# CHRONOS
1.4
High-Speed Camera

User Manual
for
Software v0.3

Document Rev. 12
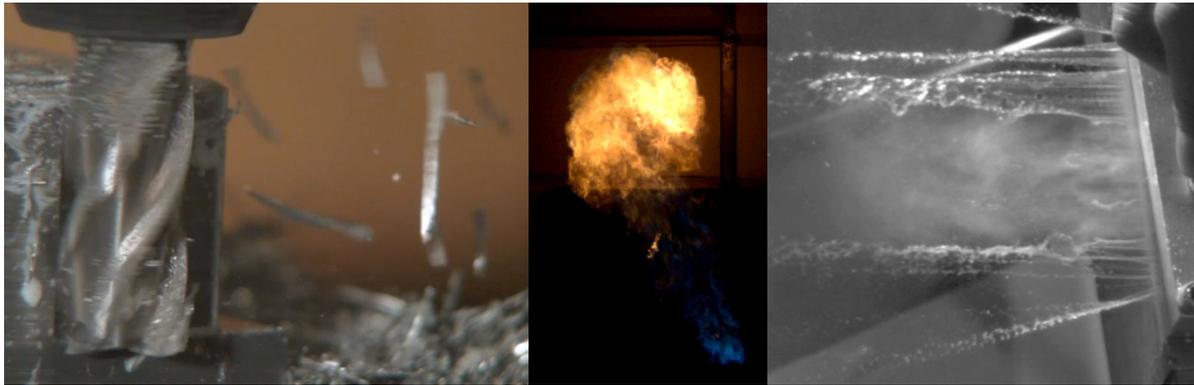
Thank you for choosing the Chronos 1.4 High Speed camera! The team here at Kron Technologies wishes you all the best of luck in your research, experimentation or just plain fun with the Chronos 1.4. This camera was designed to be accessible to everyone. We encourage you to share a hacking night with 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.

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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. 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 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 or shutter. (Black calibration issues often manifest as lines across the video.)
4. (*Optional*, for colour cameras) - Set white balance. Place a white card at the center of the frame and tap White Balance to calibrate colour 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 or USB drive in to the camera. The device must be formatted as FAT32, EXT2 or EXT3. For fastest saving, a class 10 SD card 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:
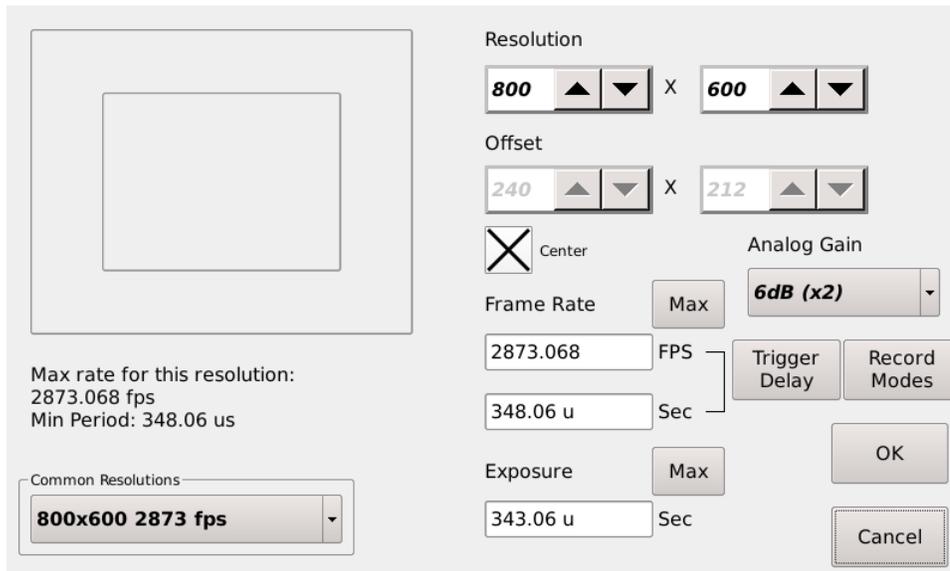
Figure 2 - Record Settings page

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 it 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, then click Apply to save the new value. 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 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 is 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. 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.
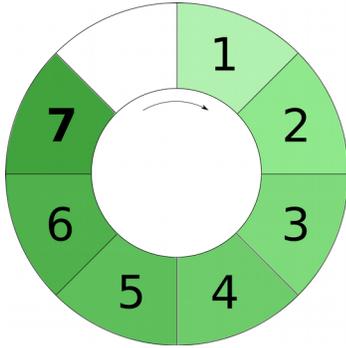
Figure 3 - 7 frames of video recorded into an 8-frame ring buffer.
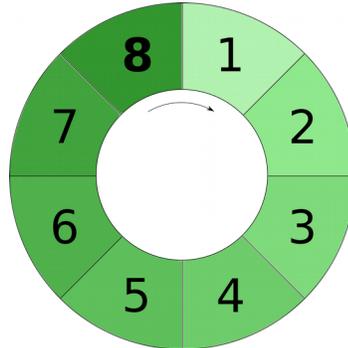
Figure 4 - 8 frames of video recorded into an 8-frame ring buffer.
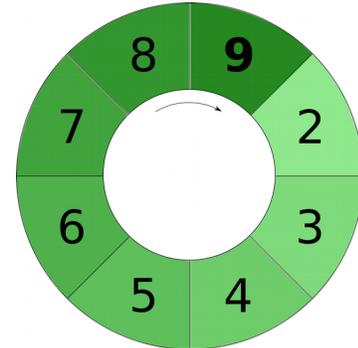
Figure 5 - 9 frames of video recorded. The 9th frame has replaced the 1st frame.

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.
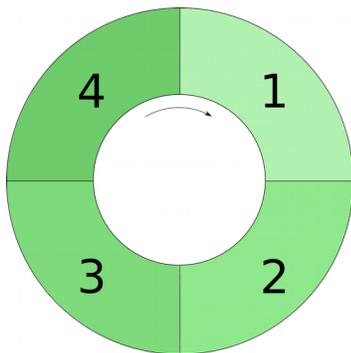
Figure 6 - 4 frames of 800×600 video fit in a ring buffer
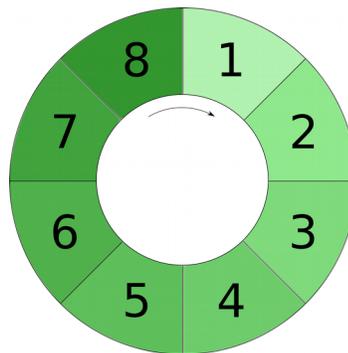
Figure 7 - 8 frames of 800×300 video fit in a ring buffer

Another way to record for longer is to record a smaller video. If 4 frames of 800×600 video fit into a ring buffer, then 8 frames of 800×300 video will fit into the same ring buffer.

