Acuros® CQD Camera User Manual

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Contents

Document Revisions

Date	Version Number	Document Changes
10/9/2019	1.0	Initial Document
6/16/2020	1.1	Updates for SVSImagIR rev 2.0A29 and higher
12/19/2022	1.2	General update regarding hard/software updates
5/2/2024	1.8	(CC035) Introduction of Dynamic NUCs and Auto Exposure
5/26/2026	1.9	General updates including terms and conditions

1 Introduction

1.1 System Description

The Acuros CQD camera line features high speed, triggerable, area array VIS-SWIR (0.4-1.7 um wavelengths) or VIS-eSWIR (0.4-2.1um) imaging, ideal for industrial inspection, security and surveillance, and scientific applications. The cameras are built around SWIR Vision Systems patented Colloidal Quantum Dot (CQD) sensors.

The Acuros CQD cameras are supplied with a 12 VDC/2A power supply adaptor and cable integrated with a 12 pin Hirose trigger cable. The analog output signal of the CQD sensor is digitized with either 10 or 14 bits using an analog-to-digital converter. The digital data is then manipulated by an on-board field-programmable gate array (FPGA) and transmitted through a GigE or USB3 interface to the host machine. The PC compatible SVSImagIR software allows the user to send commands to the camera, view a live display, capture image and video files, and manipulate the digitalized output. SDK support is available through third-party GenICam-compliant vendors.

This guide outlines the basic operation of the camera including software installation, camera startup, and basic and advanced imaging procedures for the camera models listed below.

1.2 Scope

This user guide describes the technical specifications, electrical interfaces, dimensions, GUI and camera operation for the following product families:

Camera Product Families
ACUROS-0640-USB3-XXX
ACUROS-0640-GIGE-XXX
ACUROS-1280-USB3-XXX
ACUROS-1280-GIGE-XXX
ACUROS-1920-USB3-XXX
ACUROS-1920-GIGE-XXX

Table 1. List of camera models covered by this user guide.

1.3 Order Description

A complete Acuros CQD camera order includes the following:

- Acuros CQD camera body, electronics, and sensor with either GigE or USB3 interface
- Lens mount for C and M42 lenses (Imaging series only)
- 12V, 2A, AC-to-DC power adapter
- 12 Pin Hirose Power and Trigger Cable
- Communication interface cable: CAT6 Ethernet or USB3.0 (micro-B to A)
- USB flash drive with software, firmware, and this user manual
- Protective case
- Frosted glass diffuser for software NUC creation

1.4 Safety Considerations

⚠ **Power Warning:** Exceeding the recommended voltage may result in damage to the camera.

⚠ **Exposed Sensor**: Use care to not touch, damage, or scratch the sensor when exposed. Always keep the sensor port covered with the provided body cap to prevent particulate accumulation on the sensor. If you need to clean particulates off the sensor, use a low-pressure, non-contact air blower such as a bulb pump or electronic air duster. For laser products (identified by the wedged sensor glass), do not use cotton swabs or microfiber cloth as there are fragile wirebonds on either side of the sensor glass that could be damaged. For imaging cameras, which include a protective lid, microfiber cloth may be used for cleaning.

⚠ **Environmental conditions:** Do not expose the camera to excessive moisture to prevent shock hazard, or damage.

⚠ **Electrostatic discharge (ESD):** Follow standard ESD precautions when handling the camera to prevent ESD damage.

1.5 Product Global Limited Warranty

See the **onsemi** Standard Terms and Conditions of Sales.

1.6 Quality Assurance

SWIR Vision Systems is committed to a policy of continuous development for which we reserve the right to make changes and improvements to any of the products described in this manual without prior notice.

1.7 Contact Information

For support, contact **onsemi** customer support or contact your local distributor.

1.8 Acuros CQD Camera Product Data

Information including datasheets, mechanical drawings, and CAD are available online.

2 Electrical Interfaces and Specifications

This section details the electrical connections for power and camera communications.

2.1 Specification and Camera Connectors

Interface	Camera Connector	Specification
Power	Hirose HR10A-10R-12PB (71)	See Power Specifications (Table 3) below
Trigger	BNC	Low level CMOS 3.3V SN74AHCT1G125 compatible
Ethernet	RJ45	TCP/IP 1Gbps maximum GigE Vision compatible
USB	10-pin USB 3.0 Micro-B receptacle	USB Vision compatible

Table 2. Camera interface connector and specifications.

2.2 Power Specifications

Camera Connector	Specification
Input Voltage Range:	6VDC minimum to 16VDC maximum.
Input Power Range:	6.5W minimum to 12W maximum. (depending on the amount of TE cooling required).
External Power Adapter:	Rated 12V @ 2Amps
Allowable noise:	100mV ripple
Power over Ethernet (POE):	POE is not supported and must not be connected.

Table 3. Power specifications

2.3 Hirose pinout

A pinout of the Hirose 12-pin connector is shown and described below. When building custom cable assemblies, one must connect GND pin 1 and GND pin 5 to a common ground.

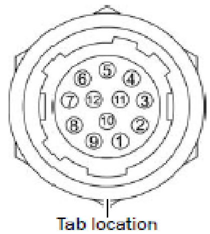


Figure 1. Hirose pinout diagram.

Pin	Name	Type	Notes
1	RET	Power Return	Ground
2	VIN	Power Input	Protected by 600W @ 1.0ms PP Zener TVS. Receives 6V to 16V DC input. Reverse voltage protection to -30VDC.
5	RET	Power Return	Trigger ground.
10	Trigger	Input	Trigger signal. Protected by ESD suppression to IEC61000-4-2 level. EMI filtered by ferrite bead (120 Ohm @ 100Mhz)
9	GP Output	Output	General Purpose Output. Protected by ESD suppression to IEC61000-4-2 Level. EMI filtered by ferrite bead (120 Ohm @ 100Mhz)

Table 4. Pinout for Hirose connector.

2.4 LED Indicators

The meaning of the various LED indicators is shown in the figures and tables below.

2.4.1 LED Indicators for GigE Cameras

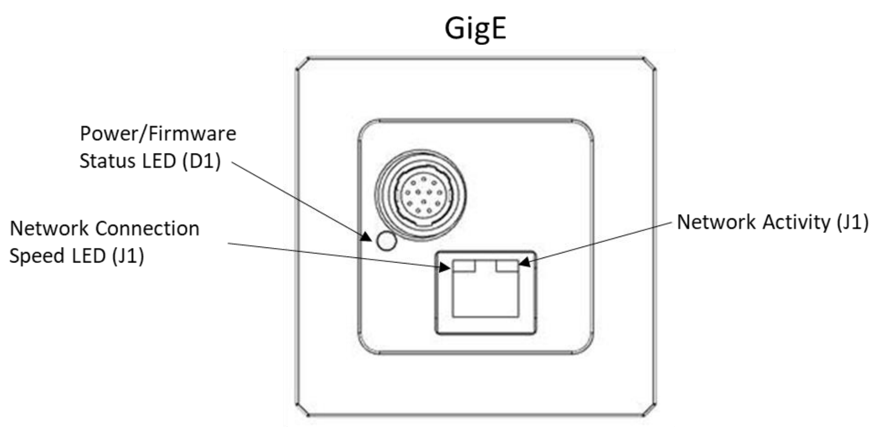


Figure 2. LED indicator status diagram for GigE cameras.

LED	ID	Description
Power/Firmware	D1	**Off:** Power is not supplied. **Green:** Power is supplied. **Yellow:** The backup load is running
Network Activity	J1	**Off:** No ethernet connection. **Green on:** Ethernet link. **Green on blinking:** Data is being transmitted or received.
Network Connection Speed	J1	**Off:** No connection, 10Mbps connection, or 100Mbps connection. **Green on:** 1 Gps connection

Table 5. LED indicator status table for GigE cameras.

