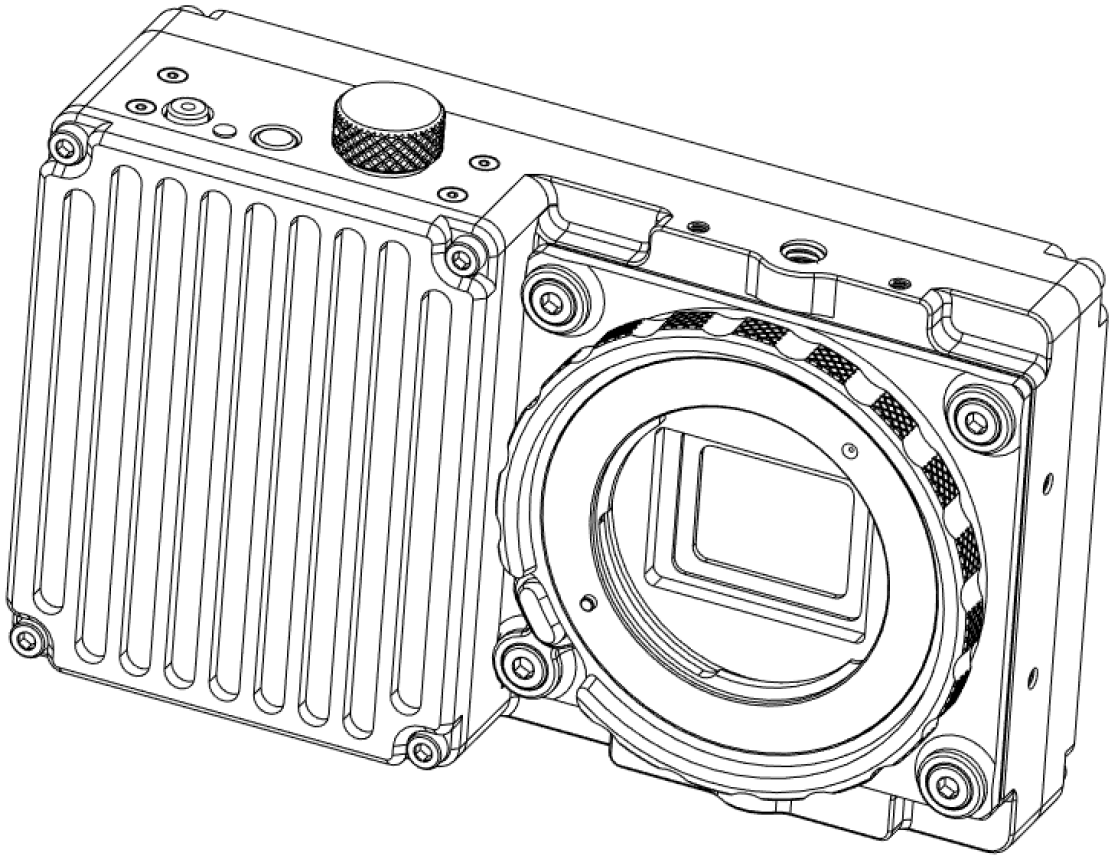

Wave

Continuous High-Speed Video Camera

User Guide

Rev6 | 2021-10-18 | Camera Firmware v1.4.x | Wave Player v1.4.x

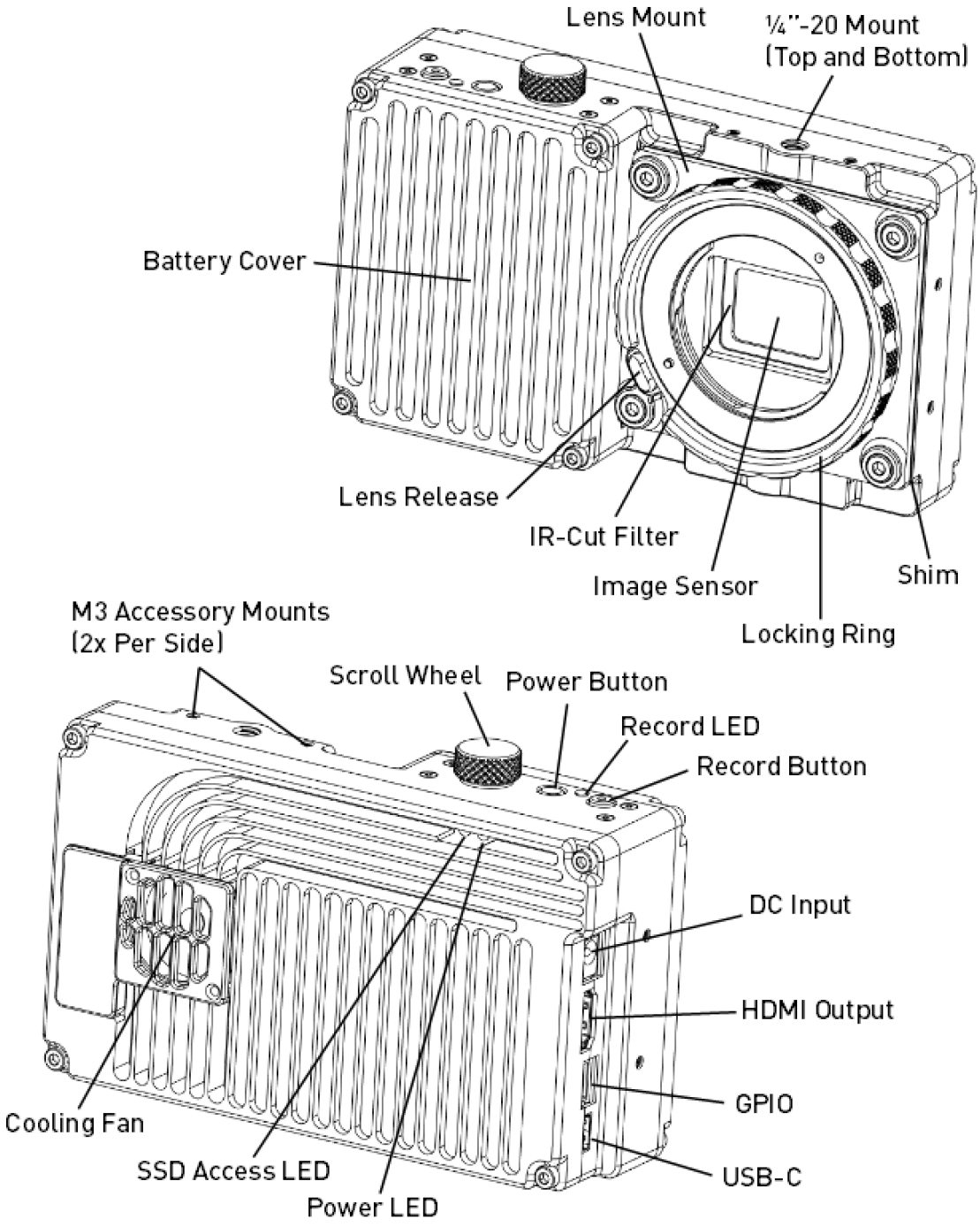

Figure 1: Wave Camera Components

1 Quick Start

1.1 Install Wave Player

1. Download the latest version of Wave Player from the following URL: https://freefly.gitbook.io/freefly-public/products/wave-camera/downloads
2. For installation on Windows:
    a. Unzip the **WavePlayer_[version]** folder.
    b. Run **WavePlayerSetup.msi** and follow the instructions. If Microsoft Defender prevents setup.exe from running, click **More info -> Run anyway**.
    c. Run **WavePlayer.exe** from the installed location and confirm that a suitable graphics adapter is indicated in the Title Bar, for example:

1.2 Capture Test Clip

1. Connect an HDMI monitor to the HDMI Output.
2. Power on the camera (Power Button single press) and wait for a preview image.
3. Use the Scroll Wheel to navigate the camera menu and adjust settings:
    a. Scroll to select a setting.
    b. Click to display that setting's options.
    c. Scroll to select an option.
    d. Click to apply the selected option and return.
4. Adjust settings, exposure, and focus as-desired for the test clip.
5. Note the clip number in the bottom-left corner.
6. Record the clip by pressing the Record Button to start and stop recording.

1.3 View and Export Test Clip

1. Connect the USB-C port to the device with Wave Player installed.
2. In Wave Player, click **Open Clip / Drive** and navigate to the camera's drive.
3. Select the folder corresponding to the clip number recorded.
4. Navigate within the clip using the Timeline Slider or keyboard shortcuts:
    a. Spacebar: Play/Pause
    b. Left/Right: Step Frame-by-Frame
    c. I/O: Set In and Out Marks for Export
5. Apply image adjustments as-desired using the Image Sliders.
6. Select an export format (ProRes, H.264, etc.).
7. Click **Export** and select an export location and file name.
8. Wait for the clip export to progress from the In Mark to the Out Mark.

2 Specifications

2.1 Key Specifications

Specification	Condition	Value
Image Sensor		
Format	-	S35
Aspect Ratio	-	4:3
Pixel Size	-	5.5µm x 5.5µm
Native Resolution	-	4096 x 3072
Active Area	-	22.53mm x 16.90mm
Shutter Type	-	Global Electronic
Native ISO	-	250
Lens Mount		
Standard Lens Mount	-	E-mount Compatible
Removable	-	Yes
Positive Locking	-	Yes
Electronic	-	No
Recording		
Media	-	Internal NVMe SSD
Media Size	-	1TB or 2TB
Native Format	-	Compressed RGB
Native Bit Depth	-	10-bit
Compression Ratio	Typical	5:1 to 6:1
Resolutions / Frame Rates	-	See Table 1.
Bit Rate	Maximum	1.00GB/s (8.00Gb/s)
	4096 x 2176, 422fps, 5.5:1	0.89GB/s (6.84Gb/s)
	2048 x 1088, 1461fps, 5.5:1	0.74GB/s (5.92Gb/s)
Continuous Capture Time	4096 x 2176, 422fps, 1TB	19min
	4096 x 2176, 422fps, 2TB	39min
	2048 x 1088, 1461fps, 1TB	23min
	2048 x 1088, 1461fps, 2TB	45min
	Others	Limited only by Media Size
Power		
Battery	-	Internal 11.1V, 2200mAh
Run Time	Standby	90min
	Recording (Max Rate)	60min
Charge Time	Powered Off	90min
DC Input Voltage	Operation	12V – 26V
	Charging to 100%	14V – 26V
Power Consumption	Standby	15W
	Recording (Max Rate)	19W
	Charging (Max)	24W

Interface		
DC Input	-	Barrel Jack 5.5mm OD x 2.1mm ID
HDMI Output	-	HDMI A (Full Size) 1080p30
GPIO	-	6-Pin JST GH Optically Isolated Start/Stop/Sync UART (3.3V or 5.0V) API[1]
USB	-	Type C (Reversible) USB 3.2 Gen1x1 SuperSpeed 5Gb/s
Wireless	-	WiFi 802.11b/g/n[2] Bluetooth v4.2[2]
Wave Player Software		
Operating System	-	Windows 10
Export Formats	-	Camera-Native ProRes[3] CineForm[4] H.264 PNG Sequence JPEG Sequence
Other Features		
Firmware Update	-	via USB-C
Upgradeable Storage	-	Yes
LCD	-	No
Audio Recording	-	No
Autofocus	-	No
Physical		
Dimensions	w/ E-mount	150mm x 97mm x 47mm
Weight	w/ E-mount	716g
Mounting Points	¼-20	2: 1x Top, 1x Bottom
	M3	8: 2x per Side
Environmental		
Operating Temperature	-	0°C to 40°C
Ingress Protection	-	IP52

[1]Hardware capability, API details TBD.

