AxCIS Quick Installation and Start-Up Guide

Overview

This guide outlines the steps for the initial mechanical setup, camera configuration and imaging with AxCIS module along with a Teledyne DALSA Xtium2-CLHS FX8 frame grabber to capture synchronized images, ensuring a seamless imaging process.

Requirements & Installation

The following must be available or installed:

Hardware

The following table lists the recommended AxCIS models. A 24V 5A (minimum) power supply is required. Refer to the AxCIS documentation for cable, connector, power and pinout information.

AxCIS Model	Description
AX-FM-04B12H-00	400 mm field of view
AX-FC-04B06T-00	400 mm field of view
AX-FM-08B12H-00	800 mm field of view
Accessories	
AC-LE-10004-xx	White LED light 400 mm
AC-LE-10008-xx	White LED light 800 mm
AC-CA-00424-xx-x	Power cable for CIS module

The following table is provided to support the specific fiber optic cabling needs of the user (2 or 4 per AxCIS). For the complete table with all cable lengths (10, 15, 30 and 50 m) refer to the AxCIS user manual. The individual parts can be ordered from Teledyne DALSA or a third party.

Part #	Child Part	Mfg'er part#	Description		MFG
	720-00335-00	OM3-LC-LC-DX-FS-10M-PVC	Fiber Optic Cable;10M		Fiberstore
AC-CA-00220-00-R	730-00091-00	SFP-10GSR-85	XCVR 10GBASE-SR SFP+		Fiberstore
Compatible Frame Grabber					
OR-A8S0-FX840		Teledyne DALSA Xtium2-CLHS FX8			
Accessories					
OR-YXCC-27BE2M1		DH40-27S Cable to Blunt End. Cable for External I/O Signals			

Refer to the Xtium2-CLHS FX8 documentation for cable, connector and pinout information.

Software

Sapera LT CamExpert tool (included with installation of Sapera LT SDK 8.74 or higher) for AxCIS configuration; available for download from the Teledyne DALSA website: https://www.teledynedalsa.com/en/products/imaging/vision-software/sapera-lt/

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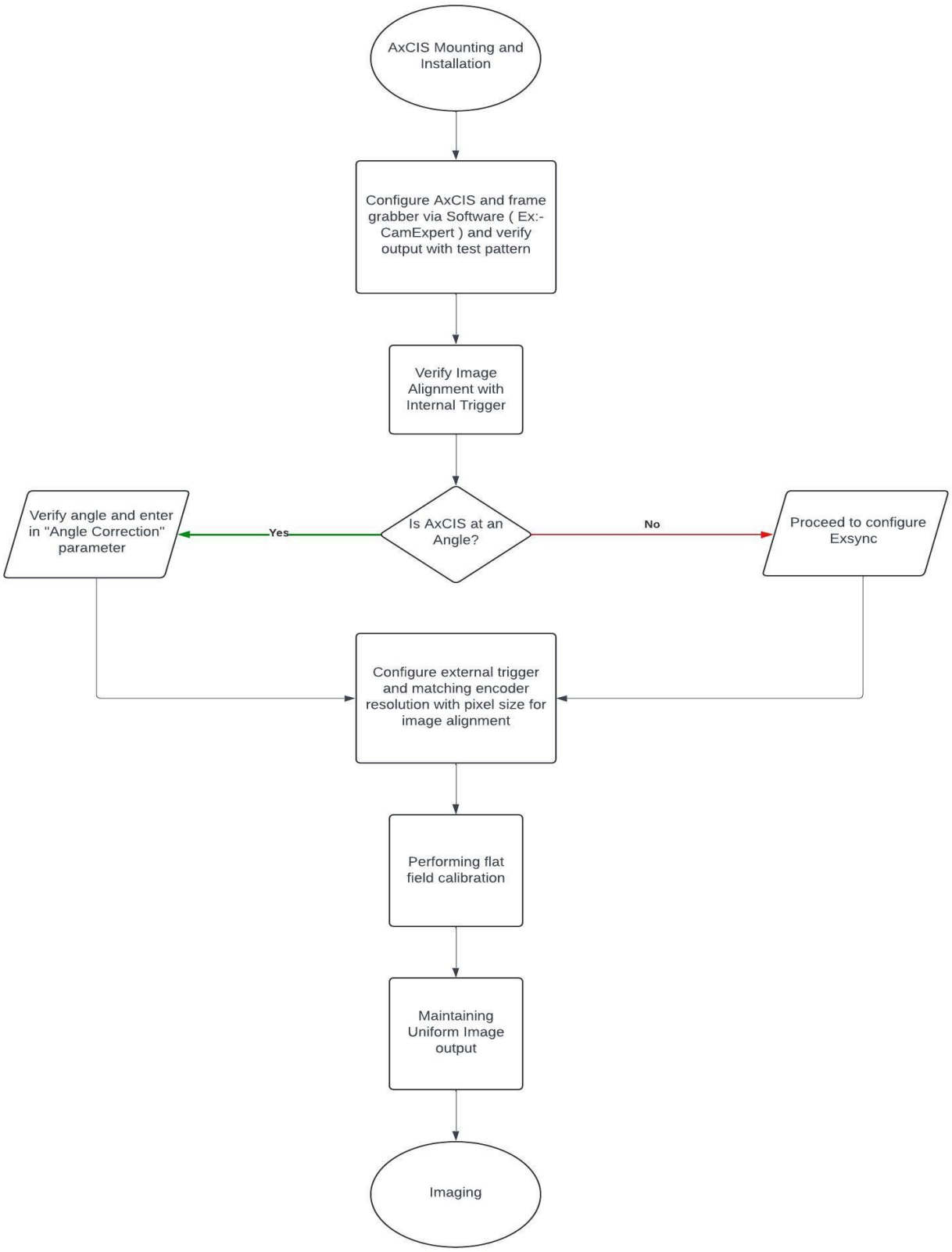
AxCIS Installation and Setup Flowchart



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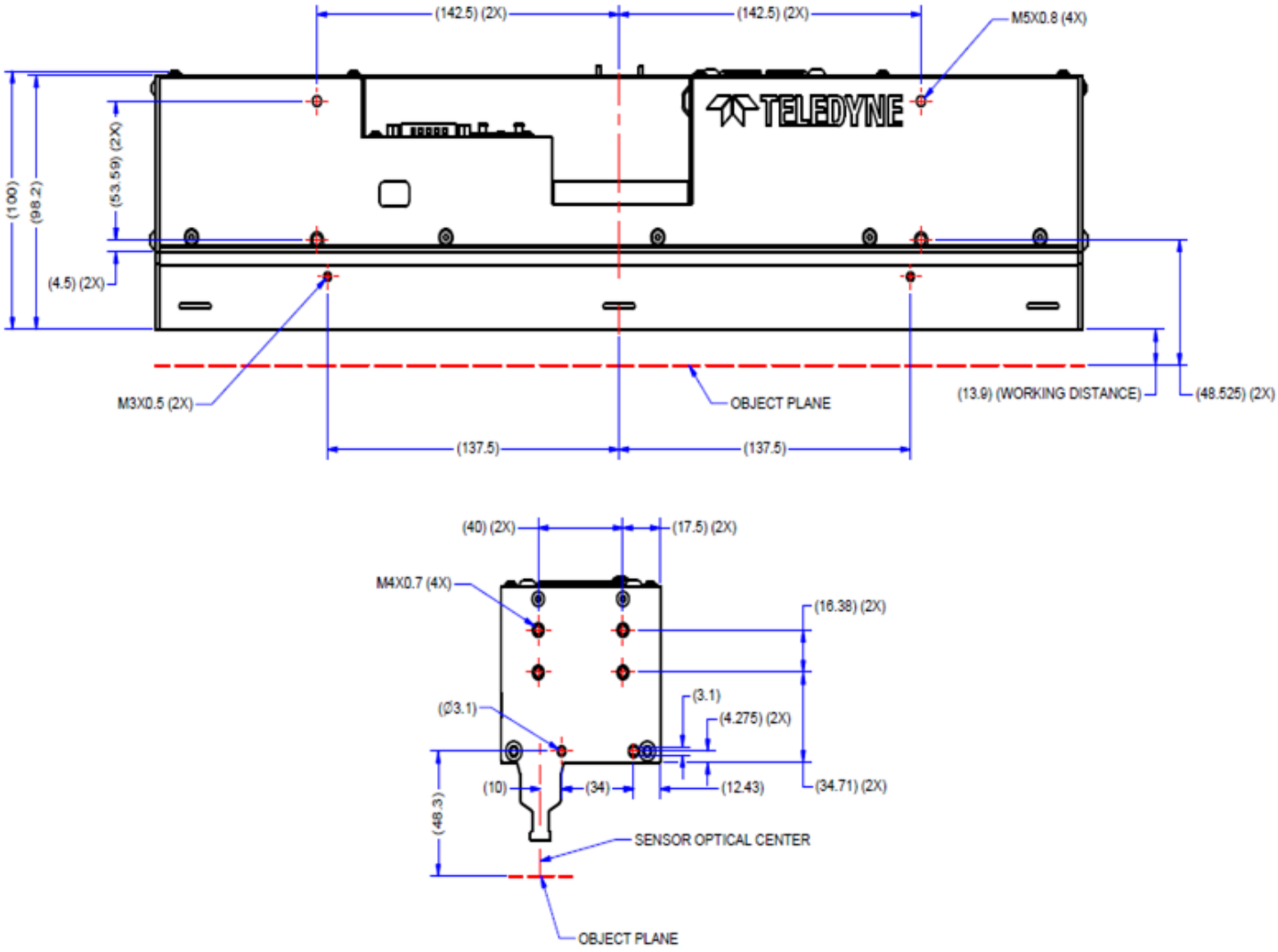
AxCIS Mounting and Installation



AxCIS module includes mounting holes on the top, bottom, and sides. Use these holes for mounting as required, considering the following steps:

- Ensure the module is parallel to the target surface and aligned along the same axis.
- To get a sharp image output ensure both sides of the module are at a working distance of 13.9 mm (± 0.5 mm) so that the entire field of view (400/800 mm) is in focus.

