C-RED 3

User Manual

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1. INTRODUCTION

Thank you for choosing C-RED 3!

C-RED 3 features and performances are described in detail within this User Manual. It contains all information and advice needed to get the optimum performance from C-RED 3.

You can also find an up-to-date version of this User Manual on our website: [https://www.first-light-imaging.com/user-manuals/](https://www.first-light-imaging.com/user-manuals/)

Please contact our support for any question at: support@first-light.fr

1.1. Caution

⚠️ Your C-RED 3 camera contains fragile components.

This User Manual describes precisely how to handle your material properly and to avoid accidents.

Please follow the instructions of use to take advantage of all C-RED 3 performances. Please read carefully the warnings (section 2) and follow the safety precautions to avoid any personal injury or damage when using the camera.

1.2. Overview

C-RED 3 is a revolutionary ultra-high-speed low noise camera designed for high resolution short wave infrared imaging.

It is equipped with an Indium Gallium Arsenide (InGaAs) (640 x 512) pixels sensor of 15 µm each. Thanks to its advanced technology in electronics, software, and its innovative mechanics, C-RED 3 is capable of unprecedented performances: up to 600 images per second at full frame. C-RED 3 offers Camera Link® or USB3 interface depending on your camera configuration.

Your C-RED 3 camera contains fragile components, especially the detector. Please always handle your camera with care.

**Note:** The truly useful area is 638 x 510. Indeed, the contour of the detector may behave differently.

⚠️ Always follow the instructions of use.

1.3. Symbols and Indications

Please read this User Manual and the following definitions carefully to understand the potential dangers and the precautions to take.

Please refer to this User Manual if a WARNING symbol is marked on the camera.
The CE marking indicates the conformity of the camera to the European legislation.

This pictogram indicates a direct current operation.

This pictogram invites the user to refer to the instructions / user manual.

This pictogram refers to indoor use.

This pictogram refers to Protection class category 1.

This pictogram indicates that the product is compliant with the RoHS limitation.

1.4. Disposal - DEEE

C-RED 3’s sensor contains specific material such as:
- InAs CAS n° 1303-11-3 / EC n° 215-115-3
- GaAs CAS n° 1303-00-0 / EC n° 215-114-8.

⚠️ In case of disposal, do not throw your camera in waste disposal and send it back to First Light Imaging.
2. WARNINGS

2.1. General warnings

The equipment must be plugged on an electrical wiring compliant with the relevant standards in the country (in France: NFC 15-100). This wiring must be protected from overcurrent, overvoltage and ground defaults.

Connected equipment’s must be compliant with the EN 60950-1 Ed.2006 standard, or to their own standards.

The power cable plug serves as a disconnection device and should be easily accessible.

Do not place the equipment close to a heating source or a humidity source.

The security of the system which integrates the equipment is the responsibility of the system assembler only.

For your safety, the equipment must be TURNED OFF AND UNPLUGGED before any technical intervention.

The security provided with this equipment is only guaranteed with a use in accordance with the specified purpose. Only use the provided (MEAN WELL USA Inc, model GST18A12-P1J) power supply.

2.2. Never open your camera

Do not ever attempt to open your camera. There are indicators inside the camera, if you try to open it your warranty will be void.

⚠️ Do not open the camera, your warranty will be void.

2.3. Power circuitry

Use the camera with the voltage indicated. Using a different voltage may damage your camera and lead to fire or electric shock.

⚠️ Always use the supplied power unit.
3. TECHNICAL SPECIFICATIONS AND OPERATIONAL ENVIRONMENT

<table>
<thead>
<tr>
<th></th>
<th>Voltage</th>
<th>85 – 264 VAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>47 – 63 Hz</td>
<td></td>
</tr>
<tr>
<td>AC Current</td>
<td>0.5A / 115VAC – 0.3A / 230VAC</td>
<td></td>
</tr>
<tr>
<td>Camera’s dimensions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>60 mm</td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>55 mm</td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td>55 mm</td>
<td></td>
</tr>
<tr>
<td>Operation conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Non-condensing condition)</td>
<td>Maximum temperature</td>
<td>35°C</td>
</tr>
<tr>
<td></td>
<td>Minimum temperature</td>
<td>-40°C</td>
</tr>
<tr>
<td></td>
<td>Humidity</td>
<td>95%</td>
</tr>
<tr>
<td>Storage conditions</td>
<td>Maximum temperature</td>
<td>60°C</td>
</tr>
<tr>
<td></td>
<td>Minimum temperature</td>
<td>-40°C</td>
</tr>
</tbody>
</table>
4. CONTENTS OF PACKAGE

When you open the package, please check that all items described below are included.

4.1. List of items

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camera</td>
<td>1</td>
</tr>
<tr>
<td>Power supply</td>
<td>1</td>
</tr>
<tr>
<td>Power supply cable (IEC or NEMA)</td>
<td>1</td>
</tr>
<tr>
<td>USB3 cable (if USB version)</td>
<td>1</td>
</tr>
<tr>
<td>C-Mount adapter</td>
<td>1</td>
</tr>
<tr>
<td>Press button tool (cf. rescue software)</td>
<td>1</td>
</tr>
<tr>
<td>Quick Start Manual</td>
<td>1</td>
</tr>
<tr>
<td>USB key containing User manual + Demo software + Test report</td>
<td>1</td>
</tr>
</tbody>
</table>

![Fig. 1: On the left, closed Pelicase®. On the right, opened Pelicase® with dedicated spaces.](image)

![Fig. 2: Package items description.](image)

**Note 1:** Cooling plate, cooling unit and personal computer can be bought separately.

**Note 2:** The latest release of software is available on demand at: support@first-light.fr.

**Note 3:** A list of C-RED 3's various accessories are available on demand at: contact@first-light.fr

**Note 4:** Items may differ from pictures.
4.2. Camera serial number

The camera serial number is available at the rear of the camera. For any support request please indicate the serial number of your camera.
5. DESCRIPTION AND TECHNICAL SPECIFICATIONS

5.1. SWIR CMOS sensor

5.1.1. SNAKE-SW TECLESS introduction

Designed and fabricated by SOFRADIR, the SNAKE-SW TECLESS sensor is dedicated for flux imaging applications in the SWIR band. On the one hand, it is responding to night vision, airborne tracking, surveillance needs, and on the other hand, on various medical applications in preclinical and clinical such as real-time intra/per/postoperative, oncology, dentistry and neurosciences, for example.

SNAKE-SW TECLESS includes a focal plane array (FPA) composed of a (640 x 512) pixels pitch of 15 µm each. It is made of photovoltaic (PV) Indium Gallium Arsenide (InGaAs) on Indium Phosphide (InP) substrate connected by bump bonding to a silicon readout integrated circuit (ROIC).

Standard InGaAs used in SNAKE-SW TECLESS allows to detect wavelength ranges between 0.9 and 1.7 µm. The digital and analog functions are controlled by a serial interface. The readout of SNAKE-SW TECLESS allows to read windows in cropping mode.

5.1.2. Spectral response

Typical curve (20°C) is represented on Fig. 3:

![InGaAs quantum efficiency between 900 and 1800 nm.](image)
5.2. C-RED 3 camera

5.2.1. Mechanical and optical interfaces

C-RED 3 integrates a SNAKE-SW TECLESS sensor. The camera is designed to deliver the best precision possible regarding the optical alignment of the sensor.
5.3. Description and minimum specification accessories

5.3.1. Power input

C-RED 3 requires a single power input, supplied in the package. Power supply must provide a stable 12 V DC, with at least 1.5 A of current available (18 W) to properly power C-RED 3. The mating connector is a FISCHER CONNECTORS® S 102 A053-130+.

Fig. 4: On the left, C-RED 3 USB back view. The yellow box shows the female power connector cabling. On the center, C-RED 3 CL back view. The yellow box shows the female power connector cabling. On the right, the female power connector. 1 and 2 represent the GND power connectors. 3 and 4 represent the +12VDC power connectors.

Always use the provided power supply.

5.3.2. Thermal management

The design of C-RED 3 camera is optimized to dissipate heat by the bottom face. First Light recommend to fastening the camera with thermal grease between the support and the bottom face of the camera.

5.3.3. Cooling system

The camera doesn’t have its own thermal regulation system to maintain a setpoint. To maintain the detector temperature, C-RED 3 can use an external liquid cooling system sold separately. For more information please contact First Light Imaging at support@first-light.fr

5.3.4. Communication interface

Control and data acquisition are done either through Camera Link® or USB 3.0 connection depending on the model of your camera.
5.3.4.1. Camera Link

The Camera Link® Full interface requires two data cables with male SDR-26 Mini Camera Link® connectors as shown in Fig. 5:

![Camera Link cables](image)

**Note:** The Camera Link® cables are numbered.

Connector 1 must be plugged to the right, and connector 2 to the left. If the cables are reversed, the camera will not be able to send the data properly, however it doesn’t have any harmful effect on the camera, nor on the grabber.

5.3.4.2. Micro USB 3.0 Type B

The USB3 interface requires a micro USB 3.0 Type B connector.

![USB 3.0 connector](image)

**Note:** C-RED 3 is compatible with USB-B screw locking cables
6. SETTING UP AND START UP CAMERA

6.1. Connecting your camera

Each step below can be realized independently of one another in any order.

6.1.1. Power FISCHER CONNECTORS cable connection

The provided power supply/FISCHER CONNECTORS cable described in section 5.3.1 is connected to the back of the camera and connected to the line plug.

⚠️ First, plug the FISCHER CONNECTORS power connector to the camera, then plug the power unit to the line plug.

![Image: C-RED 3 with power supply connected thanks to the FISCHER CONNECTORS connector.]

6.1.2. Camera Link® connection (for C-RED 3 CL only)

The Camera Link® connectors can be plugged and fastened in any order but reversing the order will prevent camera operation. The Camera Link® connections can be plugged or unplugged either if the camera is ON or OFF.
6.1.3. **USB connection (for C-RED 3 USB only)**

The USB connection is done using a USB-B connector located on the rear side of the camera. The camera only supports USB 3.0 connection.

Note that USB-A 3.0 compliant connectors are typically blue on standard PC.

To use the camera USB connection, it is strongly recommended to use a Windows ® 10 PC. For convenience, drivers for Windows® 7 OS are provided, but this OS is not officially supported by First Light Imaging.
Since Windows® 7 does not support USB 3.0 natively, USB 3.0 support is heterogeneous, and performance is hardly predictable. Please note that First Light Imaging will not provide any support for issues regarding the use of Windows® 7.

Also, before using USB3 connection, the C-RED 3 USB3 drivers must be installed on the PC. The drivers are included in the USB SDK library. By default, this library is installed with the GUI demo software. Please simply install the demo software and the drivers will be installed.

**Note:** In order to have the full USB3 bandwidth, it is needed for some PC to disable all the energy saving settings (cf. C-RED 2-3 TS2 disable power saving for USB3). Also, to get the full USB3 bandwidth, it is usually required to use native USB3 port.

### 6.2 Demo GUI software

The Graphical User Interface (GUI) demo software is provided in the USB key supplied with the C-RED 3 camera, or available on demand at support@first-light.fr. It is a dedicated interface developed by First Light Imaging which allows to control almost all the parameters of the camera. This demo software has its own manual.

### 6.3 Powering up/down

#### 6.3.1 Power ON:

When the power FISCHER CONNECTORS is connected to the camera, and the power supply to the line plug, the camera is ON.