Playback
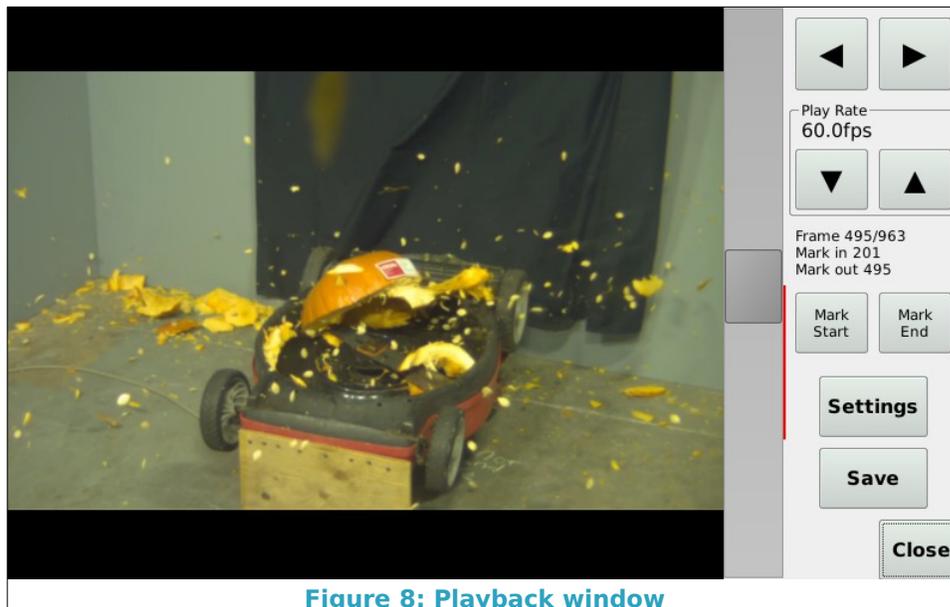
Figure 8: Playback window

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 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 or Raw 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 coloured bar.)

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.
4. (optional) Repeat to save another range of video.

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

Save Settings
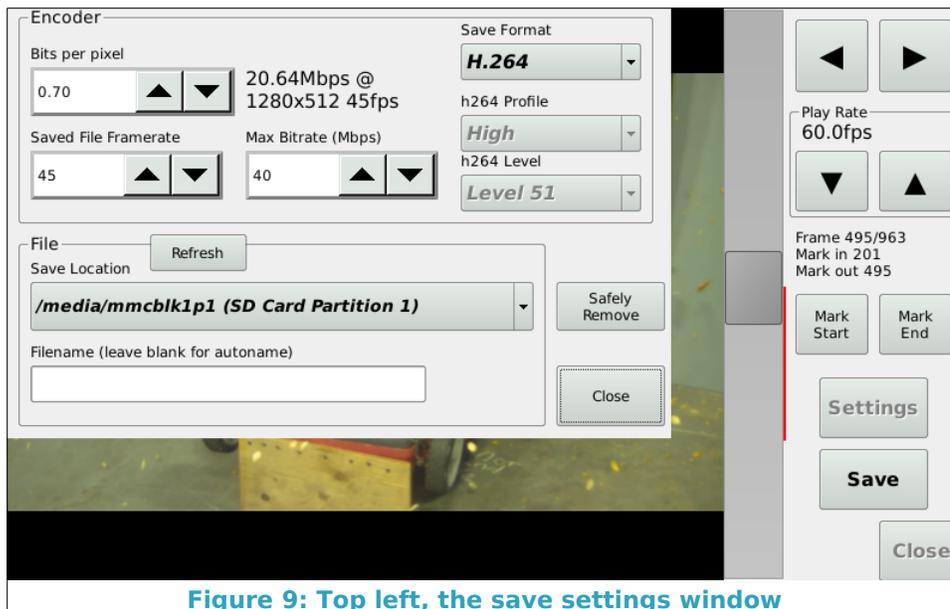
Figure 9: Top left, the save settings window

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 H264 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.

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, like 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

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. Delay from when the signal is received to when the action is taken is configured in *Record Settings → Trigger Delay*.

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

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

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 *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 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. (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 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 1us must be maintained, undefined operation may occur with a pulse width below 1us.
2. Exposure start must occur at least 2us after the end of the previous exposure.
3. Exposure end must occur at least one frame period (1 / (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.
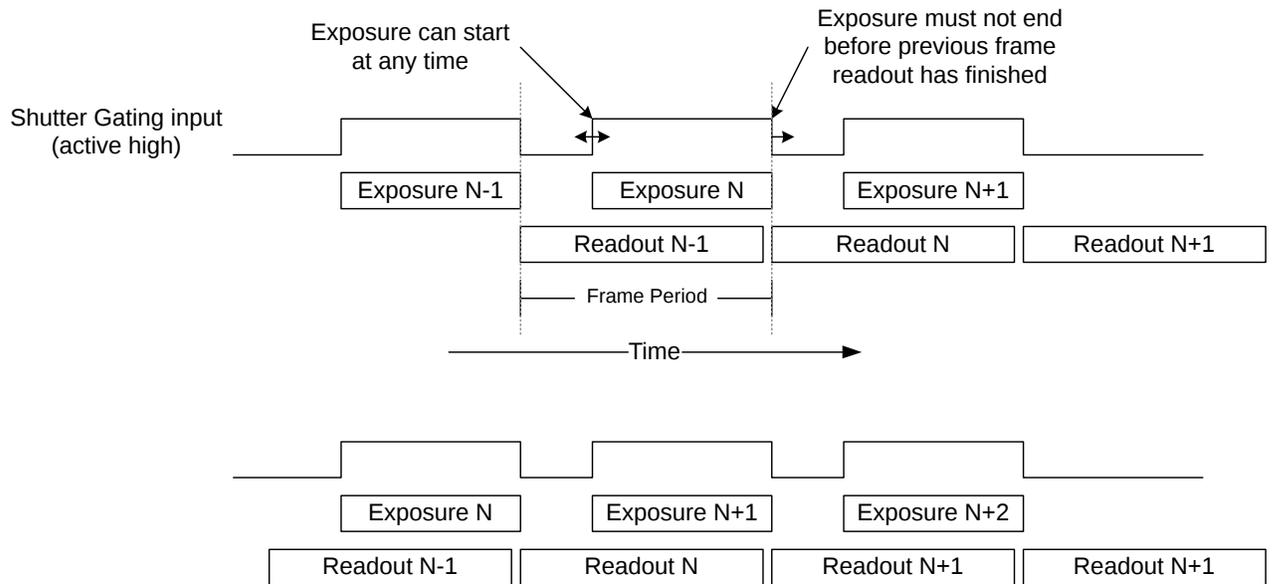
Figure 10 - Shutter gating timing

