

# PROTON OS

Reference Manual

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# 1 Introduction

This manual describes the usage of PROTON cameras running the PROTON Operating System (short: PROTON OS).

Details on the general operation of a camera running PROTON OS can be found in chapter 2. Instructions for firmware updates in chapter 3.

PROTON OS uses a custom control protocol, but it is also compatible with the ProVideo protocol from ATOM one cameras via alias functions (see chapter 5.3).

PROTON cameras can be controlled with PROTON Control, an easy-to-use PC and Mac application (see chapter 4.1). If you want to control the device via a terminal application or a custom hardware controller, see chapter 4.2 for tool recommendations and chapters 5 and following for a detailed description of the command protocol.

## 1.1 Supported Devices

This manual covers the following PROTON devices:

- PROTON CAM (and its RAIN, FLEX and ZOOM variants)
- PROTON PRO
- PROTON 4K (and its FLEX, ZOOM and 3D variants)
- PROTON HFR

For a full list of all supported devices and instructions on how to identify them see the `system info` and `identify` commands.

# 2 General Operation

The device is connected via two sockets which are either integrated into the housing or detached via cables:

1. Power and control: 6 pin Hirose HR10 connector, see chapter 2.1.
2. SDI video: Mini BNC or Micro BNC connector.

The device will immediately power on when the supply voltage is connected, the boot process takes a few seconds. Once the device is operational the LED on the back side will blink blue. For details on the status LED see chapter 2.2.

The device is controlled via an RS485 half-duplex serial interface. The camera acts as a slave device and will not send data without a request from the host. That makes it possible to connect multiple devices to the same host without data corruption. In this case each device must have a unique device address. For details on how device addressing works, see chapter 5.1.1.1.

To control the device attach it to an RCP (e.g. [CyanView](#)) or connect it to a PC using the bundled RS485 USB dongle.

## 2.1 Power and Control Connector

For power and control a 6 pin Hirose HR10 connector is used. The pin assignment is as follows:

Table 1: Pinning of the power and control connector.

Pin	Function	Camera Cable <sup>1</sup>	Breakout Cable
1	RS485 A / +	White	White
2	RS485 B / -	Black	Green
3		Unused	
4		Unused	
5	Ground	Blue	Black
6	Supply Voltage (4.5V to 25V)	Brown	Red

<sup>1</sup> Only present if the camera has detached (not integrated) connectors.

## 2.2 Status LED

On the back of the device is an RGB status LED that indicates the current device state. You can change the brightness of the status LED with the `system status_led` command. The following blink codes are possible:

Table 2: Status LED blink codes.

State	Blink Code	Description
<b>Boot</b>	<b>Blinks cyan</b> , 2.5x per second (200ms on, 200ms off)	Device is booting after power got connected. This state is very short so normally this code is barely visible for a few milliseconds. If a firmware install is interrupted due to power-loss this state will take longer while the bootloader recovers.
<b>Verify / Upgrade Firmware</b>	<b>Blinks green</b> , 2.5x per second (200ms on, 200ms off)	Device is verifying or installing a firmware. This happens both during normal boot (a few seconds) and during a firmware upgrade (about two minutes).
<b>Boot Error</b>	<b>Flashes red</b> , 1x per second (200ms on, 800ms off)	Device failed to start. This is a critical error that cannot be recovered. Contact PROTON customer support.
<b>Startup</b>	<b>Blinks purple</b> , 2.5x per second (200ms on, 200ms off)	Device is initializing after boot (loading stored settings).
<b>Normal</b>	<b>Blinks blue</b> , 2.5x per second (200ms on, 200ms off)	Device is streaming video and waiting for commands.
<b>Busy</b>	<b>Blinks yellow</b> , 2.5x per second (200ms on, 200ms off)	Device is busy processing a command.
<b>Error</b>	<b>Blinks red</b> , 2.5x per second (200ms on, 200ms off)	Device encountered an error, e.g. while loading settings or processing a command or due to a “previous over temperature” event. This should not happen during normal operation. To get the error log use the <code>system error</code> command. If the error persists, contact PROTON customer support.
<b>Over Temperature</b>	<b>Blinks red long</b> , 1x per second (800ms on, 200ms off)	Device reached critical temperature and is in cooldown mode. For details see chapter 2.3.

## 2.3 Overtemperature Protection

Since PROTON cameras are optimized for a small form factor, they will reach high temperatures under operation. You can check the current temperature using the `system temp` command. The device also logs the maximum temperature since the last power cycle which can be read using the `system temp max` command.

To protect the device, it will enter a cooldown mode if the critical system temperature of **90°C** is reached. Cooldown mode is signaled by a red status LED which is turned on long (800ms) and off shortly (200ms). In this mode the camera does not output a video signal to reduce the heat output and reach a safe temperature again. The device will still respond to commands, but most camera and video commands will fail or have no effect. This error can be checked remotely using the `system error` command.

Once the system temperature falls below **85°C** video processing is restarted. To make it easier to detect previous over temperature events the LED will continue to blink red (200ms on, 200ms off) and the “previous over temperature” event can be read using the `system error` command

Every time the camera reaches the critical temperature the over temperature counter is incremented. It can be read using the `system temp count` command. The counter is persistent and is not reset by a power cycle or reboot.

Some camera models come with a cooling fan installed. By default, the fan is configured to turn on once the camera’s temperature reaches **70°C**, it turns off when the temperature has fallen by 10°. The turn-on

temperature can be changed with the `system temp fan` command. Regardless of the setting the fan will always turn on once the camera reaches **85°C** to ensure stable operation.

For more details regarding the temperature commands see section 7.3.14.

## 2.4 Humidity Detection

Weatherproof devices like the PROTON RAIN have an additional internal temperature and humidity sensor. You can use the `system humidity` command to keep track of the current relative humidity (%RH) inside the camera.

If the humidity exceeds **80%RH** the camera should be dried out (see below). This error case is indicated by a flashing red LED and can be checked via the `system error` command. When the threshold is exceeded a permanent “humidity event” is logged. The event counter can be read with the `system humidity count` command. Please note that the camera stays in this error state until the next power cycle or reboot, even if the humidity falls below the 80%RH threshold again. This is done so that humidity issues can easily be detected by the operator.

### Drying the Camera:

When high humidity is detected, the camera must be set up in a dry and warm environment. Remove the lens completely so that the front of the camera is open and keep the camera running for at least 1 hour. The heat produced by the camera will dry out any moisture that is inside it. Afterwards install the lens again as described in the operational manual. Check the `system humidity` command to confirm that humidity is now reduced.

## 2.5 Integrated Microphones and Cooling Fan

Some camera models feature built-in stereo microphones which are enabled by default, the audio data is embedded into the SDI signal. To enable or disable audio or change the volume see the `system audio` commands.

On devices with a cooling fan the audio quality will be reduced when the fan is turned on. If good audio quality is required, mount the camera with a good thermal connection. Additionally, the fan start temperature can be increased with the `system temp fan` command. Using a combination of good mounting and a high fan start temperature should allow for silent operation of the camera.

**Caution:** Using a high fan start temperature will cause the camera to be very hot. Make sure the camera cools down before touching it!

## 2.6 Synchronization

Some camera models have a synchronization port. This can be used to run the camera frame synchronous to another camera or an external synchronization source.

There are 3 synchronization modes available which can be selected via the `system sync` command:

- **Off:** Camera is free running and sync output disabled.
- **Master / Internal:** The camera outputs a synchronization signal on the sync port. This mode is also used on all cameras of a multi-camera rig for internal synchronization.
- **Slave / External:** The camera synchronizes to an external signal received on the sync port.

When the camera is switched to slave mode it will try to synchronize to the master signal for up to 10 seconds. If synchronization fails because there is no master attached or its sync signal does not match the configured video mode, the device switches into free-running operation. In that case the error codes -113 (no master signal) or -111 (invalid master signal) are returned. In the background the camera keeps trying to synchronize. Once the synchronization was successful a short interruption of the SDI signal occurs while the image pipeline is restarted synchronously.

While in slave mode every command that restarts the pipeline (e.g. `video mode`, `video phases`, `video phases packing`, `system sdi clock_tune`, `settings load` and `settings reset`) will also trigger a re-sync to the master signal so these commands may take longer to finish. If the synchronization fails, the same error codes as for the `system sync` command are returned (-111 or -113).

When the system is locked to an external sync signal the currently configured clock offset can be read using the `system sync offset` command. To speed up the synchronization process when starting the camera or switching video mode the current offset can be permanently stored as the system's clock tuning value with the `system sync calibrate` command.

The following example shows how the calibration works on a slave camera which is already synchronized. Note that while the synchronization offset is in ppb (parts per billion) the clock tuning is specified in ppm (parts per million) so the offset is rounded to the nearest ppm value.

```
→ 1 system sync offset
← system sync offset 1510      # Current offset is 1510 ppb
← OK
→ 1 system sync calibrate     # Calibrate clock tuning
← OK
→ 1 system sync offset
← system sync offset -677     # Offset after calibration is -677 ppb
← OK
→ 1 system sdi clock_tune
← system sdi clock_tune 2     # Clock tuning is set to 2 ppm
← OK
```

In the above example only the `system sync calibrate` is needed to run the calibration, the other commands are only used to showcase how the calibration works.

If the system does not lock to an external sync source, it may help to clear the current clock tuning by setting it to 0:

```
→ 1 system sdi clock_tuning 0
← OK
```

## 2.7 3D Stereo Camera Rigs

Devices like the PROTON 4K 3D consist of two cameras integrated into one housing. Both cameras share the RS485 control interface, by default the "A" camera has the ID 1 and the "B" camera has ID 2. To control both cameras at the same time the broadcast group 0 is used. Camera "A" is configured as the broadcast master by default so only the "A" camera replies:

```
→ 0 video mode 31           # Change video mode to UHDp60 on both cameras using
                             the default broadcast ID 0
← OK                         # Reply from broadcast master camera "A"
```

In the case of a misconfiguration (e.g. both devices have the same ID) they can be reset to their default settings via the fail-safe address 100. In that case both devices will reply so the output may be scrambled.

```
→ 100 settings reset all    # Reset all settings including RS485 config
← ...                       # Ignore garbage reply
→ 0 settings save           # Save settings using default broadcast ID
← OK                        # Reply from camera "A"
```

Note that for 3D rigs the "interactive" shell mode is not supported as this would make the device inaccessible due to the shared RS485 interface.

For details on device addressing and broadcasting see chapter 5.1.1.

To synchronize the video output of both cameras in the stereo rig they have an internal sync connection. The synchronization process can take a few seconds. That means when turning the camera on or switching the video mode the slave camera will take a few seconds longer to come up than the master camera. Therefore the "B" camera of the rig acts as the sync master and the "A" camera as the slave. This ensures that the slower camera (the sync slave) is the broadcast master.

To speed up the synchronization run the `system sync calibrate` command (need only be done once per rig, the value is saved permanently):

```
→ 0 system sync calibrate
```

---

← OK

For details on camera synchronization see chapter 2.6.

## 2.8 Error Recovery

In case the device runs into an unexpected condition several reporting and recovery mechanisms are implemented.

Should the camera lock up due to faulty firmware, instable power-supply or other unexpected errors the internal watchdog will reboot the device trying to resume operation. When this happens the status LED blinks red afterwards and the `system error` command shows that a watchdog event was logged:

```
→ 1 system error
← Watchdog: System got reset by watchdog.
← OK
```

If this does not resolve the issue the camera will enter a safe operational mode after the watchdog got triggered three times in a row. In safe mode the camera does not output any video but can be reset to default settings or a firmware update can be performed to recover the device (see below). This mode is indicated by a red LED and a critical error message in the `system error` log:

```
→ 1 system error
← Critical: System got reset by watchdog three times, try to reset settings or
upload a different firmware to recover.
← OK
```

The error flags are cleared when the camera starts successfully after a power-cycle or reboot.

### 2.8.1 Recovery via Settings Reset

To recover a camera which is in safe mode first try to reset the settings to their default values (see chapters 6 and 7.3.4 for details):

```
→ 1 settings reset
← OK
→ 1 settings save
← OK
→ 1 system reboot
← OK
```

Note that the reboot is needed to clear the error flags and resume normal operation.

### 2.8.2 Recovery via Firmware Update

If the camera is still stuck in safe mode after a settings reset, try to perform a firmware update as described in chapter 3.

### 2.8.3 Recovery via Firmware Rollback

If for some reason the firmware update does not work, e.g. the camera does not accept the update file, a rollback to the previously installed firmware can be performed, if it is still available in the backup partitions.

To do so first check if there is a backup firmware image available using the `firmware list` command:

```
→ 1 firmware list
← image 0:
← swap type: none
← confirmed: yes
←
← image 1:
← swap type: none
← confirmed: yes
←
← image 0: primary area (1):
```

```
← version: 1.7.0+0 # Currently active software version
← image size: 299288
← magic: good
← swap type: test
← copy done: set
← image ok: set
←
← image 0: secondary area (2):
← version: 1.6.1+0 # Software version in the backup partition
← image size: 282380
← magic: unset
← swap type: none
← copy done: unset
← image ok: unset
←
← image 1: primary area (3):
← version: 2.3.0+0 # Currently active video processor version
← image size: 1381101
← magic: good
← swap type: test
← copy done: set
← image ok: set
←
← image 1: secondary area (4):
← version: 2.1.0+0 # Video processor version in the backup
# partition
← image size: 1331437
← magic: unset
← swap type: none
← copy done: unset
← image ok: unset
← OK
```

In the above output image 0 is the software image and image 1 is the video processor image. For each image the primary area contains the currently active image while the secondary area contains the previously installed version.

Both images can be reverted independently. To do so request an upgrade for the image you want to restore from the backup partition with the `firmware request_upgrade` command (usually it makes sense to revert both to the last known good state):

```
→ 1 firmware request_upgrade 0
← OK
→ 1 firmware request_upgrade 0
← OK
```

Now reboot the camera:

```
→ 1 reboot
← OK
```

The bootloader will now swap the update images (just like during a regular firmware update). This process may take a few minutes and the camera blinks green while it copies the data (see

After the camera is reachable again you can check if the update was successful using the `system info` or `firmware list` commands.

## 2.9 Optional Features and License Keys

Some PROTON devices have optional features which extend the product's functionality. They are enabled via a license key which can either be purchased with the camera, so it is already activated in the factory, or later. The following optional features are available:

Table 3: Optional feature overview.

Model	Optional Features
PROTON HFR	<b>12G SDI Output:</b> Allows the camera to output UHD video signals for packed SQD or 2SI output. See the <code>video phases packing</code> command for details.

Each camera can only have one active license key at a time. If the camera already has a license key activated and an additional feature shall be enabled the key must be upgraded so it contains all enabled features.

To purchase a new key or upgrade an existing one please contact the PROTON sales team at [sales@proton-camera.com](mailto:sales@proton-camera.com).

To activate a license key, use the `system license` command, it can also be used to dump the currently activated license key. To check which optional features are available and how their current license state is, use the `system license list` command. Alternatively, this functionality is also available in the “Camera Info” tab of PROTON Control:

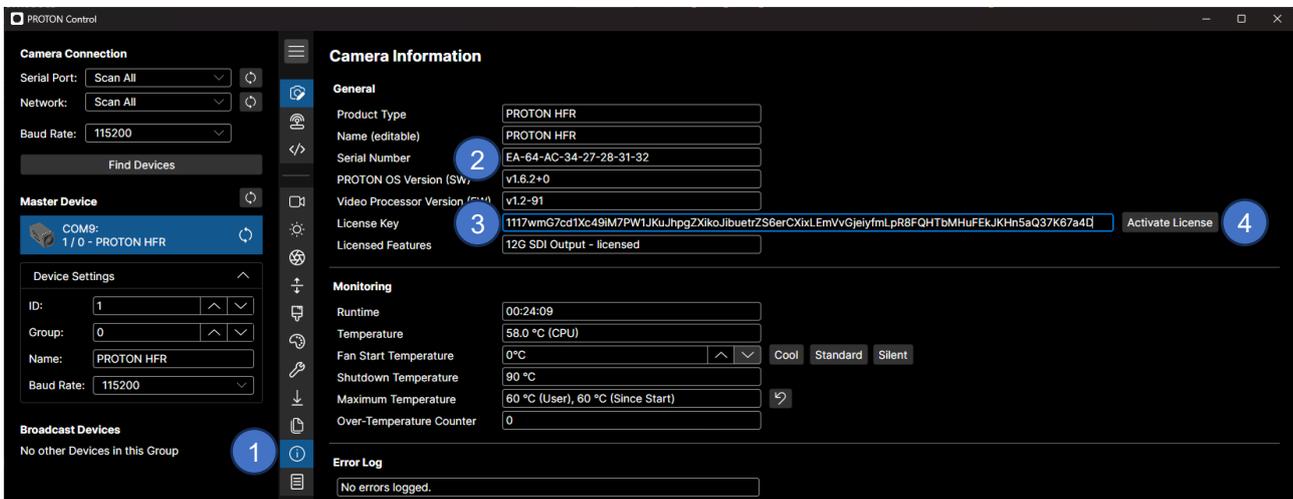


Figure 1: License key management with PROTON Control.

On the Info tab (1) you can see the device’s serial number (2) which is needed to purchase an optional feature for your camera, you can copy-paste it from the text box.

After receiving the license key enter it in the license key field (3). Make sure to override any previous text in that field, again copy-paste works fine. Afterwards click the “Activate License” button (4). The camera checks the key for validity and PROTON Control displays a message box with the result.

Note that the license management commands and UI controls are only available on devices which have optional features (see Table 3 above).

### 3 Firmware Update

Firmware updates are performed via the camera’s serial interface. The update is a two-step process:

1. Transfer new firmware to the device.
2. Install and verify new firmware.

This process is executed automatically by the PROTON Control or PROTON Updater software which are described in the following chapters. For details on the update process see chapter 3.3.

#### 3.1 PROTON Control

Firmware updates via PROTON Control are described in the Control Software chapter, see section 4.1.

## 3.2 PROTON Updater

Alternatively, firmware updates can also be performed via the PROTON Updater application. The app is supplied with every firmware release and runs under Windows and macOS. It can be downloaded here: <https://proton-camera.com/downloads/>

**Note:** The updater only works if the camera is connected via a serial port interface (e.g. USB) as the Updater does not support IP transfer. If you want to update the device via IP, use the fully featured PROTON Control application instead (see chapter 4.1).

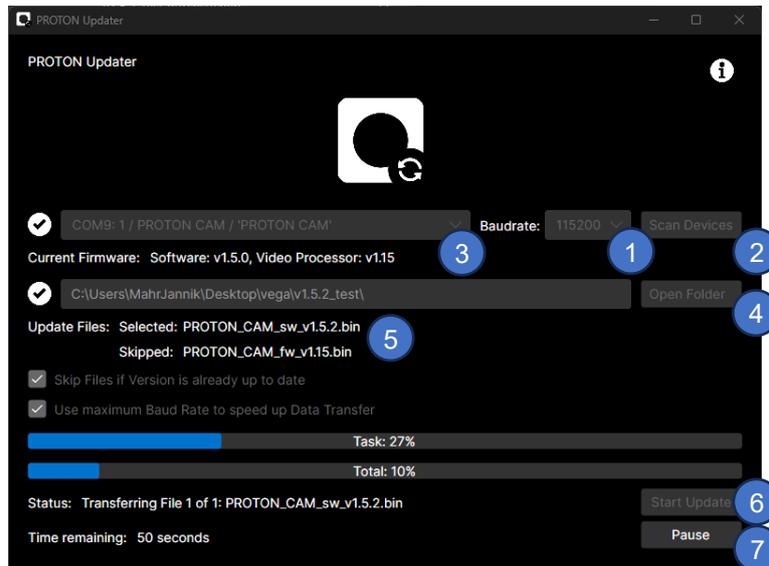


Figure 2: Example for the PROTON Updater application

To install a firmware update with the PROTON Updater GUI, follow these steps:

- Connect the camera to your PC using a USB to RS485 adapter. It is possible to have multiple devices on the same RS485 interface.
- Open the “PROTON Updater.exe” from the firmware release folder.
- Select the baud rate which is currently configured in the camera (1) and click *Scan Devices* (2), the GUI will automatically scan all available COM ports for connected PROTON devices and show them in the drop-down menu besides the *Scan Devices* button.
- If only one camera is connected it will automatically be selected. If you have multiple cameras connected (via separate RS485 dongles or on the same bus) select the camera which you want to update from the drop-down list (3).
- Click the *Open Folder* button (4) and navigate to the folder which contains the firmware updates you want to install.
- Verify that the GUI has found the correct update files, they are displayed below the update folder path (5).
- Click *Start Update* (6) The whole process takes several minutes, depending on the camera model. The upper progress bar will fill several times (once for each update file and finally for the install and verify step). The overall progress and the estimated total time remaining are displayed at the bottom of the window.
- The process can be aborted anytime by clicking the *Abort* button (7). Unless you close the GUI or disconnect the camera, the progress is retained, and you can continue by clicking the *Start Update* button (6) again.
- **Note:** Only after all files have been transferred successfully, is the update made permanent. If the camera is power cycled before all files are transferred, the progress is lost.

### 3.3 Update Process

This chapter is provided for reference only; users can use the PROTON Updater or PROTON Control for firmware updates which automatically perform the required steps.

#### 3.3.1 Data Transfer

Before data transfer starts, the camera must be switched to firmware update mode, see `system update` command for details. The update process is robust regarding interruptions and data corruption. To check if a camera is already in update mode you can use the `system status` command.

The update speed mainly depends on the configured RS485 baud rate which can be changed before starting the update with the `system rs485 baudrate` command.

#### 3.3.2 Install and Verify

After the firmware has been transferred successfully the camera is restarted with the `system reboot` command. During boot it will detect the new firmware, install and verify it. This process can take **several minutes**, depending on the device. During installation, the status LED will blink cyan and green. In case the image cannot be verified by the bootloader (wrong image uploaded, data got corrupted) the update will be aborted, and the camera starts with the previous firmware.

After the firmware has been installed and verified the camera continues to boot. During the initialization of the application a self-check is performed. Should the camera not be able to initialize, the status LED will blink red. In this case the camera will revert to the previous firmware when it is power cycled or rebooted with the `system reboot` command.

## 4 Control Software

### 4.1 PROTON Control

All features of the camera can be controlled via the PROTON Control application which runs under Windows and macOS. The app is supplied with every firmware release and can also be downloaded here:

<https://proton-camera.com/downloads/>

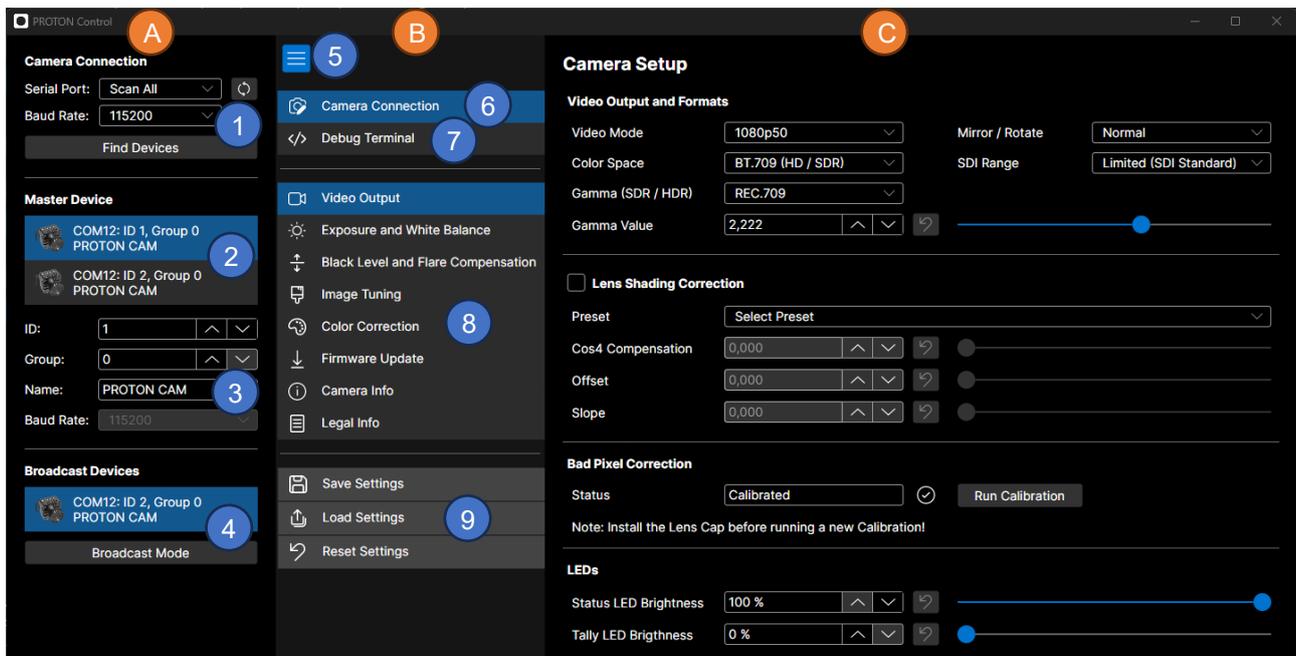


Figure 3: Example for the PROTON Control application

The application is split into three major panes which are marked with orange dots in the figure above. These are, from left to right:

- (A) **Camera Connection Pane:** Find and select devices, set up serial port parameters and configure broadcasting.
- (B) **Selection Pane:** Select which settings shall be displayed in the control pane and manage settings storage.
- (C) **Control Pane:** Control camera settings.

Usage instructions:

- To **list available devices**, select a serial or use “Scan All” to scan on all ports. Choose a baud rate and click the “Find Devices” button **(1)**. The scan may take a few seconds depending on the amount of available serial ports.
- If only a single device is found the application automatically loads the device settings. If multiple devices are found select a master device from the list **(2)**. To **load the device settings**, move the mouse into the control pane **(C)**. For touch displays tap on the control area.
- In section **(3)** you can **change the RS485 settings** of the selected device and assign a new **device name**. Note that changing the baud rate is only supported if this is the only device on the port or all devices are in the same broadcast group and broadcasting is enabled.
- For **broadcast operation** (sending commands to multiple devices on the same port) the same group address must be assigned to all devices. This can easily be done by selecting the desired broadcast devices from the list **(4)** which will add them to the broadcast group of the current master device. To remove a device from the group simply click it again. In the example above the camera with ID 2 is already in the group of the master camera with ID 1. To enable broadcasting, click the “Broadcast Mode” toggle button.
- Click the menu button **(5)** to **expand or close the settings pane**. It is closed by default to make the app more compact.
- Click the “Camera Connection” button **(6)** to **expand or close the camera connection pane** to further decrease the size of the application when it is not needed.
- **Open a debug terminal** at the bottom of the application by clicking the “Debug Terminal” button **(7)**. It can be used to manually send commands to the device. Note that the app will not track the commands sent via the terminal, so changes to the device will not be reflected in the app.
- **Select which controls shall be displayed** in the control pane **(C)** by selecting one of the tabs **(8)**.
- **Save, load and reset settings** on the camera **(9)**. The app will automatically fetch the changed settings as needed.