[2]Hardware capability, no software support or mobile app available as of this release.

[3]Only available on Wave Player Mac and iPad.

[4]Only available on Wave Player Windows.

2.2 Maximum Frame Rates

The maximum frame rate depends on image resolution as set by the Width and Height settings. Table 1 lists the maximum frame rate by aspect ratio for both Width options. Continuous recording is possible at all frame rates from 1fps up to the maximum in increments of 1fps. A set of standard frame rates is available in the menu under the rame Rate setting. For more details, see Section Error! Reference source not found.: Error! Reference source not found..

*Table 1: Maximum frame rates by aspect ratio for **4096** (4K and **2048** (2K) width options.*

	Width: 4096 (4K)		Width: 2048 (2K)	
Aspect Ratio	**Height**	**Max FPS**	**Height**	**Max FPS**
4:3	3072	300	1536	1049
16:9	2304	398	1152	1384
17:9	**2176**	**422**	**1088**	**1461**
2:1	2048	448	1024	1548
2.13:1	1920	477	960	1646
2.29:1	1792	511	896	1758
2.46:1	1664	549	832	1885
2.67:1	1536	594	768	2032
2.91:1	1408	647	704	2204
3.2:1	1280	711	640	2408
3.56:1	1152	788	576	2653
3.76:1	1088	833	544	2796
4:1	1024	884	512	2955
4.27:1	960	941	480	3132
4.57:1	896	1006	448	3333
4.92:1	832	1081	416	3561
5.33:1	768	1168	384	3822
5.82:1	704	1270	352	4125
6.4:1	640	1392	320	4480
7.11:1	576	1540	288	4901
8:1	512	1722	256	5411
9.14:1	448	1954	224	6038
10.67:1	384	2257	192	6830
12.8:1	320	2673	160	7861
16:1	256	3275	128	9259

The **2048** (2K) width option uses subsampling, which preserves the crop factor of the Image Sensor but does not increase its light sensitivity. For more information, see Section 4.1.2: Width.

3 Camera Operation Basics

3.1 Power and Charging

The camera is powered by an internal 11.1V, 2.2Ah lithium ion battery, which provides about 90min of standby time or 60min of continuous recording. For continuous operation beyond this, the included power supply can be connected to the DC Input. This supply provides enough power to both charge the battery and run the camera. When powered off, fully charging from 0% to 100% takes about 90min. When powered on, the charging time depends on simultaneous camera usage.

The DC Input can also be used to supply power from another source, such as an external battery or gimbal power supply. Table 2 lists the requirements for a power supply connected to the DC Input. An external V-Lock battery connected to the DC input is the preferred method for mobile operation with battery swapping. The internal battery is not meant for swapping, but can be accessed by removing the Battery Cover if needed.

WARNING	**The voltage applied at the DC Input must not exceed 26V.**

Table 2: DC Input Supply Requirements

Requirement	Value
Voltage (Operation)	12V – 26V
Voltage (Full Charge)	14V – 26V
Power (Recommended Supply Capability)	30W (12V, 2.50A) (18V, 1.67A) (24V, 1.25A)

To power on the camera, press the Power Button once. To power off the camera, press and hold the Power Button for three seconds. The Power LED indicates the power and charging state as shown in Table 3.

Table 3: Power and charging states indicated by the Power LED.

Power LED	Camera Power State
● Off	Powered Off, Charging Complete
● Orange	Powered Off, Charging in Progress
● Yellow	Powered On, Charging in Progress
● Green	Powered On, Charging Complete

3.2 Lens Mount

The camera has a positive-locking E-mount-compatible Lens Mount. There is no electrical connection between the lens and the passive mount, so **electronic lenses with focus-by-wire are not supported**.

The Lens Mount can be detached by removing the four M4 screws. Behind it is an IR-Cut Filter assembly that can also be detached for cleaning or for IR photography. A set of shims (0.5mm, 0.8mm, 0.9mm, 1.0mm, and 1.1mm) are included for fine-tuning the back focal distance (see Section 3.2.2: Back Focus Adjustment). The 1.0mm shim is installed as-shipped from the factory and should provide adequate back focus with most lenses.

Caution	**When removing the lens mount and IR-Cut Filter assembly, be careful not to touch the IR-Cut Filter glass or Image Sensor cover glass.**

The Lens Mount supports for manual E-mount lenses. There is no electrical connection between the lens and the passive mount, so **electronic lenses with focus-by-wire are not supported**. E-mount has one of the shortest flange focal distances of any S35-size lens mount, allowing it to be readily adapted to other mounts. For a list of recommended lenses and adapters, visit the following URL:

https://freefly.gitbook.io/freefly-public/products/wave-camera/lens-recommendations

3.2.1 Locking Ring Operation

The Lens Mount features a Locking Ring that secures the lens firmly to the camera body, instead of relying on leaf springs. To attach an E-mount lens:

1. Align the lens marking with the dimple in the flange and insert the lens.
2. Rotate the lens clockwise (as seen from in front of the camera) until the Lens Release clicks into place.
3. Rotate the Locking Ring clockwise until it tightens on the lens. **Do not overtighten.** Use about the force it takes to turn a doorknob.

To remove the lens:

1. Rotate the Locking Ring counterclockwise as far as it will go.
2. Press down the Lens Release.
3. Carefully rotate the lens counterclockwise until it can be removed.

3.2.2 Back Focus Adjustment

A set of shims (0.5mm, 0.8mm, 0.9mm, 1.0mm, and 1.1mm) are included for fine-tuning the back focal distance. The 1.0mm shim is installed as-shipped from the factory and should provide adequate back focus with most lenses, but adjustments can be made in cases where back focus is especially critical, for example:

- Maintaining parfocal condition on a parfocal zoom lens.
- Matching up perfectly to lens markings.
- Achieving infinity focus exactly at a lens marking or hard stop.

To adjust the back focus, first set a focus target a fixed distance from the camera's focal plane, which is in line with the M3 Accessory Mounts on the left side. The distance should match one of the distances marked on the lens. Adjust the lens until the target is in focus, then follow the action indicated in Figure 2.

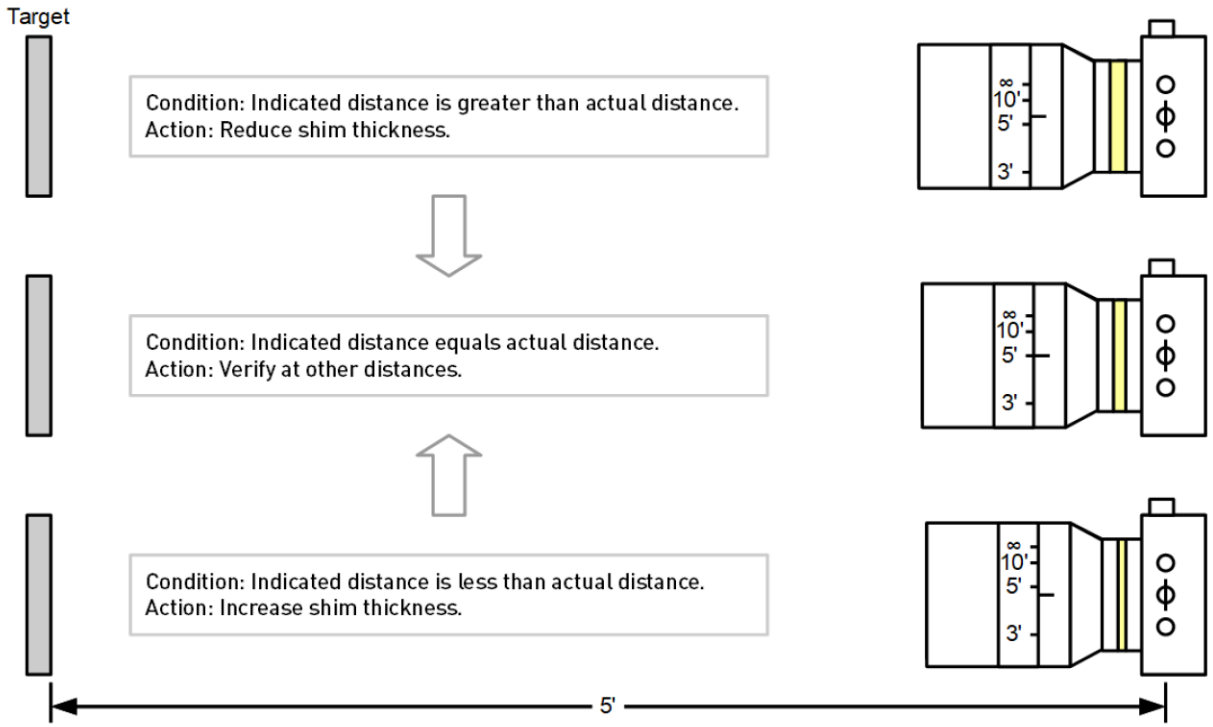

Figure 2: Back focus adjustment procedure.

3.3 Workflow

The Wave camera can record high-speed video continuously at any available frame rate, limited only by the size of the internal SSD. As such, there is no trigger or buffer setup required. The capture workflow is just like an ordinary video camera: press the Record Button once to start recording a clip and again to stop recording.