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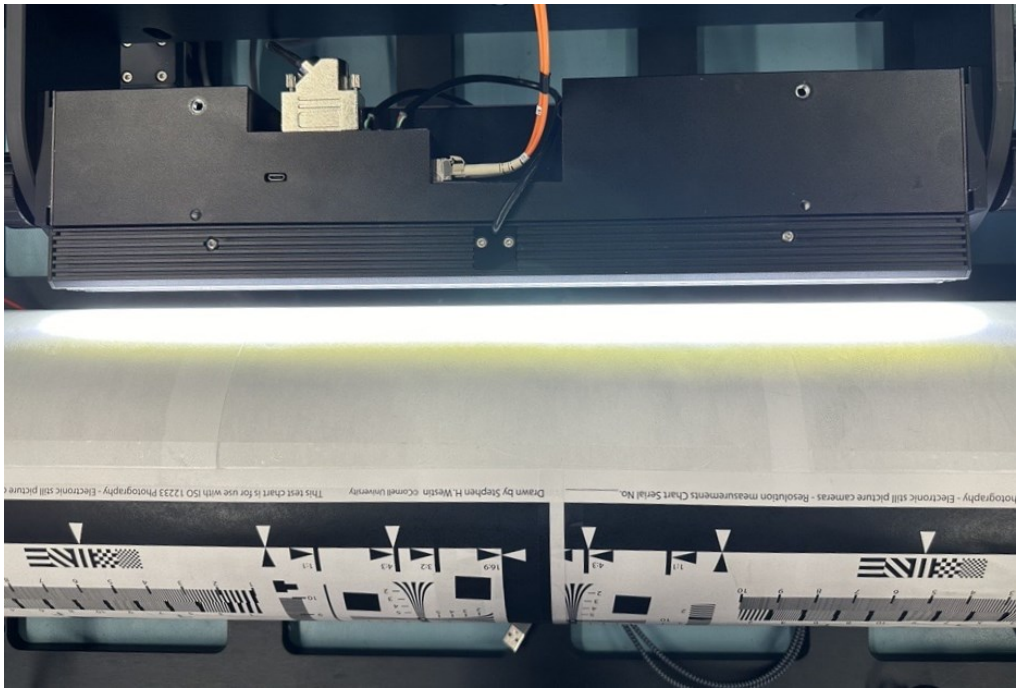

Figure 1: AxCIS mounted parallel to target

1) Position the optical axis perpendicular to the target surface.

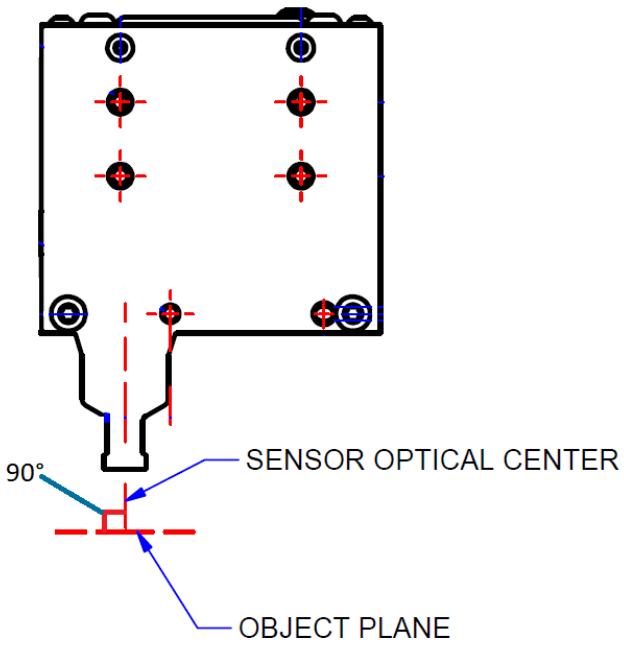

Figure 2: Optical center perpendicular to object surface

2) Orient the length of the module perpendicular to the direction of the object under inspection.The module's complete length must be aligned perpendicular to the width of the object's direction under inspection. This ensures that the module is correctly oriented relative to the object under inspection.

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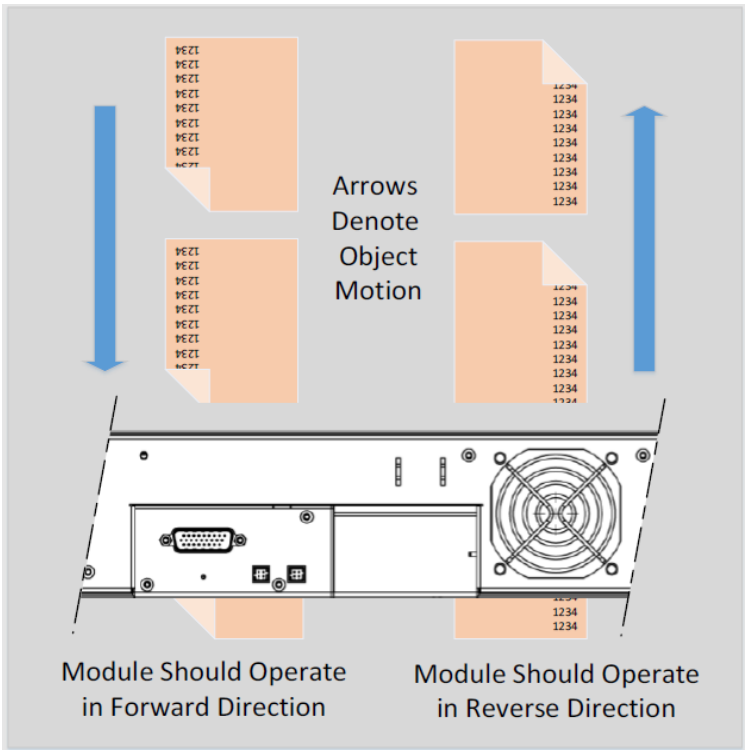

Figure 3: Perpendicular to the scan direction

AxCIS Architecture Overview

Currently, AxCIS is available in two field of view options: 400 mm and 800 mm modules.

The 400 mm variant is a single primary module that can be connected to the frame grabber to begin image acquisition.

The AxCIS 800 mm configuration consists of two 400 mm camera modules that collectively offer a larger field of view. In this architecture, the modules operate in a Parent-Child relationship, with each 400 mm module being recognized independently as a line scan camera by the frame grabber.

The CLHS interface to each 400 mm module are completely independent. That is, when external triggers (EXSYNC) are received by the frame grabber, they are forwarded to both the Parent and Child modules at the same time. The Child module uses the LVAL from the Parent; in this manner, the Parent module controls the Child module's acquisition. If no LVAL is present on the Parent, the Child will not grab, even if a trigger, for example from a shaft encoder, is received by the Child.

Figure 4: AxCIS 800 mm Overview

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The Parent LC fiber optic cables are connected to the frame grabber port 1 and 2; the Child to port 3 and 4. One or two LC fiber optic cables are supported; using 2 cables per module allows for higher bandwidth and corresponding higher possible maximum line rates. For 400 mm variant, one or two LC fiber optic cables can by connected to port 1 and 2.

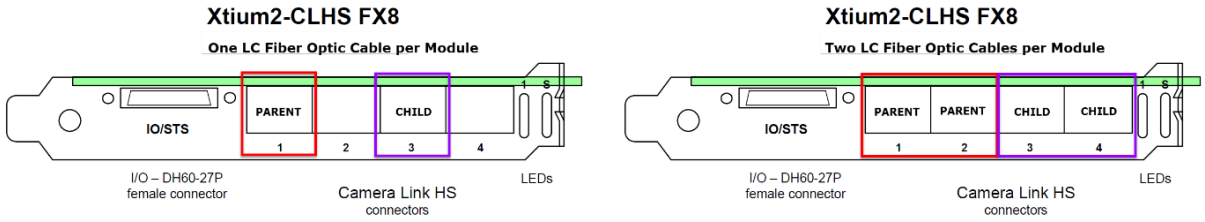


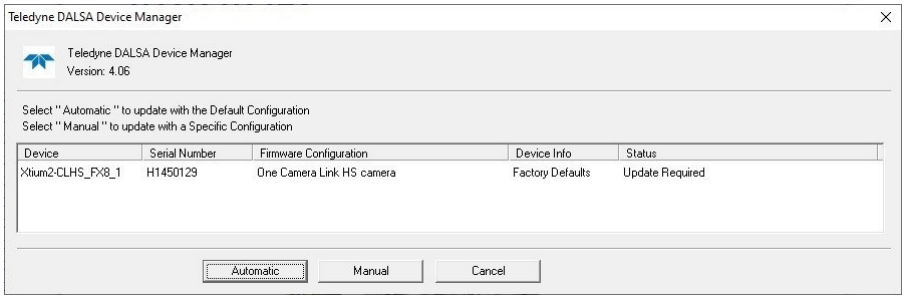
Figure 5: Xtium2-CLHS Camera Link HS Connections for AxCIS Parent & Child Modules

Typically, shaft encoder and external triggers are connected to the frame grabber through the I/O connector using the DH40-27S cable (OR-YXCC-27BE2M1). Alternatively, triggers can also be connected directly to the camera using the GPIO pins; refer to the AxCIS user manual for more information.

Selecting the Required Firmware Configuration

Refer to the Xtium2-CLHS FX8 documentation for details on installation.

To complete the installation, update the Xtium2-CLHS FX8 firmware when prompted; select Automatic to update the firmware to default configuration or select Manual to choose an alternate configuration.



When using a single AxCIS module, such as the 400 mm version, select the default firmware configuration **One Camera Link HS camera.**

When using an AxCIS with 2 modules, such as the 800 mm version, the frame grabber must use firmware configuration **Two Camera Link HS cameras.** The firmware configuration is set using the Teledyne DALSA Device Manager tool included with the frame grabber driver installation and is available through the Windows Start menu (administrative rights are required to update the firmware configuration).

First, on the Device Update tab, select the required firmware from the Configuration drop-down list. Second, click Start Update button which should be green.