## 4.2 Terminal Applications

For direct control via commands, you can also use any terminal application which supports opening serial ports including:

- Putty: <https://www.putty.org/>
- Tera Term: <https://teratermproject.github.io/index-en.html>
- Serial Monitor for VS Code: <https://marketplace.visualstudio.com/items?itemName=ms-vscode.vscode-serial-monitor>

## 5 Command Interface

PROTON cameras are controlled via a text-based command interface on the RS485 serial port. All commands consist of human readable ASCII characters.

The interface uses the following settings:

- Default baud rate: 115200 baud (adjustable, see `system rs485 baudrate` command)

- 8-bit data, no parity, 1 stop bit (aka 8BitN1)
- No HW flow control

## 5.1 Operational Modes

The camera has two operational modes:

1. Controller Mode: Default mode, RS485 addressing is enabled, echo is disabled.
2. Interactive Mode: For testing and debugging, RS485 addressing is disabled, echo is enabled.

These are described in detail below.

To switch between the modes, use the `system rs485 mode` command or the `controller` and `interactive` alias commands.

**Note:** Interactive mode is not supported on 3D camera rigs as it would make the devices inaccessible due to the shared RS485 interface (see chapter 2.7). Trying to switch to interactive mode on such a device will return error code -134 (operation not supported).

### 5.1.1 Controller Mode

This is the default mode. In controller mode the camera uses RS485 addressing (see below) so that multiple cameras can be connected to one host on the same RS485 bus.

In this mode the camera has reduced output to keep the RS485 bus as free as possible:

- No prompt printed at new line.
- No echo output.
- No or reduced help and error messages.

This mode is used when controlling the camera via a HW controller or the GUI.

#### 5.1.1.1 RS485 Addressing

In controller mode each command sent to the camera must be prefixed with the camera's RS485 address. The address is an integer value from 0 to 99 which can be changed using the `system rs485 device_address` command.

When multiple devices are connected to the same RS485 bus each camera must have a unique address, otherwise multiple devices will reply to the same command causing garbage on the bus. You will have to set up each device separately before connecting them to the same bus.

The address 100 is reserved as the fail-safe address. Every device will always reply to commands sent on address 100. This can be used if the current device address is unknown but should only be used if only one device is currently connected to the RS485 bus. Exception: To scan the bus for connected devices you can send the `system identify` command to the fail-safe address and all devices will report back in order of their device addresses. For details see the `identify` command description.

#### 5.1.1.2 RS485 Broadcasting

In addition to a unique device address each camera also has a broadcast address. Multiple cameras that have the same broadcast address form a broadcast group. Within each group one camera acts as the broadcast master. Commands which are sent to the broadcast group are processed by all cameras which are part of that group, but only the broadcast master will reply, keeping the bus clean.

The Broadcast address can be changed using the `system rs485 broadcast_address` command, valid addresses are values from 0 to 99 but it is not allowed to set it to the same value as the device address. To completely disable broadcasting for this device set the special address -1.

After the broadcast address has been configured select the broadcast master using the `system rs485 broadcast_master` command. The following example shows how to set up the broadcast group 10 which consists of three cameras with device addresses 1, 2 and 3 where camera 3 becomes the broadcast master:

```
→ 1 system rs485 broadcast_address 10  
← OK
```

```

→ 2 system rs485 broadcast_address 10
← OK
→ 3 system rs485 broadcast_address 10
← OK
→ 10 system rs485 broadcast_master 3
← OK
  
```

Note that the last `OK` was sent from camera 3 while camera 1 and 2 processed the command but stayed silent.

### 5.1.2 Interactive Mode

Interactive mode is intended for **single device operation** (only one camera on the RS485 bus) using a terminal program.

In this mode the camera provides an interactive console (like a UNIX shell) so the local echo must be turned off and the terminal program should support VT100 emulation for the best user experience (see chapter 4.2 for recommended terminal applications). This mode is mainly used for debugging, but it is also a good way to play around with the command interface and get to know the camera.

Interactive mode disables RS485 addressing, so commands must not be prefixed with the device address. Also, the camera produces extended output:

- At the start of each line the prompt `proton-os:~$` is printed.
- Echo is enabled so all characters sent to the device are sent back to the host.
- Extended help and error messages.

Additionally, there are several comfort features enabled which implement a fully featured command shell:

- **Command editing:** You can navigate in the typed text by using the *Arrow Left* and *Arrow Right* keys, delete text with *Backspace* or *Delete*, insert text with *Insert* and jump to the start or end of the command with the *Home* and *End* keys.
- **Tab auto completion:** Type only part of a command and hit *Tab* to automatically complete the command. When multiple matches are found all of them are printed.
- **Command history:** Use the *Arrow Up* and *Arrow Down* keys to quickly scroll through the last typed commands. To print the whole history, use the `history` command.
- **Clear:** Send the `clear` command to clear the whole screen.
- **Resize:** Adjust the width of the terminal to your current terminal application's window size with the `resize` command.
- **Colored output and cursor control:** Messages are colored for better readability (e.g. errors are red, warnings yellow and info messages green) and the cursor is controlled using VT100 commands.
- **Extended command output:** Some commands (e.g. `video mode list`) will print additional information.

The shell also supports the following meta-keys:

Table 4: Shell Meta-Keys.

Meta-Key	Action
<b>Ctrl + A</b>	Moves the cursor to the beginning of the line.
<b>Ctrl + B</b>	Moves the cursor backward one character.
<b>Ctrl + C</b>	Preserves the last command on the screen and starts a new command in a new line.
<b>Ctrl + D</b>	Deletes the character under the cursor.
<b>Ctrl + E</b>	Moves the cursor to the end of the line.
<b>Ctrl + F</b>	Moves the cursor forward one character.
<b>Ctrl + K</b>	Deletes from the cursor to the end of the line.
<b>Ctrl + L</b>	Clears the screen and leaves the currently typed command at the top of the screen.
<b>Ctrl + N</b>	Moves in history to next entry.
<b>Ctrl + P</b>	Moves in history to previous entry.
<b>Ctrl + U</b>	Clears the currently typed command.

<b>Ctrl + W</b>	Removes the word or part of the word to the left of the cursor. Words separated by period instead of space are treated as one word.
<b>Alt + B</b>	Moves the cursor backward one word.
<b>Alt + F</b>	Moves the cursor forward one word.

## 5.2 Command Format

A command consists of one or multiple command words followed by no, one, or multiple parameters.

In **controller mode** the general format of a command is:

```
<RS485 address> <command name> <parameters>
```

In **interactive mode** the RS485 address is omitted:

```
<command name> <parameters>
```

The camera stores each received character in an input buffer until a CRLF (Carriage Return and Line Feed or “\r\n”) is received. Then the command is evaluated and, if valid, executed.

During command execution no new commands should be sent until the device responds. Once execution is done the camera replies with the command’s result (nothing or a string) followed by either `OK` or, in case of an error, `FAIL` followed by an error code.

**Note:** In the following examples the camera has the default RS485 address of 1.

### 5.2.1 Parameter Data Types

The following parameter data types are supported:

- **Signed Decimals**, e.g.: -2947, 40687
- **Signed Hexadecimals**, e.g.: -0x100, 0x123AF7
- **Strings**, e.g.: plain\_text\_string
- **Booleans:** For commands that accept a Boolean parameter, like an enable flag, the following values can be used:
  - 0 or 1
  - true or false
  - on or off
  - enable or disable

For an example the following commands have the same effect:

```
settings auto_save 1
settings auto_save true
settings auto_save on
settings auto_save enable
```

### 5.2.2 Hierarchical Command Structure

Commands are structured hierarchically, that means a command can have subcommands. A command string is built by concatenating command words starting from the top level. For an example the command to get or set the RS485 baud rate is:

```
system rs485 baudrate
```

It is part of the `system` top-level command group which has the `rs485` subcommand group which provides the `baudrate` command.

### 5.2.3 Command Types

The following chapter lists the different command types.

#### 5.2.3.1 Direct Commands

Commands that do not change a setting but execute a fixed function are called “Direct” commands. Some have no parameters like `settings save`, some do have parameters, e.g. `settings reset`.

### 5.2.3.2 Setter and Getter Commands

Most of the commands provide two modes, a “Setter” mode to change a setting and a “Getter” mode to retrieve the current value of the setting.

A setter commands takes one or multiple parameters and applies the given values. The reply only consists of either OK or FAIL <error\_code> and no further output.

Example:

```
→ 1 video mode 9  
← OK
```

A getter command takes no arguments and replies with the command name followed by one or multiple values and is terminated by either OK or FAIL <error\_code>.

The above video mode command can be called without arguments to act like a getter command:

```
→ 1 video mode  
← video mode 9  
← OK
```

### 5.2.3.3 Pure Getter Commands

There are also commands which are pure getters, that means they do not have a setter function, e.g.:

```
→ 1 system runtime  
← system runtime 237700  
← OK
```

### 5.2.3.4 Getter Commands with Arguments

These are special getter commands which require one or multiple arguments. Example:

```
→ 1 system temp 0  
← system temp 0 43.6 CPU  
← OK
```

### 5.2.3.5 List Commands

Some commands have a list subcommand (e.g. video mode list) which lists all valid options for this command. If the list is an enumeration (1, 2, 3, ...) each value is preceded by a hash (#) so that the output cannot be confused with a command ID by other devices on the bus. Example:

```
→ 1 video mode list  
← #4  
← #5  
← ...  
← OK
```

In interactive mode a short string is added to the numbers:

```
→ video mode list  
← #4 - FHD (1920x1080) p30  
← #5 - FHD (1920x1080) p25  
← ...  
← OK
```

Some commands always add the info string even if not in interactive mode (e.g. video lsc preset list).

### 5.2.3.6 Special Commands

Some commands combine multiple of the above modes or are completely unique, for an example the system info command will only print information but does not have the leading command name and the video mcc phase command can be called as a setter, a getter (which lists all MCC phases) or as a getter with arguments (to only list one MCC phase).

These intricacies are described in detail in chapter 7.

### 5.2.4 Error Codes

The following table lists the error codes which can be returned after the `FAIL` keyword:

Table 5: Common command error codes.

Error Code	Description
<b>1</b>	The help message was printed because the command was malformed.
<b>-8</b>	Command not found: The command is unknown and cannot be executed.
<b>-14</b>	An error occurred during command execution.
<b>-19</b>	Missing device: An internal device (e.g. temperature sensor or lens drive) is missing or does not respond.
<b>-22 or -34</b>	Invalid parameter value(s): The given parameters are outside the valid value range.
<b>-28</b>	The given parameter is too long (e.g. for the device name).
<b>-71</b>	Invalid number of parameters: The number of parameters is not supported by the command.
<b>-111</b>	Synchronization to master device failed: Invalid master signal (e.g. video mode mismatch).
<b>-113</b>	Synchronization to master device failed: No master signal detected (loss-of-link).
<b>-134</b>	Operation not supported: The requested operation is not supported by this device.
<b>(-)139</b>	Overflow (positive) or underrun (negative) detected, e.g. if a value is not in required range during a calibration operation.
<b>-140</b>	Operation is currently not allowed because another setting blocks it or the device is in firmware update or over temperature protection mode.

For an example the `video mode` command expects exactly 1 parameter. If it is called with 2 parameters, the device replies with error `-71`:

```
→ 1 video mode 1 2
← FAIL -71
```

## 5.3 Command Alias and ProVideo Protocol Compatibility

To be compatible with the ProVideo protocol and to support shortened command names a command can have an alias. Instead of using the full command syntax, the alias can be used. For an example the command `system temp max` can also be called by its alias `temp_max`.

For compatibility with the ProVideo protocol, some commands behave slightly differently when called via the alias instead of the full command syntax. This is noted in the respective command description; one example is the `system info` command.

To get a list of all available aliases use the `alias` command. Example:

```
→ 1 alias
← Available command alias:
← cam_gain -> camera gain
← cam_exposure -> camera exposure
← ...
← OK
```

Aliases can also be combined with the normal command syntax. For example, to change the MCC phase setting you can use any of:

```
video mcc phase    (full syntax)
mcc phase          (mcc alias for video mcc)
mcc_set            (alias for video mcc phase)
```

## 5.4 Built-in Help

PROTON OS includes extensive help messages for all commands. To list general help instructions and a list of all top-level commands, use the `help` command.

To get specific help messages for a command send the command name followed by `-h`. Example:

```
→ 1 video lut -h
← lut - [alias: lut_enable] [getter] [getter with args]
← Enable gamma LUT (0 = bypass, 1 = enabled)
← If called via the alias 'lut_enable' this function expects two
← arguments:
← Index and enable flag. Since only one LUT is supported, the index is
← always 0. This is done for compatibility reasons.
← Usage: lut <enable: [0, 1]>
← lut_enable <idx: 0> <enable: [0, 1]>
← Subcommands:
← mode : [alias: log_mode] [getter]
← Set LUT mode. To get supported modes use the 'lut mode
← list'
← subcommand.
← ...
← OK
```

The first line of the reply contains some general information about the command (e.g., does it have an alias). It is followed by a detailed description of the command and its usage. Finally, all subcommands are listed (if it has any).

## 5.5 Auto Completion

It is possible to call commands without using their full name if the name is unique. For an example the `system rs485 device_address` command could also be called as:

```
→ 1 system rs485 dev
← system rs485 dev 1
← OK
```

But it is not possible to call the `rs485 broadcast_address` command like this:

```
→ 1 system rs485 br
← FAIL -8
```

Because that would be ambiguous with the `broadcast_master` command.

**Note:** For getter commands the device always replies with the same command name that was used to query the value, e.g. `system rs485 dev` instead of `system rs485 device_address` for the above example.

Auto completion also works for aliases, for an example you can use `save`, `load` and `reset` instead of the `save_settings`, `load_settings` and `reset_settings` aliases.

**Warning:** When new commands are added to the device in the future old commands may become ambiguous. Therefore, it is not recommended to use shortened commands in your controller software!

## 5.6 Tx Delay for slow Host Devices

The RS485 interface used to control PROTON devices only has a shared line for data Rx and Tx. By default, the camera is in Rx mode and waits for commands from a host. As soon as a command is received a reply is sent and the camera switches from Rx to Tx. Vice versa the host must switch its interface from Tx to Rx to receive the data.

In some cases, the Tx to Rx switch on the host takes some time so that replies from the camera are lost or scrambled. To work around this, use the `system rs485 tx_delay` command, e.g. to set a delay of 2000  $\mu$ s (2 ms):

```
→ system rs485 tx_delay 2000  
← OK
```

If a delay is set the camera ensures that all replies are delayed until at least the configured time has elapsed, e.g. if the delay is set to 2 ms the host is guaranteed to have duration of at least 2 ms to switch from Tx to Rx mode.

Note that the delay is only applied in controller mode. In interactive mode it is ignored as it would make the interactive shell unusable (see chapter 5.1 for details on the operational modes).

## 6 Settings Handling

The device has two types of setting storage:

1. Runtime Storage: Gets reset as soon as the device is rebooted, or power-cycled.
2. Persistent Storage: Permanent storage that survives reboot and power-cycle.

By default, all changes made to settings are only stored in the runtime storage. To transfer settings between the two storage types, use the following commands:

- `settings save`: Save all settings to the persistent settings storage.
- `settings load`: Load and apply all settings from persistent storage (restore stored state).

### 6.1 Reset

The camera can be reset to its default state using the `settings reset` command. When called without parameters it will only reset non-critical settings.

To perform a full reset, use the `settings reset all` command, it will also reset the following critical settings:

- Auto-save (section 7.2.4)
- Device name (section 7.3.2)
- RS485 configuration (section 7.3.11):
  - Baud rate
  - Mode (controller / interactive)
  - Device and broadcast addresses
  - TX delay
- Synchronization to an external sync signal (section 7.3.19)

There are some settings which are considered calibration data which are never reset:

- The bad pixel table calibration data. Should you find the data to be incorrect (defect pixels are visible), recalibrate the camera as described in chapter 7.5.8.1.
- The adjustment of the SDI clock frequency can be tuned with the `system clock_tune` command described in chapter 7.3.16.4.

### 6.2 Auto-Save

It is also possible to save settings automatically after a change has been made, to do so enable the auto-save feature using the `settings auto_save` command:

```
→ 1 settings auto_save 1  
← OK
```

Saving settings is a slow operation, therefore command execution will take a lot longer when auto-saving is enabled. For this reason, auto-saving is disabled by default and manual saving is recommended for a responsive user experience.

**Note:** For usage with **CyanView RCPs** auto-saving should always be disabled as the RCP manages all settings internally and enabling auto-saving in the camera has no benefit.

Calibration data like the defect pixel table or the SDI clock tuning are always saved automatically, regardless of auto-saving being enabled or not.

## 7 Command Reference

The following chapters document all commands in detail. Each sub-section describes a command group.

Notes regarding the command tables:

- If a command has no alias, it will be indicated by a forward slash (/).
- Commands that have a getter function reply with their command name first if they are called with no parameters or the required number of parameters for the getter function. Commands that do not have a getter function either reply with a special string (without sending the command name first) or do not produce any output at all despite the final `OK / FAIL` delimiter. For details on the command types see chapter 5.2.3.
- Most commands that change a setting have a default value. This is the value which the setting is reset to when calling the `settings reset` command.
- In the command syntax parameters are written in angle brackets, e.g. `<parameter name>`, and optional parameters are additionally wrapped in round brackets like `(<optional parameter>)`.
- Most of the commands can be executed almost immediately (in less than 100 ms). For those commands no runtime is specified. If the command needs longer to process this is stated in the third line of the command table.

### 7.1 General Commands

These commands are called without any parent command. They control basic shell functionality or print help messages.

#### 7.1.1 alias

<b>Command</b>	alias		
<b>Alias</b>	/	<b>Type</b>	Special
<b>Description</b>	Print a list of all available command aliases.		

#### 7.1.2 clear

<b>Command</b>	clear		
<b>Alias</b>	/	<b>Type</b>	Special
<b>Description</b>	Clear screen / terminal. Only works in interactive mode.		

#### 7.1.3 help

<b>Command</b>	help		
<b>Alias</b>	/	<b>Type</b>	Special
<b>Description</b>	Print the top-level help message which lists basic help instructions and a list of the top-level commands.		

#### 7.1.4 history

<b>Command</b>	history		
<b>Alias</b>	/	<b>Type</b>	Special
<b>Description</b>	Print a list of the recently used commands.		

### 7.1.5 rem

<b>Command</b>	rem		
<b>Alias</b>	/	<b>Type</b>	Special
<b>Description</b>	Ignore the following command. Can be used when running a script to comment out single lines. When using this in controller mode, “rem” must be added in front of the address.		

### 7.1.6 resize

<b>Command</b>	resize		
<b>Alias</b>	/	<b>Type</b>	Special
<b>Description</b>	Resize terminal output to current terminal window width.		

### 7.1.7 firmware

The firmware commands are used during the firmware update process and should normally not be executed manually by the user. The `firmware` command itself does not have any functionality, see subcommands below.

#### 7.1.7.1 firmware list

<b>Command</b>	firmware list		
<b>Alias</b>	/	<b>Type</b>	Special
<b>Description</b>	List current firmware configuration.		

#### 7.1.7.2 firmware request\_upgrade

<b>Command</b>	firmware request_upgrade <image_id>		
<b>Alias</b>	/	<b>Type</b>	Direct
<b>Description</b>	Request upgrade of the image with the given ID. This command must be used <i>after</i> uploading a new image to the device, otherwise the update will not be performed.		
<b>Parameter</b>	image_id		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	ID of the image that shall be upgraded.		
<b>Valid Values</b>	0: Upgrade software image (PROTON OS) 1: Upgrade firmware image (Video Processor)		

## 7.2 Settings Commands

These commands control the handling of device settings. They are called with the `settings` command prefix.

### 7.2.1 settings save

<b>Command</b>	settings save		
<b>Alias</b>	save_settings	<b>Type</b>	Direct
<b>Runtime</b>	< 10 sec		
<b>Description</b>	Save current device settings to persistent storage.		

### 7.2.2 settings load

<b>Command</b>	settings load		
<b>Alias</b>	load_settings	<b>Type</b>	Direct
<b>Runtime</b>	< 12 sec, if sync slave < 21 sec		
<b>Description</b>	Load device settings from persistent storage and apply them. Executing this command requires a restart of the image pipeline. If this camera supports synchronization and slave mode is enabled, it will return -113 (no sync signal) or -111 (invalid sync signal) when synchronization fails and the device falls back to free-running operation.		

### 7.2.3 settings reset

<b>Command</b>	settings reset <all>		
<b>Alias</b>	reset_settings	<b>Type</b>	Direct
<b>Runtime</b>	< 2 sec, if sync slave < 12 sec, +10 sec if auto-save is enabled		
<b>Description</b>	<p>Resets all settings to the default value. To save settings afterwards use the <code>save</code> command (not needed when auto-save is enabled).</p> <p>By default, only non-critical settings are reset. If all settings shall be reset (including RS485 configuration) call the command with <code>all</code> as shown below.</p> <p>Executing this command requires a restart of the image pipeline. If this camera supports synchronization and slave mode is enabled, it will return -113 (no sync signal) or -111 (invalid sync signal) when synchronization fails and the device falls back to free-running operation.</p>		

Examples:

```
→ 1 settings reset          # Reset non-critical settings.
← OK
→ 1 settings reset all     # Reset all settings.
← OK
```

**Note:** For a list of all critical settings that are reset by the `reset all` command, see chapter 6.1.

### 7.2.4 settings auto\_save

<b>Command</b>	settings auto_save <enable>		
<b>Alias</b>	auto_save	<b>Type</b>	Getter, Setter
<b>Runtime</b>	< 10 sec		
<b>Description</b>	<p>Enable automatic saving of settings after each change.</p> <p>Saving settings is a slow operation, that means commands will take a lot longer to execute with auto-save enabled. This makes interacting with the camera slower, therefore auto-save is disabled by default and manual saving is recommended.</p> <p>Turning auto-save on or off immediately saves the settings.</p>		
<b>Parameter</b>	enable		
<b>Type</b>	Boolean		
<b>Description</b>	Enable or disable auto-save.		
<b>Default</b>	Off		

## 7.3 System Commands

These commands control basic system functionality like:

- RS485 configuration
- Temperature monitoring
- Audio
- Timecode
- Status LEDs
- ...

They are called with the `system` command prefix.

### 7.3.1 system info

<b>Command</b>	system info		
<b>Alias</b>	version	<b>Type</b>	Special
<b>Runtime</b>	< 200 ms		
<b>Description</b>	<p>Get system information.</p> <p>If called via the alias <code>version</code> this command prints the information in a style that can be parsed by ProVideo protocol compatible controllers.</p>		

Example Output:

```
platform           : vega
device name       : PROTON CAM
serial number     : DF-61-9C-58-CB-66-51-2A
video processor version : v1.0-253
software version  : v1.0.0+0
resolution mask   : 00000000-000007FF-00000000
```

**Example Output when called via the version alias:**

```
platform          : vega
device name       : PROTON CAM
system-id        : DF-61-9C-58-CB-66-51-2A
hw revision      : 0001000000000253
system validity  : LICENSED
feature mask HW  : 00000000
feature mask SW  : 00000000
resolution mask  : 00000000-000007FF-00000000
loader version   : Unknown
sw-release-id    : v1.0.0+0
sw-release-date  : Unknown
sw-build-date    : Unknown
```

As you can see most of the extra fields in the ProVideo compatible output are blank as they are not used / supported by PROTON OS.

**Notes on the output:**

- `platform`: The platform string is unique for each PROTON device. It can be used by a controller to determine which device type it is talking to. It is also included in the `system identify` command. For a full list of all devices supported by PROTON OS see the table below.
- `device name`: Can be set by the user with the `system name` command.
- `serial number`: Unique device serial number.
- `video processor version`: Version of the programmable video processor.
- `software version`: PROTON OS version.
- `resolution mask`: Shortened list of all supported video modes in hexadecimal format where each bit represents one mode, see table below.

Table 6: Supported Devices

Product Family	Platform String	Product
<b>PROTON CAM</b>	vega	PROTON CAM
	vega_rain	PROTON RAIN
	vega_flex	PROTON FLEX
	vega_zoom	PROTON ZOOM
<b>PROTON PRO</b>	vega_pro	PROTON PRO
<b>PROTON 4K</b>	polaris	PROTON 4K
	polaris_flex	PROTON 4K FLEX
	polaris_zoom	PROTON 4K ZOOM
	polaris_3d_a / polaris_3d_b	PROTON 4K 3D "A" and "B" camera
<b>PROTON HFR</b>	titan	PROTON HFR

**How-To Use the Resolution Mask**

The table below lists all modes which are known to PROTON OS, each camera only supports a subset of those modes. When using the `system info` command a camera will set the bits of the modes which are supported.

**Example:** The PROTON CAM reports the following resolution mask in hexadecimal format:

```
00000000-000007FF-00000000
```

Decoded according to Table 7:

- Left Block (HD): 0x00000000 → No bits set, none supported.
- Middle Block (2K): 0x000007FF → Bits 1 to 11 set, all 1080p and 1080i modes supported
- Right Block (4K): 0x00000000 → No bits set, none supported

**Note:** A list of the supported modes per camera model can be found in the `video mode` command description. A controller may use the resolution mask or the `video mode list` command to get all supported video modes.

Table 7: Resolution Mask

Bit	HD Modes (Left Block)	FHD / 2K Modes (Middle Block)	UHD / 4K Modes (Right Block)
1	720p60 <sup>2</sup>	1080p30	UHDp30
2	720p50 <sup>2</sup>	1080p25	UHDp25
3	720p59 <sup>2</sup>	1080p24	UHDp24
4		1080p23	UHDp23
5		1080p29	UHDp29
6		1080p50	UHDp50
7		1080p60	UHDp60
8		1080i60	UHDp59
9		1080i50	UHDp48
10		1080i59	UHDp47
11		1080p59	4Kp30 <sup>2</sup>
12		2Kp30 <sup>2</sup>	4Kp25 <sup>2</sup>
13		2Kp25 <sup>2</sup>	4Kp24 <sup>2</sup>
14		2Kp24 <sup>2</sup>	4Kp23 <sup>2</sup>
15		2Kp23 <sup>2</sup>	4Kp29 <sup>2</sup>
16		2Kp29 <sup>2</sup>	4Kp50 <sup>2</sup>
17		2Kp50 <sup>2</sup>	4Kp60 <sup>2</sup>
18		2Kp60 <sup>2</sup>	4Kp59 <sup>2</sup>
19		2Kp59 <sup>2</sup>	4Kp48 <sup>2</sup>
20		2Kp48 <sup>2</sup>	4Kp47 <sup>2</sup>
21		2Kp47 <sup>2</sup>	

### 7.3.2 system name

<b>Command</b>	<code>system name &lt;name string&gt;</code>		
<b>Alias</b>	<code>name</code>	<b>Type</b>	Getter, Setter
<b>Description</b>	Set device name. The name string may contain up to 5 words which in total (and including white spaces) have a length of 32 characters.		
<b>Parameter</b>	<code>name string</code>		
<b>Type</b>	String		
<b>Description</b>	Device name to set, max 32 characters.		