2.4.2 LED Indicators for USB Cameras

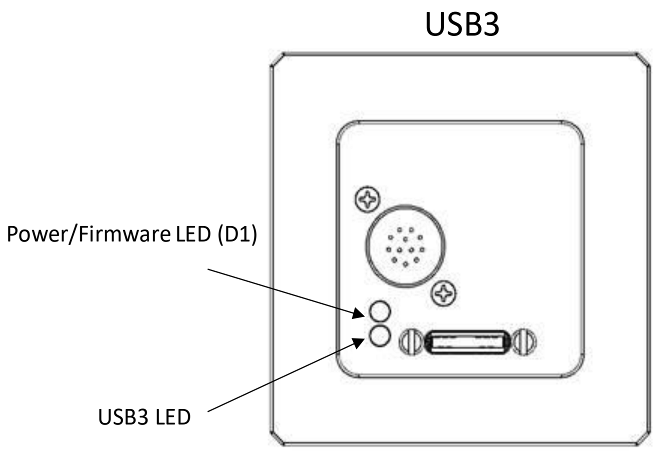


Figure 3. LED indicator status diagram for USB3 cameras.

LED	ID	Description
Power/Firmware	D1	**Off:** FPGA not configured or USB not connected. **Green:** Power is supplied*, and the FPGA is configured. **Yellow:** The backup load is running.
USB3		**Yellow (flashing quickly):** The embedded video interface is operating properly. **Yellow (flashing):** Indicates GenCP traffic between the embedded video interface and the host. **Yellow (solid):** Indicates a connection of any speed has been established, but the power connector is not receiving power. **Green (solid):** A SuperSpeed (USB 3.0) connection is established. **Off:** A USB 2.0 connection is established.

Table 6. LED indicator status table for USB3 cameras.

***If the Power/Firmware LED is solid Green while the USB3 LED is yellow, the power cable may not be providing power to the camera.**

3 Optical Interfaces

In this section we describe how to attach a lens and filter for each of the available lens mount types (C, M42 & Laser Filter). Lenses should be SWIR coated and sized to cover the sensor in the selected Acuros CQD model to provide optimum imaging results.

3.1 Lens and Filter Mount Plates

The Acuros CQD Camera can be configured for imaging or laser profiling applications. Imaging configurations accommodate C-mount and M42 @ C-mount working distance lens options. The laser profiling configuration is designed to minimize working distance to the FPA and includes a filter plate ideal for mounting 2in square OD filters.

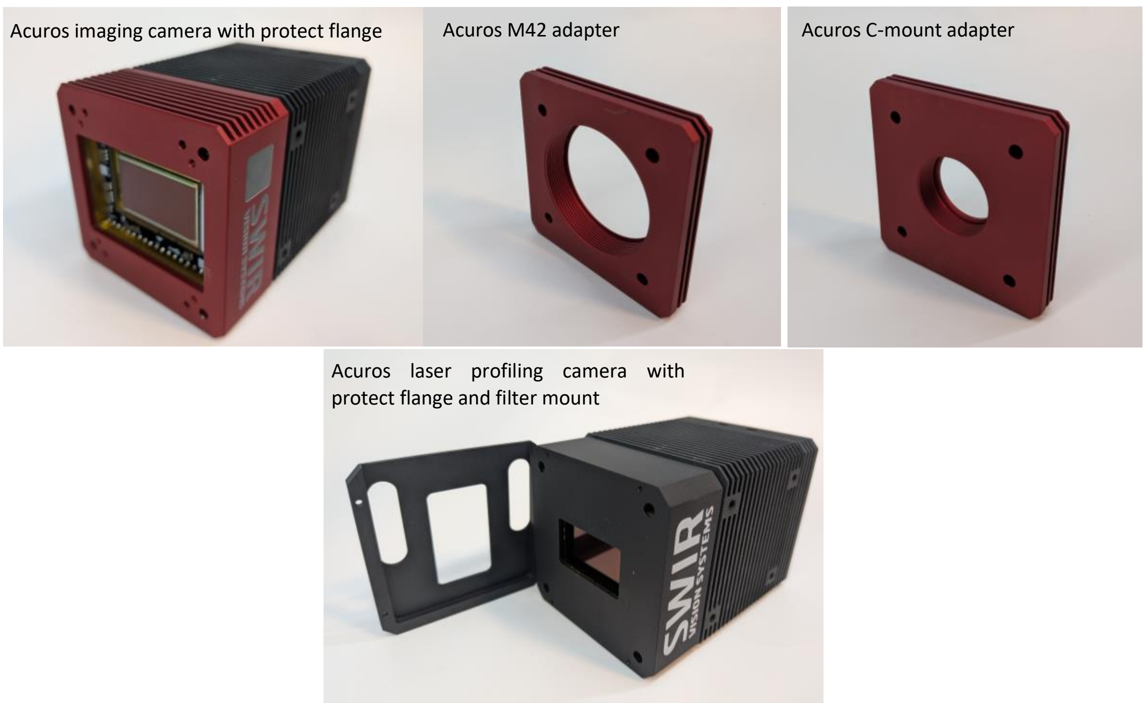


Figure 4: Imaging & Laser Beam Profiling Camera Configurations

3.1.1 Removing and attaching a lens and mount

Removing a lens mount flange may be necessary to perform cleaning and/or to swap between lens mounts. Follow the instructions below to avoid damaging the sensor during this process.

1. Set the sensor on its side as shown below. Never perform the following steps with the camera positioned vertically to avoid the risk of objects falling onto the sensor.
2. There are four M2x0.4 hex screws in recessed holes of the lens mount plate that secure it to the camera body. Use a 1.5mm hex screwdriver to remove them.
3. Pull the mount away from camera body. The camera's sensor will be exposed so use caution to prevent damage.
4. Perform cleaning, lens mount swap as needed.

5. Place the mount back onto the camera body.
6. Insert the four M2x0.4 hex screws back into the recessed holes and tighten.