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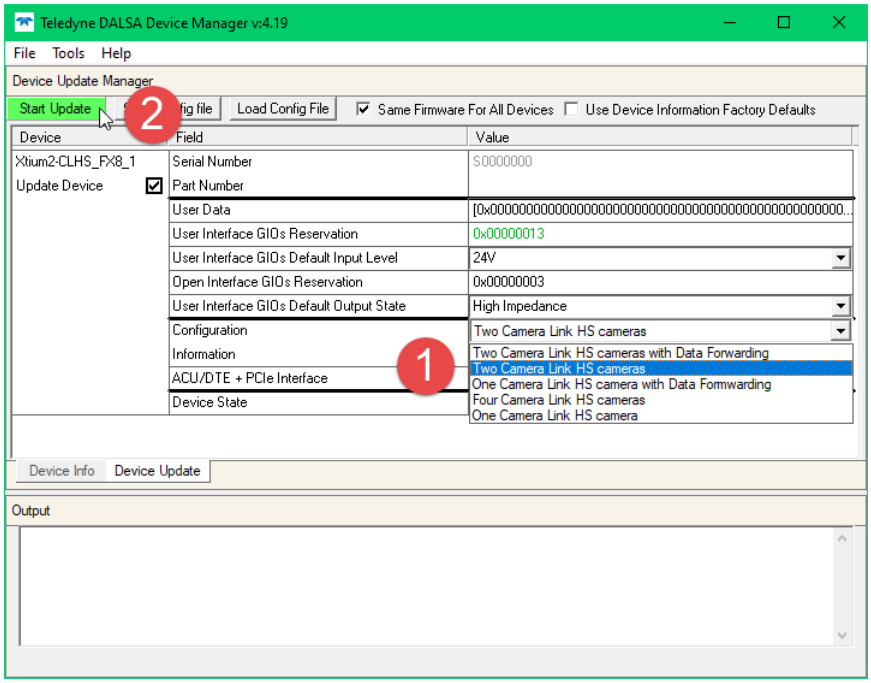


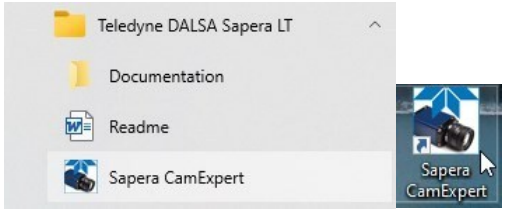
Reboot the system when all software and board drivers are installed.

AxCIS Configuration Using CamExpert

This procedure details the steps required for an AxCIS 800 mm; for the 400 mm model no synchronization is necessary since it is seen as a single camera and setup is like that of any other line scan camera.

When using an AxCIS 800 mm, two instances of CamExpert are required since each module is seen as a separate camera.

Use the Windows Start menu or desktop shortcut to launch CamExpert:



For the Parent module, in the first instance of CamExpert, in the Device drop-down list, select **CameraLink HS Mono #1** (Mono Camera) or **CameraLink HS Color RGB #1** (Color Camera).

For the Child module (only for 800 mm), in the second instance of CamExpert, in the Device drop-down list, select **CameraLink HS Mono #2** (Mono Camera) or **CameraLink HS Color RGB #2** (Color Camera).

Parent Module Child Module

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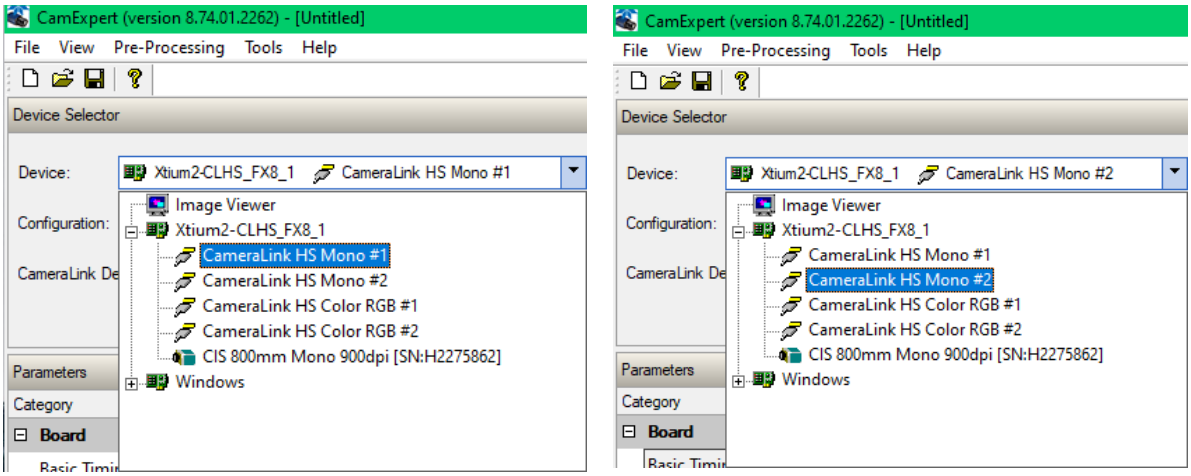
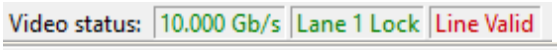
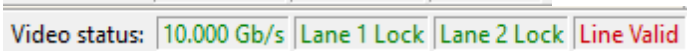


If the camera is properly connected to the frame grabber, the Video status bar at the the bottom right of the display window should show the CLHS connection speed and lane locks in green. At this point, the line valid shows red since trigger configuration has not been completed.

When using 2 cables per module, the CamExpert Video status bar displays Lane 1 Lock and Lane 2 Lock in green; 1 cable displays Lane 1 Lock in green.

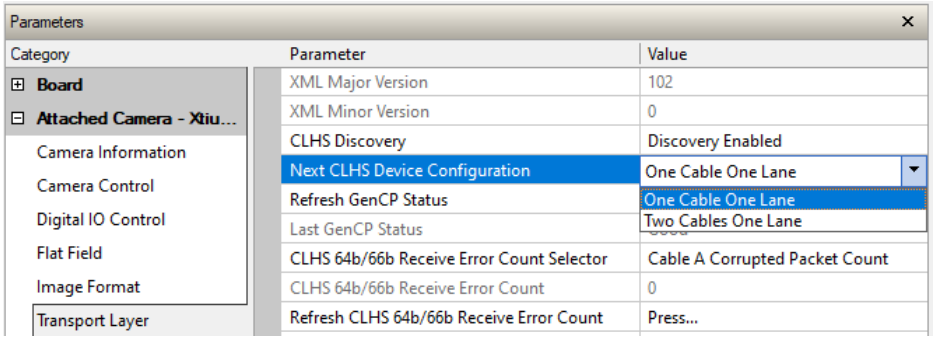
1 cable: 

2 cables: 

Setting the CLHS Cable Configuration

In the camera section's Transport Layer category, set the number of LC fiber optic cables used by the module in the Next CLHS Device Configuration feature; One Cable One Lane or Two Cables One Lane.

For AxCIS 800 mm, this must be done for each module, Parent and Child.



If the *Next CLHS Device Configuration* is modified, reset the camera to initiate the CLHS discovery process.

In the Board section Basic Timing category, verify that the *Data Lanes* parameter is set to the number of cables, 1 or 2. In addition, ensure that *Camera Type* is set to Linescan.

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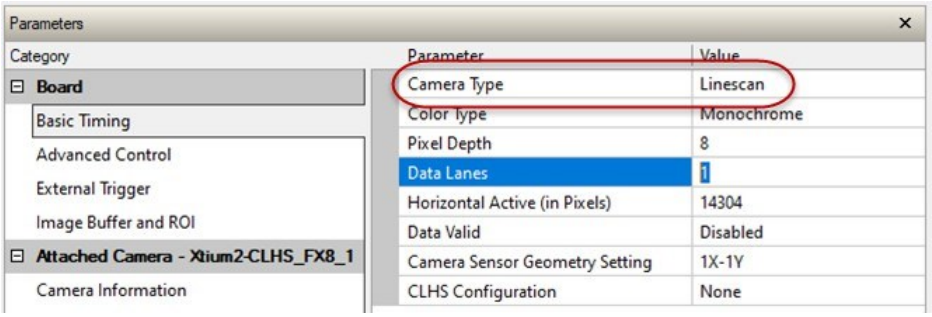
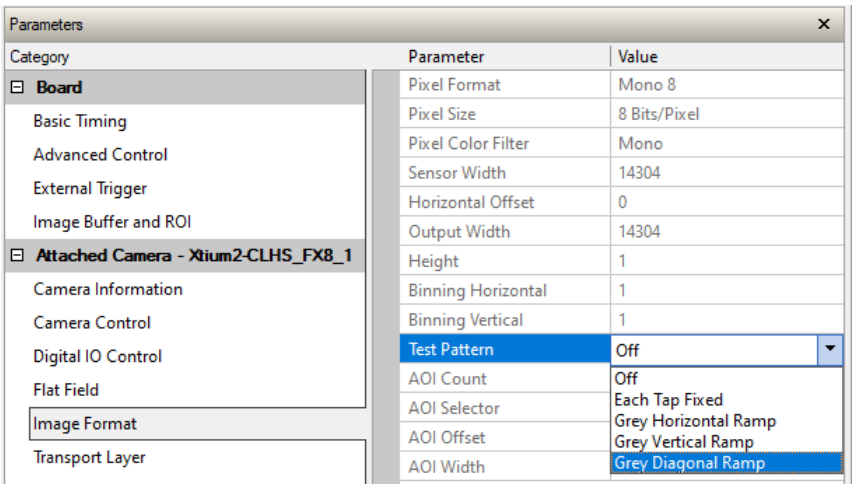


Initial Verification with Test Pattern

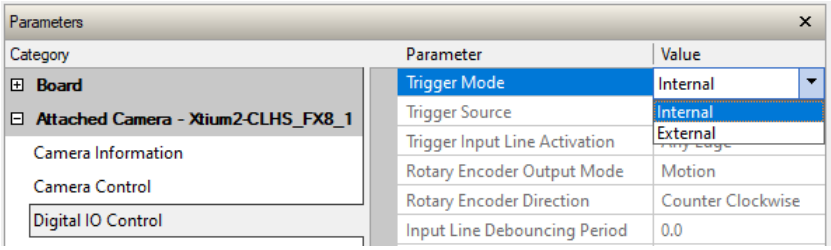
To verify communication with the frame grabber and image acquisition is possible, the camera can output a test pattern using its internal line trigger.

To do so, in the camera's Image Format category, select a test pattern. For 800 mm module both the Parent and Child, has to be set for test pattern.



In the Digital IO Control category, set the *Trigger Mode* to Internal.

In the 800 mm module, the Child module's *Trigger Mode* and *Trigger Source* features are set automatically by the Parent.