### 7.3.3 system runtime

<b>Command</b>	<code>system runtime</code>		
<b>Alias</b>	<code>runtime</code>	<b>Type</b>	Pure Getter
<b>Description</b>	Print device runtime since boot in seconds. The counter gets reset by a power cycle or reboot.		

### 7.3.4 system reboot

<b>Command</b>	<code>system reboot</code>		
<b>Alias</b>	<code>reboot</code>	<b>Type</b>	Direct
<b>Description</b>	Reboot the device.		

<sup>2</sup> This mode is currently not supported by any PROTON camera and reserved for future use.

### 7.3.5 system update

<b>Command</b>	system update		
<b>Alias</b>	update	<b>Type</b>	Direct
<b>Runtime</b>	< 200 ms + time to reboot		
<b>Description</b>	<p>Put the device into firmware update mode. In update mode the device will respond to firmware update messages. Additionally, video processing is stopped to increase the performance of the update process.</p> <p>The device will respond to commands as usual, but video and camera related commands will fail.</p> <p>Firmware update mode can only be left via a reboot.</p> <p>To check if the system is currently in update mode use the <code>system status</code> command.</p>		

### 7.3.6 system identify

<b>Command</b>	system identify		
<b>Alias</b>	identify	<b>Type</b>	Special
<b>Description</b>	<p>Print essential system information (platform, RS485 configuration, device name) with a delay depending on the RS485 device address.</p> <p>Can be used to quickly identify all devices on an RS485 bus by sending it to the fail-safe address 100.</p> <p>Maximum delay: <math>99 * 10\text{ms} \approx 1\text{s}</math> (99 is the maximum RS485 address).</p> <p>Output: <code>id &lt;platform&gt; &lt;dev addr&gt; &lt;bc addr&gt; &lt;is master&gt; &lt;dev name&gt;</code></p>		

Example for an RS485 bus with 3 cameras of which the cameras with the device IDs 20 and 21 are part of broadcast group 2 and camera 20 is the broadcast master (has the `is_master` flag set):

```

→ 100 system identify
← id: vega 1 0 0 Camera Left After 10ms
← OK
← id: vega 20 2 1 Wide Angle After 200ms
← OK
← id: vega 21 2 0 Top View After 210ms
← OK
  
```

**Note:** For details on the platform string (`vega` in the above example) see the `system info` command.

### 7.3.7 system status

<b>Command</b>	system status		
<b>Alias</b>	status	<b>Type</b>	Special
<b>Description</b>	<p>Get a short system status which can be either of:</p> <p><i>streaming</i>: Normal operation.</p> <p><i>update</i>: Device is in firmware update mode (see <code>system update</code> command).</p> <p><i>over_temp</i>: Device is in over temperature mode (see <code>system temp</code> commands).</p> <p><i>error</i>: Device is in error mode, use the <code>system error</code> command to get details.</p>		

### 7.3.8 system error

<b>Command</b>	system error		
<b>Alias</b>	error	<b>Type</b>	Special
<b>Description</b>	<p>Print error log. In case no errors are logged it only returns OK.</p> <p>The status LED blinks red when an error was logged and the <code>system status</code> command will also report that the system is in "error" state.</p>		

### 7.3.9 system volatile

<b>Command</b>	system volatile <value>		
<b>Alias</b>	volatile	<b>Type</b>	Getter, Setter
<b>Description</b>	Set a 32-bit runtime variable which will keep its value until a reboot is performed.		

	Can be used by a controller to store arbitrary information or check if device got rebooted (volatile value got reset to 0).
<b>Parameter</b>	value
<b>Description</b>	Volatile value to set.
<b>Min</b>	0
<b>Max</b>	4294967295 = 0xFFFFFFFF
<b>Default</b>	0

### 7.3.10 system ping

<b>Command</b>	system ping		
<b>Alias</b>	ping	<b>Type</b>	Special
<b>Description</b>	Check if device exists and replies. This command does nothing except replying with "OK".		

### 7.3.11 system rs485

<b>Command</b>	system rs485		
<b>Alias</b>	rs485	<b>Type</b>	Special
<b>Description</b>	Setup RS485 console interface, see subcommands for details. If called without arguments prints a summary of the current settings.		

Example:

```
→ 1 system rs485
← Mode: controller - device address: 1, broadcast group: 0 (none), broadcast
master: -1 (none)
← OK
```

#### 7.3.11.1 system rs485 mode

<b>Command</b>	system rs485 mode <mode>		
<b>Alias</b>	prompt	<b>Type</b>	Setter, Getter
<b>Description</b>	Set RS485 operational mode: 0 = Controller Mode: Shell addressing is enabled to allow multiple devices on the same RS485 bus. Prompt and echo are disabled. 1 = Interactive Mode: Shell addressing is enabled, to allow multiple devices on the same RS485 bus. Prompt and echo are disabled.		
<b>Parameter</b>	mode		
<b>Type</b>	Unsigned Integer		
<b>Valid Values</b>	0 = Controller Mode 1 = Interactive Mode (not allowed for cameras in a 3D rig, see chapter 2.7)		
<b>Alias</b>	controller → system rs485 mode 0 interactive → system rs485 mode 1		
<b>Default</b>	0 = Controller Mode		

#### 7.3.11.2 system rs485 device\_address

<b>Command</b>	system rs485 device_address <dev_addr>		
<b>Alias</b>	rs485_addr	<b>Type</b>	Setter, Getter
<b>Description</b>	Set RS485 device address. Cannot be identical to broadcast address. The address 100 is the fail-save address, the device will always respond to that address.		
<b>Parameter</b>	dev_addr		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Device address to set.		
<b>Min</b>	0		
<b>Max</b>	99		
<b>Default</b>	1 (2 for "B" cameras of a 3D rig, see chapter 2.7)		

### 7.3.11.3 system rs485 broadcast\_address

<b>Command</b>	system rs485 broadcast_address <bc_addr>		
<b>Alias</b>	rs485_bc_addr	<b>Type</b>	Setter, Getter
<b>Description</b>	Set RS485 broadcast group address. Cannot be identical to the device address. The device will process commands received on the broadcast address but not reply to them unless it is the broadcast master. To disable broadcasting, use the special broadcast address -1.		
<b>Parameter</b>	bc_addr		
<b>Type</b>	Signed Integer		
<b>Description</b>	Broadcast address to set.		
<b>Min</b>	-1		
<b>Max</b>	99		
<b>Default</b>	0		

### 7.3.11.4 system rs485 broadcast\_master

<b>Command</b>	system rs485 broadcast_master <dev_addr>		
<b>Alias</b>	rs485_bc_master	<b>Type</b>	Setter, Getter
<b>Description</b>	Set RS485 broadcast master. The device with the given address becomes the broadcast master. Should be send to a broadcast group to ensure there is only one active master. Only the master will reply to commands received on the broadcast address, all other devices are silent. To disable the broadcast master, use the special device address -1. When called without arguments this command will not return the address of the current broadcast master but a flag indicating if this device is currently the master.		
<b>Parameter</b>	dev_addr		
<b>Type</b>	Signed Integer		
<b>Description</b>	Device address of the device which shall become master of the broadcast group.		
<b>Min</b>	-1 = disable broadcast master		
<b>Max</b>	99		
<b>Default</b>	-1 = disabled (1 for the cameras of a 3D rig, see chapter 2.7)		

For an example see chapter 5.1.1.2.

### 7.3.11.5 system rs485 baudrate

<b>Command</b>	system rs485 baudrate <rate>		
<b>Alias</b>	rs485_baud	<b>Type</b>	Setter, Getter
<b>Description</b>	Set RS485 baud rate. To get supported rates use the <code>baudrate list</code> subcommand.		
<b>Parameter</b>	rate		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	New RS485 baud rate to set.		
<b>Valid Values</b>	9600, 1440, 19200, 57600, 115200, 230400, 250000		
<b>Default</b>	115200		

#### 7.3.11.5.1 system rs485 baudrate list

<b>Command</b>	system rs485 baudrate list		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List all supported baud rates of the RS485 interface.		

**Note:** Since this command does not print IDs, but explicit values, it does not use the leading hash (#) like other `list` commands.

Example:

```

→ 1 system rs485 baudrate list
← 9600
← ...
← 115200
← OK
  
```

### 7.3.11.6 system rs485 tx\_delay

<b>Command</b>	system rs485 tx_delay <delay_us>		
<b>Alias</b>	rs485_tx_delay	<b>Type</b>	Setter, Getter
<b>Description</b>	<p>Add a delay between receiving a command and sending the reply. This can be used to ensure that the sender of the command has enough time to perform the TX/RX switch or do other processing.</p> <p>Setting the value to 0 disables the delay, the maximum value is 100000 µs.</p> <p>Note that the given delay is the minimum time before the camera sends a reply after receiving a command. The actual time can be longer depending on the device and the command.</p> <p>Also note that the delay is only applied in controller mode. In interactive it is ignored as it would make the interactive shell unusable.</p>		
<b>Parameter</b>	delay_us		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	TX delay to set.		
<b>Min</b>	0 (disabled)		
<b>Max</b>	100000 µs		
<b>Default</b>	0 (disabled)		

### 7.3.12 system status\_led

<b>Command</b>	system status_led <brightness>		
<b>Alias</b>	status_led	<b>Type</b>	Setter, Getter
<b>Description</b>	Set brightness off the status LED from 0 to 10, set to 0 to turn it off.		
<b>Parameter</b>	brightness		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Status LED brightness.		
<b>Min</b>	0 (off)		
<b>Max</b>	10 (100%)		
<b>Default</b>	10 (100%)		

### 7.3.13 system tally

<b>Command</b>	system tally <brightness>		
<b>Alias</b>	status_led	<b>Type</b>	Setter, Getter
<b>Description</b>	<p>Set brightness off the tally light in %, set to 0 to turn it off.</p> <p>The tally light is only controlled by the user, it is not turned on automatically.</p>		
<b>Parameter</b>	brightness		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Tally light brightness in %.		
<b>Min</b>	0 (off)		
<b>Max</b>	100 (100%)		
<b>Default</b>	0 (off)		

### 7.3.14 system temp

For details on the overtemperature protection see chapter 2.3.

<b>Command</b>	system temp (<sensor_idx>)		
<b>Alias</b>	temp	<b>Type</b>	Pure Getter with optional Arguments
<b>Description</b>	<p>List all supported temperature measurements in °C, the number of temperature sensors varies between camera models.</p> <p>To get a single temperature value specify the optional <code>sensor_idx</code> parameter.</p> <p>For temperature logging see subcommands.</p> <p>Output: &lt;sensor_idx&gt; &lt;temperature&gt; &lt;description&gt;</p>		
<b>Parameter</b>	sensor_idx		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Optional index of the sensor		
<b>Min</b>	0		
<b>Max</b>	Depends on camera model		

## Examples:

```

→ 1 system temp
← system temp 0 63.5 CPU
← system temp 1 57.8 Case
← OK
→ 1 system temp 0
← system temp 0 67.2 CPU
← OK
  
```

### 7.3.14.1 system temp max

<b>Command</b>	system temp max		
<b>Alias</b>	max_temp	<b>Type</b>	Pure Getter
<b>Description</b>	<p>Show maximum logged system temperature. It prints the following values:</p> <p>max_temp_user: User resettable maximum temperature in °C since boot. It can be reset with the 'temp reset' command or via a power-cycle or reboot.</p> <p>max_temp: Maximum temperature in °C since boot which can only be reset via power-cycle or reboot.</p> <p>shutdown_temp: Shutdown temperature in °C. When the shutdown temperature is reached, the device enters a safe state and tries to cool down. Video processing is restarted when it is cooled sufficiently.</p> <p>Whenever the shutdown temperature is reached an over temperature event is logged (see temp count command).</p> <p>Output: &lt;max_temp_user&gt; &lt;max_temp&gt; &lt;shutdown_temp&gt;</p>		

### 7.3.14.2 system temp reset

<b>Command</b>	system temp reset		
<b>Alias</b>	max_temp_reset	<b>Type</b>	Direct
<b>Description</b>	<p>Reset the user resettable maximum logged temperature (see temp max command) to the current system temperature.</p> <p>The temperature is also reset when the camera is power-cycled or rebooted.</p>		

### 7.3.14.3 system temp count

<b>Command</b>	system temp count		
<b>Alias</b>	over_temp_count	<b>Type</b>	Pure Getter
<b>Description</b>	<p>Show number of logged over temperature events. This is the number of times the device had to shut down because the temperature reached the shutdown temperature (see temp max command).</p> <p>This counter is persistent and cannot be reset.</p> <p>Output: &lt;over_temp_count&gt;</p>		

### 7.3.14.4 system temp fan

**Note:** This command is only available on devices with a cooling fan.

<b>Command</b>	system temp fan <turn_on_temp>		
<b>Alias</b>	fan_target	<b>Type</b>	Setter, Getter
<b>Description</b>	<p>Set fan turn-on temperature in °C. The fan turns on when the configured temperature is reached and turns off again when the temperature is 10° below the turn-on temperature.</p> <p>The default turn-on temperature is 75°C. Setting the temperature to 0° permanently turns on the fan.</p> <p>Instead of using a temperature value one of three presets can be given:</p> <ul style="list-style-type: none"> <li>- cool: Fan always on</li> <li>- standard: Use default turn-on temp</li> <li>- silent: Only turn fan on if necessary to avoid overheating</li> </ul>		
<b>Parameter</b>	turn_on_temp		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Temperature in °C at which the cooling fan turns on.		
<b>Min</b>	0 or cool preset (= always on)		
<b>Max</b>	85 or silent preset		

<b>Default</b>	75 or standard preset
----------------	-----------------------

#### Note regarding the presets:

- The `standard` preset should allow for silent operation under normal operating conditions (20°C) when the camera is mounted to a metal tripod or similar mounting hardware. In this setting the camera can get hot but touching it is still possible.
- If fan noise is an issue, use the `silent` preset but make sure the camera is cooled down before touching it!
- If noise is not an issue but a cool camera is preferred, use the `cool` preset.

Despite the presents, a custom start temperature can be used to match the use case.

### 7.3.15 system humidity

**Note:** This command group is only available on weatherproof devices.

For details on the humidity detection see chapter 2.4.

<b>Command</b>	system humidity		
<b>Alias</b>	humidity	<b>Type</b>	Pure Getter
<b>Description</b>	Get current relative humidity inside the device in percent.		

Example:

```
→ 1 system humidity
← system humidity 53.79
```

In the above example the relative humidity inside the camera (%RH) is 53.79%.

#### 7.3.15.1 system humidity count

<b>Command</b>	system humidity count		
<b>Alias</b>	humidity_count	<b>Type</b>	Pure Getter
<b>Description</b>	Show number of logged humidity events. This is the number of times the device detected an internal humidity level above the safe threshold. This counter is persistent and cannot be reset. Output: <humidity_count>		

### 7.3.16 system sdi

**Note:** SDI commands are only available on devices with configurable SDI outputs.

**Caution:** These are advanced settings. We do not guarantee conformity to the SDI standard when changing any of the values in this command group.

#### 7.3.16.1 system sdi outputs

<b>Command</b>	system sdi outputs		
<b>Alias</b>	sdi_outputs	<b>Type</b>	Pure Getter
<b>Description</b>	Get number of SDI output channels. The output index for the <code>sdi amplitude</code> command has a range of [0, num_out - 1]. Output: <num_out>		

#### 7.3.16.2 system sdi amplitude

<b>Command</b>	system sdi amplitude <out_idx> <amplitude>		
<b>Alias</b>	sdi_amplitude	<b>Type</b>	Setter, Getter
<b>Description</b>	Tune amplitude of the SDI output(s) in percent. By default, all outputs are set to 100% for best SDI standard conformity. Depending on the cable length and SDI receiver the output signal strength can be decreased down to 0% until reception is stable (an amplitude of 0% does not mean 'no output' but 'lowest supported amplitude'). Note that the internal resolution of the amplitude can be less than 100 steps so not every change in percentage will result in a measurable difference in output amplitude.		

	<b>Caution:</b> Reducing the amplitude decreases the achievable cable length, so only use it if needed! The first output has the index '0', the last output has index 'num_out - 1'. The number of SDI output channels depends on the camera model and can be fetched with the <code>sdi outputs</code> command. To set all outputs to the same value use '-1' as the <code>out_idx</code> . To list the values of all outputs at once call the command without arguments or '-1' as the <code>out_idx</code> .	
<b>Parameter</b>	<code>out_idx</code>	amplitude
<b>Type</b>	Unsigned Integer	Unsigned Integer
<b>Description</b>	Index of the SDI output channel to configure. Use -1 to set all channels, omit or use -1 to get all channels.	Output amplitude in %
<b>Min</b>	-1 (all channels) or 0 (first channel)	0 = lowest amplitude
<b>Max</b>	<code>num_out - 1</code> (see <code>sdi outputs</code> command)	100 = maximum amplitude
<b>Default</b>	/	100 = maximum amplitude

**Note:** The `out_idx` parameter is mandatory for the setter and optional for the getter. The getter will return both the `out_idx` and the amplitude value.

Examples:

```

→ 1 system sdi amplitude 0 80      # Increase amplitude of output 0 to 80%
← OK
→ 1 system sdi amplitude 0         # Get amplitude of output 0
← 1 system sdi amplitude 0 80
← OK
→ 1 system sdi amplitude -1 67    # Decrease amplitude of all outputs to 67%
← OK
→ 1 system sdi amplitude -1       # Get amplitude of all outputs (in this
                                  example the device has 2 output channels)
← 1 system sdi amplitude 0 67
← 1 system sdi amplitude 1 67
← OK
→ 1 system sdi amplitude          # Get all amplitude of all outputs by not
                                  giving an index.
← 1 system sdi amplitude 0 67
← 1 system sdi amplitude 1 67
← OK
    
```

### 7.3.16.3 system sdi slew\_rate

<b>Command</b>	<code>system sdi slew_rate &lt;out_idx&gt; &lt;slew_rate&gt;</code>		
<b>Alias</b>	<code>sdi_slew_rate</code>	<b>Type</b>	Setter, Getter
<b>Description</b>	Set SDI slew rate: <b>0</b> = Normal: Use default slew rate for all modes for maximum signal strength and cable length. <b>1</b> = Reduced UHD: Reduce the slew rate for 6G and 12G signals to improve compatibility with some SDI receivers when short SDI cables (< 1m) are used. Has no effect on 1.5G and 3G signals. <b>Caution:</b> Reducing the slew rate decreases the achievable cable length, so only use it if needed! The first output has the index '0', the last output has index 'num_out - 1'. The number of SDI output channels depends on the camera model and can be fetched with the <code>sdi outputs</code> command. To set all outputs to the same value use '-1' as the <code>out_idx</code> . To list the values of all outputs at once call the command without arguments or '-1' as the <code>out_idx</code> . To list all slew rates that are supported by this device use the <code>slew_rate list</code> subcommand.		
<b>Parameter</b>	<code>out_idx</code>	slew_rate	

<b>Type</b>	Unsigned Integer	Unsigned Integer
<b>Description</b>	Index of the SDI output channel to configure. Use -1 to set all channels, omit or use -1 to get all channels.	Slew Rate Mode
<b>Min</b>	-1 (all channels) or 0 (first channel)	0 = Normal
<b>Max</b>	num_out - 1 (see sdi outputs command)	1 = Reduced UHD Slew Rate
<b>Default</b>	/	0 = Normal

**Note:** The `out_idx` parameter is mandatory for the setter and optional for the getter. The getter will return both the `out_idx` and the `amplitude` value.

For usage examples, please see the `system sdi amplitude` command which has the same syntax except for the value range of the parameter.

#### 7.3.16.3.1 sdi slew\_rate list

<b>Command</b>	System sdi slew_rate list		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List supported slew rate modes.		

#### 7.3.16.4 system sdi clock\_tune

<b>Command</b>	system sdi clock_tune <ppm>		
<b>Alias</b>	sdi_clock_tune	<b>Type</b>	Setter, Getter
<b>Runtime</b>	Setter: < 2 sec if free running, < 11 sec if synchronized		
<b>Description</b>	<p>Fine-tune the SDI video clock frequency in ppm.</p> <p>The frequency of the video clock source can change slightly over time. In case you experience incompatibilities with connected devices use measuring equipment to determine the SDI clock and adjust it accordingly.</p> <p>The following SDI frequencies are expected:</p> <ul style="list-style-type: none"> <li>• 1.5G: 1485.00 MHz (non-fractional), 1483.52 MHz (fractional)</li> <li>• 3G: 2970.00 MHz (non-fractional), 2967.03 MHz (fractional)</li> </ul> <p>Deviations of +/- 10 ppm are within the limits of the SDI specification.</p> <p>The clock tuning in ppm is calculated as:</p> $tune = \frac{freq_{expected} - freq_{measured}}{freq_{measured}} * 10^6$ <p><b>Example:</b> If the measured frequency for 3G output in a non-fractional mode (e.g. p50) is 2969.84 MHz the tuning is:</p> $tune = \frac{2970.00 - 2969.93}{2969.93} * 10^6 \approx 24 \text{ ppm}$ <p>Setting the value of 24 ppm should result in an SDI frequency of 2970 MHz. If needed the value can be further tuned up or down.</p> <p>Executing this command requires a restart of the image pipeline. If this camera supports synchronization and slave mode is enabled, it will return -113 (no sync signal) or -111 (invalid sync signal) when synchronization fails and the device falls back to free-running operation.</p> <p><b>Note:</b> Since this is a calibration value it is automatically saved in the persistent setting storage even if auto save is disabled. Also, this setting is not reset by the <code>settings reset</code> command.</p>		
<b>Parameter</b>	ppm		
<b>Type</b>	Signed Integer		
<b>Description</b>	Clock frequency adjustment in ppm.		
<b>Min</b>	-50		
<b>Max</b>	50		
<b>Default</b>	0, can be overridden by factory calibration.		

#### 7.3.17 system audio

**Note:** Audio commands are only available on devices with integrated microphones.

**Note:** On devices with a cooling fan, you should mount the camera with a good thermal connection and may want to increase the fan start temperature to avoid fan noise in the audio stream. For details see chapter 2.4 and the `system temp fan` command.

<b>Command</b>	<code>system audio &lt;enable&gt;</code>		
<b>Alias</b>	<code>audio_enable</code>	<b>Type</b>	Setter, Getter
<b>Description</b>	Enable stereo audio. If enabled 2 channels of audio will be embedded into the SDI signal. To change audio volume, see subcommands.		
<b>Parameter</b>	<code>enable</code>		
<b>Type</b>	Boolean		
<b>Description</b>	Enable or disable SDI audio.		
<b>Default</b>	On		

### 7.3.17.1 system audio gain

<b>Command</b>	<code>system audio gain &lt;factor&gt;</code>		
<b>Alias</b>	<code>audio_gain</code>	<b>Type</b>	Setter, Getter
<b>Description</b>	Set digital audio gain. Gain is given as a 4.12 fixed point number, range [0.0, 16.0) with a default of 1.0 = 4096. The digital audio gain is applied to all channels. For devices with built-in microphones this is the only gain setting available. For devices with analog audio inputs the analog gain can be set separately for each input with the <code>audio volume</code> command. Setting a gain of 0 will mute (but not disable) all audio channels in the SDI output.		
<b>Parameter</b>	<code>factor</code>		
<b>Type</b>	Unsigned 4.12 Fixed Point Number		
<b>Description</b>	Digital audio gain factor to set.		
<b>Min</b>	0.0 = 0		
<b>Max</b>	15.999 = 65535		
<b>Default</b>	1.0 = 4096		

### 7.3.17.2 system audio inputs

<b>Command</b>	<code>system audio inputs</code>		
<b>Alias</b>	<code>audio_inputs</code>	<b>Type</b>	Pure Getter
<b>Description</b>	Get number of external audio inputs. The input index for the <code>audio volume</code> and <code>audio bias</code> commands has a range of [0, <code>num_in</code> - 1]. Output: <code>&lt;num_in&gt;</code>		

### 7.3.17.3 system audio volume

**Note:** This command is only available on devices with at least one external audio input (`audio inputs` command returns a value  $\geq 1$ ).

<b>Command</b>	<code>system audio volume &lt;in_idx&gt; &lt;gain&gt;</code>		
<b>Alias</b>	<code>audio_volume</code>	<b>Type</b>	Setter, Getter
<b>Description</b>	Set analog audio gain for the given input. Gain is given in dB as a 6.1 fixed point number, range [0.0, 40.0] with a default of 0.0 = 0. In addition to the per input analog gain a global digital gain can be applied with the <code>audio gain</code> command. The number of analog audio inputs depends on the camera model and can be fetched with the <code>audio inputs</code> command. To list the gains for all outputs call this command without arguments.		
<b>Parameter</b>	<code>in_idx</code>	<code>gain</code>	
<b>Type</b>	Unsigned Integer	Unsigned 6.1 Fixed Point Number	
<b>Description</b>	Index of the audio input to configure.	Analog audio gain in dB to set.	
<b>Min</b>	0	0.0 dB = 0	
<b>Max</b>	<code>num_in - 1</code> (see <code>audio inputs</code> command)	40.0 dB = 80	
<b>Default</b>	/	0.0 dB = 0	

**Note:** The `in_idx` parameter is mandatory for the setter and optional for the getter. The getter will return both the `in_idx` and the `gain` value.

**Examples:**

```

→ 1 system audio volume 0 21      # Set analog gain of input 0 to 10.5 dB
→ 1 system audio volume 0          # Read analog gain of input 0
← system audio volume 0 21
← OK
← 1 system audio volume            # List audio volume for all inputs (in this
                                  example the camera has 2 inputs)

← system audio volume 0 21
← system audio volume 1 0
← OK
    
```

**7.3.17.4 system audio bias**

**Note:** This command is only available on devices with at least one external audio input (audio inputs command returns a value  $\geq 1$ ).

<b>Command</b>	system audio bias <in_idx> <enable>		
<b>Alias</b>	audio_bias	<b>Type</b>	Setter, Getter
<b>Description</b>	If enabled a microphone bias voltage of 2.5V is enabled for the selected audio input. For line-in sources it should be disabled. The number of analog audio inputs depends on the camera model and can be fetched with the audio inputs command. To list the bias for all outputs call this command without arguments.		
<b>Parameter</b>	in_idx	enable	
<b>Type</b>	Unsigned Integer	Boolean	
<b>Description</b>	Index of the audio input to configure.	Microphone bias enable.	
<b>Min</b>	0	0 = Off	
<b>Max</b>	num_in - 1 (see audio inputs command)	1 = On	
<b>Default</b>	/	0 = Off	

**Note:** The in\_idx parameter is mandatory for the setter and optional for the getter. The getter will return both the in\_idx and the enable state.

