Piranha HS-xx
Detailed Getting Started Guide and Worksheet

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Piranha HS-xx Cameras

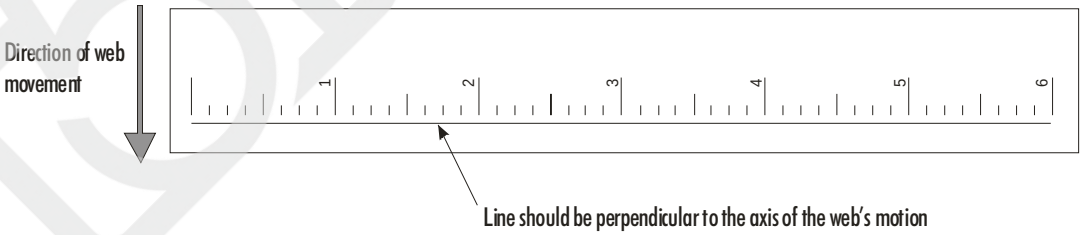
Detailed Getting Started Guide

Welcome. This Getting Started Guide is intended to lead first time TDI users through a detailed set up procedure that will result in a high quality first image. It introduces you to image reconstruction, optical alignment, data output selection, and camera calibration using both Area and TDI operating modes of the camera.

Before you begin, ensure that you have:

- An installed framegrabber with appropriate Camera Link™ capability (Base, Medium, Full). During this procedure you will be creating configuration files to set up the framegrabber for both TDI and Area mode of operation.
- A light source, preferably with intensity control.
- The lens that you intend to use for your application,attached to the camera.
- Terminal program (or framegrabber equivalent) such as Windows HyperTerminal (in Windows 2000 Start → Programs → Accessories → Communications → HyperTerminal) for sending commands to the camera.
- Camera power cable and Camera Link cables
- A flat white surface (preferably plastic) for white calibration
- An alignment test object that is square to direction of motion and has sufficient detail that enables camera focus and alignment. See example below.

Figure 1: Example Alignment Test Object



Note: All commands mentioned in this Getting Started Guide are described in the camera user's manual. You will have to refer to the user's manual while performing some of the tasks in this guide.

Part 1: Creating Framegrabber Configuration Files

In total, you will need at least two framegrabber files: one for Area Mode and one for TDI Mode. Although, your final goal will be to image in TDI Mode, you will use Area Mode for aligning and focusing the camera to your object. In order to create your framegrabber files, you must determine some preliminary camera operating conditions such as number of taps, bit depth, line rate, etc. The following steps will help you to determine these required operating conditions and set up your framegrabber configuration files.

1. Determine the line rate required by your application.

   Line rate = [transport speed inches per second] x [dots per inch]

   Record the required line rate _____

2. Record the minimum throughput needed in your application

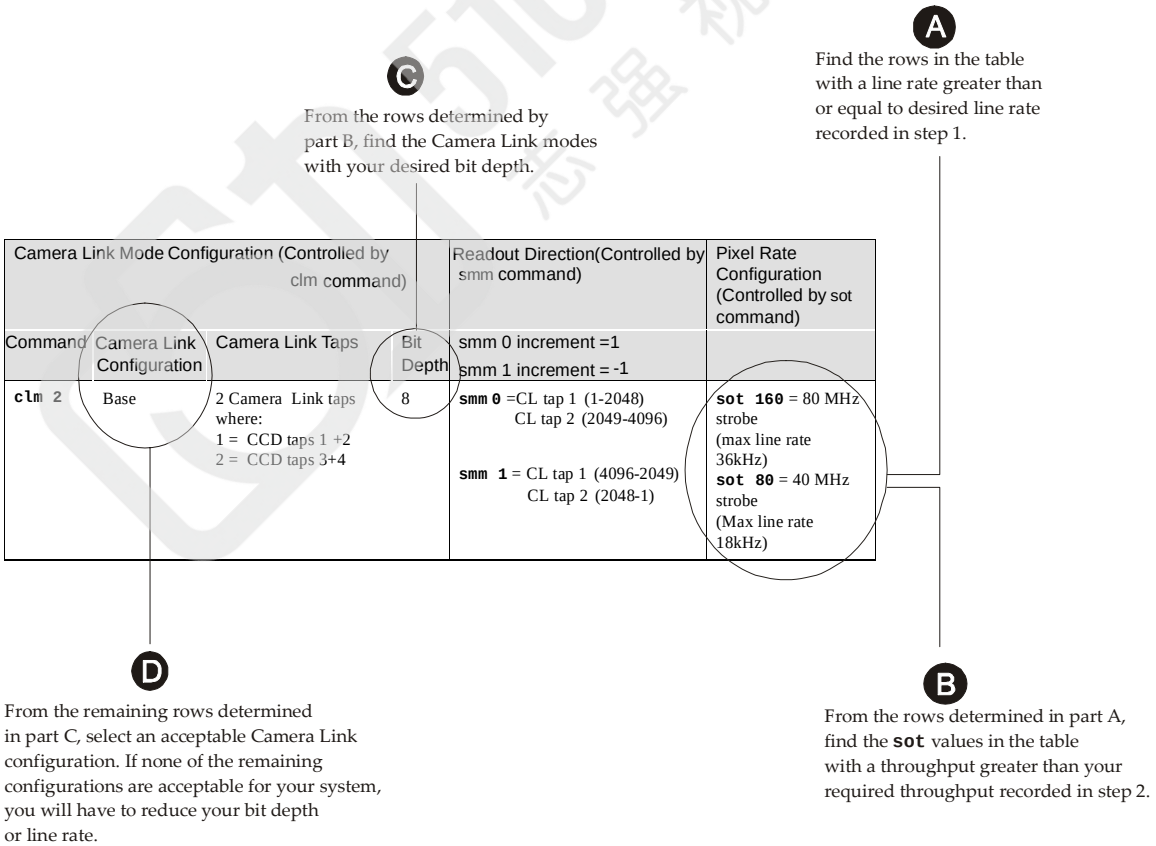
   Minimum Throughput = Number of horizontal pixels in sensor x Line rate