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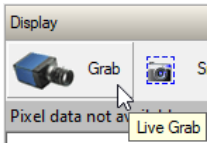
To start the acquisition, click the Grab button.



The display window should show the test pattern; the frame rate, resolution and buffer format are also displayed in the bottom of the Display window menu bar.

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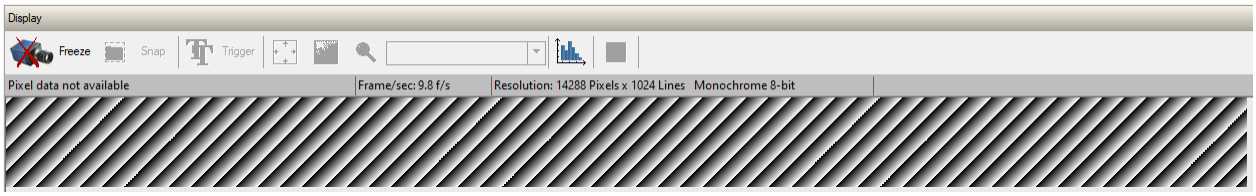
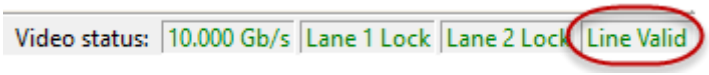


The Video status bar should show the Line Valid as green.



The buffer navigation pane should also toggle rapidly between Buffer IDs.

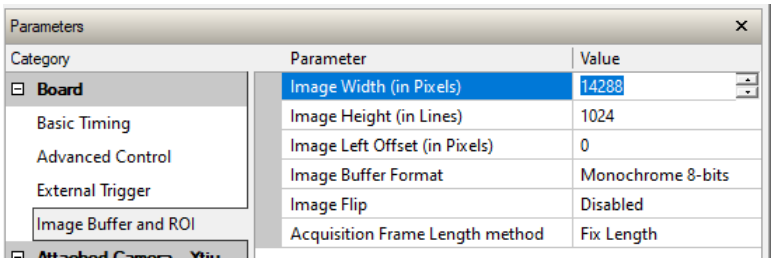
NOTE

The Test Pattern function only supports Monochrome 8-bits image format; it does not support other formats, such as Monochrome 8-bits (2 planes) used with Dual Exposure mode.

Image Width and Format Considerations

When using the full image width, the camera uses multiples of 32 for the horizontal active (maximum = 14304 for 900 dpi) for optimizing the CLHS link. However, the actual maximum number of valid pixels output by the camera is 14288, therefore the image width should be set to 14288 to eliminate the 16 padding pixels (DN 0) added to the end of the line.

To do so, in the Board's Image Buffer and ROI category, set the *Image Width* (in Pixels) to 14288. For the 800 mm, it has to be done for both the Parent and Child.



Dual Exposure Mode Image Format

When using the AxCIS Dual Exposure mode to output data from both sensor rows, in the Camera Control category, set the *Exposure Mode* parameter to Dual Exposure.

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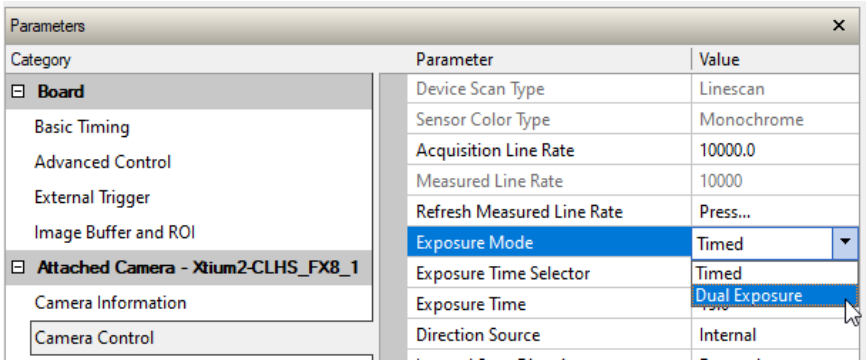
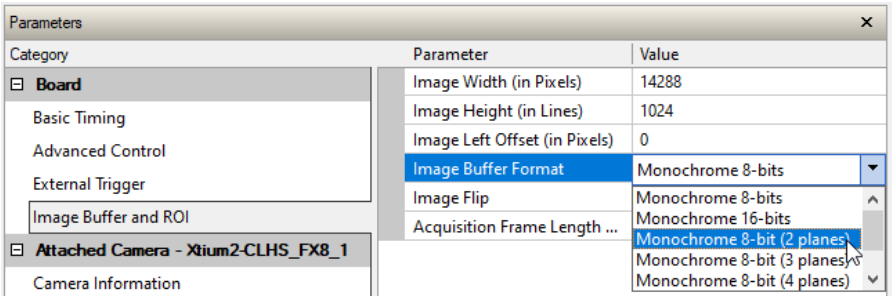


In the Board's Image Buffer and ROI category, set the Image Buffer Format to Monochrome 8-bit (2 planes).

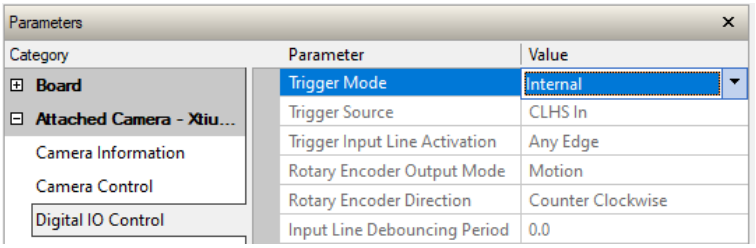


Verifying Image Alignment and Quality

Once the AxCIS is configured with the frame grabber and the image output has been verified using the test pattern, the system is ready for imaging.

Internal Trigger

The most straightforward method is to set the *Trigger Mode* feature to “Internal” to verify image alignment and uniformity. This triggers the camera using an internal timer, which can be adjusted via the *Acquisition Line Rate* feature and is especially useful when setting up the camera with a static image.



For moving objects, it is essential to ensure that the internal line rate corresponds to the object's speed in mm/sec, divided by the selected pixel size:

- 300 dpi = 0.084 mm
- 450 dpi = 0.056 mm
- 600 dpi = 0.042 mm
- 900 dpi = 0.028 mm

This ensures proper alignment of the sensor's images and achieves a 1:1 aspect ratio square image.

The main objectives of running the module with internal triggers are to verify the following.

- Sharp image quality across the entire field of view.
- Image alignment and accuracy in the scanning direction.

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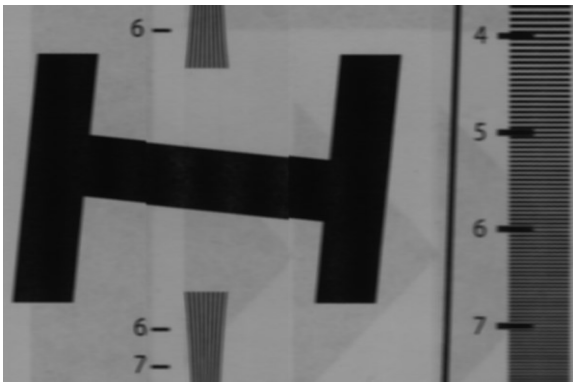
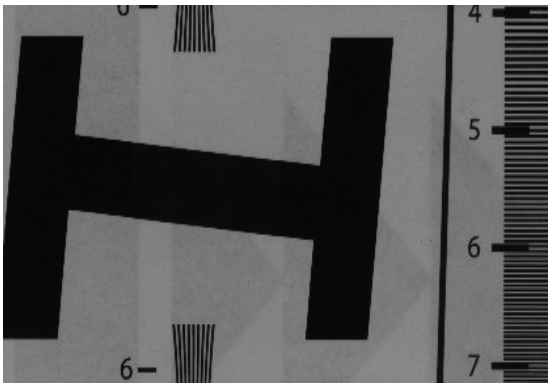
In the initial step of AxCIS mounting, precise alignment of a consistent working distance of 13.9 mm at both ends of the module was necessary to ensure that the module is parallel to the target surface along the same axis. Incorrectly setting the working distance can result in image defocus and blurring in both horizontal (cross-scan) and vertical (in-scan) directions.

When using internal triggers for image acquisition, minor adjustments to the working distance (± < 0.5 mm) can be made based on the sharpness and focus of the output image.



Out-of-focus image with vertical misalignment



Sharp and precisely aligned image

Setting the correct *Internal Scan Direction* feature, available in the Camera Control category, is another important consideration. The correct scan direction can be verified through live imaging. A properly set scan direction will display a clear, sharp image that is well-aligned. Any observed shifts in scan direction within each 25 mm field of view indicate an incorrect *Internal Scan Direction* setting.