For usage examples, please see the system audio volume command which has the same syntax except for the value range of the parameter.

**7.3.18 system timecode**

<b>Command</b>	system timecode <enable>		
<b>Alias</b>	timecode_enable	<b>Type</b>	Setter, Getter
<b>Description</b>	Enable SDI time code insertion. Disabling the time code resets the value to 0. To set or pause the time code, see subcommands.		
<b>Parameter</b>	enable		
<b>Type</b>	Boolean		
<b>Description</b>	Enable or disable SDI time code.		
<b>Default</b>	On		

**7.3.18.1 system timecode value**

<b>Command</b>	system timecode value <hour> <minute> <second>		
<b>Alias</b>	timecode	<b>Type</b>	Setter, Getter
<b>Description</b>	Set time code to given value or get current value. New value is applied with the next frame. If time code insertion is currently disabled, setting a value has no effect and the new value is ignored. When setting the time code, the frame counter is always reset to 0.		
<b>Parameter</b>	hour	minute	second
<b>Type</b>	Unsigned Integer	Unsigned Integer	Unsigned Integer
<b>Description</b>	Hour value.	Minute value.	Second value.

Min	0	0	0
Max	23	59	59

### 7.3.18.2 system timecode pause

<b>Command</b>	system timecode pause <enable>		
<b>Alias</b>	timecode_hold	<b>Type</b>	Setter, Getter
<b>Description</b>	Pause time code. While paused the transmitted time code is no longer incremented which can be used to control an external SDI recorder. Internally the counter keeps running so when pause is released the transmitted time code value jumps to the current time. This setting is not stored in the persistent storage, so pause is always disabled when the camera is powered on.		
<b>Parameter</b>	enable		
<b>Type</b>	Boolean		
<b>Description</b>	Pause timecode at current value.		
<b>Default</b>	Disabled		

### 7.3.18.3 system timecode drop

<b>Command</b>	system timecode drop <enable>		
<b>Alias</b>	timecode_drop	<b>Type</b>	Setter, Getter
<b>Description</b>	Enable 'drop frame' mode for fractional video modes. This feature is enabled by default and causes the camera to occasionally skip frame numbers in the frame counter for fractional video modes to ensure that the time runs as close to a real clock as possible. This setting has no effect on non-fractional (integer) video modes.		
<b>Parameter</b>	enable		
<b>Type</b>	Boolean		
<b>Description</b>	Use 'drop frame' mode for fractional video modes.		
<b>Default</b>	Enabled		

### 7.3.19 system sync

**Note:** Synchronization commands are only available on devices with an external (or internal, in case of a 3D camera rig) synchronization input.

<b>Command</b>	system sync <mode>		
<b>Alias</b>	sync	<b>Type</b>	Setter, Getter
<b>Runtime</b>	Setter: < 11 sec if setting to slave mode else < 2 sec		
<b>Description</b>	Set synchronization mode: <b>0 = Off:</b> Camera is free running and sync output disabled. <b>1 = Master / Internal:</b> Output sync signal to slave devices, also used for internal synchronization on multi-camera rigs. <b>2 = Slave / External:</b> Synchronize to an external sync signal. To list modes that are supported by this device use the <code>sync list</code> subcommand. Switching the device into slave mode restarts the video pipeline and tries to synchronize to the master device. If no master device is connected the operation times out and the command fails with error code -113. If an invalid master signal is detected (e.g. video mode mismatch) error code -111 is returned. In both cases the device switches to free-running mode and synchronizes to the master as soon as a valid sync signal is detected. Once the device is synchronized a short loss of the SDI output signal occurs while the video output is restarted synchronously.		
<b>Parameter</b>	mode		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Synchronization mode to set		
<b>Valid Values</b>	0 = Off 1 = Master 2 = Slave		
<b>Default</b>	Master for multi-camera devices (e.g. 3D rigs), Off for all other devices		

### 7.3.19.1 system sync list

<b>Command</b>	system sync list		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List supported synchronization modes.		

### 7.3.19.2 system sync offset

<b>Command</b>	system sync offset		
<b>Alias</b>	sync_offset	<b>Type</b>	Pure Getter
<b>Description</b>	<p>Get currently configured synchronization offset in ppb (parts per billion). This offset is automatically determined by the camera in slave mode, and it is expected to change slightly with each measurement. The value indicates how much the clock of the camera must be adjusted to be in sync with the external sync source.</p> <p>To make the offset permanent see the <code>system sync calibrate</code> command.</p>		

### 7.3.19.3 system sync calibrate

<b>Command</b>	system sync calibrate		
<b>Alias</b>	sync_calib	<b>Type</b>	Direct
<b>Runtime</b>	Setter: < 11 sec if setting to slave mode else < 100 ms		
<b>Description</b>	<p>If in slave mode, the current synchronization offset (see <code>system sync offset</code> command) is set as the calibrated SDI clock tuning value (see <code>system sdi clock_tune</code> command). This speeds up the synchronization process when turning on the device or switching video modes.</p> <p>Note that the synchronization offset is measured in ppb (parts per billion) while the SDI clock tuning is done in ppm (parts per million). Therefore, the measured offset is rounded to the nearest ppm value.</p> <p>If the device is currently not configured as a synchronization slave -134 is returned. If the device is in slave mode but not synchronized to an external sync signal yet -14 is returned.</p> <p>Executing this command restarts the image pipeline with the new calibrated clock tuning. This may fail with -113 (no sync signal) or -111 (invalid sync signal).</p>		

## 7.3.20 system license

**Note:** License commands are only available on cameras that have optional features which can be unlocked with a license key. For details see chapter 2.9.

<b>Command</b>	system license <key>		
<b>Alias</b>	sync	<b>Type</b>	Setter, Getter
<b>Description</b>	<p>Get or set license key to enable optional features. If no license key is set the getter returns "none".</p> <p>A key consists of max 127 alphanumeric characters. When the given key is too long the command fails with error code -28, when the key is invalid, it fails with -22.</p> <p>If the key is valid, the camera reconfigures to make the new features available. Executing this command requires a restart of the image pipeline. If this camera supports synchronization and slave mode is enabled, it will return -113 (no sync signal) or -111 (invalid sync signal) when synchronization fails and the device falls back to free-running operation.</p> <p>There can only be one active license key. If new features shall be activated the current key must be upgraded to include those features. To acquire or upgrade a license key please contact the PROTON sales team at <a href="mailto:sales@proton-camera.com">sales@proton-camera.com</a>.</p> <p>To list all optional features and their license state use the <code>list</code> subcommand.</p>		
<b>Parameter</b>	key		
<b>Type</b>	String		
<b>Description</b>	Alphanumeric license key to set.		
<b>Default</b>	none = No key set, all optional features disabled		

### 7.3.20.1 system license list

<b>Command</b>	system license list		
<b>Alias</b>	/	<b>Type</b>	Special
<b>Description</b>	List licensable features and their current activation state.		

	The format is a short description followed by a dash and either 'licensed' for features which are enabled or 'locked' for features which are not part of the current license. Example: Feature A - licensed Feature B - locked
--	---

## 7.4 Camera Commands

These commands control the image sensor (gain and exposure). They are called via the `camera` command prefix.

### 7.4.1 camera gain

<b>Command</b>	<code>camera gain &lt;value&gt;</code>		
<b>Alias</b>	<code>cam_gain</code>	<b>Type</b>	Setter, Getter
<b>Description</b>	Set camera gain as (linear gain * 1000). For an example gain 1.0 = 1000 or gain 4.5 = 4500. Use the <code>camera info</code> command to get the gain range (the first value is the minimum, the second value the maximum gain). To set the gain to minimum or maximum value you can also pass <code>min</code> or <code>max</code> as value. Setting the gain is not possible if it is currently being controlled by the auto exposure algorithm, in this case error code -134 is returned. You can disable the AEC with the <code>camera auto</code> command.		
<b>Parameter</b>	value		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Linear gain scaled by 1000 (see examples below).		
<b>Min</b>	1.0 = 1000		
<b>Max</b>	Depends on camera model, use <code>camera info</code> command to get range.		
<b>Default</b>	1.0 = 1000		

This command sets the linear gain scaled by 1000 for fine-grained gain control. Examples:

```

→ 1 camera gain 1000    # Set gain to 1.0
← OK
→ 1 camera gain 5237    # Set gain to 5.237
← OK
    
```

To convert linear gain to ISO, use the `camera info` command to get the ISO at gain 1.0 and then simply multiply that value with the gain:

$$gain_{ISO} = ISO_{1.0} * gain_{linear}$$

#### 7.4.1.1 camera gain mode

<b>Command</b>	<code>camera gain mode &lt;mode&gt;</code>		
<b>Alias</b>	<code>gain_mode</code>	<b>Type</b>	Setter, Getter
<b>Description</b>	Switch gain mode to adjust the cameras base sensitivity to the light conditions. This changes the ISO value at gain 1.0 and possibly also the allowed gain range. The updated values can be read using the <code>camera info</code> command. Depending on the camera model the following modes may be available: <b>0 = Standard:</b> For normally lit environments. <b>1 = Low-Light:</b> Boost base gain for dark environments. <b>2 = Auto:</b> Use full gain range by automatically switching between Standard and Low-Light mode. The "Auto" mode requires the camera to be calibrated once with the <code>camera gain mode auto calibrate</code> command and is only available after the calibration was successful To list supported modes, use the <code>gain mode list</code> subcommand.		
<b>Parameter</b>	mode		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Gain mode to set.		

<b>Valid Values</b>	0 = Standard 1 = Low-Light (if supported) 2 = Auto (if supported and calibrated)
<b>Default</b>	2 = Auto if supported and calibrated, else 0 = Standard

The default is Standard mode which results in a good gain range for operation in normally lit environments. In dark environments, Low-Light mode can be enabled to boost the base gain of the image sensor (if supported by the camera model).

Some cameras also support automatic switching between Standard and Low-Light modes. In Auto mode the camera uses the Standard mode for low gain settings and seamlessly switches to Low-Light mode for higher gains. This makes the full gain range usable without having to manually switch between gain modes.

**Note:** The automatic gain mode is currently only available on PROTON CAM and PROTON 4K (and their RAIN, FLEX and ZOOM variants). To use it each camera must be calibrated once. Newer cameras will already be calibrated from the factory; on older devices calibration can be done with the `camera gain mode auto calibrate` command by the user.

#### 7.4.1.1.1 camera gain mode list

<b>Command</b>	<code>camera gain mode list</code>		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List all supported gain modes.		

The supported modes may vary between camera models, so a controller should check which modes are supported.

Each mode is printed in a separate line. Example:

```
→ 1 camera gain mode list
← #0
← #1
← OK
```

#### 7.4.1.1.2 camera gain mode auto

<b>Command</b>	<code>Camera gain mode auto</code>		
<b>Alias</b>	<code>gain_auto</code>	<b>Type</b>	Direct, Getter
<b>Description</b>	Show current auto gain mode calibration status: 0: Uncalibrated 1: Calibrated To run calibration on an uncalibrated system, use the <code>calibrate</code> subcommand.		

#### 7.4.1.1.2.1 camera gain mode auto calibrate

<b>Command</b>	<code>camera gain mode auto calibrate</code>		
<b>Alias</b>	<code>gain_auto_calib</code>	<b>Type</b>	Direct
<b>Runtime</b>	< 30 sec		
<b>Description</b>	<p>Run calibration of the auto gain mode. Without calibration the auto gain mode is not available (see <code>camera gain mode</code> command).</p> <p>For correct results the camera must be uniformly illuminated, e.g. with a grey chart, and the lighting conditions must be stable (closed room, with flicker-free artificial light). The calibration process takes less than 30 seconds. If the process fails, the previous calibration value (or no value if camera was uncalibrated) is kept.</p> <p>If the image is not correctly illuminated during calibration this function returns <code>(-)139</code> where a negative value indicates that the image is too dark, and a positive value indicates that it is too bright. In this case adjust the light source and try again.</p> <p>If the light source is unstable the calibration will time out and fail with error code <code>-14</code>. Ensure that the calibration is done in a closed room (no sunlight) with a fixed, flicker-free light source.</p> <p>If calibration is successful, the gain mode is automatically switched to “Auto” and saved.</p> <p>The calibration data is considered critical, so it is not cleared by the <code>settings reset</code> command.</p>		

	To check if the gain is already calibrated run the <code>camera gain mode auto</code> command.
--	--

**Note:** This command is only available on cameras which support the “Auto” gain mode (see chapter 7.4.1.1).

### 7.4.2 camera exposure

<b>Command</b>	<code>camera exposure &lt;value&gt;</code>		
<b>Alias</b>	<code>cam_exposure</code>	<b>Type</b>	Setter, Getter
<b>Description</b>	Set camera exposure time in microseconds. Use the <code>camera info</code> command to get the exposure range (the third value is the minimum, the fourth value the maximum exposure time). To set the exposure to minimum or maximum value you can also pass <code>min</code> or <code>max</code> as value. Setting the exposure time is not possible if it is currently being controlled by the auto exposure algorithm, in this case error code <code>-134</code> is returned. You can disable the AEC with the <code>camera auto</code> command.		
<b>Parameter</b>	<code>value</code>		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Exposure time in $\mu$ s.		
<b>Min</b>	Depends on camera model, use <code>camera info</code> command to get range.		
<b>Max</b>	Depends on video mode, use <code>camera info</code> command to get range.		
<b>Default</b>	Maximum value for default video mode.		

### 7.4.3 camera info

<b>Command</b>	<code>camera info</code>		
<b>Alias</b>	<code>cam_info</code>	<b>Type</b>	Pure Getter
<b>Description</b>	Prints the capabilities of the image sensor: <code>gain_min</code> : Minimum gain setting, fixed. <code>gain_max</code> : Maximum gain setting, fixed, may depend on gain mode setting. <code>exp_min</code> : Minimum exposure setting, fixed. <code>exp_max</code> : Maximum exposure setting, depends on video mode. <code>base_iso</code> : ISO at gain 1.0 (= 1000), depends on gain mode setting. Output: <code>&lt;gain_min&gt; &lt;gain_max&gt; &lt;exp_min&gt; &lt;exp_max&gt; &lt;base_iso&gt;</code>		

### 7.4.4 camera auto

<b>Command</b>	<code>camera auto &lt;enable&gt;</code>		
<b>Alias</b>	<code>aec</code>	<b>Type</b>	Setter, Getter
<b>Description</b>	Enable or disable automatic exposure control. For setup of the auto exposure mode and other parameters see subcommands. Settings that are currently controlled by the auto exposure (e.g. gain or exposure) cannot be set manually, but you can use their getter functions to check the values that have been applied by the AEC.		
<b>Parameter</b>	<code>enable</code>		
<b>Type</b>	Boolean		
<b>Description</b>	Enable or disable automatic exposure control.		
<b>Default</b>	Enabled		

Example to enable the AEC:

```
→ 1 camera auto 1
← OK
```

For other AEC settings, see the subcommands in section 7.4.4.2 and following.

### ProVideo Protocol Compatibility

When called via the `aec` alias the command behaves according to the ProVideo protocol that means either 1 parameter (`enable`) or 10 parameters can be passed (see below). The `clm_tolerance` setting from the ProVideo protocol is not supported and the passed value is ignored.

The following modes are supported:

- **Gain Control:** `cost_gain > 0, cost_tint = cost_apt = 0`
- **Exposure Time Control:** `cost_tint > 0, cost_gain = cost_apt = 0`
- **Combined Gain and Exposure Time Control:** `cost_gain > 0, cost_tint > 0, cost_apt = 0`
- **Iris Control:** `cost_apt > 0, cost_gain = cost_tint = 0` (only available on devices with a motor iris)

When an unsupported combination of the cost values is used, the command returns `FAIL`.

With 1 parameter the behavior is identical to the `camera auto` command and only the enable state is changed:

```
aec <enable>
```

```
→ 1 aec 1
```

```
← OK
```

When called with 10 parameters the ProVideo protocol settings are converted to PROTON OS settings:

```
aec <enable> <set_point> <speed> <clm_tolerance> <const_gain>  
    <cost_tint> <cost_apt> <taf> <max_gain> <use_custom_weights>
```

ProVideo Paramater	Value Range	Related PROTON OS Command
<code>enable</code>	[0, 1]	<code>camera auto</code>
<code>set_point</code>	[256, 3000]	<code>camera auto target</code> , range gets converted to [0, 1000]
<code>speed</code>	[3, 30]	<code>camera auto speed</code> , range gets converted to [0, 100]
<code>clm_tolerance</code>	[10, 500]	None, value is ignored, getter always returns 50
<code>cost_gain</code>	0 + [250, 8000]	If set greater 0: <code>camera auto mode 0</code> , getter returns 0 when disabled and 8000 when enabled.
<code>cost_exp</code>	0 + [250, 8000]	If set greater 0: <code>camera auto mode 1</code> , getter returns 0 when disabled and 8000 when enabled.
<code>cost_apt</code>	0 + [250, 8000]	If set greater 0: <code>camera auto mode 3</code> , getter returns 0 when disabled and 8000 when enabled.
<code>taf</code>	[5000, 20000]	<code>camera auto anti_flicker</code> , if set to 10000: 50 Hz anti-flicker is used, if set to 8333: 60 Hz anti-flicker is used, for all other settings anti-flicker is disabled.
<code>max_gain</code>	Camera specific	<code>camera auto max_gain</code>
<code>use_custom_weights</code>	[0, 1]	<code>camera auto custom</code>

The following example shows the returned default settings:

```
→ 1 aec
```

```
← 1 1170 17 50 8000 8000 0 0 32000 0
```

```
← OK
```

Example to enable AEC in exposure control mode:

```
→ 1 aec 0 1170 17 50 0 8000 0 0 32000 0
```

```
← OK
```

#### 7.4.4.1 camera auto mode

<b>Command</b>	camera auto mode <mode>		
<b>Alias</b>	aec_mode	<b>Type</b>	Setter, Getter
<b>Description</b>	Set auto exposure mode: <b>0 = Gain Control:</b> Gain is set automatically; exposure can be set manually using the camera exposure command. The maximum gain used by the algorithm can be limited using the camera auto max_gain command. <b>1 = Exposure Time Control:</b> Exposure time is set automatically; gain is set manually using the camera gain command. <b>2 = Combined Gain and Exposure Time Control:</b> Both gain and exposure time are set automatically. The algorithm prefers increasing the exposure time and tries to minimize the gain to reduce noise in the output image. The maximum gain used by the algorithm can be limited using the camera auto max_gain command. In this mode anti-flicker can be enabled with the camera auto anti_flicker command to limit the exposure time to flicker free values when using artificial light sources. <b>3 = Iris Control:</b> The iris aperture is set automatically, gain and exposure are set manually. Only available on devices with a motor iris. To get supported modes use the mode list subcommand.		
<b>Parameter</b>	mode		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Auto exposure mode to set.		
<b>Valid Values</b>	0 = Gain Control 1 = Exposure Time Control 2 = Combined Gain and Exposure Time Control 3 = Iris Control		
<b>Default</b>	2 = Combined Gain and Exposure Time Control		

##### 7.4.4.1.1 camera auto mode list

<b>Command</b>	camera auto mode list		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List all supported auto exposure modes.		

A controller can expect modes 0, 1 and 2 (Gain, Exposure and Combined Control) to be available on all devices. Mode 3 (Iris Control) is only available on devices with a motorized iris.

#### 7.4.4.2 camera auto target

<b>Command</b>	camera auto target <brightness>		
<b>Alias</b>	aec_target	<b>Type</b>	Setter, Getter
<b>Description</b>	Set target brightness for the auto exposure algorithm. Valid range [0, 1000] which equals [0.0, 1.0] or [0%, 100%]. The default is 333 = 0.333 = 33.3%.		
<b>Parameter</b>	brightness		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Relative brightness in percent multiplied by 10 for higher resolution.		
<b>Min</b>	0 = 0%		
<b>Max</b>	1000 = 100%		
<b>Default</b>	333 = 33.3%		

#### 7.4.4.3 camera auto speed

<b>Command</b>	camera auto speed <speed>		
<b>Alias</b>	aec_speed	<b>Type</b>	Setter, Getter
<b>Description</b>	Set auto exposure control speed in range [0, 100] which equals [0%, 100%]. Bigger values result in a faster reaction to scene brightness changes. The default is 50 = 50%.		
<b>Parameter</b>	speed		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	AEC control speed (reaction speed to brightness changes).		
<b>Min</b>	0 = 0%		
<b>Max</b>	100 = 100%		
<b>Default</b>	50 = 50%		

#### 7.4.4.4 camera auto max\_gain

<b>Command</b>	camera auto max_gain <value>		
<b>Alias</b>	aec_max_gain	<b>Type</b>	Setter, Getter
<b>Description</b>	Set the maximum gain that the AEC algorithm is allowed to use. The gain range is identical to the camera gain command and can be fetched with the camera info command. To set the maximum gain to the minimum or maximum value pass min or max as value.		
<b>Parameter</b>	value		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Maximum linear gain that the AEC algorithm is allowed to use.		
<b>Min</b>	1.0 = 1000		
<b>Max</b>	Depends on camera model, use camera info command to get range.		
<b>Default</b>	Maximum gain.		

#### 7.4.4.5 camera auto anti\_flicker

<b>Command</b>	camera auto anti_flicker <mode>		
<b>Alias</b>	aec_anti_flicker	<b>Type</b>	Setter, Getter
<b>Description</b>	Set the anti-flicker mode for the combined (gain and exposure) auto exposure mode. In all other modes this setting has no effect. When anti-flicker is enabled the auto exposure algorithm tries to use only exposure times that allow for a flicker free output image when using artificial light sources. To get supported modes use the anti_flicker list subcommand.		
<b>Parameter</b>	mode		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Auto exposure anti-flicker mode to set.		
<b>Valid Values</b>	0 = Disabled 1 = 50 Hz (EU) 2 = 60 Hz (US)		
<b>Default</b>	0 = Disabled		

##### 7.4.4.5.1 camera auto anti\_flicker list

<b>Command</b>	camera auto anti_flicker list		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List all auto exposure anti-flicker modes.		

This command is mainly intended for interactive use. A controller can expect all modes to be available for every camera model.

#### 7.4.4.6 camera auto custom

<b>Command</b>	camera auto custom <enable>		
<b>Alias</b>	aec_custom	<b>Type</b>	Setter, Getter
<b>Description</b>	Enable to use custom weights for the 25 measurement areas of the auto exposure algorithm. Weights can be configured with the auto weight command. If disabled (default), all measurements are weighted equally with a weight of 1.		
<b>Parameter</b>	enable		
<b>Type</b>	Boolean		
<b>Description</b>	Enable or disable usage of custom weights for the measurement areas.		
<b>Default</b>	Disabled		

#### 7.4.4.7 camera auto weight

<b>Command</b>	camera auto weight <index> (<weight>)		
<b>Alias</b>	aec_weight	<b>Type</b>	Setter, Getter with optional Arguments
<b>Runtime</b>	Getter without arguments: < 200 ms		
<b>Description</b>	The AEC algorithm measures the brightness in an evenly split 5x5 grid. Each area of the grid has a weight which determines how much this area shall influence the algorithm. A higher weight results in a stronger focus on that area, a weight of 0 completely ignores the measurement for that area. The index parameter selects the measurement area for which the weight is set. Index 1 is the top-left measurement area while 25 is bottom-right:		

	1	2	3	4	5	
	6	7	8	9	10	
	11	12	13	14	15	
	16	17	18	19	20	
	21	22	23	24	25	
	When the command is called with the index parameter only, the weight for that index is printed. If it is called without parameters all weights are printed. These weights are only used if custom weights are enabled with the <code>auto custom</code> command, otherwise all areas are weighted equally.					
<b>Parameter</b>	index		weight			
<b>Type</b>	Unsigned Integer		Unsigned Integer			
<b>Description</b>	Index of the weight to set.		Weight for selected measurement window.			
<b>Min</b>	1		0 = Ignore this area			
<b>Max</b>	25		25 = Very strong focus on this area			
<b>Default</b>	/		1			

#### 7.4.4.8 camera auto brightness

<b>Command</b>	camera auto brightness		
<b>Alias</b>	aec_brightness	<b>Type</b>	Pure Getter
<b>Description</b>	Get the mean image brightness from the auto exposure algorithm taking into consideration the configured weights (see <code>auto custom</code> and <code>auto weight</code> commands). Works regardless of the AEC being enabled or disabled so it can be used for external exposure control. The returned value is in 1.16 fixed point format with a range of [0.0 = 0, 1.0 = 4194304] where 0.0 is black and 1.0 is white.		

#### 7.4.5 camera pan

**Note:** Panning is only available on cameras which also support the `video scale` command, and it requires a scale mode > 1 to be set. The pan range increases the bigger the scale mode is.

<b>Command</b>	camera pan <offset>		
<b>Alias</b>	cam_pan	<b>Type</b>	Setter, Getter
<b>Description</b>	Pan image (move cropping window horizontally). The range is normalized to [-1000, 1000], the actual value range in pixels depends on the currently selected <code>scale</code> mode (more zoom = bigger pan range) and a scale mode > 1 must be selected for it to have any effect. Negative values pan the image to the left, positive values to the right.		
<b>Parameter</b>	offset		
<b>Type</b>	Signed Integer		
<b>Description</b>	Panning offset.		
<b>Min</b>	-1000		
<b>Max</b>	1000		
<b>Default</b>	0 (centered)		

##### 7.4.5.1 camera pan left

<b>Command</b>	camera pan left		
<b>Alias</b>	pan_left	<b>Type</b>	Direct
<b>Description</b>	Pan image left by the smallest visible step. The step size depends on the <code>scale</code> mode and a scale mode > 1 must be selected for it to have any effect. When the image is already at the leftmost position, the command fails with error code - 34.		

##### 7.4.5.2 camera pan right

<b>Command</b>	camera pan right		
<b>Alias</b>	pan_right	<b>Type</b>	Direct
<b>Description</b>	Pan image right by the smallest visible step. The step size depends on the <code>scale</code> mode and a scale mode > 1 must be selected for it to have any effect.		

	When the image is already at the rightmost position, the command fails with error code - 34.
--	--

### 7.4.6 camera tilt

**Note:** Tilting is only available on cameras which also support the `video scale` command, and it requires a scale mode `> 1` to be set. The tilt range increases the bigger the scale mode is.

