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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:

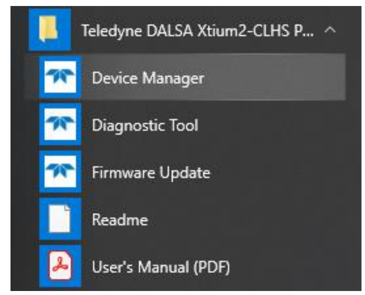
- Resolution is improved by 2x;
- Detectability, particularly for subpixel defects, is improved with 4~5x higher effective SNR for a given object;
- Responsivity, Full Well, SNR and MTF remain high, compared to typical, smaller pixels;
- Existing components can be reused: 16k/5μm lens, lighting, encoder, 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-**PX**870), but this combination will NOT provide super resolution functionality.*

1) Close all Sapera applications, including CamExpert and open the **Sapera 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*.

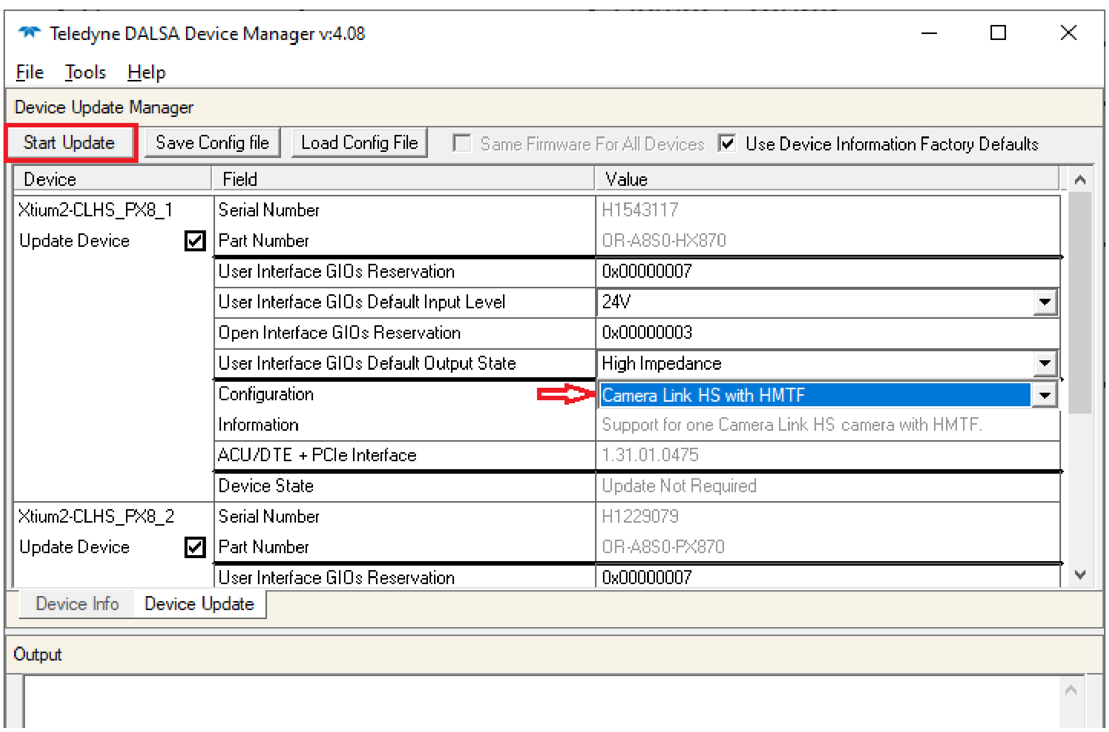


Figure 1: HX870 frame grabber - firmware update to SR mode

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.