3.3.1 HDMI Preview and Menu Overlay

An HDMI monitor capable of receiving a 1080p30 input is required to view a preview image and interact with the camera menus. On-camera monitors typically also provide useful tools such as histograms and focus assist. The ¼-20 Mount on top of the camera is intended for monitor mounts. For a list of recommended on-camera monitors and monitor mounts, visit the following URL:

https://freefly.gitbook.io/freefly-public/products/wave-camera/monitor-recommendations

3.3.2 User Interface

The primary user input to the camera is the Scroll Wheel. This multi-purpose input can be used to enter and exit menus (by clicking) and adjust settings (by scrolling). The typical workflow for adjusting camera settings is as follows:

1. If it's not already visible, click the Scroll Wheel to display the settings menu.
2. Scroll to select a setting.
3. Click to display that setting's options.
4. Scroll to select an option.
5. Click to apply the selected option and return to the settings menu.
6. To hide the settings menu, scroll to and click the **X** in the top-left corner.

See Section 4.1 for a detailed description of each setting and its options. Some settings have additional levels of user input that are described in more detail there.

3.3.3 Viewing, Offloading, and Exporting Clips

Wave clips are recorded internally in a native file format optimized for speed, but they can't yet be opened directly by other editing tools. Wave Player is the software used to view native Wave clips, trim them, apply basic image adjustments, and export them to other formats. See Section 6: Wave Player Software for details.

Clips are organized by folders on the camera's drive, with the folder name corresponding to the clip number (e.g. D:\c0003 for clip 3). Within a clip folder, there are files containing clip metadata and clip frames. A specification for the Wave native file formats will be published separately at a later date.

Wave Player can open clips either directly from the camera's drive or from a local copy. To make a local copy of a clip, copy the entire clip folder from the camera's drive or use the Native export format in Wave Player. For Camera FW v1.3.0 and newer, the internal SSD is read-only over USB. For older firmware, it's important to avoid adding or deleting files over USB, as it leaves the file system fragmented and limits the SSD write performance.

Caution	**Camera FW prior to v1.3.0: Do not add or delete files from the camera's internal drive manually, as it leaves the file system fragmented and limits SSD write performance. Use the on-camera Format setting to erase the internal SSD cleanly.**

3.4 Firmware Update

The latest camera firmware can be downloaded from the following URL:

https://freefly.gitbook.io/freefly-public/products/wave-camera/downloads

The camera firmware can be updated over USB using the following procedure:

1. While holding down the Scroll Wheel, press and release the Power Button to power on the camera in Firmware Update mode. Continue to hold down the Scroll Wheel until the Record LED flashes slowly.
2. Plug in the USB cable. The camera will appear as a USB drive. **This drive is separate from the one where clips are stored, so your footage won't be visible but is safe and not affected by the firmware update.**
3. Drag the new firmware file (WAVE.BIN) into the fw folder.
4. Click the Scroll Wheel. The Record LED will begin to flash quickly as the firmware is updated.
5. Wait for the camera to automatically restart with the new firmware. This should take at most 30 seconds.

4 On-Screen Display

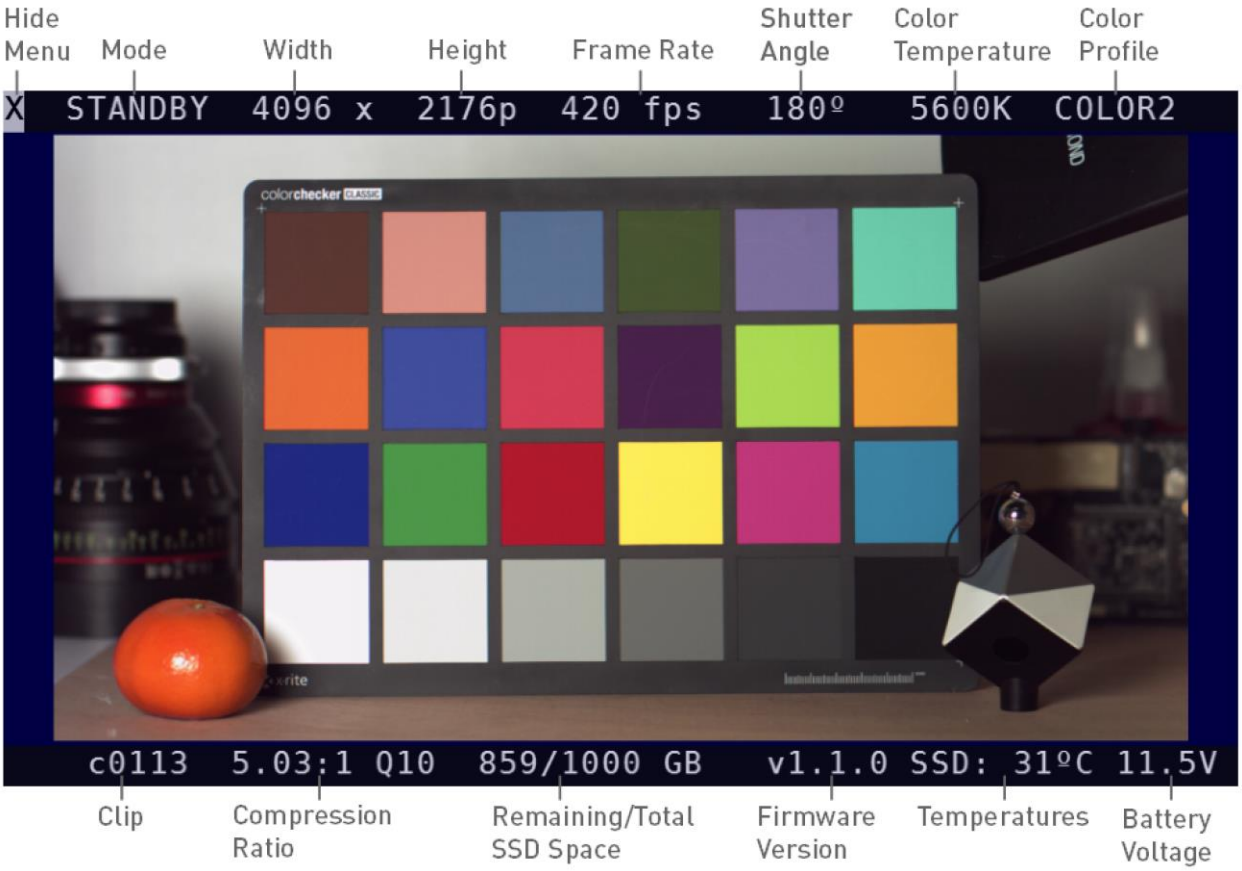

Figure 3: Camera settings menu.

The on-screen display is visible by default at the top and bottom of the HDMI preview. To hide it, scroll to and click the **X** in the top-left corner. To make it visible again, click the Scroll Wheel. The on-screen display consists of two parts: the Camera Settings Menu, at the top edge, and the Camera Status Bar, at the bottom edge.

4.1 Camera Settings Menu

This section covers the settings available in the on-camera menu. The settings menu is displayed across the top edge of the HDMI preview image when the on-screen display is made visible by clicking the Scroll Wheel.

On boot, the camera loads settings from the most recently recorded clip. Settings are reset to default values when the firmware is updated or the SSD is formatted. Settings can also be manually reset to defaults from the menu. In the sections below, the default values are listed in **BOLD**.

4.1.1 Mode

This setting is used to switch between capture and playback modes. It will display **STANDBY** when the camera is ready for capture and REC during capture. To switch to playback, click the Mode setting, scroll to and click PLAYBACK. This will launch the playback interface, which is detailed in Section 5. The Mode setting will return to **STANDBY** when the playback interface is closed.

4.1.2 Width

This setting is the width in pixels of the captured image. The two options are **4096** (4K) and 2048 (2K). **4096** (4K) is the native width of the sensor and uses all available pixels. 2048 (2K) uses subsampling to generate a 2K image from the full width of the sensor, as in Figure 4, so the crop factor and angle of view don't change. This allows higher frame rates, but with reduced image quality. The native ISO is the same in both width options, so proportionally more light is required for higher frame rates of the 2048 (2K) width.

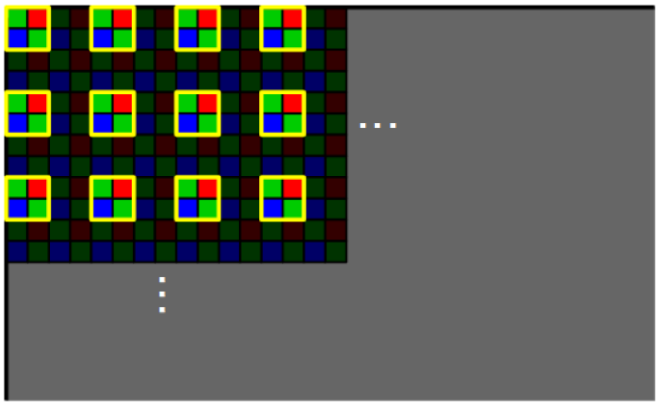

Figure 4: Subsampling pattern in the 2048 (2K) width option.

The available options for the Height and

Frame Rate settings both depend on the Width option selected.

4.1.3 Height

This setting is the height in pixels of the captured image. The available options range from 128px to 3/4 of the Width setting (4:3 aspect ratio). Decreasing the Height increases the maximum Frame Rate. The closest Width and Height combinations that fully cover some common resolutions are shown in Table 4.

Table 4: Closest Width and Height settings that fully cover some common resolutions.

Deliverable Resolution	Width	Height	Max FPS
DCI 4K (4096 x 2160)	4096	**2176**	422
UHD 4K (3840 x 2160)	4096	**2176**	422
1080p HD (1920 x 1080)	2048	1088	1461
720p HD (1280 x 720)	2048	768	2032

4.1.4 Frame Rate

This setting is the number of frames per second (FPS) captured. The options listed include a set of standard frame rates (select multiples of **24fps**, 25fps, and 30fps) from **24fps** up to 9120fps. The available options are dependent on the Width and Height settings, limited by the maximum frame rate defined in Table 1.

A special option, USER, allows for entering any frame rate from 1fps up to the maximum in increments of 1fps. One application for this is for closely synchronizing to a vibrating or rotating object to measure its frequency or visualize its periodic movement (like a stroboscope). To enter a user frame rate:

1. Click the Frame Rate setting.
2. Scroll to and click USER.
3. Scroll left or right to adjust the user frame rate.
4. Click to apply the user frame rate.

