



Teledyne DALSA • 605 McMurray Road • Waterloo, Ontario, N2V 2E9 • Canada

<https://www.teledynedalsa.com/>

Linea HS 32K TDI Camera (HL-HM-32K) Super Resolution Mode

Overview

This document demonstrates how to configure the Linea HS 32K TDI line scan camera for super resolution ("SR") mode.

Advantage of Super Resolution Imaging

The super resolution method brings many benefits to applications:

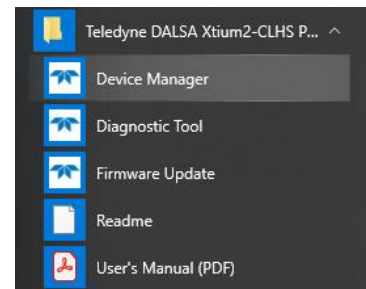
- Resolution is improved by 2x;
- Detectability, particularly for subpixel defects, is improved with 4~5x higher effective SNR for a given object;
- Responsivity, Full Well, SNR and MTF remain high, compared to typical, smaller pixels;
- Existing components can be reused: 16k/5 μ m lens, lighting, encoder, mechanical components, ...;
- Imaging performance is upgraded while maintaining low system costs.

Configuring the Frame Grabber in CamExpert

The LA-HM-32k camera **must be paired** with an Xtium2-CLHS_PX8-HR (**part number: OR-A8S0-HX870**) frame grabber to support super resolution functionality.

*Note: The camera will image with an Xtium2-CLHS PX8 (part number: OR-A8S0-**PX870**), but this combination will **NOT** provide super resolution functionality.*

- 1) Close all Spera applications, including CamExpert and open the **Spera Device Manager** from Windows start menu.



- 2) Select *Device Update* tab and select **Camera Link HS with HMTF** (High Modulation Transfer Function) from the *Configuration Information* options, then press *Start Update*.

