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Configuring Linea ML(ML-HM-16K30H) for Multi-light Source Imaging

Overview

This document demonstrates how to configure the Linea ML Mono line scan camera for multiple light sources imaging.

Advantage of Multi-light Source Imaging

With pulsed light sources, the new mode can be used to capture multiple images with different wavelengths, intensities, angles of light incidence, and polarization states etc. in a single scan.

Connecting Light Source

The camera outputs strobe signals via its general I/O, and can output four signals in total. The I/O pin numbers are 3(Line 3), 4(Line 4) and 7(Line 5), 8(Line 6). The strobe logic level is 3.3V. Typically modern light sources are designed to work with 3.3V TTL signal. In this case, you can directly connect the strobe signal to the light controller, otherwise, you need an additional driving circuit, refer to your light source manual. The following is an example of direct wiring.

Pin Number	Input / Output	Signal Details	Notes
1		Power Ground*	
2		+12 V to +24 V power*	
3	Output	Line 3 Out	0 to 3.3V TTL
4	Output	Line 4 Out	0 to 3.3V TTL
5	Input	Line 1 / Trigger / Phase A	0 to 3.3V TTL
6	Input	Line 2 / Scan Direction / Phase B	0 to 3.3V TTL
7	Output	Line 5 Out	0 to 3.3V TTL
8	Output	Line 6 Out	0 to 3.3V TTL

9		Power Ground*	
10		+12 V to +24 V power*	
11		Signal Ground	Note: intended as a return path for GPIO signal and not intended as a power ground
12		Signal Ground	Note: intended as a return path for GPIO signal and not intended as a power ground
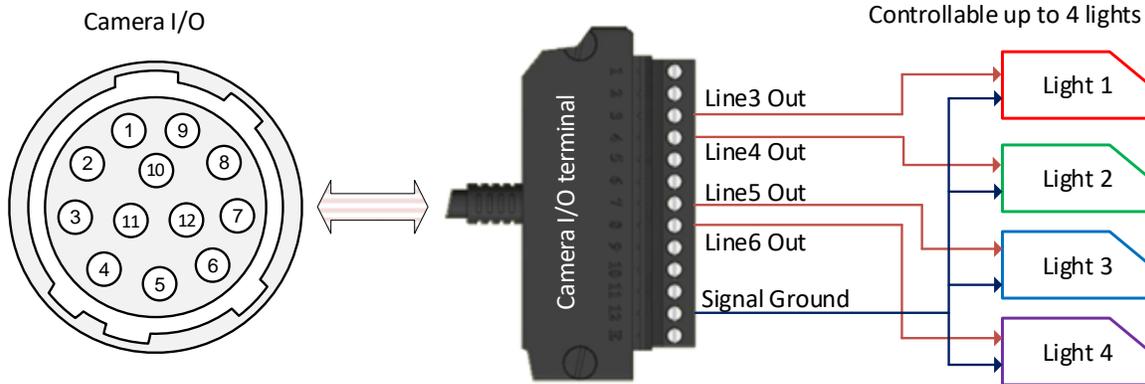
# of Light	Line #	I/O Pin #	Remark
2	3, 4	3, 4	
3	3, 4, 5	3, 4, 7	
4	3, 4, 5, 6	3, 4, 7, 8	

Configuring Frame Grabber in CamExpert

This camera works with Xtium2-CLHS_PX8 frame grabber,
https://www.teledynedalsa.com/en/products/imaging/frame-grabbers/xtium2-clhs-px8/

There are no special requirements for the frame grabber whether it's multi-light source mode or else. Select **CameraLink HS Mono** in the **Device Selector** and load a pre-prepared CCF file. The prepared files can be downloaded from the following link.
https://www.teledynedalsa.com/en/support/downloads-center/

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The following explains how to configure the frame grabber manually. Once you select **CameraLink HS Mono** in the **Device Selector**, the frame grabber automatically configures right parameters, such as number of Data Lanes, etc. Otherwise, select correct parameters manually.