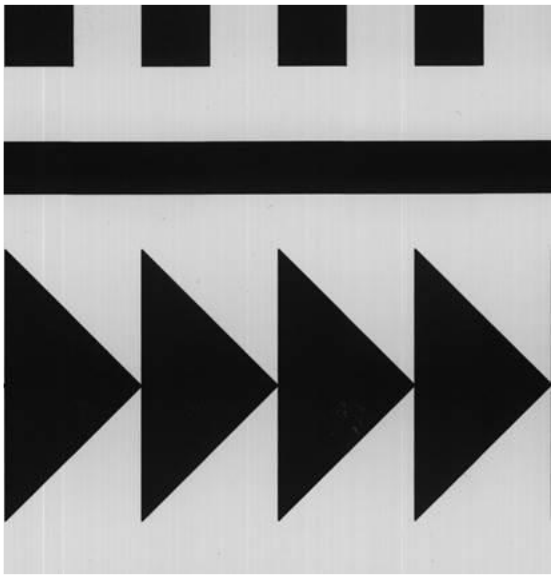


Image with correct scan direction

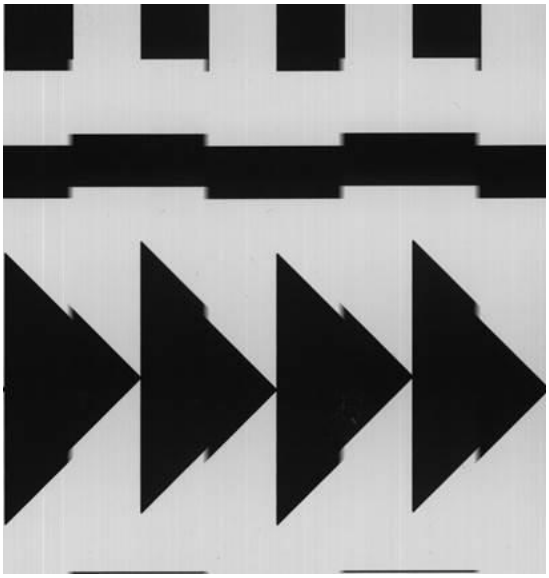


Image with incorrect scan direction

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Maintaining Image Alignment

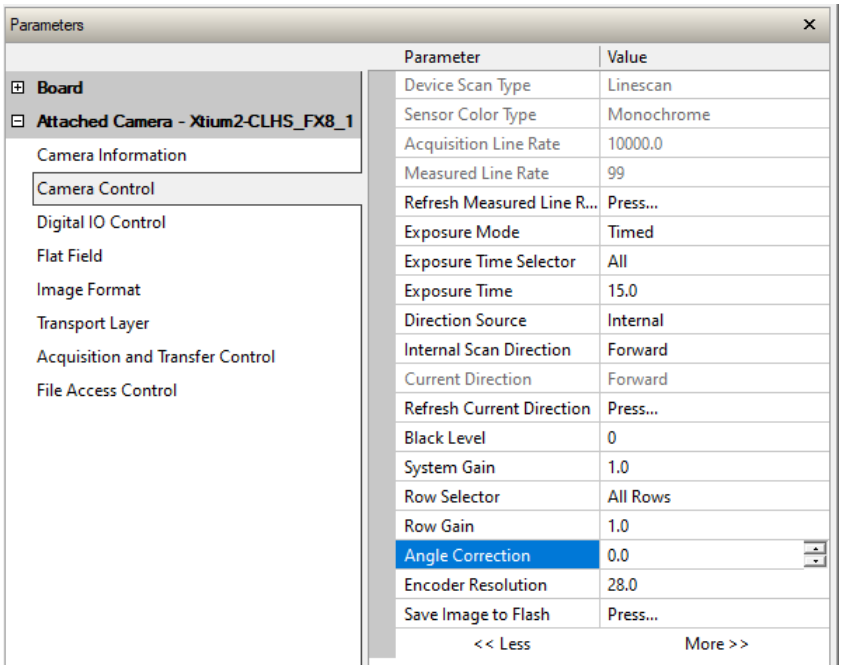
Unlike other CIS modules that use a linear array of small sensors butted end to end, which can result in lost pixels and interpolated image quality issues at the joints, AxCIS modules employ a staggered sensor approach. This design ensures 100% image coverage by overlapping adjacent sensors' fields of view, thereby preserving image quality without pixel loss which is ideal for certain applications requiring metrology.

During production calibration, each sensor's precise physical location is measured, and alignment parameters are stored in the module. In normal operation, the module automatically aligns the image data from each sensor in real-time along both the x and y directions, creating a continuous, seamlessly aligned image. Any overlap in image data is appropriately managed and eliminated.

Imaging when optical axis is not perpendicular to the target surface

Certain applications may require the module to be placed at an angle with regards to the object surface to get the best imaging performance. This alters the distance between sensor images, impacting the module's alignment algorithms.

To correct alignment, input the module's angle deviation from perpendicular in the *Angle Correction* parameter, available in the Camera Control category. The module will automatically adjust alignment parameters for optimal image alignment. Large angle correction (>30°) may result in MTF degradation therefore image quality should be evaluated.



NOTE

Acquisition must be stopped to access the *Angle Correction* feature; use the *Acquisition Stop* feature to do so. Use the *Acquisition Start* feature to restart acquisition.

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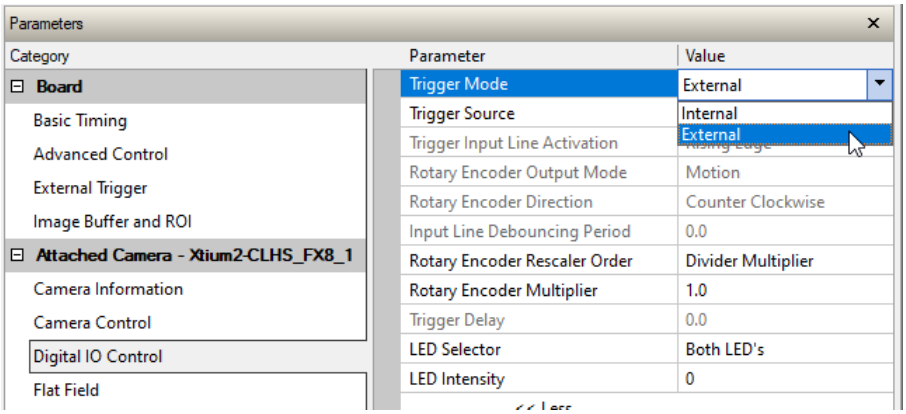
Trigger Configuration with Shaft Encoder

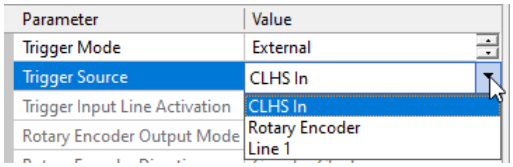
For this example, the trigger configuration uses a typical setup with a shaft encoder and a frame trigger connected to the frame grabber.

Camera Trigger Configuration

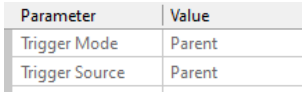
In the Parent module, in the Digital IO Control category, set the *Trigger Mode* to External.



Since triggers are sent to the AxCIS modules via the frame grabber, the *Trigger Source* is set to CLHS In (default).



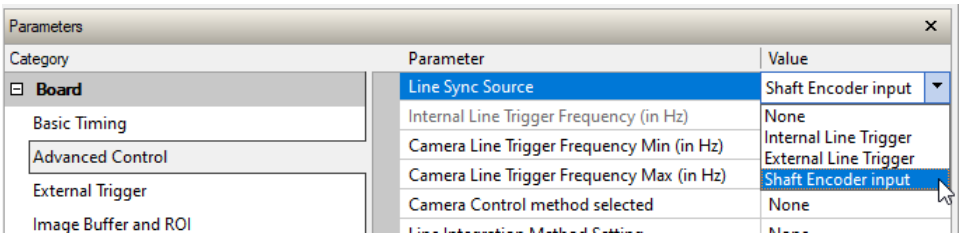
For the Child module (for 800 mm only), the *Trigger Mode* is always set to Parent, is read-only and cannot be modified.



Frame Grabber Trigger Configuration

In the Board's Advance Control category, set the *Line Sync Source* to Shaft Encoder Input.

The frame grabber trigger configuration is the same for both the Parent and Child for the 800 mm.



Click on the *Line Trigger Method Setting* field to open its dialog.

Select Method 2 and click OK.

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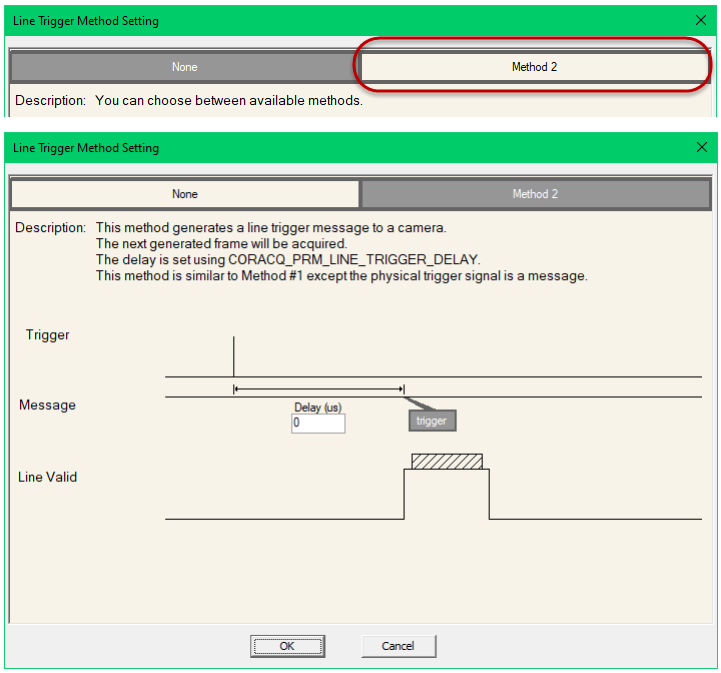
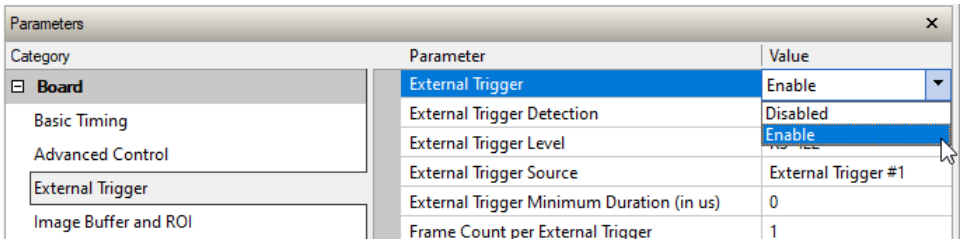


A second dialog is presented to set a trigger delay, if necessary; click OK to close the dialog.

Optionally, if using an external frame trigger, in the External Trigger category, set *External Trigger* to Enable.

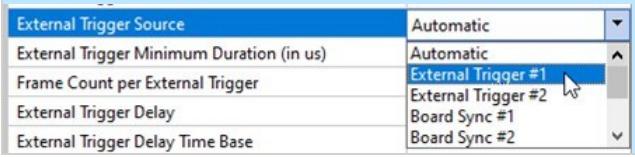


Set the *External Trigger Detection*, *External Trigger Level*, *External Trigger Source* and other relevant parameters, such as the *Shaft Encoder Edge Drop* and *Multiplier*, as required according to the shaft encoder model and the imaging system.

For more information on correctly setting triggers, refer to the Application Note for Multiplier & Divider available on the Teledyne DALSA website as well as the AxCIS user manual.

