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Channel Alignment Instruction for Linea TDI Color and Multifield Cameras

Camera Mounting and Mechanical System Requirements

The TDI Linescan camera requires that its sensor surface to be installed parallel to the surface of the object being scanned and the relative motion axis of the object and camera must coincide with the longitudinal axis of the sensor. The area mode and alignment markers functions can be helpful.
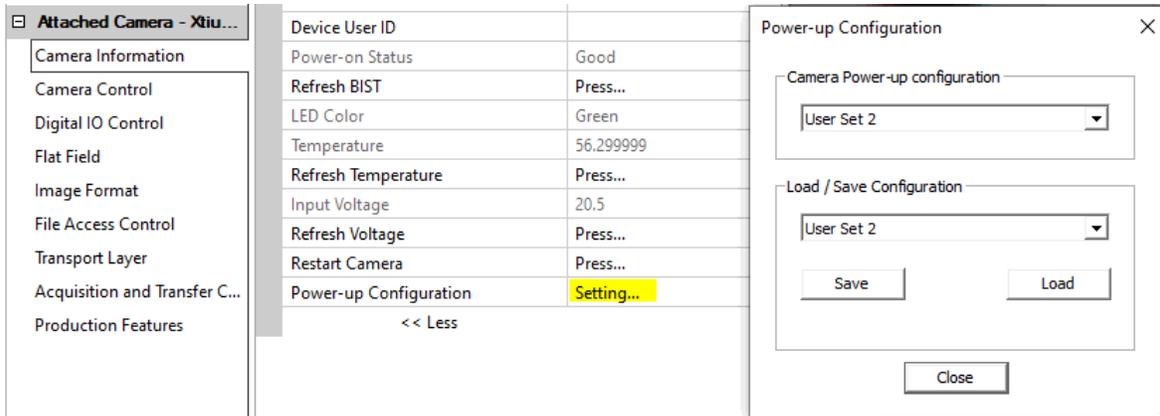
Flat Field Correction(FFC)

FFC(FPN and PRNU corrections) is required to use the Red Pixel Alignment.
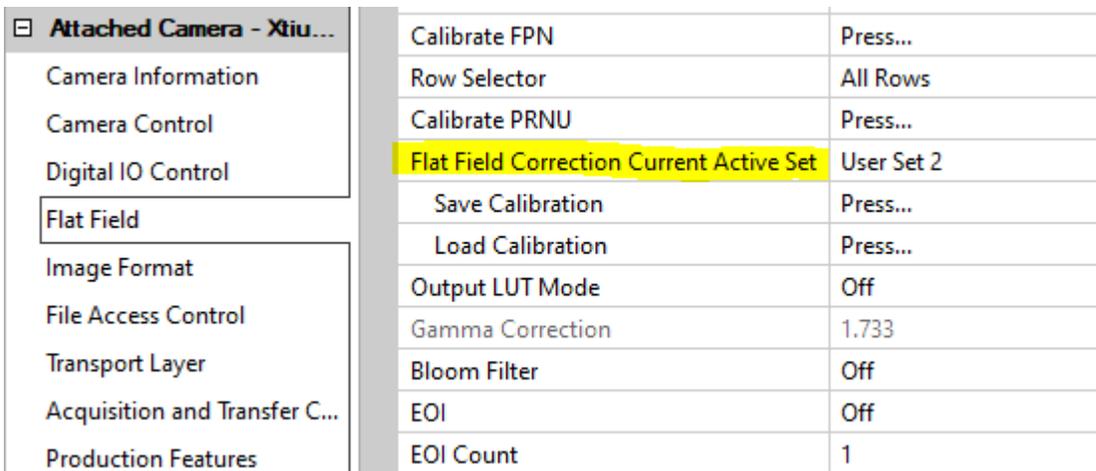
Bare Image Observation