   Record the minimum throughput _____

3. Referring to the **clm** command in the camera user's manual, determine the most compatible Camera Link Mode matching your desired throughput and line rate value, bit depth, number of taps, and Camera Link configuration.

The **clm** command is described in the Configuring Data Readout section of chapter 3 of the camera user's manual.

Figure 2: How to Read the Camera Link Mode Table



Record the **clm** value from the table. **clm** _____

Record the **sot** value from the table. **sot** _____

The **smm** command (set mirror mode) is described in the Configuring Data Readout section of chapter 3 of the camera user's manual.

4. Referring to the **smm** command in the same table in the camera user's manual (refer to Figure 2 above for an example), determine the pixel readout direction. Record the applicable tap pixels start, stop and increment values from the reference table into the table below and record the **smm** value. **smm**____ (0 is the default and generally a good choice for most installations)

Table 1: smm Command Start and Stop Pixel Values

Tap #	Start Pixel Location	End Pixel Location	Increment Value either SMM 0: Inc = 1 SMM 1: Inc = -1
1			
2			
3			
4			
5			
6			
7			
8			

5. Using the information gathered in the steps above, create the framegrabber configuration file for TDI Mode of operation. Be sure to set the framegrabber configuration of the control lines (CC1 (EXSYNC) and CC3 (FORWARD)) as required for your system application.
6. Create the framegrabber configuration for Area Mode of operation using the same information with the additional knowledge that the image height will be 96 rows with row 1 to 96 being output sequentially with an increment of 1.

   Note: Using the **stg** (stage select) command, you select the height of the image. In most cases, it is best to select 96 stages (**stg 96**) for optical alignment. It may be necessary to reduce the number of stages if the field of view is less than 96 rows and the edges are highly reflective. Highly reflective edges may result in excessive smear in the image.

   Note: If you plan to use less than 96 TDI stages in TDI Mode, create another framegrabber configuration file for Area Mode of operation using that number of stages as the number of rows.

Part 2: Mounting and Connecting the Camera

1. Mount the camera with lens at the calculated distance for the desired magnification. See the application note located at http://vfm.dalsa.com/docs/appnotes/72_Practical_Radiometry_03-36-00008-00.pdf if you require more information.
2. Mount the test alignment target in place of the true object. This essentially is a white card with a black ruler which is perpendicular to object motion. Refer to Figure 1 to view a test alignment target picture example. Since the Area Mode of operation has about 10x more integration time than TDI Mode, the white can be of low reflectivity.
3. Connect the Camera Link data cables.

   The Camera Link Base configuration is supported on DATA1 (labeled on the back of the camera). It must be plugged into the correct framegrabber

connector. The DATA2 cable is for the Medium and Full configurations and should be connected to the framegrabber Medium/Full connector.

4. Connect the shaft encoder and the direction control, if applicable, to the framegrabber. TDI mode requires that the speed of the image is matched to the speed of the object. A mismatch in speed will cause blurring in the scan direction. You will need a shaft encoder if the speed of the object will be ramped. The integration time and the output level will change during the ramping period if the gain or light level is not adjusted.
5. Ensure the power cable is correctly wired and the power supply set to between 12 and 15 volts.

Figure 3: Hirose 6-pin Circular Male—Power Connector

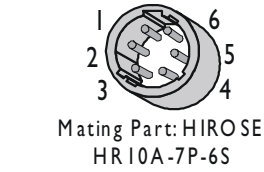


Table 2: Hirose Pin Description

Pin	Description	Pin	Description
1	Min +12 to Max +15V	4	GND
2	Min +12 to Max +15V	5	GND
3	Min +12 to Max +15V	6	GND

6. Connect the power cable to the camera and power on.

Part 3: Verifying Framegrabber and Camera Communication in Area Mode

1. Open your framegrabber application and load the framegrabber file for Area Mode operation.
2. Connect HyperTerminal (or equivalent terminal program) to the framegrabber configuring it for 9600 baud, 1 start bit, 1 stop bit, 8 data bits, no flow control using the framegrabber com port. The camera doesn't echo characters so local echoing should be turned on.
3. Confirm serial communication between the camera and the framegrabber by pressing the **ENTER** key.

   If the camera does not respond with OK>, check that:

   - HyperTerminal is connected to the correct com port and correctly configured.
   - DATA 1 cable is connected to the Base connector on the framegrabber and, if applicable, the DATA2 cable is connected to the Medium/Full connector on the framegrabber.
   - The LED is green on the back of the camera indicating that power is applied.

