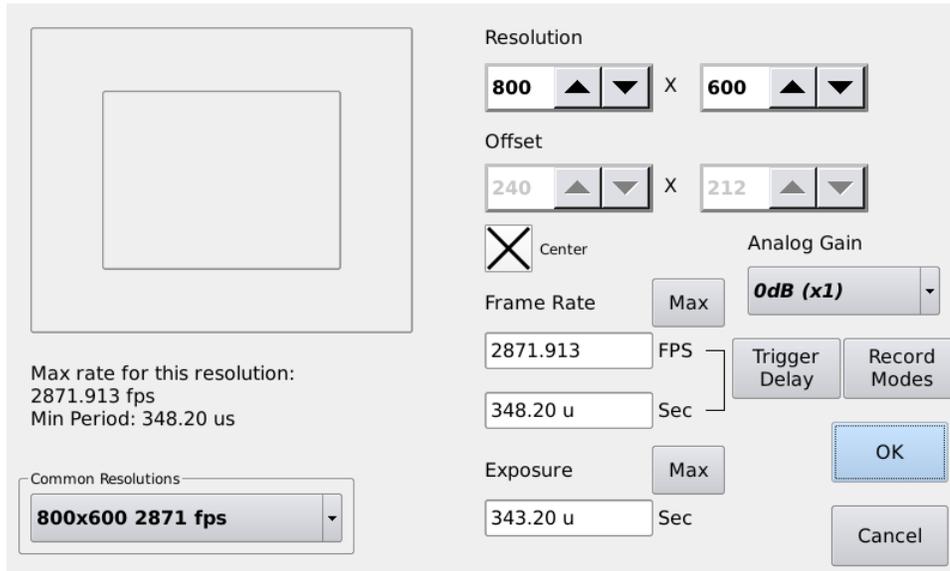


Figure 2 - Record Settings page

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 in 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. Alternatively, 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 60fps up to the maximum displayed under the ROI display. The Max buttons will set the frame rate 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 calibrated at the factory. When an uncalibrated resolution is selected, a basic black calibration is automatically taken with the shutter speed at minimum. This allows a reasonable image display for immediate use, but a full black calibration is recommended for best quality.

Black Calibration

For best image quality, the camera automatically subtracts a black reference image from all captured frames during operation. This corrects for pixel variations that occur on the camera's image sensor. This black reference is updated by performing a black calibration.

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

For best image quality, perform a black calibration after changing the resolution, frame rate or shutter speed.

It is recommended to let the camera reach normal operating temperature before performing a black calibration. Let the camera run for 15-25 minutes to reach normal operating temperature.

Performing Black Calibration

Perform the black calibration by either closing the iris fully or putting the lens cap on. Once all light is completely blocked from falling on 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. This will discard any unsaved video. Performing black cal can take up to 15 seconds depending on resolution.

Once the record light has flashed, you can safely open the iris or remove the lens cap, as the black reference frames are fully captured.

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

Recording

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

Recording does not draw any additional power from the battery.

Ring Buffer

A ring buffer is a data structure that is used to hold frames of recorded video.

The ring buffer stores recorded frames until full. Once it is full, the oldest frames will be overwritten as new frames are captured. This allows the camera to record for an unlimited period, however only the most recent frames are kept.

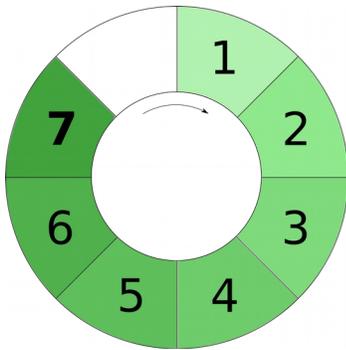


Figure 3 - 7 frames of video recorded into an 8-frame ring buffer.

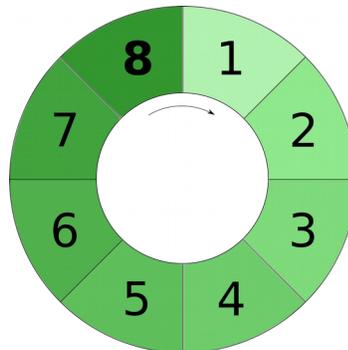


Figure 4 - 8 frames of video recorded into an 8-frame ring buffer.

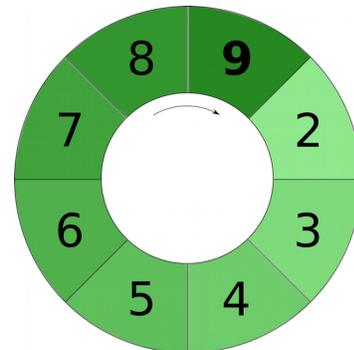


Figure 5 - 9 frames of video recorded. The 9th frame has replaced the 1st frame.

The length of the buffer depends on the record settings.

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.

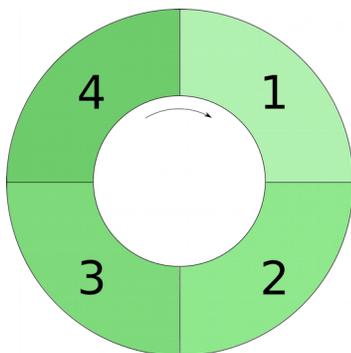


Figure 6 - 4 frames of 800x600 video fit in a ring buffer

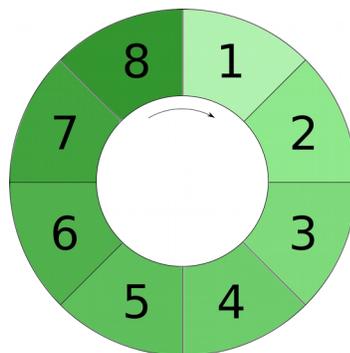


Figure 7 - 8 frames of 800x300 video fit in a ring buffer

Another way to record for longer is to record a smaller video. If 4 frames of 800x600 video fit into a ring buffer, then 8 frames of 800x300 video will fit into the same ring buffer.

Playback



Figure 8: Playback window

The playback and save functionality is accessed through the Play button on the main screen. The playback screen only plays back the most recently recorded video segment(s) stored in RAM.

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 10 up to 1920fps. This frame rate is for on-camera 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.

If “Demo Mode” was enabled on the Util screen, there will be a “Play” button that activates Demo Mode and will be situated just to the left of “Close” In this mode, the playback will loop between the marked start and end points, once the button is tapped on the Play screen.

The other controls on this window are described in Saving below.

Saving

Video can be saved in compressed H.264, Raw, CinemaDNG and TIFF formats to removable storage such as SD cards, USB drives, external hard drives, etc.

To save a video:

1. From the Play page, use the navigation controls and mark start/mark end buttons to select the range of video you want to save. Mark start at the bottom and end at the top of the desired save region. (The save region is marked by a colored bar.)
2. (optional) Adjust save settings such as save format, location, bitrate, saved file frame rate, etc in the Save Settings window.
3. Tap Save and wait for saving to complete.
4. (optional) Repeat to save another range of video. Each saved region will be highlighted with a different color.

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

Save Settings

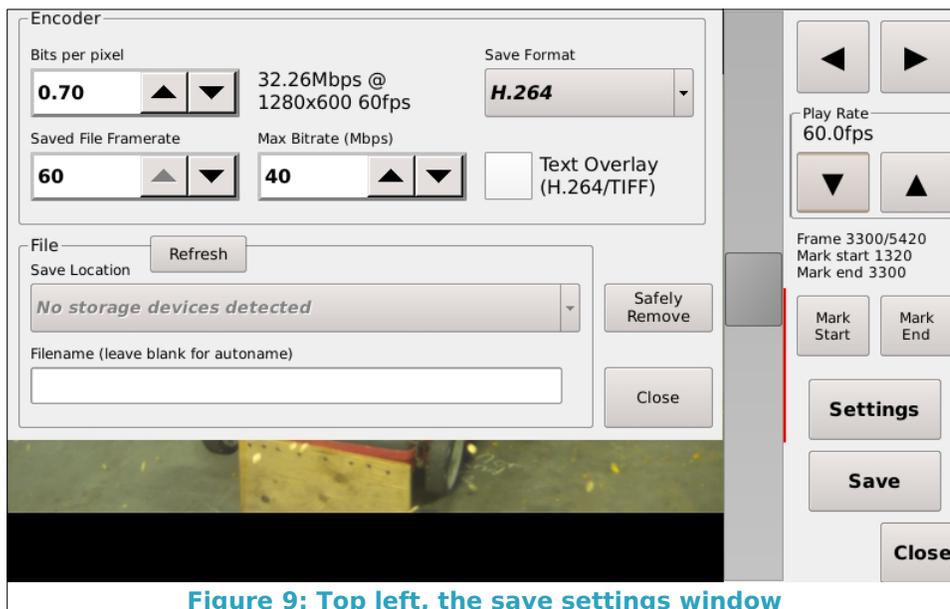


Figure 9: Top left, the save settings window

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. It does not affect the quality or the total number of frames in the saved video.

The maximum ultimate bitrate is 60Mbps at a 60fps save speed, and is limited by the hardware H.264 encoder on the camera's CPU. If the saved file frame rate is set lower than 60fps, the maximum bitrate will be lower than 60Mbps.

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, like vid_«date and time».mp4. For the CinemaDNG and TIFF save formats, this will change the name of the folder in which the files are saved.

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 start/stop the recording immediately regardless of any trigger delay that has been set.**

External Trigger Sources

Triggers can be configured to start a recording, stop a recording, and control the camera shutter. The Chronos has three external trigger inputs available:

- Trig 1 (IO 1): The BNC connector.
- Trig 2 (IO 2): Located on the green connector.
- Trig 3 (Input 3): Isolated input, located on the green connector.

Triggers are configured in *Trigger/IO Settings*, on the camera.

Triggers 1 and 2 can also output a frame sync signal.

See *Side Connectors* and *Trigger I/O* for more information.

Debounce

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

Trigger Delay

Delay from when the signal is received to when the recording is started or stopped is configured in *Record Settings* → *Trigger Delay*.

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/frame rate, if longer exposures are desired, you must reduce the frame rate. 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 and 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 for as long as the signal is active. (Support for other IO sources will be added in a future software update.)

To use this mode, first select the desired resolution in Record Settings, and set the maximum frame rate. (If you select a frame rate lower than maximum, the sensor may be set to a low-frame-rate mode. This mode will limit 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 and 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 μ s must be maintained, undefined operation may occur with a pulse width below 1 μ s.
2. Exposure start must occur at least 2 μ 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. Sensor readout time can be assumed to be the shortest frame period for the configured resolution, and can be determined for your current resolution in the Record Settings window, under the ROI display.