It is recommended that observe the bare image(1x gains, FFC parameters are cleaned) before starting calibration.
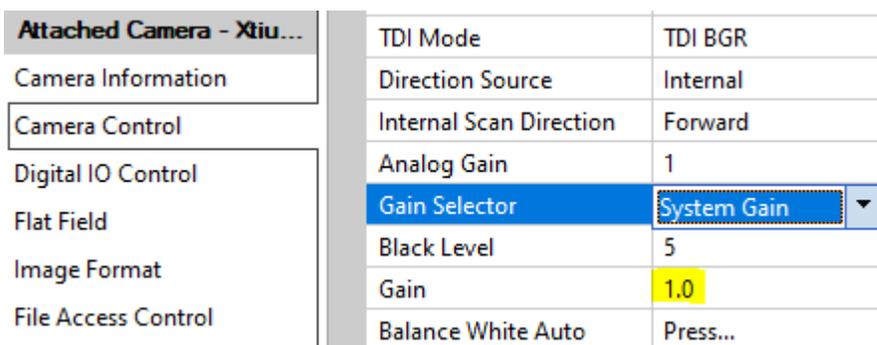
Select a user set for saving your configurations.

Select a FFC Current Active Set, typically select the same number as the user set number.

Set all gains(system and each channel) to 1x

Attached Camera - Xtiu...		
Camera Information	TDI Mode	TDI BGR
Camera Control	Direction Source	Internal
Digital IO Control	Internal Scan Direction	Forward
Flat Field	Analog Gain	1
Image Format	Gain Selector	All Rows
File Access Control	Black Level	5
	Gain	1.0
	Balance White Auto	Press...

Clear coefficents and observe if the image is normal.

Board		
Basic Timing	Flat Field Correction Mode	On
Advanced Control	Clear Coefficients	Press...
External Trigger	Calibration Algorithm	Set Target
Image Buffer and ROI	Flat Field Calibration Target	200
	Flat Field Calibration Offset X	0
	Flat Field Calibration Width	16384

FPN Calibration

Set the **Black Level** to be greater than zero, for example, 5.

Block illumination and calibrate FPN. Once done, save the coefficients.

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 - Xtiu...**	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...
	Load Calibration	Press...
	Output LUT Mode	Off

You can change the black level according to your application requirements now. For example, change it to 1 or 0, etc. the smaller it is, the greater the dynamic range will be.

PRNU Calibration

Place a white target under the field of view of the camera. The ideal target is a material with uniform surface and diffusive properties.

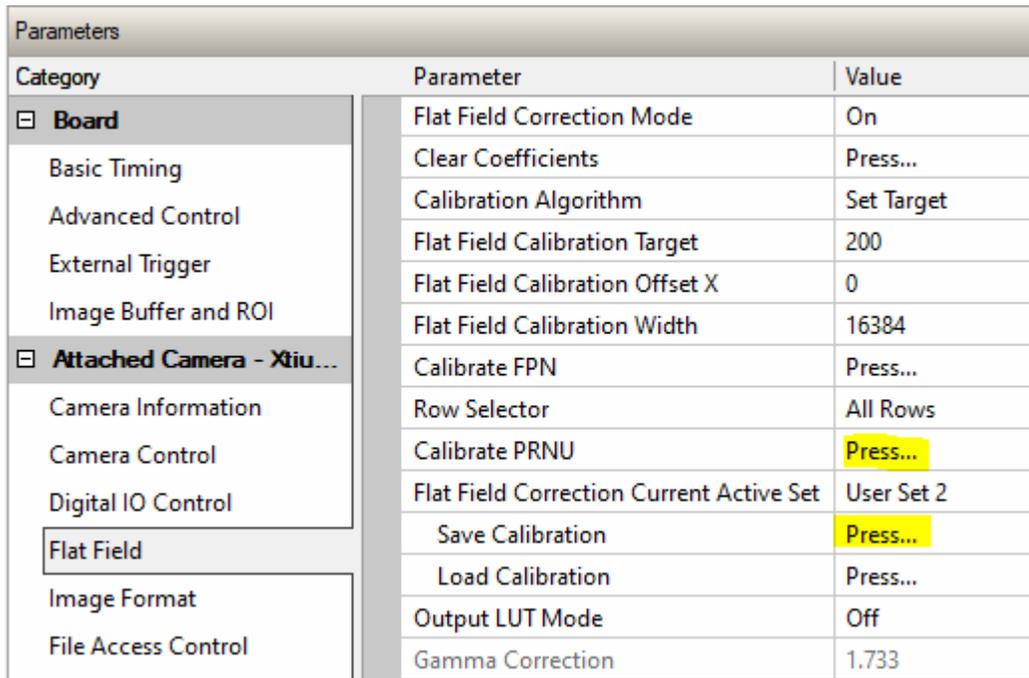Select appropriate Target value, for example 200.