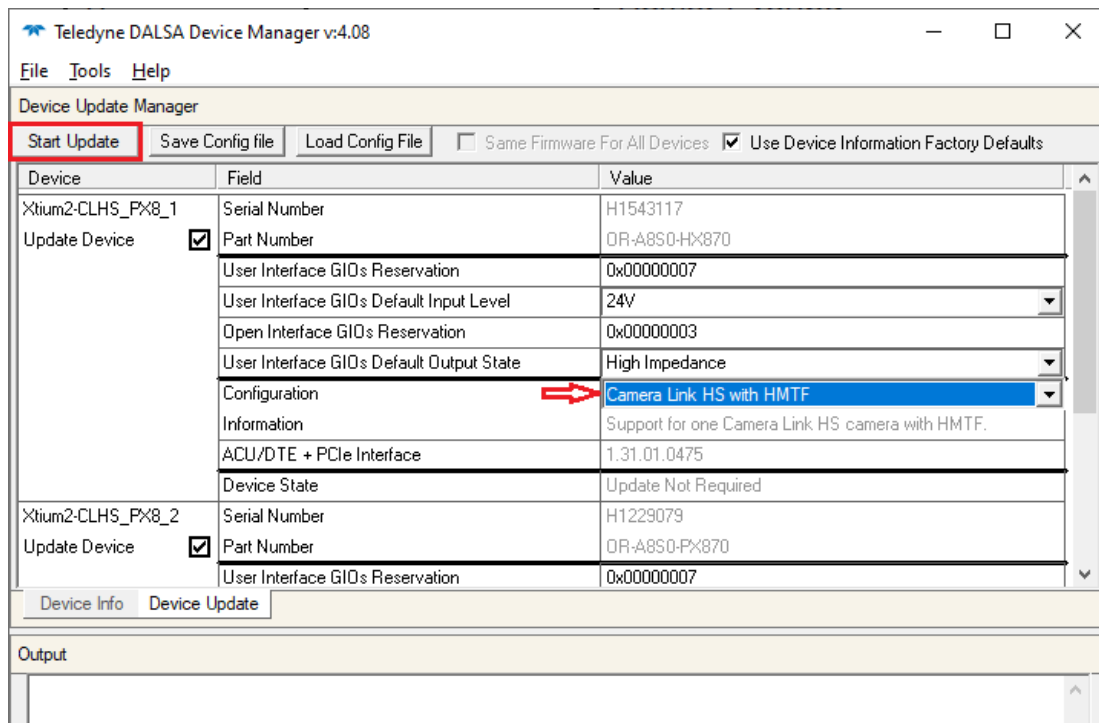


Figure 1: HX870 frame grabber - firmware update to SR mode

- 3) Close the Device Manger and open the CamExpert.

4) Select **CameraLink HS Mono** in the **Device Selector**. The frame grabber can be configured in one of the following two ways:

- a. Load a pre-configured file (.ccf). Some examples can be downloaded from:
<https://www.teledynedalsa.com/en/support/downloads-center/>
- b. Configure manually (see following)

Once **CameraLink HS Mono** is selected in the **Device Selector**, the frame grabber automatically configures basic parameters, such as number of Data Lanes, pixel depth, etc. They can be corrected, if necessary. Note that the frame grabber parameters are grouped under **Category / Board**. The following selection panes are available.

In **Basic Timing**, change to the desired resolution (e.g. 32768) in the **Value** column of **Horizontal Active (in Pixels)** - see selection in Figure 2.

Category	Parameter	Value
Board	Camera Type	Linescan
	Color Type	Monochrome
	Pixel Depth	8
	Data Lanes	5
	Horizontal Active (in Pixels)	32768
	Data Valid	Disabled
	CLHS Configuration	None
	PoCL	Enable
	PoCL Status	Active

Figure 2: Expected Basic Timing frame grabber parameters (note: image captured with non-SR PX8)

For best TDI results, Teledyne DALSA recommends shaft-encoder-based triggering. In **Advanced Control**, select **Shaft Encoder input** as **Line Sync Source** when supplying an external trigger from a shaft encoder.

Select **Method 2** in **Line Trigger Method Setting** as a physical trigger signal is supplied via the frame grabber.