NOTE

By default, the board's *External Trigger Source* is set to Automatic, which for the first camera (Parent) uses External Trigger #1, while for the second camera (Child) uses External Trigger #2. Therefore, it may be necessary, if using an external frame trigger, to change the *External Trigger Source* from Automatic to a specific setting. If so, do this for both the Parent and Child since both use the same trigger) so that a single *.ccf* file can be used.

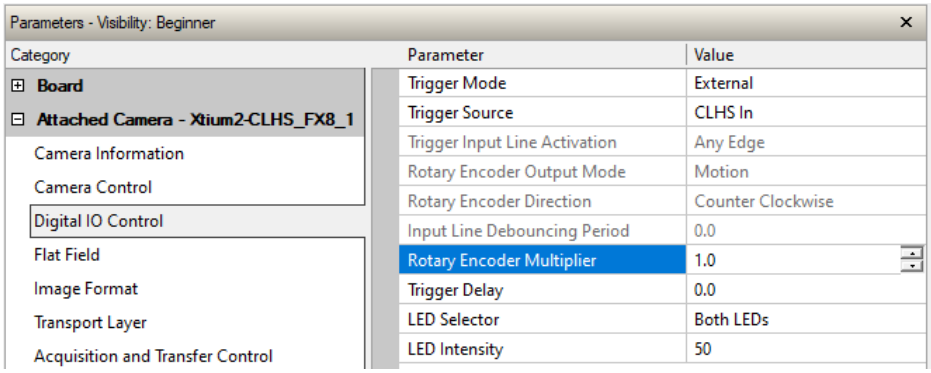


continued >

Maintain Image Alignment by adjusting the encoder pulses (Exsync) Input

Image alignment is ensured when encoder (Exsync) pulses occur every 84 µm (300 dpi), 56 µm (450 dpi), 42 µm (600 dpi) or 28 µm (900 dpi) of object travel. If achieving this exact encoder (Exsync) resolution is challenging, users can adjust the incoming period using the Encoder Multiplier and Divider option available in the frame grabber.

Additionally, the camera provides a *Rotary Encoder Multiplier* option as well, users can adjust this value apart from the frame grabber multiplier/divider option to adjust the encoder resolution and achieve the desired precision.



NOTE

The *Rotary Encoder Multiplier* parameter in the camera utilizes a Divide-Multiply approach, enabling users to input fractional values with a precision of 0.01.

Achieving Optimal Image Response

After achieving uniform image alignment with Exsync, the next step is to ensure a consistent image output response.

A key performance characteristic of the module is its responsivity and associated noise level at the system's maximum line rate with the required illumination configuration. This can be assessed using a stationary, plain white diffusing target and optional LED illumination. However, to accurately evaluate the module's real-life performance, the setup should closely resemble the final system configuration including the line rate, integration time, etc.

The ideal test setup should meet the following conditions:

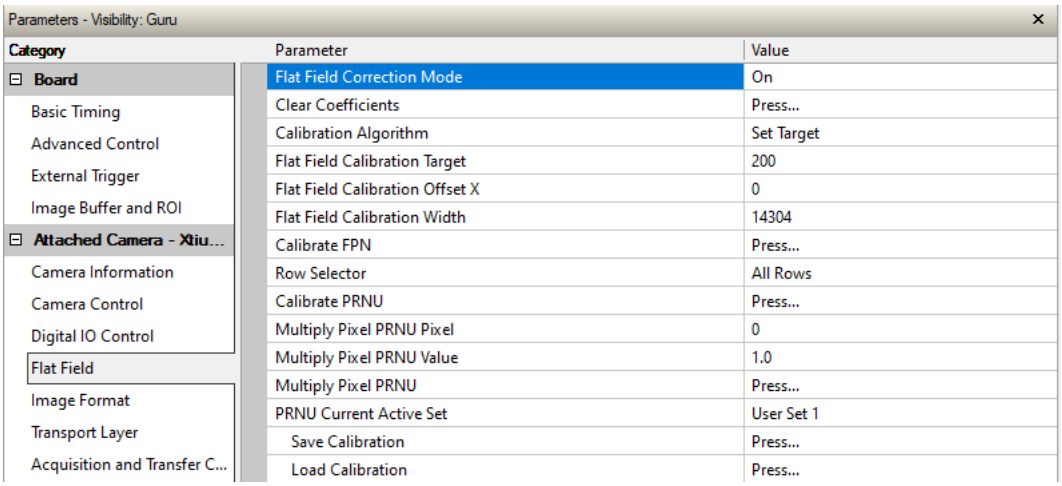
- Ensure the correct working distance to maintain focus.
- Use an illumination configuration and intensity equivalent to that planned for the inspection system.
- Use the same module angle which will be used in the final inspection system.
- Operate the module with an exposure time that achieves the system's maximum line rate. The module's internal line rate generator and exposure control can be used for a stationary target.
- Ensure the stationary target is texture-free, avoiding materials like paper with grain.

continued >

Flat Field Calibration

Variations in image response across the field of view can arise from the sensor pixel responses, illumination intensity profile, and the Selfoc Lens Arrays' transmission characteristics. The module can correct for these optical non-uniformities using flat field calibration.

AxCIS also provides the option of performing Flat Field Calibration with a Region of Interest (ROI) to accommodate any “no inspection zones”. Please refer the AxCIS user manual for more information.

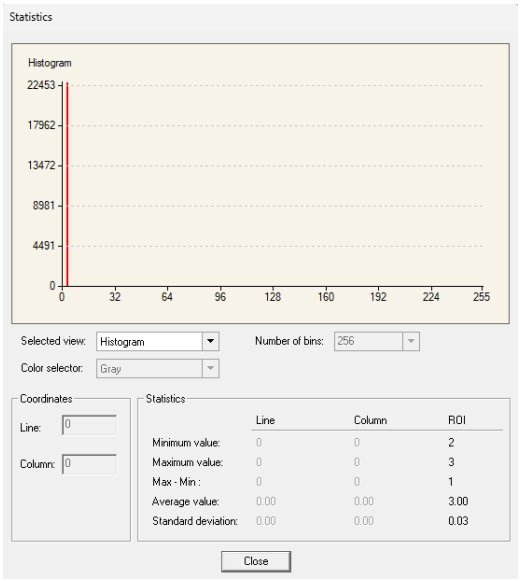


FPN Correction

In general, the factory FPN correction of the camera is sufficient for most applications, so doing a FPN correction can be skipped. For applications which require FPN correction, please follow the below steps.

1) Turn off the internal LEDs and place the sensor in dark by covering the module.

2) Select Off from the *Flat Field Correction Mode* drop-down menu and check the line profile / histogram. If some, or all, of the pixels outputs are zero, than adjust the *Black Level* value, available in the Camera Control category, to ensure that all pixels’ output are above zero.



3) Turn ON *Flat Field Correction Mode*.

4) Enter the *Flat Field Calibration Width* and *Flat Field Calibration Offset X* parameter, if required. Enter the complete sensor width here if you’re not planning set an ROI for FFC.

continued >

5) Click *Calibrate FPN*.

PRNU Correction

To perform PRNU calibration:

1) Apply illumination and place a white flat target where the object will be positioned. Ideally, use a professional target, but for convenience, white paper can be used. However, using paper may cause a grain effect, where visible vertical lines appear in the captured images.

   One method to correct this grain effect is to keep the object moving when the PRNU correction is performed.

   Turn OFF *Flat Field Correction Mode* to check if the image line profile is acceptable.

2) Select the user set under *PRNU Current Active Set* to save coefficients.

3) Generally, we can choose the "Set Target" option for the *Calibration Algorithm*. Alternatively, the "Peak" algorithm can be used, where each pixel is adjusted to match the brightest one.

4) Set the target value under *Flat Field Calibration Target*.

   For instance, set the target value based on the line rate, exposure time, and illumination. If the output is slightly below 200 DN, set the target to 200 DN. You can set the target higher, such as 250 DN, but this will increase noise. Ideally, adjust the illumination to achieve an output close to 250 DN before performing PRNU calibration.

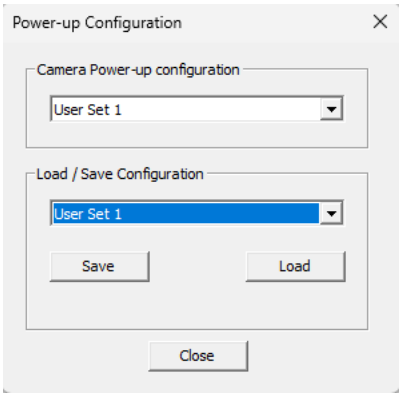
6) Enter the *Flat Field Calibration Width* and *Flat Field Calibration Offset X* parameter, if required. Enter the complete sensor width here if you're not planning set an ROI for FFC.

5) Click *Calibrate PRNU*.

6) Check the results with a line profile; if satisfied click *Save Calibration* to apply the coefficients.

To save the FFC coefficients, click the *Power-up Configuration* Setting... field, available in the Camera information category. In the *Power-up Configuration* dialog box select one of 16 User Sets for both *Camera Power-up configuration* and *Load / Save Configuration* and click Save.

This will ensure that the camera loads the saved parameters the next time the camera is turned on.



NOTE

Flat field calibration should be done when the camera temperature has stabilized. AxCIS has many different modes of operation. It is strongly recommended that the camera be flat fielded for that mode of operation that is intended including direction of scan. The best flat field calibration is achieved at the mid DN level of the working range. Calibrating at the mid-level minimizes flat field errors due to residual non-linearity in the pixels, halving the error compared to calibrating at the peak value. To achieve this, reduce the exposure time to half of the operational level for calibration. After completing the calibration, restore the original exposure time.

continued >

Ensuring Uniform Image Response

Response Leveling

Analog circuitry, found in all types of sensors and associated analog-to-digital converters, can change characteristics with temperature fluctuations. This may cause minor variations in sensor responses. The module can automatically perform sensor-to-sensor response leveling to address this.

Response leveling can be done during imaging by clicking the *Response Levelling Trigger* field, available in the Camera Control category. The user can control the timing of this process using the *Response Levelling Trigger*, but applying it may cause a slight disturbance in the image. The object being imaged must be in motion during response leveling. The process completes more quickly with faster motion, as it involves averaging multiple lines.