To eliminate the grain effect, the following methods are often used.

1) Moving the target during calibration, or

2) Defocusing the target.

As a method of defocusing a target, there may be a method of defocusing by adjusting the working distance or a method of actually defocusing by adjusting the lens. However, rather than touching the lens, if you can, it is better to defocus by positioning the target a little closer (or further away) from the lens while keeping its plane and the object plane parallel.

Apply illumination.

Once ready calibrate PRNU and save the parameters.

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
	Flat Field Calibration Width	16384
□ **Attached Camera - Xtiu...**	Calibrate FPN	Press...
Camera Information	Row Selector	All Rows
Camera Control	Calibrate PRNU	Press...
Digital IO Control	Flat Field Correction Current Active Set	User Set 2
Flat Field	Save Calibration	Press...
	Load Calibration	Press...
Image Format	Output LUT Mode	Off
File Access Control	Gamma Correction	1.733

Spatial correction

The spatial correction function is an auxiliary function for channel alignment. However, before using this function, as a TDI camera, getting a square image(1:1 aspect ratio) is prerequisite.
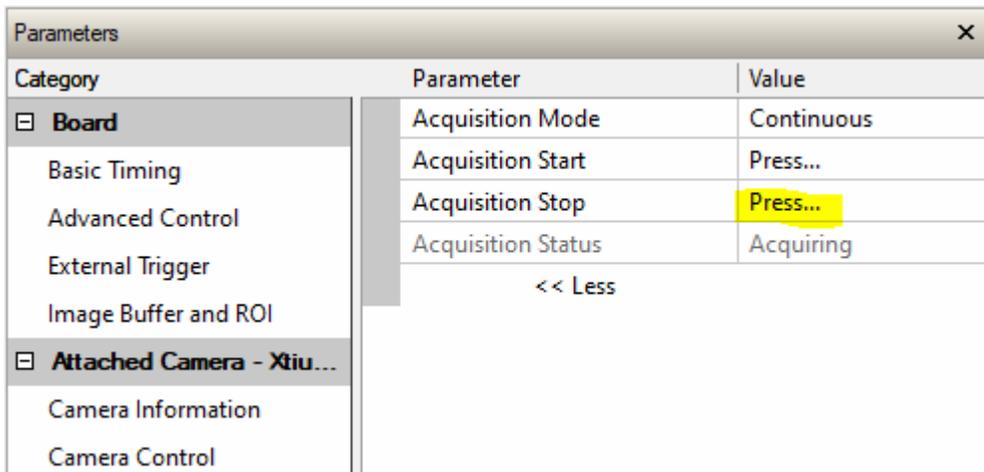
Getting Square Image

Place a square or circular object with high accuracy under the camera. The larger the size of the object within the FOV range, the better. Scan it and measure the length(by pixel) of the horizontal axis and vertical axis.

It would be ideal if both axes are exactly the same length, but in practice it is not easy. The difference should be reduced as much as possible by adjusting the linerate or optical magnification. The higher the system resolution, the higher the demand for accuracy.

Adjust Spatial Correction Parameter

Alignment can be adjusted by red and blue based on the green channel. The control range is from -5 to +5, respectively, and only the integer is accepted. In principle, the decimal number is meaningless. Minus and plus signify control in opposite directions.

To adjust the spatial correction parameters, stop acquisition - press the **Press...**in Acquisition Stop.

Parameters		✕
Category	Parameter	Value
⊟ **Board**	Acquisition Mode	Continuous
Basic Timing	Acquisition Start	Press...
Advanced Control	Acquisition Stop	Press...
External Trigger	Acquisition Status	Acquiring
Image Buffer and ROI	<< Less	
⊟ **Attached Camera - Xtiu...**		
Camera Information		
Camera Control		

Adjust red or/and blue channel spatial correction parameters in Camera Control category.