Select **Shaft Encoder input** in the **Line Sync Source** when you supply external trigger with shaft encoder, and select **Method 2** in **Line Trigger Method Setting** as a physical trigger signal is supplied through a frame grabber.

An Exsync can also be applied directly to the camera through the camera I/O, refer to the camera manual(03-032-20263). In this case, select **None** in the **Line Sync Source**.

In case use a single-ended TTL signal as Exsync, select the **External Line Trigger** instead of **Shaft Encoder input**.

The **Internal Line Trigger** is another option, however, it is not recommended in this mode as it requires accurate synchronization between senor lines and strobes unless the stability of the object speed is good enough for your application.

Use the **Shaft Encoder Edge Drop** and **Shaft Encoder Edge Multiplier** to adjust the aspect ratio of the images. The right combination should be determined according to the specific application.

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When you are imaging two or three or four sources images, select **2 planes** or **3 planes** or **4 planes** accordingly.

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

Configuring Linea ML in CamExpert

The procedure described below is for a two light sources configuration. The procedure is similar for three and four light sources.

To configure the camera for use with 2 light sources

1. Connect the light sources to Line 3 and Line 4.

2. In the **Format Controls** category, set **Binning Vertical** = *1* if it is not 1(to change this parameter, you need to stop acquisition first in the **Acquisition and Transfer Control** menu, and don't forget to start acquisition back after binning is set).

3. In the **Camera Control** category, set both:

   - **Exposure Mode** = *Timed*.
   - **TDI Mode** = *Multi-Light Source*.

External Trigger	
Image Buffer and ROI	
□ Attached Camera - Xtium2-CLHS_PX8_1	
Camera Information	
Camera Control	
Digital IO Control	

Refresh Measured Line Rate	Press...
TDI Mode	Multi-Light Source
TDI Stages	Not Enabled
Full Well Mode	Not Enabled
Exposure Mode	Timed
Exposure Time Selector	All

4. In the **Digital IO Control** category, and **Multi-Light Count** menu select *Two colors*.

You now have to configure each light source.

5. Select *Light 1 configure* from **Multi-Light Mode**. This will output the first plane.

6. Set all the followings in **Digital IO Control** category:

- **Trigger Mode** = *External*

- **Trigger Source** = *CLHS In*

  Note: When you apply Exsync through the frame grabber, select **CLHS In**, when you apply Exsync directly through the camera I/O, select **Rotary Encoder** or **Line 1**(TTL signal)

- **Line Selector** = *Line 3* (for 2nd color).
- **Output Line Source** = *On*.
- **Pulse Duration =** *1.0 (1μs)*
  Note: May vary depending on the specification of the light source controller. Typically, there are two types of controller need to be taken into consideration.
 1) The light controller detects trigger edge and controls light on time itself. In this case, the parameter only needs to be detected by the controller. So that, it can be 0.5, 1, 2, 3, etc. vary.
  2) The light on time is controlled by trigger signal high time. In this case, the parameter should be set to the period of the application requires.

- **Output Line Software Command** = *Low* (High for triggering the light continuously).
- **Line Selector** = *Line 4* (for 2nd color).
- **Output Line Source** = *On*.
- **Pulse Duration =** *1.0 (1µs)*
- **Output Line Software Command** = *Low*.

Parameters		×
Category	**Parameter**	**Value**
⊟ **Board**	Trigger Mode	External
Basic Timing	Trigger Source	CLHS In
Advanced Control	Trigger Input Line Activation	Rising Edge
External Trigger	Rotary Encoder Output Mode	Motion
Image Buffer and ROI	Rotary Encoder Direction	Counter Clockwise
⊟ **Attached Camera - Xtium2-CL...**	Input Line Debouncing Period	0.0
	Rotary Encoder Multiplier	1
Camera Information	Rotary Encoder Divider	1
Camera Control	Rotary Encoder Rescaler Order	Multiplier Divider
Digital IO Control	Trigger Delay	0.0
Flat Field	Line Selector	Line 3
Image Format	Output Line Source	On
File Access Control	Output Line Pulse Delay	0.0
Transport Layer	Pulse Duration	1.0
Acquisition and Transfer Control	Line Inverter	Off
Production Features	Output Line Software Command	Low
	Refresh Line Status	Not Enabled
	Line Status	Low
	Multi-Light Mode	On
	Multi-Light Count	Two colors