Note: All commands are terminated with a carriage return. You need to press ENTER after typing a command string.

Note: All camera commands and their ranges are listed alphabetically in Appendix B of the camera's user's manual.

4. Enter the command **`tdi 0`** to operate the camera in Area Mode.
5. Set the Camera Link mode to the configuration selected in Part 1 using the command **`clm desired camera link mode`**. The camera should respond with OK> or a warning message. The warning can be ignored.
6. Set the horizontal mirror mode to the mode recorded in Part 1. Enter **`smm desired mirroring mode`** (either 0 for left to right or 1 for right to left).
7. Set the throughput to the configuration entered in Part 1. Enter **`sot desired throughput`**. Camera responds with OK> or a warning message if

the throughput is too low for internally generated line/frame rate. The warning can be ignored.

8. Execute the following commands to ensure that the camera is configured as expected.

Table 3: Camera Configuration Commands (Area Mode)

Description	Command	Camera Response
Part 1. Configure the Sensor Readout		
Set the vertical **binning** factor to 1	`sbv 1`	OK> or a warning message depending on internal frame rate
Set the horizontal binning factor to 1	`sbh 1`	OK> or a warning message depending on CLM and throughput
Set the number of stages to 96	`stg 96`	OK> or a warning message depending on internal frame rate
Part 2: Configure the Video Chain		
Set the analog offset. Typically, this should be 3x the random noise. 100 DN 12 bit is a good value and will work.	`sao 0 100`	OK>
Set the A/D offset or digital offset subtract value to 0 for all taps	`sdo 0 0`	OK>
Set the optical background subtract value to zero for all taps	`ssb 0 0`	OK>
Set the Digital output gain or system gain to unity for all taps	`ssg 0 4096`	OK>
Select a ramp input into the video chain	`svm 1`	OK>
Part 3: Configure the Exposure Mode and User Controls		
Select the exposure mode. Exposure mode 7 operates using the maximum exposure time.	`sem 7`	OK>
Select internal frame rate. 17Hz gives approximately a 20:1 smear ratio and is a good starting point (if operating the 4k@sot 160 or 8k@sot 320). Generally a 20:1 or 10:1 smear ratio is sufficient for focus. (max *line rate in TDI mode/1000 to 2000).*	`ssf 17`	OK>
Select Internal Forward direction.	`scd 0`	OK>

In this procedure, binning is set to 1 (no binning) for best camera resolution. Higher binning factors are sometimes used for extremely low light conditions or to achieve better MTF since the pixel size is effectively increased by the binning factor. Refer to the camera's user's manual for more information on binning.

Smear is expected with lighting that is not strobed. The effects of smear can be reduced by using a long integration time.

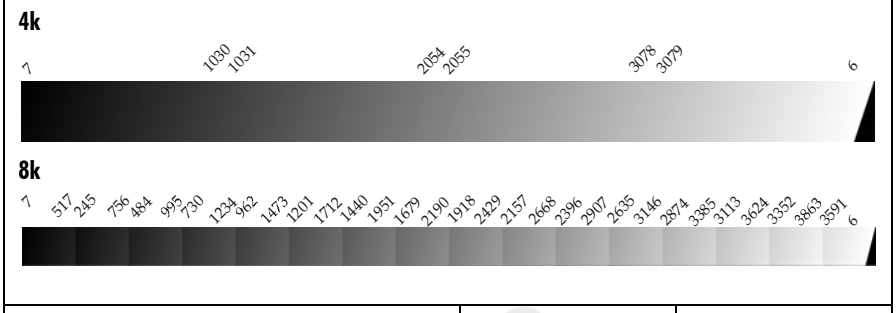
9. Enter `svm 1` to observe the camera's test pattern. Grab an image with your framegrabber. Ensure that you are viewing your entire image. The test pattern should look like the one below. **Note:** The following diagrams show

12-bit pixel values. When operating in 8-bit mode, pixel values will be 1/16th of pixel values in the diagram.

Area Mode, Forward Internal Direction, Test Pattern 1(`tdi 0`, `scd 0`, `svm 1`)

If your framegrabber file matches your mirroring mode, you will see this pattern.

Camera and framegrabber settings are listed under the test pattern. Notice how the framegrabber configuration matches the camera mirroring mode.

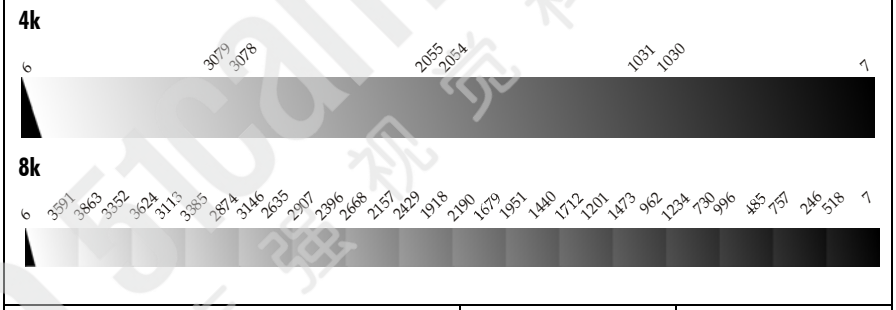


Framegrabber Configuration	Camera Mirror Mode	Direction
Configuration matches smm 1 readout	smm 1	scd 0
Configuration matches smm 0 readout	smm 0	

If you do not see the test pattern above, you may see one of the following:

Area Mode, Forward Internal Direction, Test Pattern 1 (`tdi 0`, `scd 0`, `svm 1`)

If you see this test pattern, your framegrabber configuration file **does not match** your mirroring mode. You will need to reconstruct the pixel readout definitions in your framegrabber configuration file. Repeat Part 1.