Attached Camera - Xtiu...	
Camera Information	
Camera Control	
Digital IO Control	
Flat Field	
Image Format	
File Access Control	
Transport Layer	
Acquisition and Transfer C...	
Production Features	

TDI Mode	TDI BGR
Direction Source	Internal
Internal Scan Direction	Forward
Analog Gain	1
Gain Selector	System Gain
Black Level	5
Gain	1.0
Balance White Auto	Press...
Red Spatial Correction	0
Blue Spatial Correction	0
Align Red Pixels	Off

To grab images - press the **Press...**in Acquisition Start.

Parallax Correction

Channel aberration in edges is almost unavoidable due to various causes such as optical system and mounting deviations, etc. The function to correction this aberration is parallax correction.

The parallax correction parameters apply to all red, green, and blue channels. This parameter has no effect above the center of the image, but gradually increases towards the edges. It would be good to imagine that the extent of its effect is similar to that of a lens curve.
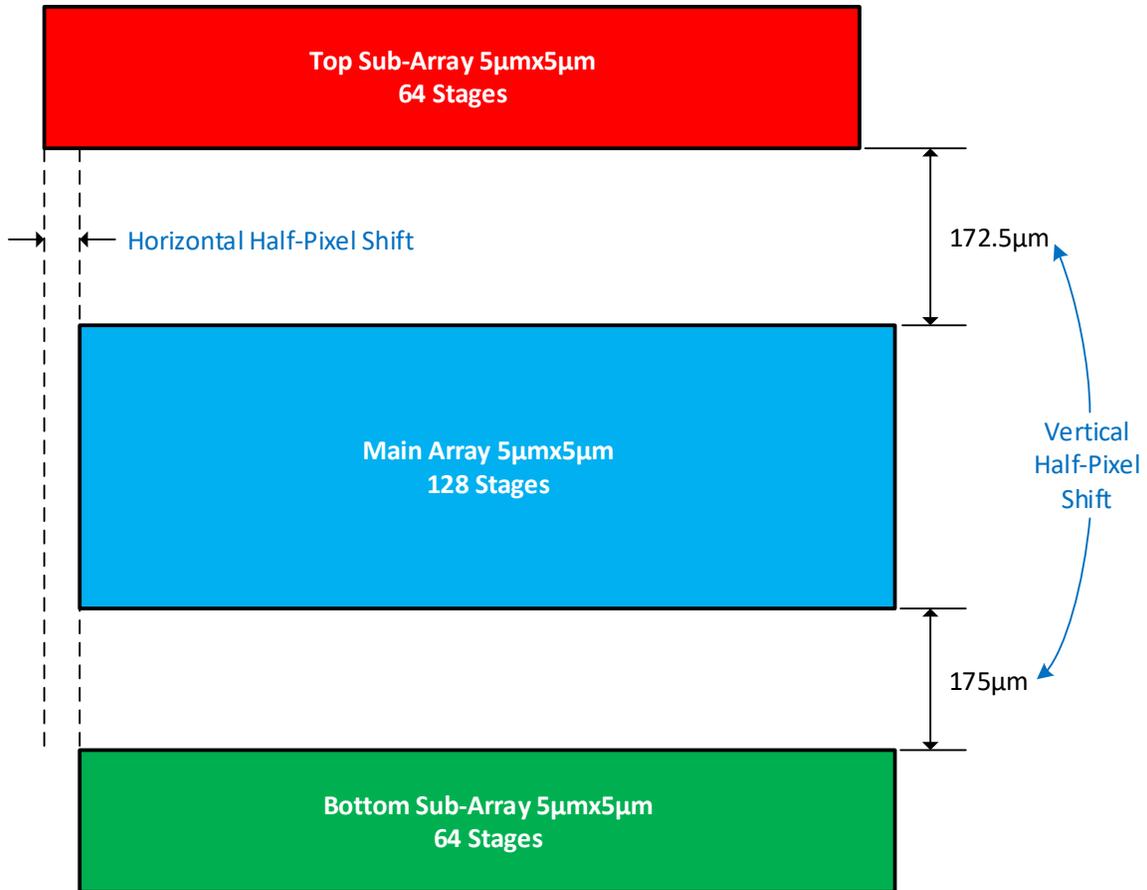
Again, stop the acquisition to activate the parameter input and adjust necessary parameters.