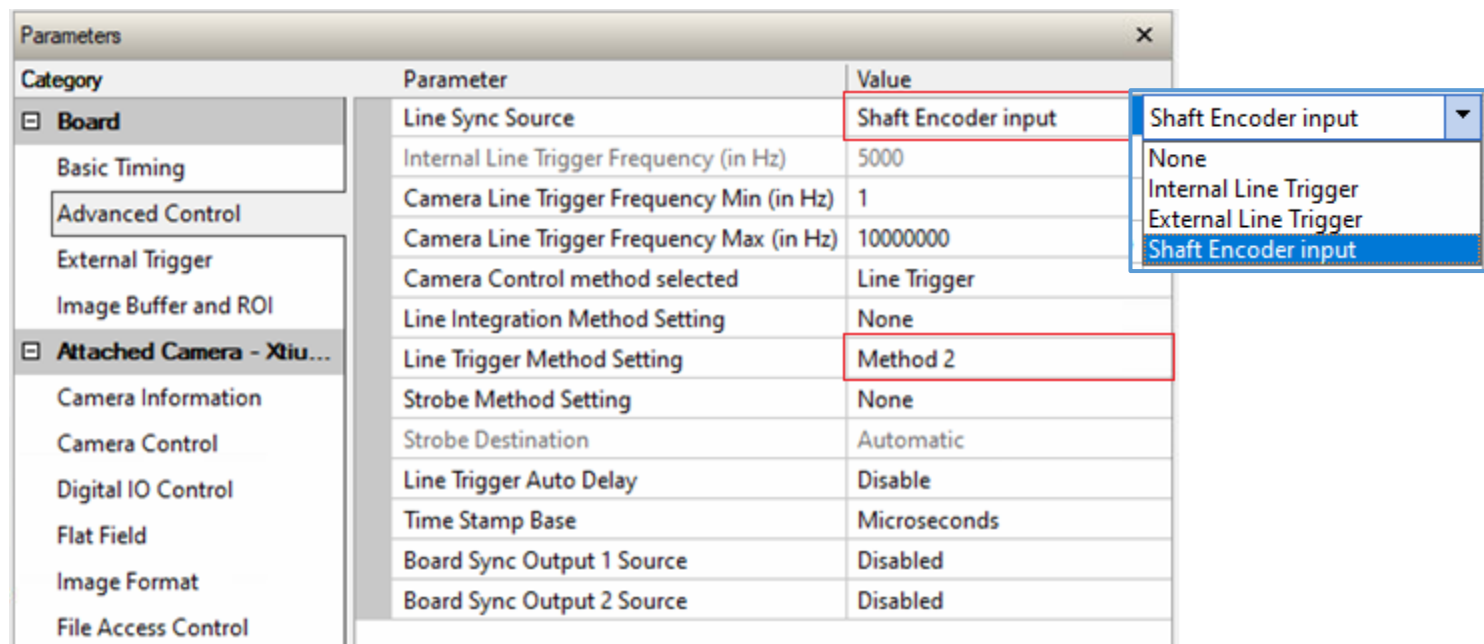


Figure 3: Setting up encoder-based triggering, routed through the frame grabber

There are additional selection options for **Line Sync Source** (EXSYNC):

External Line Trigger - supply EXSYNC as single-ended TTL

None - EXSYNC input to the camera. Teledyne DALSA provides a floating-point EXSYNC rescaler, upgraded from the multiplier-divider feature. Refer to video instruction:

<https://youtu.be/ZifmHXvOUZs> and camera manual 03-032-20263.

Internal Line Trigger (with **Internal Line Trigger Frequency (in Hz)**) - camera speed programmed. TDI in-scan sharpness is strongly dependent on matched camera and object speed. This mode is not recommended where object speeds can vary.

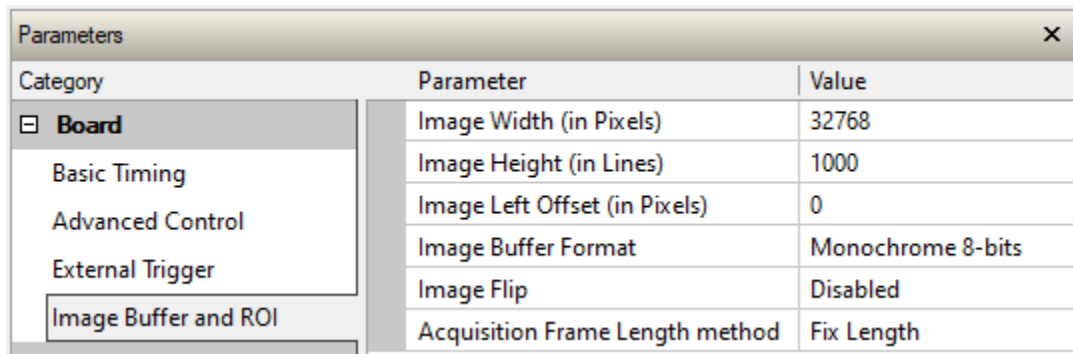
Shaft Encoder Edge Drop and **Shaft Encoder Edge Multiplier** features can be used to adjust the sync rate and maximize the in-scan sharpness (reducing blur due to scan rate mismatch). The right combination can be determined according to the specific application, either experimentally or by calculation from magnification, shaft encoder specification and transport speed.

Note: this functionality has been upgraded to a floating-point re-scaler when EXSYNC is provided to the camera I/O.