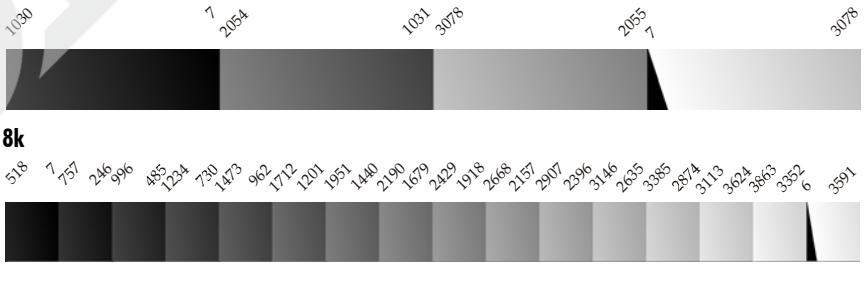


Framegrabber Configuration	Camera Mirror Mode	Direction
Configuration matches smm 1 readout	smm 0	scd 0
Configuration matches smm 0 readout	smm1	

Area Mode, Reverse Internal Direction, Test Pattern 1 (`tdi 0`, `scd 1`, `svm 1`)

If you see this test pattern, you are operating in Reverse Internal Direction. If you want to operate in forward direction control, enter the command **`scd 0`**.

Note: If you need to change your direction, you have to re-enter all of the commands in Table 3 to ensure proper camera configuration.



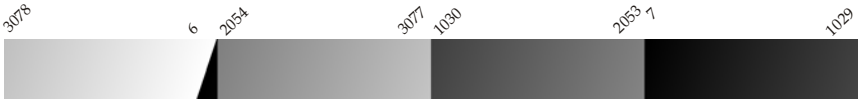
Framegrabber Configuration	Camera Mirror Mode	Direction
Configuration matches smm 1 readout	smm 1	scd 1
Configuration matches smm 0 readout	smm 0	

Area Mode, Reverse Internal Direction, Test Pattern 1(`tdi 0`, `scd 1`, `svm 1`)

If you see this test pattern, your framegrabber configuration file **does not match** your mirroring mode. You will need to reconstruct the pixel readout definitions in your framegrabber configuration file. If you want to operate in forward direction control, enter the command **`scd 0`**.

Note: If you need to change your direction, you must re-enter all of the commands in Table 3 to ensure proper camera configuration.

4k



8k

Framegrabber Configuration	Camera Mirror Mode	Direction
Configuration matches smm 1 readout	smm 0	scd 1
Configuration matches smm 0 readout	smm 1	

10. Enter **`svm 2`** to select a different test pattern. Grab an image with your framegrabber. The test pattern should look like the one below.

Area Mode, Test Pattern 2 (`tdi 0`, `scd 0`, `svm 2`)

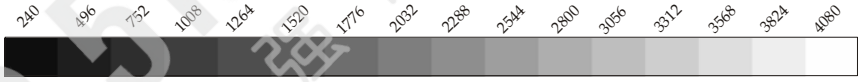
If your framegrabber file matches your mirroring mode, you will see this pattern.

Camera and framegrabber settings are listed under the test pattern. Notice how the framegrabber configuration matches the camera mirroring mode.

Note: If you need to change your direction, you have to re-enter all of the commands in Table 3 to ensure proper camera configuration.

4k

8k



Framegrabber Configuration	Camera Mirror Mode	Direction
Configuration matches smm 0 readout	smm 0	scd 0 or 1
Configuration matches smm 1 readout	smm 1	

If you do not see the test pattern above, you may see one of the following:

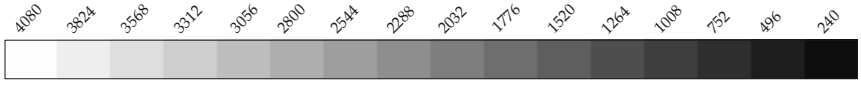
Area Mode, Test Pattern 2 (`tdi 0`, `scd 1`, `svm 2`)

If you see this test pattern, your framegrabber configuration file **does not match** your mirroring mode. You will need to reconstruct the pixel readout definitions in your framegrabber configuration file. Repeat Part 1.

Note: If you need to change your direction, you have to re-enter all of the commands in Table 3 to ensure proper camera configuration.

4k

8k



Framegrabber Configuration	Camera Mirror Mode	Direction
Configuration matches smm 1 readout	smm 0	scd 0 or 1
Configuration matches smm 0 readout	smm 1	

11. If you are planning to use an external EXSYNC source to generate your frame rate, enter **`sem 3`** to operate the camera in an externally controlled frame rate, otherwise skip to Part 4. This mode accepts an external trigger on the falling edge of CC1.
12. Enter **`svm 1`** and observe that the test pattern displayed by the framegrabber returns to the original ramp. This indicates that the camera is receiving the external trigger.