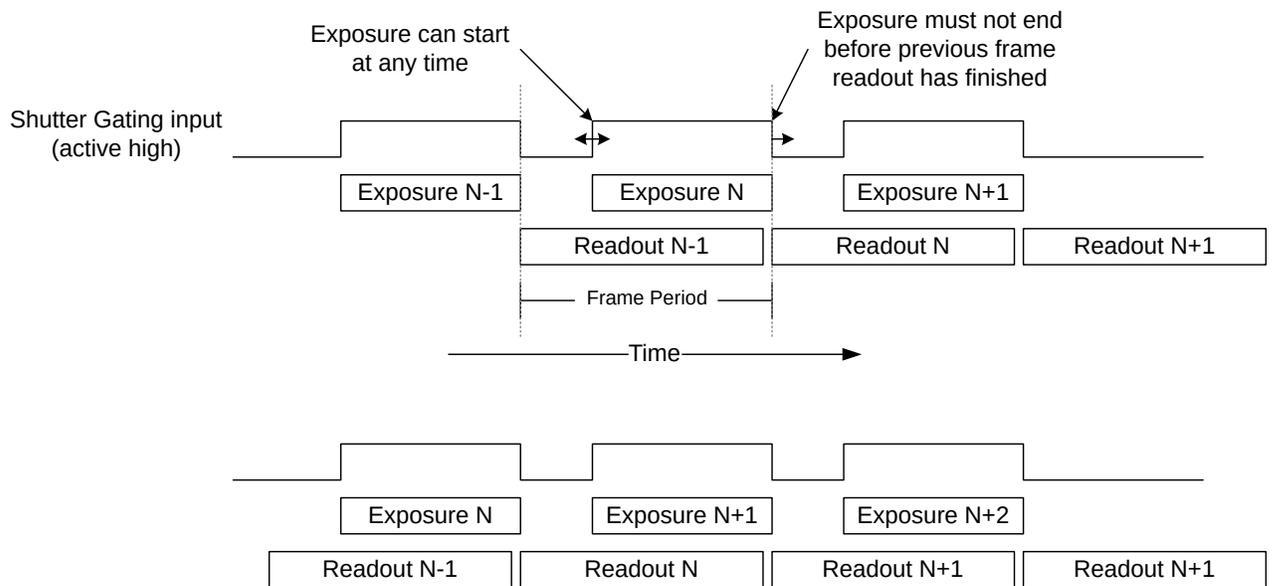


Figure 10 - Shutter gating timing

Hardware Reference

Hardware Overview

Back/Top

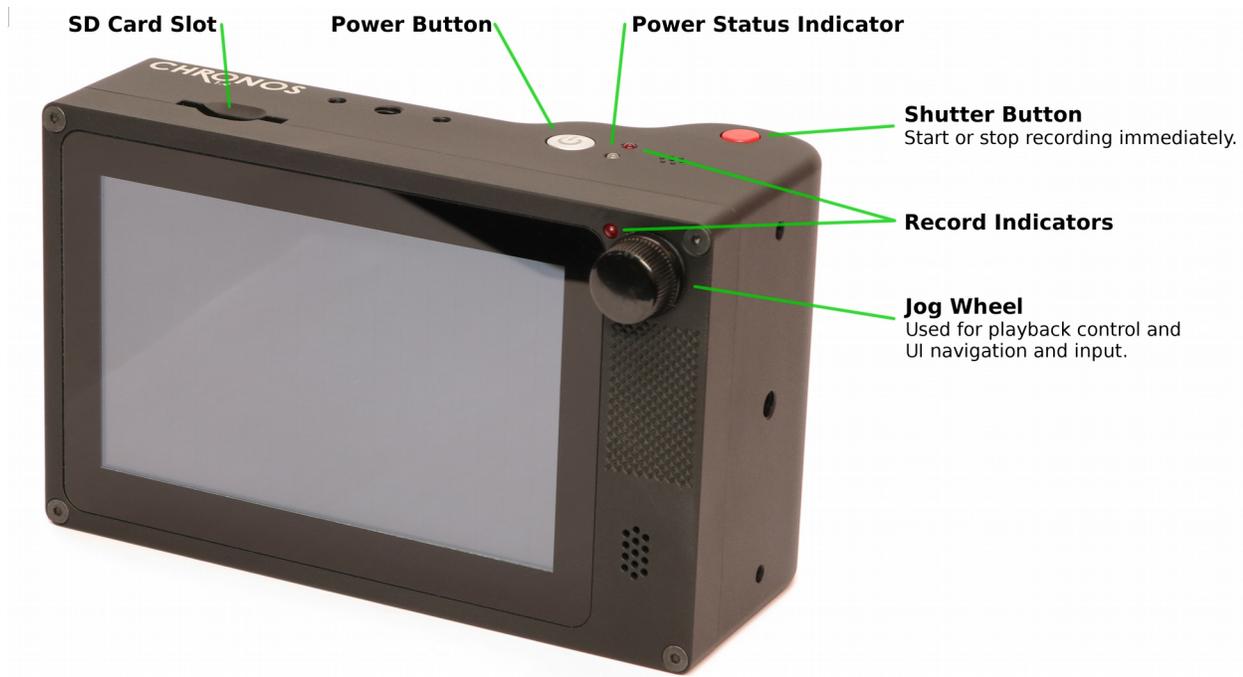


Figure 11 - Overview of camera (Back)

SD Card Slot

A Class 10 or faster SD card is recommended for quickest video saving. However, any properly formatted SD card will work. (Fat32, Ext2 and Ext3 filesystems are supported.)

Power Button

Press 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 or stops recording. The shutter button is not affected by trigger settings.

Record Indicators

Illuminates to indicate the camera is currently recording

Power Status Indicator

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

LED	Indication
Un-lit	No AC power connected.
Solid Yellow	Charging, less than 80% charged.
Alternating Green/Yellow	Charging, more than 80% charged.
Green	Battery fully charged.

Table 1 - Power status indicator patterns

Jog Wheel

Used for playback control, adjusting shutter speed, and UI navigation and input. During playback, moves playback 1 frame per detent (rotational click). Press and hold dial clicked in to move fast (40 frames per detent). On the main screen, rotation adjusts shutter speed. During UI navigation, rotation cycles through the widgets on the user interface, and a click will activate the currently highlighted widget.

Side Connectors

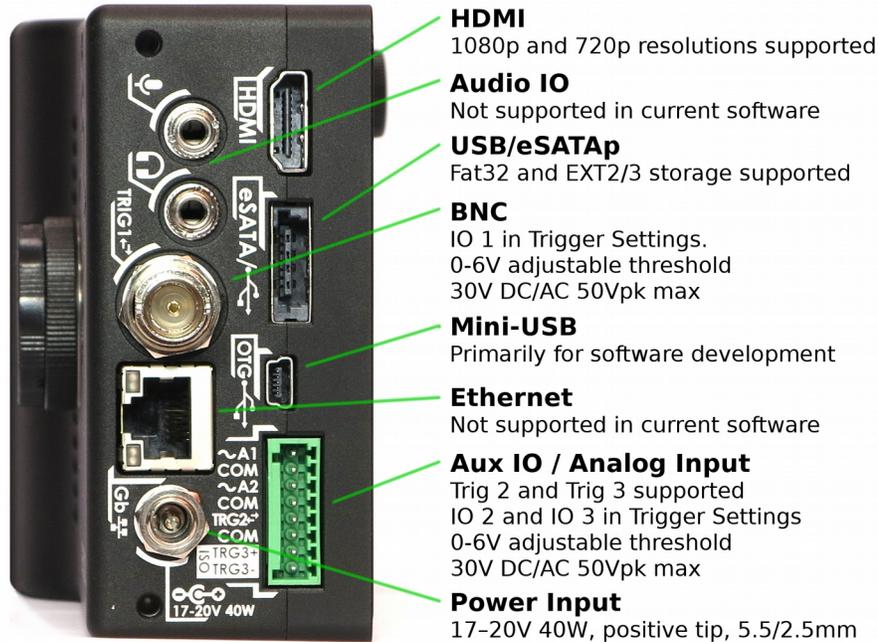


Figure 12 - Overview of camera (Front)

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. This port is also able to supply power using an eSATAp cable.

Most 2.5" hard drives and SSDs will work with the Chronos, but most 3.5" drives will not. This is because the eSATAp port only supplies 5v, not 12v.

Mini USB OTG

Primarily used for software development and debugging. USB mass storage devices, such as flash drives and hard drives, will not work on this port.

Aux IO

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

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 (-)

Table 2 - Pinout

See *Trigger / IO* section for specifications.

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 for the latest software update for Ethernet support.

HDMI

When the camera is connected to a monitor via HDMI, the camera will automatically output a video signal during live video feed, recording, and playback, but not during saving.

The camera will output a 1080p signal over HDMI by default. If the monitor supports 720p, but not 1080p, then 720p will be used instead.

Audio IO

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

Bottom

Figure 13 - Overview of camera (bottom)

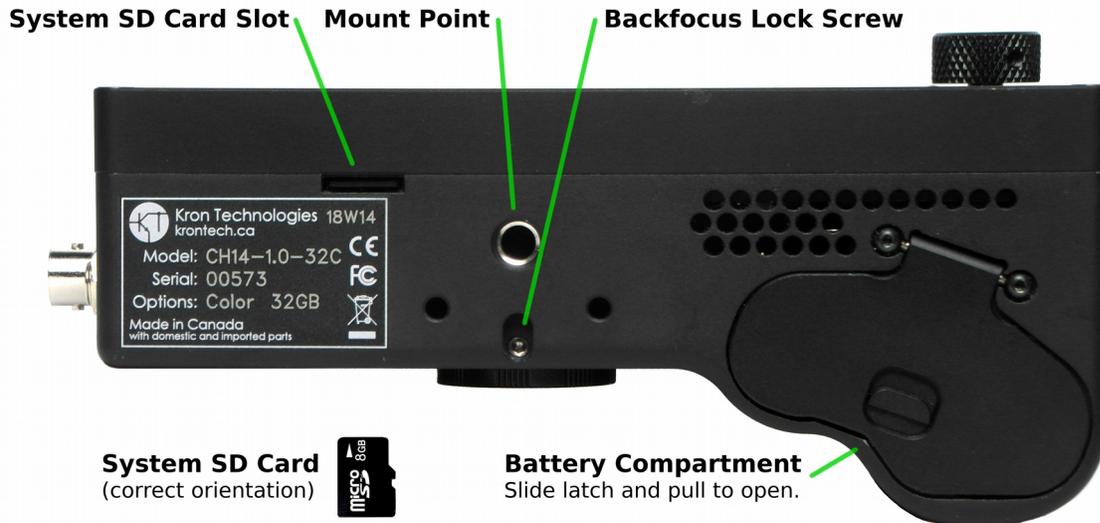


Figure 14 - Overview of camera (bottom)

Mount Point

Standard mount point for the camera, to attach tripods or other equipment.

Backfocus Lock Screw

Prevents the backfocus ring from moving. See *Backfocus* for usage.

System SD Card

Bootable media for the camera. Holds the camera's operating system. During software upgrades, the camera writes new files to this card.

Warning: Ensure the card is correctly oriented as above when inserting into the System SD Card Slot. The card is very difficult to retrieve if flipped or forced.

System SD Card Slot

Holds the System SD Card.

Battery Compartment

To open, push latch up and pull out. Holds an EN-EL4a 11.1V 2500mAh battery during normal operation. **Always remove battery for shipping.**

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 3 - 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 results in vignetting, a black ring around the border of the video.

Backfocus

Backfocus is the distance between the lens mounting flange and the image sensor.