#### 6.3.2 Power OFF:

Please use the CLI command “shutdown” from a simple terminal before turning off the camera. First unplug the power supply from the line plug, then unplug the FISCHER CONNECTORS cable from the camera. The shutdown command is recommended (specially to store the latest logs), however, the direct switch off of the camera doesn’t damage it.
6.4. Camera status

Once the camera is properly powered up by following the steps of section 6, the system boots and C-RED 3 is ready to operate.

A purple diode signal, visible through the camera’s body holes, confirms the operability.

<table>
<thead>
<tr>
<th>Camera status</th>
<th>Camera’s led color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting</td>
<td>Blue</td>
<td>Camera starting</td>
</tr>
<tr>
<td>Configuring</td>
<td>Blue</td>
<td>Camera configuration is applied</td>
</tr>
<tr>
<td>Operational</td>
<td>Purple</td>
<td>Camera is operational</td>
</tr>
<tr>
<td>Safe</td>
<td>Red double blink</td>
<td>The camera detects an error. The detector is turned off. To be able to reuse the camera, you must restart it.</td>
</tr>
<tr>
<td>Prevsafe</td>
<td>Yellow</td>
<td></td>
</tr>
<tr>
<td>Locked</td>
<td>Red</td>
<td>The camera detects a critical error. The camera is unusable, please contact First Light Imaging for support.</td>
</tr>
<tr>
<td>Safe (rescue FW)</td>
<td>Orange double blink</td>
<td>The camera detects a critical error. The camera is unusable, please contact First Light Imaging for support.</td>
</tr>
</tbody>
</table>

**Note:** turned off led does not necessary mean that there is an issue with the camera. Indeed, the camera can be configured to switch off the led automatically once boot is completed.
7. READOUT MODES

7.1. Integration/readout function

The acquisition speed can be set to any value from 0.0001 to 600 fps. The integration time can also be set. The normal integration time range is [50µs - ~1/fps]. However, integration time of less than 50µs is possible up to 165 ns with degraded performance (more noise, less dynamic).

Integration time granularity must be set to off to be able to set very small integration times.

Please contact First Light Imaging at support@first-light.fr for more information regarding very short exposure time.

7.1.1. Integrate while read (IWR)

For maximum integration time, the camera integrates the signal in IWR mode.

![IWR mode overview](image)

**Fig. 10: IWR mode overview.**

[1] **Variable time:** This time (1) is either reset time, or integration time, depending of the FPS and Tint set by the user.
7.1.2. Integrate then read (ITR)

In this mode, the integration of the next image is done when the readout of the current image is fully completed. Light integration is lost for the frame readout time. So, for an identical fps, the integration time is always shorter than in IWR mode.

![Diagram showing ITR mode overview.](image)

7.1.3. ITR / IWR consideration

The mode is determined by the integration time only. If you set an integration time small enough to have the time to readout the frame, the camera will work in ITR mode. Otherwise the camera will work in IWR mode. In IWR mode, the camera starts the integration of a new frame while the readout of the current frame is still running. Depending of the integration time, it can have a small impact on the image. A kind of noisy line can be observed at the integration starting point of the next frame. This issue can be mitigated using bias correction. In ITR, with small integration time, the noisy line can’t be seen because it is below the last line of the current image. Same in IWR with the maximum integration time, because it is above the first line of current image. However, between these two integration times, you may see it.
7.2. Readout mode

7.2.1. Single Read

The entire frame is read once before a reset period. The particularity of C-RED 3 readout mode allows to adjust the integration time (Tint) independently of the frame rate. Depending of these two parameters, the camera will run in ITR or IWR mode, please refer to Fig. 10 and Fig. 11 for further information. By default, in single read readout, the images are acquired in correlated double sampling (CDS) mode. An internal CDS is done directly on the sensor.

7.2.2. HDR

**Note:** Please note that this feature is an option and requires a specific license file into the camera. For more information please contact us: contact@first-light.fr

HDR mode is a readout mode that provides high dynamic range images by combining successive images acquired using high and low conversion gain of the sensor.

Two different options are available:
- HDR mode standard: output dynamic is 83.2 dB, pixels are sent in 16 bits signed format
- HDR mode extended: output dynamic is 89.2 dB, pixels are sent in 16 bits unsigned format

The HDR standard mode exists to maintain the compatibility with CDS mode where pixels are output as signed 16 bits numbers.

For more information about HDR: theory of operation, system gain, restrictions and limitations, please read the specific technical note dedicated to HDR mode: C-RED 2-3 TN1 HDR Mode.

In order to operate properly, the HDR mode needs a proper bias correction. If the HDR mode is enabled without bias correction, or with invalid bias correction (for example bias correction file made at different temperature, different integration time ...) the resulting combined image will not be correct. Flat correction improves even more the images but remains optional.

To build the bias correction cf. 8.6 Bias/Flat correction with the HDR mode enabled.

To enable the hdr mode use the command:
```
"set hdr on"
```
To disable it:
```
"set hdr off"
```
To enable/disable the extended mode (unsigned 16 bits pixels).
```
"set hdr extended on" or "set hdr extended off"
```

You can get the current status of the previous parameters with the commands:
```
"hdr"
"hdr extended"
```
**Note:** There is a limitation for the cropping geometry in HDR mode. The range is from 96*72 pixels up to full sensor geometry.

### 7.2.3. AGC

The Auto Gain Control is not a readout mode but a functionality of the camera. In CDS mode, the camera can automatically switch of gain in order to eliminate saturation or under exposure on the detector.

If enabled, the camera can switch:
- From High Gain to Medium Gain if over-exposition is detected on High Gain frame
- From Medium Gain to Low Gain if over-exposition is detected on Medium Gain frame
- From Low Gain to Medium Gain if under-exposition is detected on Low Gain frame
- From Medium Gain to High Gain if under-exposition is detected on Medium Gain frame

![Possible gain switch when AGC is enabled](image)

For every transition, the user can set 3 parameters:
- Level of over or under-exposition
- Number of pixels over or under-exposed per frame
- Number of consecutives frames with pixels over or under-exposed

In Medium Gain, the user can adjust priorities of AGC algorithm:
- none: if saturation and under exposure are detected at the same time, no change
- over-exposed: if saturation and under exposure are detected at the same time, the camera switches to Low Gain
- under-exposed: if saturation and under exposure are detected at the same time, the camera switches to High Gain

The user has the possibility to reduce the area of the image analyzed by the AGC of the camera. The ROI can be set using the “set agc x, y, w, h” command.
The current cropping can be read using the “agc roi” command.

Note that the ROI selection is relative to the current cropping window, e.g. (x,y) set to (0,0) selects the top left pixel of the current cropping window.

7.3. Data acquisition mode

7.3.1. Detector geometry

The SNAKE-SW TECLESS sensor has a (640 x 512) diode array and 8 buffered analog outputs (see Fig. 14 :).

The pixel clock of the sensor is set to 18.2 MHz, which implies a read-out speed peak about 292 Mpix/s. At 600 fps, the average rate is 196.6 Mpix/s (~=393Mbytes/s).
7.3.2. Pixel format [ADU]

C-RED 3 digitizes the signal from the sensor with 14-bits precision. However, the pixel values are sent as 16 bits signed format. Indeed, after embedded bias subtraction, some pixels may have negative value.

7.3.3. Full frame mode

Pixels are read from left to right and up to down (see Fig. 15 : and Fig. 16 :) starting from the left top corner.
Detector geometry and read out pixels scheme.

Cropping mode

On the sensor, it is possible to select one region of interest and acquire data from this selected window only. Column granularity is 32 and line granularity is 4.

So, the starting column and line must be a multiple of 32 and 4 pixels, respectively.

In the same way, the width and the height of the window must also be a multiple of 32 and 4 (see Fig. 17 :).

The intersection of both lines and columns forms the readout window.

Pixels are sent like in full frame mode, from left to right and up to down (see Fig. 19 :).
**Note:** To set a cropping window using the command line interpreter, the user must indicate the starting column, the ending column, the starting row and the ending row. Please refer to the camera commands for more detail.
7.4. Conversion gain

Signal can be integrated in low, medium or high gain corresponding to high, medium and small integration capacity, respectively. The modification of the integration capacity impacts the dynamic of the signal and thus implies a change of the noise level.

It is possible to modify the integration capacity using “set sensibility low”, “set sensibility medium” or “set sensibility high” commands in the command line interpreter.

**Note:** sensibility must be understood as sensitivity.
8. OPERATION

8.1. Data format

8.1.1. Camera Link® (for C-RED 3 CL only)

C-RED 3 CL uses the Camera Link® Full interface which requires two data cables. Data are transmitted with a standard protocol using 4 taps of 16 bits width. With this configuration, pixels are sent 4 by 4 through the Camera Link®, and the Camera Link® Pixel Clock is 72.9 MHz.

![Camera Link Interface Diagram]

**Note:** When a Matrox acquisition board is used, the user needs to set x to 160\(=640/4\).

8.1.2. Camera Link® frame grabber

The camera is compliant with Camera Link® standard. However, please note that our cameras have been developed and tested with specific grabbers, and we highly recommend using these grabbers. Any malfunctions related to the use of a non-certified grabber will not be supported by First Light Imaging.

List of tested and recommended grabbers:

- MATROX Radiant eV-cl full (drivers available for Linux® and Windows®)
- DALSA/TELEDYNE X64 Xcelera-CL (drivers available for Windows® only)
- EDT visionLink F4 (drivers available for linux and windows) [NEW]
The C-RED 3 firmware communicates with the user through the serial line embedded in the Camera Link®
cables.
Usually the driver for the frame grabber exposes the serial line of the Camera Link as a virtual COM port on
the acquisition system.
To communicate both ways with the camera, the COM port must be configured with the following settings:
115200 Bauds, 8 bits, no parity, 1 stop bit, no flow control.

8.1.3. USB (for C-RED 3 USB only)
C-RED 3 USB uses a USB 3.1 Gen 1 interface.

It is detected as a composite USB device (control interface + acquisition interface).
The control interface is exposed as a standard serial port whereas the data acquisition interface is exposed
as a Imaging device.

So, as for Camera Link®, both image and configuration interfaces are available.
The configuration interface is also a pseudo COM port (USB virtual COM port).

Before using USB interface, the C-RED 3 USB driver must be installed on the acquisition computer.
(cf. doc install C-RED 3 demo software).

When the camera is detected on the USB 3.1 Gen 1 port, Windows ® automatically installs the C-RED 3
drivers.

Under Linux, the Firstlight USB SDK manages the frame acquisition frame using the standard libusb directly.
The USB virtual COM port is also managed directly by the standard Linux driver and is exposed as
/dev/ttyACMx.
Fig. 21: *Windows device manager illustration*

The COM port settings are the same as Camera Link® serial port interface:

**115200 Bauds, 8 bits, No parity, 1 Stop bit, no flow control**

A USB SDK for windows 10 and Linux is provided in both binary and source forms to perform frame grabbing.

Proper operation of the camera has been tested when using common one-meter long USB 3.0 cables, and with up to five-meters industrial grade USB 3.0 cables.

### 8.2. Internal synchronization

In this mode, the camera generates frames according to the configured acquisition framerate. Each image is integrated during the configured integration time.

This is the default configuration of the camera.
8.3. External synchronization

In this mode, the acquisition frame rate is configured using an external signal, typically FPS_Tint_in signal on the synchro connector available on all C-RED 3 models.