7. Set **Multi-Light Mode** to *On* for acquisition.

8. Save your configuration and calibration parameters in a user set. There are 16 user sets the user can choose from.
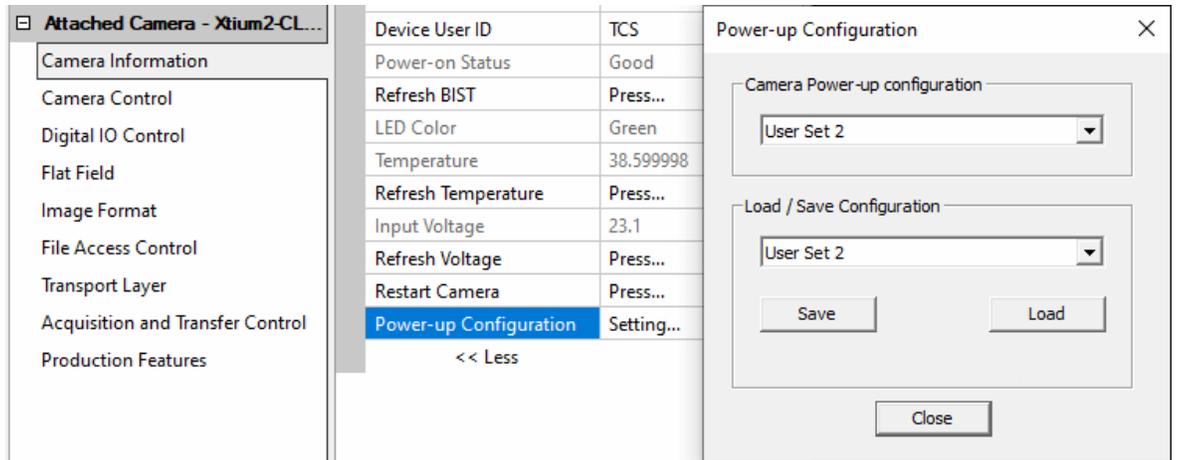
Now you can imaging two-light-source images.

Flat Field Calibration(FFC)

The camera uses factory default FFC parameters unless the user specify your own, some applications, however, user calibration probably is needed. The procedure described below is for a two-light-source calibration. The procedure is similar for three and four light sources.

1. It is important that you check the **bare images**(images without correction) prior to calibrate. The bare images tell you the nature of your optical system and give you an idea of how to calibrate it. To do so,

    1) Set parameters, such as exposure time, gains, etc. properly from **Camera Control** category.

Parameters		✕
Category	**Parameter**	**Value**
⊟ **Board**	Device Scan Type	Linescan
Basic Timing	Sensor Color Type	Monochrome
Advanced Control	Acquisition Line Rate	10000.0
External Trigger	Measured Line Rate	53731
Image Buffer and ROI	Refresh Measured Line Rate	Press...
⊟ **Attached Camera - Xtium2-CL...**	TDI Mode	Multi-Light Source
Camera Information	TDI Stages	Not Enabled
Camera Control	Full Well Mode	Not Enabled
Digital IO Control	Exposure Mode	Timed
Flat Field	Exposure Time Selector	All
Image Format	Exposure Delay	Not Enabled
File Access Control	**Exposure Time**	**12.0**
Transport Layer	Direction Source	Internal
Acquisition and Transfer Control	Internal Scan Direction	Forward
Production Features	Gain Selector	All Rows
	Black Level	0
	Gain	1.0
	Line Spatial Correction	1.0
	Image Distortion Correction Mode	Off
	Image Distortion Correction Algorithm	ParallaxCorrection
	Image Distortion Correction Line Selector	Row 3
	Image Distortion Parallax Correction Pixel Stretch	0.0
	Drift Correction Mode	Off

2) Click *Press…* from **Clear Coefficients** and select *Off* from **Flat Field Correction Mode**(refer to step 4 below). Then set **Multi-Light Mode** to *On* and grab images. After verification is done, proceed to next steps.