Hardware Reference

Hardware Overview

Back/Top
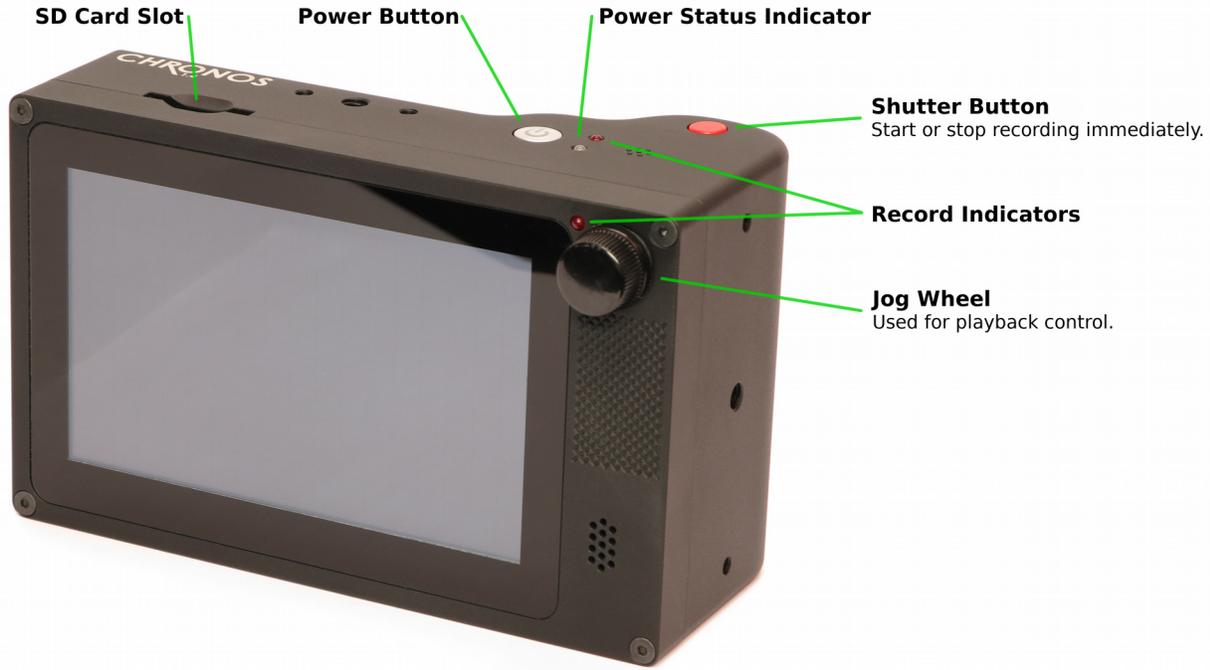
Figure 11 - Overview of camera (Back)

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

Side Connectors

HDMI
Not supported in current software

Audio IO
Not supported in current software

USB/eSATA
Fat32 and EXT2/3 storage supported

BNC
IO 1 in Trigger Settings.
0-6V adjustable threshold
30V DC/AC 50Vpk max

Mini-USB
Not supported in current software

Ethernet
Not supported in current software

Aux IO / Analog Input
Trig 2 and Trig 3 supported
IO 2 and IO 3 in Trigger Settings
0-6V adjustable threshold
30V DC/AC 50Vpk max

Power Input
17–20V 40W, positive tip, 5.5/2.5mm

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.

Mini USB OTG

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

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

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 HDMI support.

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
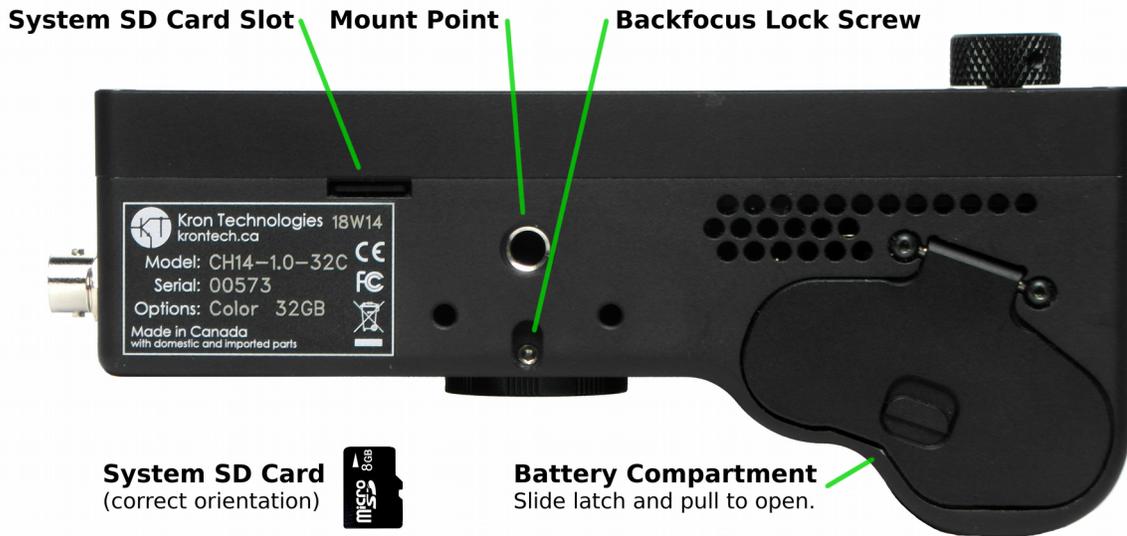
Figure 13 - Overview of camera (bottom)

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. Software upgrades are performed by writing 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 cut filter is standard on all cameras. The colour version of the camera comes with an IR cut filter for proper colour reproduction. All the colour 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 IO

Two trigger input/outputs and one isolated trigger input are available on the camera. Trigger IO is used by the camera to communicate to other equipment such as lights or external triggers. For example, if you had several cameras set up, you could use a trigger to start or stop them all at once.

Trigger IO 1 and 2

These non-isolated triggers are referenced to the camera's power and chassis ground, and can provide either input functionality with adjustable 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 14 - 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.
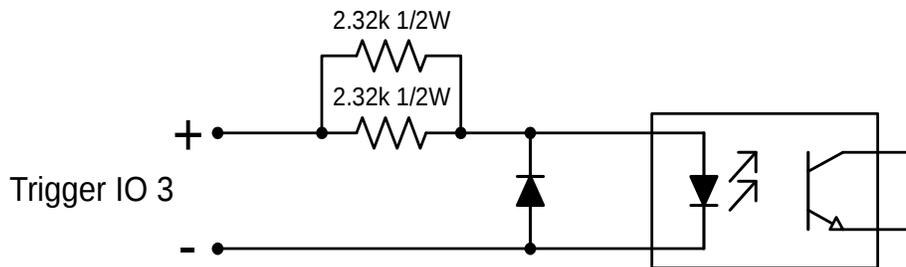
Figure 15 - Trigger IO 3 Schematic

Storage Devices

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

SD cards, USB thumb drives, and USB external hard drives are all fully supported. A class 10 or faster SD card, from a reputable manufacturer, is recommend. Different USB storage devices can have varying write speeds.

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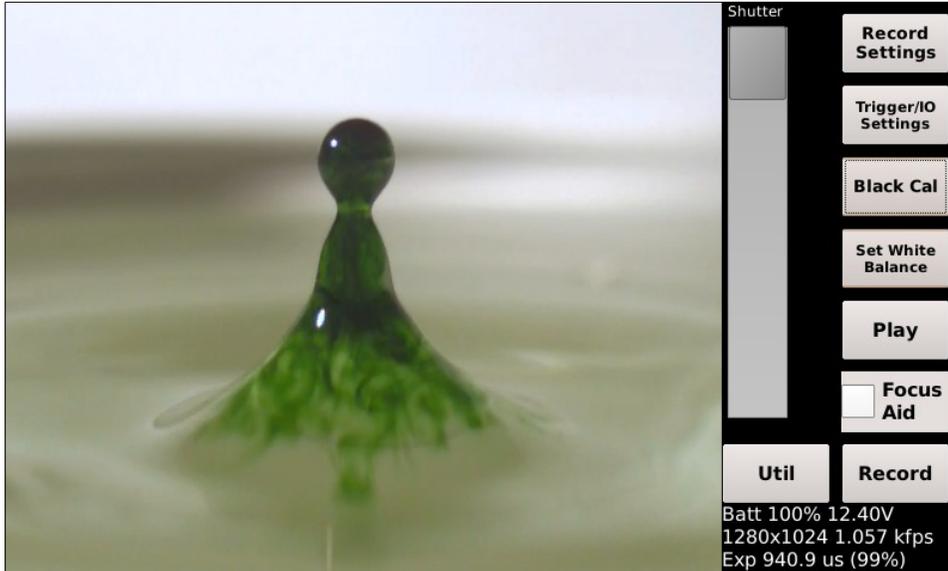
The main screen appears when the camera starts. The image on the left is what will be recorded.