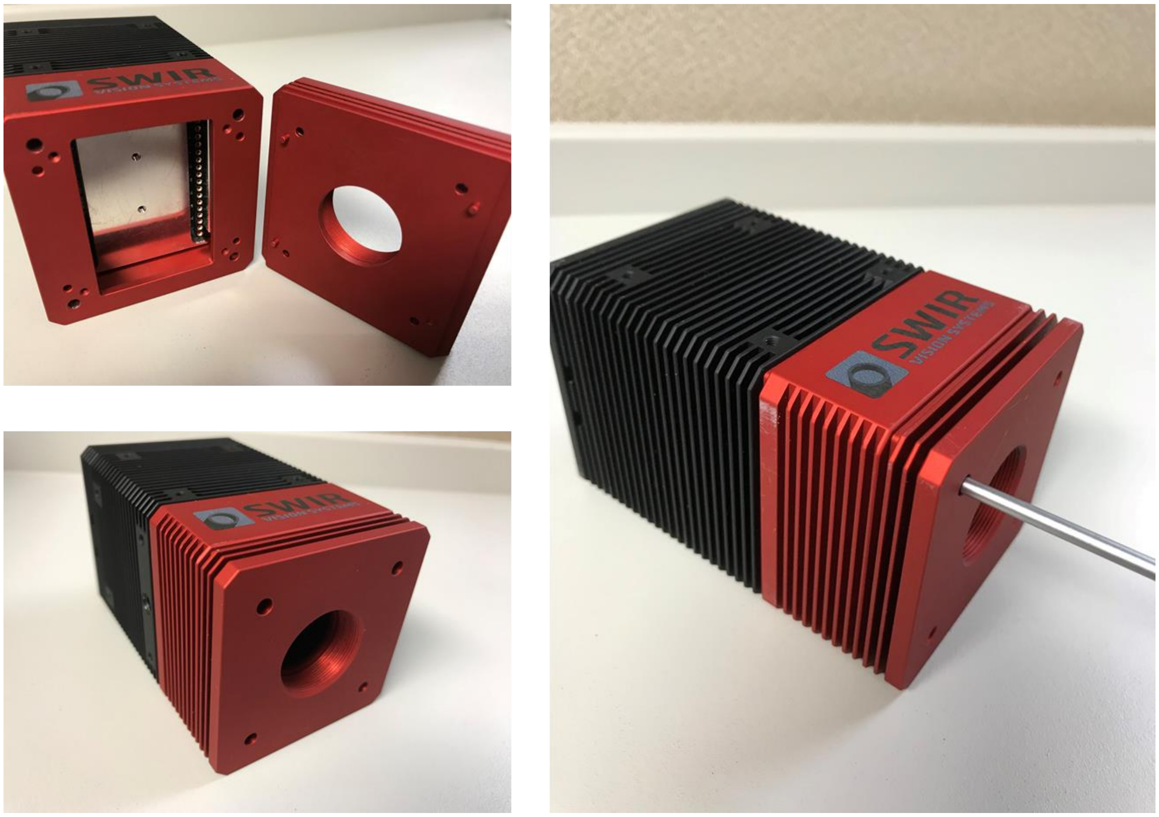


Figure 5: Acuros CQD Camera showing C-mount attachment process.

3.2 Sensor Cleaning

Remove the lens mount as described in the previous section. The preferred, safest method of cleaning is to use dry compressed air to remove loose particulates from the sensor lid surface. There is a high chance that permanent, catastrophic damage will occur if you attempt to physically touch, wipe or scrub the sensor. Doing so will void the warranty.

Physical damage to, or removal of the sensor from the camera body will void the warranty.

Figure 6: Lens cleaning devices

4 Getting Started

This section outlines the software and hardware installation processes.

4.1 Hardware Installation

4.1.1 Camera Electrical Interfaces

All Acuros CQD Camera electrical interfaces are located on the back panel of the camera, shown below in the below figure.

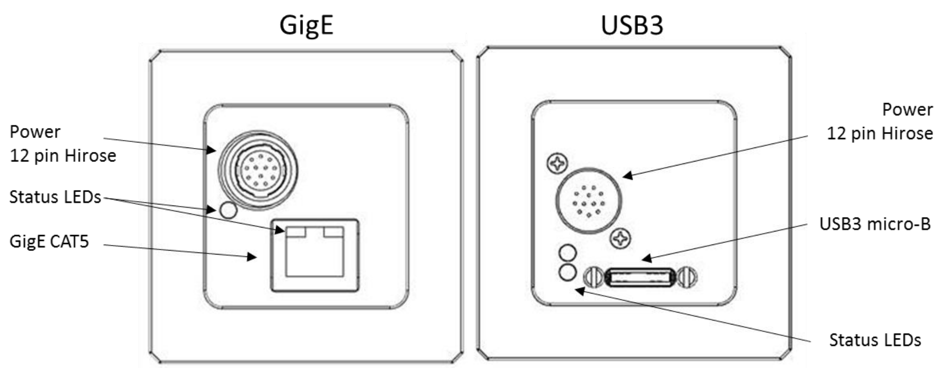


Figure 7. Acuros CQD Camera rear panel schematic showing power and interface connection ports.

4.1.2 Powering up the camera:

The camera power is supplied by the AC adapter through the 12 pin Hirose connector and via the USB3 connector for models so equipped.

Figure 8. Acuros CQD Camera cable connections. Connections should be made in the listed order.

Important note: The camera must be connected in the following order:

1. Plug the AC adapter into an AC source. Use international plug convertors as needed.
2. Plug the Hirose cable into the AC adapter.
    a. The trigger cable connection is optional.
3. Connect the Hirose cable to the camera. GigE cameras will show a steady green power light. The USB3 camera power light will not illuminate.
4. Connect the communications cable (USB3 or GigE) between the camera and host machine. The USB3 status and power lights will illuminate. The RJ45 jack on GigE cameras will illuminate.
5. See Section 2.4 for details on LED indicators.

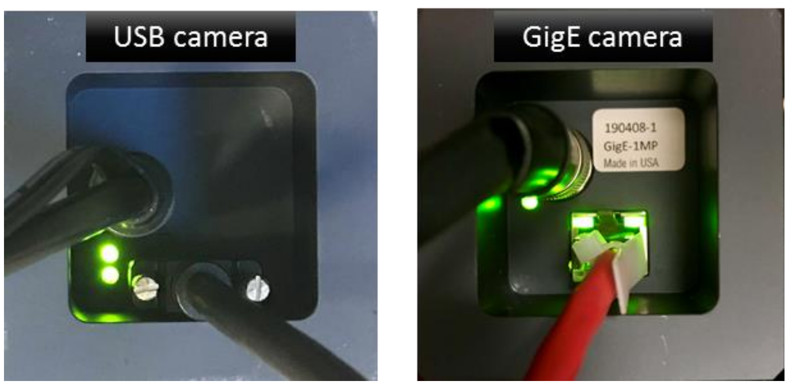


Figure 9. Acuros CQD Camera back panel after communication and power have been supplied.

4.2 Software Installation

The SVSImagIR software is designed for a PC with the Windows 10 or Windows 11 operating system.

1. Insert the SWIR Vision Systems flash drive and run the file named SVSImagIR30A##.exe, where ## is the version number.
2. A prompt to install the Pleora eBUS software will appear after the SVSImagIR software is installed.
    a. This window can appear in the background. Please check the taskbar for the eBUS installation window.
3. In the Pleora InstallShield Wizard screen, it is recommended to select only the driver required for your device type (GigE or USB3).
4. The SVSImagIR software is launched from the programs menu or by using the new shortcut on the desktop.
    a. If the shortcut does not appear, the program is in the Program Files (x86)/SVS folder.

Important note: If a version of Pleora eBUS software already exists on the PC, conflicts will arise during installation. It is recommended to locate the existing installation and remove it from the system before proceeding with the SVSImagIR installation.

5 Connecting to the Camera

5.1 Opening the Software

Open the installed software, *SVSImagIR*. The software revision number is located at the top left of the graphical user interface (GUI) and should read SVS ImagIR 3.0A5 or higher. Earlier release versions have reduced functionality.

5.2 Connecting a Camera

Make sure the camera is powered on and connected to the host machine.

Note: The camera can take up to 60 seconds to be recognized by the host machine.

Press the "connect device" button in the upper left-hand corner of the GUI to connect the software to the camera. If the camera is not recognized as an Acuros device, please see the **Troubleshooting** section below. A pop-up window will show the Acuros line under the USB or GigE device in the list. The fields in the GUI automatically populate with the most recently saved parameters including Firmware NUC settings.