A special option, MAX, applies the maximum frame rate for the current Width and Height settings, as defined in Table 1. This is usually slightly higher than the maximum standard frame rate option listed.

4.1.5 Shutter Angle

This setting is the exposure time expressed as an angular fraction of the time between frames, as shown in Figure 5. At the default value of **180º**, the sensor accumulates light for half of the frame interval. At 360º, the Image Sensor accumulates light for (nearly) the entire frame interval, resulting in twice as much light gathered but also twice as much motion blur. Conversely, at lower shutter angles, less light is gathered and there is less motion blur. The Wave Image Sensor uses a global electronic shutter, so all pixels are exposed at the same time.

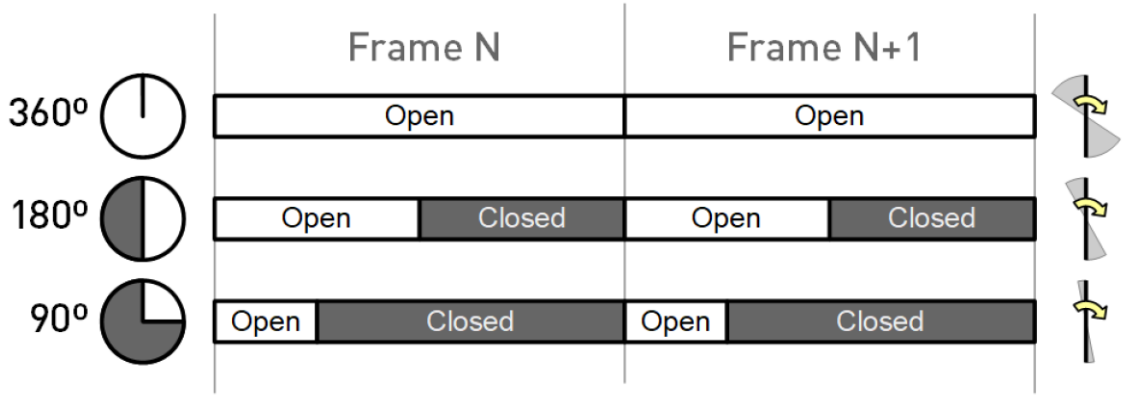

Figure 5: Shutter angle definition.

Table 5 lists the available shutter angle options and their equivalent value in stops above or below the default of **180º**. To convert between Shutter Angle and an exposure time in seconds, use the following equation:

$$(Exposure\ Time) = \left(\frac{Shutter\ Angle}{360º}\right)\left(\frac{1}{Frame\ Rate}\right)$$

*Table 5: Shutter angle options and their equivalent in stops relative to **180º**.*

Shutter Angle	Stops Relative to 180º
360º	+1
270º	+0.59
180º	**0**
135º	-0.42
90º	-1
63.6º	-1.5
45º	-2
31.8º	-2.5
22.5º	-3
15.9º	-3.5
11.3º	-4
7.96º	-4.5
5.63º	-5
3.98º	-5.5
2.81º	-6
1.99º	-6.5
1.41º	-7
0.99º	-7.5
0.70º	-8

4.1.6 Color Temperature

This setting adjusts the color temperature associated with the captured image. It is used by the HDMI preview to compensate for ambient lighting (white balance), and also embedded in the clip metadata so the Wave Player software can apply the same white balance by default. The setting does not affect the recorded image data, so the color temperature option can be changed later in the Wave Player software.

Color temperature options range from 2000K to 9600K, with higher values corresponding to cooler (bluer) ambient lighting conditions. The camera is calibrated at the 3200K (tungsten) and **5600K** (daylight) color temperatures.

4.1.7 Color Profile

This setting selects the color profile used to display the preview/playback image via HMDI, and as a starting point for image adjustments in the Wave Player Software. The

Color Profile controls image characteristics like the color space, black level, tone curve (gamma), and saturation. The setting does not affect the recorded image data, so the image characteristics can be changed later in the Wave Player Software. Table 6 lists the available color profiles as of this firmware version.

Table 6: Color Profile options.

Color Profile	Description
COLOR0	Colors are corrected for white balance only. This is a legacy option included to match v1.0.x firmware, where this was the only available color profile and was called Linear.
COLOR1	Adds correction for saturation and color cross-coupling to more closely match Rec.709 color space. Color corrections are scaled so that no sensor clipping occurs before the white point.
COLOR2	**Scales color corrections to allows some sensor clipping before the white point. This increases the output dynamic range slightly, as some data from the unclipped sensor channels can be included in highlights. More aggressive highlight desaturation is used to compensate for color shifts due to sensor clipping.**

4.1.8 GPI Setting

This setting configures the General-Purpose Input (GPI), which can be used to remotely start and stop recording. Table 7 lists the input trigger options. For more details about the electrical specification of the General-Purpose Input, see Section 8.2.

Table 7: General Purpose Input (GPI) trigger options.

GPI Setting	Description
EDGE	**Recording is toggled on and off at each rising edge of the input.**
LVL	Recording is started at the input falling edge and stopped at the input rising edge. (Recording is active while the input is low.)

4.1.9 Fan Setting

This setting controls the standby/playback mode fan setting, either low speed (**LO**) or high speed (HI). The fan is always set to high speed during recording or if any camera component exceeds its warning temperature. It's recommended to use the high speed (HI) setting when operating the camera outdoors in ambient temperatures above 30°C or in direct sunlight, to help reduce the internal temperatures between shots.

4.1.10 Default

This resets the camera settings to their default values. The reset will be temporary unless a clip is recorded with the defaults. (On boot, the camera loads settings from the most recently recorded clip.) Settings are also reset to defaults when firmware is updated or when the SSD is formatted.

4.1.11 Date/Time Set

This setting is used to change the camera's internal date and time, used for time-stamping clip files. The date and time are maintained when the camera is shut down normally, but may be lost if the battery is drained too low (below 9.0V).

4.1.12 Format

This setting triggers a format (clean erasure) of the internal SSD. This is the only method of erasing clips, and it restores the file system to ideal, unfragmented condition. To format the SSD, click the Format setting, scroll to and click **Confirm**.

Caution	**Formatting the SSD will erase all clips permanently.**

4.2 Camera Status Bar

This section covers the information displayed in the status bar. The status bar is displayed across the bottom edge of the HDMI preview image when the on-screen display is made visible by clicking the Scroll Wheel.

4.2.1 Clip

This displays the file name of the clip being recorded, or the next clip to be recorded when in STANDBY mode. Clips are numbered sequentially on the SSD.

4.2.2 Compression Ratio

This displays the current compression ratio and quantization (Q) setting. The camera always targets a compression ratio of between 5:1 and 6:1 (constant bit rate) and will adjust the quantization setting based on the content of the scene, from least quantization (Q19) to most quantization (Q0).

4.2.3 Remaining/Total SSD Space

This displays the remaining and total space available on the internal SSD. A flashing **LOW** warning is issued here at 60GB remaining, which is about a one-minute warning at maximum frame rate. A flashing **FULL** warning is issued here at 5GB remaining, and starting a new clip will be inhibited. After offloading or exporting all necessary clips, Format the SSD to erase the clips and reset the remaining SSD space.

In rare instances, the SSD may fail to initialize properly during boot-up. In this case, a flashing **REBOOT SSD** warning will be issued here. Reboot the camera to clear the warning. If the warning persists, it may indicate a missing or defective SSD.

4.2.4 Firmware Version

This displays the current Camera FW version.

4.2.5 Temperatures

This displays the current temperatures of the major heat-generating camera components. Table 8 lists the components monitored, with their warning and error (shutdown) temperatures.

Table 8: Camera component temperatures monitored.

Component	Warning Temp.	Error (Shutdown) Temp.
Image Sensor (IS)	57°C	67°C
SSD	57°C	67°C
CPU	67°C	77°C

If any component exceeds its warning temperature, a flashing **HIGH TEMP** warning will be issued here and the fan will be set to high speed, regardless of the Fan Setting. If this warning is present for extended periods of time, consider using the high speed (HI) Fan Setting, and shading the camera from direct sunlight/high-wattage lighting or providing additional airflow to the rear of the camera.

If any component exceeds its error temperature, the camera will go into a low-power state with the fan remaining on.

4.2.6 Battery Voltage

This displays the current battery voltage, which ranges from 9.0V (empty) to 12.6V (fully charged). A flashing **LOW** warning is issued here at below 10.0V and indicates that the camera should be plugged in to its charger or another suitable DC power source as soon as possible.

If the camera shuts down due to undervoltage, clips recorded up to the point of shutdown and all but the last 1GB (~1s at maximum frame rate) of any clip recording during the shutdown will be preserved on the SSD.