Parameters			×
Category	Parameter	Value	
Board	External Trigger	Disabled	
Basic Timing	External Trigger Detection	Falling Edge	
Advanced Control	External Trigger Level	24V	
External Trigger	External Trigger Source	Automatic	
Image Buffer and ROI	External Trigger Minimum Duration (in us)	0	
	Frame Count per External Trigger	1	
Attached Camera - Xti...	External Trigger Delay	0	
Camera Information	External Trigger Delay Time Base	Nanoseconds	
Camera Control	External Trigger Ignore Delay	0	
Digital IO Control	Shaft Encoder Direction	Ignored	
Flat Field	Shaft Encoder Edge Drop	5	
Image Format	Shaft Encoder Edge Multiplier	4	
File Access Control	Shaft Encoder Order	Device Specific	
Transport Layer	Shaft Encoder Averaging Enable	Disabled	
Acquisition and Transfer C...	Shaft Encoder Averaging Pulses (2^N)	1	
Production Features	Shaft Encoder Averaging Period Minimum (in ns)	10000	
	Shaft Encoder Averaging Period Maximum (in ns)	1000000	
	External Line Trigger Detection	Rising Edge	
	External Line Trigger Source	Automatic	

Figure 4: Re-Scaling the shaft encoder signal

Select/set parameters of *Image Buffer and ROI* as following.



The screenshot shows a 'Parameters' dialog box with a tree view on the left and a table on the right. The tree view has a root 'Board' with sub-items: 'Basic Timing', 'Advanced Control', 'External Trigger', and 'Image Buffer and ROI'. The 'Image Buffer and ROI' item is selected. The table on the right lists parameters and their values:

Category	Parameter	Value
Board	Image Width (in Pixels)	32768
	Image Height (in Lines)	1000
	Image Left Offset (in Pixels)	0
	Image Buffer Format	Monochrome 8-bits
	Image Flip	Disabled
	Acquisition Frame Length method	Fix Length

Figure 5: Defining the size of a captured image

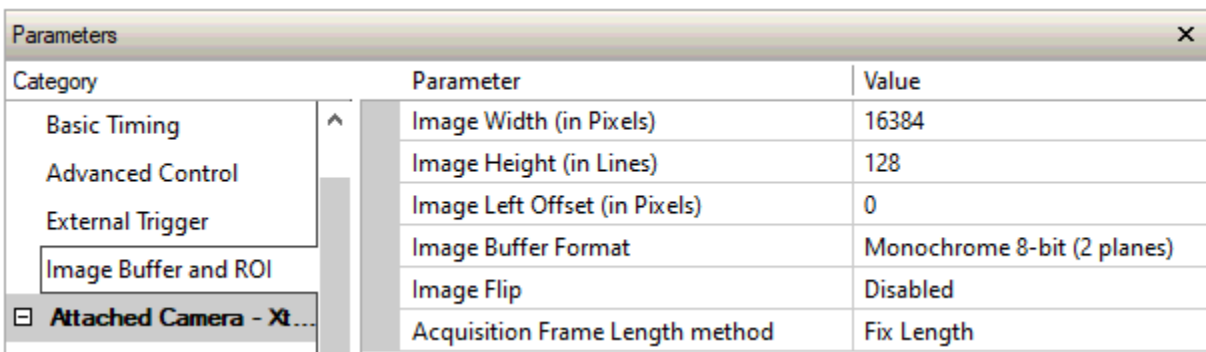
Once the frame grabber configuration is properly done, you can save the settings as a CCF file for future use.

Operation with other Frame Grabbers

Should the application be unable to use an HX870 frame grabber, separate post processing must be used. Contact Teledyne DALSA for availability of the proprietary reconstruction algorithm.

In this case, configure the camera to supply raw data in two, ½ pixel shifted, 16K images.

Set the **Horizontal Active (in Pixels)** in **Basic Timing** and **Image Width (in Pixels)** in **Image Buffer and ROI** to 16384. Then select **Monochrome 8-bit (2 planes)** in the **Image Buffer Format**.