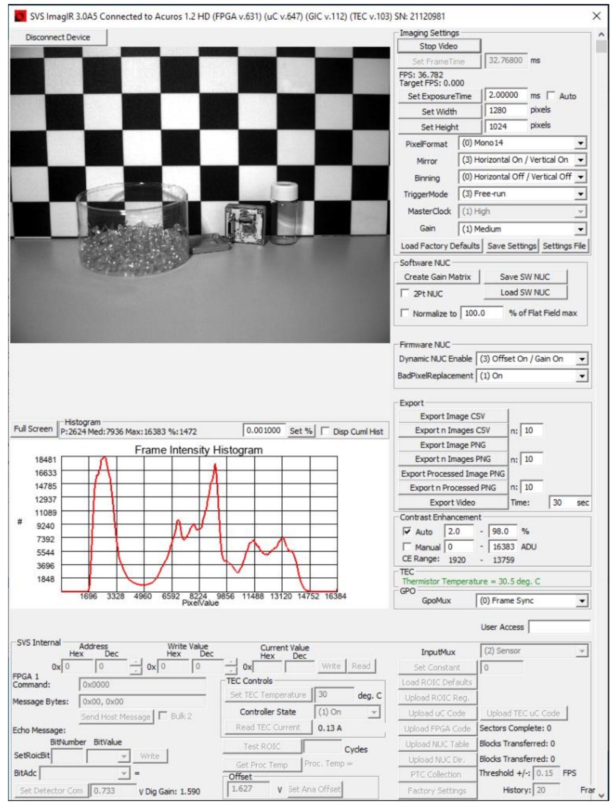


Figure 10: SVSImagIR Graphical User Interface displaying a scene with firmware NUC enabled

5.3 Imaging

The "Start Video" button under "Imaging Settings" turns on the live camera feed and displays an image on the upper left of the GUI.

Troubleshooting

When using a USB3 camera, it may be possible that a different software driver has been bound to the camera by default instead of the Pleora eBUS USB3 driver (see 4.2 Software Installation). To switch to the driver supplied by the Pleora eBus software, follow these steps:

1. Open the Device Manager application in Windows.
2. Locate the camera, listed as "USB3 Vision Device" under USB3 Vision Devices, and right-click to select the Update Driver option.
3. Select "Browse my computer for drivers."

4. Select “Let me pick from a list of available drivers on my computer.” This will automatically load any available drivers on your computer for the Acuros camera.
5. Select the “USB3 Vision Device Model” if there are multiple options and press Next.

Important note about Imaging

The GUI and image portion of this guide is designed for the user to begin by connecting the camera and starting the video to see images, then move to non-uniformity correction, contrast enhancement, and other features. In general, each session with the camera should follow this same process. Details on image control settings, contrast enhancement and other software features can be found in Section 6. Software non-uniformity correction (NUC) generation and use can be found in Section 7.

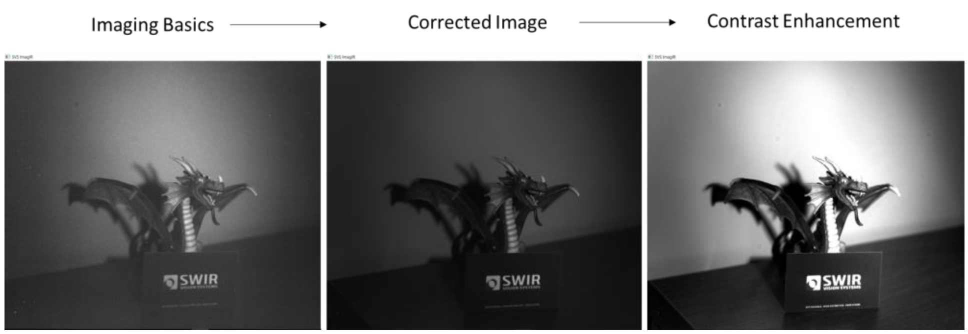


Figure 11. General flow for image and display enhancement.

6 Software and Image Controls

Important note: Field buttons must be pressed for GUI parameter value changes to take effect. Pressing Enter on the keyboard, will NOT lock in the change. For example, the "Set Exposure Time" button must be pressed after entering a new number in the "Set Exposure Time" field. This is not required for settings using pull-down menus.

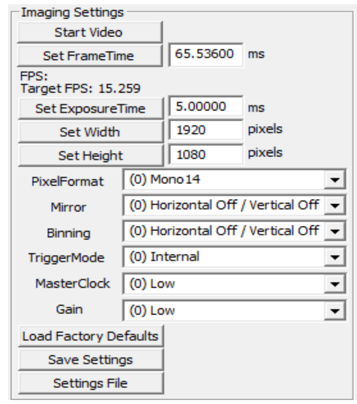


Figure 12: SVSImagIR Image and Video Controls

6.1 Video Data Path

The figure below shows the data path from the sensor (Readout integrated circuit or ROIC) through the FPGA's digital video output.

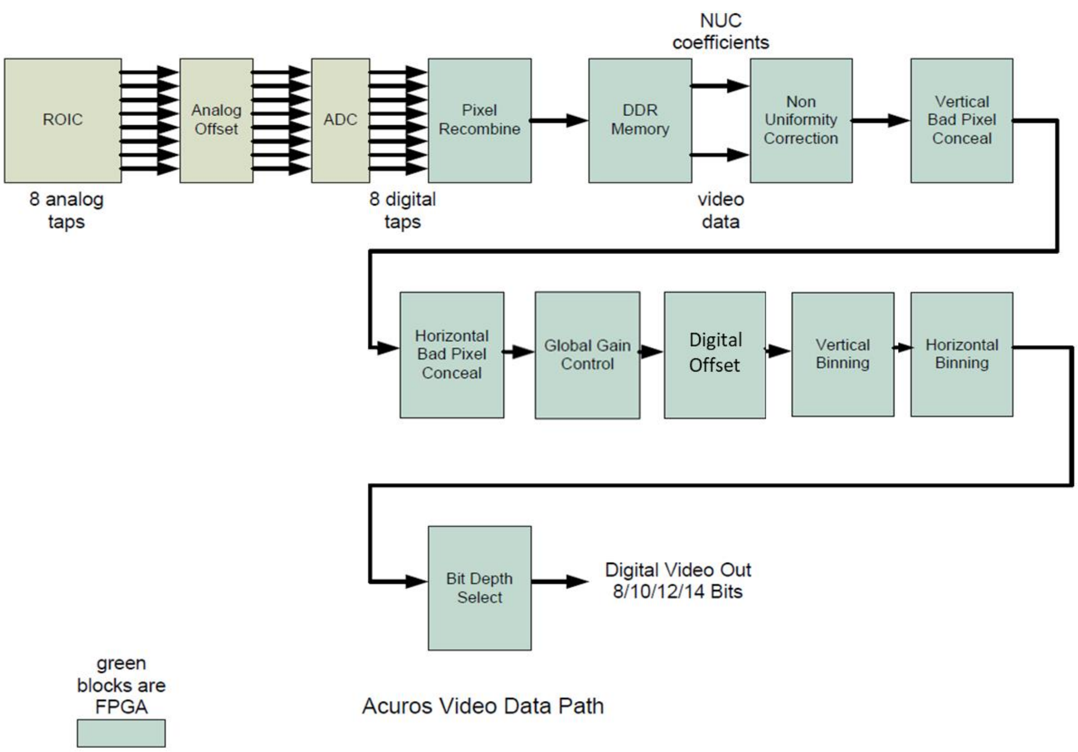


Figure 13: Acuros Video Data Path

6.2 Set Frame Time

Sets the frame time of the camera. The frame time cannot be set to a smaller value than the exposure time.

6.3 Frames per Second (FPS)

The actual frames per second (FPS) output from the camera and the target FPS are displayed below the Set Frame Time button. The primary parameter determining the FPS is the frame time, and other factors include the camera resolution, pixel format, clock speed, and windowing settings.

- Each version of the camera has a minimum frame time/maximum FPS depending on the resolution.
- There is a fixed, 2ms overhead on the camera readout time which gives a hardware-determined maximum frame rate of 500fps.
- The minimum vertical resolution is 256 pixels.
- Some example maximum frames per second data are shown in the table below for a 0.1ms exposure times and varying windowing settings.