Alternatively, on C-RED 3 CL model, the acquisition can also be controlled using one of the camera link control signals available on the camera link connector #1 (requires Firmware 1.1.0 or above).

The selection between the different external source is done using one of the following commands:

- `set extsynchro source external`: selects FPS_Tint_in signal on Lemo® connector as input signal
- `set extsynchro source cc1`: selects Camera Link/CC1 as input signal
- `set extsynchro source cc2`: selects Camera Link/CC2 as input signal
- `set extsynchro source cc3`: selects Camera Link/CC3 as input signal
- `set extsynchro source cc4`: selects Camera Link/CC4 as input signal

The integration duration can either be controlled using the same signal (external) or configured by software (internal).

The selection between external or internal configuration of the integration duration is done using `set extsynchro exposure external` and `set extsynchro exposure internal` commands.

The polarity of the control signal can be inverted if required.

The inversion of the signal is enabled or disabled using `set extsynchro polarity inverted` or `set extsynchro polarity standard` commands.

It is also possible to configure an extra delay when processing synchronization signal, allowing to synchronize different devices with the same signal. The granularity of this extra delay is the camera master clock rate (18214 kHz).

The synchronization extra delay can be set using the `set syncdelay` command. Current extra delay value can be read using `syncdelay` command. Setting extra delay value to 0 disables the generation of an extra delay during external synchro signal processing, requesting the camera to process the synchro signal as fast as possible.

`minsyncdelay` and `maxsyncdelay` commands allow to retrieve the valid range of extra synchronization delay parameter.

The camera is equipped with one sync connector on its rear side (see Fig. 22 :).
To be connected on the external synchronization, use the command "set extsynchro on" in the command line interpreter. If not, you will stay connected to the internal synchronization.

You can check if external synchro is on or off using the "extsynchro" command.

**Note:** Proper connection of external synchronization signals must be done before issuing the "set extsynchro on" signal.

### 8.3.1. Cable assembly

You can make your own synchronization cable using FGG.00. 304.CLAD35 LEMO Male connectors in association with a four-wire cable.

It is strongly advised to use shielded cable to respect Electromagnetic Compatibility (EMC) recommendations.

This cable will allow you to use all the functionalities of the external synchro.

Wiring is detailed below:

**Fig. 22:** C-RED 3 USB on the left and C-RED 3 CL on the right from the back. The yellow box shows the sync connector C1.

**Fig. 23:** On the left, a C-RED 3 synchro female connector. On the right, wire cables corresponding to connector.
Input signals (Trigger_in and FPS_Tint_in) are 5V compatible.

⚠️ The maximum voltage value is 5.5V. Applying higher voltage will result in a permanent damage of the camera.

Output signals (LVAL_out and FSYNC_out) are in LVCMOS 3.3V.
8.3.2. **FPS_Tint_in timing diagrams**

### 8.3.2.1. **Standard polarity / externally controlled integration time**

When external signal polarity is set to standard, and integration duration is controlled externally, the falling edge triggers the start of integration, the rising edge triggers the frame readout and the time between the falling edge and the rising edge is the integration time.

Non-integrating time. Min value: 3µs

### 8.3.2.2. **Inverted polarity / externally controlled integration time**

When external signal polarity is set to inverted, and integration duration is controlled externally, the rising edge triggers the start of integration, the falling edge triggers the frame readout and the time between the rising edge and the falling edge is the integration time.

Non-integrating time. Min value: 3µs
8.3.2.3. **Standard polarity / internally controlled integration time**

When external polarity is set to standard and integration time is controlled by software, the falling edge triggers the start of the integration time. The readout starts automatically once the configured integration time has been elapsed. The rising edge of the signal is ignored.

![Diagram of standard polarity/externally controlled integration time]

8.3.2.1. **Inverted polarity / externally controlled integration time**

When external polarity is set to inverted and integration time is controlled by software, the rising edge triggers the start of the integration time. The readout starts automatically once the configured integration time has been elapsed. The falling edge of the signal is ignored.

![Diagram of inverted polarity/externally controlled integration time]
8.3.3. Latency

Camera latency is the delay between the rising edge of FPS_Tint_in signal and the first valid data on camera link. This delay depends on the tlsydel parameter value.

The table below contains typical camera latency in normal (CDS) readout mode full frame.

<table>
<thead>
<tr>
<th>Latency for tlsydel = 324 (default)</th>
<th>22.2 µs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latency for tlsydel = 54 (min)</td>
<td>7.4 µs</td>
</tr>
</tbody>
</table>

8.4. Triggered acquisition

This feature allows the camera to be configured to grab a specified number of frames at a specified framerate / exposure duration.

This mode is similar to internal synchronization since framerate and integration times are controlled through software, but the acquisition will start only after the reception of an acquisition trigger and will automatically stop after the acquisition of a preconfigured number of images.

If a new acquisition trigger is received whereas the previous acquisition has not been completed, the current acquisition sequence will be aborted, and a new acquisition sequence will take place.

The triggered acquisition mode is enabled using the command "set swsynchro on" and is disabled using the "set swsynchro off" command using the CLI interpreter.

You can check if the triggered acquisition mode is on or off using the "swsynchro" command.

The triggered acquisition feature initially developed only supports the generation of the acquisition trigger by sending a command using the CLI, described in 8.4.2.

Firmware 1.1.0 introduces the capability to generate the acquisition trigger using FPS_Tint_in signal on synchronization Lemo® connector or using one camera link control signal (C-RED 3 CL only).

8.4.1. Trigger selection

On firmware version 1.1.0 and above, the origin of the acquisition trigger can be set using the "set swsynchro source" commands.

The "set swsynchro source swtrig" command selects the software trigger as the source of the triggered acquisition. This is the default camera configuration.

The "set swsynchro source external" command selects the external trigger as the source of the triggered acquisition.
8.4.2. Software trigger

The generation of the software trigger is done using the “swtrig” command.

On firmware versions 1.1.0 and above, the acquisition can also be aborted using the “swtrigabort” command. It is useful for sequences with long integration time.

8.4.3. External trigger

When the source is set to “external”, the acquisition can be controlled using the FPS_Tint_in signal on the synchro connector available on all C-RED 3 models. On C-RED 3 CL model, the acquisition can also be controlled using one of the camera link control signals available on the camera link connector #1.

The selection between the different external source is done using one of the following commands:

“set extsynchro source external”: selects FPS_Tint_in signal on Lemo® connector as input signal
“set extsynchro source cc1”: selects Camera Link/CC1 as input signal
“set extsynchro source cc2”: selects Camera Link/CC2 as input signal
“set extsynchro source cc3”: selects Camera Link/CC3 as input signal
“set extsynchro source cc4”: selects Camera Link/CC4 as input signal

When standard extsynchro polarity is selected, the acquisition is started on the rising edge of the input signal. The input signal must remain high during the whole duration of the acquisition burst. Lowering input signal whereas acquisition is not complete aborts the current acquisition.

When reversed extsynchro polarity is selected, the acquisition is started on the falling edge of the input signal. The input signal must remain low during the whole duration of the acquisition burst. Raising input signal whereas acquisition is not complete aborts the current acquisition.

Below some captures of triggered acquisitions with the following parameters, showing the FPS_Tint_in (1/Yellow) and the resulting FSYNC_out (2/Blue) signals.

The acquisitions are performed using the following parameters:

- Framerate set to 100 fps
- Tint set to 0.479749 ms
- 4 frames per trigger
- Standard synchronization polarity
Full acquisition of 4 frames in triggered acquisition mode

The integration period of the first frame of the burst starts on the rising edge of the FPS_Tint_in signal (in Yellow). The frames are then generated at a framerate of 100 fps. The acquisition ends when 4 frames have been generated.
Aborted acquisition of 4 frames in triggered acquisition mode

The integration period of the first frame of the burst starts on the rising edge of the FPS_Tint_in signal (in Yellow). The frames are then generated at a framerate of 100 fps. On this figure, the acquisition is aborted after 3 frames have been produced, due to FPS_Tint_in signal going low before the end of the acquisition.

Abort of the acquisition is delayed after the current frame of the burst has been complete (integration time + reading). This ensure that all frames sent by the camera have valid integration times.
Delayed abort of triggered acquisition of 3 frames

This figure puts in evidence the delayed abort of a triggered acquisition of 3 frames. Even if the FPS_Tint_in signal falls to zero during the acquisition of the second frame, the second frame exposure and reading is done as usual. The transmission of the third frame is not done.

On some specific situations (long exposure durations for example), it may be useful to abort the acquisition of the frame immediately. This can be done by setting a very short exposure duration. The abort will occur within a few milliseconds (roughly the time to read the frame).

8.5. Bad Pixel Correction

Bad pixel correction can be made on the fly by the camera.

During the production characterization of the camera, First Light Imaging computes a map of the bad pixels and upload it into the camera.

When enabled, bad pixel correction is the first correction applied on pixel values received from the sensor. The bad pixels' value is replaced by the value of an adjacent pixel (left or right)
8.5.1. Bad Pixel map edition

Firmware version 1.1.0 introduces the possibility to modify the bad pixel map embedded in the camera.

The camera now contains two bad pixels map, a factory map built by First Light Imaging during the production of the camera and a customizable user map. The user map is by default identical to the factory map.

The user bad pixel file can be retrieved using the following commands

- `recv userbadpixel size` returns the size in byte of the user bad pixel map
- `recv userbadpixem md5sum` returns the md5sum of the user bad pixel map
- `recv userbadpixel content` returns the content of the user bad pixel map

The factory bad pixel file can be retrieved using the following commands

- `recv factbadpixel size` returns the size in byte of the factory bad pixel map
- `recv factbadpixem md5sum` returns the md5sum of the factory bad pixel map
- `recv factbadpixel content` returns the content of the factory bad pixel map

Bad pixel size and md5sum allow to ensure that the bad pixel map has been received successfully. The transfer is done in raw mode on the serial connection with the camera.

The user bad pixel map can be sent using the command `sendfile userbadpixel <size> <md5>` command. The transmission is done in raw mode on the serial connection with the camera.

Restoring the factory map can be easily done by reading the factory bad pixel and storing it in the camera.

The bad pixel map is a file of 40960 bytes [640*512/8]. Pixels are described from the top left pixel to the right bottom pixel of the sensor.

Each byte represents 8 successive bad pixels, most significant bit corresponding to the left pixel, and least significant bit corresponding to the right pixel. Valid pixels are set to 0, whereas invalid pixels are set to 1.

Example: most significant bit (bit 7) of the first byte of the file corresponds to the first pixel of the first line of the sensor. Least significant bit (bit 0) of the first byte of the file corresponds to the 8th pixel. Most significant bit of the second byte of the file corresponds to the 9th pixel of the first line. And so on...

The format of the bad pixel map corresponds to standard 1-bit depth black and white image that can be easily manipulated by imageJ [https://imagej.nih.gov/ij/] software.

8.6. Bias/Flat Correction

Bias/Flat correction can be done on the fly by the camera.

Building bias correction requires to put the camera in the dark.

Building flat correction requires to put the camera in front of a flat field.
Flat and Bias correction files can be computed automatically by the camera. Alternatively, custom correction files can be uploaded to the camera using serial connection (either USB or CL) or using TCP/IP connection.

The bias correction is the second correction applied on pixel values read from the sensor. The flat correction is the third correction applied on pixel values read from the sensor.

Even if it is possible to activate the different corrections independently from each other, it is important to understand that the correction will depend from all previous corrections applied.

For example, a bias correction file generated with bad pixels correction enabled will not be valid if bad pixels correction is disabled.