<b>Command</b>	<code>camera tilt &lt;offset&gt;</code>		
<b>Alias</b>	<code>cam_tilt</code>	<b>Type</b>	Setter, Getter
<b>Description</b>	<p>Tilt image (move cropping window vertically). The range is normalized to <code>[-1000, 1000]</code>, the actual value range in pixels depends on the currently selected <code>scale mode</code> (more zoom = bigger tilt range) and a scale mode <code>&gt; 1</code> must be selected for it to have any effect.</p> <p>Negative values tilt the image downward, positive values upward.</p> <p><b>Warning:</b> Changing the tilt produces a single invalid frame which will be partially overexposed, depending on the current <code>exposure</code> setting. By default this frame is hidden by masking it with a black image from the test pattern generator, if this is not desired this can be disabled with the <code>video test hide_invalid</code> command. The effect can be minimized by fixing the exposure time to maximum and adjusting the tilt slowly making it possible to use this feature while on air.</p>		
<b>Parameter</b>	<code>offset</code>		
<b>Type</b>	Signed Integer		
<b>Description</b>	Tilting offset.		
<b>Min</b>	-1000		
<b>Max</b>	1000		
<b>Default</b>	0 (centered)		

#### Changing tilt while on air:

As described above changing the tilt results in partially overexposed output images. If you want to use this feature while the camera is on air, the following steps must be taken:

- 1) Show the overexposed frames (disable masking with black frames):  
`video test hide_invalid 0`
- 2) Fix exposure time to maximum:
  - a) Either use auto exposure in gain-only mode:  
`camera auto 1`  
`camera auto mode 0`  
`camera exposure max`
  - b) Or disable auto exposure:  
`camera auto 0`  
`camera exposure max`
- 3) Now slowly adjust the tilt either by using small increments on the `tilt` command or by using the `tilt up` and `tilt down` commands. If the steps are small enough there are no visible artifacts in the output image.

#### 7.4.6.1 camera tilt up

<b>Command</b>	<code>camera tilt up</code>		
<b>Alias</b>	<code>tilt_up</code>	<b>Type</b>	Direct
<b>Description</b>	<p>Tilt image up by the smallest visible step. The step size depends on the <code>scale mode</code> and a scale mode <code>&gt; 1</code> must be selected for it to have any effect.</p> <p>When the image is already at the highest position, the command fails with error code - 34.</p> <p>The tilt functionality comes with limitations, for details see the top-level <code>tilt</code> command description.</p>		

### 7.4.6.2 camera tilt down

<b>Command</b>	camera tilt down		
<b>Alias</b>	tilt_down	<b>Type</b>	Direct
<b>Description</b>	Tilt image down by the smallest visible step. The step size depends on the <code>scale</code> mode and a scale mode > 1 must be selected for it to have any effect. When the image is already at the lowest position, the command fails with error code - 34. The tilt functionality comes with limitations, for details see the top-level <code>tilt</code> command description.		

## 7.5 Video Commands

These commands control the video processing features of the camera. They are called with the `video` command prefix.

### 7.5.1 video mode

<b>Command</b>	video mode <mode>		
<b>Alias</b>	video_mode	<b>Type</b>	Setter, Getter
<b>Runtime</b>	Setter: < 2 sec if free running, < 11 sec if synchronized		
<b>Description</b>	Set image format of the video pipeline. This will stop video processing, reconfigure for the new format and restart processing. To list supported modes, use the <code>mode list</code> subcommand or evaluate the resolution mask from the <code>system info</code> command. If the current exposure setting is bigger than the maximum of the new mode it will be clipped. For high-framerate cameras the resulting framerate also depends on the number of active phases, e.g. in 1080p50 mode with 3 active phases the total framerate is $3 * 50 = 150$ fps. For details see the <code>video phases</code> command. Additionally, the output format of a high-framerate camera can change when a different packing mode is selected, for details see the <code>video phases packing</code> command. When an interlaced format is used packing modes other than 'single' are not supported because there is no 6G or 12G interlaced standard. Therefore, when switching to an interlaced video mode packing is automatically set to 'single'. Executing this command requires a restart of the image pipeline. If this camera supports synchronization and slave mode is enabled, it will return -113 (no sync signal) or -111 (invalid sync signal) when synchronization fails and the device falls back to free-running operation.		
<b>Parameter</b>	mode		
<b>Description</b>	Video mode ID.		
<b>Valid Values</b>	Depends on camera model, see Table 8 below.		
<b>Default</b>			

The following table lists the supported video modes and the default video mode for each camera model:

Table 8: Supported Video Modes.

ID	Mode	PROTON CAM (all variants) PROTON PRO	PROTON 4K (all variants)	PROTON HFR
4	1080p30	✓	✓	✓
5	1080p25	✓	✓	✓
6	1080p24	✓	✓	
7	1080p23	✓	✓	
8	1080p29	✓	✓	✓
9	1080p50	✓ Default	✓	✓ Default
10	1080p60	✓	✓	✓
11	1080i60	✓	✓	✓
12	1080i50	✓	✓	✓
13	1080i59	✓	✓	✓
14	1080p59	✓	✓	✓
25	UHDp30		✓	

ID	Mode	PROTON CAM (all variants) PROTON PRO	PROTON 4K (all variants)	PROTON HFR
26	UHDp25		✓	
27	UHDp24		✓	
28	UHDp23		✓	
29	UHDp29		✓	
30	UHDp50		✓ Default	
31	UHDp60		✓	
32	UHDp59		✓	
33	UHDp48		✓	
34	UHDp47		✓	

### 7.5.1.1 video mode list

<b>Command</b>	video mode list		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List all supported video modes.		

This command can be used by a controller to check which video modes are supported by the device (instead of evaluating the resolution mask from the `system info` command or hardcoding the values).

Each mode is printed in a separate line. Example:

```
→ 1 video mode list
← #4
← #5
← ...
← #14
← OK
```

### Field Order for Multi-Phase Interlaced Output

For multi-phase cameras the field order differs from the SDI standard. For details see the `video phases` command description in chapter 7.5.3.

### 7.5.2 video scale

**Note:** This command is not available on all camera models.

<b>Command</b>	video scale <mode>		
<b>Alias</b>	scale	<b>Type</b>	Setter, Getter
<b>Runtime</b>	Setter: < 2 sec if free running, < 11 sec if synchronized		
<b>Description</b>	Set scale mode. A higher scale mode results in an increased scale or zoom factor. This allows different fields-of-view with the same lens or using a lens that was designed for a smaller image sensor. Changing the scale mode briefly interrupts the video stream. To list supported modes, use the <code>scale list</code> subcommand which shows the mapping of scale mode to zoom factor and effective sensor diagonal which can differ between camera models. Executing this command requires a restart of the image pipeline. If this camera supports synchronization and slave mode is enabled, it will return -113 (no sync signal) or -111 (invalid sync signal) when synchronization fails and the device falls back to free-running operation.		
<b>Parameter</b>	mode		
<b>Description</b>	Scale mode ID.		
<b>Valid Values</b>	Depends on camera model, see Table 8 below.		
<b>Default</b>			

Depending on the camera model, a different number of scale modes will be available, and each scale mode will result in a different zoom factor and a different readout diagonal of the image sensor. The tables below show the resulting zoom factors and resulting sensor diagonals for all supported models.

**PROTON CAM (also RAIN, FLEX and ZOOM variants):**

Table 9: Scale modes for PROTON CAM.

Scale Mode	1	2	3	4	5	6	7	8	9	10	11
Zoom Factor	1.00	1.08	1.11	1.14	1.20	1.25	1.33	1.43	1.50	1.56	1.60
Sensor Diagonal in mm	8.8	8.2	7.9	7.7	7.3	7.0	6.6	6.2	5.9	5.7	5.5

### 7.5.2.1 video scale list

<b>Command</b>	video scale list		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List all supported scale modes and their resulting zoom factor and effective sensor diagonal.		

This command can be used by a controller to check which scale modes are supported by the device and to display the resulting zoom factor and effective sensor diagonal. It dumps the mode ID followed by a dash, the factor with two decimal places and the diagonal with one decimal place in mm. All parts are separated by spaces.

Example for PROTON CAM:

```

→ 1 video scale list
← #1 - 1.00x 8.8mm
← #2 - 1.08x 8.2mm
← ...
← #11 - 1.60x 5.5mm
← OK
  
```

### 7.5.3 video phases

**Note:** The `phases` command and its subcommands are only available on high-framerate devices.

<b>Command</b>	video phases <num>
<b>Alias</b>	phases <b>Type</b> Setter, Getter
<b>Runtime</b>	Setter: < 2 sec if free running, < 11 sec if synchronized
<b>Description</b>	<p>Set number of active phases for high-framerate video output. Since SDI has a limited maximum framerate of 60 fps the output of a high-framerate camera must be split into multiple phases. The total framerate then results from the selected video mode multiplied with the number of active phases, e.g. a video mode of 1080p50 and 3 active phases results in a framerate of <math>3 * 50 = 150</math> fps. Each group of images will have the same SDI timecode as they are transmitted in parallel (although they were recorded sequentially). Unused phases will mirror the signal of the first phase and can be used as a monitor output.</p> <p>Example output for 4 active phases:</p> <pre>SDI 1: 1, 5, 9, ... SDI 2: 2, 6, 10, ... SDI 3: 3, 7, 11, ... SDI 4: 4, 8, 12, ...</pre> <p>Example output for 2 active phases:</p> <pre>SDI 1: 1, 3, 5, ... SDI 2: 2, 4, 6, ... ----- SDI 3: 1, 3, 5, ... (Mirror of SDI 1) SDI 4: 1, 3, 5, ... (Mirror of SDI 1)</pre> <p>The number of supported phases depends on the camera model, to list supported phase numbers use the <code>phases list</code> subcommand. Executing this command requires a restart of the image pipeline. If this camera supports synchronization and slave mode is enabled, it will return -113 (no sync signal) or -111 (invalid sync signal) when synchronization fails and the device falls back to free-running operation.</p>
<b>Parameter</b>	num
<b>Type</b>	Unsigned Integer
<b>Description</b>	Number of active phases.

<b>Valid Values</b>	Depends on camera model, see Table 10 below.
<b>Default</b>	

Table 10: Supported number of output phases.

ID	Slow-Motion Factor	PROTON HFR
1	1x (no slow-motion)	✓
2	2x	✓
3	3x	✓
4	4x	✓ Default

### Field Order for Multi-Phase Interlaced Output

For interlaced multi-phase output (number of phases > 1) the field order differs from the SDI standard to be conformant with [recording systems from EVS](#). The EVS system assumes that the camera produces a consecutive interlaced video stream which is then split on the available phases so that the receiver can reorder the frames and then do the deinterlacing.

**Note:** When interlacing the first line of the output image is an odd line and the second line is an even line (the line count starts at 1). Also, the first frame produced by the camera becomes an odd field as the SDI standard transmits odd fields first, even fields second.

The following examples show the field order for 2, 3 and 4 phases with 50 fps per output.

#### 2 Phases, 100 Hz:

	0 ms	10 ms	20 ms	30 ms
	-----	-----	-----	-----
Parity	Odd	Even	Odd	Even
Frame number	1	2	3	4
Phase 1		Odd / 1		Odd / 3
Phase 2		Even / 2		Even / 4
Video Timing		Odd		Even

For 2 phases the first phase contains only odd field data while the second phase contains only even field data. The actual SDI timing is not changed so from an SDI perspective for each output the video timing does not match the content for every second frame.

#### 3 Phases, 150 Hz:

	0 ms	6.6 ms	13.3 ms	20 ms	26.6 ms	33.3 ms
	-----	-----	-----	-----	-----	-----
Parity	Even	Odd	Even	Odd	Even	Odd
Frame number	1	2	3	4	5	6
Phase 1			Even / 1			Odd / 4
Phase 2			Odd / 2			Even / 5
Phase 3			Even / 3			Odd / 6
Video Timing			Odd			Even

For 3 phases note that the output from the camera now starts with an even field. That means phases 1 and 3 transmit even field data in the odd field time slot and vice versa.

#### 4 Phases, 200 Hz:

	0 ms	5 ms	10 ms	15 ms	20 ms	25 ms	30 ms	35 ms
	-----	-----	-----	-----	-----	-----	-----	-----
Parity	Even	Odd	Even	Odd	Even	Odd	Even	Odd
Frame number	1	2	3	4	5	6	7	8
Phase 1				Even / 1				Even / 5
Phase 2				Odd / 2				Odd / 6
Phase 3				Even / 3				Even / 7
Phase 4				Odd / 4				Odd / 8
Video Timing				Odd				Even

Again, output starts with an even field. Now phase 1 and 3 always output even fields and phases 2 and 4 always output odd fields. This means phases 1 and 2 are now inverted compared to the 2 phases output.

## Monitor Outputs

If the number of active phases is less than 4 the unused outputs are configured to mirror the content of SDI 1. The data is multiplexed in front of the video out module so the field order setting for each output can be set independently and we always output the monitor outs with the correct (standard) SDI field order regardless of how SDI 1 is configured.

### 7.5.3.1 video phases list

<b>Command</b>	video phases list		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List supported number of phases.		

### 7.5.3.2 video phases packing

<b>Command</b>	video phases packing <mode>		
<b>Alias</b>	phases_packing	<b>Type</b>	Setter, Getter
<b>Runtime</b>	Setter: < 2 sec if free running, < 11 sec if synchronized		
<b>Description</b>	<p>Control how the multiple phases of the high-framerate video output are packaged:</p> <p><b>0 = Single:</b> By default, each output of the camera shows a single phase, e.g. each output shows a 1080p50 signal if this is the configured video mode.</p> <p><b>1 = SQD (square division):</b> In this mode output 1 shows a UHD image which contains all phases packed into a single frame. Output 1 is top-left, output 2 top-right, output 3 bottom-left and output 4 bottom-right:</p> <pre> -----   1   2    --- ---    3   4   -----                     </pre> <p>For unused outputs a black image is inserted into the packed image, e.g. when phases are set to 3 the bottom-right part of the quad image is black.</p> <p>This mode is ideal if the signal is being compressed afterwards using a video codec as the image geometry stays intact.</p> <p><b>2 = 2SI (2-sample interleave):</b> In this mode each of the four phases is directly mapped to one of the four sub images of the 12G SDI signal. For unused outputs the sub image shows a black image.</p> <p>This mode is ideal if the signal is transmitted uncompressed as it allows for easy decoding without a frame buffer.</p> <p>In SQD and 2SI mode all other outputs will mirror the signal of the first phase for monitoring.</p> <p>Packing is only supported for progressive video modes because there is no 6G or 12G interlaced standard. If packing is enabled while an interlaced video mode is selected the video mode is automatically changed to its progressive equivalent (e.g. i50 to p60). Supported modes can differ between camera models and some modes may be optional and only available after a license key has been purchased. To list supported packing modes, use the <code>packing list</code> subcommand.</p> <p>Executing this command requires a restart of the image pipeline. If this camera supports synchronization and slave mode is enabled, it will return -113 (no sync signal) or -111 (invalid sync signal) when synchronization fails and the device falls back to free-running operation.</p>		
<b>Parameter</b>	mode		
<b>Description</b>	Packing mode to set.		
<b>Valid Values</b>	Depends on camera model, see Table 11 below.		
<b>Default</b>			

Table 11: Supported packing modes.

ID	Packing Mode	PROTON HFR
0	Single	✓ Default
1	SQD (square division)	✓ Optional, requires 12G SDI feature (see chapter 2.9), only for progressive output
2	2SI (2-sample interleave)	

### 7.5.3.2.1 video phases packing list

<b>Command</b>	video phases packing list		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List supported packing modes.		

### 7.5.3.3 video phases marker

<b>Command</b>	video phases marker <enable>		
<b>Alias</b>	phases_marker	<b>Type</b>	Setter, Getter
<b>Description</b>	Enable markers in each output to indicate its phase number.		
<b>Parameter</b>	enable		
<b>Type</b>	Boolean		
<b>Description</b>	Enable or disable optical markers to identify output phase.		
<b>Default</b>	Off		

## 7.5.4 video flip

<b>Command</b>	video flip <mode>		
<b>Alias</b>	flip	<b>Type</b>	Setter, Getter
<b>Description</b>	Flip output image. To list all modes, use the <code>flip list</code> subcommand.		
<b>Parameter</b>	mode		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Flip mode to set.		
<b>Valid Values</b>	0 = Normal 1 = Vertical 2 = Horizontal 3 = Rotated (H+V)		
<b>Default</b>	0 = Normal		

### 7.5.4.1 video flip list

<b>Command</b>	video flip list		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List all flip modes.		

This command is mainly intended for interactive use. A controller can expect all modes to be available for every camera model.

## 7.5.5 video black\_sensor

<b>Command</b>	video black_sensor <red/all> (<green> <blue>)		
<b>Alias</b>	black_sensor	<b>Type</b>	Setter, Getter
<b>Description</b>	Set all sensor black level offsets. All values are 17 bit signed integers with a range of [-65536, 65535]. The offsets are subtracted, that means a negative offset results in an addition. Usually, positive values will be programmed to subtract the sensor black level from the image signal. If only one value is given, all offsets are set to the same value. Otherwise, all three values must be given. Changing the sensor black level is usually not recommended, use the flare compensation or master black level instead. To set a single offset value use the subcommands.		
<b>Parameter</b>	red/all	green	blue
<b>Type</b>	Signed Integer		
<b>Description</b>	Red or all components black level offset.	Optional green offset.	Optional blue offset.
<b>Min</b>	-65536		
<b>Max</b>	65535		
<b>Default</b>	0		

### 7.5.5.1 video\_black\_sensor\_red

<b>Command</b>	video_black_sensor_red <offset>		
<b>Alias</b>	black_red	<b>Type</b>	Setter, Getter
<b>Description</b>	Set red black level offset as 17 bit signed integer.		
<b>Parameter</b>	factor		
<b>Type</b>	Signed Integer		
<b>Description</b>	Red component black level offset.		
<b>Min</b>	-65536		
<b>Max</b>	65535		
<b>Default</b>	0		

### 7.5.5.2 video\_black\_sensor\_green

<b>Command</b>	video_black_sensor_green <offset>		
<b>Alias</b>	black_green	<b>Type</b>	Setter, Getter
<b>Description</b>	Set green black level offset as 17 bit signed integer.		
<b>Parameter</b>	factor		
<b>Type</b>	Signed Integer		
<b>Description</b>	Green component black level offset.		
<b>Min</b>	-65536		
<b>Max</b>	65535		
<b>Default</b>	0		

### 7.5.5.3 video\_black\_sensor\_blue

<b>Command</b>	video_black_sensor_blue <offset>		
<b>Alias</b>	black_blue	<b>Type</b>	Setter, Getter
<b>Description</b>	Set blue black level offset as 17 bit signed integer.		
<b>Parameter</b>	factor		
<b>Type</b>	Signed Integer		
<b>Description</b>	Blue component black level offset.		
<b>Min</b>	-65536		
<b>Max</b>	65535		
<b>Default</b>	0		

## 7.5.6 video\_lsc

<b>Command</b>	video_lsc <enable> (<k> <radius> <slope>)			
<b>Alias</b>	lsc	<b>Type</b>	Setter, Getter	
<b>Description</b>	Configure lens shading correction. The parameters <code>k</code> , <code>radius</code> and <code>slope</code> are optional and given as 2.30 fixed point numbers. If any of the 3 parameters shall be changed, all 3 must be specified! For details on how to calibrate LSC for a specific lens see below. To set a preset for an officially supported lens use the <code>lsc preset</code> subcommand.			
<b>Parameter</b>	enable	k	radius	slope
<b>Type</b>	Boolean	Unsigned 2.30 Fixed Point Number		
<b>Description</b>	Enable or disable correction.	Natural vignetting correction factor.	Artificial vignetting correction radius.	Artificial vignetting correction slope.
<b>Min</b>	0 (Off)	0.0 = 0	0.0 = 0	0.0 = 0
<b>Max</b>	1 (On)	2.0 = 2147483648	1.0 = 1073741824	2.0 = 2147483648
<b>Default</b>	Off	0.0 = 0	0.0 = 0	0.0 = 0

Due to the physical properties of the lenses used in optical imaging a reduction of the luminescence occurs from the middle of the image sensor to its borders. This is commonly known as vignetting. This effect can be separated into natural and artificial vignetting, both can be corrected using the lens shading correction function.

Please note that this is an advanced feature that requires the right measurement equipment to be set up correctly (see setup instructions at the end of this chapter). The lens shading correction uses a correction function to increase the gain in the outer image areas. The parameter `k` configures the natural vignetting compensation (cos4 compensation), a higher value will result in a higher compensation. The parameters `radius` and `slope` configure the artificial vignetting compensation. If the value for `radius` is increased, the

radius where the compensation starts will be increased (moved to the image border). The higher the `slope`, the stronger the compensation is.

To set up the lens shading correction, follow these steps:

1. Point the camera at a homogeneous light source.
2. On cameras that support scaling, make sure the lowest scale mode is selected (no zoom). See `video scale` command for details.
3. Connect the camera to a wave monitor and select a line in the middle of the image, you should see a decrease in luminescence towards the edges of the image.
4. Enable lens shading correction, start with the parameters `k`, `radius` and `slope` set to 0.
5. Now turn up the `k` factor, this should correct the lens shading in the middle area of the image, the edges will probably still not be ideally illuminated. Make sure to not overcompensate, this will create a wavelike appearance of the luminescence on the monitor.
6. Set the `radius` to 0.5 and set to `slope` to a high value like 1.5, you should now clearly see where the compensation starts. Now adjust the `radius` until you hit the point where the luminescence starts decreasing. Finally decrease the `slope` until the result is not overcompensated anymore.
7. Make fine adjustments until you are satisfied with the result. Please note that, depending on the optical lens used, the aperture and focal length have influence on the lens shading, so you should use your default setup for configuring the compensation. Also, it might be helpful to turn off the auto exposure during the setup, see `camera auto` command.

Each PROTON camera comes pre-calibrated for officially supported lenses. To select a calibrated lens preset, use the `lsc preset` command described below.

#### 7.5.6.1 video lsc preset

<b>Command</b>	<code>video lsc preset &lt;idx&gt;</code>		
<b>Alias</b>	<code>lsc preset</code>	<b>Type</b>	Setter, Getter
<b>Description</b>	Apply preset for selected lens. Setting a preset automatically enables the lens shade correction. Use the <code>preset list</code> subcommand to show all supported lenses and their corresponding indices. When called as a getter the index of the currently configured preset is returned. If a custom LSC configuration is used -1 is returned.		
<b>Parameter</b>	<code>idx</code>		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	LSC preset to set.		
<b>Valid Values</b>	Depend on camera model, use <code>preset list</code> subcommand to get list.		
<b>Default</b>	-1 (no preset configured)		

##### 7.5.6.1.1 video lsc preset list

<b>Command</b>	<code>video lsc preset list</code>		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List all available LSC presets.		

The available presets depend on the camera model and new firmware versions may add new calibration presets to the list. It is guaranteed that the index of a preset does not change between firmware releases (that means new entries are always appended to the list, the list is not reordered).

Each entry of the list consists of the preset's index followed by:

- Horizontal angle of aperture in degree
- Focal length in mm
- Aperture in F-stops
- Length of the lens in mm
- The PROTON reference number.

Example:

```

→ 1 video lsc preset list
← #0 - 124 degree: 2.2mm, F/2.2, 24mm length (PCI-LENS-22-22)
← #1 - 110 degree: 2.7mm, F/2.8, 22mm length (PCI-LENS-27-28)
← #2 - 97 degree: 3.2mm, F/2.3, 22.5mm length (PCI-LENS-32-23)
← #3 - 88 degree: 3.9mm, F/2.8, 22.2mm length (PCI-LENS-39-28)
← OK
    
```

### 7.5.7 video wb

<b>Command</b>	video wb		
<b>Alias</b>	wb	<b>Type</b>	Direct
<b>Runtime</b>	< 1100 ms		
<b>Description</b>	Run auto white balance. This command blocks until the measurement is done which takes between 500ms and 1s. Has no effect if continuous auto white balance is currently enabled. Running the white balance resets the <code>user gain</code> settings. For manual white balance and configuration of the auto white balance, see subcommands.		

#### 7.5.7.1 video wb gain

<b>Command</b>	video wb gain <red> <green> <blue>		
<b>Alias</b>	wb_gain	<b>Type</b>	Setter, Getter
<b>Description</b>	Set RGB white balance gains. All values are in 4.8 fixed point format with a range of [0.0 = 0, 15.999 = 4095] (1.0 = 256). The gain values will be overridden when a color temperature or white balance preset is set. When auto white balance is enabled, this command returns the currently configured gains and setting it is not possible. Instead of specifying the absolute gains you can also use the <code>user gain</code> command to specify user gains which are applied on top of the gains from the selected color temperature or preset. This means that this command also updates the user gains and vice versa. To set a single gain value use the subcommands.		
<b>Parameter</b>	red	green	blue
<b>Type</b>	Unsigned 4.8 Fixed Point Number		
<b>Description</b>	Red gain.	Green gain.	Blue gain.
<b>Min</b>	0.0 = 0		
<b>Max</b>	15.999 = 4095		
<b>Default</b>	Values for color temperature 6500K, depends on camera calibration.		

The RGB white balance gains are linked with the user gains which can be set with the `user gain` command that means if one of them gets changed the other one is updated automatically.

The RGB gains represent the total gains which are programmed in the video processor. They are internally calculated by multiplying the calibrated gains resulting from the selected color temperature (see `wb temp` command) and the user gains:

$$Gain_{min} = \min(R_{calib}, G_{calib}, B_{calib})$$

$$R_{wb} = \frac{R_{calib}}{Gain_{min}} * R_{user}$$

$$G_{wb} = \frac{G_{calib}}{Gain_{min}} * G_{user}$$

$$B_{wb} = \frac{B_{calib}}{Gain_{min}} * B_{user}$$

Note that the calibrated gains are only used internally and are not directly visible to the user (they can be read when all user gains are at their default value of 1.0).

#### 7.5.7.1.1 video wb gain red

<b>Command</b>	video wb gain red <gain>		
<b>Alias</b>	gain_red	<b>Type</b>	Setter, Getter
<b>Description</b>	Set red white balance gain in 4.8 fixed point format (1.0 = 256).		
<b>Parameter</b>	gain		
<b>Type</b>	Unsigned 4.8 Fixed Point Number		
<b>Description</b>	Red white balance gain.		
<b>Min</b>	0.0 = 0		
<b>Max</b>	15.999 = 4095		
<b>Default</b>	Value for color temperature 6500K, depends on camera calibration.		

#### 7.5.7.1.2 video wb gain green

<b>Command</b>	video wb gain green <gain>		
<b>Alias</b>	gain_green	<b>Type</b>	Setter, Getter
<b>Description</b>	Set green white balance gain in 4.8 fixed point format (1.0 = 256).		
<b>Parameter</b>	gain		
<b>Type</b>	Unsigned 4.8 Fixed Point Number		
<b>Description</b>	Green white balance gain.		
<b>Min</b>	0.0 = 0		
<b>Max</b>	15.999 = 4095		
<b>Default</b>	Value for color temperature 6500K, depends on camera calibration.		