2. Select *Light 1 configure* from **Multi-Light Mode** (other parameters set so far remain unchanged).

3. Select one of sixteen user sets from **Flat Field Correction Current Active Set**, e.g. *User Set 2*.

4. Select *On* from **Flat Field Correction Mode** and set Flat Field Calibration Target to appropriate numbers, e.g. 200.

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Parameters			✕
Category	Parameter	Value	
⊟ **Board**	Flat Field Correction Mode	On	
Basic Timing	Clear Coefficients	Press...	
Advanced Control	Calibration Algorithm	Set Target	
External Trigger	Flat Field Calibration Target	200	
Image Buffer and ROI	Flat Field Calibration Offset X	0	
⊟ **Attached Camera - Xtium2-CL...**	Flat Field Calibration Width	16384	
Camera Information	Calibrate FPN	Press...	
Camera Control	Row Selector	All Rows	
Digital IO Control	Calibrate PRNU	Press...	
Flat Field	Flat Field Correction Current Active Set	User Set 2	
Image Format	Save Calibration	Press...	
File Access Control	Load Calibration	Press...	
Transport Layer	Output LUT Mode	Off	
Acquisition and Transfer Control	Gamma Correction	1.733	
Production Features	EOI	Off	
	EOI Count	1	
	EOI Selector	1	

5. Close the lens with a lens cap(stop lights entering the camera) and click *Press…* from **Calibrate FPN**. After a while press *Press…* from **Save Calibration** to save calibrated coefficients to the user set you have chosen.

6. Open the lens cap and put an even white target in the FOV(defocusing the lens slightly or moving the target while calibrating gives better results). Then press *Press…* from **Calibrate PRNU**. After a while press *Press…* from **Save Calibration** to save calibrated coefficients to the user set you have chosen.

7. Select *Light 2 configure* from **Multi-Light Mode** and repeat above step 2 to 6.

8. This completes the calibration for two light sources. Select *On* from **Multi-Light Mode** to switch to acquisition mode.

Some Results

The screen image below is an observation of the relationship between two strobe signals and line trigger signals.
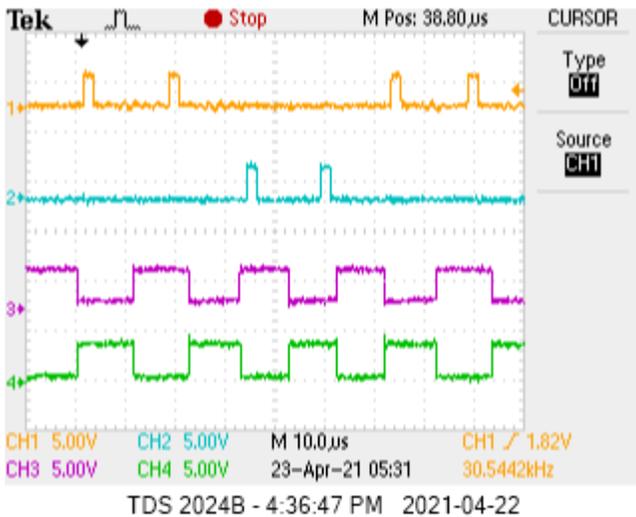
The #1 (yellow) and #2 (cyan) are strobes output from the camera, and they are following (0 delay in this example) the shaft encoder trigger(purple – Phase A and green – Phase B) exactly as expected.

As mentioned above, there are two options for the line trigger, which can be applied through the camera I/O or through the frame grabber. Whichever you can choose, the result is the same. All you need to do is set the parameters accordingly, refer to relevant instructions.