Flat correction should always be used with bias correction enabled.

Bias and flat corrections also depend from the acquisition parameters (frame rate, integration time, sensor temperature...). It is highly recommended to rebuild them when acquisition parameters are modified.

8.6.1. Legacy bias/flat computation

Computation of bias and flat correction computation are initiated using "exec buildbias" or "exec buildflat", "exec buildflat hdr_c1" and "exec buildflat hdr_c2" on the command line interpreter.

The frames used to compute the bias and flat correction are grabbed for 2s up to 256 frames. With low framerate, not enough frames are grabbed, and the embedded bias/flat computation mustn’t be used. Bias/Flat frames must be computed outside the camera and uploaded on the camera. Automatic computation of bias and flat correction files is only possible if the frame rate is above 5 fps.

8.6.2. bias/flat computation

Firmware 1.1.0 introduces a new set of commands that supersede the functionalities provided by the legacy commands.

The new commands allow to launch background computation of bias and flat correction files. When using these commands, the acquisition framerate is not limited, allowing to compute bias/flat for low fps/long exposure durations.

The number of images to be used for the NUC computation is now specified in the command parameters and must be in the range [10-256].

Higher number of images increases the quality of the computed NUC correction file, whereas lower increases the speed of the acquisition/computation.

During the computation of the NUC correction file, the camera enters a specific “busy” state, that only allows to retrieve the progress of the current computation or to abort it. This is needed to ensure that camera parameters remain consistent during the acquisition/computation process.
The estimated remaining time for the computation (in seconds) can be read using the "buildnuc progress" command.

The current computation can be aborted using the "buildnuc abort" command.

### 8.6.3. Adaptative Bias

On uncooled cameras, the sensor temperature varies with the environment temperature. The bias file initially built will be obsolete if the temperature changes.

To keep a good corrected image whatever the temperature is, the C-RED 3 camera embeds an automatic system which recalculates the bias file applied according to the sensor’s temperature.

It is not necessary to be in dark conditions to rebuild the bias files because the correction system is factory calibrated for each camera, and so is fully autonomous.

Note: The bias evolution calibration is built with factory settings.

If the sensor settings are modified using the advanced ‘set snake xxx’ command, it is not guarantee that the adaptative bias still work properly.

Also, the value set with the ‘darkoptimlevel’ command is ignored when the adaptative bias is on. The factory value is used instead. When the adaptative bias is disabled, the darkoptimlevel is restored.
8.6.4. HDR Bias/Flat correction additional information

The HDR mode must be enabled before using buildbias and HDR buildflat commands.

Also, in HDR mode, for flat embedded computation, it is recommended to use the "set hdr calibration c1 (or c2)" command before using HDR buildflat commands.

In ‘calibration c1 (or c2)’ specific modes, the camera operating in HDR mode will send images composed of pixels acquired using C1 (small) and respectively C2 (large) integration capacitor. These modes are useful for controlling the level of the flat field applied for flat file correction.

To build manually, externally, the bias and/or flat correction files the use of the “hdr calibration” is mandatory to get the dark and flat images from the high and low gain capacities used in HDR mode.

**Reminder:** The correct operation of HDR readout mode requires the activation of the bias correction.

Using bias/flat correction is easier with the demo software. Furthermore, additional details are provided in the software demo user manual, notably the use of custom correction files.

8.6.5. Bias correction file format

The bias correction file contains an image to be subtracted from the frame sent by the sensor. The bias correction allows to counterbalance the difference of offsets between the different pixels.

Bias correction file geometry must match the actual sensor geometry and must contain pixels values in the range [0-16383].

Pixels must be stored in left-to-right/top-to-bottom order (the same order than the pixels in a received frame from the sensor). Each pixel value is stored on 16-bits, as for frames received from the sensor.

8.6.6. Flat correction file format

The flat correction file contains an array of fixed-point real values that are used to counterbalance the difference of integration ramp slopes between the different pixels.

Flat correction file geometry must match the actual sensor geometry. Values are stored in left-to-right/top-to-bottom order (the same order than the pixels in a received frame from the sensor).

When flat correction is active, pixel values read from the sensor are multiplied by the corresponding value in the flat correction file.

Values are stored using fixed-point representation.

Bits 15-13 are used to store the integral part of the multiplication factor.

Bits 12-0 are used to store the decimal part of the multiplication factor.

Examples of values:

- 00100000000000000b / 0x02000000 is the representation of value 1.0
- 01000000000000000b / 0x04000000 is the representation of value 2.0
- 00010000000000000b / 0x01000000 is the representation of value 0.5
- 00110000000000000b / 0x01000000 is the representation of value 1.5
8.7. Pixel value offset

It is possible to add an offset to the pixel value. It can be used to keep the pixel values strictly positive. Indeed, the camera pixel format is 16 bits signed but some acquisition software cannot manage signed pixel. In this case, adding an offset can be useful to avoid negative pixels.

To add an offset, please use the command:

```
set aduoffset <aduOffsetValue>
```

You can read the currently applied offset using the command:

```
aduoffset
```

**Note:** It is possible to have negative pixels value when the bias correction is used.

8.8. Dark optimization

A parameter optimizes the dark current. There is a tradeoff to do between the readout noise and the dark current, with the command:

```
set darkoptimlevel [0-100]
```

It is possible to arbitrate between the readout noise and the dark level. Usually for short integration time, this parameter must be set to 0 and for long integration time to 100.

To read the current dark optimization value, use the command:

```
darkoptimlevel
```

8.9. Tag generation

The C-RED 3 camera offers the possibility to replace the first 4 pixels of acquired images by information generated by the camera.

This function is controlled by the "set imagetags on" and "set imagetags off" commands.

When enabled, the first and second pixels of the camera are used to store a frame counter that increments by one for each frame acquired from the sensor. This counter can be used to check if some frames are lost during acquisition.

When the USB3 interface is used (for C-RED 3 USB only), the USB3 acquisition software uses this information to check the frame grabbing and eventually resynchronize the flow. So, when the USB3 interface is used, it is strongly advised to keep the image tags on.

The third pixel value depends on the current readout mode of the camera.

In CDS mode and in HDR mode, it is set to 0x0000.

The fourth pixel of the image is used to reflect the frame marker signal value and the integration capacitor used to acquire the image.

<table>
<thead>
<tr>
<th>Bits 31-3</th>
<th>Bit 2-1</th>
<th>Bit 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFU (set to 1)</td>
<td>Integration capacitor</td>
<td>Frame marker signal</td>
</tr>
<tr>
<td></td>
<td>0: high gain, small capacitor size</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1: medium gain, medium capacitor size</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2: low gain, large capacitor size</td>
<td></td>
</tr>
</tbody>
</table>
8.9.1. Frame marker configuration

On firmware version 1.0.0, the frame marker signal corresponds to the signal trigger_in of the Lemo® connector. On firmware versions 1.1.0 and above, on C-RED 3 CL camera, the frame marker signal can also be configured to correspond to one of the camera link control signal (CCx) located on the camera link connector #1.

The selection is done using one of the following commands:

- `set extsynchro source external`: selects trigger_in signal on the Lemo® connector
- `set extsynchro source cc1`: selects CC1 signal on the cameral link connector #1
- `set extsynchro source cc2`: selects CC2 signal on the cameral link connector #1
- `set extsynchro source cc3`: selects CC3 signal on the cameral link connector #1
- `set extsynchro source cc4`: selects CC4 signal on the cameral link connector #1

The current configuration can be retrieved using the “extsynchro source” command.

8.10. Thermal protection

In case of overheating or too cold temperature depending on external operating conditions, the camera will automatically shut down itself to protect electronic components.

Please note that it is not possible to switch off this functionality.

The internal firmware monitors at each time the temperatures on different parts and boards. Each temperature must be in the accepted range described in the following table.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Min temperature (°C)</th>
<th>Max temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>-20</td>
<td>90</td>
</tr>
<tr>
<td>BACKEND</td>
<td>-20</td>
<td>70</td>
</tr>
<tr>
<td>INTERFACE</td>
<td>-20</td>
<td>70</td>
</tr>
<tr>
<td>AMBIANT</td>
<td>-20</td>
<td>60</td>
</tr>
<tr>
<td>SENSOR</td>
<td>-20</td>
<td>60</td>
</tr>
</tbody>
</table>

To recover the use of the camera, after the camera went back in the authorized range of temperature, the user must reboot the camera by unplugging/plugging the power, as described in paragraph “6.1.1 Power FISCHER CONNECTORS cable connection”.

8.11. Camera presets

C-RED 3 allows to store up to ten different user configurations, called presets.

Presets contain all parameters settable by user, plus corresponding bias and file correction files. Using presets allow to switch easily from one configuration to another, without need to rebuild correction files.

A specific preset is selected using the “preset <n>” command. After loading a preset, the user is free to change any parameter. Changes can then be saved in the current present using the “save” command.
At any time, the current preset can be reloaded by using the “preset” command. All changes in the running configuration not previously saved will then be lost.

Factory camera presets can be restored using the “restorefactory” command.


C-RED 3 camera is provided with HDR optional feature. This extra feature is enabled through license file uploaded into the camera during the production, or later directly by the customer.

The transfer of a license file into the camera is done using serial link connection, using either “sendfile license” or “xsendfile license” command.

A license file previously uploaded into a camera can be removed using the “exec dellicense” command.

For convenience, it is possible to enable/disable optional features without removing the corresponding license file.

Disabling of a license is done using the “exec disablelicense” command. Reenabling is done using the “exec enablelicense” command.

**Note:** When a license file is uploaded into the camera, it is enabled by default.

List of the currently installed licenses files and their status can be retrieved using the ‘licenses’ command.

**Note:** uploading, enabling, disabling or removing a license require a camera reboot to be effective.

Below are some examples of license management commands:

```
fli-cli> licenses
hdr.lic
OK

fli-cli> exec disablelicense hdr.lic
OK

fli-cli> licenses
hdr.lic.disabled
OK

fli-cli> exec enablelicense hdr.lic
OK

fli-cli> licenses
hdr.lic
OK
fli-cli>
```
8.13. Camera advanced settings

8.13.1. Dark level adjustment

Vref adjustment parameter is used to set automatically the best black level. However, it is possible to set it manually.

To do so, set vrefadjust parameter to off ‘set vrefadjust off’ and use the command ‘set voltage vref [1.9-2.3]’ to manually set the black level.

8.13.2. Integration time granularity

Integration time granularity is set to a value providing the best performances by default. However, for very short integration time, this granularity can be too large.

It is possible to increase the integration time granularity to the max possible value using the command ‘set tintgranularity off’.

Then, the granularity will be only 1 pixel clock.

For comparison, in full frame with tintgranularity on, it is ~50 pixels clocks.

8.13.3. Anti-blooming

The anti-blooming feature is activated by default. The anti-blooming feature ensures that bad pixels do not disturb their neighbors. However, when enabled, the saturation occurs earlier, and a kind of grey speckling can be seen instead of white saturation.

For low light, it is advised to leave the anti-blooming on, but to disable it for strong light.

It is possible to disable the anti-blooming feature using the command:

‘set snake blm_en 0’

8.13.4. Camera tuning

Firmware 1.1.0 allows to tune the camera configuration according to the kind of application.