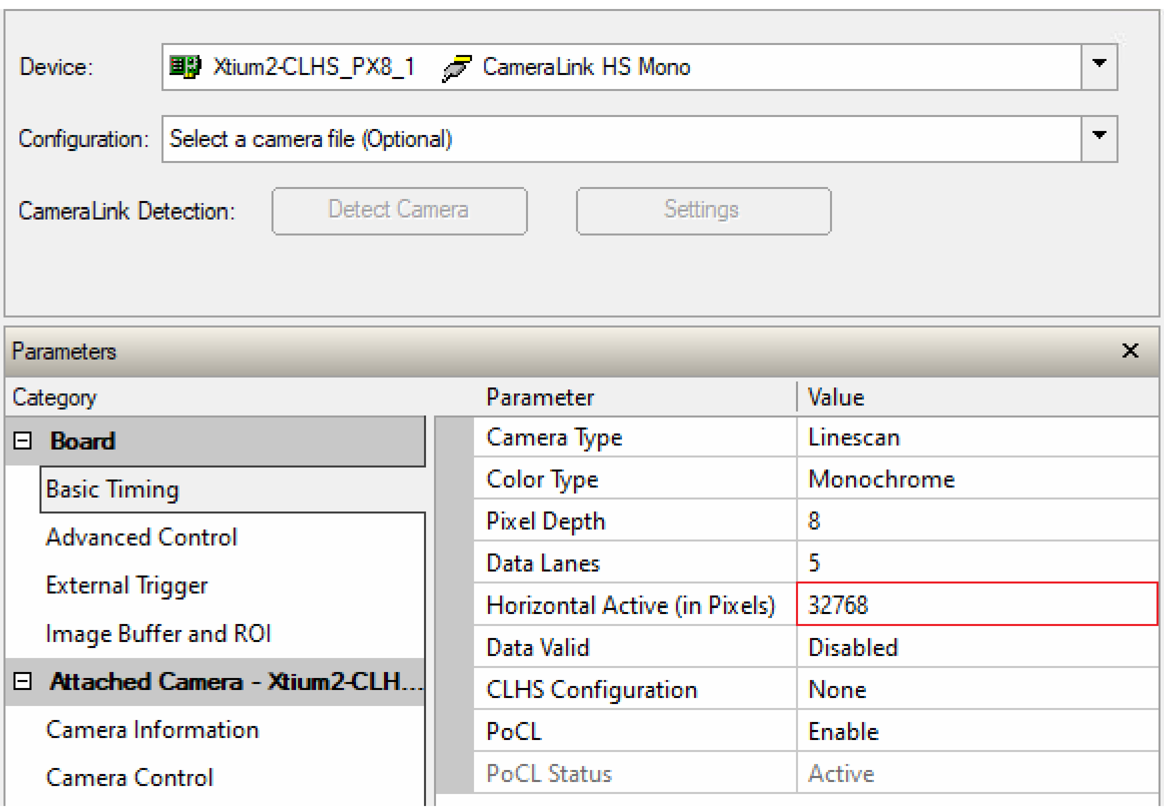


Figure 2: Expected Basic Timing frame grabber parameters (note: image captured with non-SR PX8)

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.