Width setting	Height setting	Max Frames per Second (Low clock)	Max Frames per Second (High Clock)
1920	1080	30	60
1280	1024	47	94
640	512	167	333
256	256	500	500

Table 7: Maximum frames per second for different windowing settings.

6.4 Set Exposure Time

The exposure time, also known as the integration time, is set in this field. Typical exposure times range from 0.5ms (high speed applications) to 15ms (low light applications). The exposure time must be set to a value less than or equal to the frame time and has a 4290ms maximum. The minimum exposure time is 0.1ms.

6.5 Auto Exposure

When Auto Exposure is enabled, Exposure Time becomes a function of the median histogram level and manual entry is disabled. Auto-exposure is recommended for outdoor imaging applications or other applications where signal fluctuation cannot be controlled.

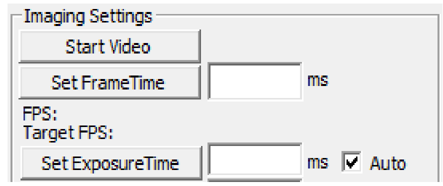


Figure 14. Auto Exposure Toggle

Important note: Always "Stop Video" before toggling Auto Exposure on or off.

6.6 Windowing Settings

Windowing settings allow the user to select the pixels read by the ROIC and are limited by the camera format. The table below shows the maximum values for the width and height settings for each format.

Format	Width	Height
VGA	640	512
1MP	1280	1024
HD	1920	1080

Table 8: Table showing windowing maximums for each Acuros CQD product

6.6.1 Set Width

This value sets the total number of pixels read by the ROIC in the horizontal axis. The value range is 64 to 1920 pixels and must be a multiple of 16.

6.6.2 Set Height

This value sets the total number of pixels read by the ROIC in the vertical axis. The value range is 4 and 1080 pixels and must be a multiple of 2.

6.6.3 Load Factory Defaults

This button allows you to restore factory default settings which are permanently stored in the camera firmware.

6.6.4 Save Settings

This button saves the current camera settings to non-volatile memory including the Imaging settings and Firmware NUC settings. The next time the camera is powered on it will have these settings. Software NUCs and contrast enhancement settings are not saved.

6.7 Pixel Format

Pixel format sets the bit-depth of the camera output as needed for user communication speed or to reduce the amount of output data. The video feed must be stopped before changing this setting. Note that only the Mono14 and Mono8 are supported by the current software version. Mono10 and mono12 are currently unavailable in the SVSImagIR interface but are available through the Pleora eBUS interface.

6.8 Mirror

This setting reflects the image on the x or y axis and is modified depending on the mounting position. Horizontal On/Vertical On is used in conjunction with a lens.

6.9 Binning

Binning forms a lower resolution image by summing the digital count values of adjacent pixels and is used only after a Firmware NUC Table has been enabled. This is implemented when imaging conditions result in a dark noise dominated output and may be useful in cases where more signal is desired and image resolution can be sacrificed.

6.10 TriggerMode

Image capture is triggered in three ways: internal, external, and external PWM (Pulse Width Modulation), and is set using the TriggerMode pull down menu.

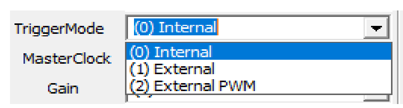


Figure 15: SVSImagIR Trigger Mode Menu

6.10.1 Internal Trigger

Internal trigger is used by the CSV (comma-separated value) export feature and uses the exposure time set in the user interface. Export PNG does not activate a trigger since the video must be stopped before export. The internal trigger delay has a sub-nanosecond jitter.

6.10.2 External Trigger

An external trigger signal input connection is available at the BNC connector attached to the Hirose power cable shown in Section 4.1. This trigger input accepts signals from 0V to a 5.5V maximum. The thresholds for the trigger input are 0.8V for logic low and 2.0V for logic high. The trigger input presents a 10K ohm load to ground to the signal driving source.

Two different trigger modes are offered with different exposure control mechanisms: external trigger uses the exposure time set in the user interface and external PWM uses the exposure time from the PWM input. Acuros cameras use Integrate Then Read (ITR) mode by default.

1. As shown in the first figure below, the trigger pulse width is a minimum of 1us. The exposure time here is determined by the Set Exposure Time field in the software interface. The trigger pulse input can be used to control the trigger period from the minimum frame time allowed. The minimum trigger period varies with camera format and windowing settings. More information on minimum frame time can be found in Section 6.3.

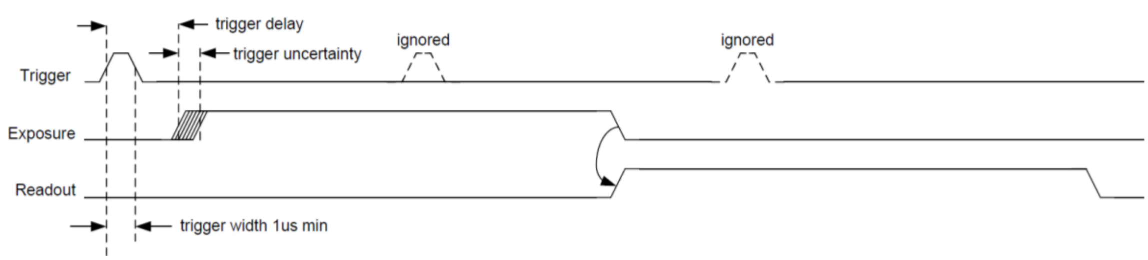


Figure 16: External Trigger timing diagram

2. Pulse width modulated (PWM) trigger uses an externally generated pulse to determine the frame exposure time. The exposure time is governed by the time between the rising edge and falling edge of the trigger pulse and has an associated trigger delay and uncertainly (jitter). The trigger period is determined by the time between the first trigger's rising edge and the next trigger's rising edge. Minimum trigger periods and trigger delay values are determined by the Acuros CQD camera format and are listed in the table below.

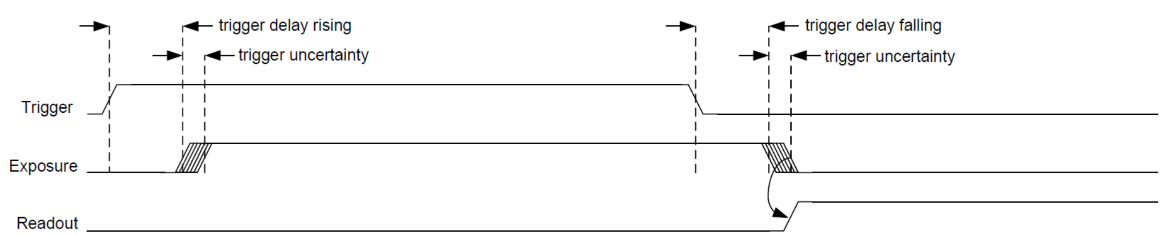


Figure 17: External Trigger PWM timing diagram.

Trigger Variables	Low Speed Clock	High Speed Clock
External trigger delay	250µs	125µs
PWM trigger delay rising	250µs	125µs

PWM trigger delay falling	750ns	375ns
Trigger uncertainty	250ns	125ns
Minimum HD PWM trigger period	33.3ms	16.7ms
Minimum 1MP PWM trigger period	21.3ms	10.7ms
Minimum VGA PWM trigger period	6ms	3ms

Table 9: Trigger timing values for the Acuros CQD 1.1 camera products

6.11 Master Clock

The Acuros CQD Camera Master clock has two settings, High and Low and governs the sensor readout IC frequency.

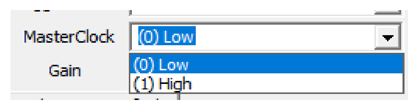


Figure 18: Master Clock Pull-Down Menu

Low master clock can be used with the Mono14 pixel format and provides guaranteed 14bit precision on the camera's output imagery.