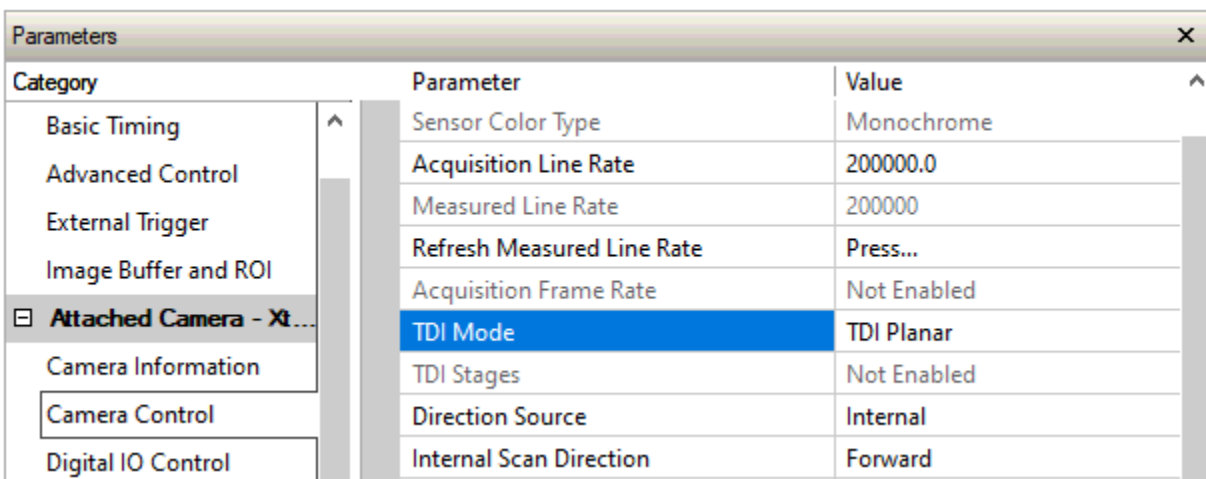


The screenshot shows a 'Parameters' dialog box with a tree view on the left and a table of parameters on the right. The tree view has categories: Basic Timing, Advanced Control, External Trigger, Image Buffer and ROI, and Attached Camera - Xt... (selected). The table lists parameters and their values:

Category	Parameter	Value
Image Buffer and ROI	Image Width (in Pixels)	16384
	Image Height (in Lines)	128
	Image Left Offset (in Pixels)	0
	Image Buffer Format	Monochrome 8-bit (2 planes)
	Image Flip	Disabled
Attached Camera - Xt...	Acquisition Frame Length method	Fix Length

Figure 6: Setting up raw data read-out - frame grabber

On the camera side, in **Camera Control / TDI Mode**, select **TDI Planar** instead of TDI Super Resolution.



The screenshot shows a 'Parameters' dialog box with a tree view on the left and a table of parameters on the right. The tree view has categories: Basic Timing, Advanced Control, External Trigger, Image Buffer and ROI, Attached Camera - Xt... (selected), Camera Information, Camera Control, and Digital IO Control. The table lists parameters and their values:

Category	Parameter	Value
Attached Camera - Xt...	Sensor Color Type	Monochrome
	Acquisition Line Rate	200000.0
	Measured Line Rate	200000
	Refresh Measured Line Rate	Press...
	Acquisition Frame Rate	Not Enabled
Camera Control	TDI Mode	TDI Planar
	TDI Stages	Not Enabled
	Direction Source	Internal
	Internal Scan Direction	Forward