    Readout is triggered by an EXSYNC pulse. EXSYNC pulses arriving during readout of the test pattern are ignored.

    If the captured test pattern doesn't change, check:

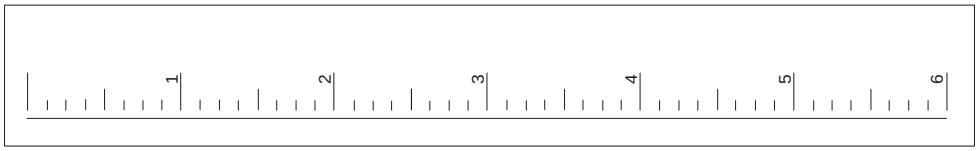
    - The shaft encoder connection
    - That the shaft encoder is generating pulses and is rotating
    - The framegrabber configuration file for the CC1 line.

Part 4: Focusing and Aligning the Camera in Area Mode

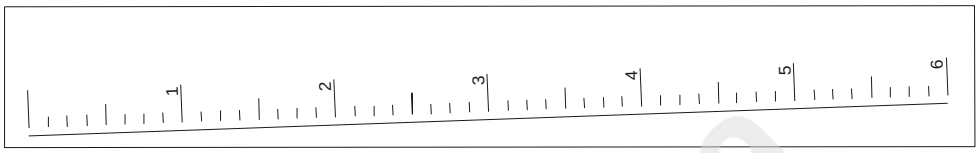
1. Enter **`sem 7`** to return to an internally generated frame rate.
2. Enter **`svm 0`** to select real video for output. The test pattern should now be replaced by a real image.
3. It may be necessary to adjust the gain or light level to observe an image on the screen. If you need to adjust the video output, use the command **`sag 0 i`** where ***`i`*** is the gain value in a range from -10 to +10dB.
    - If you are using the minimum gain value and the framegrabber still shows a white image, you will need to increase the camera's frame rate. Use the command **`ssf f`** where ***`f`*** is the new frame rate in Hz or reduce the light.
    - If you using the maximum gain and the image is still dark you will need to add more light.
    - If you have a highly reflective aperture where the blacks are washed out and the edge of the image is clipped at white, reduce the number of stages **`stg i`**, where ***`i`*** is the number of stages, until the bloomed part of the image is eliminated. If you reduce the number of stages, you will have to create another framegrabber configuration file to handle the reduced image height. When using fewer stages it is important that the direction be identical to the TDI direction so that the same portion of the image sensor is used. If you are using the TDI camera in both directions, then the aperture needs to be adjusted so that is not part of the field of view.
4. Using a test alignment object, position the camera to required magnification (field of view) necessary for your system (for example, 600 dpi will require that there is 3000 pixels measured between 5 inches on the test target). Use the framegrabber tools to measure this distance.
5. Focus the lens. The black to white transition should occur in as few pixels as possible.
6. Align the camera so that it is square to the test target. If there is a 10 row tilt in the line over 1000 pixels then this will result in about a 1 pixel blurring (96 stage operation) in TDI mode of operation. See diagram for good alignment definitions.

Figure 4: Alignment Example

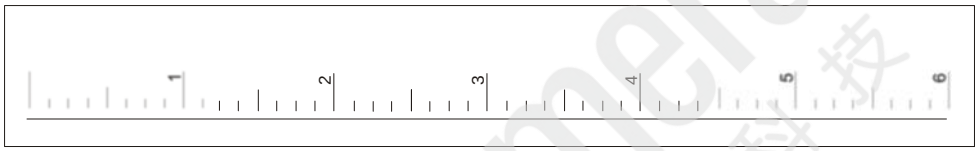
Good alignment: Camera is square with the test object and image is uniformly in focus.



Camera Rotated: Camera is not square with the test object



Camera tilted: Camera is not parallel to inspection surface and image is not uniformly in focus (depth of field issues).



7. Enter the **wus** command to save these settings for future use.
8. If you plan to operate the camera in the reverse tdi direction, enter the **gcp** command and record the analog gain values (in order to enter the same values for the reverse direction) for each of the camera's taps, otherwise, skip to Part 5.

Tap #	Gain Value
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

9. Select the reverse direction by entering **scd 1**.

10. Issue the commands in the table below and readjust the gains to those recorded in the forward direction.

Configure the digital video chain		Camera Response
Set analog offset to 100LSB	**sao 0 100**	OK>
Set the A/D offset or digital offset subtract value to 0 for all taps	**sdo 0 0**	OK>
Set the optical background subtract value to zero for all taps	**ssb 0 0**	OK>
Set the Digital output gain or system gain to unity for all taps	**ssg 0 4096**	OK>
Set the gain to the forward direction values	**sag *Tap Value***	OK>

11. Observe that the image captured by the framegrabber is mirrored vertically (96 stages) or captures a different image and is mirrored vertically when less than 96 stages are selected.
12. Enter **wus** to save the current settings.

Part 5: Verifying TDI Mode Operation

The camera is now properly aligned and focused. Now you need to verify the framegrabber configuration files for image reconstruction in TDI mode and, if necessary, verify that the forward and reverse hardware input works in your application.