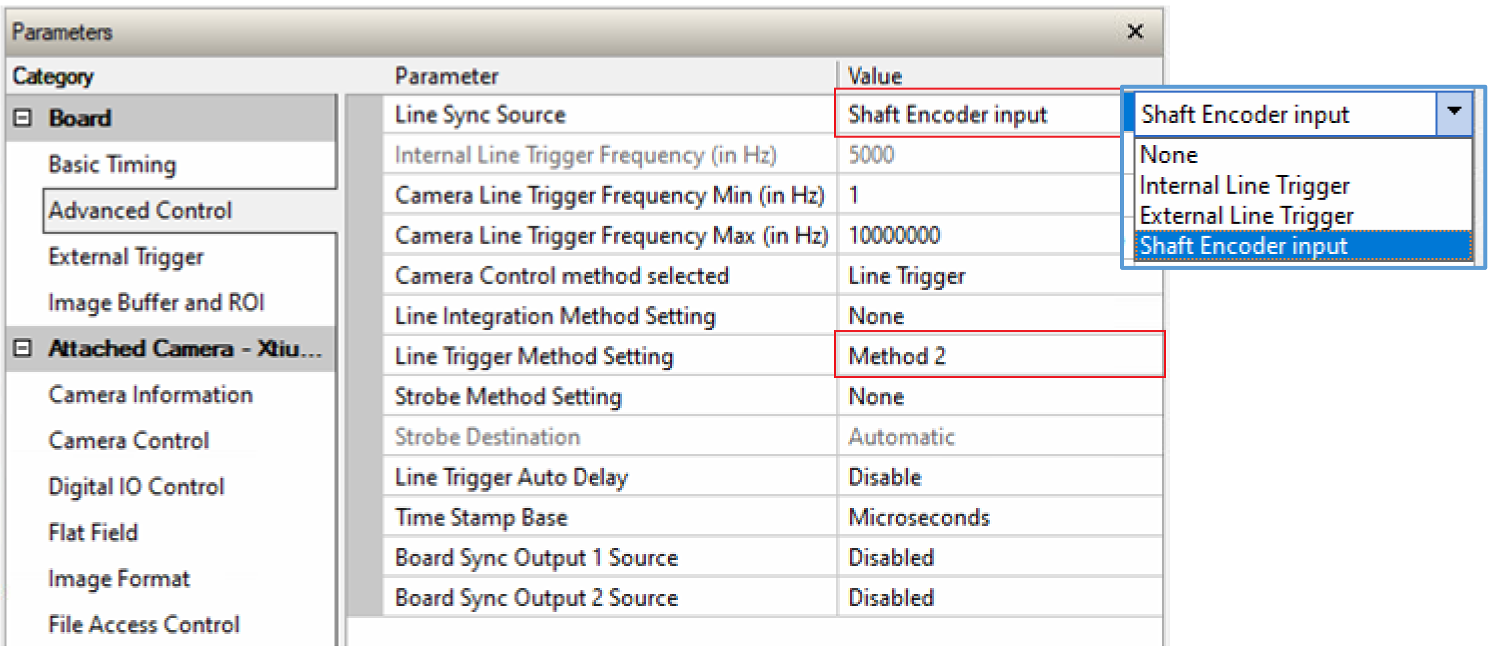


Figure 3: Setting up encoder-based triggering, routed through the frame grabber

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/ZjfmHXvOUZs 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.