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 Adjustment

To correctly set backfocus for your 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 focus at infinity.
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. Adjust the rotation until best focus on a distant object is obtained.
 - Do not adjust the focus ring on the lens.
 - If the CS ring will not rotate far enough, check to see if your lens requires a CS-C adapter.
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 all the way 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. Adjust the rotation until best focus on the same object is obtained.
 - Do not adjust the focus ring on the lens or any other lens controls.
 - If the CS ring will not rotate far enough, check to see if your lens requires a CS-C adapter.
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

An IR (infrared light) cut filter is standard on all cameras.

The color version of the camera benefits from the IR filter because of improved color reproduction. 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. Using an IR filter results in sharper images, at the penalty of reduced sensitivity.

Removing and Installing the IR Filter

You can remove the infrared filter for cleaning or for 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 filter 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. Be careful not to overtighten it!
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 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.

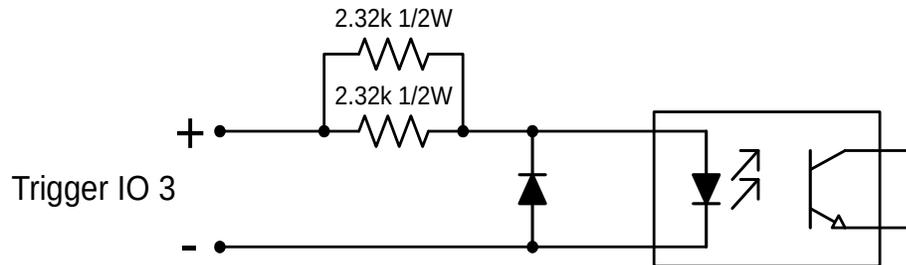


Figure 16 - Trigger IO 3 Schematic

Storage Devices

All storage devices must be formatted as FAT32, EXT2 or EXT3.

SD cards, USB thumb drives, and USB and eSATAp external hard drives and SSDs are all supported. For SD cards, it is recommended to use a class 10 or faster SD card, from a reputable manufacturer. Different USB storage devices can have varying write speeds.

Most 2.5” hard drives and SSDs will work with the Chronos, but most 3.5” drives will not. This is because the eSATAp port only supplies 5v, not 12v.

Chronos 1.4 does not support the TRIM feature, which some SSDs require to sustain full performance. Some SSDs are better than others in dealing with lack of TRIM support. When saving to one of the worse ones, saving may randomly pause for a few seconds.

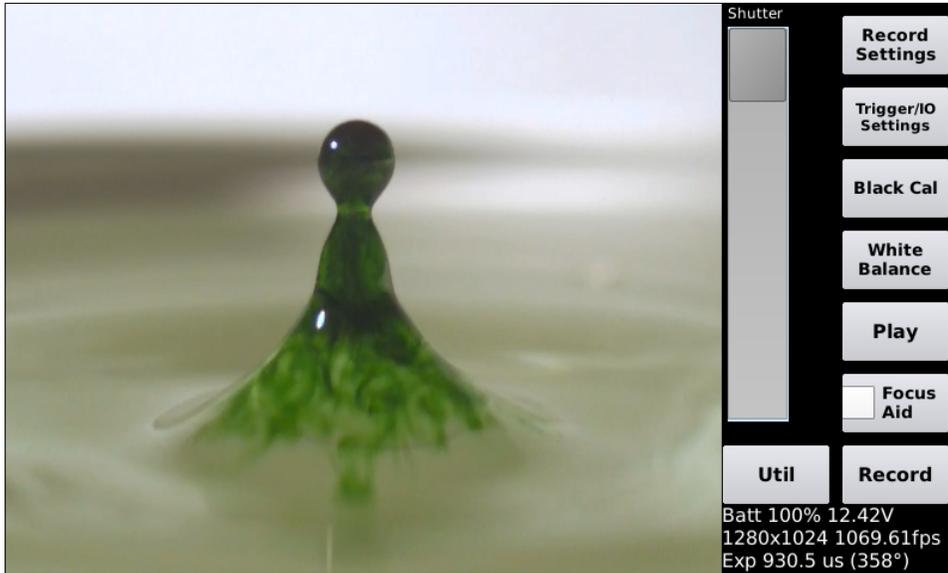
When using a new storage device, always test it by making and saving a recording, then playing it back on a PC.

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Software Reference

Menu/Screen Overview

Main Window

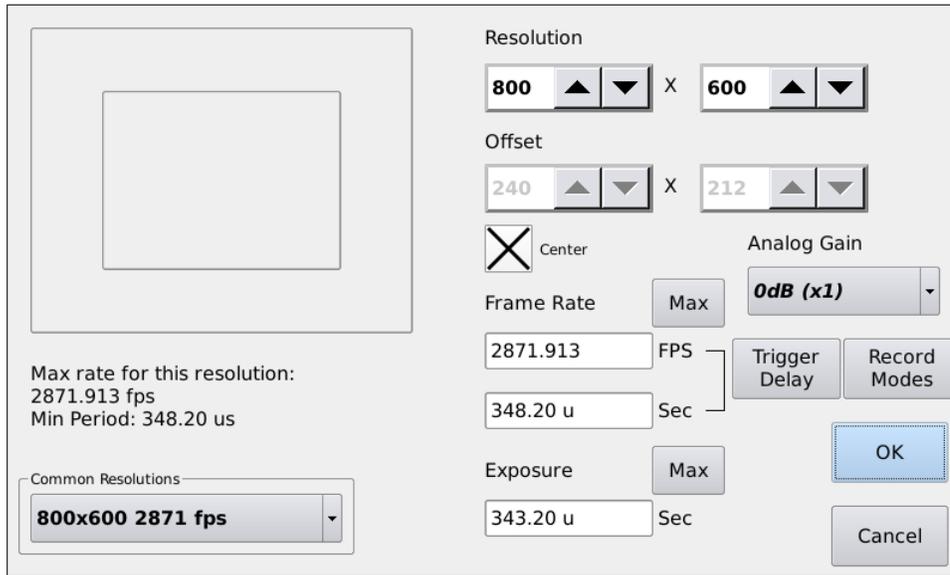


The main screen appears when the camera starts. The image on the left is what will be recorded.

Control	Function
Record Settings	Shows the record settings window, which allows adjustment of resolution, frame rate, analog gain (ISO), exposure, record modes, and trigger delay.
Trigger Settings	Shows the Trigger Settings window, which allows selection of trigger and synchronization IO signals.
Black Cal	Performs a black level calibration. This increases image quality by subtracting noise and sensor artifacts, such as vertical lines. Each resolution has a separate black calibration. No light should hit the image sensor while calibration is underway.
White Balance (color cameras only)	Shows the white balance dialog, which allows setting the color temperature of the recorded video.
Focus Aid	Enables/disables focus peaking, which highlights sharp edges in a conspicuous color. This can be used when adjusting focus is challenging. The color and sensitivity are adjustable from the Util menu.

Record (or Stop)	Starts and stops recording. Performs the same function as the red Shutter Button.
Util	Shows the utility menu, which contains various functions such as the clock, software update, and focus peaking/zebra controls.

Record Settings

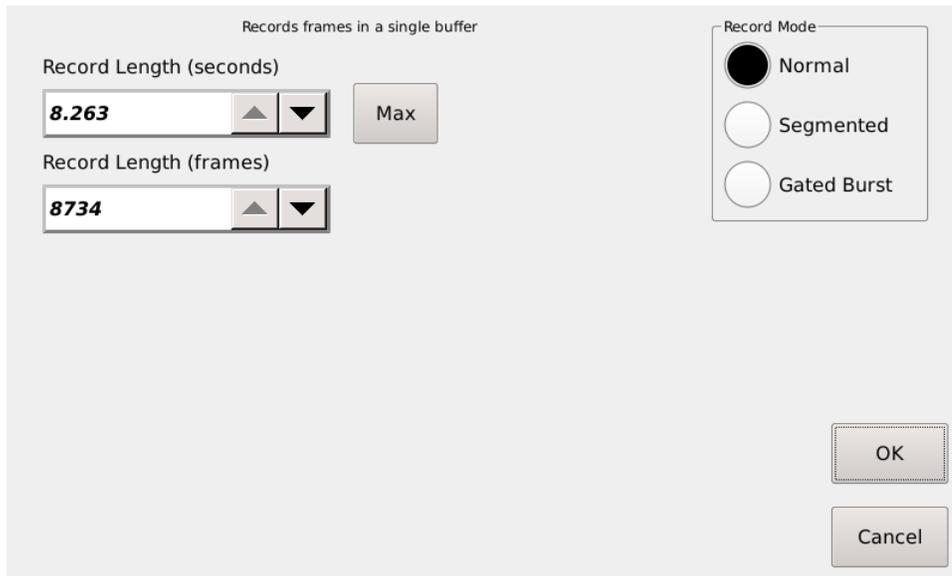


The record settings page allows adjustment of the size and position of the recorded area on the sensor and the frame rate at which the recording is taken. Lower resolutions can be captured at higher frame rates and/or longer record times.

Control	Function
Resolution (width, height)	Sets the recorded video size. Adjustable in multiples of 16 pixels horizontally and 2 pixels vertically.
Offset (horizontal, vertical)	Adjusts the position of the recorded video relative to the top left corner of the image sensor. When the “Center” box is checked, the offset is set automatically and cannot be adjusted. Adjustable in multiples of 16 pixels horizontally, 2 pixels vertically.
Center	Affects the position of the image when using a resolution below 1280x1024. When checked, the image is centered in the sensor area.
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 the maximum for the resolution by pressing Max. To increase record time and maximum exposure time, manually enter a framerate less than max.

Exposure	Sets the exposure (shutter speed) in seconds. Range is 1 μ s up to slightly less than 1/FPS. Can be set to the maximum for the current frame period by pressing Max.																		
Analog Gain	Adjusts the 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" data-bbox="688 510 1258 730"> <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	Select a preset from common picture sizes and frame rates. The frame rate will be set to to maximum after setting resolution via the Common Settings dropdown, but not after setting it manually with the up/down buttons on the top-right of Record Settings.																		
Recorded Area Display	Shows the size and position of the recorded area in relation to the sensor's full resolution. The outer box represents the sensor's 1280x1024 resolution, and the inner box represents the currently selected area to be recorded.																		
Max Rate display	Shows the maximum frame rate and minimum period for the current resolution setting.																		
Trigger Delay button	Opens a screen to configure the amount of record time before and after a triggered event. Events are caused by external I/O, through the BNC connector and the green connector on the side of the camera, but not the red shutter button on the top of the camera.																		
Record Modes button	Open a screen to switch between Normal, Segmented, and Gated Burst modes. (Segmented lets you record multiple video clips, and gated burst only records while the trigger is active.)																		
OK button	Applies changes and closes window.																		
Cancel button	Discards changes and closes window.																		