#### 7.5.7.1.3 video wb gain blue

<b>Command</b>	video wb gain blue <gain>		
<b>Alias</b>	gain_blue	<b>Type</b>	Setter, Getter
<b>Description</b>	Set blue white balance gain in 4.8 fixed point format (1.0 = 256).		
<b>Parameter</b>	gain		
<b>Type</b>	Unsigned 4.8 Fixed Point Number		
<b>Description</b>	Blue white balance gain.		
<b>Min</b>	0.0 = 0		
<b>Max</b>	15.999 = 4095		
<b>Default</b>	Value for color temperature 6500K, depends on camera calibration.		

#### 7.5.7.2 video wb temp

<b>Command</b>	video wb temp <color_temp>		
<b>Alias</b>	wb_temp	<b>Type</b>	Setter, Getter
<b>Description</b>	Set white balance temperature in Kelvin. When auto white balance is enabled, this command returns the temperature which is currently set by the auto algorithm and manually setting it is not possible. After adjusting the temperature use the <code>wb tint</code> command to fine tune the green balance. Changing the color temperature preserves the gains set with the <code>user gain</code> command. To return to a clean state they must manually be reset to 1.0.		
<b>Parameter</b>	color_temp		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Color temperature in Kelvin.		
<b>Min</b>	3000		
<b>Max</b>	10000		
<b>Default</b>	6500		

#### 7.5.7.3 video wb preset

<b>Command</b>	video wb preset <id>		
<b>Alias</b>	wb_preset	<b>Type</b>	Setter, Special Getter
<b>Description</b>	Set white balance preset. To get supported presets call command without arguments. This command is for compatibility with the ProVideo protocol, it is recommended to use the <code>wb temp</code> command instead which allows for continuous manual white balance control.		

	Setting a preset is not possible when auto white balance is enabled. Selecting a preset automatically resets the <code>user_gain</code> to 1.0.
<b>Parameter</b>	<code>id</code>
<b>Type</b>	Unsigned Integer
<b>Description</b>	White balance preset ID.
<b>Valid Values</b>	0 = Tungsten 3200 (3200K) 1 = Fluorescent TL84 (4200K) 2 = Flash (5000K) 3 = Daylight D55 (5500K) 4 = Daylight D60 (6000K) 5 = Daylight D65 (6500K) 6 = Shady (7500K) 7 = Cloudy (8500K) 8 = Blue Sky (10000K)
<b>Default</b>	5 = Daylight D65 (6500K)

When called without arguments it prints a list of all supported white balance presets:

```
→ 1 wb_preset
← 0= Tungsten 2800 (2800K)
← ...
← 9= Blue Sky (10000K)
← OK
```

Note that the command name is not printed (it is not a typical getter command) and that there are no spaces in front of the “=” and between the description and the “(“. This is according to the ProVideo protocol.

#### 7.5.7.4 video wb tint

<b>Command</b>	<code>video wb tint &lt;value&gt;</code>		
<b>Alias</b>	<code>wb_tint</code>	<b>Type</b>	Setter, Getter
<b>Description</b>	Set tint value for the white balance temperature calculation. In manual white balance mode, the tint value is applied as a gain on the green value which is calculated from the calibration data. It is used to fine-tune the green balance if the white balance calibration does not perfectly match the used lens or lighting conditions. When auto white balance is enabled, the tint is adjusted automatically, and this command returns the last value which has been set by the AWB. Manually setting the tint while the AWB is enabled is not possible.		
<b>Parameter</b>	<code>value</code>		
<b>Type</b>	Unsigned 1.8 Fixed Point Number		
<b>Description</b>	Tint value (green gain)		
<b>Min</b>	0.8 = 205		
<b>Max</b>	1.2 = 308		
<b>Default</b>	1.0 = 256		

Setting a tint `value` other than 1.0 changes the formulas for the gains from chapter 7.5.7.1 as follows:

$$G_{calib,tinted} = G_{calib} * G_{tint}$$

$$Gain_{min} = \min(R_{calib}, G_{calib,tinted}, B_{calib})$$

$$G_{wb} = \frac{G_{calib,tinted}}{Gain_{min}} * G_{user}$$

Where  $G_{tint}$  is the configured tint value.

### 7.5.7.5 video wb auto

<b>Command</b>	video wb auto <enable>		
<b>Alias</b>	awb	<b>Type</b>	Setter, Getter
<b>Description</b>	<p>Enable continuous auto white balance. The camera will automatically determine the current color temperature and adjust the white balance gains, color cross matrix and tint value accordingly.</p> <p>The detected color temperature and resulting settings can be read back using the <code>wb temp</code>, <code>wb gain</code> and <code>wb tint</code> commands, it is not possible to set them manually while the AWB is enabled.</p> <p>Enabling the AWB resets the <code>user gain</code> settings and they cannot be changed. Use the <code>auto offset</code> command instead to configure a color temperature offset.</p> <p>When auto white balance is switched from on to off the color temperature stays at the last measured value.</p> <p>To configure AWB behavior, see subcommands.</p>		
<b>Parameter</b>	enable		
<b>Type</b>	Boolean		
<b>Description</b>	Enable or disable continuous auto white balance.		
<b>Default</b>	Enabled		

#### 7.5.7.5.1 video wb auto speed

<b>Command</b>	video wb auto speed <speed>		
<b>Alias</b>	awb_speed	<b>Type</b>	Setter, Getter
<b>Description</b>	<p>Set control speed of the auto white balance algorithm:</p> <p>0: Slow (default)          1: Medium          2: Fast</p>		
<b>Parameter</b>	speed		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Auto white balance control speed.		
<b>Allowed Values</b>	0: Slow 1: Medium 2: Fast		
<b>Default</b>	0: Slow		

#### 7.5.7.5.2 video wb auto offset

<b>Command</b>	video wb auto offset <offset>		
<b>Alias</b>	awb_offset	<b>Type</b>	Setter, Getter
<b>Description</b>	<p>Set color temperature offset in Kelvin which is added to the color temperature that is calculated by the auto white balance algorithm.</p> <p>A negative offset results in a blueish output image, a positive offset in a reddish image. The default is 0 (neutral).</p>		
<b>Parameter</b>	offset		
<b>Type</b>	Signed Integer		
<b>Description</b>	AWB color temperature offset in Kelvin.		
<b>Min</b>	-2000		
<b>Max</b>	2000		
<b>Default</b>	0		

#### 7.5.7.5.3 video wb auto tint\_offset

<b>Command</b>	video wb auto tint_offset <offset>		
<b>Alias</b>	awb_tint_offset	<b>Type</b>	Setter, Getter
<b>Description</b>	<p>Set tint offset which is added to the tint that is measured by the auto white balance algorithm.</p> <p>The tint offset influences the green balance where a negative offset increases red and blue and a positive offset increases green. The default is 0 (neutral).</p>		
<b>Parameter</b>	offset		
<b>Type</b>	Signed 1.8 Fixed Point Number		
<b>Description</b>	AWB tint offset.		
<b>Min</b>	-0.1 = -26		

<b>Max</b>	0.1 = 26
<b>Default</b>	0.0 = 0

### 7.5.8 video bpc

<b>Command</b>	video bpc		
<b>Alias</b>	bpc	<b>Type</b>	Direct, Getter
<b>Description</b>	Show current bad pixel calibration status: 0: Uncalibrated 1: Calibrated		

PROTON cameras do not have an on-the-fly bad pixel detection mechanism as these typically find a lot of false positives which degrade the image quality. Instead, static calibration is used.

Each camera is calibrated during production. If new defects become visible during operation, you can re-run the calibration anytime using the `video bpc calibrate` command described below.

#### 7.5.8.1 video bpc calibrate

<b>Command</b>	video bpc calibrate		
<b>Alias</b>	dpc_auto_load	<b>Type</b>	Direct
<b>Runtime</b>	< 60 sec		
<b>Description</b>	Run automatic bad pixel calibration which can take up to 30 seconds. For correct results this must be done with the lens cap installed! Devices with an integrated lens drive and iris control will automatically close the iris for calibration. For consistent results the calibration is always done at the default video mode. The currently configured mode is automatically restored after the calibration is done. The calibration data is considered critical, so it is not cleared by the <code>settings reset</code> command.		

**Caution:** For the calibration to work properly it is crucial that the lens cap is installed, otherwise the detected bad pixels will not be correct! (Exception: Devices with a lens drive that supports iris control, on these the iris is closed automatically during calibration).

**Note:** Although `dpc` would be a legal shorthand of the `dpc_auto_load` alias (since it is unambiguous) the camera will not accept it to avoid confusion with the `dpc` command from the ProVideo protocol which is not supported by PROTON OS.

### 7.5.9 video flare

<b>Command</b>	video flare <red/all> (<green> <blue>)		
<b>Alias</b>	flare	<b>Type</b>	Setter, Getter
<b>Description</b>	Set RGB flare compensation values. All values are 16 bit unsigned integers with a range of [0, 65535]. If only one value is given, all offsets are set to the same value. Otherwise, all three values must be given. To set a single value use the subcommands.		
<b>Parameter</b>	red/all	green	blue
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Red or all components compensation value.	Optional green compensation value.	Optional blue compensation value.
<b>Min</b>	0		
<b>Max</b>	65535		
<b>Default</b>	0		

#### 7.5.9.1 video flare red

<b>Command</b>	video flare red <offset>		
<b>Alias</b>	flare_red	<b>Type</b>	Setter, Getter
<b>Description</b>	Set red flare compensation value as 16 bit integer.		
<b>Parameter</b>	factor		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Red component flare compensation value.		

<b>Min</b>	0
<b>Max</b>	65535
<b>Default</b>	0

#### 7.5.9.2 video flare green

<b>Command</b>	video flare green <offset>		
<b>Alias</b>	flare_green	<b>Type</b>	Setter, Getter
<b>Description</b>	Set green flare compensation value as 16 bit integer.		
<b>Parameter</b>	factor		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Green component flare compensation value.		
<b>Min</b>	0		
<b>Max</b>	65535		
<b>Default</b>	0		

#### 7.5.9.3 video flare blue

<b>Command</b>	video flare blue <offset>		
<b>Alias</b>	flare_blue	<b>Type</b>	Setter, Getter
<b>Description</b>	Set blue flare compensation value as 16 bit integer.		
<b>Parameter</b>	factor		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Blue component flare compensation value.		
<b>Min</b>	0		
<b>Max</b>	65535		
<b>Default</b>	0		

#### 7.5.10 video color\_space

<b>Command</b>	video color_space <id>		
<b>Alias</b>	color_space	<b>Type</b>	Setter, Getter
<b>Description</b>	Set color space (also known as gamut). To list all color spaces, use the <code>color_space list</code> subcommand.		
<b>Parameter</b>	id		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Color space to set.		
<b>Valid Values</b>	0 = BT.709 (HD / SDR) 1 = BT.2020 (UHD / HDR) 2 = Sony S-Gamut3 3 = Sony S-Gamut3.Cine		
<b>Default</b>	0 = BT.709 (HD / SDR)		

##### 7.5.10.1 video color\_space list

<b>Command</b>	video color_space list		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List all color spaces.		

This command is mainly intended for interactive use. A controller can expect all modes to be available for every camera model.

#### 7.5.11 video sdi\_range

<b>Command</b>	video sdi_range <range>		
<b>Alias</b>	sdi_range	<b>Type</b>	Setter, Getter
<b>Description</b>	Set SDI output range: 0 = Limited or Legal range: SDI standard. Y values are limited to the range [64, 940] and chroma values to [64, 960]. 1 = Full range: Maximum dynamic. Y and chroma values are limited to the range [4, 1019]. Note that the output range is forced to full range if the <code>lut_mode</code> is set to S-Log3 as the standard requires it. You can still change the output range, but the setting will only be applied once S-Log3 mode is deactivated.		

<b>Parameter</b>	range
<b>Type</b>	Unsigned Integer
<b>Description</b>	SDI range to set.
<b>Valid Values</b>	0 = Limited (SDI Standard) 1 = Full (Maximum Dynamic)
<b>Default</b>	0 = Limited

### 7.5.12 video filter

<b>Command</b>	video filter <enable>		
<b>Alias</b>	filter_enable	<b>Type</b>	Setter, Getter
<b>Description</b>	Enable detail (sharpening) and denoise post processing filters (0 = bypass, 1 = enabled). To achieve bypass behavior with the filter enabled, the detail level must be set to 10% and the denoise level to 0%.		
<b>Parameter</b>	enable		
<b>Type</b>	Boolean		
<b>Description</b>	Enable or bypass post processing filters.		
<b>Default</b>	On		

#### 7.5.12.1 video filter detail

<b>Command</b>	video filter detail <level>		
<b>Alias</b>	filter_detail	<b>Type</b>	Setter, Getter
<b>Description</b>	Set detail (sharpening) level of the post processing filter from 0 to 100%.		
<b>Parameter</b>	level		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Detail level in %.		
<b>Min</b>	0		
<b>Max</b>	100		
<b>Default</b>	10		

#### 7.5.12.2 video filter denoise

<b>Command</b>	video filter denoise <level>		
<b>Alias</b>	filter_denoise	<b>Type</b>	Setter, Getter
<b>Description</b>	Set denoise level of the post processing filter from 0 to 100%.		
<b>Parameter</b>	level		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Denoise level in %.		
<b>Min</b>	0		
<b>Max</b>	100		
<b>Default</b>	0		

### 7.5.13 video mcc

<b>Command</b>	video mcc <enable>		
<b>Alias</b>	mcc	<b>Type</b>	Setter, Getter
<b>Description</b>	Enable multi matrix color correction (0 = bypass, 1 = enabled). Disabling the MCC disables blinking and gating (see <code>mcc blink</code> and <code>mcc gate</code> subcommands).		
<b>Parameter</b>	enable		
<b>Type</b>	Boolean		
<b>Description</b>	Enable or bypass multi matrix.		
<b>Default</b>	Off		

For details on how the multi matrix color correction works, see description of the `mcc mode` and `mcc phase` commands below.

### 7.5.13.1 video mcc mode

<b>Command</b>	video mcc mode <mode>		
<b>Alias</b>	mcc_opmode	<b>Type</b>	Setter, Getter
<b>Description</b>	Set MCC operating mode which defines the number of active phases. To get supported modes use the <code>mcc mode list</code> subcommand. Changing the operational mode disables blinking and gating (see <code>mcc blink</code> and <code>mcc gate</code> subcommands).		
<b>Parameter</b>	mode		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Set MCC mode which defines number of active phases.		
<b>Valid Values</b>	0 = 12 phases 1 = 16 phases 2 = 24 phases 3 = 32 phases		
<b>Default</b>	2 = 24 phases		

The multi matrix module splits the color of the input image into equally sized parts depending on the hue which we call phases. Below are examples for 12 and 24 phases. The numbers in the segments are the IDs of the according MCC phases.

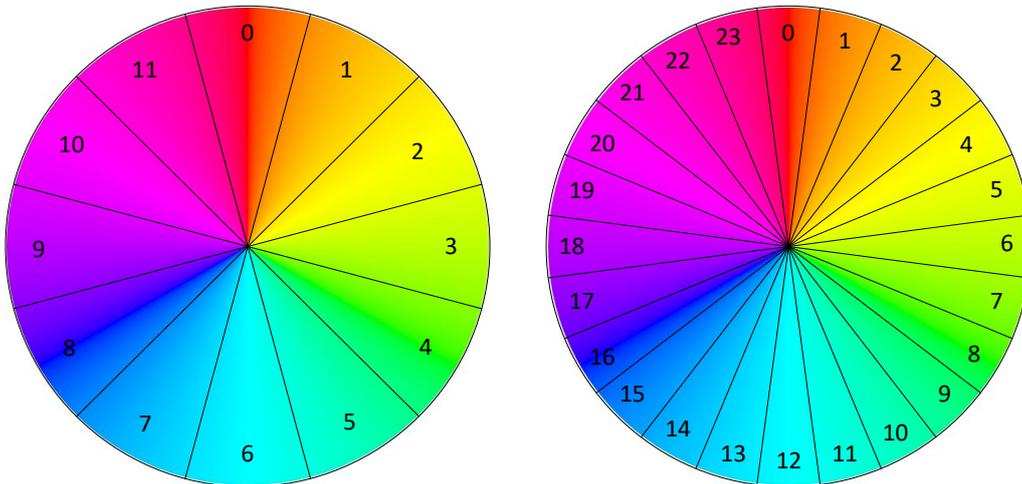


Figure 4: Example of 12 and 24 MCC Phases.

Note that phase 0 is always at the top in the red part of the color circle.

#### 7.5.13.1.1 video mcc mode list

<b>Command</b>	video mcc mode list		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List all MCC operational modes.		

This command is mainly intended for interactive use. A controller can expect all modes to be available for every camera model.

### 7.5.13.2 video mcc phase

<b>Command</b>	video mcc phase <id> (<saturation> <hue>)		
<b>Alias</b>	mcc_set	<b>Type</b>	Setter, Getter with optional Arguments
<b>Runtime</b>	Getter without arguments: < 200 ms		
<b>Description</b>	Set one phase of the multi matrix consisting of a saturation and a hue value. The number of phases that can be set depends on the currently configured MCC mode. The saturation is an unsigned fixed point integer in 2.14 format, range [0.0 = 0, 3.999 = 35535], default: 1.0 = 16384. The hue is a signed fixed point integer in 1.15 format, range [-1.0 = -32768, 0.999 = 32767], default: 0.0 = 0.		

	When saturation and hue are not specified the phase with the given ID is printed. When no parameter is given all active segments are printed.		
<b>Parameter</b>	id	saturation	hue
<b>Type</b>	Unsigned Integer	Unsigned 2.14 Fixed Point Number	Signed 1.15 Fixed Point Number
<b>Description</b>	ID of the phase to configure.	Saturation factor of given phase.	Hue angle of given phase.
<b>Min</b>	0	0.0 = 0	-1.0 = -32768 → -180°
<b>Max</b>	(Number of Phases) – 1 Example: 23 for 24 phases	3.999 = 65535	0.999 = 32767 → 179.999°
<b>Default</b>	/	1.0 = 16384	0.0 = 0 = → 0°

Each phase controls one of the pie segments shown in Figure 4. The number of segments depends on the `mcc mode` setting.

For each phase / segment the saturation and hue can be adjusted independently. The saturation value is a factor by which the saturation is either increased (if >1.0) or decreased (if <1.0). The hue specifies the angle by which the color in the selected phase is shifted. Negative values shift the color counterclockwise, positive values clockwise. A value of +1.0 or -1.0 results in a +/- 180° rotation. The example below shows how the hue works for phase 0:

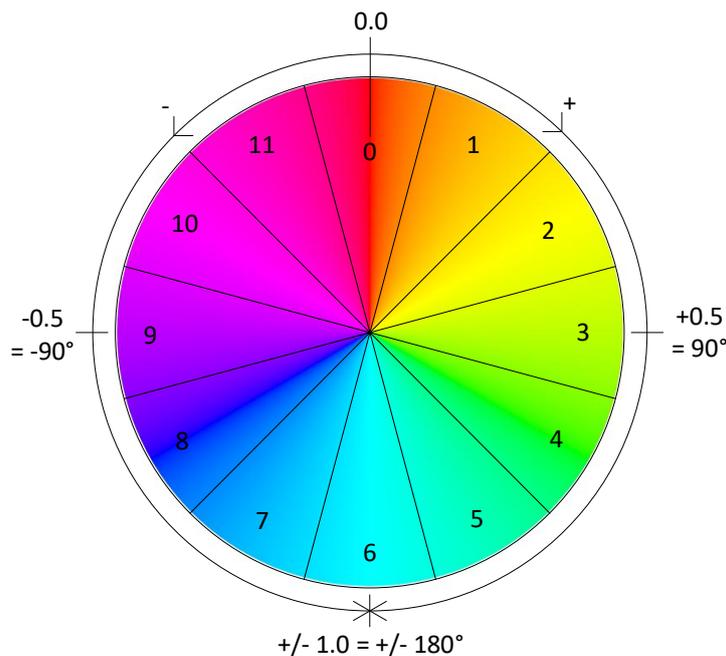


Figure 5: Hue Example for Phase 0.

### 7.5.13.3 video mcc blink

<b>Command</b>	video mcc blink <mask> (<period>)		
<b>Alias</b>	mcc_blink	<b>Type</b>	Setter, Getter
<b>Description</b>	<p>Toggle blinking of masked multi matrix phases. Can be used to highlight areas in the image affected by certain phases.</p> <p>The mask parameter is a bitmask where each bit represents one phase of the multi matrix. Bits of unused phases are ignored and have no effect.</p> <p>The optional period parameter defines the blink period in ms. The blink state will toggle every (period / 2) ms. If no period is specified, the default of 1s will be used, the minimum period is 100ms, the maximum 10s.</p> <p>Enabling blinking disables gating (see <code>mcc gate</code> command) and vice versa. Changing the number of MCC phases or disabling the MCC also disables blinking.</p> <p>This setting is not saved, that means after a reboot or power cycle blinking will always be disabled!</p>		

<b>Parameter</b>	mask	period
<b>Type</b>	Unsigned Integer	Unsigned Integer
<b>Description</b>	Each bit selects one phase for blinking.	Optional blinking period in ms.
<b>Min</b>	0x00000000	100
<b>Max</b>	Depends on number of active phases: 12 phases: 0x00000FFF 16 phases: 0x0000FFFF 24 phases: 0x00FFFFFF 32 phases: 0xFFFFFFFF	10000
<b>Default</b>	0	1000

#### 7.5.13.4 video mcc gate

<b>Command</b>	video mcc gate <mask>		
<b>Alias</b>	mcc_gate	<b>Type</b>	Setter, Getter
<b>Description</b>	Toggle gating of masked multi matrix phases. Can be used to highlight areas in the image affected by certain phases. The mask parameter is a bitmask where each bit represents one phase of the multi matrix. Bits of unused phases are ignored and have no effect. For each selected phase the saturation is set to 0 which will grey out all image areas that lie within that phase. To isolate a single phase set the gate bits of all other phases. Enabling gating disables blinking (see <code>mcc blink</code> command) and vice versa. Changing the number of MCC phases or disabling the MCC also disables gating. This setting is not saved, that means after a reboot or power cycle gating will always be disabled!		
<b>Parameter</b>	mask		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Each bit selects one phase for blinking.		
<b>Min</b>	0x00000000		
<b>Max</b>	Depends on number of active phases: 12 phases: 0x00000FFF 16 phases: 0x0000FFFF 24 phases: 0x00FFFFFF 32 phases: 0xFFFFFFFF		
<b>Default</b>	0		

Examples:

To gate a single phase set only one bit of the mask. This sets the saturation of the selected phase to 0 (turns it grey in the output image):

```
→ 1 video mcc gate 0x00000001 # Gate phase 1
← OK
```

To highlight a phase and do isolated tuning, e.g. when using a vector scope, it is useful to gate all phases except the selected phase as it will then be the only phase that shows up with color in the vector scope:

```
→ 1 video mcc gate 0xFFFFFFFFE # Gate all phases except phase 1.
← OK
```

#### 7.5.14 video black\_master

<b>Command</b>	video black_master <red/all> (<green> <blue>)		
<b>Alias</b>	black_master	<b>Type</b>	Setter, Getter
<b>Description</b>	Set all master black offsets. All values are 12 bit signed integers with a range of [-2048, 2047]. The offsets are added, that means positive values increase the black level and negative values decrease the black level. If only one value is given, all offsets are set to the same value. Otherwise, all three values must be given. To set a single offset value use the subcommands.		
<b>Parameter</b>	red/all	green	blue

<b>Type</b>	Signed Integer		
<b>Description</b>	Red or all components master black offset.	Optional green offset.	Optional blue offset.
<b>Min</b>	-2048		
<b>Max</b>	2047		
<b>Default</b>	0		

#### 7.5.14.1 video black\_master red

<b>Command</b>	video black_master red <offset>		
<b>Alias</b>	black_master_red	<b>Type</b>	Setter, Getter
<b>Description</b>	Set red master black offset as 12 bit signed integer.		
<b>Parameter</b>	factor		
<b>Type</b>	Signed Integer		
<b>Description</b>	Red component master black offset.		
<b>Min</b>	-2048		
<b>Max</b>	2047		
<b>Default</b>	0		

#### 7.5.14.2 video black\_master green

<b>Command</b>	video black_master green <offset>		
<b>Alias</b>	black_master_green	<b>Type</b>	Setter, Getter
<b>Description</b>	Set green master black offset as 12 bit signed integer.		
<b>Parameter</b>	factor		
<b>Type</b>	Signed Integer		
<b>Description</b>	Green component master black offset.		
<b>Min</b>	-2048		
<b>Max</b>	2047		
<b>Default</b>	0		

#### 7.5.14.3 video black\_master blue

<b>Command</b>	video black_master blue <offset>		
<b>Alias</b>	black_master_blue	<b>Type</b>	Setter, Getter
<b>Description</b>	Set blue master black offset as 12 bit signed integer.		
<b>Parameter</b>	factor		
<b>Type</b>	Signed Integer		
<b>Description</b>	Blue component master black offset.		
<b>Min</b>	-2048		
<b>Max</b>	2047		
<b>Default</b>	0		

#### 7.5.15 video black\_gamma

<b>Command</b>	video black_gamma <range> <level>		
<b>Alias</b>	black_gamma	<b>Type</b>	Setter, Getter
<b>Description</b>	<p>Set the black gamma value to fine-tune the brightness in dark image areas which changes the perceived image contrast.</p> <p>The <code>range</code> parameter adjusts how far the effect stretches into the bright image areas where 0 is bypass (no effect), 1 is narrow (only affects very dark areas), 100 is wide (also affects gray areas) and 50 is the default (middle) setting.</p> <p>The <code>level</code> parameter defines the strength of the effect where the default value of 0 is bypass, negative values decrease the brightness in dark areas, positive values increase it.</p>		
<b>Parameter</b>	range	level	
<b>Type</b>	Unsigned Integer	Signed Integer	
<b>Description</b>	Width of the black gamma curve.	Strength of the black gamma effect.	
<b>Min</b>	0 = Bypass	-100	
<b>Max</b>	100	100	
<b>Default</b>	50	0 = Bypass	

The following diagram shows the effect of the black gamma function on the gamma curve.