Figure 7: Setting up raw data read-out - camera

Configuring Camera in CamExpert

To configure the camera for TDI Super Resolution

1. In the **Camera Control** category, set:
 - **TDI Mode** = *TDI Super Resolution*

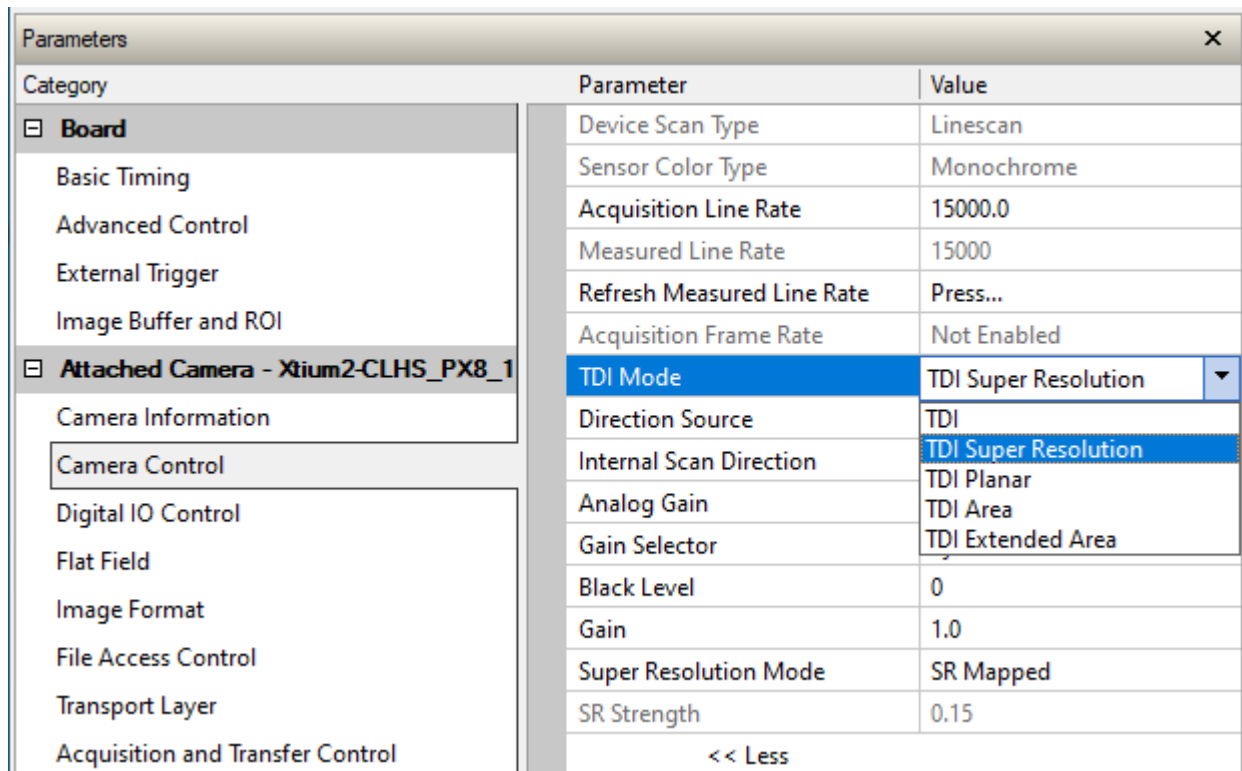


Figure 8: Enable Super Resolution ("SR") in the camera

2. In the **Camera Control** category, set: **Super Resolution Mode** = *SR Mapped*.

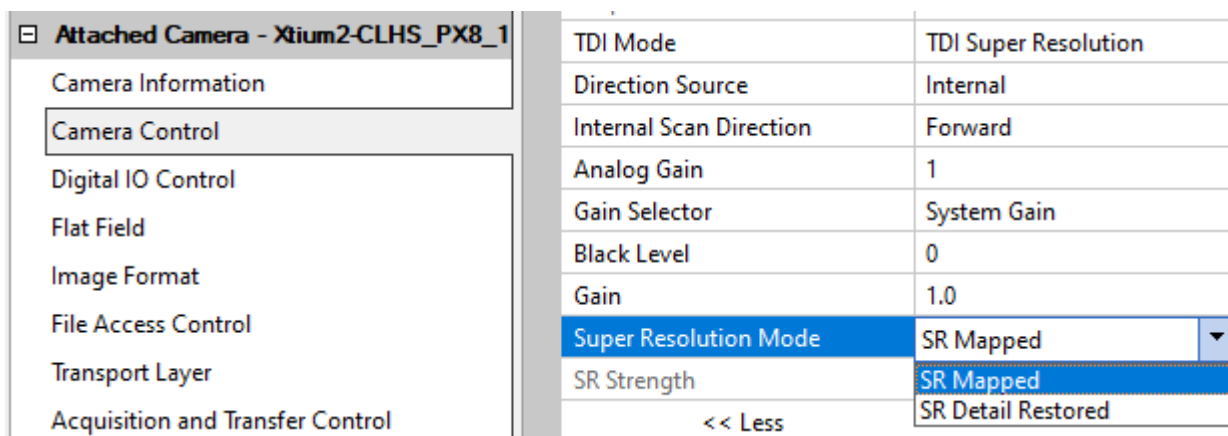


Figure 9: Selecting Super Resolution Options

Note : Unlike typical bilinear or bicubic interpolation methods, Teledyne DALSA's proprietary and patent-pending super resolution system derives a balanced, artefact free 32k image that provides higher detectability, especially for small defects, high MTF, low noise and high SNR, all with the responsivity of a 5µm pixel. The combination of camera, CLHS interface and High-Resolution frame grabber enables this functionality up to full line rate.

The **SR mapped** function utilizes the first stage in Teledyne DALSA's patented processing chain. The high resolution image is created, benefitting the system with higher Full Well, higher SNR and lower noise.

This mode provides the lowest level of data processing in the Teledyne DALSA system and hence poses the lowest risk of affecting subsequent user data processing. Use this mode in the initial setup to evaluate whether your system benefits enough from the 32k SR operation and to avoid conflicts for sub-sequent algorithms.

3. In the **Camera Control** category, set **Super Resolution Mode** = *SR Detail Restored*.