Record Mode, Normal



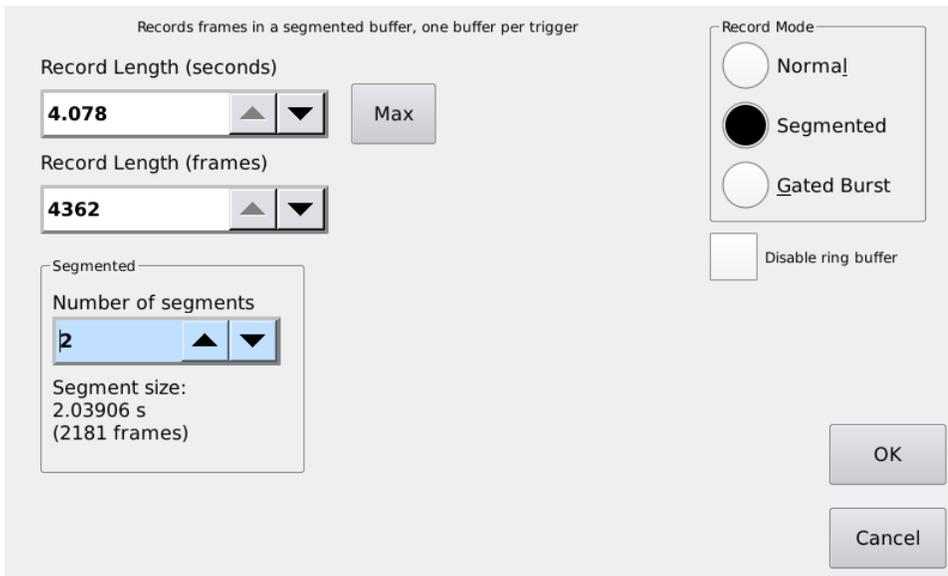
The default capture mode. A single video is recorded using all of the camera’s memory.

Note: The red record button on the top of the camera always operates as start/stop recording. It is unaffected by record mode. Record mode only affects external triggers.

Control	Function
Record Length (seconds)	Set the duration of the triggered recording, in seconds . The timing of this recording can be changed in the Trigger Delay window.
Record Length (frames)	Set the duration of the triggered recording, in recorded frames . The timing of this recording can be changed in the Trigger Delay window.
Max button	Sets record length to the maximum available for your model. This value is dependent on your resolution settings, which can be changed in the Record Settings screen.
Record Mode column	Choose how externally triggered videos are saved to memory. In Normal mode, one video is saved into all available memory.
OK	Applies the record mode changes and closes the window. (Changes will still be discarded if ‘ok’ is not selected in the record settings window.)
Cancel	Discards the record mode changes and closes the window

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Record Mode, Segmented



In Segmented mode, multiple video segments are kept in memory. This is different than Normal mode, where only one video can be kept in memory.

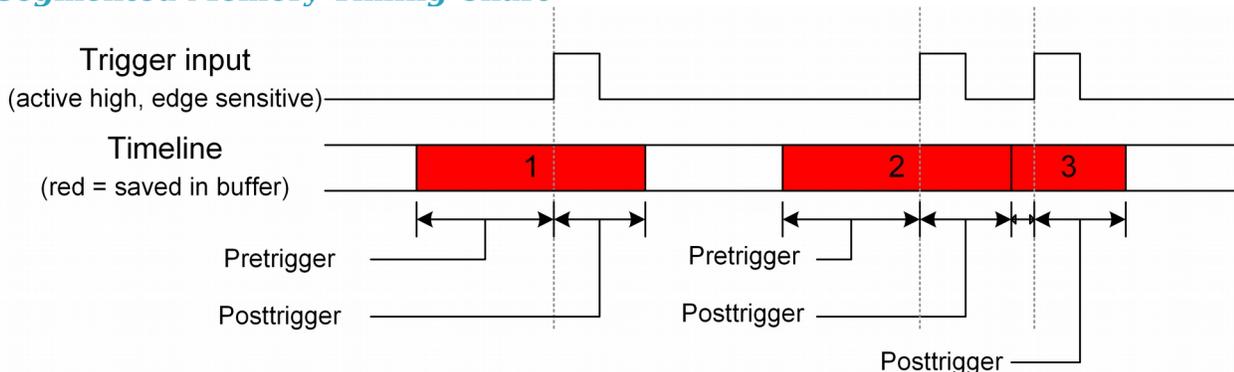
When the recording is started, and with each trigger, a new segment is stored in memory. The segments of video are concatenated during playback and saving.

By default, the ring buffer is enabled. So, after the buffer fills, the earliest segment may be overwritten with a new one. New segments will be created until the recording is stopped with the red shutter button on the top of the camera, or the Stop button on the main screen. This behavior can be changed by checking Disable Ring Buffer so that the camera will instead stop recording when the buffer is full.

Currently, there are two limitations for recordings and segments:

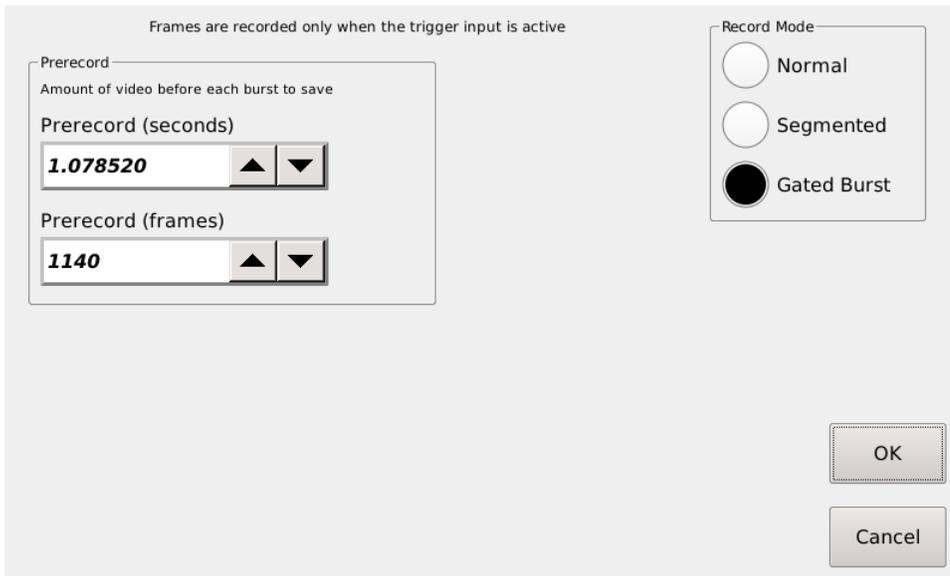
- New recordings are only be started using the red shutter button on the top of the camera, or the Record button on the main screen.
- New segments are only started when a signal is received a trigger input on the side of the camera, depending on the configuration in IO Settings.

Segmented Memory Timing Chart



Control	Function
Record Length (seconds)	Set the duration of the recorded segment, in seconds . The timing of this recording can be changed in the Trigger Delay window.
Record Length (frames)	Set the duration of the recorded segment, in frames . The timing of this recording can be changed in the Trigger Delay window.
Max button	Sets record length to the maximum available for your model and the selected number of segments.
Number of Segments	The minimum number of recordings to hold in memory. Each time a recording is triggered, it is saved into a subsequent region of memory. If a recording is stopped early, the unused recording time is returned for future segments to draw from. For example, two 0.5-second segments can be recorded instead of one 1-second segment.
Record Mode column	Choose how externally triggered videos are saved to memory. In Segmented mode, many videos can be stored in memory before having to save them.
Disable Ring Buffer	When the buffer is full with segments, stop recording instead of overwriting the oldest segment with a new one.
OK	Applies the record mode changes and closes the window. (Changes will still be discarded if 'OK' is not selected on the record settings window.)
Cancel	Discards the record mode changes and closes the window.

Record Mode, Gated Burst

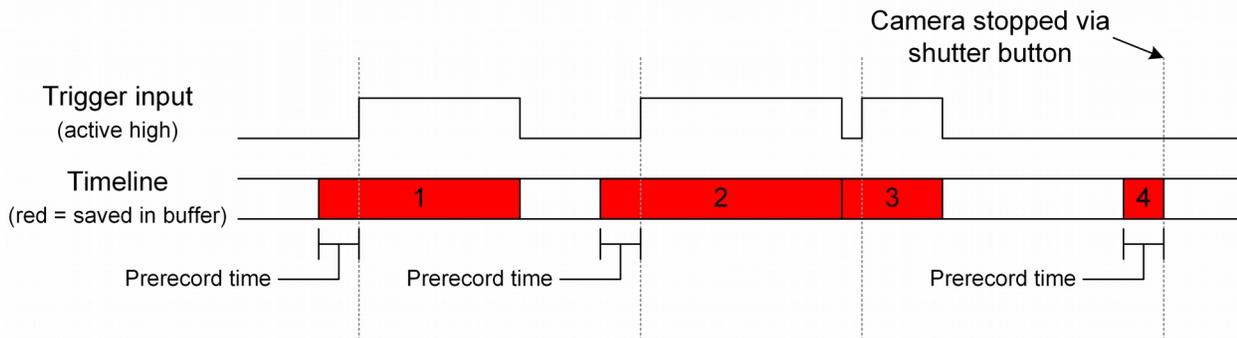


In Gated Burst mode, multiple videos are kept in memory. Video is only recorded when the trigger input is active. Record mode only affects which frames are stored in memory; it does not affect exposure time. As frames are recorded, they are stored in a ring buffer. The oldest frames are overwritten with new frames as the trigger continues to be active. Recorded frames are concatenated during playback and saving.

Currently, there are two limitations for gated burst mode:

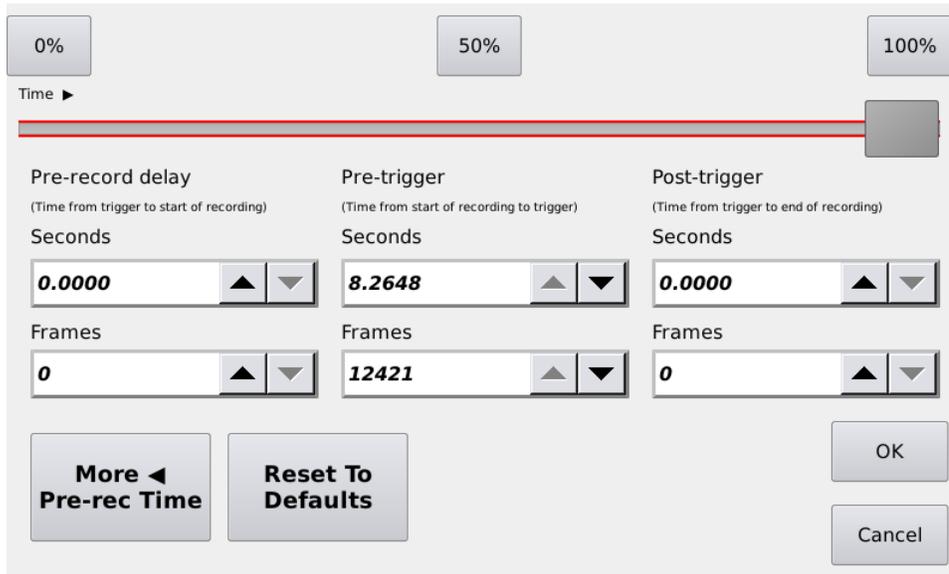
- New recordings can only be started/stopped using the red shutter button on the top of the camera, or the Record button on the main screen, not the trigger inputs.
- New frames are only recorded when the Record End Trigger, as configured on the IO Settings screen, is held high.