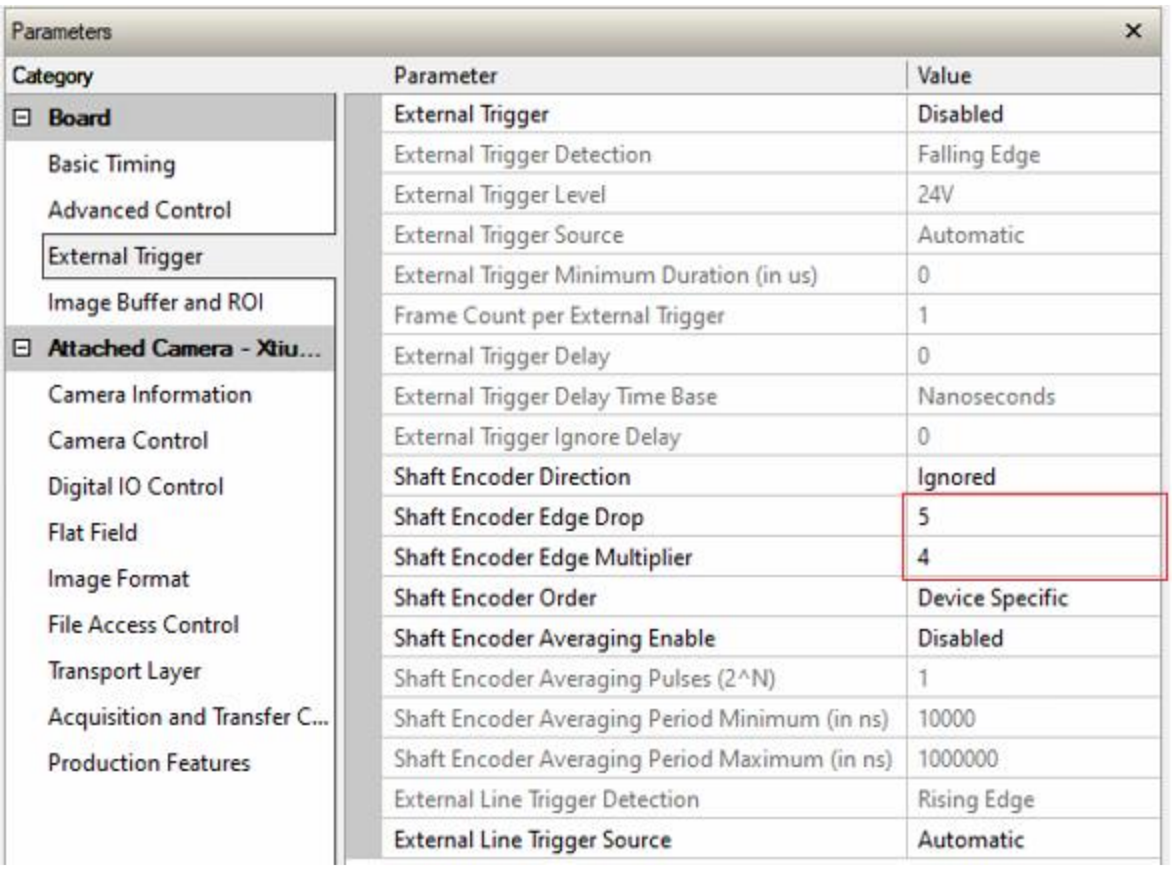


Figure 4: Re-Scaling the shaft encoder signal

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

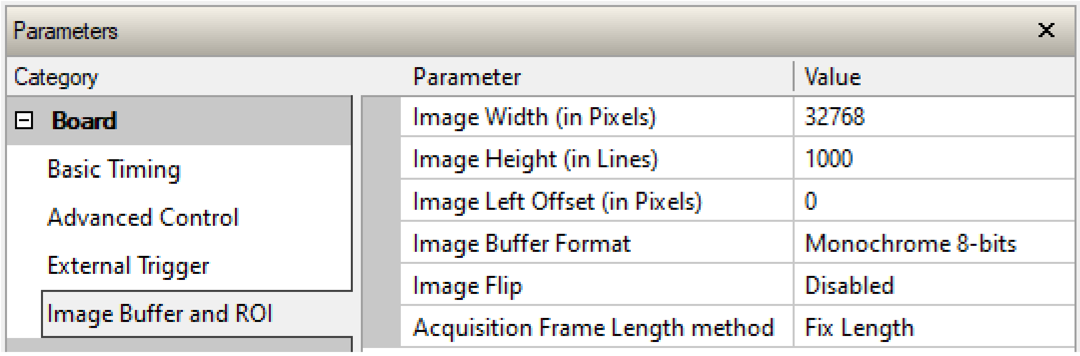


Figure 5: Defining the size of a captured image

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**.