5 Playback Interface

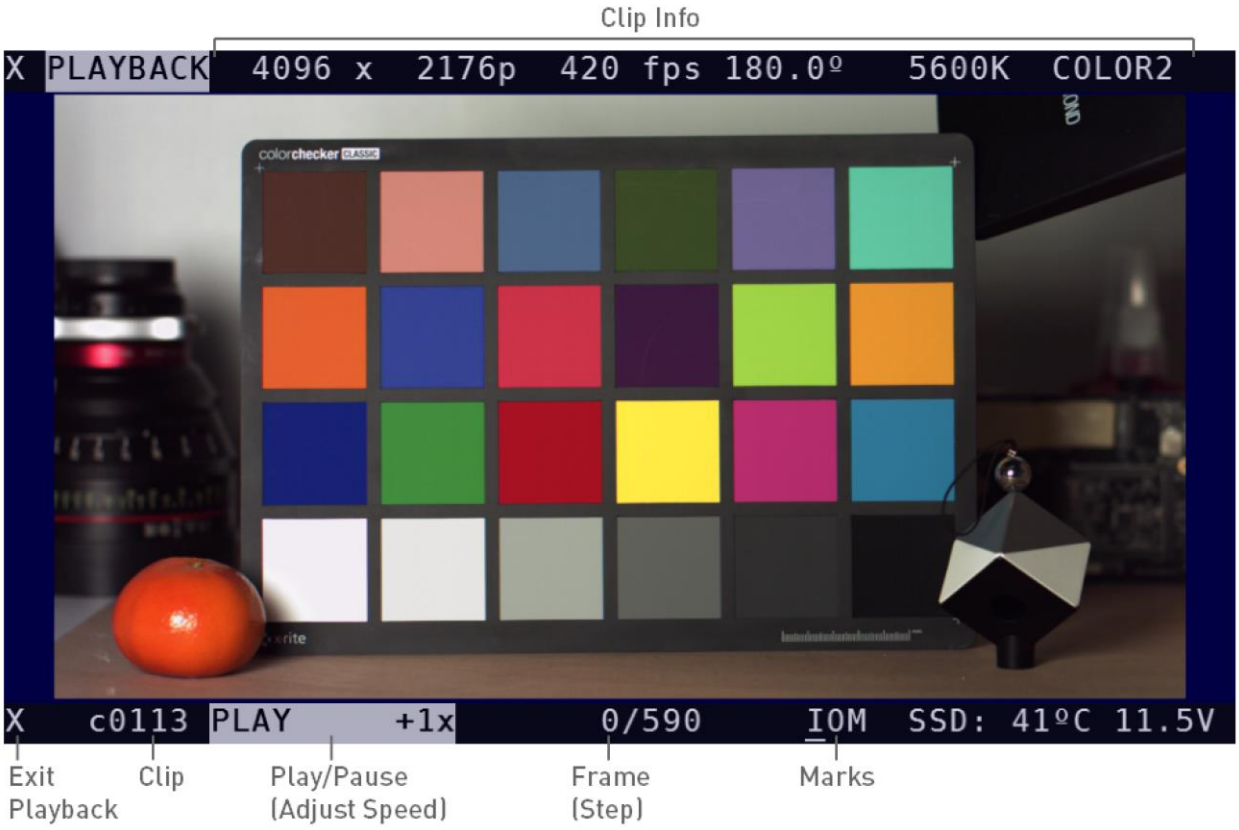

Figure 6: On-camera playback interface.

To switch to playback, click the Mode setting while it displays STANDBY, then scroll to and click PLAYBACK. This will launch the playback interface, shown in Figure 6. The Scroll Wheel cursor moves to the bottom bar playback menu and the most recently captured clip is opened for playback. The top bar is used to display Clip Info for the clip currently open. To exit playback and return to the Camera Settings Menu, click the **X** in the bottom-left corner.

5.1 Clip Selection

To select a different clip for playback, first highlight the Clip number and click the Scroll Wheel. This will display a list of available clips. While scrolling through the clips, the first frame will be displayed to help identify the clip. Find the desired clip and click the Scroll Wheel to load it. Depending on the size of the clip, it may take several seconds to fully load. Playback may be choppier while a clip is still loading.

5.2 Play/Pause

To start playback, highlight PLAY and click the Scroll Wheel. This will begin playing the clip at 1x speed. While the clip is playing, scroll left or right to change the playback

speed. To pause playback, scroll to 0x speed. To reverse the playback direction, scroll left until the playback speed becomes negative. To stop playback, click the Scroll Wheel.

Playback speeds above 1x or below -1x are fast-seeking modes that require the HDMI preview to discard its frame buffer and start reading the clip data from scratch for every frame. As such, the preview will update at a lower frame rate even though the progress through the clip is faster (similar to fast-forwarding or rewinding a streaming video).

5.3 Frame-by-Frame Stepping

The current frame and total number of frames in the clip are displayed at the center of the playback menu. To step frame-by-frame through the clip, first highlight the current frame and click the Scroll Wheel. Then, scroll left or right to step backwards or forward through the clip. To exit frame-by-frame stepping, click the Scroll Wheel again.

5.4 Marks

While in playback, an In Mark and an Out Mark can be set to highlight a section of a clip. These marks are used by Wave Player to limit export of the clip to the marked section. The In Mark and Out Mark can be moved in Wave Player Software as well if needed. By default, the In Mark and Out Mark are on the first and last frames of the clip, respectively. General-Purpose Marks can also be placed to indicate frames of interest.

Marks can be attached to individual frames by scrolling to and clicking the **I** (In Mark), **O** (Out Mark), or **M** (General-Purpose Mark) mark letter. Once the frame is marked, the corresponding mark letter will be underlined. Clicking a mark letter again will clear the mark. (If it's an In Mark or Out Mark, it will be reset to the first or last frame, respectively.)

Note that as of Wave Player Software v1.4.0, General-Purpose Marks are not yet displayed on the clip timeline. In and Out Marks set on-camera are imported, though.

6 Wave Player Software

Wave clips are recorded internally in a native file format optimized for speed, but they can't yet be opened directly by other editing tools. Wave Player is the software used to view native Wave clips, trim them, apply basic image adjustments, and export them to other formats.

Clips are organized in folders on the camera's drive, with the folder name corresponding to the clip number (e.g. D:\c0003 for clip 3). Within a clip folder, there are files containing clip metadata and clip frames. A specification for the Wave native file formats will be published separately at a later date.

Wave Player can open clips either directly from the camera's drive or from a local copy. To make a local copy of a clip, copy the entire clip folder from the camera's drive or use the Native export format in Wave Player. For Camera FW v1.3.0 and newer, the internal SSD is read-only over USB. For older firmware, it's important to avoid adding or deleting files over USB, as it leaves the file system fragmented and limits the SSD write performance.

Caution	**Camera FW prior to v1.3.0: Do not add or delete files from the camera's internal drive manually, as it leaves the file system fragmented and limits SSD write performance. Use the on-camera Format setting to erase the internal SSD cleanly.**

6.1 Basic Image Adjustments

A set of basic image adjustments are available in all versions of Wave Player. These can be used for initial tone and color corrections, but aren't meant to replace the full suite of color correction tools available in downstream editing software.

Where applicable, the default values of these adjustments are populated from clip metadata when a clip is opened. For example, if a clip was recorded with a Color Temperature setting of 4000K, this will be the value set on the Color Temp. adjustment by default when the clip is opened. This can be changed as desired since the Color Temperature setting has no effect on the actual recorded data.

6.1.1 Black Level

This adjusts the level of the darkest part of the frame and sets a baseline for the other tonal corrections. If there is a black reference in the frame, this can be used to match its expected level. Otherwise, it can be set by eye to preference.

6.1.2 Color Temp.

This adjusts the color temperature associated with the captured image, to compensate for ambient lighting (white balance). Color temperature options range from 2000K to

9600K, with higher values corresponding to cooler (bluer) ambient lighting conditions. The camera is calibrated at the 3200K (tungsten) and 5600K (daylight) color temperatures.

Increasing the Color Temp. will associate the image with a cooler (bluer) ambient lighting condition, adding more red into the output to compensate. Decreasing the Color Temp. will have the opposite effect.

6.1.3 Gain

This adjusts the overall amplification of the image, multiplying all three color channels by the same amount. A gain of 1.00 represents the point where no sensor clipping occurs before the white point when shooting a gray target. Decreasing the gain allows some sensor clipping (typically the green channel) before the white point. However, the unclipped channels can be used to recover some detail in highlights, aided by Saturation Rolloff.

6.1.4 Shadows

This fine-tunes the contrast of the lower third the tone curve. Increasing the Shadows slider pulls up details in dark areas of the image, but will also amplify noise. Decreasing the Shadows slider suppressed detail in dark areas of the image, and can be used to reduce noise.

6.1.5 Highlights

This fine-tunes the contrast of the upper third of the tone curve. Increasing the Highlights slider brightens highlights. Decreasing the Highlights slider has the opposite effect.

6.1.6 Gamma

This adjusts how much the tone curve is lifted from the baseline linear exposure. As the shadows are amplified, so is the Image Sensor's inherent noise. This setting can be adjusted along with the Shadows slider to achieve the best balance of shadow detail to noise for a given scene.

6.1.7 Contrast

This adjusts the overall contrast of the output image. Increasing the Contrast stretches out the image's tonal curve, making shadows darker and highlights brighter. Decreasing the Contrast has the opposite effect. Shadow and Highlight contrast can be fine-tuned further with the corresponding Image Sliders.

6.1.8 Tint

This adjusts the relative amount of green in the output image. Color temperature mostly affects red and blue, so Tint is used as separate adjustment for green. Increasing the Tint will add more green. Decreasing the Tint will remove green, leaving more magenta.

6.1.9 Saturation

This adjusts the color saturation of the output image. Increasing the Saturation pushes colors further away from gray, making them more vibrant. Decreasing the Saturation has the opposite effect.

6.1.10 Highlight Rolloff

This adjusts the saturation rolloff curve of highlights. Sensor color channels don't always clip at the same point, which can lead to tinted highlights or fringing. This is especially true with a Gain setting less than 1.00. To reduce color shift in highlights, the saturation is gradually reduced from the Saturation setting to zero between the two brightness values set here.

6.1.11 Shadow Rolloff

This adjusts the saturation rolloff curve of shadows. Variations in black level can lead to over- or under-correction of colors in shadows. To reduce color shift in shadows, the saturation is gradually reduced from the Saturation setting to zero between the two brightness values set here.

6.1.12 Row Filter

This adjusts the threshold of the filter used to reduce temporal row noise. Temporal row noise appears as random, time-varying changes in brightness of entire rows in the image, especially in shadows. It's exaggerated by underexposure and excessive use of the Gain, Shadows, and Gamma adjustments to boost shadow detail beyond the information available from the sensor. (See Section 7 for exposure guidance.)

The Row Filter threshold sets the level of brightness change the filter uses to separate noise from true signal. A higher value gives more filtering, but may introduce static row artifacts in scenes with strong horizontal edges. A value of zero disables the Row Filter entirely.

6.1.13 Nearest 16x9 Crop

Some Wave native resolutions are slightly larger than standard HD and UHD resolutions. (See Table 9 for examples.) By default, the full native resolution will be exported. However, the clip can be cropped to the nearest 16x9 resolution by enabling the Nearest 16x9 Crop setting and adjusting the X and Y offset as desired.

Table 9: Nearest 16x9 crops available for certain Height settings.

Height	Output Resolution after Nearest 16x9 Crop
2176	3840 x 2160 (2160p, UHD)
1088	1920 x 1080 (1080p, FHD)
768	1280 x 720 (720p)

Note that Native and JPEG Sequence export formats do not support cropping.

6.2 Windows Workflow

6.2.1 System Requirements

Table 10 lists the minimum and recommended PC system specifications for running Wave Player in Windows. Performance, in particular export frame rate, will improve significantly with system components meeting or exceeding the recommended specifications.

Table 10: Wave Player PC system specifications.

System Component	Minimum	Recommended
Operating System	Windows 10	Windows 10
CPU Cores	4	8
Memory	8GB	32GB
Graphics	2GB VRAM[1]	Discrete, 8GB VRAM
DirectX Support	DX12	DX12
Display	2560 x 1440	4K
USB	USB 3.x (SS)	USB 3.x (SS)

[1]4GB of VRAM is required for using Amplify or AI Enhance.