Gated Burst Trigger Timing Chart



Control	Function
Prerecord (seconds)	Set the amount of video to save before the trigger becomes active, in seconds .
Prerecord (frames)	Set the amount of video to save before the trigger becomes active, in recorded frames .
Record Mode column	Choose how externally triggered videos are saved to memory. In Gated Burst mode, many videos can be stored in memory before having to save them.
OK	Applies the record mode changes and closes the window. (Changes will still be discarded if 'ok' is not selected in the record settings window.)
Cancel	Discards the record mode changes and closes the window.

Trigger Delay



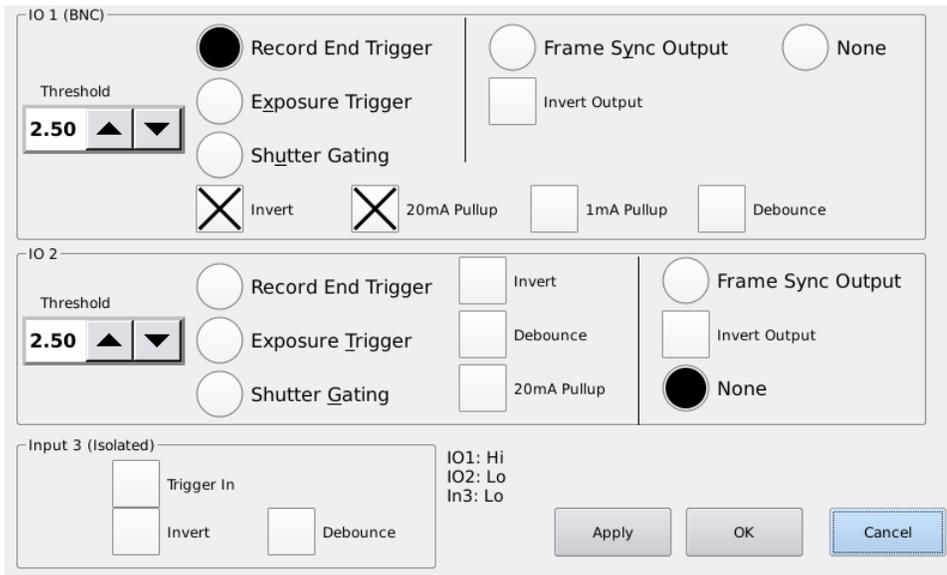
The Trigger Delay page lets you configure when video is captured relative to an external trigger, such as TRIG1, on the side of the camera. **Note: Does not apply to the red record button on the camera.**

The total record duration is set in the Record Modes screen.

Control	Function
0%, 50%, 100%	Move the slider to the start, middle, or end of the red "recording this" region. This sets the pre-record delay, pre-trigger, and post-trigger values. A value of 0% means that all video saved will be after the trigger (post-trigger mode). A value of 100% means that all video saved will be before the trigger (pre-trigger mode).
Slider	Drag to set when the saved video starts and stops relative to a trigger.
Pre-record delay	Sets the amount of time to wait, after a trigger occurs. When the waiting period is over, the video will begin recording. You can specify this delay in either seconds or in frames. Example: If you are making a 0.5-second long recording, and you set the pre-record delay to 0.2 seconds, then the camera will wait for 0.2 seconds after you trigger it, start recording, and finally stop recording 0.7 seconds after you initially triggered it.

Pre-trigger	<p>Sets the amount of time to record before a trigger happens.</p> <p>Example: If you are making a 5000-frame long recording, and you have a pre-trigger time of 2000 frames, when the trigger occurred the camera would record 2000 frames of footage from before the trigger, and another 3000 after the trigger.</p> <p>Note: The Chronos is always recording to a ring buffer. (the digital equivalent of a loop of tape). New footage is constantly replacing old. Since the camera is always recording, there is no additional battery drain from using pre-trigger time.</p>
Post-trigger	<p>Sets the amount of time after a trigger to record. If both pre-record delay and pre-trigger are 0, post-trigger is the total length of the recorded video.</p> <p>Example: If you are making a 0.5-second long video, and you set the post-trigger delay to 0.3 seconds, then the pre-trigger delay would be 0.2 seconds because the half-second of video would have to start before you triggered the recording.</p>
More ◀ Pre-Rec Time	Add or increase margin to the left of the slider to enable selecting a delay after trigger before recording.
Reset to Defaults	Set pre-record delay to 0, post-trigger to 0, and pre-trigger to the duration of the video to be captured. (That is, the recording will end on the trigger event.)
OK	Applies the trigger delay changes and closes the window. (Changes will still be applied even if 'ok' is not selected in the Record Settings window.)
Cancel	Discards the trigger delay changes and closes the window.

Trigger / IO



The Trigger I/O screen allows the configuration of external inputs and how they affect the recording process.

Multiple triggers of the same effect are combined with a logical OR. Edge detection, which is used for record end trigger, is applied after this operation.

Note: If using either “Exposure Trigger” and “Shutter Gating” mode, there must be a stable and repetitive trigger at the desired framerate on the chosen trigger input. Normal recording is prevented when either mode is used without such a signal.

Control	Function
Threshold	Sets the input threshold voltage (in volts) for that IO. When the threshold is crossed, the input state changes between high and low. Range is 0 to 6.6V.
Record End Trigger	Sets function of IO to trigger input, allowing that input to be used to trigger the end of recording.
Exposure Trigger	Sets function of IO to control the start of exposure for each frame. See “Synchronizing to External Sources” for details.
Shutter Gating	Sets function of IO to control the start and length of exposure for each frame. See “Synchronizing to External Sources” for details.

Frame Sync Output	Sets function of IO to frame sync output. Output will be active when shutter is open. Can be inverted with Invert checkbox under Frame Sync Output radio button.
None	Disables the associated IO.
Invert (Trigger Input)	Inverts the input level, so that trigger input will be sensitive to low level instead of high when checked (ie. Recording ends when trigger is pressed instead of when it is released).
Debounce	Use a 10ms debounce filter on the input. This is recommended when using a physical button or switch on the input to avoid glitches due to contact bounce.
Pullup checkboxes	Enables 1mA or 20mA pullup on trigger input when checked. Enabling both will result in a 21mA pullup.
Input 3 Trigger In	Enables input 3 for trigger input.
Input Status	Shows the current level of 3 inputs, after optional inversions are applied. (Located to the right of Input 3.)
Apply button	Applies IO settings but leaves window open.
OK button	Applies IO settings and closes window.
Cancel button	Discards changes and closes window.

Play Screen

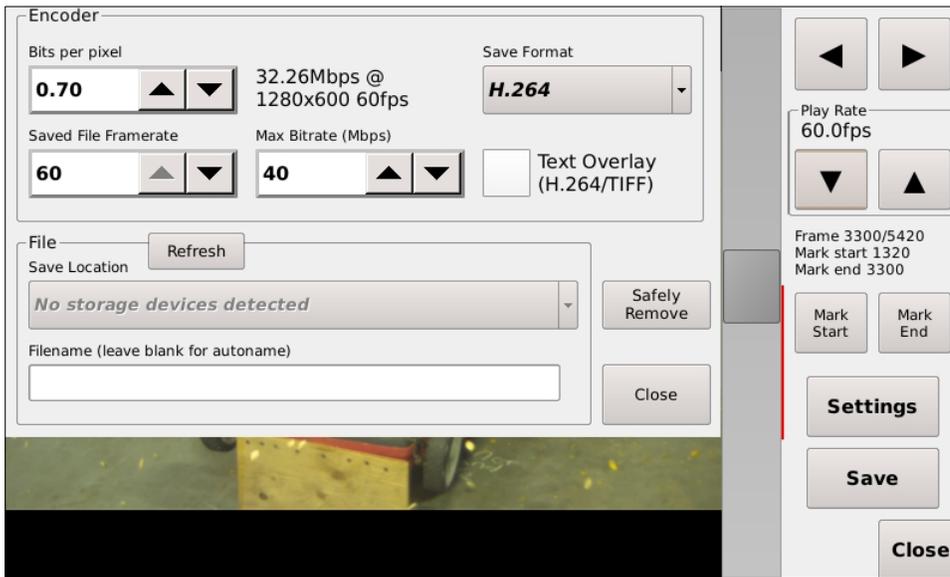


The playback mode allows review, trimming and saving of the recorded video on the Chronos. The image on the left displays what was previously recorded. The colored bar to the right of the playback slider indicates the region to be saved, along with any previously saved regions. Each saved region is colored differently.

Control	Function
Playback Slider	Scroll bar controls playback position over the entire recording. The bottom is the beginning of the buffer, and the top is the end.
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.
◀ or ▶ buttons	Plays back recorded video backwards or forwards.
Play Rate ▲ or ▼ buttons	Increases or decreases playback rate when play buttons are pressed. Range: 10 to 1920fps. This control does not affect the playback rate of saved video - that is set in the Settings popup.
Frame/Mark indicators	Shows the current frame, number of frames recorded, and the current mark start and mark end frame positions.
Mark Start or Mark End buttons	Sets the save start or save end position to the currently displayed frame. Only the marked region will be saved.
Settings button	Opens the Save Settings popup. This is where the framerate, save format and Text Overlay are set.

Save button	Starts saving the marked region of video.
Close button	Returns to live video mode. This does not erase the recording; it will remain in memory until a new recording is started, a black cal is performed, resolution is changed, or the video is otherwise cleared.

Save Settings



The save settings popup, in the top-left corner of the Play Mode screen, lets you set how the file is written to the external storage device. By default, it saves H.264-encoded .mp4 files to the most recently attached storage device.

Bits per pixel, Saved File Framerate and Max Bitrate are only used when saving in H.264, so they are disabled when any other format is selected.

Save Settings:

Control	Function
Bits per pixel	Primary quality control for H.264 (MPEG) encoded saved video. Resolution- and Frame-rate-independent control of video bitrate.
Max Bitrate	Sets a limit to the playback data rate, in megabits per second, used by the H.264 encoder.
Resultant bitrate	Shows the bitrate and frame rate calculated from the bits per pixel setting.
Saved File Framerate	Sets the playback frame rate for saved video files. This is limited to whole numbers. It does not affect the quality or size of the file.

Text Overlay (H.264/TIFF)	When enabled, the timestamp overlay will be shown on top of the image in playback mode, and in videos that are saved in the H264 or TIFF formats. Information about each frame's position within the recording will be burned into the saved image, in the bottom right corner. It follows this format: CurrentFrame/TotalLength sg=CurrentSegment/TotalSegments T=TimeAfterTrigger
Save Location	Selects the storage device for saved video. This list automatically refreshes, selecting the most-recently attached device, although 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 named vid_<date and time>.mp4
Safely Remove	Finish any outstanding writes to selected storage device. When this has completed, you can unplug the storage device without losing data.
Close button	Closes the Save Settings dialog. (Settings are applied automatically as they are changed.) Enables closing the playback screen to the main screen.