Three profiles are defined:

General use, which corresponds to the behavior of previous firmware releases. This profile can be selected using the command “set tuning general_use”

Long exposures: optimized for long exposure durations (integration periods above 10s). This profile can be selected using the command “set tuning long_exposure”

Short exposures: optimized for short exposure durations (integration periods below 10 µs). This profile can be selected using the command “set tuning short_exposure”

These tunings allow to obtain the maximum camera performances for these different use cases.
8.14. Camera capabilities

Firmware 1.1.0 introduces two commands to get details about camera hardware and software capabilities. This information can be used to handle the different variants of the camera.

The command “hwfeatures” returns a combination of the following bits:

```
#define HW_FEATURES_INTERFACE_CL 0x0001
#define HW_FEATURES_INTERFACE_USB 0x0002
#define HW_FEATURES_INTERFACE_CL_BASE 0x0100
#define HW_FEATURES_INTERFACE_CL_FULL 0x0200
#define HW_FEATURES_INTERFACE_CL_CC 0x0400
```

<table>
<thead>
<tr>
<th>Bit value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW_FEATURES_INTERFACE_CL</td>
<td>Camera can be operated via Camera Link</td>
</tr>
<tr>
<td>HW_FEATURES_INTERFACE_CL_BASE</td>
<td>The camera supports Camera Link Base configuration</td>
</tr>
<tr>
<td>HW_FEATURES_INTERFACE_CL_FULL</td>
<td>The camera supports Camera Link Full configuration</td>
</tr>
<tr>
<td>HW_FEATURES_INTERFACE_CL_CC</td>
<td>Camera Controls (CC1..CC4) are available on the camera.</td>
</tr>
<tr>
<td>HW_FEATURES_INTERFACE_USB</td>
<td>Camera can be operated via USB</td>
</tr>
</tbody>
</table>

The command “swfeatures” returns a combination of the following bits:

```
#define SW_FEATURES_READOUT_CDS 0x0001
#define SW_FEATURES_READOUT_NDR 0x0002
#define SW_FEATURES_READOUT_HDR 0x0004
#define SW_FEATURES_AGC 0x0008
#define SW_FEATURES_ADAPTATIVE_BIAS 0x0010
```

<table>
<thead>
<tr>
<th>Bit value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>SW_FEATURES_READOUT_CDS</td>
<td>Camera supports standard (CDS readout)</td>
</tr>
<tr>
<td>SW_FEATURES_READOUT_NDR</td>
<td>The camera supports NDR readout</td>
</tr>
<tr>
<td>SW_FEATURES_READOUT_HDR</td>
<td>The camera supports HDR readout. Note that the feature needs to be enabled via a specific license acquisition.</td>
</tr>
<tr>
<td>SW_FEATURES_AGC</td>
<td>The camera supports AGC.</td>
</tr>
<tr>
<td>SW_FEATURES_ADAPTATIVE_BIAS</td>
<td>The camera supports adaptative bias correction.</td>
</tr>
</tbody>
</table>

**Note:** grayed features are not available on C-RED 3 cameras.
9. DESCRIPTION OF VARIOUS FONCTIONS

The list of available commands of the camera can be displayed using ‘help’ command in the terminal of the demo GUI software. The available commands are listed below.