The **SR Detail Restored** function utilizes the full Teledyne DALSA's patented processing chain. The high resolution image is created as in the SR Mapped function, but details from the original images are retained and reconstructed, delivering higher detectability (via higher SNR and MTF) for small, and especially sub-pixel, defects.

Adjust the **SR Strength** between 0 and 1 (default 0.15) to optimize the detection of key features in the application. Teledyne DALSA's experience is that reconstruction between 0.15 and 0.5 is the most acceptable range. Higher factors may to disturb subsequent algorithms due to higher noise or false positives. Experimental verification in the final application is recommended.

Attached Camera - Xium2-CLHS_PX8_1	
Camera Information	
Camera Control	
Digital IO Control	
Flat Field	
Image Format	
File Access Control	
Transport Layer	
Acquisition and Transfer Control	
TDI Mode	TDI Super Resolution
Direction Source	Internal
Internal Scan Direction	Forward
Analog Gain	1
Gain Selector	System Gain
Black Level	0
Gain	1.0
Super Resolution Mode	SR Detail Restored
SR Strength	0.15
<< Less	

Figure 10: Setting the Detail Restoration Strength

For more details, refer to the camera user manual: 03-032-20290.

Super Resolution Fundamentals

The 32k camera uses two 16k/5µm TDI arrays, each charge-summing 64 TDI stages for high sensitivity, photon collection and Responsivity. The pixel arrays are shifted ½ pitch in both, horizontal (cross-scan) and vertical (in-scan) direction.