With this configuration, you should be able to recreate two individual images. The following two images(same target different brightness) are example images acquired with above configuration.
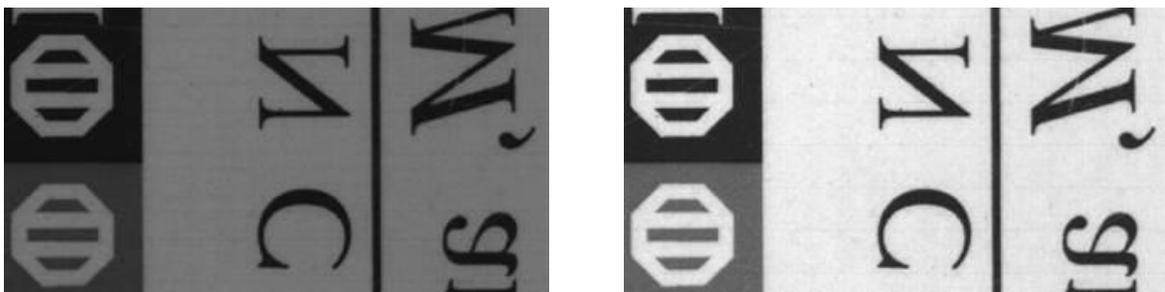

How multi-light source imaging works?

Compared to other modes, the Multi-light source mode has its own unique advantages. In regular mono planar or RGB mode, there is 100% coverage(of an object surface) on each channel, but all use the same light source. In sequential mode, different light sources can illuminate each channel but there

is no 100% coverage. In multi-light source mode, however, there is 100% coverage available and each channel can be illuminated independently. This is accomplished with unique sensor timing and using the four general-purpose outputs to control the different light sources.
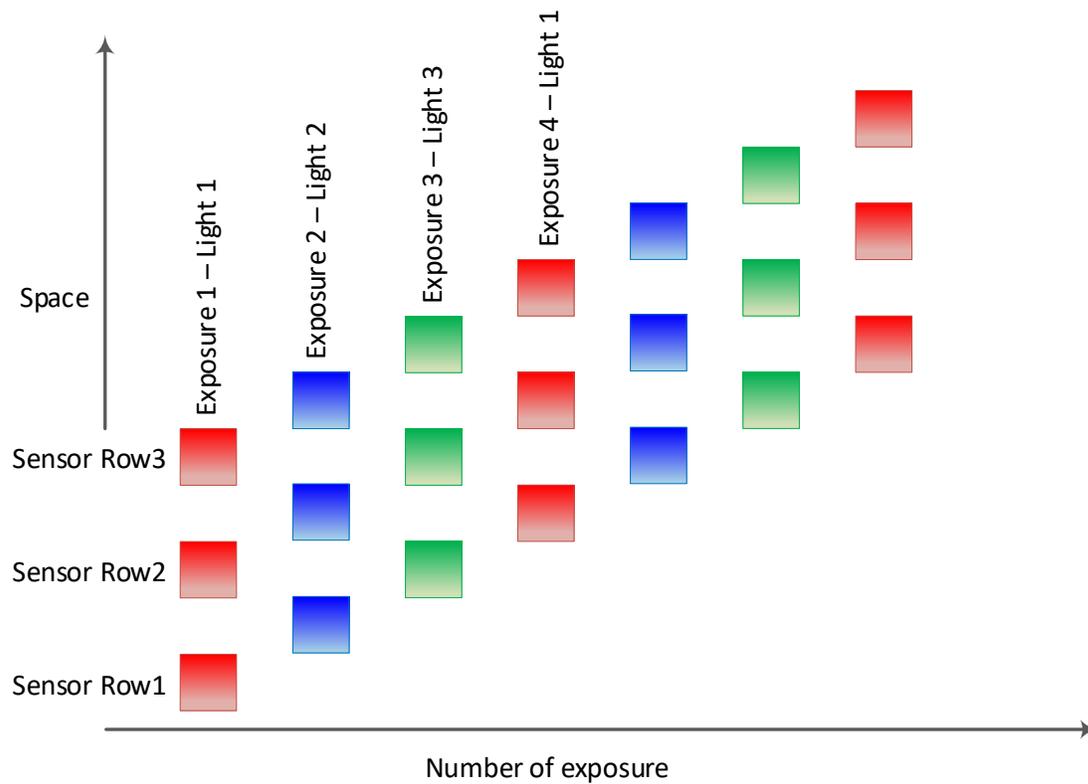
Two Light Sources