High master clock speed doubles the maximum allowable frame rate for a given set of parameters, but the readout IC settling time reduces guaranteed accuracy to 10bits. Master clock speed combines windowing and pixel format settings to determine the maximum possible frame rate.

When dynamic NUCs are enabled, master clock is automatically set to the default value of **(0) Low**.

Refer to Section 6.3 for more specifics on how windowing and clock speed interact.

6.12 Gain

The Gain setting adjusts the integration capacitor in the pixel input amplifier. Higher gain modes increase the signal to noise ratio when the noise is dominated by the camera electronics. The **(1) Medium** and **(2) High** Gain modes are most useful at shorter integration times and lower light levels. At longer integration times, the sensor dark current can dominate and will override noise improvements seen in higher gain modes.

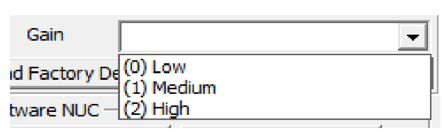


Figure 19: Gain Mode Pull-Down Menu

The table below describes the designed full well capacity (FWC) of the pixel input amp for each gain mode.

Gain mode	FWC [e-]
High	26,000
Mid	110,000
Low	550,000

Table 10: Full Well Capacity of Each Gain Mode

6.13 Load Factory Defaults and Save Settings

The Acuros CQD Camera parameters can be changed to achieve the desired image output. **Save Settings** will record all the current camera parameters into nonvolatile memory which will become the new power-on defaults. Two-point Software NUCs and Contrast Enhancement are host-machine parameters and will not persist when the SVSImagIR GUI has been closed. The SW NUC can be explicitly saved - see SW NUC section below 7.1.2.

The **Load Factory Defaults** command can be used to reset all the Acuros CQD Camera software parameters to their original (factory) values. These will not be recorded into non-volatile memory until **Save Settings** is issued.

6.14 Settings File

The Settings File button opens a dialog box with options to load a camera settings file or to create a new settings file with the current camera parameters. Clicking either option opens a standard Windows dialog box to either open or save a .CSV format file, 'Load Settings File' and 'Create Settings File' respectively. The parameters affected include Imaging and FW NUC settings.

Figure 20: Settings File Dialog Box

The User Access password will include the SVS Internal Parameters in addition to the above settings. An SVS provided password is required to load or save these parameters in the Settings Files.

6.15 Contrast Enhancement

Under most imaging conditions, the camera output occupies a portion of the camera's full digital output range. By default, the software maps the full camera output range (0 to 16383 ADU) onto the full display range, typically between 0 and 255 for an 8-bit greyscale image. With contrast enhancement, the software maps a subset of the camera's range onto the host machine display's full digital range. The camera's display range can be selected manually or automatically.

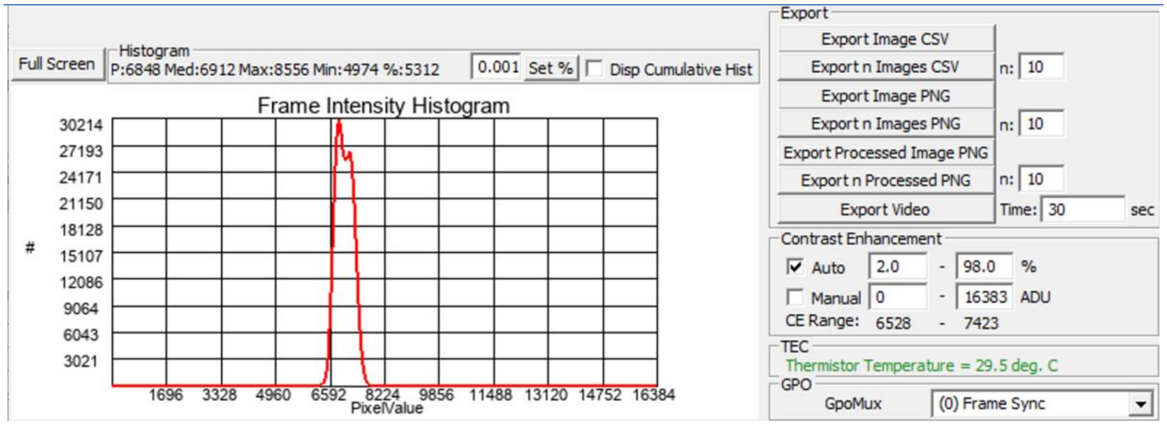


Figure 21: SVSImagIR Export, Contrast Enhancement, Histogram and Output Interface

6.15.1 Auto-Contrast Enhancement (ACE)

Auto-contrast enhancement (ACE) selects a percentile of the camera output range to expand onto the full display range. ACE is enabled by checking the box to the left of the ACE text with typical settings of 2-5% in the box on the left and 95-98% on the right. ACE mapping is automatically updated with changing imaging conditions. The Cumulative Histogram setting shows the camera output and CE Low and CE High values indicate the upper and lower ADU (Analog-to-Digital Units) limits of the mapping range.

Auto-contrast Enhancement is set to 2.0-98.0% upon software startup by default.

6.15.2 Manual Contrast Enhancement (MCE)

The user can choose which portion of the camera's digital output is mapped onto the display's digital range. This range is enabled once the checkbox next to Manual is checked.

6.16 Other Software Features

This section describes other software features except the Non-Uniformity Correction (NUC) controls. For NUC control, please refer to Section 7.

6.16.1 Export

The export feature allows the user to export the imaging data in various formats.

6.16.1.1 Export Image CSV

These buttons export CSV ADU values for each pixel to a single file from a static image or to a group of 10 files from a video feed in real time. The video must be stopped for the single image CSV. Video must be running for the multiple images CSV and a Windows Explorer dialog box will prompt the user for a file name and location.

6.16.1.2 Export Image PNG

These buttons export a static image in a portable network graphic (PNG) file to a single file. Export Image PNG exports a camera image without the contrast enhancement applied. Export Processed Image PNG exports the camera image with the applied contrast enhancement. The video feed is stopped for these exports and a Windows Explorer dialog box will prompt the user for a file name and location.

6.16.1.3 Export Video

This feature exports up to 30 seconds of the video feed in an .mp4 format. A Windows Explorer dialog box will prompt the user for a file name and location.

Note: The exported video is encoded for a 30fps playback, regardless of the camera settings during video capture. The video capture duration is determined by its time setting (default 30sec) and will record all the frames output from the camera during the capture time. When using the default time setting of 30 seconds, if the camera is set for less than 30 fps, the total video time will be proportionally shorter; e.g., a camera frame rate of 15 fps will result in a total video time of 15 seconds instead of 30 seconds and will appear accelerated. Conversely, if the camera frame rate is 60fps, the exported video, played back at 30fps, will appear in slow motion, and will last 60sec.

Frame rate is primarily governed by Set Frame Time, Window and Master Clock settings. Section 6.1 has more details on maximum frame rates.

6.16.2 Histogram

The camera histogram displays the number of pixels at each PixelValue bin (the analog-to-digital unit) as is highlighted in Figure 39 by the pink and yellow boxes. At the top of the histogram are basic statistics: peak (red box), median (green box), maximum, minimum, and the value of the pixel(s) at the specified percentile of the distribution (blue box).