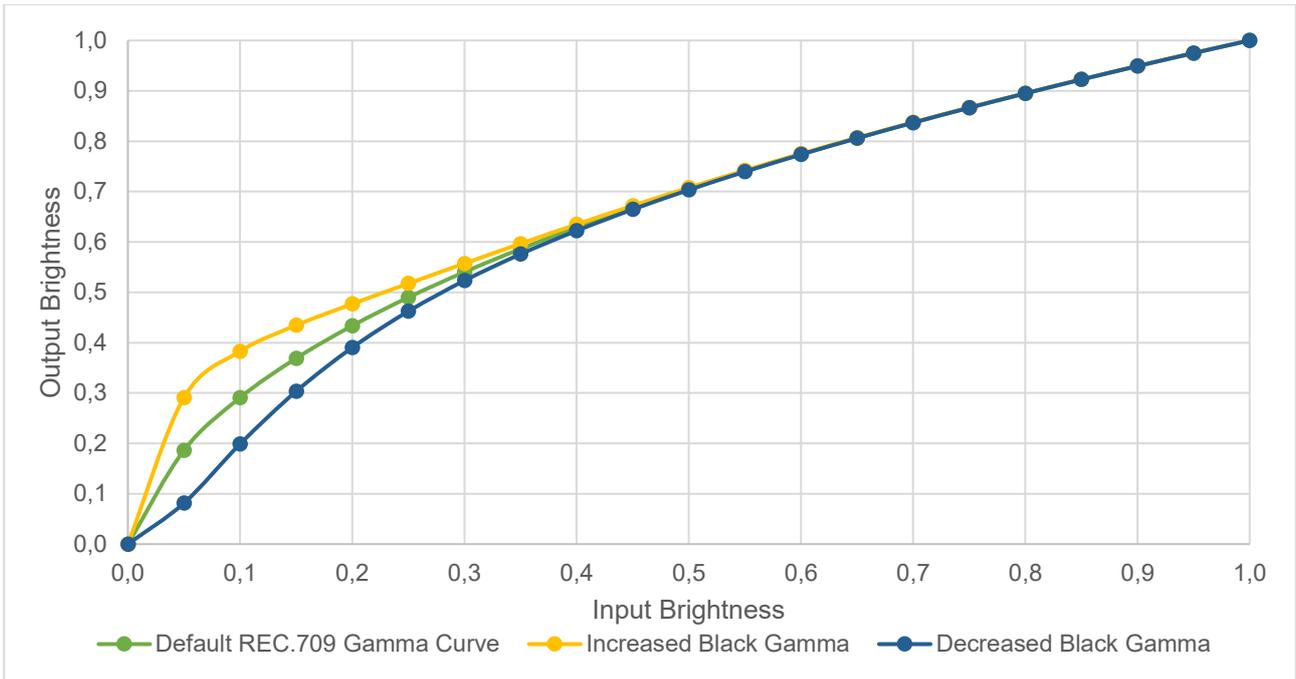


Figure 6: Black Gamma Examples

### 7.5.16 video knee

<b>Command</b>	video knee <enable> (<point> <slope>)		
<b>Alias</b>	knee	<b>Type</b>	Setter, Getter
<b>Description</b>	<p>Configure knee function for highlight limiting defined by the starting point in percent and the slope in degree.</p> <p>Until the starting point a 1:1 mapping of input to output value is used. After the starting point a root function is used. For a slope of 45° it also has a 1:1 mapping which equals bypass behavior. For angles &lt;45° highlights get limited, for angles &gt;45° highlights get boosted.</p> <p>If either point or slope shall be changed both must be specified, if only enable shall be changed both can be omitted.</p>		
<b>Parameter</b>	enable	point	slope
<b>Type</b>	Boolean	Unsigned Integer	Unsigned Integer
<b>Description</b>	Enable or bypass knee module.	Knee starting point as percentage.	Knee angle in degree.
<b>Min</b>	0 = Bypass	0	0
<b>Max</b>	1 = Enable	100	90
<b>Default</b>	0 = Bypass	85	45

The following figure visualizes how the knee function works:

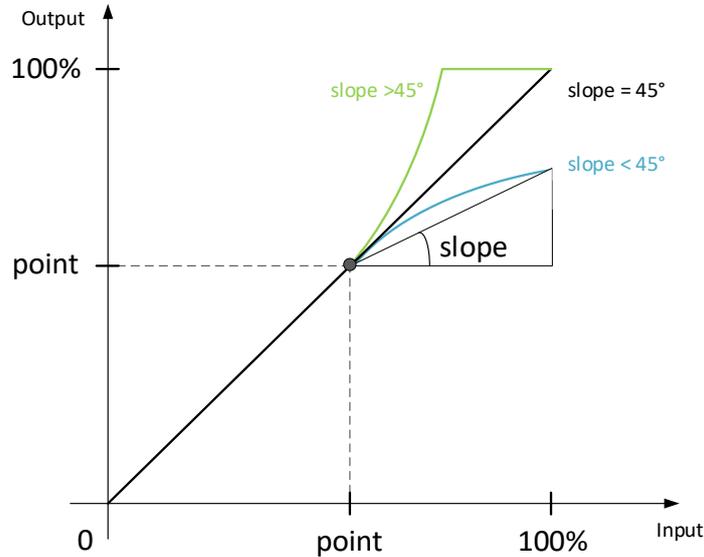


Figure 7: Knee Function Diagram.

Up to the knee `point` the output function is linear with a 1:1 mapping. From there on the function depends on the `slope` which describes the opening angle of the triangle that connects the knee point and output value at 100% input value.

- For a `slope` of 45° the output stays linear with a 1:1 mapping causing bypass behavior.
- The blue line shows a `slope` <45° which limits highlights and reduces the maximum output value.
- The green line shows a `slope` >45° which boosts highlights and causes big input values to get clipped to white.

Typical values for the knee `point` range from 60% to 90% while the `slope` is usually set to 20° to 40° for highlight limiting.

### 7.5.17 video lut

<b>Command</b>	video lut (<index>) <enable>		
<b>Alias</b>	lut_enable	<b>Type</b>	Setter, Getter
<b>Description</b>	Enable gamma LUT (0 = bypass, 1 = enabled). The gamma LUT transforms the linear RGB signal into the gamma space that is expected by a monitor or recorder. If called via the alias <code>lut_enable</code> this function expects two arguments: Index and enable flag. Since only one LUT is supported, the index is always 0. This is done for compatibility with the ProVideo protocol.		
<b>Parameter</b>	index	enable	
<b>Type</b>	Unsigned Integer	Boolean	
<b>Description</b>	Optional LUT index for compatibility with ProVideo protocol.	Enable or bypass gamma LUT.	
<b>Valid Values</b>	0	0 / 1	
<b>Default</b>	/	1 = On	

Examples with and without the optional index that are functionally identical:

```

→ 1 video lut 1
← OK
→ 1 lut_enable 0 1
← OK
    
```

### 7.5.17.1 video lut mode

<b>Command</b>	video lut mode <mode>		
<b>Alias</b>	log_mode	<b>Type</b>	Setter, Getter
<b>Runtime</b>	Setter: < 200 ms		
<b>Description</b>	Set LUT mode. To list all modes, use the <code>lut mode list</code> subcommand. Note that in S-Log3 mode the SDI output range (see <code>video sdi_range</code> command) is forced to full range as this is required by the standard. When a different mode is selected the previous SDI range setting is restored.		
<b>Parameter</b>	mode		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Gamma LUT mode.		
<b>Valid Values</b>	0 = REC.709 1 = BT.2100 HLG 2 = BT.2100 PQ 3 Sony S-Log3		
<b>Default</b>	0 = REC.709		

For **SDR content** the default REC.709 gamma curve is used. For **HDR productions** you can select from HLG, PQ or S-Log3 gamma curves which have a higher dynamic compression.

While the HLG curve is fixed you can make adjustments in the other modes:

- REC.709: Adjust gamma value (`lut gamma` subcommand).
- PQ: Set maximum display brightness (`lut max_brightness` subcommand).
- S-Log3: Set master gain (`lut master_gain` subcommand).

#### 7.5.17.1.1 video lut mode list

<b>Command</b>	video lut mode list		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List all LUT operational modes.		

This command is mainly intended for interactive use. A controller can expect all modes to be available for every camera model.

### 7.5.17.2 video lut gamma

<b>Command</b>	video lut gamma <value>		
<b>Alias</b>	lut_fast_gamma	<b>Type</b>	Setter, Getter
<b>Runtime</b>	Setter: < 200 ms		
<b>Description</b>	Only applicable if <code>lut mode</code> is set to 0 = REC.709. Set gamma value of gamma curve. The value includes the scaling factor 1000 which results in a range of [1100, 3000] which equals [1.1, 3.0] in floating point numbers. The default is 2222 = 2.222 which results in a gamma curve according to the REC.709 standard. A bigger value results in a steep gamma curve, a smaller value in a flat curve.		
<b>Parameter</b>	value		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	REC.709 gamma value.		
<b>Min</b>	1.1 = 1100		
<b>Max</b>	3.0 = 3000		
<b>Default</b>	2.222 = 2222		

### 7.5.17.3 video lut max\_brightness

<b>Command</b>	video lut max_brightness <value>		
<b>Alias</b>	pq_max_brightness	<b>Type</b>	Setter, Getter
<b>Runtime</b>	Setter: < 200 ms		
<b>Description</b>	Only applicable if <code>lut mode</code> is set to 2 = PQ. Set maximum display brightness of the PQ curve in cd/ m <sup>2</sup> . Valid range [100, 10000], default: 1000.		

	The PQ curve uses an absolute mapping of output value to display brightness, that means the full SDI code range will be used for the maximum setting of 10000 cd/ m <sup>2</sup> . For lower settings the curve will be compressed so that highlights are mapped to the desired maximum brightness (which does reduce the used SDI code range!).
<b>Parameter</b>	value
<b>Type</b>	Unsigned Integer
<b>Description</b>	Maximum display brightness in cd/m <sup>2</sup>
<b>Min</b>	100
<b>Max</b>	10000
<b>Default</b>	1000

#### 7.5.17.4 video lut master\_gain

<b>Command</b>	video lut master_gain <value>		
<b>Alias</b>	slog3_master_gain	<b>Type</b>	Setter, Getter
<b>Runtime</b>	Setter: < 200 ms		
<b>Description</b>	Only applicable if lut_mode is set to 3 = S-Log3. Set master gain of the S-Log3 curve in dB. Valid range [-6, 12], default: 0. The master gain compresses (or expands) the gamma curve to decrease or increase the output code values. The full SDI code range will be used for 10 dB but most workflows use 0 or -3 dB. For everything >10 dB highlights will be clipped.		
<b>Parameter</b>	value		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	S-Log3 master gain in dB.		
<b>Min</b>	-6		
<b>Max</b>	12		
<b>Default</b>	0		

#### 7.5.17.5 video lut mode\_compat

<b>Command</b>	video lut mode_compat <mode>		
<b>Alias</b>	lut_mode	<b>Type</b>	Setter, Getter
<b>Description</b>	This command is only for compatibility with the ProVideo protocol to provide the lut_mode alias. The only allowed mode is '1' which is equal to "fast gamma" mode in the ProVideo protocol.		
<b>Parameter</b>	mode		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	ProVideo LUT mode for compatibility.		
<b>Valid Values</b>	1 = Fast Gamma		
<b>Default</b>	1 = Fast Gamma		

### 7.5.18 video post

<b>Command</b>	video post		
<b>Alias</b>	post	<b>Type</b>	Special
<b>Description</b>	Configure post processing, see subcommands for details.		

This command has no functionality, it is only used to group the post-processing subcommands (see below).

#### 7.5.18.1 video post brightness

<b>Command</b>	video post brightness <value>		
<b>Alias</b>	post_bright	<b>Type</b>	Setter, Getter
<b>Runtime</b>	Setter: < 200 ms		
<b>Description</b>	Set post processing brightness value in signed 1.7 fixed point format. Valid range [-128, 127] = [-1.0, 1.0], default (neutral) is 0 = 0.0. Instead of changing the brightness during post processing it is recommended to change exposure or gain for improved image quality. This setting has no effect if the device is in HDR mode (video lut mode is set to > 0 = REC.709).		

<b>Parameter</b>	value
<b>Type</b>	Signed 1.7 Fixed Point Number
<b>Description</b>	Brightness factor.
<b>Min</b>	-1.0 = -128
<b>Max</b>	0.999 = 127
<b>Default</b>	0.0 = 0

#### 7.5.18.2 video post contrast

<b>Command</b>	video post contrast <value>		
<b>Alias</b>	post_cont	<b>Type</b>	Setter, Getter
<b>Runtime</b>	Setter: < 200 ms		
<b>Description</b>	Set post processing contrast value in unsigned 1.7 fixed point format. Valid range [0, 255] = [0.0, 2.0), default (neutral) is 128 = 1.0. Instead of changing the contrast during post processing it is recommended to turn on the flare compensation for improved image quality. This setting has no effect if the device is in HDR mode (video lut mode is set to > 0 = REC.709).		

<b>Parameter</b>	value
<b>Type</b>	Unsigned 1.7 Fixed Point Number
<b>Description</b>	Contrast factor.
<b>Min</b>	0.0 = 0
<b>Max</b>	1.999 = 255
<b>Default</b>	1.0 = 128

#### 7.5.18.3 video post saturation

<b>Command</b>	video post saturation <value>		
<b>Alias</b>	post_sat	<b>Type</b>	Setter, Getter
<b>Description</b>	Set post processing saturation value in 1.7 fixed point format. Valid range [0, 255] = [0.0, 2.0), default (neutral) is 128 = 1.0.		

<b>Parameter</b>	value
<b>Type</b>	Unsigned 1.7 Fixed Point Number
<b>Description</b>	Saturation factor.
<b>Min</b>	0.0 = 0
<b>Max</b>	1.999 = 255
<b>Default</b>	1.0 = 128

#### 7.5.18.4 video post hue

<b>Command</b>	video post hue <value>		
<b>Alias</b>	post_hue	<b>Type</b>	Setter, Getter
<b>Description</b>	Set post processing hue value in signed 1.7 fixed point format. Valid range [-128, 127] = [-1.0, 1.0) = [-90°, 90°), default (neutral) is 0 = 0.0 = 0°.		

<b>Parameter</b>	value
<b>Type</b>	Signed 1.7 Fixed Point Number
<b>Description</b>	Brightness factor.
<b>Min</b>	-1.0 = -128 → -90°
<b>Max</b>	0.999 = 127 → 90°
<b>Default</b>	0.0 = 0 → 0°

### 7.5.19 video osd

**Note:** The `osd` command is not available on all devices and can differ on devices which do support it. Below is a description of all available features.

<b>Command</b>	video osd <mode>		
<b>Alias</b>	osd	<b>Type</b>	Setter, Getter
<b>Description</b>	Set on-screen display mode. To get a list of supported modes use the <code>osd list</code> subcommand. To enable the live indicator animation (runs independently from other OSD modes) see the <code>live_indicator</code> subcommand.		
<b>Parameter</b>	mode		

<b>Type</b>	Unsigned Integer
<b>Description</b>	OSD mode.
<b>Valid Values</b>	0 = Disabled 1 = Show PROTON logo in top-right corner
<b>Default</b>	0 = Disabled

Note that while the command syntax is identical to the ProVideo protocol, the available OSD modes differ.

#### 7.5.19.1 video osd list

<b>Command</b>	video osd list		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List all OSD modes.		

This command is mainly intended for interactive use. A controller can expect all modes to be available for every camera model that supports setup of OSD modes.

#### 7.5.19.2 video osd live\_indicator

<b>Command</b>	video osd live_indicator <enable>		
<b>Alias</b>	live_indicator	<b>Type</b>	Setter, Getter
<b>Description</b>	Enable a rotating live-indicator animation in the top-right corner of the image. Useful to check if video transmission is live or got interrupted.		
<b>Parameter</b>	enable		
<b>Type</b>	Boolean		
<b>Description</b>	Enable or disable live-indicator.		
<b>Default</b>	Off		

#### 7.5.20 video user

<b>Command</b>	video user		
<b>Alias</b>	user	<b>Type</b>	Special
<b>Description</b>	Configure user settings which override or tune the camera calibration. See subcommands for details.		

This command has no functionality, it is only used to group the `user` subcommands (see below).

#### 7.5.20.1 video user gain

<b>Command</b>	video user gain <red> <green> <blue>		
<b>Alias</b>	user_gain	<b>Type</b>	Setter, Getter
<b>Description</b>	<p>Use the user gains to fine tune the RGB white balance gains. The user gains are multiplied with the gain values which result from the selected white balance temperature or preset. The resulting total gains can be read and set with the 'wb gain' command. Note that changing the total gains also updates the user gains. All values are in signed 5.8 fixed point format with a range of 0.0 = 0, 15.999 = 4095] (1.0 = 256).</p> <p>To use the original (calibrated) values, set all user gains to the default value of 1.0 = 256 (see usage example below).</p> <p>The user gains are preserved when changing the color temperature with the <code>wb temp</code> command but they are reset to 1.0 when a preset is selected using the <code>wb preset</code> command or if the auto white balance is run.</p> <p>The gains cannot be changed while auto white balance is enabled.</p> <p>To set a single gain value use the subcommands.</p>		
<b>Parameter</b>	red	green	blue
<b>Type</b>	Unsigned 4.8 Fixed Point Number		
<b>Description</b>	Red gain.	Green gain.	Blue gain.
<b>Min</b>	0 = 0		
<b>Max</b>	15.999 = 4095		
<b>Default</b>	1.0 = 256		

The user gains are linked with the RGB white balance gains which can be set with the `wb gain` command that means if one of them gets changed the other one is updated automatically. For details see chapter 7.5.7.1.

To reset the user gains to neutral settings, they must be set to 1.0:

```
→ 1 video user gain 256 256 256
← OK
```

#### 7.5.20.1.1 video user gain red

<b>Command</b>	video user gain red <gain>		
<b>Alias</b>	user_gain_red	<b>Type</b>	Setter, Getter
<b>Description</b>	Set user defined red gain in unsigned 4.8 fixed point format (1.0 = 256).		
<b>Parameter</b>	gain		
<b>Type</b>	Unsigned 4.8 Fixed Point Number		
<b>Description</b>	Red user gain.		
<b>Min</b>	0 = 0		
<b>Max</b>	15.999 = 4095		
<b>Default</b>	0.0 = 0		

#### 7.5.20.1.2 video user gain green

<b>Command</b>	video user gain green <offset>		
<b>Alias</b>	user_gain_green	<b>Type</b>	Setter, Getter
<b>Description</b>	Set user defined green gain in unsigned 4.8 fixed point format (1.0 = 256).		
<b>Parameter</b>	gain		
<b>Type</b>	Unsigned 4.8 Fixed Point Number		
<b>Description</b>	Green user gain.		
<b>Min</b>	0 = 0		
<b>Max</b>	15.999 = 4095		
<b>Default</b>	0.0 = 0		

#### 7.5.20.1.3 video user gain blue

<b>Command</b>	video user gain blue <offset>		
<b>Alias</b>	user_gain_blue	<b>Type</b>	Setter, Getter
<b>Description</b>	Set user defined blue gain in unsigned 4.8 fixed point format (1.0 = 256).		
<b>Parameter</b>	gain		
<b>Type</b>	Unsigned 4.8 Fixed Point Number		
<b>Description</b>	Blue user gain.		
<b>Min</b>	0 = 0		
<b>Max</b>	15.999 = 4095		
<b>Default</b>	0.0 = 0		

#### 7.5.20.2 video user matrix

<b>Command</b>	video user matrix <c0> ... <c8>		
<b>Alias</b>	user_matrix	<b>Type</b>	Setter, Getter
<b>Description</b>	Set a user defined RGB color matrix. The matrix consists of 9 coefficients which are in signed 4.12 fixed point format with a range of [-8.0 = -32768, 8.0 = 32767] (1.0 = 4096). To reset the matrix to neutral, program the identity matrix (see usage examples below).		
<b>Parameter</b>	c0 ... c8		
<b>Type</b>	Signed 4.12 Fixed Point Number		
<b>Description</b>	User matrix coefficients.		
<b>Min</b>	-8.0 = -32768		
<b>Max</b>	7.999 = 32767		
<b>Default</b>	Identity matrix, see below.		

To reset the matrix to neutral, the identity matrix must be programmed (diagonal values set to 1.0):

```
→ 1 video user matrix 4096 0 0 0 4096 0 0 0 4096
← OK
```

## 7.5.21 video test

<b>Command</b>	video test		
<b>Alias</b>	test	<b>Type</b>	Special
<b>Description</b>	Commands for testing, e.g. test pattern output.		

This command has no functionality, it is only used to group the `test` subcommands (see below).

### 7.5.21.1 video test pattern

<b>Command</b>	video test pattern <mode>		
<b>Alias</b>	test_pattern	<b>Type</b>	Setter, Getter
<b>Description</b>	Show a test pattern instead of live video. To list supported modes, use the 'pattern list' subcommand. This setting is not saved, that means after a reboot or power cycle the test pattern will always be disabled!		
<b>Parameter</b>	mode		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Test pattern mode to set.		
<b>Valid Values</b>	0 = Off / Live Video 1 = Black Image 2 = Color Bars		
<b>Default</b>	0 = Off / Live Video		

#### 7.5.21.1.1 video test pattern list

<b>Command</b>	video test pattern list		
<b>Alias</b>	/	<b>Type</b>	List
<b>Description</b>	List all available test patterns.		

This command is mainly intended for interactive use. A controller can expect all modes to be available for every camera model.

### 7.5.21.2 video test hide\_invalid

<b>Command</b>	video test hide_invalid <enable>		
<b>Alias</b>	test_hide	<b>Type</b>	Setter, Getter
<b>Description</b>	Depending on the camera model some operations like <code>flip</code> or <code>pan / tilt</code> can cause invalid output images. By default, these are hidden by showing a black image from the test pattern generator instead. Disable this setting to show the invalid frames instead of hiding them.		
<b>Parameter</b>	enable		
<b>Type</b>	Boolean		
<b>Description</b>	Hide or show invalid frames.		
<b>Default</b>	Enabled		

## 7.6 Lens Commands

These commands control the optional lens drive features of the camera. They are called with the `lens` command prefix. The following commands are only available on devices with an integrated motor zoom lens like PROTON ZOOM and 4K ZOOM.

Depending on the camera model the following motors can be available: **Iris, Focus, Zoom**.

Each of the available motors can be driven in two modes:

- **Absolute Mode:** The motor is driven to a new target position with a given speed.
- **Relative Mode:** The motor is driven forward or backward with a given speed until the end of the driving range is reached or speed is set to 0 again.

At any time, the current position of each motor can be queried. An additional flag indicates if the motor has reached the target position (within its mechanical accuracy).

## 7.6.1 lens iris

<b>Command</b>	lens iris <f-number> (<speed> <at-target>)		
<b>Alias</b>	iris	<b>Type</b>	Setter, Getter
<b>Description</b>	<p>Set aperture. The value is scaled by 100 so f/2.4 is represented as '240'. To fully close the iris, e.g. for black level calibration, drive it to the maximum position. For convenience, instead of the f-number the <code>open</code> and <code>close</code> keywords can be used to fully open or close the iris.</p> <p>Optionally the speed as a percentage can be passed, if no speed is set it stays at the last set value. Setting a speed of 0 immediately stops the motor ignoring the given f-number value.</p> <p>The &lt;at-target&gt; flag is set to 1 when the motor has reached its target position and is stopped. Setting the flag has no effect.</p> <p>Setting the iris is not possible if it is currently being controlled by the auto exposure algorithm, in this case error code -134 is returned. You can disable the AEC with the <code>camera auto</code> command.</p>		
<b>Parameter</b>	f-number	speed	at-target
<b>Type</b>	Unsigned Integer	Unsigned Integer	Boolean
<b>Description</b>	F-number scaled by 100 (e.g. f/2.4 = 240)	Motor speed as percentage	If motor has reached its target, ignored on set
<b>Valid Values</b>	<code>open</code> : Fully open iris <code>close</code> : Fully close iris For value range see <code>range</code> subcommand	<b>0 to 100 %</b> where: <b>0</b> : Stop Motor <b>1</b> : Minimum Speed <b>100</b> : Maximum Speed	<b>0</b> : Motor is still moving <b>1</b> : Motor has reached its target and is stopped
<b>Default</b>	Fully open	100 (Maximum Speed)	/

Examples:

```

→ 1 lens iris 240 50    # Drive to position f/2.4 with a speed of 50 %
← OK
→ 1 lens iris 240 0    # Stop motor (f-number value is ignored)
← OK
→ 1 lens iris         # Get current position
← lens iris 203 5 1    # Motor has reached target at position f/2.03 (because
← OK                  # it was stopped before reaching f/2.4)
→ 1 lens iris open    # Fully open iris
← OK
→ 1 lens iris close   # Fully close iris
← OK
  
```

### 7.6.1.1 lens iris range

<b>Command</b>	lens iris range		
<b>Alias</b>	iris_range	<b>Type</b>	Pure Getter
<b>Description</b>	<p>Get minimum and maximum f-number supported by the iris motor. Depending on the current zoom position, not all apertures are reachable. The motor will be driven as close to the target as possible and will adjust when the zoom position is changed.</p> <p>Output: &lt;min&gt; &lt;max&gt;</p>		

Example:

```

→ 1 lens iris range
← lens iris range 138 12800 # Iris range is f/1.38 to f/128.00
← OK
  
```

### 7.6.1.2 lens iris relative

<b>Command</b>	lens iris relative <speed>		
<b>Alias</b>	iris_relative	<b>Type</b>	Setter, Getter
<b>Description</b>	Close iris (positive speed) or open iris (negative speed) until it reaches the max or min position. Use speed = 0 to stop the motor at the current position.		
<b>Parameter</b>	speed		
<b>Type</b>	Signed Integer		
<b>Description</b>	Motor speed		
<b>Allowed Values</b>	<b>0</b> : Stop motor <b>-100 to 100</b> : Drive motor backward or forward with given speed		

Example:

```

→ 1 lens iris relative 10      # Slowly close iris (10 % speed)
← OK
→ 1 lens iris relative 0      # Stop motor
← OK
→ 1 lens iris relative -90    # Open iris fast (90 % speed)
← OK
    
```

### 7.6.2 lens focus

<b>Command</b>	lens focus <distance> (<speed> <at-target>)		
<b>Alias</b>	focus	<b>Type</b>	Setter, Getter
<b>Description</b>	Set focus to given object distance in cm. For convenience, instead of the distance the <i>near</i> and <i>far</i> keywords can be used to set the focus to minimum object distance or infinity. Optionally the speed as a percentage can be passed, if no speed is set it stays at the last set value. Setting a speed of 0 immediately stops the motor ignoring the given object distance value. The <at-target> flag is set to 1 when the motor has reached its target position and is stopped. Setting the flag has no effect.		
<b>Parameter</b>	distance	speed	at-target
<b>Type</b>	Unsigned Integer	Unsigned Integer	Boolean
<b>Description</b>	Object distance in cm	Motor speed as percentage	If motor has reached its target, ignored on set
<b>Valid Values</b>	<i>near</i> : Min object distance <i>far</i> : Infinity For value range see <i>range</i> subcommand	<b>0 to 100 %</b> where: <b>0</b> : Stop Motor <b>1</b> : Minimum Speed <b>100</b> : Maximum Speed	<b>0</b> : Motor is still moving <b>1</b> : Motor has reached its target and is stopped
<b>Default</b>	150 cm (if supported by camera)	100 (Maximum Speed)	/

Examples:

```

→ 1 lens focus 2000 30 # Set focus to 2000cm = 20m with a speed of 30 %
← OK
→ 1 lens focus 2000 0  # Stop motor (distance value is ignored)
← OK
→ 1 lens focus        # Get current position
← lens focus 1270 3 1  # Motor has reached target at distance 12.7m (because it
← OK                  # was stopped before reaching 20m)
→ 1 lens focus near   # Set focus to minimum object distance
← OK
→ 1 lens focus far    # Set focus to infinity
← OK
    
```