TDI Mode	TDI BGR
Direction Source	Internal
Internal Scan Direction	Forward
Analog Gain	1
Gain Selector	System Gain
Black Level	5
Gain	1.0
Balance White Auto	Press...
Red Spatial Correction	0
Blue Spatial Correction	0
Align Red Pixels	Off
Align Red Threshold	10
Align Red X Shift	0.5
Align Red Y Shift	0.5
Image Distortion Correction Mode	Active
Image Distortion Correction Algorithm	ParallaxCorrection
Image Distortion Correction Line Selector	Red
Image Distortion Parallax Correction Pixel Stretch	0.0

Attached Camera - Xtiu...
- Camera Information
- Camera Control
- Digital IO Control
- Flat Field
- Image Format
- File Access Control
- Transport Layer
- Acquisition and Transfer C...
- Production Features

And do not forget to activate the function by selecting Active in Image Distortion Correction Mode.

Red Pixel Alignment

The red array in the Linea TDI color and multifield cameras is shifted ½ pixel (2.5 µm) both horizontally and vertically as illustrated below:

Top Sub-Array 5µmx5µm
64 Stages

Horizontal Half-Pixel Shift

Main Array 5µmx5µm
128 Stages

172.5µm

Vertical Half-Pixel Shift

175µm

Bottom Sub-Array 5µmx5µm
64 Stages

To align the red array with the blue and green use the following camera GenICam features found under the Camera Control tab:

| Category	Parameter	Value
Board	Device Scan Type	Linescan
Basic Timing	Sensor Color Type	Color BGR
Advanced Control	Acquisition Line Rate	100000.0
External Trigger	Measured Line Rate	100000
Image Buffer and ROI	Refresh Measured Lin...	Press...
Attached Camera - Xtiu...	Acquisition Frame Rate	Not Enabled
Camera Information	TDI Mode	TDI BGR
Camera Control	Align Red Pixels	Off
Digital IO Control	Align Red Threshold	0
Flat Field	Align Red X Shift	0.0
Image Format	Align Red Y Shift	0.0
File Access Control	Direction Source	Internal
Transport Layer	Internal Scan Direction	Forward
Acquisition and Transfer C...	Analog Gain	1
Production Features	Gain Selector	System Gain
	Black Level	0
	Gain	1.0
	Balance White Auto	Press...
	<< Less	

- alignRedPixels   Set to "Active"
- alignRedThreshold Set to "0"
- alignRedXShift   Set to "0.5"
- alignRedYShift   Set to "0.5"