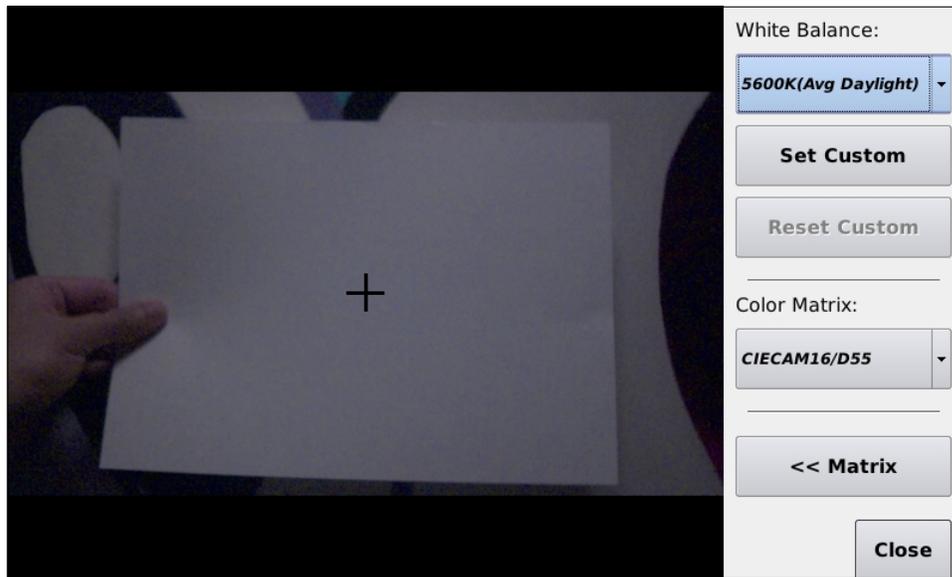
Comparison of Save Formats

H.264 and the Raw formats both save the entire video in a single file.

CinemaDNG, TIFF and TIFF Raw will create a folder and save each frame as a separate image in that folder.

Save Format	Image Quality & Use Cases	Details	Bitrate at 1280x1024 60fps
H264	<p>H264 is the quickest and easiest way to get videos off the camera, as saving is fastest, videos are small and no video editor is required.</p> <p>Some quality loss will occur due to compression. This is the only save format that uses compression.</p>	<p>Compression settings for quality and framerate are specified in the Encoder section of the save settings window.</p> <p>The overlay can be saved when using this format.</p>	Up to 60 Mbps
Raw 16bit / Raw 12bit	<p>Raw12 is the quickest way to get a raw video off of the camera, since Raw 12bit produces files 3/4 the size of Raw 16bit.</p> <p>Raw16 is kept for legacy purposes.</p>	DNG images can be extracted from the raw file using an external tool, such as our 'pyraw2dng' python script.	16bit: 1258 Mbps 12bit: 943 Mbps
CinemaDNG	<p>CinemaDNG has the best image quality and compatibility with video editing software.</p>		1258 Mbps bits/pixel: 16
TIFF	<p>TIFF is also compatible with a wide variety of software.</p> <p>On monochrome cameras, TIFF is generally preferred over CinemaDNG.</p> <p>On color cameras, image quality is slightly lower than CinemaDNG because the camera's own demosaic algorithm and color correction are applied, instead of letting it be applied after transfer to a computer.</p>	The overlay can be saved when using this format.	Mono sensor: 629 Mbps bits/pixel: 8 Color sensor: 1887 Mbps bits/pixel: 24
TIFF Raw	<p>TIFF Raw is mainly for scientific use, since brightness is linear-encoded, instead of gamma-encoded.</p>	No on-camera demosaic.	1258 Mbps bits/pixel: 16

Set White Balance



Set white balance to correct for lighting temperature or tint. Color correction and white balance are only applied when saving in the H.264 and TIFF formats.

To use a preset white balance, open the drop-down menu at the top-right and select the preset closest to your current conditions. The number component (5600K pictured) is the color temperature in which a white object will appear white. A description of when light of this color is usually encountered is listed after the number.

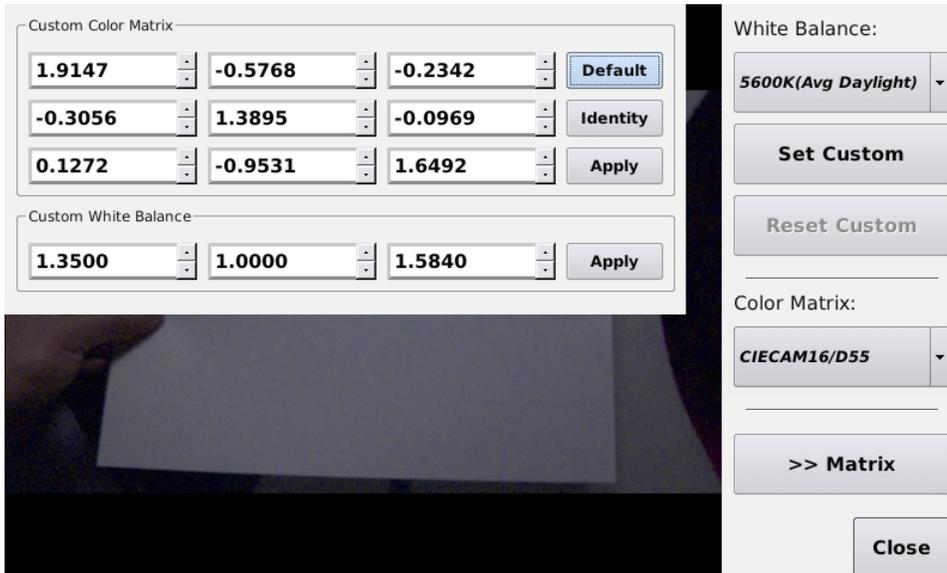
To auto-set a custom white balance based on a reference white (ideally an 80% gray card), aim the camera so the crosshair in the center is over the reference and tap the Set Custom button. Leave the Custom Color Matrix window closed during this.

To manually set a custom white balance, use the Custom Color Matrix window.

Control	Function
White Balance	Choose from preset and custom white balances.
Set Custom White Balance	Sets custom white balance based on white reference, or manually entered values if the Custom Color Matrix window is open. Stores it as "Custom" in the dropdown.
Reset Custom White Balance	Resets the custom white balance to the value it had when the White Balance dialog was opened.
Color Matrix	Displays which color correction matrix is selected - one of two presets, or Custom, if a custom matrix is in use. The presets will produce the most correct colors under a D55 illuminant.
Matrix	Opens/closes the Custom Color Matrix window.
Close button	Closes the White Balance dialog.

Custom Color Matrix Window

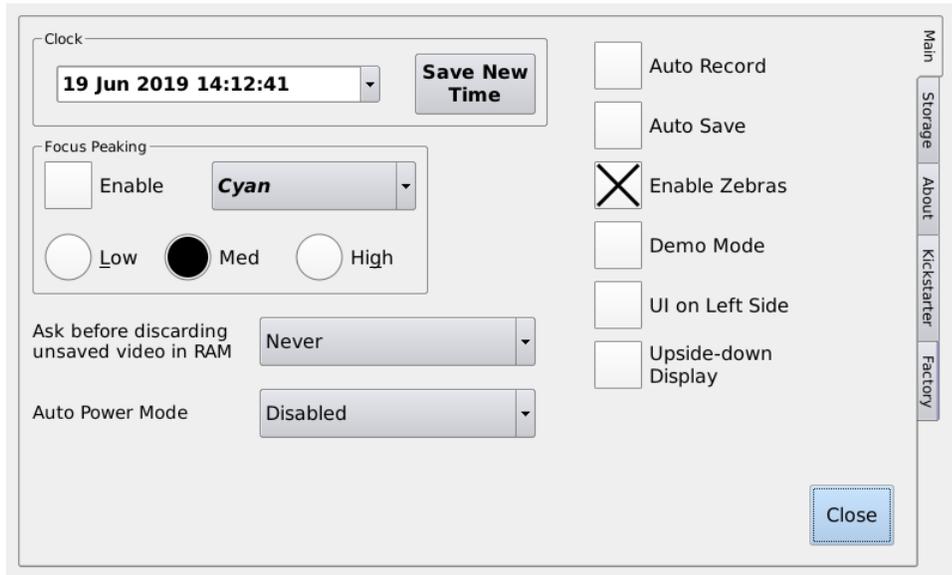
This window allows manual editing of the values used to process colors.



Control	Function
Custom Color Matrix	These 9 values are used in the process of converting between color spaces. Edits to them will be visible on the image immediately, but will be reset unless the Apply button is pressed.
Default	Resets color matrix values back to default, CIECAM16/D55.
Identity	Sets color matrix values to an identity matrix, which will effectively bypass the color space conversion step.
Apply (middle-right)	Stores the color matrix values so that they will be applied each time the "Custom" preset is selected as the Color Matrix, and after a reboot.
Custom White balance	These 3 values are used to counteract slight variations in color temperature and tint.
Apply (bottom-right corner)	Stores the white balance values so that they will be applied each time the "Custom" preset is selected as the White Balance, and after a reboot.

Util Screen

Main Tab



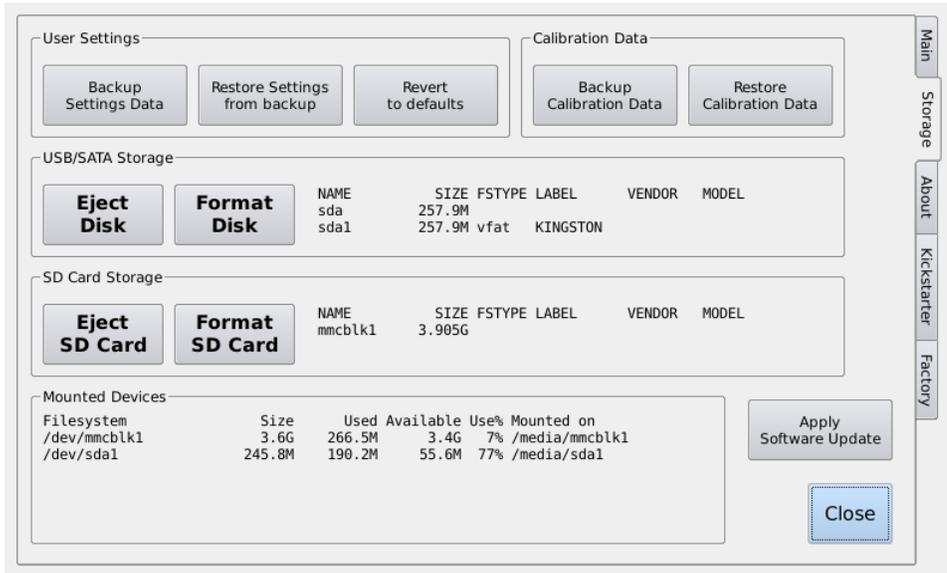
The Utilities page contains general settings and information about the camera. More functions can be accessed through the tabs on the right.

Control	Function
Clock Setting ----- Save New Time	The setting box allows you to adjust the camera's date and time. 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. The Save New Time button applies the current time in the clock adjustment box to the camera's clock.
Focus Peaking Enable	Enables focus peaking function, which highlights in-focus objects with a conspicuous color. This can also be toggled from the main screen via the "Focus Aid" checkbox there.
Focus peaking Color	Selects the color used to highlight edges.
Focus peaking sensitivity	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. Reduced sensitivity will allow more accurate focusing on bright edges.