### 7.6.2.1 lens focus range

<b>Command</b>	lens focus range		
<b>Alias</b>	focus_range	<b>Type</b>	Pure Getter
<b>Description</b>	Get minimum and maximum object distance in cm supported by the focus motor. The maximum distance equals "infinity". Output: <min> <max>		

Example:

```
→ 1 lens focus range
← lens focus range 20 5000 # Focus range is 20cm to 50m (= infinity)
← OK
```

### 7.6.2.2 lens focus relative

<b>Command</b>	lens focus relative <speed>		
<b>Alias</b>	focus_relative	<b>Type</b>	Setter, Getter
<b>Description</b>	Drive focus far (positive speed) or near (negative speed) until it reaches the max or min position. Use speed = 0 to stop the motor at the current position.		
<b>Parameter</b>	speed		
<b>Type</b>	Signed Integer		
<b>Description</b>	Motor speed		
<b>Allowed Values</b>	<b>0:</b> Stop motor <b>-100 to 100:</b> Drive motor backward or forward with given speed		

Example:

```
→ 1 lens focus relative 10 # Slowly drive focus to "far" (10 % speed)
← OK
→ 1 lens focus relative 0 # Stop motor
← OK
→ 1 lens focus relative -90 # Quickly drive focus to "near" (90 % speed)
← OK
```

### 7.6.3 lens zoom

<b>Command</b>	lens zoom <factor> (<speed> <at-target>)		
<b>Alias</b>	zoom	<b>Type</b>	Setter, Getter
<b>Description</b>	Set the zoom factor. The value is scaled by 100 so 1.8x is represented as '180'. For convenience, instead of the factor the <code>wide</code> and <code>tele</code> keywords can be used to fully zoom out or in. Optionally the speed as a percentage can be passed, if no speed is set it stays at the last set value. Setting a speed of 0 immediately stops the motor ignoring the given zoom factor value. The <at-target> flag is set to 1 when the motor has reached its target position and is stopped. Setting the flag has no effect.		
<b>Parameter</b>	factor	speed	at-target
<b>Type</b>	Unsigned Integer	Unsigned Integer	Boolean
<b>Description</b>	Zoom factor scaled by 100 (e.g. 1.8x = 180)	Motor speed as percentage	If motor has reached its target, ignored on set
<b>Valid Values</b>	<code>wide</code> : Minimum zoom <code>tele</code> : Maximum zoom For value range see range subcommand	<b>0 to 100 %</b> where: <b>0:</b> Stop Motor <b>1:</b> Minimum Speed <b>100:</b> Maximum Speed	<b>0:</b> Motor is still moving <b>1:</b> Motor has reached its target and is stopped
<b>Default</b>	100 = 1.0x	100 (Maximum Speed)	/

Examples:

```
→ 1 lens zoom 150 80 # Set zoom to 1.5x with a speed of 80 %
← OK
```

```

→ 1 lens zoom          # Get current position
← lens zoom 150 8 1    # Motor has reached target position at 1.5x.
→ 1 lens zoom wide     # Set zoom to minimum (usually 1.0x)
← OK
→ 1 lens zoom tele     # Set zoom to maximum
← OK
  
```

### 7.6.3.1 lens zoom range

<b>Command</b>	lens zoom range		
<b>Alias</b>	zoom_range	<b>Type</b>	Pure Getter
<b>Description</b>	Get minimum and maximum zoom factor supported by the zoom motor. Output: <min> <max>		

Example:

```

→ 1 lens zoom range
← lens zoom range 100 207    # Focus range is 1.0x to 2.07x
← OK
  
```

### 7.6.3.2 lens zoom relative

<b>Command</b>	lens zoom relative <speed>		
<b>Alias</b>	zoom_relative	<b>Type</b>	Setter, Getter
<b>Description</b>	Zoom in (positive speed) or out (negative speed) until zoom reaches the max or min position. Use speed = 0 to stop the motor at the current position.		
<b>Parameter</b>	speed		
<b>Type</b>	Signed Integer		
<b>Description</b>	Motor speed		
<b>Allowed Values</b>	<b>0</b> : Stop motor <b>-100 to 100</b> : Drive motor backward or forward with given speed		

Example:

```

→ 1 lens zoom relative 10    # Slowly zoom in (10 % speed)
← OK
→ 1 lens zoom relative 0     # Stop motor
← OK
→ 1 lens zoom relative -90   # Quickly zoom out (90 % speed)
← OK
  
```

### 7.6.4 lens ircut

<b>Command</b>	lens ircut <mode>		
<b>Alias</b>	ircut	<b>Type</b>	Setter, Getter
<b>Runtime</b>	Setter: < 200 ms		
<b>Description</b>	Set the IR cut filter mode. <b>Note</b> : The camera is calibrated with the IR cut filter in the optical path, driving the filter out breaks the color calibration.		
<b>Parameter</b>	mode		
<b>Type</b>	Unsigned Integer		
<b>Description</b>	Silent mode to set.		
<b>Valid Values</b>	0 = Disabled 1 = Enabled		
<b>Default</b>	1 = Enabled		

### 7.6.5 lens silent

<b>Command</b>	lens silent <enable>		
<b>Alias</b>	silent	<b>Type</b>	Setter, Getter
<b>Description</b>	Enable or disable silent lens motor mode.		

	In silent mode the lens motors get turned off when no motor is moving which eliminates noise emitted by the motor drive. When the camera is operated in a shaky environment with a lot of vibration, silent mode should be turned off otherwise the precision of the motor drive can be reduced.
<b>Parameter</b>	enable
<b>Type</b>	Boolean
<b>Description</b>	Enable or disable silent mode.
<b>Default</b>	On

## 8 Alias Reference

This chapter lists all the available command alias which also provide compatibility with the ProVideo protocol. Note that some aliases are not part of the ProVideo protocol but have been added for convenience.

The list below can also be generated by the camera with the `alias` command.

Table 12: Command alias overview.

Alias	Full Command Name	ProVideo Command	Different Behavior when called via Alias
<b>cam_gain</b>	camera gain	Yes	No
<b>gain_mode</b>	camera gain mode	No	No
<b>gain_auto</b>	camera gain mode auto	No	No
<b>gain_auto_calib</b>	camera gain mode auto calibrate	No	No
<b>cam_exposure</b>	camera exposure	Yes	No
<b>cam_info</b>	camera info	Yes	No
<b>aec</b>	camera auto	Yes	Yes
<b>aec_mode</b>	camera auto mode	No	No
<b>aec_target</b>	camera auto target	No	No
<b>aec_speed</b>	camera auto speed	No	No
<b>aec_max_gain</b>	camera auto max_gain	No	No
<b>aec_anti_flicker</b>	camera auto anti_flicker	No	No
<b>aec_custom</b>	camera auto custom	No	No
<b>aec_weight</b>	camera auto weight	Yes	No
<b>cam_pan</b>	camera pan	No	No
<b>pan_left</b>	camera pan left	No	No
<b>pan_right</b>	camera pan right	No	No
<b>cam_tilt</b>	camera tilt	No	No
<b>tilt_up</b>	camera tilt up	No	No
<b>tilt_down</b>	camera tilt down	No	No
<b>iris</b>	lens iris	No	No
<b>iris_range</b>	lens iris range	No	No
<b>iris_relative</b>	lens iris relative	No	No
<b>focus</b>	lens focus	No	No
<b>focus_range</b>	lens focus range	No	No
<b>focus_relative</b>	lens focus relative	No	No
<b>zoom</b>	lens zoom	No	No
<b>zoom_range</b>	lens zoom range	No	No
<b>zoom_relative</b>	lens zoom relative	No	No
<b>ircut</b>	lens ircut	No	No

Alias	Full Command Name	ProVideo Command	Different Behavior when called via Alias
silent	lens silent	No	No
save_settings	settings save	Yes	No
load_settings	settings load	Yes	No
reset_settings	settings reset	Yes	No
auto_save	settings auto_save	Yes	No
version	system info	Yes	Yes
name	system name	Yes	No
runtime	system runtime	Yes	No
reboot	system reboot	Yes	No
update	system update	No	No
identify	system identify	Yes	No
status	system status	No	No
error	system error	No	No
volatile	system volatile	Yes	No
ping	system ping	No	No
rs485	system rs485	No	No
prompt	system rs485 mode	Yes	No
controller	system rs485 mode 0	No	No
interactive	system rs485 mode 1	No	No
rs485_addr	system rs485 device_address	Yes	No
rs485_bc_addr	system rs485 broadcast_address	Yes	No
rs485_bc_master	system rs485 broadcast_master	Yes	No
rs485_baud	system rs485 baudrate	Yes	No
rs485_tx_delay	system rs485 tx_delay	No	No
status_led	system status_led	No	No
tally	system tally	No	No
temp	system temp	Yes	No
max_temp	system temp max	Yes	No
max_temp_reset	system temp reset	Yes	No
over_temp_count	system temp count	Yes	No
humidity	system humidity	No	No
humidity_count	system humidity count	No	No
fan_target	system temp fan	Yes	No
sdi	system sdi	No	No
sdi_amplitude	system sdi amplitude	No	No
sdi_slew_rate	system sdi slew_rate	No	No
sdi_clock_tune	system sdi clock_tune	No	No
audio_enable	system audio	Yes	No
audio_gain	system audio gain	Yes	No
audio_inputs	system audio inputs	No	No
audio_volume	system audio volume	No	No
audio_bias	system audio bias	No	No
timecode_enable	system timecode	No	No

Alias	Full Command Name	ProVideo Command	Different Behavior when called via Alias
<b>timecode</b>	system timecode value	Yes	No
<b>timecode_hold</b>	system timecode pause	Yes	No
<b>timecode_drop</b>	system timecode drop	No	No
<b>sync</b>	system sync	No	No
<b>sync_offset</b>	system sync offset	No	No
<b>sync_calib</b>	system sync calibrate	No	No
<b>license</b>	system license	No	No
<b>video_mode</b>	video mode	Yes	No
<b>scale</b>	video scale	No	No
<b>phases</b>	video phases	No	No
<b>phases_packing</b>	video phases packing	No	No
<b>phases_marker</b>	video phases marker	No	No
<b>flip</b>	video flip	Yes	No
<b>black_sensor</b>	video black_sensor	No	No
<b>black_red</b>	video black_sensor red	Yes	No
<b>black_green</b>	video black_sensor green	Yes	No
<b>black_blue</b>	video black_sensor blue	Yes	No
<b>lsc</b>	video lsc	Yes	No
<b>lsc_preset</b>	video lsc preset	No	No
<b>wb</b>	video wb	Yes	No
<b>wb_gain</b>	video wb gain	No	No
<b>gain_red</b>	video wb gain red	Yes	No
<b>gain_green</b>	video wb gain green	Yes	No
<b>gain_blue</b>	video wb gain blue	Yes	No
<b>wb_temp</b>	video wb temp	No	No
<b>wb_preset</b>	video wb preset	Yes	No
<b>awb</b>	video wb auto	Yes	No
<b>awb_speed</b>	video wb auto speed	Yes	No
<b>awb_offset</b>	video wb auto offset	No	No
<b>bpc</b>	video bpc	No	No
<b>dpc_auto_load</b>	video bpc calibrate	Yes	No
<b>flare</b>	video flare	Yes	No
<b>flare_red</b>	video flare red	No	No
<b>flare_green</b>	video flare green	No	No
<b>flare_blue</b>	video flare blue	No	No
<b>color_space</b>	video color_space	Yes	No
<b>sdi_range</b>	video sdi_range	Yes	No
<b>filter_enable</b>	video filter	Yes	No
<b>filter_detail</b>	video filter detail	Yes	No
<b>filter_denoise</b>	video filter denoise	Yes	No
<b>mcc</b>	video mcc	Yes	No
<b>mcc_opmode</b>	video mcc mode	Yes	No
<b>mcc_set</b>	video mcc phase	Yes	No

Alias	Full Command Name	ProVideo Command	Different Behavior when called via Alias
<b>mcc_blink</b>	video mcc blink	Yes	No
<b>mcc_gate</b>	video mcc gate	No	No
<b>black_master</b>	video black_master	Yes	No
<b>black_master_red</b>	video black_master red	No	No
<b>black_master_green</b>	video black_master green	No	No
<b>black_master_blue</b>	video black_master blue	No	No
<b>black_gamma</b>	video black_gamma	No	No
<b>knee</b>	video knee	Yes	No
<b>lut_enable</b>	video lut	Yes	Yes
<b>log_mode</b>	video lut mode	Yes	No
<b>lut_fast_gamma</b>	video lut gamma	Yes	No
<b>pq_max_brightness</b>	video lut max_brightness	Yes	No
<b>slog3_master_gain</b>	video lut master_gain	Yes	No
<b>lut_mode</b>	video lut mode_compat	Yes	No
<b>post</b>	video post	No	No
<b>post_bright</b>	video post brightness	Yes	No
<b>post_cont</b>	video post contrast	Yes	No
<b>post_sat</b>	video post saturation	Yes	No
<b>post_hue</b>	video post hue	Yes	No
<b>osd</b>	video osd	Yes	No
<b>live_indicator</b>	video osd live_indicator	No	No
<b>user</b>	video user	No	No
<b>user_gain</b>	video user gain	No	No
<b>user_gain_red</b>	video user gain red	No	No
<b>user_gain_green</b>	video user gain green	No	No
<b>user_gain_blue</b>	video user gain blue	No	No
<b>user_matrix</b>	video user matrix	No	No
<b>test</b>	video test	No	No
<b>test_pattern</b>	video test pattern	No	No
<b>test_hide</b>	video test hide_invalid	No	No
<b>iris</b>	lens iris	No	No
<b>iris_range</b>	lens iris range	No	No
<b>iris_relative</b>	lens iris relative	No	No
<b>focus</b>	lens focus	No	No
<b>focus_range</b>	lens focus range	No	No
<b>focus_relative</b>	lens focus relative	No	No
<b>zoom</b>	lens zoom	No	No
<b>zoom_range</b>	lens zoom range	No	No
<b>zoom_relative</b>	lens zoom relative	No	No
<b>ircut</b>	lens ircut	No	No

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## Appendix B: Document Revision History

Revision	Date	Chapter	Changes
v1.0.0	29. May. 2024	All	Initial release.
v1.0.1	14. Jun. 2024	2.4	Reworked firmware update chapter for usage of the new PROTON Updater GUI which is now described in the new chapter 3.2.
		6.1	Updated list of critical settings.
		6.2, 7.2	Updated auto-save chapter and descriptions for the <code>settings reset</code> and <code>auto_save</code> commands: Auto-save is now done immediately after changing a setting.
		7.3	Updated command descriptions for the <code>system runtime</code> , <code>temp max</code> , <code>temp reset</code> , <code>temp count</code> , and <code>error</code> commands: Runtime and temperature logging are no longer persistent.
		7.3.5	Added <code>system update</code> command description.
		7.3.17.1	Updated default <code>audio gain</code> from 1.0 to 0.5.
		8	Updated alias reference.
v1.1.0	11. Jul. 2024	2.3	Updated maximum temperature, is now 100°C.
		3.2	Updated firmware update GUI chapter.
		7.4.4	Added chapter for new auto exposure control commands.
		7.5.7	Added auto white balance commands in section 7.5.7.4 and updated <code>wb</code> , <code>wb temp</code> , <code>wb gain</code> , <code>wb color_cross</code> and <code>wb preset</code> commands descriptions.
		7.3.11.5	Added new supported baud rates: 230400 and 250000 baud.
		7.3.17.1	Changed default <code>audio gain</code> from 0.5 to 1.0.
		8	Updated alias reference.
v1.1.1	22. Jul. 2024	2.2	Improve description of error state.
		2.4	Updated firmware update chapter.
		5.2.4	Added description of error code “-140”.
		7.3.5	Updated description of <code>system update</code> command.
		7.5.6	Added <code>lsc preset</code> command to LSC chapter.
		8	Updated alias reference.
v1.1.2	16. Aug. 2024	All	Fixed typos, no major changes.
v1.2.0	10. Sep. 2024	2.2	Improved description of error state.
		2.3	Improved description of the over temperature protection. New shutdown temperature is 90°C, restart temperature is 85°C.
		7.4.1.1, 7.4.3	The <code>low_light</code> command has been replaced with the <code>gain_mode</code> command. Changing the gain mode may also change the maximum gain value, so the <code>camera info</code> command description has been updated.
		7.4.4.1	Added missing description of combined auto exposure mode and improved description of other modes.
		7.5.5	Removed <code>black_sensor auto</code> command, it is no longer supported.
		7.5.7	Added new <code>wb gain offset</code> and <code>wb color_cross offset</code> commands and updated description of the other white balance commands accordingly. Note: The minimum color temperature of the <code>wb temp</code> command has been increased from 2400 to 3000 Kelvin and the 2800 Kelvin preset has been removed from the <code>wb preset</code> command.
		8	Updated alias list.
v1.3.0	25. Oct. 2024	2.1	Updated power/control connector table.
		4.1	Replaced ProVideo GUI with PROTON Control.

Revision	Date	Chapter	Changes
		5.1.1.2, 7.3.11.3	Broadcasting can now be disabled by using the broadcast address -1.
		5.2.3.5, 7.5.6.1.1	Added description of list commands. The elements of the list are now always prefixed with a hash (#) so that other cameras on the same bus do not interpret them as device IDs. Updated all <code>list</code> commands so that the examples now include the hash.
		7.3.17.1	Corrected default audio gain which is 1.0 and not 0.5.
		7.4.1, 7.4.1.1, 7.4.4.1	Improved camera gain, camera exposure and camera auto mode command descriptions.
		7.5.7	Updated <code>wb</code> command description, manual white balance now runs up to 10 frames. Removed <code>wb color_cross</code> command and moved <code>wb gain offset</code> and <code>wb color_cross offset</code> commands to new video user commands (with slightly different functionality). Updated related commands accordingly.
		7.5.13.3	Fix typo in command string of <code>mcc blink</code> command.
		7.5.20	Added new user command section which includes the <code>user gain</code> and <code>user matrix</code> commands.
		8	Updated alias list.
<b>v1.3.1</b>	04. Nov. 2024	2.3, 7.3.14.4	Added new <code>system temp fan</code> command to control fan turn-on temperature on supported devices.
		7.3.16.4	Added note that audio commands are only available on supported devices.
		7.5.7.2, 7.5.7.4	Updated formulas in <code>video wb gain</code> command description and added description of new <code>video wb tint</code> command.
		7.5.18.1, 7.5.18.2	Added note that <code>video post brightness</code> and <code>video post contrast</code> commands have no effect in HDR mode.
<b>v1.3.2</b>	03. Dec. 2024	1.1, 7.5.1, 7.3.1, 7.3.6	Added PROTON RAIN and FLEX as well as PROTON 4K to supported devices and added its UHD video modes to <code>video mode</code> command description. Updated <code>system info</code> and <code>identify</code> command description with notes on supported platforms.
		2.4, 7.3.15	Added chapter on humidity detection and description of the <code>system humidity</code> command group.
		2.5, 7.3.14.4, 7.3.16.4	Added chapter on audio and cooling fan operation, added cooling fan note to <code>system audio</code> command description and added presets to the <code>system temp fan</code> command.
		7.1.7	Added <code>firmware</code> command chapter. This is just for reference as the user usually does not call these commands directly.
		7.5.7	Updated <code>wb</code> command description, manual white balance now runs up to 1 second.
<b>v1.4.0</b>	18. Feb. 2025	1.1, 7.3.6	Added new supported device: PROTON ZOOM.
		5.2.3, 7	Introduced new “Direct” command type. Updated all command tables: Instead of having only the “Getter Function – Yes/No” information they now have a “Type” field which references the types described in chapter 5.2.3.
		5.2.4	Added new error code -14.
		7.4.1	The <code>gain_mode</code> command is now a subcommand of the <code>camera gain</code> command (new syntax: <code>camera gain mode</code> instead of <code>camera gain_mode</code> ).
		7.4.4, 7.4.4.1 7.4.4.1.1	Added new Iris Control mode to auto exposure commands. Improved overall structure of the auto exposure description.

Revision	Date	Chapter	Changes
		7.4.4.8	Added new <code>camera auto brightness</code> command.
		7.5.6	Renamed “offset” to “radius” in <code>lsc</code> commands.
		7.5.8.1	Added note regarding BPC calibration on devices with a lens drive.
		7.5.10	Added Sony S-Gamut3 and S-Gamut3.Cine to supported color spaces.
		7.5.15	Added <code>video black_gamma</code> command chapter.
		7.5.13	Added new <code>video mcc gate</code> command, updated <code>mcc</code> , <code>mcc mode</code> and <code>mcc blink</code> command descriptions.
		7.5.19	Added note that <code>osd</code> command is not available on all devices and fixed copy paste errors.
		7.5.21	Added <code>video test</code> command chapter.
		7.6	Added <code>lens</code> command chapter which describes the usage of the optional lens drive (currently only used in PROTON ZOOM).
8	Updated alias reference with new commands.		
v1.4.1	31.Mar.2025	7.3.10	Added <code>system ping</code> command.
		7.6.1, 7.6.3	Fixed examples in <code>lens iris</code> and <code>lens zoom</code> command description.
		7.6.4, 7.6.5	Added <code>lens ircut</code> and <code>lens silent</code> command descriptions.
		8	Updated alias reference with new commands.
v1.4.2	22.Apr.2025	7.3.1	Clarified purpose and usage of the resolution mask in the <code>system info</code> command.
		7.5.1	Added missing ZOOM variant to supported video mode table.
		7.6.1, 7.6.2, 7.6.3	Added min and max keywords to set minimum and maximum speed for <code>lens iris</code> , <code>focus</code> and <code>zoom</code> commands.
		6.1, 6.2, 7.3.19	Added <code>system clock_tune</code> command description and added notes on calibration settings to the settings handling chapters.
V1.5.0	14.Jul.2025	1.1, 7.3.1 7.5.1, 7.5.3	Added PROTON FLEX 4K and PROTON HFR to supported devices. Updated <code>video mode</code> chapter and added <code>video phases</code> chapter with new features for PROTON HFR.
		1.1, 2.6, 2.7, 5.1 6.1, 7.2.2, 7.2.3, 7.3.1, 7.3.11 7.3.19, 7.5.1, 7.5.3, 8	Added and updated chapters for camera synchronization and notes on 3D camera rigs. Added PROTON 3D 4K to supported devices and updated all related chapters (mostly small notes regarding changes specific for 3D rigs). Added new <code>system sync</code> command to setup synchronization between the cameras of a 3D rig. Added missing and new commands to alias list.
		2.8	Added chapter on error recovery.
		5.2.4	Updated error code description.
		5.6, 7.3.11.6	Add chapters on the new configurable Tx delay.
		7.3.16.4	Added <code>audio inputs</code> , <code>volume</code> and <code>bias</code> commands for analog audio input control to <code>system audio</code> command chapter.
		7.3.16.4	Updated ranges and example of <code>clock_tune</code> command.

Revision	Date	Chapter	Changes
		7.6	Removed references to “max-speed” from the <code>lens</code> command chapter and updated examples as the speed range is now fixed to [0, 100] for all motors.
		7.6.1.1, 7.6.2.1, 7.6.3.1	Fixed examples for <code>lens iris range</code> , <code>focus range</code> and <code>zoom range</code> commands which were missing the command syntax in the reply.
1.5.1	18.Sep.2025	All	Fixed typos and errors and improved wording of some chapters.
		1.1, 7.3.1	Added new supported device: PROTON 4K ZOOM.
		7.3.16	Added new <code>system sdi</code> command group description. Moved <code>clock_tune</code> command to <code>sdi</code> command group.
		7.3.17.3, 7.3.17.4	Updated <code>system audio volume</code> and <code>audio bias</code> command description, they can now be called without arguments to list settings for all inputs.
		7.5.3.2	Added new “2SI” packing mode.
		8	Updated alias reference.
1.5.2	24.Sep.2025	7.5.3.2	Renamed “Quad” packing mode to “SQD” and made SQD and 2SI modes optional.
1.6.0	06.Nov.2025	7.3.16.4	Updated <code>clock_tune</code> command description which now requires a pipeline restart.
		7.4.4.3	Fixed auto exposure speed range which is [0, 100] not [1, 100].
		7.4.5, 7.4.6	Added <code>camera pan</code> and <code>tilt</code> command descriptions including subcommands.
		7.5.2	Added <code>video scale</code> command description.
		7.5.6	Added note that scaling must be disabled during LSC calibration.
		7.5.19	Updated <code>osd</code> chapter, added description of <code>live_indicator</code> subcommand.
		7.5.21.2	Added <code>video test hide_invalid</code> command description.
		8	Updated alias list.
1.6.1	13.Nov.2025	All	Changed naming of 4K cameras, the “4K” is now always put first, e.g. “PROTON FLEX 4K” is now “PROTON 4K FLEX”.
		7.5.1, 7.5.3.2	Updated <code>video mode</code> and <code>video phases packing</code> command description adding support for interlaced modes for the HFR and adding notes regarding limitations for that configuration.
		7.5.15	Added a diagram to the <code>black gamma</code> description.
1.6.2	18.Nov.2025	2.9, 7.3.20, 7.5.3	Added chapters on optional features and license key management, updated <code>video phases packing</code> command description with note on license keys.
		8	Updated alias list.
		Appendix	Added software licenses for the Base58 and uECC libraries.
1.7.0	23.Feb.2026	2.1	Clarified pinning of the power and control connector.
		2.8.3	Added chapter on error recovery via firmware rollback.
		1.1, 7.3.1 7.5.1	Added PROTON PRO to supported devices.
		2.6, 2.7, 7.3.19.2, 7.3.19.3	Added commands to get the current synchronization offset and calibrate the system clock to speed up camera synchronization in slave mode.
		7	Added maximum command runtime to commands which can take longer to execute than 100 ms.
		7.4.1, 7.4.2	Improved <code>camera gain</code> and <code>camera exposure</code> command description.

Revision	Date	Chapter	Changes
		7.4.1.1, 7.4.1.1.2	Added new <code>camera gain mode auto</code> command group and updated <code>camera gain mode</code> command description.
		7.5.1, 7.5.3	Added detailed description of field order for multi-phase interlaced output.
		7.5.7	Updated white balance chapters with changes to tint functionality (tint is now also controlled by the auto white balance).
		7.5.8.1	Updated <code>video bpc calibrate</code> command description (added note that default video mode is used for calibration).
		7.6.1	Updated <code>lens iris</code> command description (added note on error returned when auto-iris is enabled).
		8	Updated alias list.
<b>1.7.1</b>	04.Mar.2026	7.3.1	Increased runtime of <code>system info</code> command to 200ms.
		3.3.1 7.3.5, 7.3.7, 7.3.8	Added <code>system status</code> command and updated <code>system update</code> and <code>system error</code> commands.
		8	Updated alias list.