9.1. List of available commands

<table>
<thead>
<tr>
<th>COMMANDS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>hwfeatures</td>
<td>Get camera HW features (FW 1.1.0 or above)</td>
</tr>
<tr>
<td>Swfeatures</td>
<td>Get camera SW features (FW 1.1.0 or above)</td>
</tr>
<tr>
<td>temperatures</td>
<td>Get temperatures</td>
</tr>
<tr>
<td>temperatures CPU</td>
<td>Get CPU temperature</td>
</tr>
<tr>
<td>temperatures backend</td>
<td>Get back-end board temperature</td>
</tr>
<tr>
<td>temperatures interface</td>
<td>Get interface board temperature</td>
</tr>
<tr>
<td>temperatures snake</td>
<td>Get sensor temperature</td>
</tr>
<tr>
<td>temperatures ambiant</td>
<td>Get ambient temperature</td>
</tr>
<tr>
<td>tlsydel</td>
<td>Get tlsydel delay</td>
</tr>
<tr>
<td>fps</td>
<td>Get acquisition frame rate (fps)</td>
</tr>
<tr>
<td>minfps</td>
<td>Get the minimum acquisition frame rate according to current camera configuration</td>
</tr>
<tr>
<td>maxfps</td>
<td>Get the maximum acquisition frame rate according to current camera configuration (Camera Link)</td>
</tr>
<tr>
<td>maxfpsusb</td>
<td>Get the maximum acquisition frame rate according to current camera configuration (USB)</td>
</tr>
<tr>
<td>tint</td>
<td>Get integration time (seconds)</td>
</tr>
<tr>
<td>mintint</td>
<td>Get minimum integration time according to current camera configuration (seconds)</td>
</tr>
<tr>
<td>maxtint</td>
<td>Get the maximum integration time regarding current camera configuration (seconds)</td>
</tr>
<tr>
<td>maxtintitr</td>
<td>Get the maximum integration time without integration/read overlap regarding current camera configuration (seconds)</td>
</tr>
<tr>
<td>tintgranularity</td>
<td>Get the integration time granularity status when operating in IWR mode</td>
</tr>
<tr>
<td>tcdsadjust</td>
<td>Get TCDS automatic adjustment status for low integration times</td>
</tr>
<tr>
<td>vrefadjust</td>
<td>Get VREF automatic adjustment status</td>
</tr>
<tr>
<td>bias</td>
<td>Get bias correction status</td>
</tr>
<tr>
<td>adaptbias</td>
<td>Get adaptative bias status</td>
</tr>
<tr>
<td>flat</td>
<td>Get flat correction status</td>
</tr>
<tr>
<td>badpixel</td>
<td>Get bad pixel correction status</td>
</tr>
<tr>
<td>imagetags</td>
<td>Get tag generation status</td>
</tr>
<tr>
<td>led</td>
<td>Get current LED status</td>
</tr>
<tr>
<td>sendfile bias &lt;sendfileSize&gt; &lt;sendfileMD5&gt;</td>
<td>Upload a bias correction file into the camera through serial link</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td><code>sendfile bias_hdr_c1 &lt;sendfileSize&gt;</code></td>
<td>Upload a bias correction file to be used with C1 capacitor in HDR mode through serial link</td>
</tr>
<tr>
<td><code>sendfile bias_hdr_c2 &lt;sendfileSize&gt;</code></td>
<td>Upload a bias correction file to be used with C2 capacitor in HDR mode through serial link</td>
</tr>
<tr>
<td><code>sendfile flat &lt;sendfileSize&gt;</code></td>
<td>Upload a flat correction file into the camera through serial link</td>
</tr>
<tr>
<td><code>sendfile flat_hdr_c1 &lt;sendfileSize&gt;</code></td>
<td>Upload a flat correction file to be used with C1 capacitor in HDR mode through serial link</td>
</tr>
<tr>
<td><code>sendfile flat_hdr_c2 &lt;sendfileSize&gt;</code></td>
<td>Upload a flat correction file to be used with C2 capacitor in HDR mode through serial link</td>
</tr>
<tr>
<td><code>sendfile userbadpixel &lt;sendfileSize&gt;</code></td>
<td>Upload a custom bad pixel correction file (FW 1.1.0 or above)</td>
</tr>
<tr>
<td><code>sendfile license &lt;sendfileName&gt;</code></td>
<td>Upload a license file into the camera through serial link</td>
</tr>
<tr>
<td><code>xsendfile bias &lt;sendfileSize&gt;</code></td>
<td>Upload a bias file into camera through serial link using X-MODEM protocol</td>
</tr>
<tr>
<td><code>xsendfile bias_hdr_c1 &lt;sendfileSize&gt;</code></td>
<td>Upload a bias correction file to be used with C1 capacitor in HDR mode through serial link using X-MODEM protocol</td>
</tr>
<tr>
<td><code>xsendfile bias_hdr_c2 &lt;sendfileSize&gt;</code></td>
<td>Upload a bias correction file to be used with C2 capacitor in HDR mode through serial link using X-MODEM protocol</td>
</tr>
<tr>
<td><code>xsendfile flat &lt;sendfileSize&gt;</code></td>
<td>Upload a flat file into camera through serial link using X-MODEM protocol</td>
</tr>
<tr>
<td><code>xsendfile flat_hdr_c1 &lt;sendfileSize&gt;</code></td>
<td>Upload a flat correction file to be used with C1 capacitor in HDR mode through serial link using X-MODEM protocol</td>
</tr>
<tr>
<td><code>xsendfile flat_hdr_c2 &lt;sendfileSize&gt;</code></td>
<td>Upload a flat correction file to be used with C2 capacitor in HDR mode through serial link using X-MODEM protocol</td>
</tr>
<tr>
<td><code>recvfile userbadpixel size</code></td>
<td>Returns the size in bytes of the user bad pixel correction file (FW 1.1.0 or above)</td>
</tr>
<tr>
<td><code>recvfile userbadpixel md5sum</code></td>
<td>Returns the md5sum of the user bad pixel correction file (FW 1.1.0 or above)</td>
</tr>
<tr>
<td><code>recvfile userbadpixel content</code></td>
<td>Retrieve the content of the user bad pixel correction file (FW 1.1.0 or above)</td>
</tr>
<tr>
<td><code>recvfile factbadpixel size</code></td>
<td>Returns the size in bytes of the factory bad pixel correction file (FW 1.1.0 or above)</td>
</tr>
<tr>
<td><code>recvfile factbadpixel md5sum</code></td>
<td>Returns the md5sum of the factory bad pixel correction file (FW 1.1.0 or above)</td>
</tr>
<tr>
<td><code>recvfile factbadpixel content</code></td>
<td>Retrieve the content of the factory bad pixel correction file (FW 1.1.0 or above)</td>
</tr>
<tr>
<td><code>getflat &lt;url&gt;</code></td>
<td>Download a flat correction file from URL</td>
</tr>
<tr>
<td><code>getflat_hdr_c1 &lt;url&gt;</code></td>
<td>Download a flat correction file to be used with C1 capacitor in HDR mode from URL</td>
</tr>
<tr>
<td><code>getflat_hdr_c2 &lt;url&gt;</code></td>
<td>Download a flat correction file to be used with C2 capacitor in HDR mode from URL</td>
</tr>
<tr>
<td><code>getbias &lt;url&gt;</code></td>
<td>Download a bias correction file from URL</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>getbias_hdr_c1 &lt;url&gt;</td>
<td>Download a bias correction file to be used with C1 capacitor in HDR mode from URL</td>
</tr>
<tr>
<td>getbias_hdr_c2 &lt;url&gt;</td>
<td>Download a bias correction file to be used with C2 capacitor in HDR mode from URL</td>
</tr>
<tr>
<td>events</td>
<td>Get camera events sending activation status</td>
</tr>
<tr>
<td>extsynchro</td>
<td>Get usage of external synchronization status</td>
</tr>
<tr>
<td>extsynchro polarity</td>
<td>Get external synchronization polarity inversion configuration</td>
</tr>
<tr>
<td>extsynchro exposure</td>
<td>Get external synchronization exposure configuration</td>
</tr>
<tr>
<td>extsynchro source</td>
<td>Get source signal for external synchronization [FW 1.1.0 or above]</td>
</tr>
<tr>
<td>swsynchro</td>
<td>Get usage of software synchronization status</td>
</tr>
<tr>
<td>swsynchro source</td>
<td>Get software synchronization source [FW 1.1.0 or above]</td>
</tr>
<tr>
<td>nbframesperswtrig</td>
<td>Get the number of frames acquired for each software trigger</td>
</tr>
<tr>
<td>swtrig</td>
<td>Generate software trigger</td>
</tr>
<tr>
<td>swtrigabort</td>
<td>Abort software trigger [FW 1.1.0 or above]</td>
</tr>
<tr>
<td>extmarker source</td>
<td>Get source signal for frame marker [FW 1.1.0]</td>
</tr>
<tr>
<td>cropping</td>
<td>Get cropping status</td>
</tr>
<tr>
<td>cropping columns</td>
<td>Get cropping columns</td>
</tr>
<tr>
<td>cropping rows</td>
<td>Get cropping rows</td>
</tr>
<tr>
<td>version</td>
<td>Get product versions</td>
</tr>
<tr>
<td>version firmware</td>
<td>Get firmware version</td>
</tr>
<tr>
<td>version firmware detailed</td>
<td>Get detailed firmware version</td>
</tr>
<tr>
<td>version firmware build</td>
<td>Get build version</td>
</tr>
<tr>
<td>version fpga</td>
<td>Get FPGA version</td>
</tr>
<tr>
<td>version hardware</td>
<td>Get hardware version</td>
</tr>
<tr>
<td>status</td>
<td>Get camera status</td>
</tr>
<tr>
<td>status detailed</td>
<td>Get last status change reason</td>
</tr>
<tr>
<td>continue</td>
<td>Continue camera starting even if at the last use, the camera was in error</td>
</tr>
<tr>
<td>save</td>
<td>Save current camera settings into the current active preset</td>
</tr>
<tr>
<td>restorefactory</td>
<td>Restore factory parameters and reboot the camera</td>
</tr>
<tr>
<td>preset</td>
<td>Get current preset id</td>
</tr>
<tr>
<td>ipaddress</td>
<td>Get IP address of the camera</td>
</tr>
<tr>
<td>telnet</td>
<td>Get telnet status</td>
</tr>
<tr>
<td>cameratype</td>
<td>Display camera information</td>
</tr>
<tr>
<td>shutdown</td>
<td>Shutdown the camera</td>
</tr>
<tr>
<td>reboot</td>
<td>Reboot the camera</td>
</tr>
<tr>
<td>remotemaintenance</td>
<td>Get remote maintenance status</td>
</tr>
<tr>
<td>password</td>
<td>Get current password for telnet/ssh connections</td>
</tr>
<tr>
<td>sensibility</td>
<td>Get camera sensibility value</td>
</tr>
<tr>
<td>snake &lt;parameter&gt;</td>
<td>Get snake configuration parameter</td>
</tr>
<tr>
<td>hwuid</td>
<td>Get camera unique identifier</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>syncdelay</code></td>
<td>Get current delay for external synchronization</td>
</tr>
<tr>
<td><code>minsyncdelay [s]</code></td>
<td>Get minimal delay for external synchronization</td>
</tr>
<tr>
<td><code>maxsyncdelay [s]</code></td>
<td>Get maximal delay for external synchronization</td>
</tr>
<tr>
<td><code>stepsyncdelay [s]</code></td>
<td>Get granularity for external synchronization delays</td>
</tr>
<tr>
<td><code>licenses</code></td>
<td>Get currently configured license list</td>
</tr>
<tr>
<td><code>adu offset</code></td>
<td>Get ADU offset applied on all pixel of the image</td>
</tr>
<tr>
<td><code>ip mode</code></td>
<td>Get network configuration mode</td>
</tr>
<tr>
<td><code>ip address</code></td>
<td>Get static IPv4 address</td>
</tr>
<tr>
<td><code>ip netmask</code></td>
<td>Get static IPv4 netmask</td>
</tr>
<tr>
<td><code>ip gateway</code></td>
<td>Get static IPv4 gateway</td>
</tr>
<tr>
<td><code>ip dns</code></td>
<td>Get static primary DNS IPv4 address</td>
</tr>
<tr>
<td><code>ip alternate-dns</code></td>
<td>Get static alternate DNS IPv4 address</td>
</tr>
<tr>
<td><code>hdr</code></td>
<td>Get HDR status</td>
</tr>
<tr>
<td><code>hdr extended</code></td>
<td>Get HDR extended (16 bits unsigned pixels) status</td>
</tr>
<tr>
<td><code>hdr calibration</code></td>
<td>Get HDR calibration status</td>
</tr>
<tr>
<td><code>darkoptimlevel</code></td>
<td>Get tradeoff between dark current and noise (in percent)</td>
</tr>
<tr>
<td><code>agc</code></td>
<td>Get AGC status</td>
</tr>
<tr>
<td><code>agc param level_pix_high_hg</code></td>
<td>Get overexposed pixel level in high gain</td>
</tr>
<tr>
<td><code>agc param level_pix_low_mg</code></td>
<td>Get underexposed pixel level in medium gain</td>
</tr>
<tr>
<td><code>agc param level_pix_high_mg</code></td>
<td>Get overexposed pixel level in medium gain</td>
</tr>
<tr>
<td><code>agc param level_pix_low-lg</code></td>
<td>Get underexposed pixel level in low gain</td>
</tr>
<tr>
<td><code>agc param trigger_ratio_pixels_hg_to_mg</code></td>
<td>Get overexposed pixel ratio in high gain</td>
</tr>
<tr>
<td><code>agc param trigger_ratio_pixels_mg_to_hg</code></td>
<td>Get underexposed pixel ratio in high gain</td>
</tr>
<tr>
<td><code>agc param trigger_ratio_pixels_mg_to_lg</code></td>
<td>Get overexposed pixel ratio in medium gain</td>
</tr>
<tr>
<td><code>agc param trigger_ratio_pixels_lg_to_mg</code></td>
<td>Get underexposed pixel ratio in medium gain</td>
</tr>
<tr>
<td><code>agc param trigger_nb_frames_hg_to_mg</code></td>
<td>Get the number of overexposed images before transition from high gain to medium gain</td>
</tr>
<tr>
<td><code>agc param trigger_nb_frames_mg_to_hg</code></td>
<td>Get the number of underexposed images before transition from medium gain to high gain</td>
</tr>
<tr>
<td><code>agc param trigger_nb_frames_mg_to_lg</code></td>
<td>Get the number of overexposed images before transition from medium gain to low gain</td>
</tr>
<tr>
<td><code>agc param trigger_nb_frames_lg_to_mg</code></td>
<td>Get the number of overexposed images before transition from low gain to medium gain</td>
</tr>
<tr>
<td><code>agc roi</code></td>
<td>Get ROI for AGC</td>
</tr>
<tr>
<td><code>agc priority</code></td>
<td>Get priority when underexposed and overexposed pixels are present in medium gain</td>
</tr>
<tr>
<td><code>tuning</code></td>
<td>Get current camera tuning [FW 1.1.0]</td>
</tr>
<tr>
<td><code>exec upgradefirmware &lt;url&gt;</code></td>
<td>Upgrade the firmware with a new release located at the specified URL</td>
</tr>
<tr>
<td><code>exec uploadfirmware</code></td>