The disk space required by Wave Player itself is small, so a minimum or recommended local drive size is not specified. However, exporting large video files typically requires a large (1TB or greater) and fast (NVMe SSD preferred) local storage drive. **Exporting back onto the camera's internal drive is not supported.**

6.2.2 Installation

The latest Wave Player can be downloaded from the following URL:

https://freefly.gitbook.io/freefly-public/products/wave-camera/downloads

After downloading the installer, run **setup.exe** and follow the instructions. If Microsoft Defender initially blocks the installer from running, click **More info -> Run anyway**. If prompted, download and install the latest Visual C++ runtime package as well.

After installation, navigate to the folder where Wave Player was installed (typically C:\Program Files\Wave Player) and run **WavePlayer.exe**. Wave Player will select the available graphics adapter with the most video memory, typically a dedicated graphics card. Confirm an appropriate graphics adapter is indicated in the title bar.

6.2.3 Opening a Clip (Open Tab)

Figure 7: Wave Player (Windows) Open Tab

Wave Player starts on the Open tab. Click BROWSE and select a drive or folder to browse. This can be the camera's external drive or a folder on the local drive. Once a drive or folder is selected, Wave Player will generate thumbnails for any clips in that directory. Click on a clip thumbnail to open it.

Subdirectories will be shown as folders along with the thumbnails. Click on a folder to navigate down into that subdirectory. Click on the Up button to navigate up to the parent folder. To change drives, click BROWSE and select a different drive.

If you already know the exact clip you want to open, you can also select its folder in the browse dialog and it will open directly.

6.2.4 Timeline Navigation and Image Adjustment (Adjust Tab)

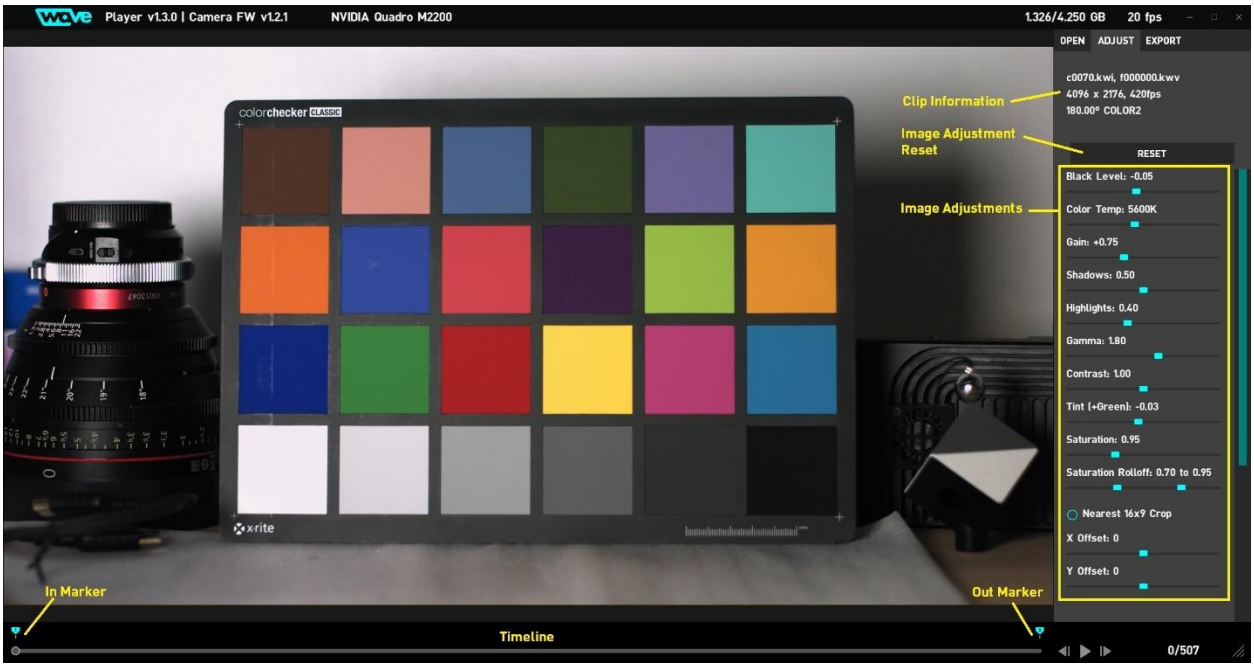

Figure 8: Wave Player (Windows) Adjust Tab

The Adjust tab is the place for interacting with a clip once it's opened. The current location in the clip is indicated by the Timeline, as well as the frame counter in the bottom right corner. There are several ways to navigate within the clip:

- Click and drag the Timeline marker.
- Use the Play/Pause, Step Left, and Step Right buttons.
- Use the keyboard:
    - Spacebar: Toggle Play/Pause
    - Left Arrow: Step Left
    - Right Arrow: Step Right

Image Adjustments are made using the sliders in the Adjust tab. The initial values for these adjustments are taken from the Color Profile used for the clip. See Section 6.1 for more information on how each adjustment can be used. To return to these values, click RESET. New values made during a Wave Player session are not saved back to the clip (original clip files are considered read-only), but will be saved to any Native export.

Two beta features are also available in the Adjust tab: Amplify, which amplifies small movement for applications like vibration analysis, and AI Enhance, which uses a deep learning super-resolution to upscale Wave 2K clips to 4K. For more details on these, see Sections 6.2.7 and 6.2.8.

6.2.5 Exporting Clips (Export Tab)

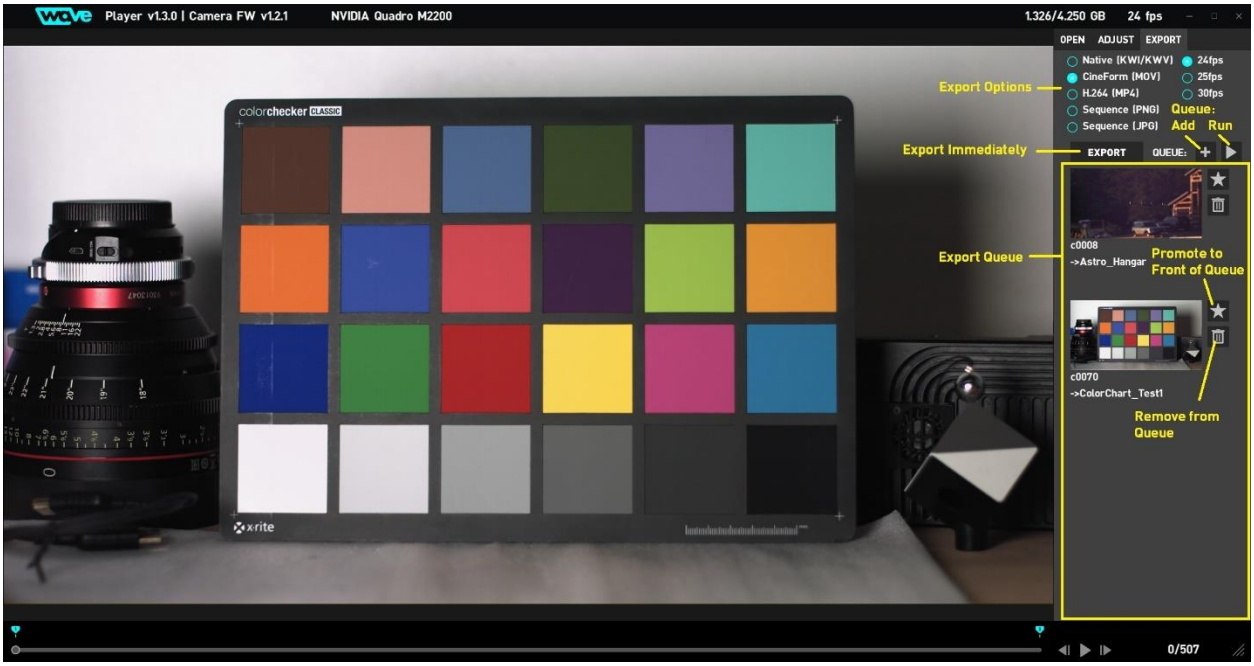

Figure 9: Wave Player (Windows) Export Tab

Clips, or sections of clips, can be exported from Wave Player in a number of different output formats for archiving, editing, or as a final deliverable. The In Mark and Out Mark set the start and end frames for export. They can be set by clicking and dragging the markers, or using the keyboard shortcuts "I" and "O".

After making any desired image adjustments and marking a section for export, switch to the Export Tab and select an export format and frame rate. To export the clip immediately, click EXPORT and select an output file location. The export will progress from the In Mark to the Out Mark as displayed in the preview. When the Out Mark is reached, the export process is finished.

Exports also be added to a queue to be processed later. To add the current clip to the export queue, click Add (+). To promote a clip to the top of the queue, click its Promote (★) button. To remove a clip from the queue, click its Remove (🗑) button.

When finished adding clips to the export queue, click Run (▶) to begin processing the queue. During queue processing, the current clip and progress will be shown in the preview. To stop the running the queue, do one of the following:

- Click Pause (⏸) to finish exporting the current clip and then pause the queue so more clips be added, or existing clips can be promoted or removed.
- Click STOP to cancel the current export immediately. It will not be removed from the queue, since it hasn't finished.

The following subsections go into more detail on the available output formats.

6.2.5.1 Native

This exports the clip in Wave camera-native format, as a folder with a single .KWI file (clip metadata) and one or more .KWV files (clip frames). The exported clip will have only the section between the In Mark and Out Mark. Image Adjustments made in Wave Player will be written to metadata, but do not alter the data saved in the .KWV files.

This export option provides an alternative to offloading large amounts of data from the camera's internal SSD to a local drive for archiving. Instead, only the sections of a clip that are needed can be marked and exported, but without transcoding to another format or committing to any color corrections.

Note that while exporting in Native format, only the first (In Mark) frame will be shown in the preview. This is because frames are not being decoded, just copied as fast as possible from one location to another. It may still take up to a few minutes to copy large clips, depending on USB interface and local storage speeds.

6.2.5.2 CineForm

This exports the clip as a CineForm-encoded .MOV file. CineForm is a high-quality and computationally-efficient wavelet compression codec that is good for both archiving and editing. It encodes output YUV data, so image adjustments made in Wave Player are "baked in" to the CineForm output. Nevertheless, it retains much of the image information and can handle further post-processing. CineForm compression is entirely intra-frame, so there are no temporal artifacts. Bit rates and file sizes are comparable to the camera's internal recording format.