Ask before discarding unsaved video in RAM	<p>Select when warnings about overwriting the video stored in memory will be shown. The warning manifests as a popup titled "Unsaved video in RAM" when you press the record button. Selecting OK continues, while Cancel lets you go back and save the video just recorded.</p> <p>This setting has three levels:</p> <ul style="list-style-type: none"> • Always: Prompts when before starting a recording regardless. • If not reviewed: Prompt when you start a new recording, but only if you haven't opened previous recording in the Play screen. • Never: disables the prompt entirely.
Auto Power Mode	<p>This sets whether the camera does one, both or neither of these:</p> <ul style="list-style-type: none"> • Turn on when AC power is connected. <ul style="list-style-type: none"> ◦ Note: If the power button is pressed while this option is enabled and the AC power is connected, the camera will reboot instead of shutting down. • Shutdown when AC power is lost.
Auto Record	<p>Upon booting the camera, and after successfully finishing a video save, automatically start a new recording, even if only a portion of the buffer was saved.</p> <p>If Auto Save is selected as well, this will form a continuous loop. This loop can be broken by tapping any of the main screen buttons except for Focus Aid or Record, and then choosing to stop the recording.</p>
Auto Save	<p>When a recording ends, automatically save the entire recording.</p> <p>If Auto Record is selected as well, this will form a continuous loop. This loop can be broken by tapping any of the main screen buttons except for Focus Aid or Record, and then choosing to stop the recording.</p> <p>Before enabling autosave, set a save location manually in savesettings, if it is not already set to a valid location. Filename does not need to be set with autosave, as videos will always be named automatically using the date and time of the save to avoid conflicts with any previously saved videos.</p>
Enable Zebras	<p>Enables the overexposure indicator which shows a rolling zebra line pattern on areas of the image that are clipped.</p>

Demo Mode	Makes available an alternative playback mode where the playback will loop in the region marked by the user, once the button is tapped on the Play screen.
UI On Left Side	Move the main window, playback and white balance windows to the left side of the screen.
Upside-down Display	Rotate the display 180°. Useful when the camera itself is mounted upside-down.
Close button	Returns to the Main window. Settings are applied automatically as they are changed, except for Upside-Down Display and the clock setting.

Storage Tab



Manage camera settings, calibration, and storage devices.

Control	Function
Backup Settings Data	Backup settings configuration, such as Focus Peaking, resolution and Trigger/IO Settings, to a USB drive. This is useful to make backups, so you can restore your camera’s configuration state, or to save your settings while replacing the system SD card.
Restore Settings from backup	Restore saved UI settings from a USB drive.
Revert to defaults	Set the camera UI settings back to the factory default.
Backup Calibration Data	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, in the bottom of the camera, becomes corrupt and needs to be recreated. This excludes saved user-made black cal data, which can be deleted using the Remove User Calibration Data button on the Factory tab.
Restore Calibration data	Restores the camera's factory calibration data from a USB drive.

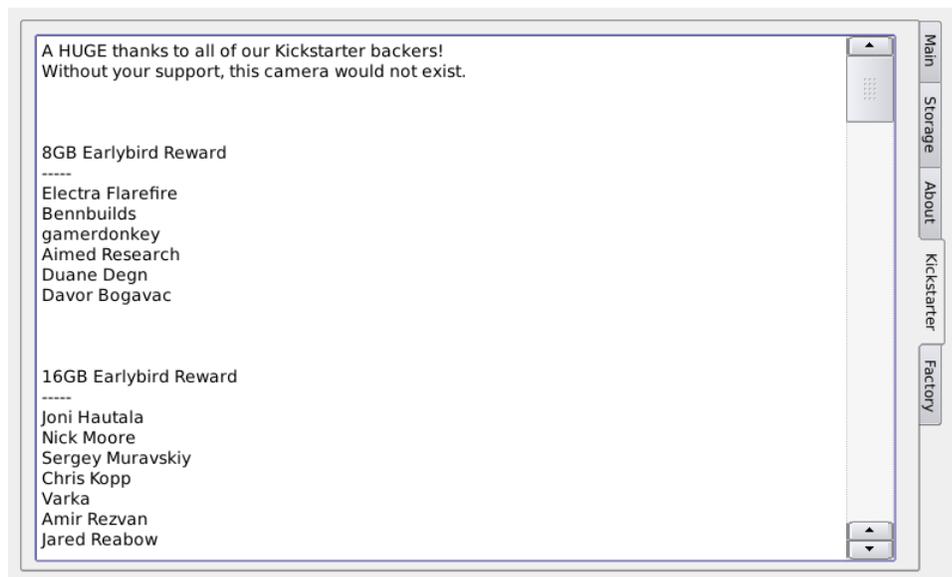
Eject Disk and Eject SD Card	Finish any outstanding writes to the selected storage device. When this has completed, you can unplug the storage device without the risk of losing unwritten data.
Format Disk and Format SD Card	Formats the selected storage device with a FAT32 filesystem, which can be used for saving videos or updating the camera's software.
Apply Software Update	Applies a software update from a USB drive or, if updating from software v0.3.1-RC1 or later, an SD card in the top slot of the camera.

About Tab



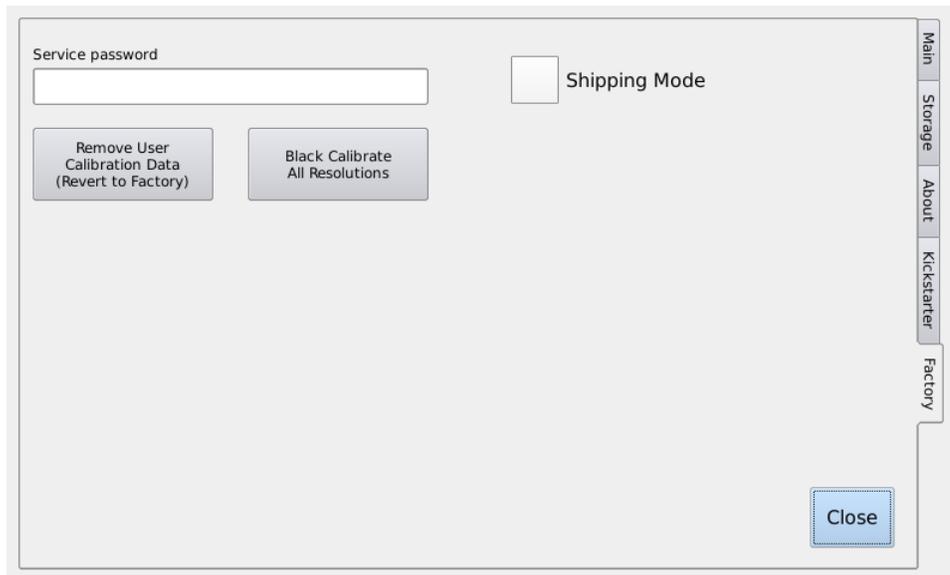
Shows information about the camera, such as model, serial number, and software version.

Kickstarter Backers Tab



A list of the excellent people who contributed to our kickstarter campaign. Without these people, the Chronos would not exist. Take a moment, and scroll through the list.

Factory Tab



The factory tab contains functionality related to the manufacturing of the camera.

Control	Function
Service Password	Enter service mode. Voids warranty if used other than under direction of Kron Technologies.
Remove User Calibration Data (revert to factory)	<p>Remove the user-saved black calibration data. One calibration file is added to the camera’s bottom SD card each time you press the black cal button on the main screen while using a combination of resolution/gain that has not been calibrated yet.</p> <p>Factory calibration data is different from black calibration data. The buttons to save and restore factory calibration data can be found back on the Main tab.</p>
Black Calibrate All Resolutions	Perform black calibration for all of the standard resolutions (the ones listed in the drop-down menu on the Record Settings screen) at their max framerate. This may take 4-10 minutes.
Shipping Mode	<p>Enable this mode before shipping the camera with a battery inserted.</p> <p>To prevent accidentally powering on the camera, the AC adapter must be plugged in to turn the camera on, even if a battery is inserted. It will not be required for subsequent powerons.</p>

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 and 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 and 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.
- **Before shipping, always enable Shipping Mode**, found on the Util menu, under the Factory tab, to avoid the possibility of the camera turning on in-transit. This mode requires the AC adapter to be connected the next time the camera is turned on.

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.
Camera won't power on, and Power status indicator flashes orange when power button is pressed	Shipping Mode is enabled.	The AC adapter must be plugged in to turn the camera on while in shipping mode, even if a battery is inserted. It will not be required for subsequent powerons.
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 or vertical lines show up in video	Black cal not done after changing shutter speed, resolution or gain	Perform black cal after every change of resolution, shutter speed or gain.

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, so focus needs to be adjusted after zooming.
Black ring around image / Corners of image are dark	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 with a larger image circle to eliminate.
Negative ghost image visible over normal image	Black cal done without lens cap on or with aperture open.	Perform black cal again by closing aperture fully, or covering lens.
Camera shows a black or still image	Trigger mode is either "Exposure Trigger" or "Shutter Gating", but there is no external signal being received.	If you do not wish to use either of these modes, go to Trigger/IO Settings and switch back to Record End Trigger for normal operation.
		If you do wish to use one of these modes, check that you have the correct input selected (IO 1 or 2) or connect a signal generator and send a signal of frequency equal to the desired framerate.

Reference Information

Specifications

Camera	<i>Imaging</i>	1280x1024 1069fps, see resolution table for details
	<i>Memory</i>	8GB, 16GB, or 32GB
	<i>Record Time</i>	4 seconds (8GB), 8 seconds (16GB), 16 seconds (32GB)
	<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	
Video formats	<i>H.264</i>	Industry-standard mp4 files at bitrates up to 60Mbps
	<i>cinemaDNG Raw</i>	standard Adobe cinemaDNG raw files
Image Sensor	<i>Resolution</i>	1280x1024 @ 1069fps
	<i>Speed</i>	1.4Gpx/s - Full throughput down to 320 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 1us (1/1000,000 s)
	<i>Dynamic Range</i>	56.7 dB
	<i>Bit Depth</i>	12-bit
Battery	<i>Type</i>	EN-EL4a
	<i>Runtime</i>	1.5 hours recording (typical)
	<i>Charge Time</i>	2 hours (0-80%)
IO	<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 only HDMI output, 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
	Trigger modes	<i>Normal Triggered</i>
<i>Triggered start</i>		Camera starts recording after a defined delay after a trigger
Trigger Sources	<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
Recording modes	<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>Gated Burst</i>	<i>Frames are captured while trigger is active.</i>
	<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>Normal + Continuous*</i>	High-speed video is recorded to the RAM buffer, while simultaneously 60fps video is saved to removable storage.
Shutter timing	<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 duration is controlled by camera.
	<i>Shutter Gating</i>	Image sensor shutter is directly controlled by an external input, exposing while the input is active.
Assistive	<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

Record Preset VS Record Duration

Maximum recording time for a sample of common resolutions at max FPS.