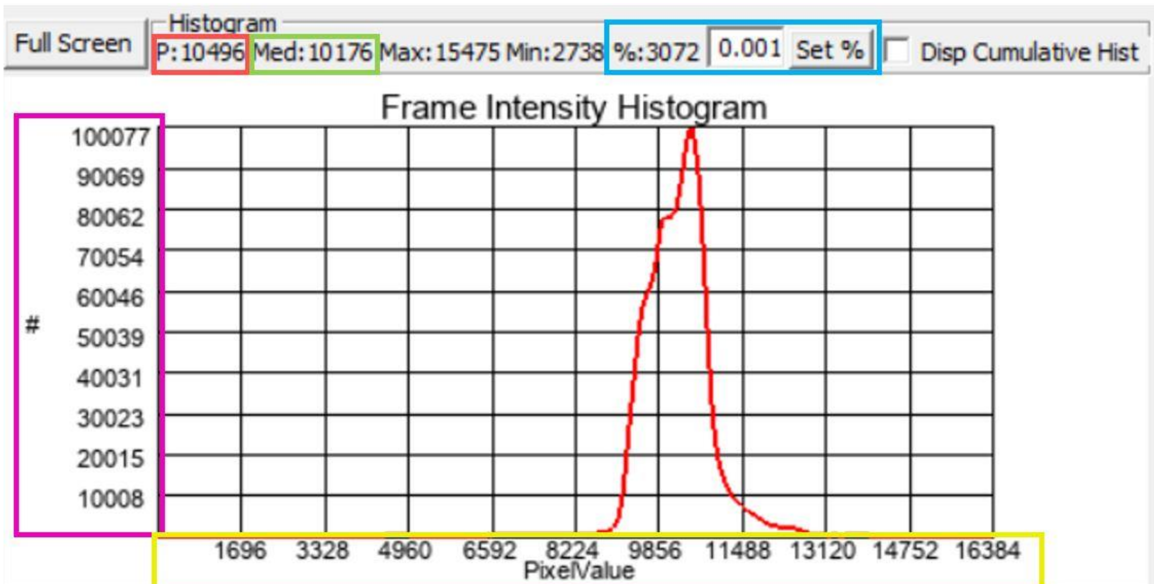


Figure 22: Typical uncorrected flat field histogram with various aspects highlighted

The cumulative display shows the total count as a function of display units.

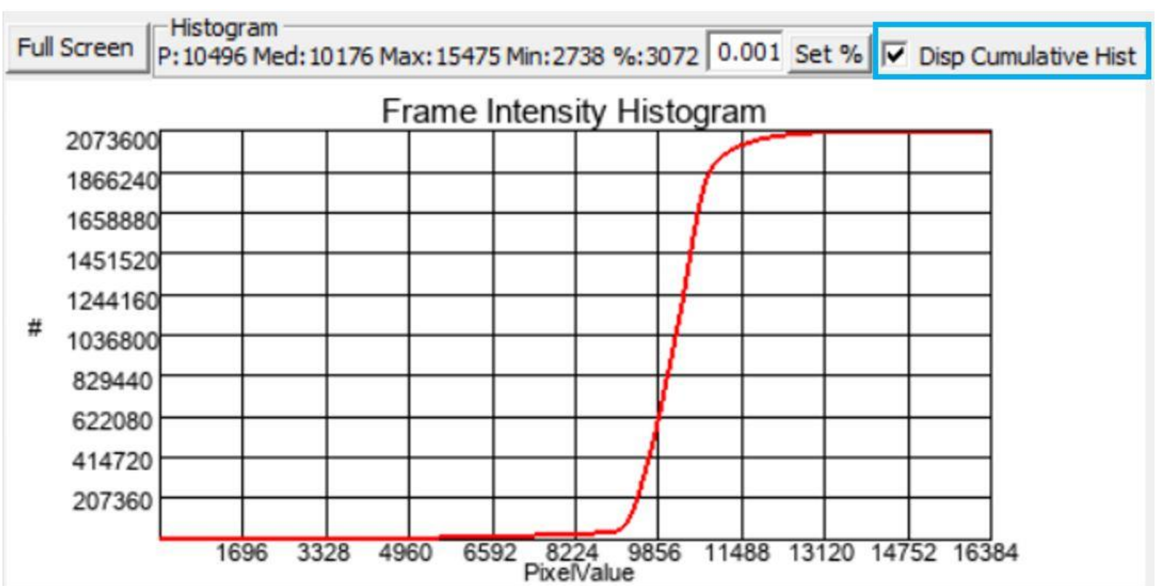


Figure 23: Typical flat field histogram with Disp Cumulative Hist checked

6.16.3 TEC (ThermoElectric Cooler)

The thermistor temperature indicates the temperature of the camera sensor in its package, not the temperature measured anywhere else on the camera. The factory default settings are Controller State 'On' and Temperature setpoint of 30°C.

6.16.4 General Purpose Output

The GPO (general purpose output) is available on Pin 9 of the rear panel Hirose power connector. It provides external access to one of three internal timing signals that may be useful for synchronizing external electronics to the readout of an image. The GPO signal is 3.3V, positive polarity and derived from internal circuitry. The user cannot change the polarity, but a custom polarity can be provided. The choices of signal are:

1) Frame Sync, which is asserted during the readout of a video frame.
2) Line Sync, which is asserted during the readout of each video line.
3) Exposure, which is asserted during the period in which the sensor is sensitive to incoming light.

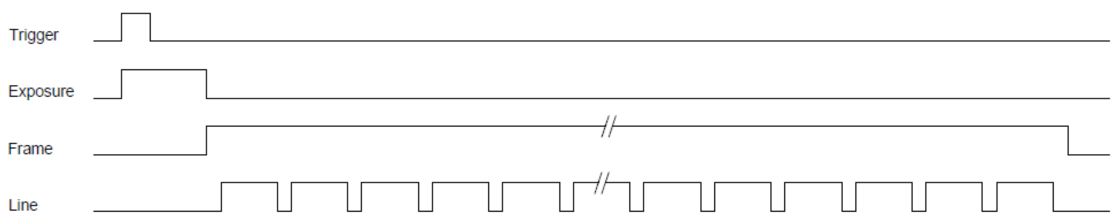


Figure 24: General Purpose Output Timing Relative to Trigger

6.16.5 Full Screen

Clicking the Full Screen button between the camera image and the histogram generates a separate window containing the live image which can be moved or expanded to full screen. This only works when the camera video is running.

6.16.6 Scrolling

1. Click and drag the side bar handle to scroll through the GUI screen.
2. Hovering the cursor over any pull-down menu allows mouse-wheel control of the option.

6.16.7 Zoom feature

When the cursor hovers over the GUI image, the mouse wheel controls the zoom of both the software display image and the full screen image.

7 Non-Uniformity Correction (NUC)

The Acuros CQD Camera uses dynamic non-uniformity correction to compensate for pixel-to-pixel spatial non-uniformities across the sensor. This method uses a fitted representation of both the dark signal and the photoresponse to calculate an offset and a gain for each pixel as a function of exposure time. These corrections are stored in the firmware Gain & Offset NUC tables. Each camera ships with three sets (1 set for each analog gain) of factory-generated firmware NUCs preloaded on the camera.

NUC quality will also depend on TEC operating temperature (see Section 8) and master clock. Default values of 30C and Low Master Clock come standard on Acuros cameras.

Acuros cameras provide additional 2pt software NUCing functionality to provide enhanced image quality required in certain applications. Software NUC tables can be generated in the field or saved to the camera firmware in non-volatile memory.

7.1 Software NUC Table Generation

The software NUC (also 2Pt NUC) is a camera feature that enables a higher quality image by correcting for non-uniformity in pixel response, lighting conditions, lens distortion and other factors that can degrade the image. This can be applied in addition to, or separate from the firmware NUC.

The software NUC is created by taking two images and loading them to the camera. The first image is an image taken in the dark and the second is an image taken of a uniformly lit field (flat field). A gain matrix is then generated automatically from these images. The gain matrix (i.e. software NUC) can be stored on the host machine. Should connection to the device be interrupted, the stored gain matrix may be reloaded.