6.2.5.3 H.264

This exports the clip as an H.264-encoded .MP4 file. H.264 is the ubiquitous standard for web video. It uses temporal compression to significantly decrease file size compared to intra-frame compression. As a result, it isn't a suitable archiving or editing format. But it can be used to create videos that can immediately be uploaded to the web. Wave Player (Windows) uses an H.264 bit rate equivalent to about 2.16bpp, which exceeds YouTube quality recommendations.

6.2.5.4 PNG Sequence

This exports individual frames as a sequence of PNG images, which use lossless compression and 8-bit color.

6.2.5.5 JPEG Sequence

This exports individual frames as a sequence of JPEG images, which use lossy compression and 8-bit color. Quality 100 is used to minimize compression loss, at the expense of file size, but JPEG frames will still typically be smaller than PNG frames.

6.2.6 User Calibration (Calibrate Tab)

To reduce the presence of Fixed Pattern Noise (FPN), a User Calibration can be created based on a short clip recorded with no light hitting the sensor. To generate a new User Calibration, follow the steps below:

1. Turn on the camera and wait 10-15 minutes for it to warm up.
2. With the lens or body cap on to prevent light from hitting the sensor, record a short clip (at least 40 frames, but more than that is not beneficial).
3. Connect the camera via USB and open the clip.
4. Switch to the CALIBRATE tab.
5. Select a location for the calibration data using SELECT CAL FOLDER. (This only needs to be done once and will persist across sessions and updates.)
6. Click MAKE CAL FROM CLIP.

At a minimum, this should be done at once for 4K and once for 2K. However, since FPN is affected by temperature and exposure and may change over time, it can be beneficial to generate new User Calibrations periodically or if operating conditions have changed substantially. Use camera settings that closely match the target operating point(s).

User Calibrations already present in the selected folder will be displayed in the CALIBRATE tab. The most relevant calibration for a given clip is automatically selected according to the criteria listed in Table 11, and will be highlighted. If no calibrations are valid for the selected clip, none will be highlighted.

Table 11: User Calibration selection criteria.

Criteria	Condition
Camera UID	Must match.
Width (4K or 2K)	Must match.
Height	Must match or exceed clip Height. (Closest Height selected as ranking priority #1.)
FPS	Closest FPS selected as ranking priority #2.
Shutter Angle	Closest Shutter Angle selected as ranking priority #3.
Temperature	Closest image sensor temperature selected as ranking priority #4.
Date/Time	Newest calibration selected as ranking priority #5.

To delete a User Calibration, click the Remove (🗑) button next to it. This could be used to remove an older calibration that matches more settings and enable selection of a newer calibration that might be more accurate despite matching fewer settings. It's also possible to use a custom folder structure to organize User Calibrations in a way that bypasses the default ranking priority.

6.2.7 Amplify [Adjust Tab, BETA]

Amplify is an image processing technique in Wave Player that enhances or amplifies small movements in a video for easier visual recognition. This can be used, for example, to highlight and troubleshoot vibrations in a mechanical system.

Amplify works best when the source video has low noise and minimal background movement such that the region of interest where motion is occurring remains in the same place in the video. The frame rate should be approximately 5-20x higher than the highest motion frequency of interest. (In certain cases, frame rate aliasing can also be used to visualize even higher frequencies.)

A dedicated graphics card with at least 4GB of VRAM is required to use Amplify. Note that due to memory restrictions the 1.3.0 release of Amplify only works with 2K images. 4K images can be used as source material but they will be downscaled to 2K, processed, then upscaled back to 4K. This limitation may be addressed with further memory optimization in a future release.

The following subsections explain the adjustable parameters used by Amplify.

6.2.7.1 Scale

This determines which features sizes are considered for motion amplification. Small features are at the low end of the scale and large features at the high end. Good results can usually be obtained by leaving at the default settings of 0 - 8. For Height settings below 640, better results may be obtained by setting the high end of the scale to 7 or 6.

6.2.7.2 Gain

This is the amount of amplification applied to the motion. Settings of around 5 to 10 are usually quite good. Too high a gain can cause noise and unwanted artifacts to appear. A gain of 1 is equivalent to Amplify being turned off.

6.2.7.3 Frequency

This is the frequency range over which motion amplification is applied. The left slider is a high-pass filter and the right slider is a low-pass filter. The high-pass filter is effective for removing any unwanted bulk movement in the video, for instance caused by slow panning or operator jitter. The low-pass filter can be used to reduce noise and improve the visual appearance of the video.

It is usually best to start with the low-pass filter fully to the right (off) and tune the high-pass filter for best visualisation of the motion. Then the low-pass filter can be used to reduce noise if necessary. Alternatively, if the frequency of the movement under study is known then set the range accordingly to bring out that motion.

6.2.8 AI Enhance [Adjust Tab, BETA]

AI Enhance is a deep learning super-resolution technique used to upscale Wave 2K clips to 4K. It is a Deep Neural Network that has been custom-trained for the Wave 2K frames, to take into account the subsampling used by the Wave sensor to achieve higher frame rates in 2K. So, the Ai Enhance can reduce subsampling and aliasing artifacts around edges during the super-resolution process.

With AI Enhance enabled, 2K clips (Width setting of 2048) will be processed and exported at the equivalent 4K resolution with the same aspect ratio.

A dedicated graphics card with at least 4GB of VRAM is required to use AI Enhance. The deep neural network is implemented in GPU hardware, so a higher-end desktop GPU will greatly improve the frame rate achievable with AI Enhance turned on.

Figure 10 shows how AI Enhance improves details on a 2K recording.

Figure 10: AI Enhance example of improved details on a 2K recording.

AI Enhance is still a preliminary feature and improvements are still in-work. AI Enhance works best on scenes with clear focus and good lighting (avoid underexposure).

When using AI Enhance in Wave Player, a preview of AI Enhance will activate after the video is paused for approximately 1 second. During normal playback and “scrubbing” on the timeline, the AI Enhance is temporarily disabled to allow faster preview at the tradeoff of reduced preview screen quality, since AI Enhance consumes significant GPU resources. This reduced preview effect is only for the user interface in Wave Player: images and movies exported from the Wave Player will have full image quality of AI Enhance, if AI Enhance is turned on before the Export.

7 Exposure Guide

7.1 General

7.1.1 Firmware and Wave Player Software

Continuous improvements to the color processing pipeline are made in new firmware and Wave Player software. Make sure to use the latest Camera Firmware and Wave Player, available at the following URL:

https://freefly.gitbook.io/freefly-public/products/wave-camera/downloads

In v1.1.0 Camera Firmware, highlight handling was improved, providing approximately a half-stop more dynamic range. This was done by allowing some sensor clipping and using the unclipped channels to recover highlight detail, aided by a smoother highlight desaturation curve.

In v1.4.0 Wave Player software, the ability to create User Calibrations was added to further reduce the presence of Fixed Pattern Noise (FPN), which extends the dynamic range further, especially in underexposed conditions. See Section 6.2.6 for more details.

7.1.2 Light Requirements

Shooting high speed video requires a lot of light. Each frame has less time to capture light, so more photons are required. The Wave camera's native ISO is 250. To get a feel for how much light is required at a given frame rate, you can compare with another camera using equivalent ISO and Shutter Speed settings:

Table 12: Comparable ISO and Shutter Speeds for common Wave settings.

Wave Settings	Comparable ISO and Shutter Speed
4K, 420fps, 180°	ISO 250, (1/840)s
2K, 1440fps, 180°	ISO 250, (1/2880)s

7.1.3 Bit Depth

To maximize frame rate, Wave captures in 10-bit linear with minimal processing and noise reduction. This is much different than a cinema camera that captures in 14-bit or 16-bit linear and processes the HDR image down to 10-bit log, with significant amounts of on-board noise reduction. As a result:

- The dynamic range is 10-11 stops, vs 14+ stops for a cinema camera.
- More careful control of lighting is needed to fit the scene's dynamic range to the sensor's. The image is less forgiving to under/over-exposure.
- Additional tone curve adjustment and noise reduction in post may be needed, depending on the exposure. For example, the Shadows adjustment in Wave Player can help curve out shadow noise.

7.1.4 Contrast-Dependent Black Level and Noise Floor

Black level in high-contrast scenes will be lower than black level in low-contrast scenes. This also has implications for the noise floor:

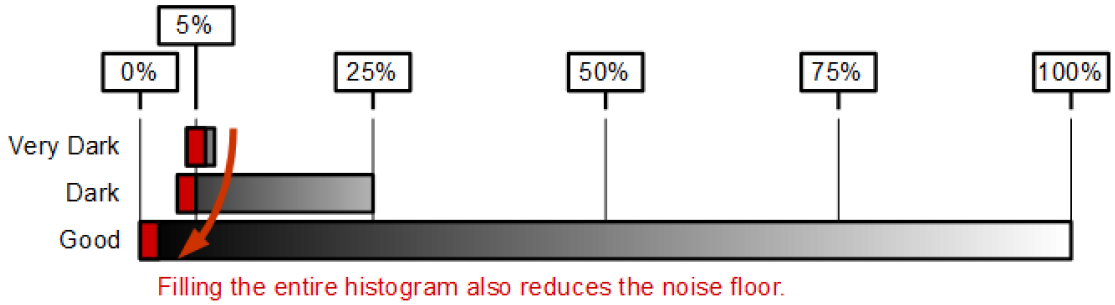

Figure 11: Contrast-dependent black level and noise floor.

If a scene is under-exposed, the black level and noise floor will be higher. Additionally, tone curve adjustment and noise reduction will be less effective, since more of the scene's information is in shadows. The noise can't be reduced without also throwing out information.

Magenta-tinted shadows are also a consequence of the artificially higher black level in underexposed scenes: too much color correction is applied to the higher shadow levels. To compensate for this, the black level can be manually adjusted downward in Wave Player, or the Shadow Rolloff setting can be adjusted to reduce shadow saturation.

7.2 Indoor

Wave works well for indoor studio and tabletop shooting, as it's usually much easier to control the lighting. You do need a lot of light, though. Set exposure to exactly fill the histogram with highlights just below 100% (other than light sources and specular). Then add light as-needed to fill shadows.