1. Change camera operating mode to TDI by entering the **tdi 1** command.
2. Open the TDI Mode framegrabber configuration file.
3. Set the Camera Link mode to the configuration entered in Part 1, step 6 using the command **clm *desired camera link mode***. The camera should respond with OK> or a warning message. The warning can be ignored.
4. Set the horizontal mirror mode to the mode recorded in Part 1, step 6. Enter **smm *desired mirroring mode***.
5. Set the throughput to the configuration entered in Part 1, step 6. Enter **sot *desired throughput***. Camera responds with OK> or a warning message if the throughput is too low for internally generated line rate. The warning can be ignored.
6. Set to internal forward direction using the command **scd 0**.
7. Execute the following commands to ensure that the camera is configured as expected.

Table 4: Camera Configuration Commands (TDI Mode)

Description	Command	Camera Response
Configure the Sensor Readout		
Set the vertical binning factor to 1	**sbv 1**	OK> or a warning message depending on internal frame rate
Set the horizontal binning factor to 1	**sbh 1**	OK> or a warning message depending

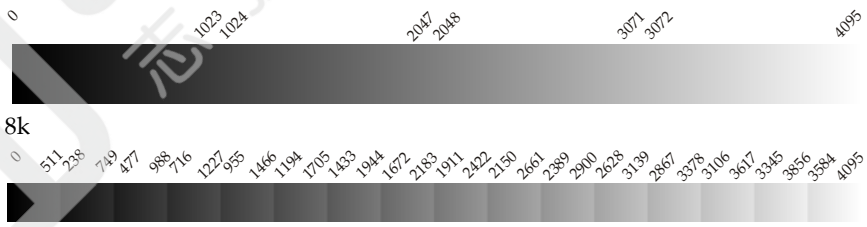
In this procedure, binning is set to 1 (no binning) for best camera resolution. Higher binning factors are sometimes used for extremely low light conditions or to achieve better MTF since the pixel size is effectively increased by the binning factor. Refer to the camera's user's manual for more information on binning.

		on clm setting and throughput
Set the number of stages to that needed (16,32, 48, 64,80, 96)	**stg *number of stages***	OK>
Configure the Video Chain		
Set the analog offset to 100 LSB	**sao 0 100**	OK>
Set the A/D offset or digital offset subtract value to 0 for all taps	**sdo 0 0**	OK>
Set the optical background subtract value to zero for all taps	**ssb 0 0**	OK>
Set the Digital output gain or system gain to unity for all taps	**ssg 0 4096**	OK>
Disable pixel coefficients	**epc 0 0**	OK>
Configure the Exposure Mode and User controls		
Select internal frame rate generation	**sem 7**	OK>
Select internal frame rate to the calculated line rate	**ssf *Calculated value from step 1 of Part 1.***	OK>

8. Enter **svm 1** to observe the camera's test pattern. Grab an image with your framegrabber. The test pattern should look like one of the figures below.
Note: The following diagrams show 12-bit pixel values. When operating in 8-bit mode, pixel values will be 1/16th of pixel values in the diagram.

If your framegrabber file matches your mirroring mode, you will see this pattern.

Camera and framegrabber settings are listed under the test pattern. Notice how the framegrabber configuration matches the camera mirroring mode.

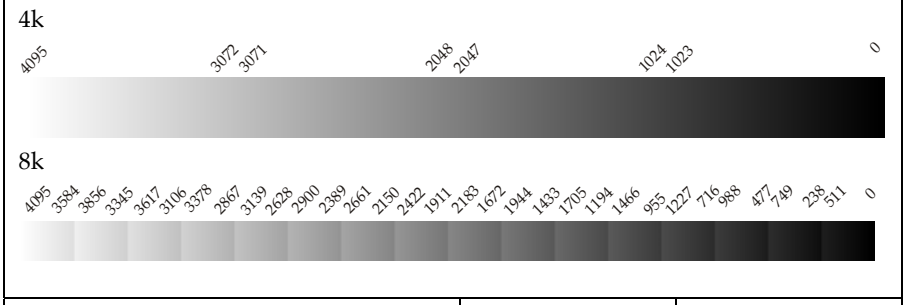


Framegrabber Configuration	Camera Mirror Mode	Direction
Configuration matches smm 0 readout	smm 0	scd 0
Configuration matches smm 1 readout	smm 1	

If you do not see the test pattern above, you may see one of the following:

TDI Mode, Forward Internal Direction, Test Pattern 1 (`tdi 1`, `scd 0`, `svm 1`)

If you see this test pattern, your framegrabber configuration file **does not match** your mirroring mode. You will need to reconstruct the pixel readout definitions in your framegrabber configuration file. Repeat Part 1 or change the **`smm`** value to match the framegrabber file.