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. Each resolution has a separate black calibration. No light should hit the image sensor while calibration is underway.
White Balance (colour 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 in a conspicuous colour. This can used when adjusting focus is challenging. The colour and sensitivity are 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 the clock, software update, and focus peaking/zebra controls.

Record Settings

The record settings page provides controls to set the captured area of the sensor and the frame rate at which the recording is taken. Lower resolutions can be captured at higher frame rates.

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	When checked, the recorded video 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 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 the maximum 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.

Gain	Colour ISO	Mono ISO
0dB (1x)	320	740
6dB (2x)	640	1480
12dB (4x)	1280	2960
18dB (8x)	2560	5920
24dB (16x)	5120	1184

Common Resolutions	Select a preset from common picture sizes and frame rates.
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 recorded area.
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 part of the camera's memory.

Note: The red trigger 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

Records frames in a segmented buffer, one buffer per trigger

Record Length (seconds)

`8.263`   ▲ ▼   Max

Record Length (frames)

`8734`   ▲ ▼

Segmented

Number of segments

`1`   ▲ ▼

Segment size:
8.26298 s
(8734 frames)

Record Mode

○ Normal

● Segmented

○ Gated Burst

OK

Cancel
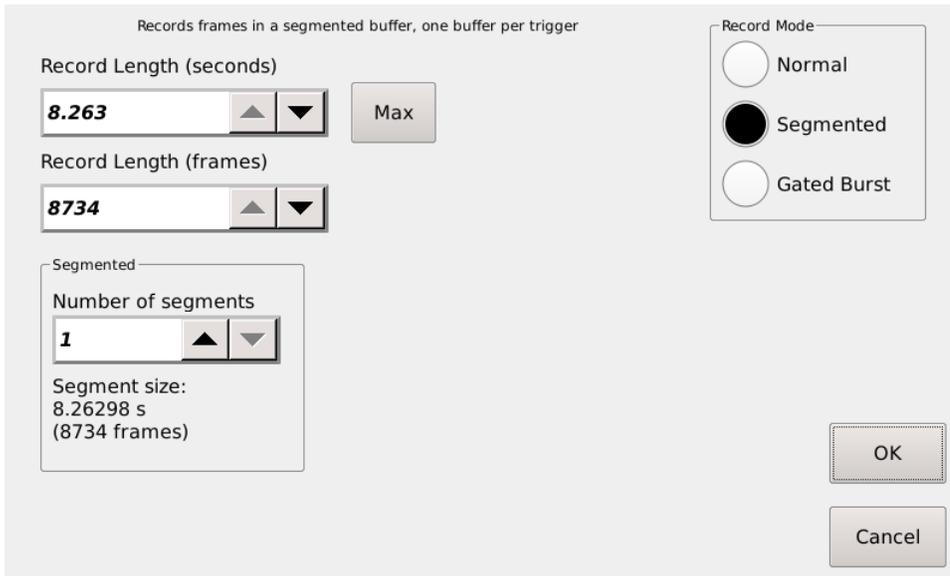
In Segmented mode, multiple videos are kept in memory. This is different than Normal mode, where only one video can be kept in memory. As segments are recorded, they are stored in a ring buffer. The oldest segments are overwritten with new segments as triggers occur. Segments of video are concatenated during playback and saving.

Segmented Memory Timing Chart

Trigger input
(active high, edge sensitive)

Timeline
(red = saved in buffer)

1   2   3

Pretrigger

Posttrigger

Pretrigger

Posttrigger

Posttrigger

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.
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.

Record Mode, Gated Burst
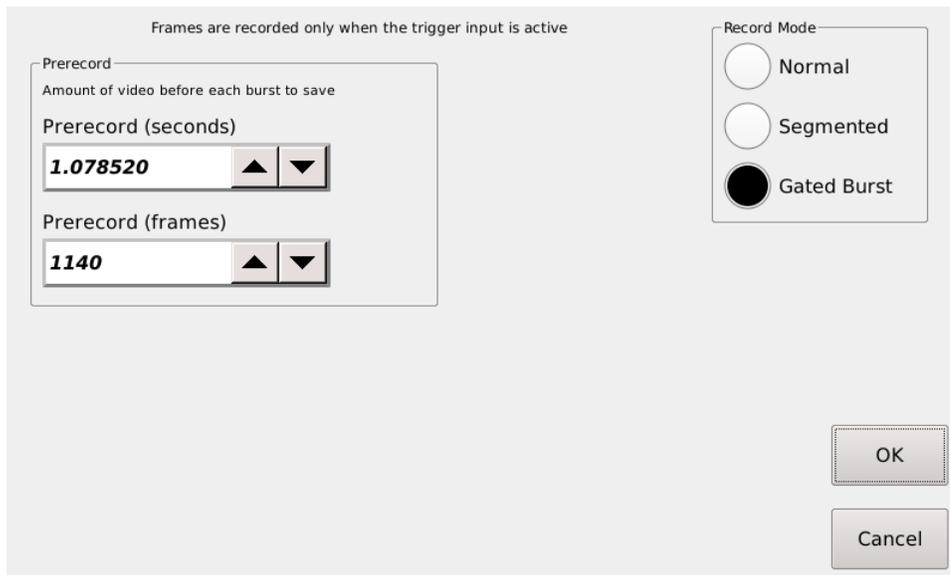
In Gated Burst mode, multiple videos are kept in memory. Video is only recorded when the trigger input is active. As segments are recorded, they are stored in a ring buffer. The oldest segments are overwritten with new segments as triggers occur. Recorded video segments are concatenated during playback and saving.

Gated Burst Trigger Timing Chart
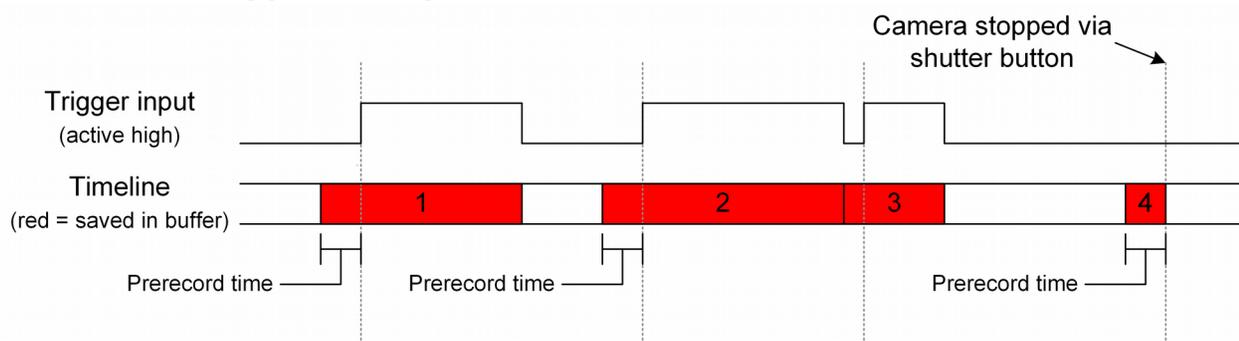
Control	Function
Prerecord (seconds)	Set the amount of video to save before the trigger becomes active, in **seconds**.
Prerecord (frames)	Set the amount of video to save before the trigger becomes active, in **recorded frames**.
Max button	Sets record length to the maximum available for your model and the selected number of segments.
Number of Segments	The minimum number of recordings to hold in memory. Each segment 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 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. This applies only to external triggers such as TRIG1, on the side of the camera. Analog channels will be supported in a future software update. The red record button on the top of the camera always functions as start/stop recording.