The following figure depicts acquisition with 2 light sources, generating 2 images.
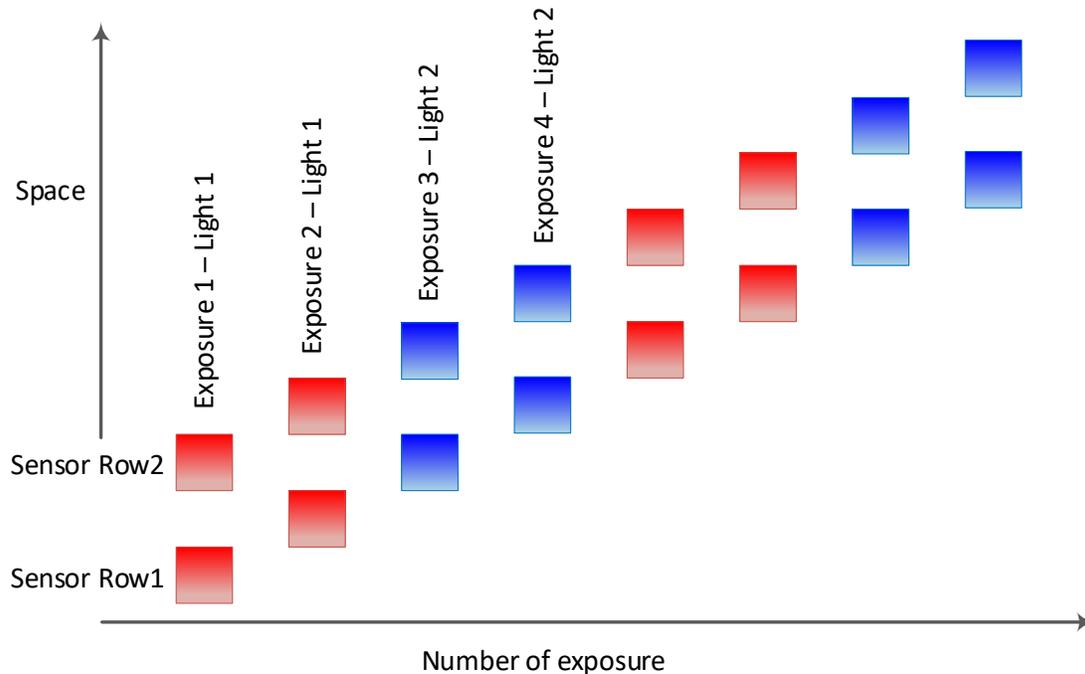
In this case, two sensor rows are enabled. The horizontal axis in the diagram represents triggers, not columns in the image. The first column is the first trigger. Only the light source connected to the first GPO (Line 3) is on. The vertical axis represents movement in the scan direction across the object being imaged. You can see that the first trigger results in a one line gap between the rows. This is filled with the second trigger (second column). With the third trigger the first light source is turned off and the second is turned on. The next two triggers capture four contiguous rows of the object illuminated by the second light source. And then it repeats with the first light source.

The camera takes care of alternately turning on the light sources and organizing the images from the two lights sources into two planes from the camera.

Three Light Sources

With three light sources, three sensor rows are used. The camera cycles through the three light sources with each trigger. You can see that the gaps between the rows from the first trigger are filled with the fourth trigger. Again, the camera takes care of turning the light sources on at the correct time and organizing the images from the three light sources into three planes.