Framegrabber Configuration	Camera Mirror Mode	Direction
Configuration matches smm 1 readout	smm 0	scd 0
Configuration matches smm 0 readout	smm 1	

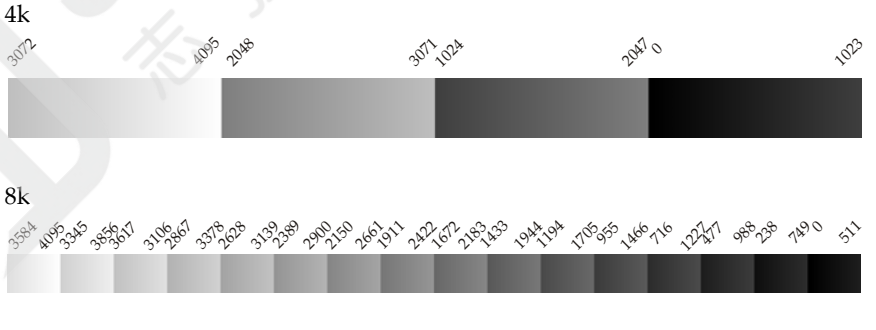
TDI Mode, Reverse Internal Direction, Test Pattern 1 (`tdi 1`, `scd 1`, `svm 1`)

If you see this test pattern, you are operating in Reverse Internal Direction. If you want to operate in forward direction control, enter the command **`scd 0`**.

Framegrabber Configuration	Camera Mirror Mode	Direction
Configuration matches smm 0 readout	smm 0	scd 1
Configuration matches smm 1 readout	smm 1	

TDI Mode, Reverse Internal Direction, Test Pattern 1(`tdi 1`, `scd 1`, `svm 1`)

If you see this test pattern, your framegrabber configuration file **does not match** your mirroring mode. You will need to reconstruct the pixel readout definitions in your framegrabber configuration file. If you want to operate in forward direction control, enter the command **`scd 0`**.



Framegrabber Configuration	Camera Mirror Mode	Direction
Configuration matches smm 1 readout	smm 0	scd 1
Configuration matches smm 0 readout	smm 1	

If you cannot see these test patterns, ensure that:

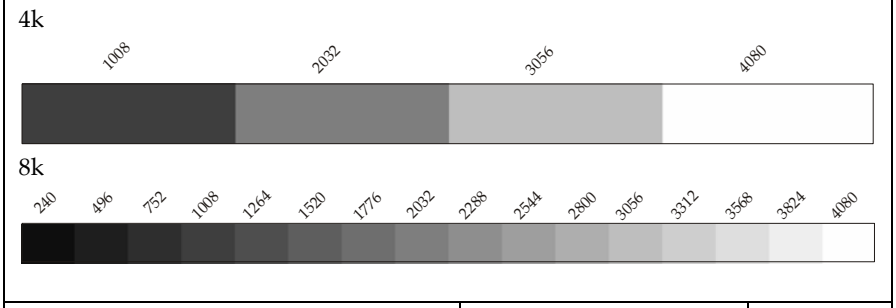
- Your framegrabber configuration file is correct
- You have entered all previous commands correctly. Repeat steps in Part 5 if you are unsure.

9. Enter **`svm 2`** to select a different test pattern and observe that the new pattern is captured by the framegrabber.

TDI Mode, Test Pattern 2 (`tdi 1`, `scd 0`, `svm 2`)

If your framegrabber file matches your mirroring mode, you will see this pattern.

Camera and framegrabber settings are listed under the test pattern. Notice how the framegrabber configuration matches the camera mirroring mode.

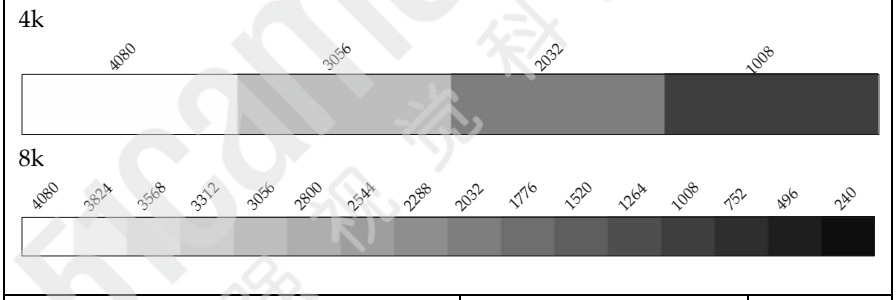


Framegrabber Configuration	Camera Mirror Mode	Direction
Configuration matches smm 1 readout	smm 1	scd 0 or 1
Configuration matches smm 0 readout	smm 0	

If you do not see the test pattern above, you may see one of the following:

TDI Mode, Test Pattern 2 (`tdi 1`, `scd 1`, `svm 2`)

If you see this test pattern, your framegrabber configuration file **does not match** your mirroring mode. You will need to reconstruct the pixel readout definitions in your framegrabber configuration file. Repeat Part 1.



Framegrabber Configuration	Camera Mirror Mode	Direction
Configuration matches smm 1 readout	smm 0	scd 0 or 1
Configuration matches smm 0 readout	smm 1	

10. Return to internal forward direction using the command **`scd 0`**.
11. Replace the test target used for focus with a uniform white field. **Note:** White paper is often not sufficient because the grain in the white paper will distort the correction. White plastic or white ceramic will lead to better balancing.
12. Enter **`svm 0`** to image the white field. The camera should respond with OK and the test pattern should no longer be imaged by the framegrabber.
13. Enter number of stages using the command **`stg` *`number of stages`***.
14. Select a full region of interest by entering **`roi 1 1` *`number of sensor pixels`* `1`**.
15. Calibrate the analog gain using the **`ccg 1 0` *`target output value`*** in a range from **`1024`** to **`4055`** referenced to the 12 bit A/D data width. This algorithm adjusts analog gain so that between 8% and 13% of ROI pixels per tap are above target. If the camera returns a warning then more/less light or more/less stages are needed.
16. Review the image captured and set the region of interest using the command **`roi` *`xyxy`***. The region of interest is the region of the image where you expect to have a good image. It is also the region used in automated gain routines and flat field correction algorithms. In most applications, the field of view exceeds the required object size and these extraneous areas should be

ignored. It is recommended that you set the region a few pixels inside the actual useable image.