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

Control	Function
0%, 50%, 100%	Move the slider to the start, middle, and 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. Note: Does not apply to the red record button on the camera.
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	Sets the amount of time to record before a trigger happens. 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. Note: The Chronos is always recording to a ring buffer. (This is 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.
Post-trigger	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. 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.
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.
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: Some configurations will prevent normal recording. Shutter gating, if never triggered, can produce a 0-frame video. If a record end trigger happens immediately, a 1-frame video may be produced.

Control	Function
Threshold	Sets the input threshold voltage (in volts) for the IO. 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. See "Synchronizing to External Sources" for details.
Shutter Gating	Sets function of IO to shutter gating input allowing image sensor shutter to be directly controlled by the input. 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, trigger input will be sensitive to low level instead of high when checked.
Debounce	Use a 10ms debounce filter on the input. This is recommended when using a 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.
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
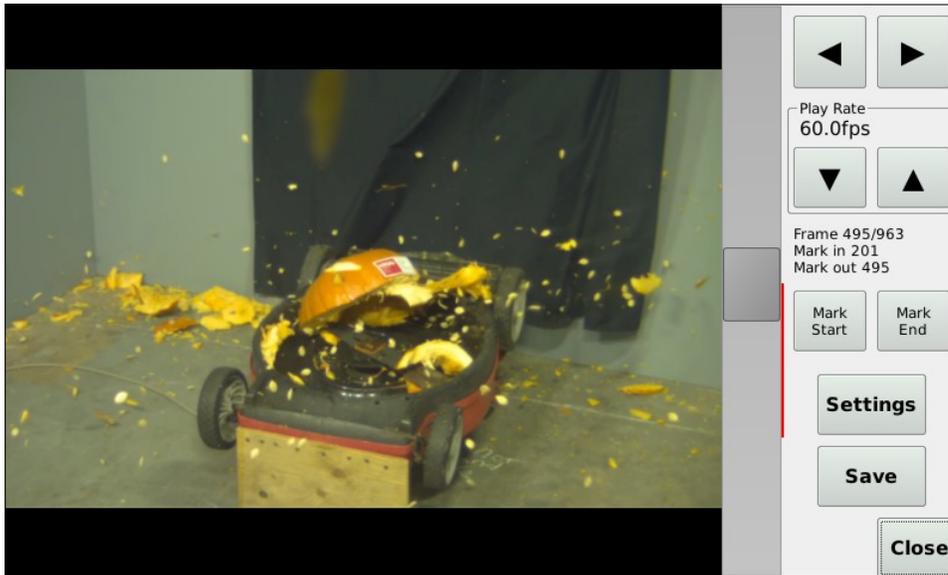
The playback mode allows saving, review, and trimming of the recorded video on the Chronos. The image on the left displays what was previously recorded. The coloured bar to the right of the playback slider indicates the region to be saved, along with any previously saved regions. Each saved region is coloured differently.

Control	Function
Playback Slider	Scroll bar controls playback position over the entire recording. The bottom is the beginning of the buffer, 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: 4.6 to 960fps. 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 current frame. Only the marked region will be saved.
Settings button	Opens the Save Settings popup. This is where the frame rate and file format of the saved video is 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, or the video is otherwise cleared.

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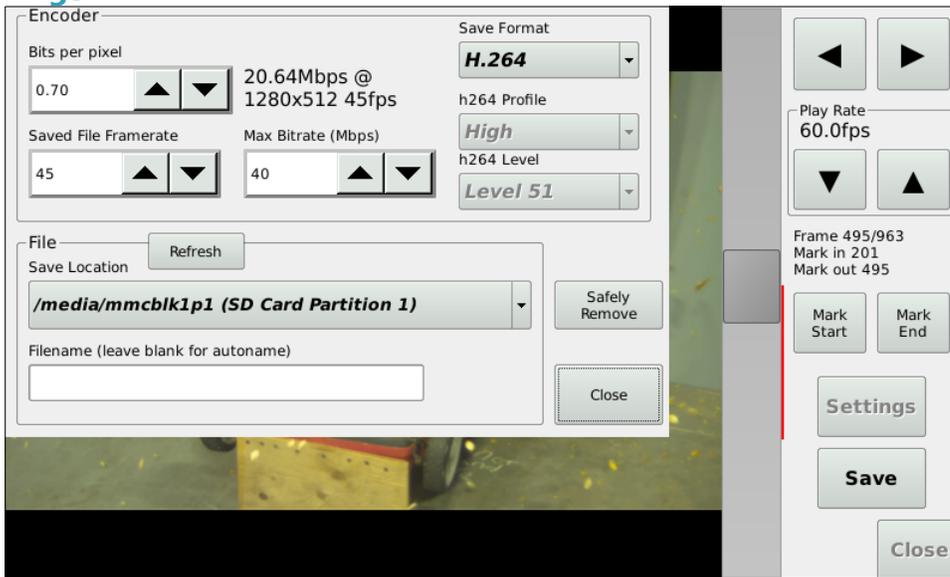
The save settings popup, in the top-left corner of the Play Mode screen, lets you set how the file is written to the external storage device. By default, it saves H.264-encoded.mp4 files to the most recently attached storage device.

Control	Function
Bits per pixel	Primary quality control for H.264 (MPEG) encoded saved video. Resolution- and Frame-rate-independent control of video bitrate. Uncompressed (raw) video is always saved at 16bpp or 12bpp, so this control is disabled when saving raw.
Max Bitrate	Sets a limit to the playback data rate, in megabits per second, used by the h.264 encoder. This control is disabled when saving raw.
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.
h264 profile	Sets the saved video encoding level. Only "High" is currently supported.
h264 Level	Sets the saved video encoding Level. Only level 51 is currently supported.

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.