<td>Upgrade the firmware</td>
</tr>
<tr>
<td><code>exec buildbias</code></td>
<td>Build the bias correction image</td>
</tr>
<tr>
<td><code>exec buildflat</code></td>
<td>Build the flat correction image</td>
</tr>
<tr>
<td><code>exec buildflat hdr_c1</code></td>
<td>Build the flat correction image to be used with C1 capacitor in HDR mode</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>exec buildflat hdr_c2</code></td>
<td>Build the flat correction image to be used with C2 capacitor in HDR mode</td>
</tr>
<tr>
<td><code>exec dellicense &lt;license&gt;</code></td>
<td>Delete a license file. Will be active on next reboot</td>
</tr>
<tr>
<td><code>exec enablelicense &lt;license&gt;</code></td>
<td>Activates a license file. Will be active on next reboot</td>
</tr>
<tr>
<td><code>exec disablelicense &lt;license&gt;</code></td>
<td>Deactivates a license file. Will be active on next reboot</td>
</tr>
<tr>
<td><code>exec logs</code></td>
<td>Collect and serve logs through http</td>
</tr>
<tr>
<td><code>exec logs &lt;from&gt;</code></td>
<td>Collect and serve logs through http</td>
</tr>
<tr>
<td><code>buildnuc bias &lt;nbframes&gt;</code></td>
<td>Build the bias correction image [asynchronous] [FW 1.1.0 or above]</td>
</tr>
<tr>
<td><code>buildnuc flat &lt;nbframes&gt;</code></td>
<td>Build the flat correction image [asynchronous] [FW 1.1.0 or above]</td>
</tr>
<tr>
<td><code>buildnuc flat_hdr_c1 &lt;nbframes&gt;</code></td>
<td>Build the flat correction image to be used in with HDR/C1 (FW 1.1.0 or above)</td>
</tr>
<tr>
<td><code>buildnuc flat_hdr_c2 &lt;nbframes&gt;</code></td>
<td>Build the flat correction image to be used in with HDR/C2 (FW 1.1.0 or above)</td>
</tr>
<tr>
<td><code>buildnuc progress</code></td>
<td>Returns the estimated remaining time in seconds [FW 1.1.0 or above]</td>
</tr>
<tr>
<td><code>buildnuc abort</code></td>
<td>Aborts the computation [FW 1.1.0 or above]</td>
</tr>
<tr>
<td><code>set voltage vref &lt;vrefValue&gt;</code></td>
<td>Set VREF voltage [V]</td>
</tr>
<tr>
<td><code>set temperatures snake &lt;snakeValue&gt;</code></td>
<td>Set sensor temperature setpoint [°C]</td>
</tr>
<tr>
<td><code>set fps &lt;fpsValue&gt;</code></td>
<td>Set acquisition framerate [Hz]</td>
</tr>
<tr>
<td><code>set tint &lt;intValue&gt;</code></td>
<td>Set integration time [s]</td>
</tr>
<tr>
<td><code>set tintgranularity on</code></td>
<td>Enable exposure time granularity in IWR mode</td>
</tr>
<tr>
<td><code>set tintgranularity off</code></td>
<td>Disable exposure time granularity in IWR mode</td>
</tr>
<tr>
<td><code>set tcdsadjust on</code></td>
<td>Enable TCDS value adjustment for small integration times</td>
</tr>
<tr>
<td><code>set tcdsadjust off</code></td>
<td>Disable TCDS value adjustment for small integration times</td>
</tr>
<tr>
<td><code>set vrefadjust on</code></td>
<td>Enable VREF value adjustment</td>
</tr>
<tr>
<td><code>set vrefadjust off</code></td>
<td>Disable VREF value adjustment</td>
</tr>
<tr>
<td><code>set bias on</code></td>
<td>Enable bias correction</td>
</tr>
<tr>
<td><code>set bias off</code></td>
<td>Disable bias correction</td>
</tr>
<tr>
<td><code>set adaptbias on</code></td>
<td>Enable adaptative bias</td>
</tr>
<tr>
<td><code>set adaptbias off</code></td>
<td>Disable adaptative bias</td>
</tr>
<tr>
<td><code>set flat on</code></td>
<td>Enable flat correction</td>
</tr>
<tr>
<td><code>set flat off</code></td>
<td>Disable flat correction</td>
</tr>
<tr>
<td><code>set badpixel on</code></td>
<td>Enable bad pixel correction</td>
</tr>
<tr>
<td><code>set badpixel off</code></td>
<td>Disable bad pixel correction</td>
</tr>
<tr>
<td><code>set imagetags on</code></td>
<td>Enable tags generation</td>
</tr>
<tr>
<td><code>set imagetags off</code></td>
<td>Disable tags generation</td>
</tr>
<tr>
<td><code>set led on</code></td>
<td>Turn on the status led</td>
</tr>
<tr>
<td><code>set led off</code></td>
<td>Turn off the status led</td>
</tr>
<tr>
<td><code>set events on</code></td>
<td>Enable camera events</td>
</tr>
<tr>
<td><code>set events off</code></td>
<td>Disable camera events</td>
</tr>
<tr>
<td><code>set extsynchro on</code></td>
<td>Enable external synchronization</td>
</tr>
<tr>
<td><code>set extsynchro off</code></td>
<td>Disable external synchronization</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>set extsynchro polarity</td>
<td>Selects standard synchronization signal polarity.</td>
</tr>
<tr>
<td>set extsynchro polarity</td>
<td>Selects inverted synchronization signal polarity.</td>
</tr>
<tr>
<td>set extsynchro exposure</td>
<td>Configuration of exposure duration done through synchronization signal.</td>
</tr>
<tr>
<td>set extsynchro exposure</td>
<td>Configuration of exposure duration done internally.</td>
</tr>
<tr>
<td>set extsynchro source</td>
<td>Use synchro connector as external synchro source (FW 1.1.0 or above).</td>
</tr>
<tr>
<td>set extsynchro source</td>
<td>Use CL CC1 as external synchro source (FW 1.1.1 or above).</td>
</tr>
<tr>
<td>set extsynchro source</td>
<td>Use CL CC2 as external synchro source (FW 1.1.1 or above).</td>
</tr>
<tr>
<td>set extsynchro source</td>
<td>Use CL CC3 as external synchro source (FW 1.1.1 or above).</td>
</tr>
<tr>
<td>set extsynchro source</td>
<td>Use CL CC4 as external synchro source (FW 1.1.1 or above).</td>
</tr>
<tr>
<td>set extmarker source</td>
<td>Use synchro connector as external frame marker source (FW 1.1.1 or above).</td>
</tr>
<tr>
<td>set extmarker source</td>
<td>Use CL CC1 as external frame marker source (FW 1.1.1 or above).</td>
</tr>
<tr>
<td>set extmarker source</td>
<td>Use CL CC2 as external frame marker source (FW 1.1.1 or above).</td>
</tr>
<tr>
<td>set extmarker source</td>
<td>Use CL CC3 as external frame marker source (FW 1.1.1 or above).</td>
</tr>
<tr>
<td>set extmarker source</td>
<td>Use CL CC4 as external frame marker source (FW 1.1.1 or above).</td>
</tr>
<tr>
<td>set swsynchro on</td>
<td>Enable software synchronization.</td>
</tr>
<tr>
<td>set swsynchro off</td>
<td>Disable software synchronization.</td>
</tr>
<tr>
<td>set swsynchro source</td>
<td>Use software trigger for triggered acquisition (FW 1.1.1 or above).</td>
</tr>
<tr>
<td>set swsynchro source</td>
<td>Use external signal for triggered acquisition (FW 1.1.1 or above).</td>
</tr>
<tr>
<td>set nbframesperswtrig</td>
<td>Set the number of frames acquired for each software trigger.</td>
</tr>
<tr>
<td>set cropping on</td>
<td>Enable cropping.</td>
</tr>
<tr>
<td>set cropping off</td>
<td>Disable cropping.</td>
</tr>
<tr>
<td>set cropping columns</td>
<td>Set cropping columns [0-639, granularity 32].</td>
</tr>
<tr>
<td>set cropping rows</td>
<td>Set cropping rows [0-511, granularity 4].</td>
</tr>
<tr>
<td>set password &lt;password&gt;</td>
<td>Change password for telnet/ssh connections.</td>
</tr>
<tr>
<td>set ip mode manual</td>
<td>Select manual network configuration.</td>
</tr>
<tr>
<td>set ip mode automatic</td>
<td>Select dynamic network configuration using DHCP.</td>
</tr>
<tr>
<td>set ip address &lt;ip&gt;</td>
<td>Set camera’s IPv4 address.</td>
</tr>
<tr>
<td>set ip netmask &lt;mask&gt;</td>
<td>Set camera’s IPv4 netmask.</td>
</tr>
<tr>
<td>set ip gateway &lt;gateway&gt;</td>
<td>Set camera’s IPv4 gateway address.</td>
</tr>
<tr>
<td>set ip dns &lt;dns&gt;</td>
<td>Set primary DNS IPv4 address.</td>
</tr>
<tr>
<td>set ip alternate-dns &lt;dns&gt;</td>
<td>Set alternate DNS IPv4 address.</td>
</tr>
<tr>
<td>set ip refresh</td>
<td>Reconfigure camera IP address.</td>
</tr>
<tr>
<td>set telnet enable</td>
<td>Enable control of the camera through telnet connection.</td>
</tr>
<tr>
<td>set telnet disable</td>
<td>Disable control of the camera through telnet connection.</td>
</tr>
<tr>
<td>set remotemaintenance on</td>
<td>Enable remote maintenance.</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>set remotemaintenance off</td>
<td>Disable remote maintenance</td>
</tr>
<tr>
<td>Set tslsydel &lt;value&gt;</td>
<td>Change tslsydel value</td>
</tr>
<tr>
<td>set sensibility low</td>
<td>Select lowest camera sensibility</td>
</tr>
<tr>
<td>set sensibility medium</td>
<td>Select medium camera sensibility</td>
</tr>
<tr>
<td>set sensibility high</td>
<td>Set highest sensibility</td>
</tr>
<tr>
<td>set snake &lt;parameter&gt; &lt;value&gt;</td>
<td>Set snake config parameter</td>
</tr>
<tr>
<td>set preset &lt;parameter&gt;</td>
<td>Reload currently active camera settings preset</td>
</tr>
<tr>
<td>set preset 0</td>
<td>Load camera settings preset #0</td>
</tr>
<tr>
<td>set preset 1</td>
<td>Load camera settings preset #1</td>
</tr>
<tr>
<td>set preset 2</td>
<td>Load camera settings preset #2</td>
</tr>
<tr>
<td>set preset 3</td>
<td>Load camera settings preset #3</td>
</tr>
<tr>
<td>set preset 4</td>
<td>Load camera settings preset #4</td>
</tr>
<tr>
<td>set preset 5</td>
<td>Load camera settings preset #5</td>
</tr>
<tr>
<td>set preset 6</td>
<td>Load camera settings preset #6</td>
</tr>
<tr>
<td>set preset 7</td>
<td>Load camera settings preset #7</td>
</tr>
<tr>
<td>set preset 8</td>
<td>Load camera settings preset #8</td>
</tr>
<tr>
<td>set preset 9</td>
<td>Load camera settings preset #9</td>
</tr>
<tr>
<td>set aduoffset &lt;aduOffsetValue&gt;</td>
<td>Set ADU offset value applied to each pixel in the acquired frames</td>
</tr>
<tr>
<td>set syncdelay &lt;delay&gt;</td>
<td>Set delay for external synchronization signal</td>
</tr>
<tr>
<td>set hdr on</td>
<td>Enable HDR (FW 3.1.1 or above)</td>
</tr>
<tr>
<td>set hdr off</td>
<td>Disable HDR (FW 3.1.1 or above)</td>
</tr>
<tr>
<td>set hdr extended on</td>
<td>Enable extended HDR (unsigned pixels) (FW 3.1.1 or above)</td>
</tr>
<tr>
<td>set hdr extended off</td>
<td>Disable extended HDR (unsigned pixels) (FW 3.1.1 or above)</td>
</tr>
<tr>
<td>set hdr calibration c1</td>
<td>Force usage of C1 in HDR (used for bias/flat computation) (FW 3.1.1 or above)</td>
</tr>
<tr>
<td>set hdr calibration c2</td>
<td>Force usage of C2 in HDR (used for bias/flat computation) (FW 3.1.1 or above)</td>
</tr>
<tr>
<td>set hdr calibration off</td>
<td>Disable HDR calibration (FW 3.1.1 or above)</td>
</tr>
<tr>
<td>set darkoptimlevel &lt;value&gt;</td>
<td>Set tradeoff between dark current and noise (in percent) (FW 3.1.1 or above)</td>
</tr>
<tr>
<td>set agc on</td>
<td>Enable AGC</td>
</tr>
<tr>
<td>set agc off</td>
<td>Disable AGC</td>
</tr>
<tr>
<td>set agc param level_pix_high_hg</td>
<td>Set overexposed pixel level in high gain</td>
</tr>
<tr>
<td>set agc param level_pix_low_mg</td>
<td>Set underexposed pixel level in medium gain</td>
</tr>
<tr>
<td>set agc param level_pix_high_mg</td>
<td>Set overexposed pixel level in medium gain</td>
</tr>
<tr>
<td>set agc param level_pix_low_lg</td>
<td>Set underexposed pixel level in low gain</td>
</tr>
<tr>
<td>set agc param trigger_ratio_pixels_hg_to_mg</td>
<td>Set overexposed pixel ratio in high gain</td>
</tr>
<tr>
<td>set agc param trigger_ratio_pixels_mg_to_hg</td>
<td>Set underexposed pixel ratio in high gain</td>
</tr>
<tr>
<td>set agc param trigger_ratio_pixels_mg_to_lg</td>
<td>Set overexposed pixel ratio in medium gain</td>
</tr>
<tr>
<td>set agc param trigger_ratio_pixels_lg_to_mg</td>
<td>Set underexposed pixel ratio in low gain</td>
</tr>
<tr>
<td>Command</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>set agc param trigger_nb_frames_hg_to_mg &lt;value&gt;</td>
<td>Set the number of overexposed images before transition from high gain to medium gain</td>
</tr>
<tr>
<td>set agc param trigger_nb_frames_mg_to_hg &lt;value&gt;</td>
<td>Set the number of underexposed images before transition from high gain to medium gain</td>
</tr>
<tr>
<td>set agc param trigger_nb_frames_mg_to_lg &lt;value&gt;</td>
<td>Set the number of overexposed images before transition from medium gain to low gain</td>
</tr>
<tr>
<td>set agc param trigger_nb_frames_lg_to_mg &lt;value&gt;</td>
<td>Set the number of underexposed images before transition from low gain to medium gain</td>
</tr>
<tr>
<td>set agc roi &lt;value&gt;</td>
<td>Set ROI for AGC</td>
</tr>
<tr>
<td>set agc priority none</td>
<td>No preference when in presence of underexposed and overexposed pixels in medium gain</td>
</tr>
<tr>
<td>set agc priority underexposed</td>
<td>Prioritize underexposed pixels when in presence of underexposed and overexposed pixels in medium gain</td>
</tr>
<tr>
<td>set agc priority overexposed</td>
<td>Prioritize overexposed pixels when in presence of underexposed and overexposed pixels in medium gain</td>
</tr>
<tr>
<td>set tuning general_use</td>
<td>Select camera standard tuning suitable for general use (FW 1.1.0 or above)</td>
</tr>
<tr>
<td>set tuning short_exposure</td>
<td>Select camera tuning suitable for short exposures (FW 1.1.0 or above)</td>
</tr>
<tr>
<td>set tuning long_exposure</td>
<td>Select camera tuning suitable for long exposures (FW 1.1.0 or above)</td>
</tr>
</tbody>
</table>