This will create a new red output by averaging the four neighboring red pixels of each red pixel, effectively shifting the red pixels down and right ½ pixel (R_1 to R).
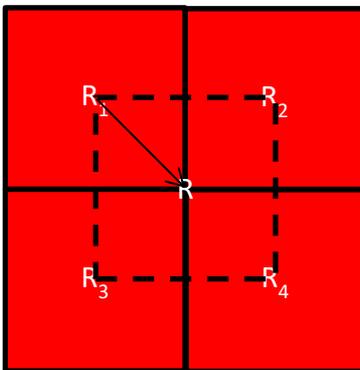
With TDI sensors it is critical to perfectly align the vertical axis of the sensor with the direction of travel so that a pixel in the first TDI stage images the same part of the object as the pixel directly below it in the last stage. If the camera is not perfectly aligned making small changes to the X and Y Shift values may help. The following figure illustrates how the red pixels can be shifted using weighted averages of the four neighboring red pixels.
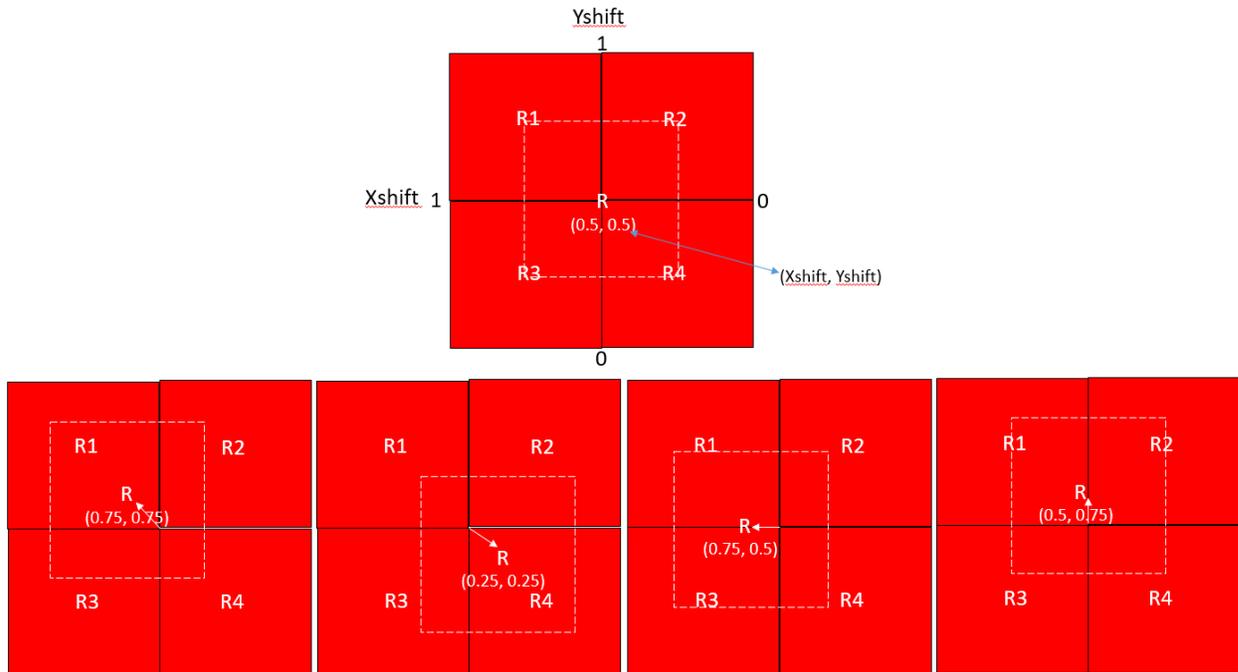
Red fringing is when there is a nice sharp edge in the green and blue but not the red. The redAlignThreshold feature is used to reduce red fringing at vertical and horizontal edges by replacing the newly calculated red pixel with the average of the red, green, and blue pixels. The substitution is made when the following are all true:

1. The gradient of the green edge is less than the threshold; 0 blocks most, 100 all pass
2. The green edge is only horizontal or vertical, not both
3. The red, blue, and green pixels are not too different (± 10%)

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In summary, if the colors are similar, green defines an edge, and there is a little red fringing, this will work to reduce the red fringing. The threshold is used to set how sharp an edge is required before this is done. In other words, it controls the process of color fringing along high-contrast edges. It is developed mainly for reducing fringing in a non-structural image such as point defects. The higher the value, the more edge pixels are processed. For structural images, the optimal settings are to set the threshold at about 10 – 20 and also set x-shift and y-shift accordingly.

To active this function, select Active in Align Red Pixels.

Attached Camera - Xtiu...		
Camera Information	TDI Mode	TDI BGR
	Direction Source	Internal
Camera Control	Internal Scan Direction	Forward
Digital IO Control	Analog Gain	1
Flat Field	Gain Selector	System Gain
	Black Level	5
Image Format	Gain	1.0
File Access Control	Balance White Auto	Press...
Transport Layer	Red Spatial Correction	0
Acquisition and Transfer C...	Blue Spatial Correction	0
Production Features	Align Red Pixels	Active
	Align Red Threshold	10
	Align Red X Shift	0.5
	Align Red Y Shift	0.5
	Image Distortion Correction Mode	Active
	Image Distortion Correction Algorithm	ParallaxCorrection
	Image Distortion Correction Line Selector	Red
	Image Distortion Parallax Correction Pixel Stretch	0.0

Note

1) Noted that due to the physical offset of the red pixel, no adjustments can make the alignment perfect, it will only improve it. If your application requires perfectly matched images, we recommend using a Linea color camera.

2) The way to get good images is to test, test, and test!

Further Supports

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