Util Screen

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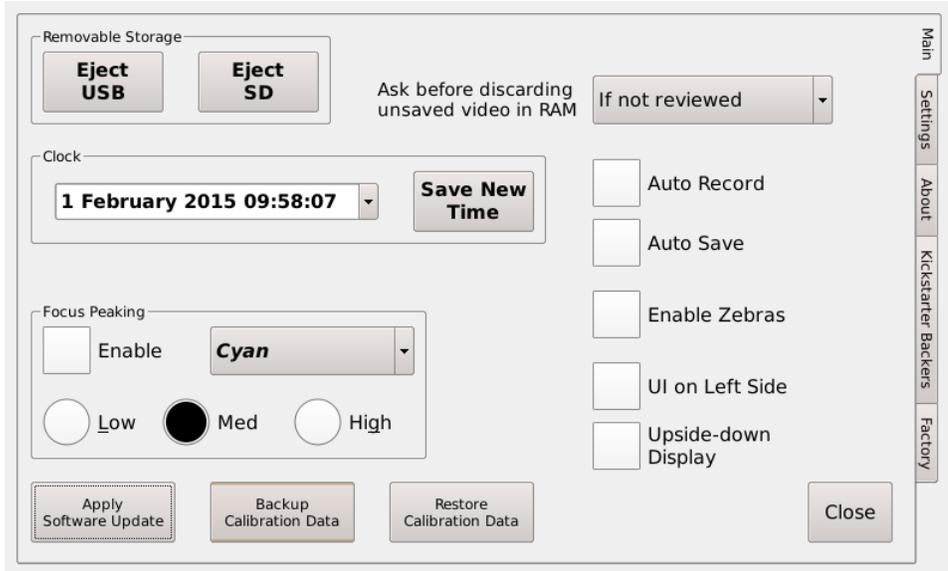
The Utilities page contains general settings and information about the camera. More functions can be accessed through the tabs on the right.

Control	Function
Eject USB and Eject SD	Finish any outstanding writes to selected storage device. When this has completed, you can unplug the storage device without the risk of losing unwritten data.
Ask before discarding unsaved video in RAM	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. This setting has three levels: • 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.
Clock Setting	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.

Set New Time	Applies the current time in the clock adjustment box to the camera's clock.
Auto Record	After a recording has finished saving, automatically start a new recording. If Auto Save is selected as well, this will form a continuous loop.
Auto Save	When a recording has ended, automatically save it. If Auto record is selected as well, this will form a continuous loop.
Focus Peaking Enable	Enables focus peaking function which highlights sharp edges with a conspicuous colour. This checkbox is on the main screen too, where it's called "Focus Aid".
Focus peaking colour	Selects the colour 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. Lower sensitivity will allow more accurate focusing on bright edges.
Enable Zebras	Enables the overexposure indicator which shows a rolling zebra line pattern on areas of the image that are clipped.
UI On Left Side	Move the main window and playback button panels to the left side of the screen.
Upside-down Display	Rotate the display 180°. Useful when the camera itself is mounted upside-down.
Apply Software Update	Applies a software update from a USB drive. Follow instructions provided with the software update.
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.
Restore Calibration data	Restores the camera's factory calibration data from a USB drive.
Close button	Returns to the Main window (Settings are applied automatically as they are changed).

Settings Tab

Save settings configuration, such as Focus Peaking settings and Trigger/IO Settings, to an external storage device. This is useful to make backups, so you can restore your camera configuration state, or to save your settings across a software update.

This excludes saved user black cal data, which is managed with the Backup and Restore User Calibration Data button in the Main tab.

Control	Function
Backup Settings Data	Save the UI settings of the camera to an external storage device.
Restore Settings from backup	Restore saved UI settings from an external storage device.
Revert to defaults	Set the camera UI settings back to the factory default.

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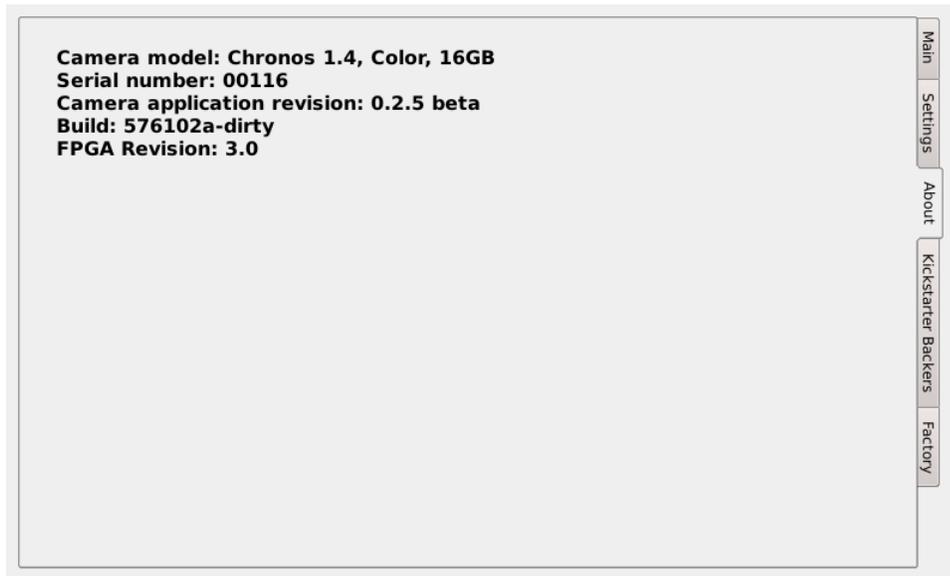
Shows information about camera, such as model, serial number, and software version.

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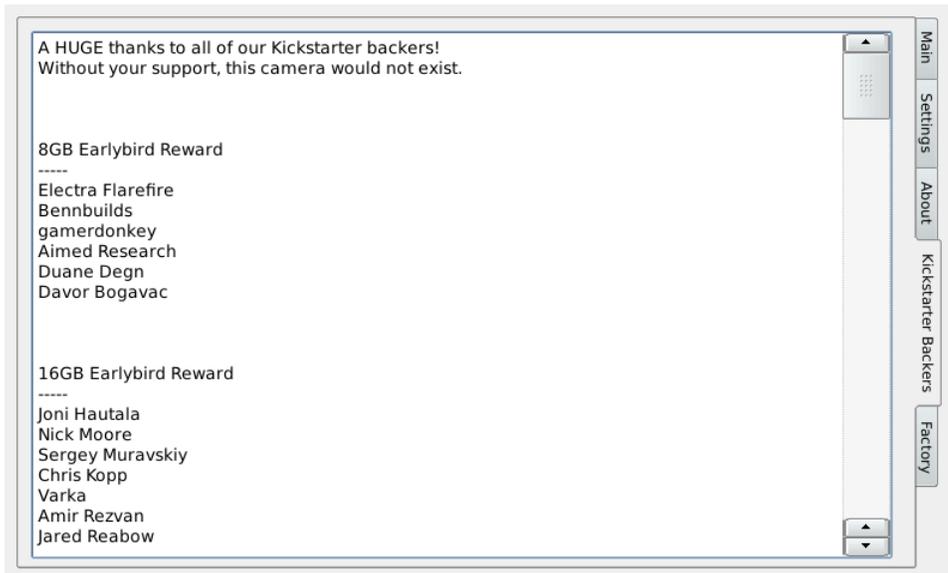
A list of the excellent people who contributed to our kickstarter campaign. Without these people, the Chronos would not exist. Take a moment, and scroll through the list.

Factory Tab

The factory tab contains functionality used for the manufacturing of the camera.

And a button to remove user calibration data. (The buttons to save and restore user calibration data are back on the Main tab.)

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)	Remove the black calibration data. This data is accumulated when you press the black cal button on the main screen, one black cal profile for every resolution you calibrate at.

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.
- **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 or vertical lines show 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.
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.