Resolution	Max FPS	Record time (sec) (8GB)	Record time (sec) (16GB)	Record time (sec) (32GB)
1280 × 1024	1069	4.08	8.16	16.33
1280 × 720	1519	4.08	8.17	16.35
1024 × 768	1770	4.11	8.22	16.45
1024 × 576	2357	4.11	8.23	16.47
800 × 600	2871	4.14	8.29	16.59
800 × 480	3586	4.14	8.29	16.58
640 × 480	4434	4.20	8.40	16.81
640 × 240	8810	4.21	8.42	16.85
320 × 240	16683	4.40	8.82	17.64
320 × 180	22090	4.41	8.82	17.66
320 × 96	40420	4.51	9.02	18.04

Record duration stays relatively constant as the resolution is lowered because the maximum frame rate is raised. There is some overhead associated with each frame, so the increase in FPS is not quite linear.

Record FPS VS Record Duration

Recording time for a sample of resolutions at max fps, half fps, and one-quarter fps.

Resolution	FPS	Record time (sec) (8GB)	Record time (sec) (16GB)	Record time (sec) (32GB)
1280 × 1024	1069	4.08	8.16	16.33
1280 × 1024	534	8.16	16.33	32.67
1280 × 1024	267	16.31	32.65	65.33
800 × 600	2871	4.14	8.29	16.59
800 × 600	1435	8.29	16.58	33.18
800 × 600	717	16.57	33.17	66.36
640 × 480	4434	4.20	8.40	16.81
640 × 480	2217	8.39	16.80	33.62
640 × 480	1108	16.79	33.60	67.23

The duration that can be recorded is doubled every time the frame rate is halved. The recording time increase is linear as the framerate decreases.

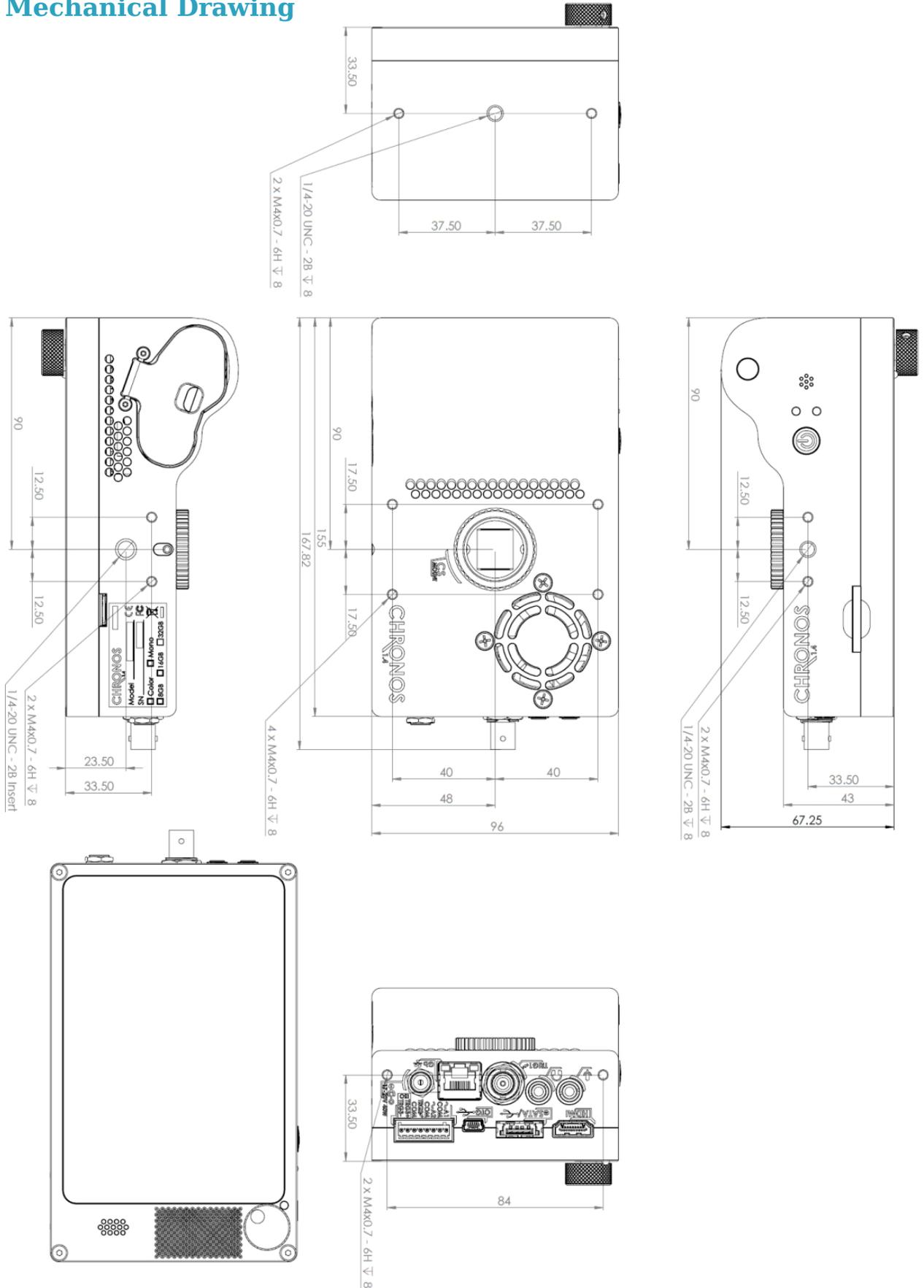
Record Resolution VS Record Duration

Recording time for a sample of frame rates as resolution is decreased.

Resolution	FPS	Record time (sec) (8GB)	Record time (sec) (16GB)	Record time (sec) (32GB)
1280 × 1024	1069	4.08	8.16	16.33
640 × 512	1069	16.31	32.65	65.33
320 × 256	1069	65.26	130.62	261.33
800 × 600	2871	4.14	8.29	16.59
400 × 300	2871	16.57	33.17	66.36
192 × 150	2871	66.29	132.67	265.44
640 × 480	4434	4.20	8.40	16.81
320 × 240	4434	16.57	33.16	66.35

As the resolution is halved in both height and width, the duration of the recording increases by multiples of 4. Halving the resolution results in $\frac{1}{4}$ the number of pixels, so 4 times the number of frames can be stored - $800 \times 600 = 480k$ pixels, while $400 \times 300 = 120k$ pixels.

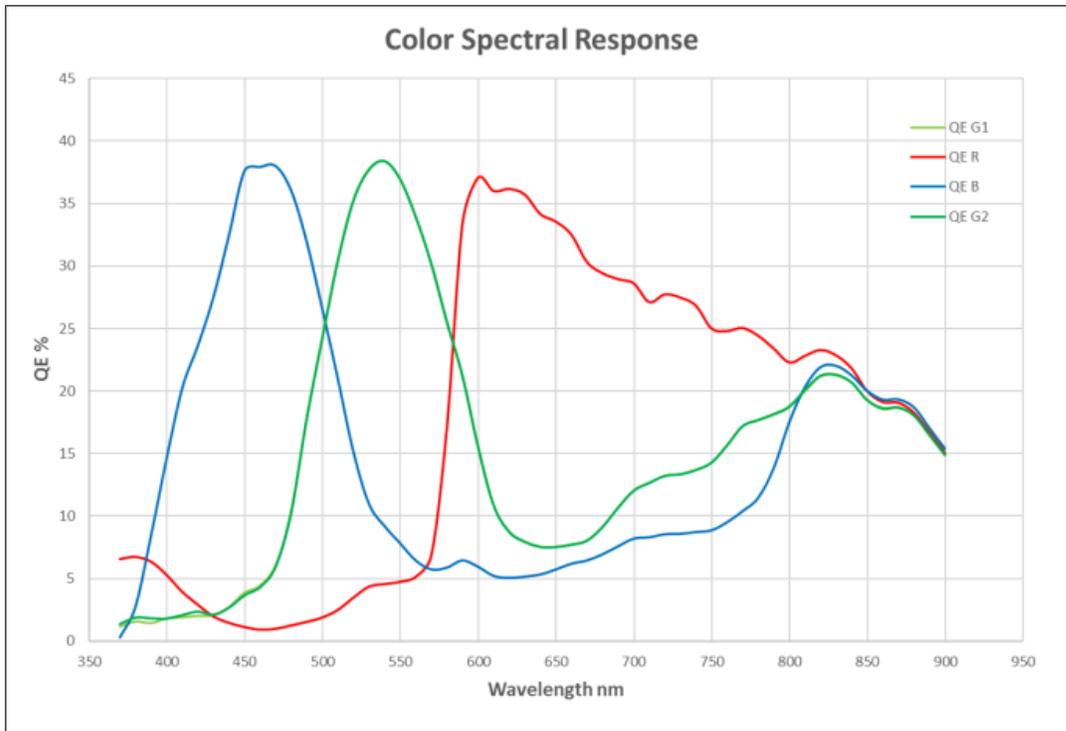
Mechanical Drawing



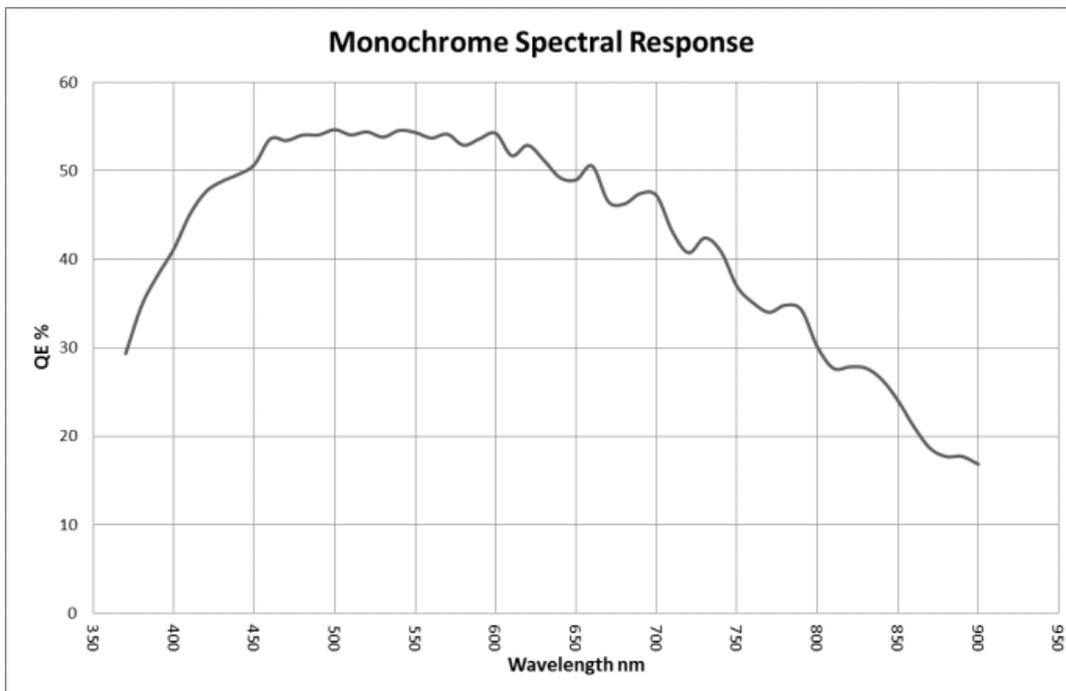
Spectral Response

Note: These spectral response curves are in units of quantum efficiency.

Color (without IR filter)



Monochrome (without IR filter)



User Notes