The screen image below is an observation of the relationship between three strobe signals and line trigger signals.
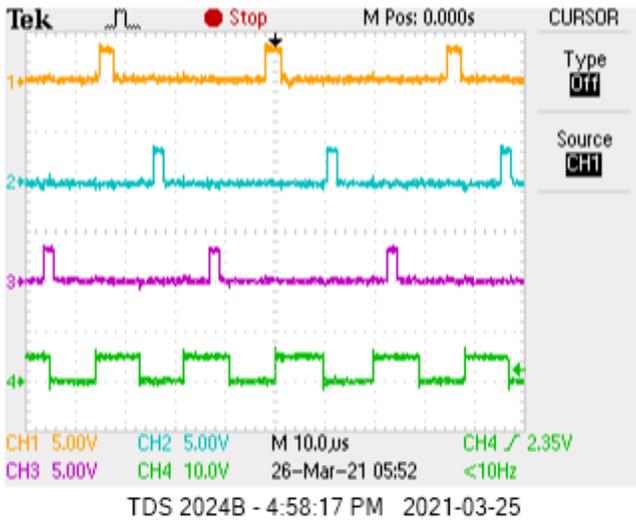
Four Light Sources
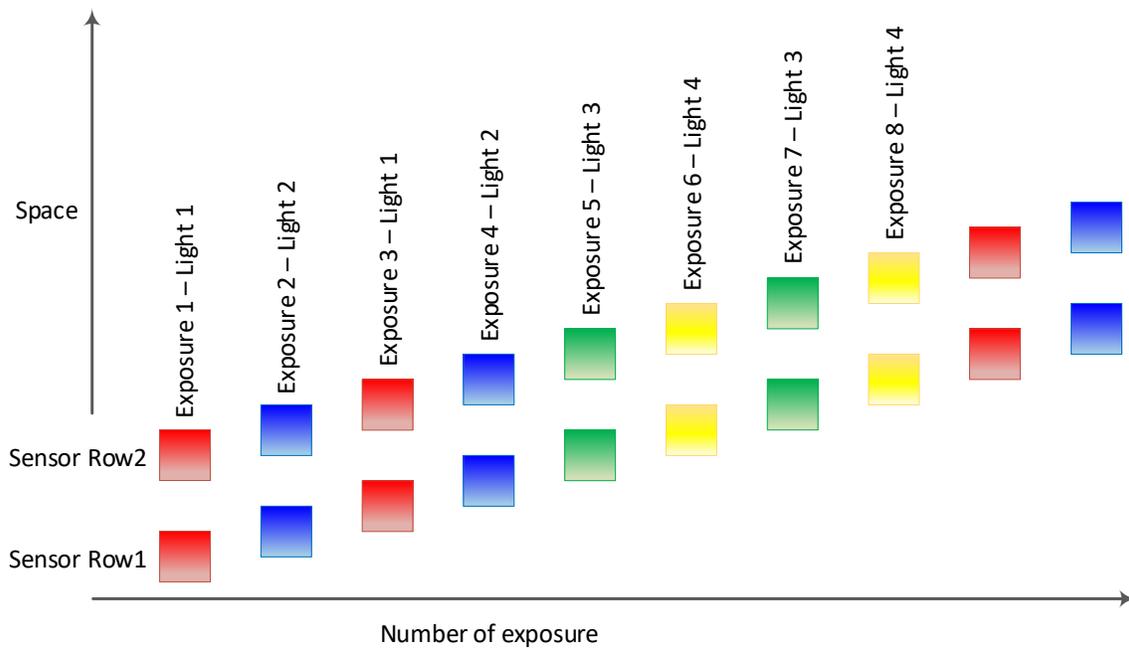
Two pairs of pixel(vertically) are offset from each other by ½ pixel. Therefore, the line rate of the trigger supplied to the camera must be doubled so that the object only advances ½ pixel with each trigger. This facilitates 100% coverage.

Effective Maximum Line Rates

Number of Sources	Number of Rows Used	Camera Line Rate [kHz]	Object Pixels per Exposure	Effective Line Rate [kHz]
1	1	300	1	300
2	2	150	1	150
3	3	100	1	100
4	4	150	0.5	75

Further Supports

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