Reference Information

Specifications

Camera	*Imaging*	1280x1024 1057fps, see resolution table for details
	Memory	8GB, 16GB, or 32GB
	Record Time	4 seconds (8GB), 8 seconds (16GB), 16 seconds (32GB)
	Lens Mount	CS mount, C mount with included adapter
	Backfocus	Field adjustable
	IR Filter	650nm, user removable, 15 x 15 x 1.1mm
	Display	5" 800x480 capacitive touchscreen
	Enclosure	Anodized CNC machined aluminum
	Cooling	Active cooling, variable-speed fan
	Dimensions	155mm x 96mm x 67.3mm (6.11" x 3.78" x 2.65") without lens
	Weight	1.06kg (2.34 lbs) without lens
Video formats	*H.264*	Industry-standard mp4 files at bitrates up to 60Mbps
	cinemaDNG Raw	.raw files are saved, and can be converted to standard Adobe cinemaDNG raw files
Image Sensor	*Resolution*	1280x1024 @ 1057fps
	Speed	1.4Gpx/s - Full throughput down to 336 pixel image width
	Dimensions	8.45 x 6.76mm
	Pixel pitch	6.6um

	Sensitivity (ISO)	colour - ISO 320 to 5 120
		Mono - ISO 740 to 11 840
	Shutter	Electronic global shutter, 1/fps to 2us (1/500 000 s)
	Dynamic Range	56.7 dB
	Bit Depth	12-bit
Battery	*Type*	EN-EL4a
	Runtime	1.5 hours recording (typical)
	Charge Time	2 hours (0-80%)
IO	*Power Input*	17-20V 40W
		5.5/2.5mm barrel jack, positive tip
	*Network**	Gigabit Ethernet
	Trigger	Two Trigger inputs/frame strobe outputs (BNC and Aux)
		Adjustable input threshold 0 to 6.6V
		Electrically isolated trigger input (Aux connector)
	*Audio**	Microphone/Line input, headphone output
	*Video**	HDMI output, video or video+menus
	USB	Two USB host ports (one on mini-B via USB OTG cable)
	SATA	eSATA 3G
	*Analog input**	1MSa/s 12-bit, 200kHz bandwidth, +/- 1V full scale
Trigger modes	*Normal Triggered*	Camera records until a defined delay after a trigger
	Triggered start	Camera starts recording a defined delay after a trigger

Trigger Sources	*Electrical*	0-6.6V threshold, optional button debounce and pullup
	*Audio**	Trigger on loud sounds
	*Acceleration**	Trigger on camera motion, tilt or shock
	*Image**	Trigger on image changes

Recording modes	*Normal*	Records into the circular buffer. Once a trigger occurs, video can be reviewed and saved.
	Segmented	RAM is divided into segments, each recording as in the Normal mode above. Number of segments is user selectable.
	Gated Burst	*Frames are captured while trigger is active.*
	*Continuous**	Video is saved continuously at up to 60fps to mp4 files on removable storage. Operates like a normal video camera.
	*Run-n-Gun**	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.
	*Normal + Continuous**	High-speed video is recorded to the RAM buffer while simultaneously 60fps videos is saved to removable storage.

Shutter timing	*Normal*	Frame rate and exposure time are controlled by the camera.
	Edge Triggered	A single frame is captured on each rising or falling edge of an external input. Exposure is controlled by camera.
	Shutter Gating	Image sensor shutter is directly controlled by an external input, exposing while the input is active.

Assistive	*Focus Peaking*	Highlights sharp edges to aid focusing.

| *Zebras* | Rolling diagonal lines indicate clipped (overexposed) areas. |
| *Focus Aid** | 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	1 057	4.1283	8.2603	16.5244
1280 × 720	1 502	4.1308	8.2654	16.5346
1024 × 768	1 771	4.1074	8.2187	16.4411
1024 × 576	2 359	4.1108	8.2254	16.4546
800 × 600	2 873	4.1436	8.2909	16.5856
800 × 480	3 587	4.1419	8.2875	16.5789
640 × 480	4 436	4.1977	8.3993	16.8025
640 × 240	8 816	4.2049	8.4137	16.8313
336 × 252	15 200	4.3760	8.7560	17.5161
336 × 190	20 020	4.4535	8.9111	17.8262
336 × 96	38 565	4.5275	9.0591	18.1224

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 recording time increase 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	1 057	4.1283	8.2603	16.5244
1280 × 1024	528.5	8.2565	16.5206	33.0489
1280 × 1024	264.25	16.5131	33.0413	66.0977
800 × 600	2 873	4.1436	8.2909	16.5856
800 × 600	1436.5	8.2871	16.5818	33.1712
800 × 600	718.25	16.5742	33.1636	66.3425
640 × 480	4436	4.1977	8.3993	16.8025
640 × 480	2218	8.3955	16.7986	33.6049
640 × 480	1109	16.7909	33.5972	67.2099

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	1 057	4.1283	8.2603	16.5244
640 × 512	1 057	16.5131	33.0413	66.0977
320 × 256	1 057	66.0523	132.1651	264.3908
800 × 600	2 873	4.1436	8.2909	16.5856
400 × 300	2 873	16.5742	33.1636	66.3425
200 × 150	2 873	66.2969	132.6546	265.3699
640 × 480	4436	4.1977	8.3993	16.8025
320 × 240	4436	16.5700	33.1552	66.3255

As the resolution is "halved", the duration of the recording increases by multiples of 4. Halving the resolution results in ¼ the number of pixels, so 4 times the number of frames can be stored – 400×300=120k pixels, while 200×150=30k pixels.