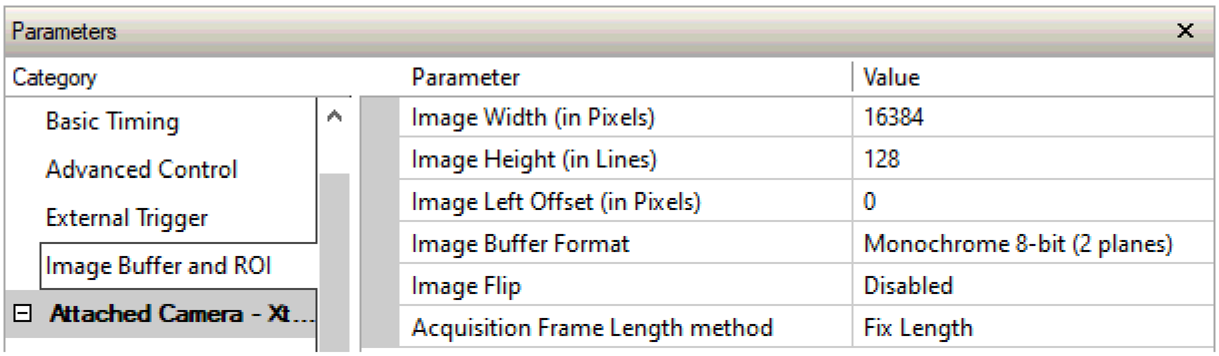


Figure 6: Setting up raw data read-out - frame grabber

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

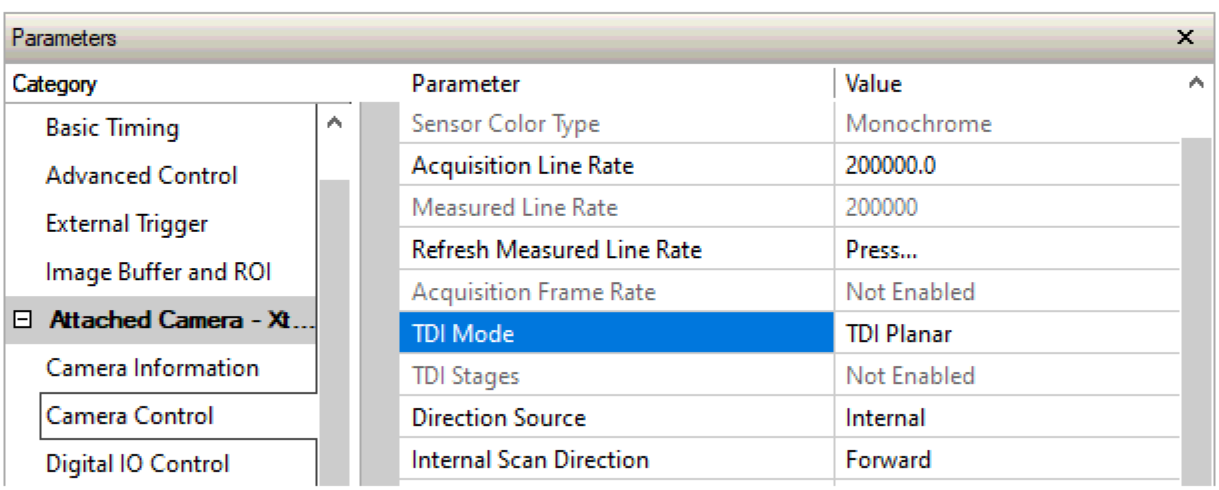


Figure 7: Setting up raw data read-out - camera

Configuring Camera in CamExpert

To configure the camera for TDI Super Resolution

1. In the **Camera Control** category, set:

- **TDI Mode** = *TDI Super Resolution*

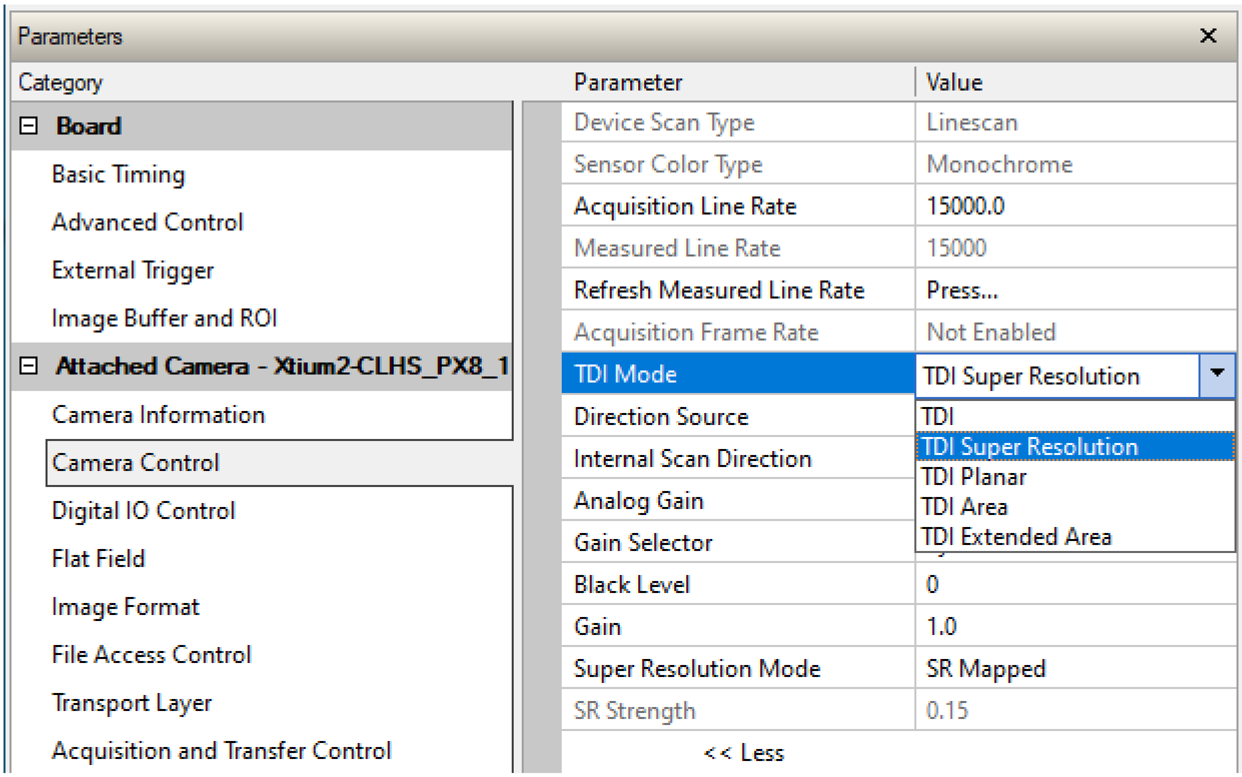


Figure 8: Enable Super Resolution ("SR") in the camera

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

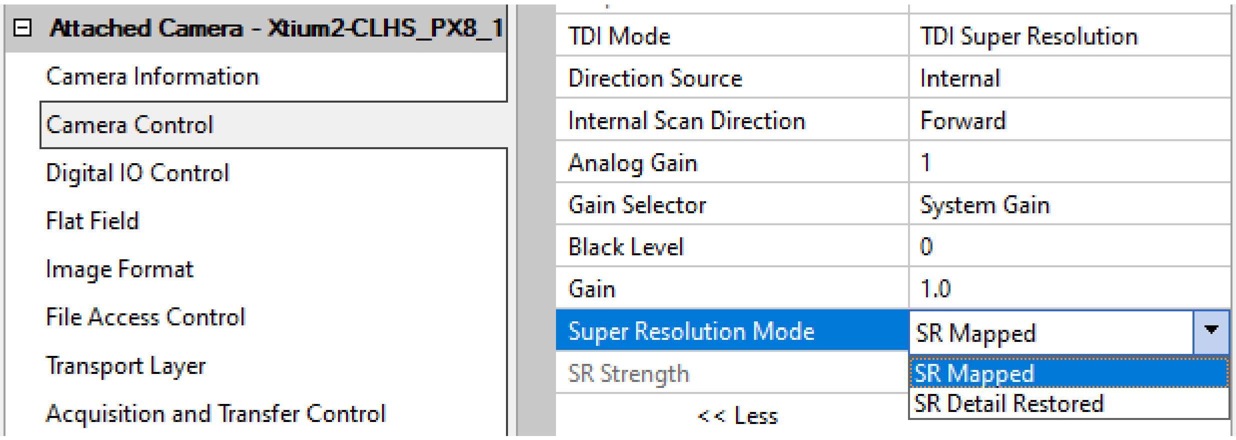


Figure 9: Selecting Super Resolution Options

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.