7.2.1 Choice of Background

- Dark, flat backgrounds will exaggerate the noise. If you want a black background, be prepared to use the Shadows curve adjustment to suppress noise. Add extra fill light to shadowed areas on the foreground/subject to compensate.
- Light or textured backgrounds work well as-is without much adjustment.
- Outdoor light from windows in the background will probably clip. If you need to also capture what's outside the window, follow the Outdoor tips.

7.3 Outdoor

There's plenty of light outdoors, but fitting an outdoor scene into the available dynamic range is more challenging. More discretion and test shooting might be required to know if Wave will work for a given outdoor shoot. Use a daylight-visible field monitor and hood to make sure you can get a good look at the preview image exposure.

7.3.1 Front Lighting

When possible, keep the sun behind you. This will reduce the scene dynamic range by illuminating the subject more, allowing more of the background to also be captured.

7.3.2 Back Lighting

If the scene has to be backlit, it will probably have more dynamic range than can be captured by the sensor. You have some choices:

- Add some fill lighting or bounce some sunlight onto the subject.
- Expose for the subject and allow the sky to clip.
- Expose for the sky, allowing the subject to be in silhouette.

8 GPIO Connector

The GPIO connector provides two general-purpose inputs (GPI) and two general-purpose outputs (GPO). Figure 12 shows the pinout of this connector and the color coding of the Mōvi Pro Wave Remote Control Cable (Freefly P/N 910-00661).

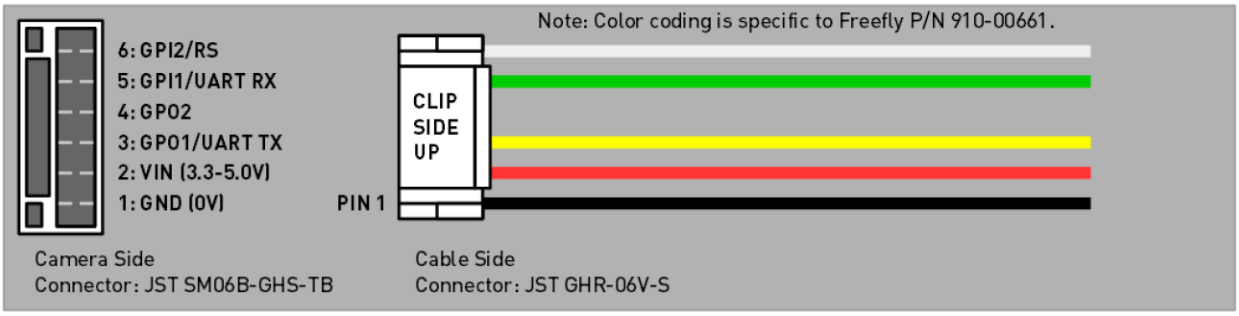

Figure 12: GPIO Connector Pinout and Color Coding

8.1 Mōvi Pro Wave Remote Control Cable

The Mōvi Pro Wave Remote Control Cable (Freefly P/N 910-00661) is available on the Freefly Store. You can use this now for remote start/stop on your Mōvi Pro. It will also enable full camera control via UART in a future firmware update. You can also use this as a donor cable to wire up a custom remote start/stop for other systems (see below).

The settings to use for remote start/stop with the Mōvi Pro and Mōvi Controller are shown in Table 13.

Table 13: Compatible settings for GPIO-based trigger with the Mōvi Controller.

Device	Setting	Value
Wave	GPI Setting	GPI:EDGE (default)
Mōvi Controller	FIZ Config->Camera Type	ARRI RS

8.2 Custom Remote Start/Stop

A custom remote start/stop cable can be created by following the wiring diagram in Figure 13. The GPIO are optically isolated, so the host must supply a voltage (3.3V or 5V is okay) to power its side of the optocoupler. The current drawn will be <20mA.

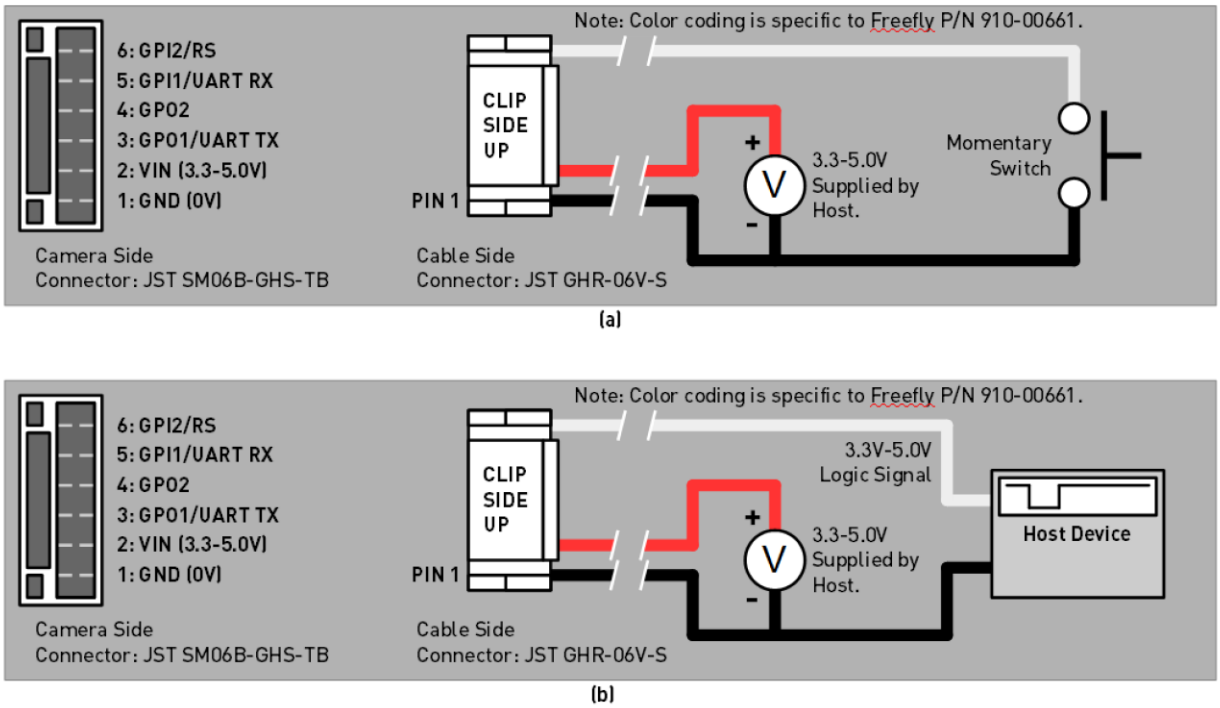

Figure 13: Wiring of a custom remote start/stop cable.

The user input connects to Pin 6: GPI2/RS. It can be a simple switch, as in Figure 13a. In this case, the switch connects the GPI2/RS pin to GND (0V). By default, each single press will toggle the recording state on or off, just like the dedicated Record Button. For wireless remote start/stop, a relay- or transistor-based RC switch can also be used.

Alternatively, a logic signal from a host device can be used to drive Pin 6: GPI2/RS. The host device should be connected to the same ground (0V) as Pin 1: GND, and the logic high voltage should match the voltage supplied to Pin 2: VIN. GPI2/RS is internally pulled-up to VIN, so open-drain logic can also be used.

The behavior of the input is determined by the GPI Setting as described below.

8.2.1 Edge-Triggered, GPI:EDGE (Default)

The recording state is toggled on or off at each rising edge of the GPI2/RS input, as illustrated in Figure 14. In the case of a simple button, recording would start or stop each time the button is released, since the button connects GPI2/RS to GND (0V). There are some restrictions on the pulse width and frequency implemented to prevent glitches, also shown in Figure 14.

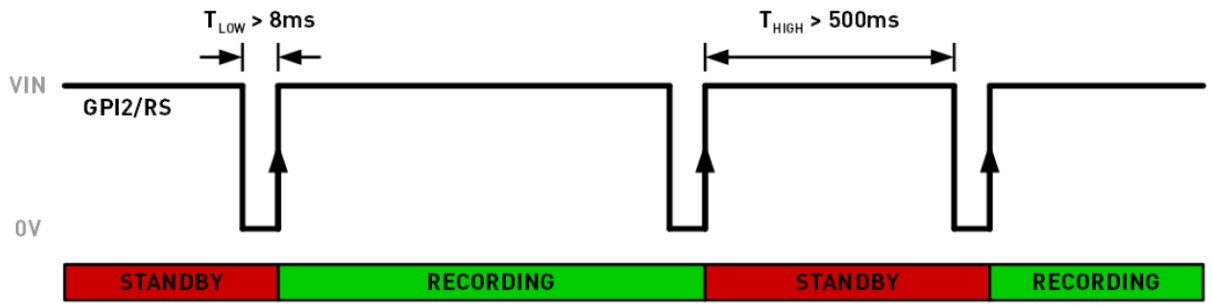

Figure 14: GPI behavior in edge-triggered mode.

8.2.2 Level-Triggered, GPI:LVL

The camera records when the GPI2/RS signal is low and returns to standby when the GPI2/RS signal is high, as illustrated in Figure 15. In the case of a simple button, the camera would record while the button is held down, since the button connects GPI2/RS to GND (0V). There are some restrictions on the pulse width and frequency implemented to prevent glitches. These are detailed in Figure 15.

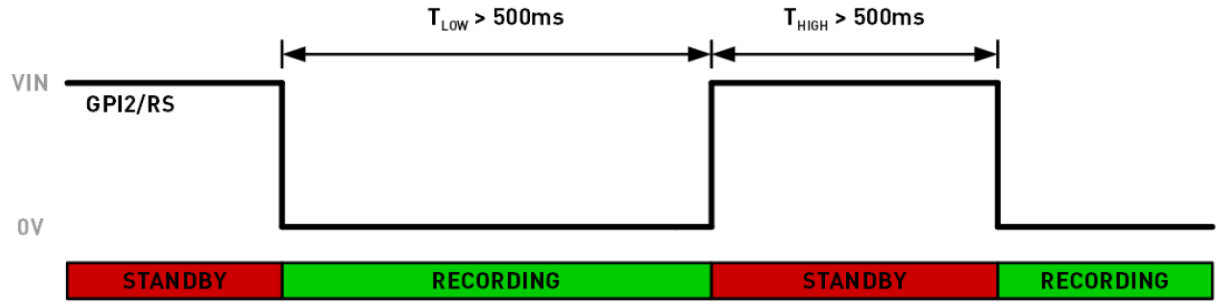

Figure 15: GPI behavior in level-triggered mode.