17. Repeat the **ccg 1 0 *i*** command. You will see tap mismatch but the PRNU algorithm (**ccp** command which is performed later) will eliminate the tap mismatch.
18. Reset the pixel coefficients to ensure that FPN values are set to zero by entering the **rpc** command.
19. For best accuracy, set the number of samples to use in the coefficient calculation algorithm to its maximum using the command **css 1024**.
20. After having adjusted the gains, selected the number of stages, and warmed up the camera with the correct line rate, you can now perform FPN correction. (Skip to step 22 if you are unable to put a lens cover onto the camera to make the image dark.) To begin, put a lens cover on the camera and enter the **ccf** command. The camera calculates the FPN values and reports a warning if more than 1% of the FPN coefficients were clipped to the maximum value or if there was too much random noise. The digital offset value is also calculated causing the A/D offset to be subtracted from the output signal.

    If you receive a warning during FPN correction:

    - Ensure the lens is covered
    - Increase the analog offset using the **sao 0 *offset value*** command. Repeat the **ccf** command if the offset is changed.
21. Enter the command **wfc *i* 1** to save the FPN coefficients.
22. If you performed FPN correction, the output video should be near zero and you can skip to the next step. If not, the value should be near 100LSB in 12 bit. Enter the command **sdo 0 100** to subtract offset.
23. Remove the lens cover and enter the command **ccp** to perform PRNU correction. The camera calculates the PRNU coefficients for all pixels using the peak pixel found in the ROI and reports statistics for the ROI. You receive a warning if more than 1% of the coefficients are clipped or there were too many clipped values in the raw data.

    If you receive a "W08: Greater than 1% of coefficients have been clipped>" message during PRNU correction:

    - Check that your region of interest is correct
    - Check that your light source uniformity is better than 50%

    If you receive a "W07: Coefficient may be inaccurate A/D clipping has occurred>"

    - Reduce the camera gain to avoid clipping. Repeat the **ccp** command if you adjust the gain.
24. Enter the command **wpc *i* 1** to save the coefficients.
25. Turn on the coefficients by entering the command **epc 1 1**. You should see a flat line approximately equal to the peak uncorrected output.
26. If you will be operating the camera in the reverse direction, enter the command **scd 1** to change to reverse direction and repeat steps 7 to 25.
27. If you will be operating the camera using external direction control, test the external control by entering the command **scd 2**, otherwise skip to step 32.
28. Have your system send the forward direction signal on CC3 (high).

29. Enter **gcp** to view the camera parameter screen. The camera parameter screen should report

    CCD Direction: external/forward

    If the reported status is incorrect, check that:

    - The connection of the direction control to the framegrabber
    - The framegrabber configuration to ensure that the hardware signal is correctly routed through the framegrabber

30. Have your system send the reverse direction signal on CC3 (low).
31. Enter **gcp** to view the camera parameter screen. The camera parameter screen should report

    CCD Direction: external/reverse

32. Enter the command **sem *exposure mode*** to select your operating exposure mode.
33. Enter the command **scd *direction*** to select your direction control method.
34. Enter the command **wus** to save the operating state. On reboot, the camera will power up in this state.
35. Check the image with a real object with real motion. You should see good image.

    It is imperative that the direction of motion is correct. If vertical smearing occurs even when using the correct line rate:

    - If you are using an external line rate, try using an internal line rate. Enter **sem 7** and then **ssf *line rate***. If you receive a clipped to max warning then you will have to change the Camera Link Mode.
    - Try changing the camera's CCD shift direction using the **scd *direction*** command.

Conclusion

This completes the procedure and your camera should now be imaging properly.

If you still need to improve your TDI image, you may want to try some of the following tips:

- In TDI Mode, gain can be adjusted by changing the number of stages. If you reach the sensor **full well**, you will have to reduce the number of stages. This is characterized by an increase in the PRNU and results from different columns reaching the antiblooming level at different light levels. The camera gain is designed so that the minimum specified gain does not cause the sensor to reach full well.

Full well is the maximum charge that can be stored in each pixel before it drains into the substrate.

- It is very important that the sensor is aligned perpendicular to the direction of motion of the object. The portion of an object which is imaged in a pixel at the first stage of integration must also be imaged in the same column at the last stage of integration, otherwise blurring of the image will occur.
- If a system design dictates that constant exposure is required where line speed variations or fluctuating illumination occurs, then some method of controlled exposure must be incorporated. This can generally be achieved with some type of synchronously strobed or intensity controlled illumination, and because of the high sensitivity of the camera, LED illumination systems can be reliably used. For further information on using

strobed LED illumination with high sensitivity line scan cameras, refer to DALSA document 03-32-00540.