Mechanical Drawing
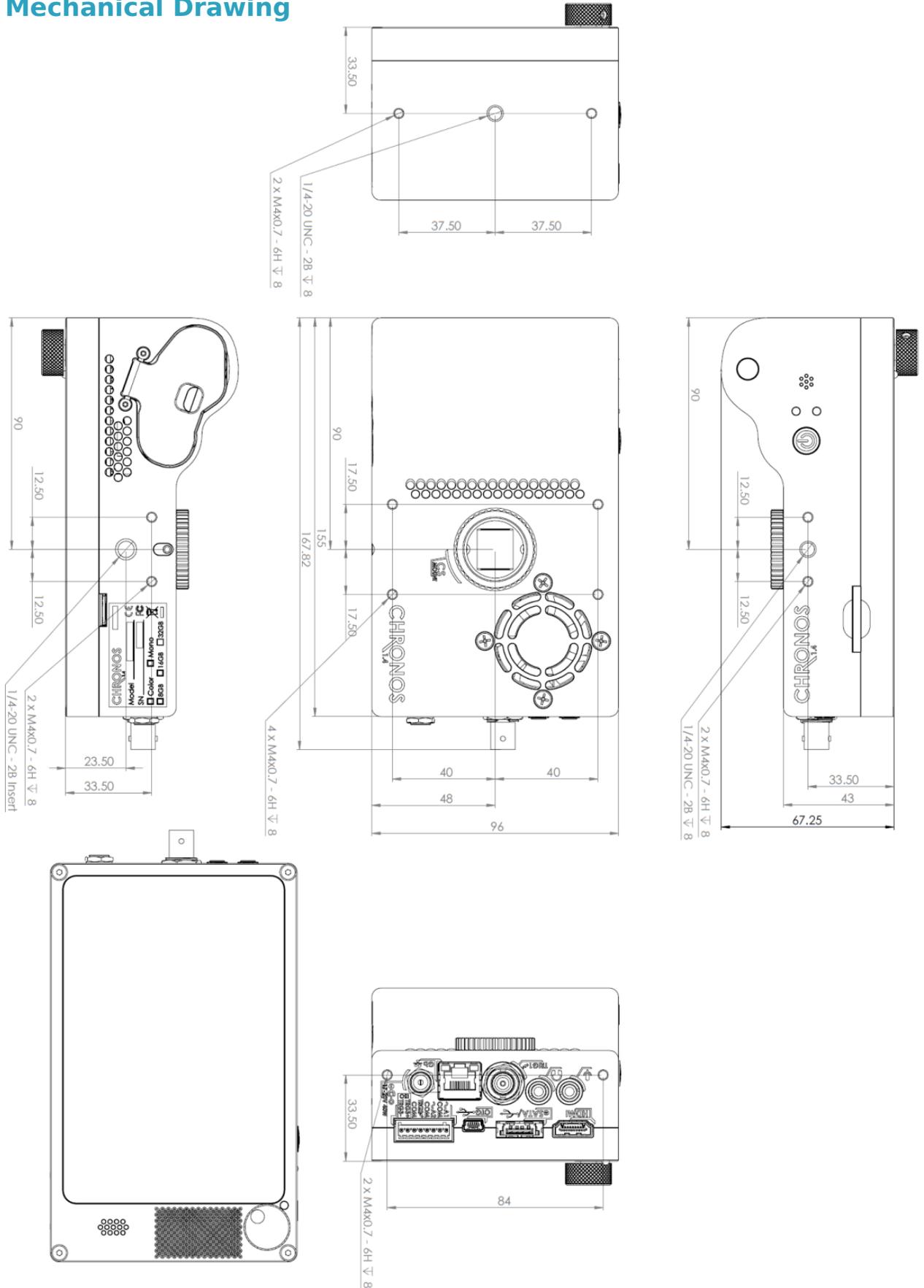
Spectral Response

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

Colour (without IR filter)
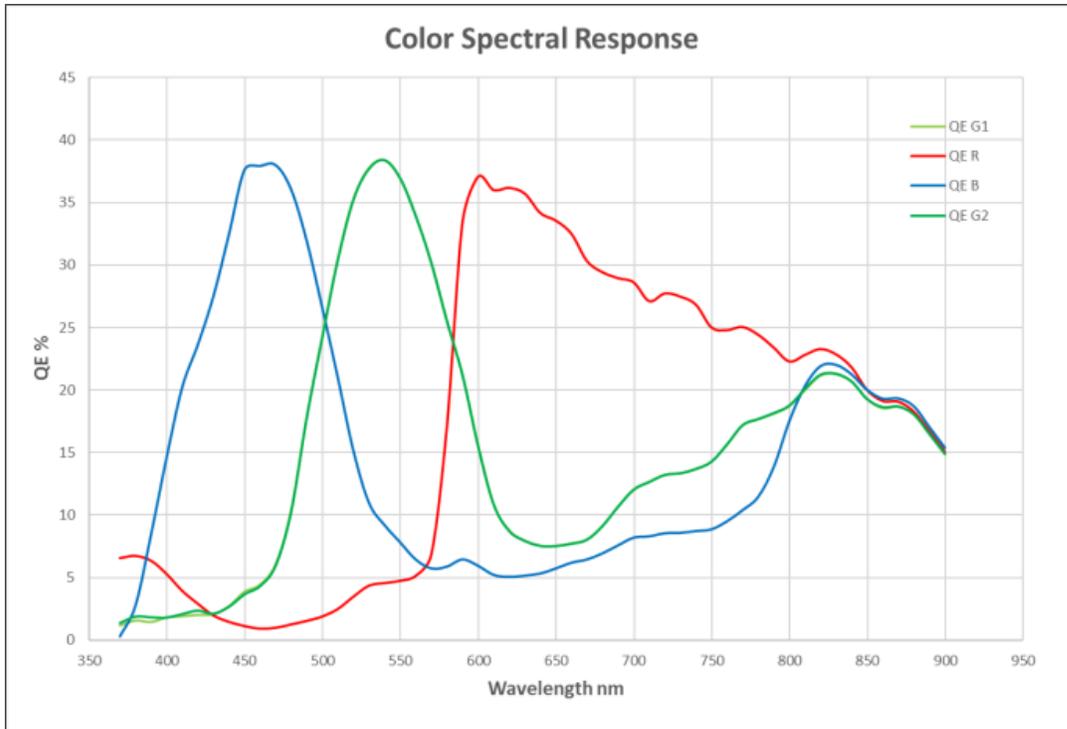
Monochrome (without IR filter)
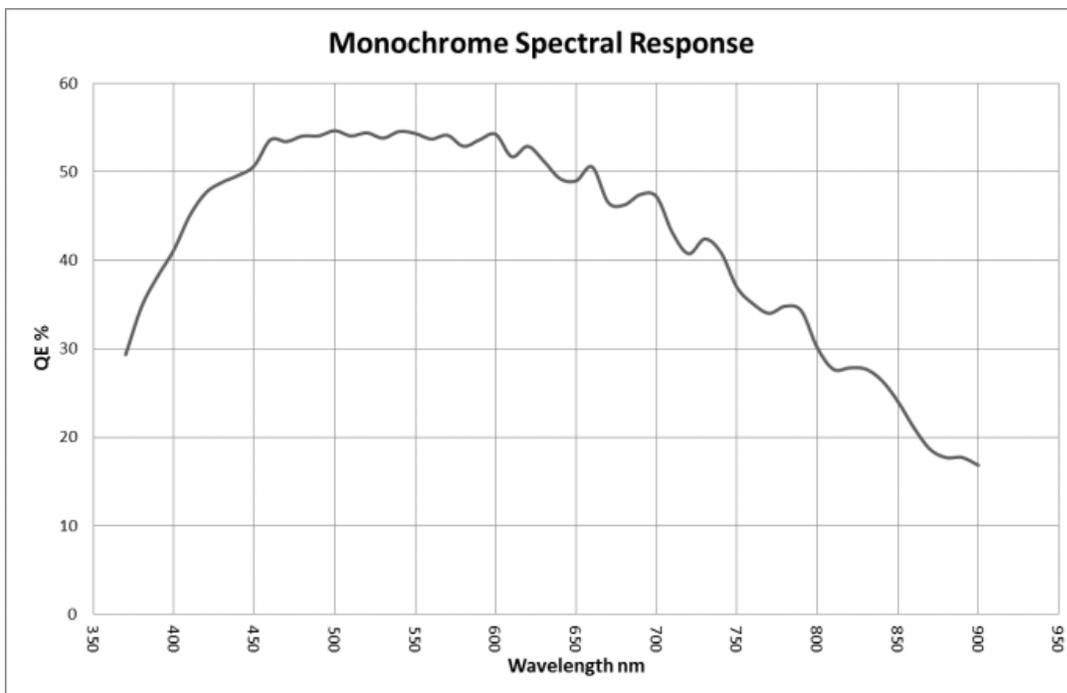
Software Change Log

Revision	Changes
1	Initial Release

User Notes