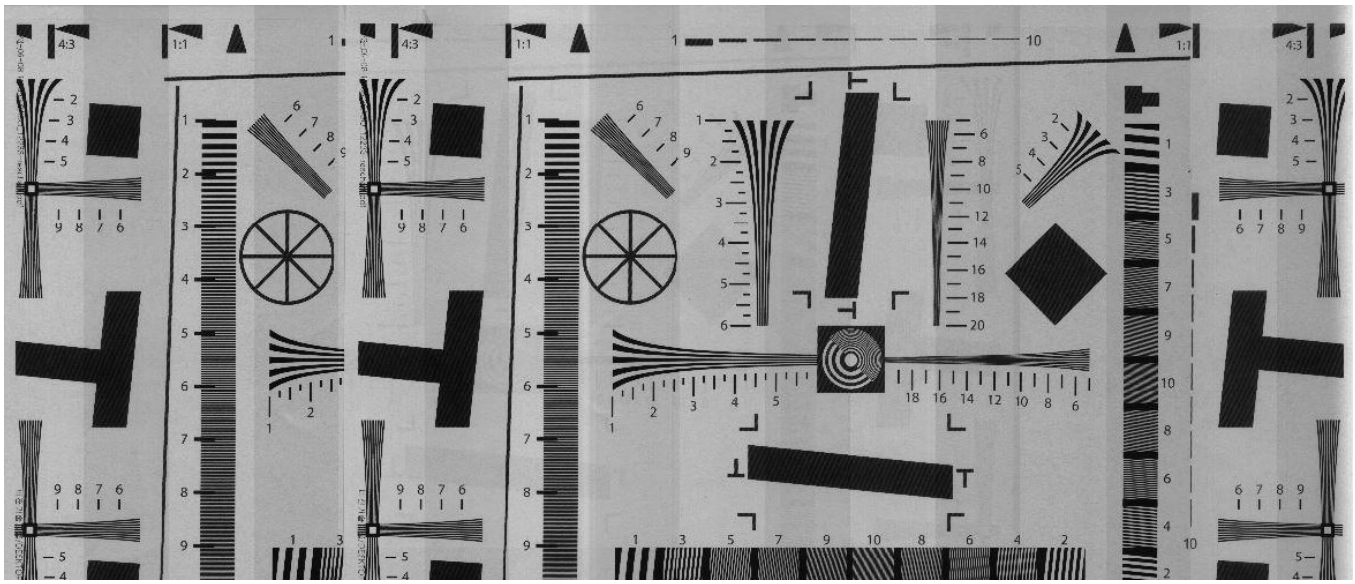


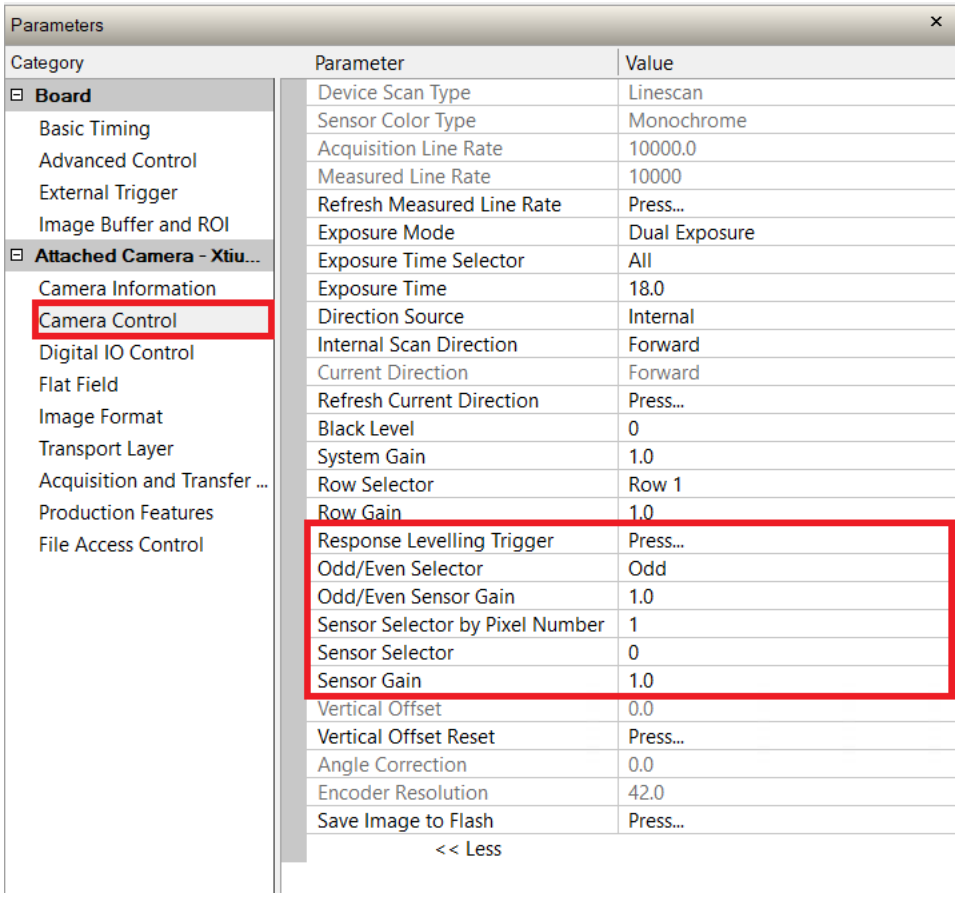
Figure 6: Sample image where response leveling ensures uniformity

For the response leveling trigger to be effective, the following considerations must be taken into account:

1) Correction is limited to pixels within the 50-220 DN range. **If any pixels in the FOV are outside this range response leveling will not be executed.**
2) Only activate the *Response Levelling Trigger* when the inspection target is within the field of view.
3) Response leveling will not be effective if the image is not aligned and there are vertical stagger issues. Any out-of-focus or Exsync synchronization issues causing vertical stagger must be resolved first for response leveling to be effective.

In situations where automatic response leveling did not reach the desired result of uniform image output, manual adjustments can be made for each sensor's gain. These adjustments can be saved in the user set under the *Power-up Configuration* in the Camera Information category.

continued >



There are two methods to manually adjust the sensor gain.

1) Manually adjusting gain for Odd and Even sensor set

The module enables the selection of the Odd/Even sensor set using the *Odd/Even Selector*, and allows for the manual input of gain values for the chosen sensor set using the *Odd/Even Sensor Gain*. When a sensor set is selected and a gain value is applied, the gain adjustment will be uniformly applied across the entire set of Odd or Even sensors.

2) Selecting Sensors by Entering Pixel Numbers

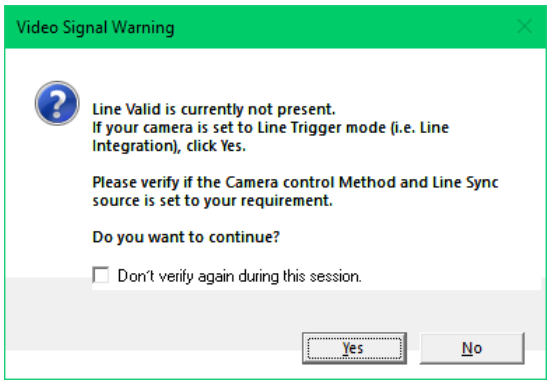
In some instances, adjusting the odd and even sensor sets may not be effective due to a higher or lower response from a specific sensor. In such cases, use the *Sensor Selector by Pixel Number* to input the pixel number. The module will then automatically identify and display the corresponding sensor under the *Sensor Selector*, allowing you to set the gain in the *Sensor Gain* field.

continued >

Acquisition Synchronization with AxCIS 800 mm

To ensure synchronization between Parent and Child for the 800 mm AxCIS module, the AxCIS acquisition should be started before triggers are sent.

Start the acquisition on both the Parent and Child modules by clicking the Grab button in both instances of CamExpert. CamExpert will advise that the Line Valid is currently not present.



Start initiating trigger pulses; both Parent and Child should now acquire the same lines and produce a seamless image.

Saving Frame Grabber and AxCIS Configurations

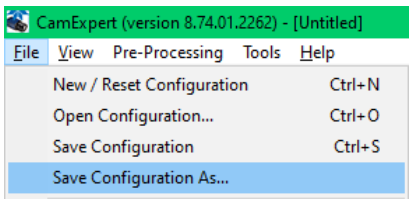
When satisfied with the quality of the image acquisition the frame grabber and camera configurations can be saved.

Saving Frame Grabber Configuration

Within a Sapera LT application, this *.ccf* file can then be passed to the SapAcquisition constructor when allocating an acquisition object.

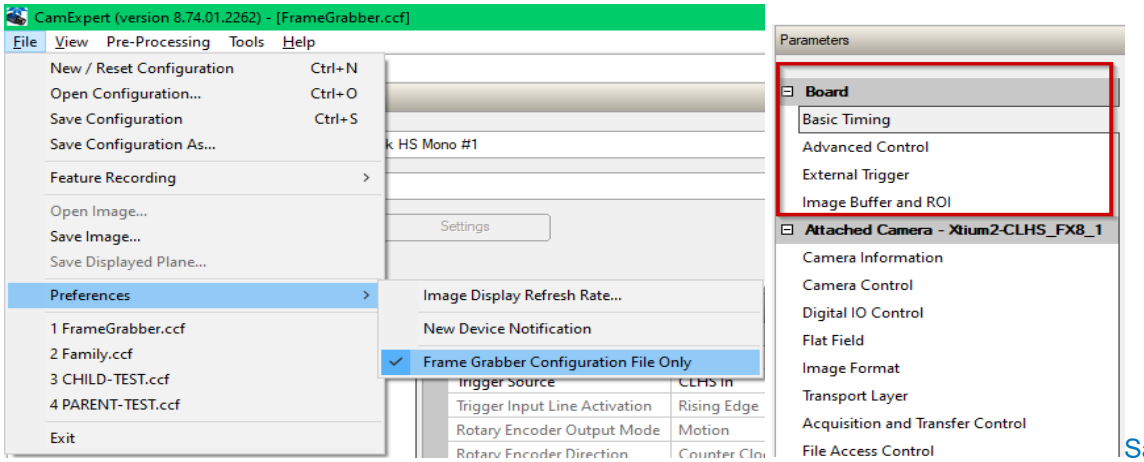
Both the Parent and Child can use the same *.ccf* file.