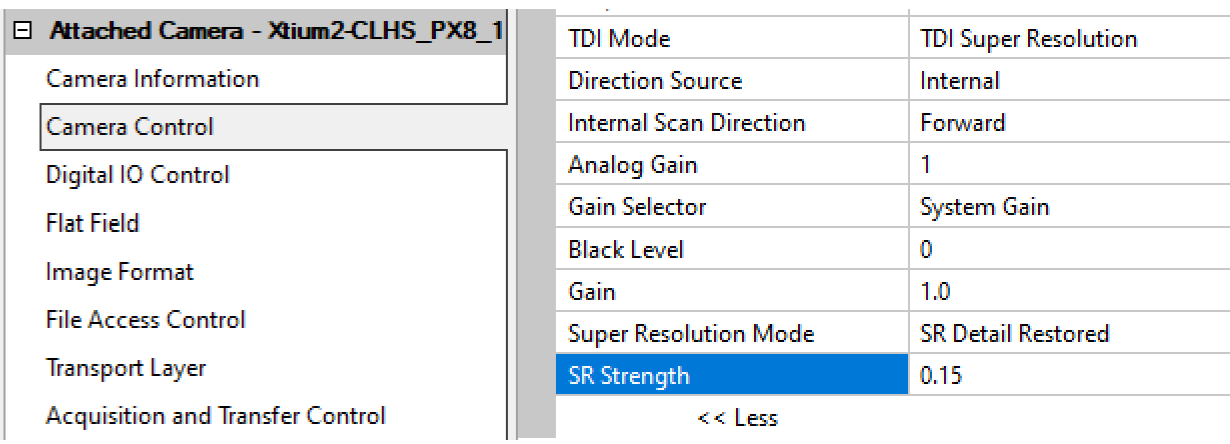


Figure 10: Setting the Detail Restoration Strength

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.

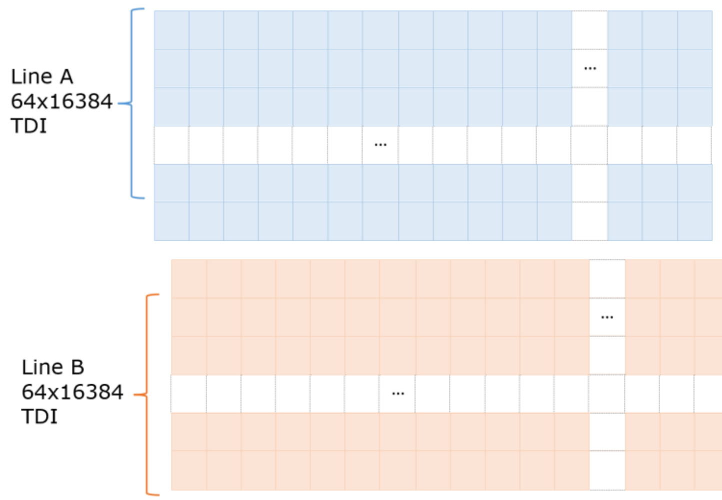


Figure 11: Logical Concept of the SR Image Sensor [1)]

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:

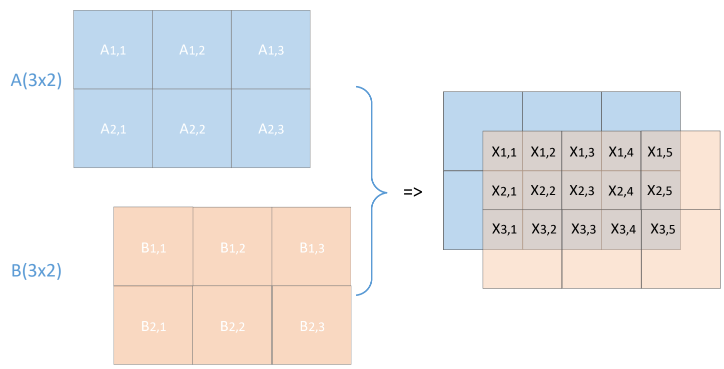


Figure 12: Super Resolution Reconstruction Concept [2,3)]

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

Figure 13: 16k Resolution

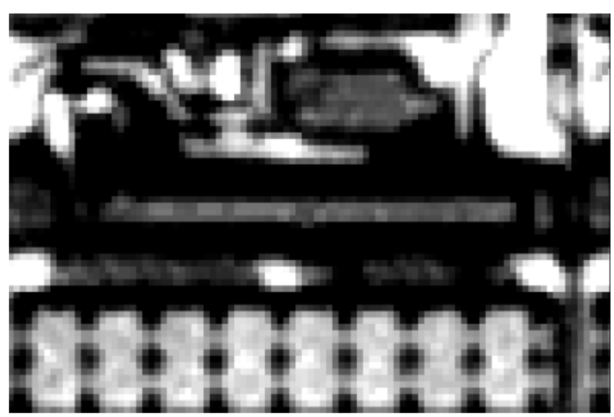


Figure 14: 32k Super Resolution

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+½ without impacting the operation (N = 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.