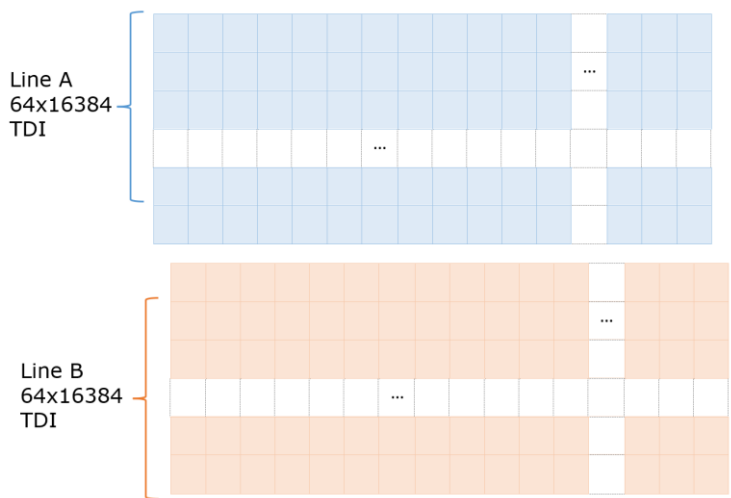


Figure 11: Logical Concept of the SR Image Sensor ¹⁾

The two 16k/5µm image lines are captured simultaneously and reconstructed in the frame grabber, in real time, to produce the super resolution image of 32k/2.5µm. A simplified reconstruction is shown here:

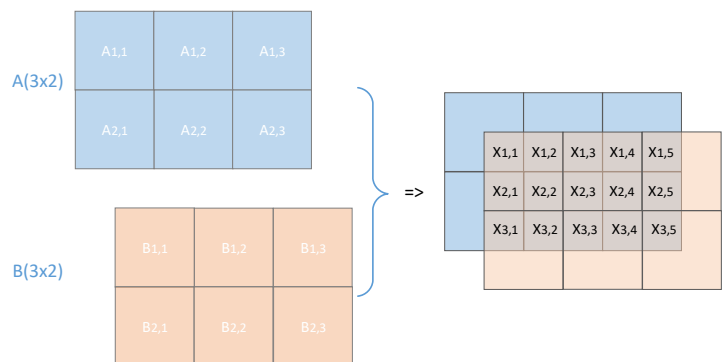


Figure 12: Super Resolution Reconstruction Concept ^{2,3)}

The following example has been obtained to compare 16k with 32k SR imaging.



Figure 13: 16k Resolution

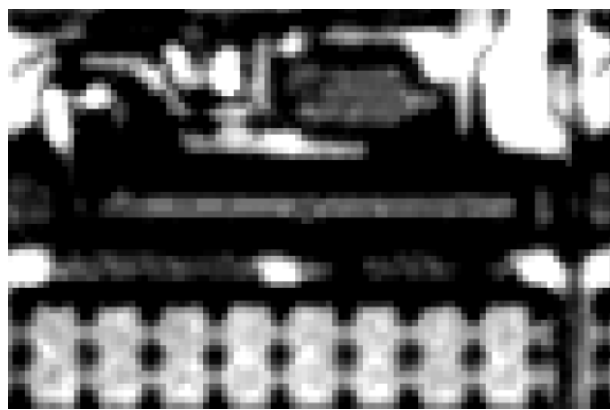


Figure 14: 32k Super Resolution

Notes:

- 1) The pixel shift shown is a logical concept. Physically, the distance of the two sub-arrays in the in-scan direction can be $N + \frac{1}{2}$ without impacting the operation ($N = \text{integer value}$)
- 2) Teledyne DALSA's patent-pending Super Resolution is a specific, sensor design and device physics based, hardware and algorithmic architecture, utilizing in-depth knowledge and experience of imaging, sensor and process technologies
- 3) Employing typical, simplified bi-linear, bi-cubic, traditional or AI-based upscaling can be employed, but will not yield the same performance benefits noted throughout.

Further Support

Should you have any questions, please feel free to contact your local TCS (Technical Customer Support) teams.