The frame grabber configuration can be saved to a *.ccf* file using the CamExpert File menu Save Configuration As... command.



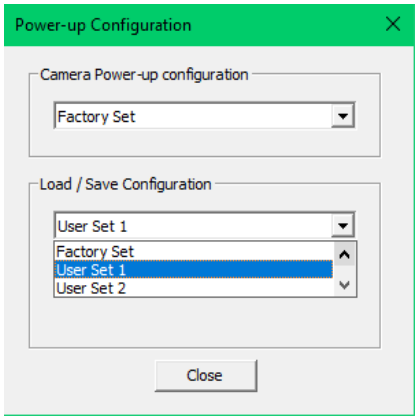
Since the AxCIS does not support *.ccf* files, enable the Frame Grabber Configuration File Only option through the File > Preferences menu command. Alternatively, before saving, select a category within the Board section of the Parameter panel.

continued >

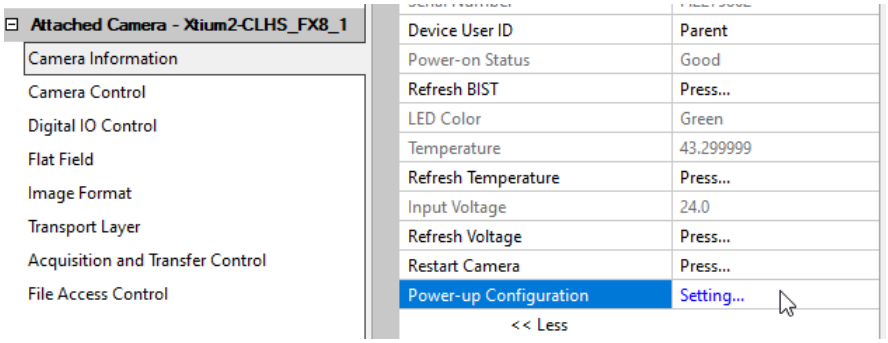


Saving AxCIS Camera Configuration

The current AxCIS camera feature settings can be saved to one of 16 User Sets which can then be reloaded on camera power-up. These user sets can also be downloaded from the camera to be then uploaded to other AxCIS modules.

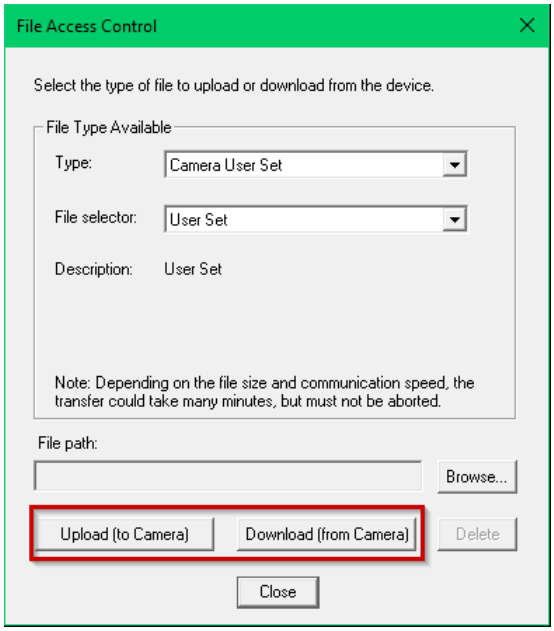


To open the Power-up Configuration dialog, in the Camera Information category, click the *Power-up Configuration* field.



The user sets can be downloaded/uploaded using the File Access Control dialog, available through the File Access Control category.l

continued >

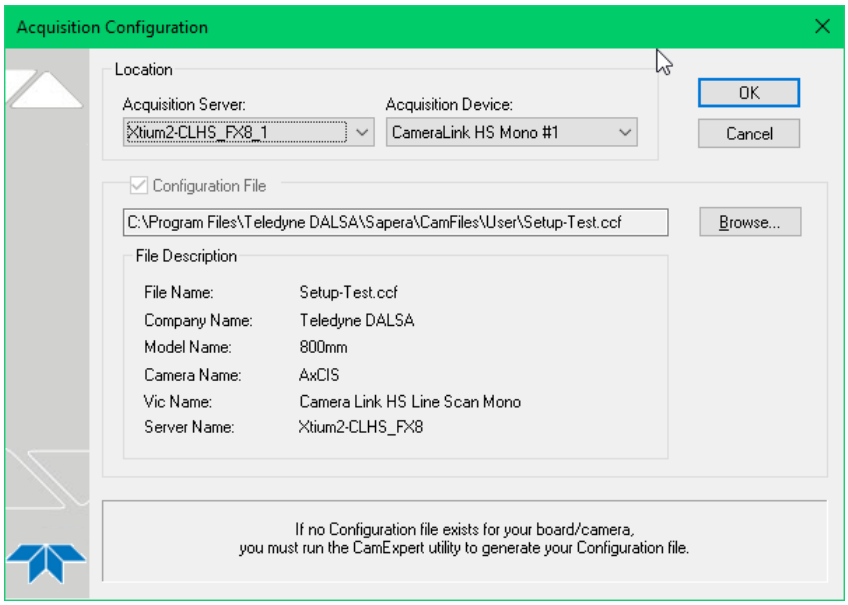


Viewing Parent and Child Outputs as a Single Image with AxCIS 800 mm

Sapera LT includes a MultiBoardSyncGrabDemo which demonstrates how to synchronize acquisition from 2 cameras and create a single image from two child buffers.

It is available in the <install directory>\Teledyne DALSA\Sapera\Demos\Binaries directory which can be opened through the Windows Start menu shortcut under Teledyne DALSA Sapera LT.

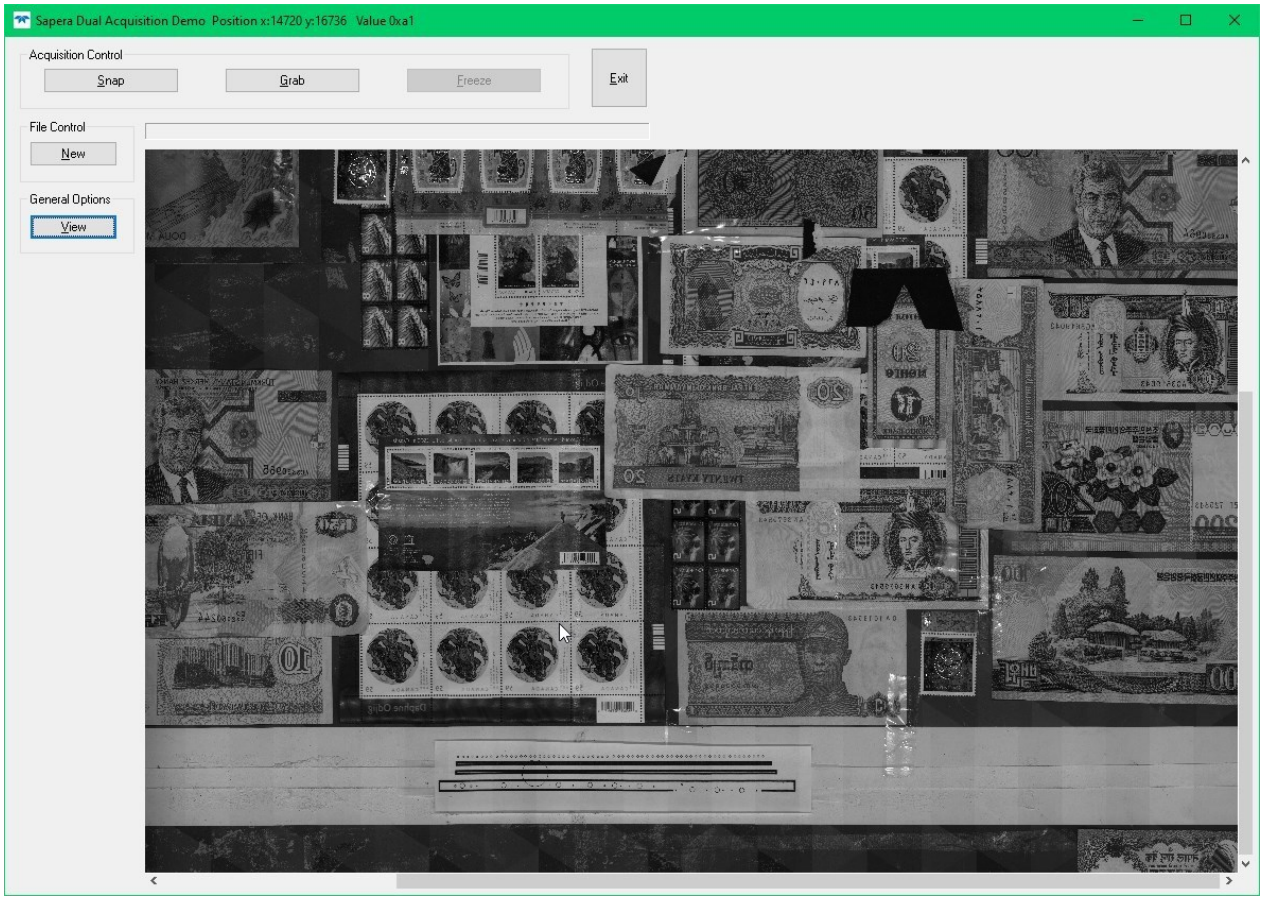
With a .ccf file available, launch the MultiBoardSyncGrabDemo.exe application. The Acquisition Configuration dialog is presented for each acquisition.



For the AxCIS, use the *Acquisition Device* drop-down list to select the module (either CameraLinkHS Mono #1 for the Parent, or #2 for the Child) and the *.ccf* (which is the same for both modules for this example). Depending on the scan direction, the Child or Parent may be selected first as it will appear as the left side of the image.

continued >

Use the Acquisition Control Snap, Grab and Freeze buttons to control the application.



The Sapera LT User's Manual includes a chapter "Working with Buffers" which describes in detail how to use parent and child buffers.

continued >

Document Revision History

Revision	Description	Date
00	Preliminary Version	Jan 10, 2023
01	Added mounting and setup information.	July 4, 2024

FOR MORE INFORMATION ON OUR FRAME GRABBER, CXP, CL, AND CLHS AREA SCAN CAMERAS AND GIGE, CL, AND CLHS LINE SCAN CAMERAS:

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