Basically, there are three kinds of commands: ‘get’, ‘set’ and ‘exec’.

The ‘get’ commands can be used to retrieve some values from the camera, ‘set’ to set parameters and ‘exec’ to ask the camera to do a task.

**For example:**

- Type ‘fps’ to get in return ‘Frames per second: 600’.
- ‘set fps 100’ gives ‘Result: OK’ when the request is implemented.

By default, commands are verbose. However, it is possible to get the parameter value only. To do so, you can add the keyword ‘raw’ at the end of the command.

**For example:**

‘fps raw’ gives ‘600’.

**Another example:**

Type ‘exec buildbias’ to ask the camera to compute a bias file.
You will get ‘Compute bias image........Done’ when the operation is completed.

**Note:** the camera must be rebooted after using the command ‘set password’, and after using every command ‘set IP’.

For details on some advanced commands like “snake command”, please contact First Light Imaging at support@first-light.fr.
9.2. Commands format detail

C-RED 3’s command line interpreter (aka CLI) on the CL or USB serial link is simple:

- Commands are only composed of ascii characters.
- Each command must be ended with line feed character: `\n`
- There is no echo of character.
- There is no escape sequence, only simple ascii characters.
- After each answer of the camera, you get the following additional sequence of character: CR LF “fli-cli>”
  (`\r` `\n` ‘f’ ‘l’ ‘i’ ‘-‘ ‘c’ ‘l’ ‘i’ ‘>` )

For example:
With the command “temperatures CPU raw”, you could get the following sequence of hexadecimal characters:

```
00000000 33 33 2e 35 30 0d 0a 66 6c 69 2d 63 6c 69 3e |33.50..fli-cli>|
```

Note: Since the configuration of the camera is done using serial interface, not only the “CRED3 DEMO” software can be used to communicate with the camera but also any terminal software like putty for example.

9.3. SSH configuration

The configuration of the camera can also be done using a ssh connection.
To be more human friendly, on ssh, the camera interpreter behaves differently. It can manage character echo and escape sequences. To use this improved mode, the ssh login is ’adminnc’.
The same behavior as on the serial link is also available using the login ‘admin’.
The default password is ”flicred1”, it can be changed using the ’set password’ command.

Note: There is no authentication on the serial links. So, an interpreter running on this kind of interface can be used to run the command ‘password’ and retrieve the password.
10. PRECAUTIONS AND MAINTENANCE

10.1. Precaution of use

Your C-RED 3 is a high-end scientific instrument, if this equipment is used in a manner not specified by the manufacturer the protection provided by the equipment may be impaired and the warranty will not be applicable.

Your C-RED 3 is an electronic equipment that requires precaution regarding static shocks. As any scientific instrument, your C-RED 3 camera is fragile and should not be exposed to shocks, extreme temperatures, humidity and dusty environment.

Your C-RED 3 camera is an expensive and fragile product, handle it with care!

10.1.1. Static / electric shocks:

Any electronic equipment that must be connected to C-RED 3 should be fitted with appropriate protection on all power lines.
Any connected equipment should be powered off before removing any connection between the computer and C-RED 3.

10.2. Maintenance

10.2.1. Never open the camera.

There are no user-serviceable parts inside your camera, do not ever attempt to open it. There are some indicators inside the camera, if you try to open it your warranty will be void.

⚠️ **Do not open the camera, your warranty will be void.**

10.2.2. Cleaning of window.

Never use an unclean cloth to wipe the window of the camera.
The window should be cleaned with a dry and soft cloth.
You can also use a clean cloth dampened with ethanol and gently wipe the window.
Please avoid touching the glass window.

10.2.3. Storage.

When not in use, please store your camera in a dry place, in its box.

10.2.4. Ethernet connection

Maintenance can be done using Ethernet connection, to upgrade the embedded firmware or for remote assistance.
The Ethernet cable is not provided in the C-RED 3 camera package. It is strongly advised to use shielded cable to respect Electromagnetic Compatibility (EMC) recommendations.
11. WARRANTY AND LIABILITY

11.1. For the USA

11.1.1. Limited Warranty

Subject to the limitations set forth herein, FLI represents and warrants that the Products (including the Sensor, if applicable) will correspond, at the time of delivery, to the specifications provided to FLI by Purchaser, and shall be free from defects in material and workmanship (the "Limited Warranty"). Such Limited Warranty shall remain in effect for a period of two (2) years from the date Purchaser takes delivery of such Products; provided, however, that such Limited Warranty as it relates exclusively to the Sensor (which shall be supplied by a third party manufacturer), if and as included in a Product, shall remain in effect for such length of time as the original manufacturer’s warranty shall be in effect. Therefore, for example purposes only, if there shall be eight months remaining on the original manufacturer’s warranty for the Sensor at the time Purchaser takes delivery of a Product which incorporates such Sensor, then the Limited Warranty hereunder as it relates exclusively to the Sensor shall be in effect for eight months. FLI shall inform Purchaser of the length of time remaining on the original manufacturer warranty for the Sensor at the time the applicable Product is delivered to Purchaser.

11.1.2. Conditions

The Limited Warranty specified above is subject to the following conditions:

- FLI shall be under no liability with respect to defects arising in the Products as a result of any incorrect drawing, design, or specification supplied by Purchaser;

- FLI shall have no liability with respect to any defect which arises from wear and tear, willful damage, negligent or abnormal use of the Product, mishandling of the Product, Force Majeure Events, or failure to comply with FLI’s instructions regarding the use and maintenance of the Product, including, but not limited to, all written instructions, and all instructions contained in the Documentation;

- the Limited Warranty shall be limited to the Products themselves, and FLI shall have no liability with respect to any damages whatsoever which are caused to, or by, third party [or Purchaser’s] parts, materials, or systems, as a result of or in connection with the integration or use of the Products.

11.1.3. Warranty Enforcement

To avail itself of the rights provided under the Limited Warranty, the Purchaser must submit, in writing, a detailed report regarding the defect exhibited by the particular Product (a "Defect Report"). Such Defect Report shall be submitted to FLI at contact@first-light.fr, with a copy of such Defect Report furnished to FLI by certified mail, or regular mail with return receipt requested, at the address listed below.

Purchaser shall have the burden of proving the defect is covered by the Limited Warranty. FLI shall have sole discretion to determine whether the Limited Warranty applies to any defect reported by Purchaser.
11.1.4. Returns

In the event the Limited Warranty applies, Purchaser shall return the Product to FLI within thirty (30) days of receiving written authorization from FLI to do so, in the same condition as the Product was originally delivered to Purchaser. Purchaser shall assume all costs, risk and liability in connection with the shipment and return of the Product. In the event the Product is not returned within the requisite time period, the Limited Warranty shall be void and of no further effect.

Purchaser agrees to the following limitations on FLI’s liability in connection with the Products:

11.1.4.1. Liability Upon Delivery

Except as otherwise provided herein, FLI disclaims any and all liability in connection with purchaser’s use of any products, including without limitation liability to third parties, to the fullest extent permitted by law, as of the date such product is delivered to purchaser.

11.1.4.2. Products Offered “As Is”

Except as provided in these terms, FLI provides the products “as is” and on an “as available” basis. Accordingly, and to the maximum extent permitted by applicable law, FLI makes no warranties, express or implied, that the products will be uninterrupted, error-free or free of harmful components.

11.1.4.3. No Other Warranties

Except as expressly set forth in these terms, and to the fullest extent permitted by applicable law, FLI does not make any warranty regarding the products or any other subject matter of these terms. Any implied warranty, including without limitation any implied warranty of merchantability and fitness for a particular purpose, shall be limited in scope to the extent permitted by applicable law, and shall be limited in duration to the duration of the limited warranty set forth above, or to such period of time as permitted by applicable law, whichever shall be shorter.

11.1.4.4. Limitation of Liability

To the fullest extent permitted by law, in no event will FLI, its affiliates, suppliers or distributors be liable for (a) any indirect, special, incidental, punitive, exemplary or consequential damages however caused, on any theory of liability, including but not limited to loss of use, loss of actual or anticipated profits or benefits, or the cost of procuring a replacement product, whether or not FLI has been advised of the possibility of such damages, arising in any way out of these terms or in connection with the products, or any undertaking or performance that may be promised, performed, or executed to implement these terms.

11.1.5. Purchaser Warranties

In addition to the other warranties, representations and covenants set forth in these terms, by using the products or placing an order, purchaser warrants and represents that purchaser has the right and authority to agree to these terms and to use the products, that purchaser’s use of the products shall not violate the rights of any third party or any contract with any third party, and that purchaser’s use of the products, FLI’s fulfillment of any orders, and the delivery of any products, shall not violate any applicable laws.

11.1.6. Purchaser Indemnification

Purchaser agrees to defend, indemnify and hold FLI harmless from and against any and all claims, liabilities, damages, penalties, forfeitures, and associated costs and expenses (including attorneys’ fees) that FLI may incur as a result of any breach by purchaser of any warranty, representation or covenant set forth in these terms.

11.2. For the rest of the World
11.2.1. FLI’s legal guarantee and limit to the guarantee

FLI hereby exclusively guarantees the Product’s compliance with the specifications agreed to within the limits of the legally applicable provisions.
FLI’s guarantee is exclusively limited to repairs or replacement of any parts that are not in compliance.
If after reasonable efforts, FLI is not able to replace the non-compliant Product, the guarantee will be limited exclusively to the reduction of the purchase price or reimbursement of the price (after deduction of depreciation for wear and tear), after the Product is returned by the Purchaser.
FLI will not be liable for any indemnification of the Purchaser for specific or indirect damage, opportunity cost, loss of income, loss of enjoyment, damage to individuals or goods not related to the purpose of the contract.
For parts or supplies that are not manufactured by FLI, the guarantee is limited to those to which FLI is entitled from its own suppliers.
This guarantee does not cover the defects of the Product resulting from any cause external to the Product, such as:

- Failure to comply with FLI’s recommendations;
- Mishandling by the Purchaser;
- Intervention by a third party involving the Product;
- Poor maintenance or misuse of the Product;
- Wear and tear;
- Damage caused by elements external to the Product or attributable to a case of force majeure: fire, lightning, water damage, external accident, etc.

11.2.2. FLI’s liability

The Products are sold by FLI in compliance with French laws in effect. FLI cannot be held liable for any failure to comply with the laws in the countries where the Product will be used.
In the event where FLI is held liable due to its failure to satisfy any of its contractual obligations, the Purchaser may not seek any indemnification for loss of income or opportunity cost, loss of enjoyment, specific, accessory or indirect damage to individuals or to goods or assets, caused by any failure in the performance of its obligations. The total amount of the indemnities that FLI may be required to pay to the Purchaser in remedy for the prejudice it suffers may not exceed the amounts paid by the Purchaser for such Product, regardless of the legal grounds for the claim and the procedure employed to resolve it.

11.2.3. Liability in connection with defective products

FLI’s liability in connection with defective products excludes remedy for any damage caused to the products through commercial use.
12. CONTACTS

12.1. For the USA:

FIRST LIGHT IMAGING Corp.
185 Alewife Brook Parkway, Ste 210
Cambridge, MA 02138
USA

Phone: + 33 4 42 61 29 20
E-mail: support@first-light.fr
Website: www.first-light.us

12.2. For the rest of the world:

FIRST LIGHT IMAGING SAS
Europarc Sainte Victoire, Bât. 6
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13590 Meyreuil
France

Tel.: + 33 4 42 61 29 20
E-mail: support@first-light.fr
Website: www.first-light-imaging.com