Once the NUC is applied, the camera image quality should be improved for the specific lighting and lens combination. SWIR Vision Systems always recommends creating and using a software NUC. A similar function may also be implemented in other applications such as Python or C++; please contact technical support for more information.

Important note: Only the Auto Contrast Enhancement, Manual Contrast Enhancement, and Normalize to % of Flat Field max features should be changed while a software NUC is enabled. Changing SetWidth, SetHeight, Exposure Time, Mirroring State, or Analog Gain State when a 2pt NUC is enabled will result in a distorted and/or poor image but should return to normal after resetting them to the values used while creating the NUC.

7.1.1 Equipment

- Camera
- Host PC with SVSImagIR software
- Light Source (halogen or SWIR)
- Light diffuser
- Flat white surface to image (e.g. a white wall)

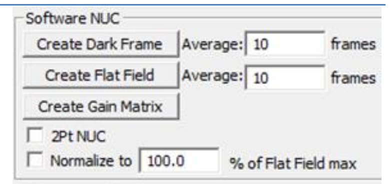


Figure 25: SVSImagIR Image Software NUC Interface

7.1.2 Procedure

1. Adjust all desired settings that affect the software NUC:

Affects Software NUC	Independent of Software NUC
ExposureTime	FrameTime
Width	TriggerMode
Height	MasterClock
PixelFormat	NucTable if NucEnable is (0) Offset Off / Gain Off
Mirror	Auto Contrast Enhancement
Binning	Manual Contrast Enhancement
Gain	GpoMUX
NucTable if NucEnable is not (0) Offset Off / Gain Off	
BadPixelReplacement	

Table 11. Summary of camera settings and their impact on non-uniformity corrections (NUCs)

2. Ensure 2pt NUC and Normalize to % of flat field max checkboxes are blank (see Figure 42)

Creation of the Gain Matrix:

3. Under **Software NUC**, click **Create Gain Matrix**.

4. A dialogue box will ask you to create Dark Field Conditions. Close the lens aperture (if applicable) and place the cap on the camera (no light should reach the sensor). Click Ok.

5. The dialogue box will ask you to create Flat Field Conditions. Remove the cap and open the aperture (if applicable) to the desired position. Point the camera at a

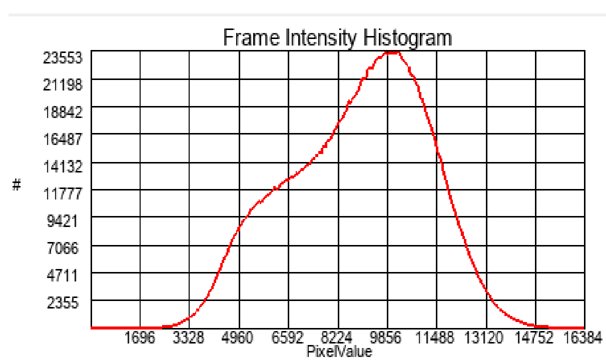


Figure 26: Sample Histogram, uncorrected flat field image.

uniformly illuminated flat scene (e.g., a reflective aluminum or white cardboard sheet).

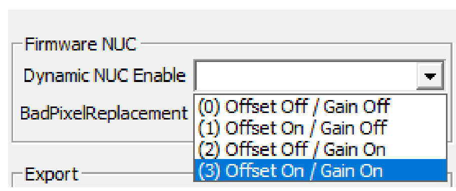
6. Cover the lens or sensor with the light diffuser.
7. Change the focus of the lens, if applicable, to be out-of-focus.
8. Click Ok.
9. A Windows Explorer dialog box will inform you that a Gain Matrix has been created and that you may now enable the NUC by checking the box labeled **2Pt NUC**.
10. The Gain Matrix can be saved for later use by clicking **Save SW NUC**. You can upload an existing NUC from the host machine by pressing **Load SW NUC**.

7.2 Firmware NUC

The Firmware NUCs preloaded on Acuros cameras are dynamic. When enabled, these NUCs will correct for signal dependent variations in dark signal and photoresponse.

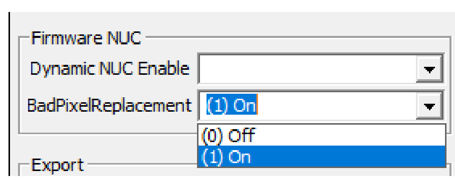
ⓘ **Important note:** Firmware NUC tables are tied to analog gain and master clock states. Changing Analog Gain states will automatically change the Firmware NUC table. Master Clock is disabled when a Firmware NUC is enabled.

7.2.1 Dynamic NUC Enable Settings



The Dynamic NUC Enable field allows the user to choose which aspect of the tables are turned on: the firmware dark offset (pixel value offset), gain matrix (pixel response) or both. For most applications, the best results will be obtained with **(3) Offset On/Gain On**. Once enabled, Offset & Gain corrections will help to improve image quality over a range of exposure times. Typically, this range is between 1ms and 15ms but performance may vary based on the application and setup.

7.2.2 Bad pixel replacement



Some of the pixels on the camera sensor may not operate correctly due to defects in the fabrication process. A firmware pixel correction table is loaded into the camera with each firmware NUC table before shipping and corrects these pixels by averaging the response of the surrounding good pixels. Bad pixel correction should be left on, **BadPixelReplacement: (1)On**, in all cases and remains on whether NUC tables are enabled or not.

8 Thermal Considerations

The Acuros CQD sensor generates heat which can affect device performance. Thermal noise, for example, can be a source of non-uniformity and is a function of operating temperature (as well as other imaging settings). To mitigate this temperature dependence, the Acuros CQD Camera uses a thermoelectric cooler (TEC) in the sensor package. In addition, the camera housing and lens mounts are designed to carry heat away from the sensor to the external environment. The default settings of the TEC Controller are 'On' with a 30°C setpoint.

8.1 TEC Control

The TEC is enabled upon camera powerup with a setpoint of 30C and does not require the User Interface to run. The TEC function uses a thermistor for its control loop and has an available temperature setpoint range of 10C to 45C. The TEC controller state can be set to 'On' or 'Off' which enables or disables the TEC. The actual thermistor temperature is displayed in the SVSImageIR GUI under the user interface section called "TEC." The controller state and the current being consumed by the TEC are also displayed in the bottom section of the GUI.

⚠**Warning:** To maximize performance and sensor lifetime, the device must be mounted securely to a large thermal mass. Alternatively, heat can be displaced away from the case using forced air. Using thermally insulating materials and blocking airflow may result in elevated case temperatures.

⚠**Warning:** Changing the controls from the default settings can result in overheating and possible damage to the camera electronics and sensor.

⚠**Warning:** Any change to the default settings must be done under the guidance of SWIR technical support and carries risk or damage to the sensor and camera.

9 Software Command Protocol

9.1 Settings and Memory

The camera parameters are loaded from a nonvolatile memory into the FPGA each time power is applied. When a camera parameter is changed (via a UART command) during normal camera usage, the change is not reflected in the nonvolatile memory. If it is desired that the change be "permanent", the **Save Settings** command will record ALL of the current camera parameters in nonvolatile memory. These parameters will then become the new "power-on defaults". The **Load Factory Defaults** command can be used to reset ALL the parameters to their original (factory) values. These parameters will not be recorded in nonvolatile memory until a **Save Settings** command is issued.

9.2 Driver compatibility

1. The SVSImagIR GUI is compatible with Windows 10 and 11. It does not support MacOS nor Linux systems.
2. Please refer to the *Software Guides and Documentation* section of the website to check for latest guides on driver compatibility.