Piranha ES

Camera User's Manual

ES-80-04k40-00-R
ES-80-08k80-00-R
ES-80-08k40-00-R

Enhanced Sensitivity Cameras

DALSA
technology with vision

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About DALSA

DALSA is an international high performance semiconductor and electronics company that designs, develops, manufactures, and markets digital imaging products and solutions, in addition to providing wafer foundry services. DALSA's core competencies are in specialized integrated circuit and electronics technology, and highly engineered semiconductor wafer processing. Products include image sensor components; electronic digital cameras; and semiconductor wafer foundry services for use in MEMS, power semiconductors, image sensors and mixed signal CMOS chips.

DALSA is a public company listed on the Toronto Stock Exchange under the symbol "DSA". Based in Waterloo, ON. Canada, the company has operations in Bromont, PQ; Billerica, MA; Eindhoven, NL; Munich, Germany and Tokyo, Japan.

All DALSA products are manufactured using the latest state-of-the-art equipment to ensure product reliability.

For further information not included in this manual, or for information on DALSA's extensive line of image sensing products, please visit the DALSA website at www.dalsa.com, or contact:

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Camera Link is a trademark registered by the Automated Imaging Association, as chair of a committee of industry members including DALSA.

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Introduction to the Piranha Enhanced Sensitivity Cameras

1.1 Camera Highlights

Features

- 8192 or 4096, 7µm x 7µm pixel pitch, 90% fill factor
- High speed, up to 640 megapixels/second throughput
- Up to 68 kHz (7 µm x 7 µm) line rate
- 32 or 16 stages, independently selectable Time Delay and Integration (TDI) imaging regions for enhanced user-controlled sensitivity
- Broadband responsivity 406 DN (nJ/cm^2) @ 10 dB, 8-bit
- 4 or 8 taps, bidirectional TDI
- 100x antiblooming

Programmability

- Serial interface (ASCII, 9600 baud, adjustable to 19200, 57600, 115200), through Camera Link™
- Programmable gain, offset, frame and frame rates, trigger mode, test pattern output, and camera diagnostics
- Mirroring and forward/reverse control
- Selectable Area or TDI Mode of operation. Area Mode facilitates camera alignment and focusing. Area mode can also be used for regular operation.

- Selectable pixel size (binning)
- Flat-field correction—minimizes lens vignetting, non-uniform lighting, and sensor FPN and PRNU,
- Selectable Medium or Full Camera Link configuration, depending on camera model.

Description

The Piranha Enhanced Sensitivisy (ES) camera family represent DALSA's latest generation of superior sensitivity, TDI based cameras. The Piranha ES family maximizes system throughput and provides the largest number of pixels available in a TDI camera. All cameras are capable of bi-directionality with 16 or 32 stages of integration.

Applications

The Piranha ES family is ideal for applications requiring high speed, superior image quality, and high responsivity. Applications include:

- Solar cell inspection
- Postal sorting (flats)
- Flat panel display inspection
- Printed circuit board inspection
- High performance document scanning
- Large web inspection
- Low-light applications

Models

The Piranha ES-xx cameras are available in these models.

Table 1: Piranha ES-xx Camera Models Overview

Model Number	Description
ES-80-04k40-00-R	4k resolution, programmable 4 or 8 taps, up to 320 megapixels/second throughput, 34 kHz line rate, Medium or Full Camera Link configuration. 7 µm x 7 µm pixel size. 16 or 32 stage TDI.
ES-80-08k80-00-R	8k resolution, programmable 4 or 8 taps, up to 640 megapixels/second throughput, 68 kHz line rate, Medium or Full Camera Link configuration. This is the only model that can operate 8 taps at 80MHz each. 7 µm x 7 µm pixel size. 16 or 32 stage TDI.
ES-80-08k40-00-R	8k resolution, programmable 4 or 8 taps, up to 320 megapixels/second throughput, 34 kHz line rate, Medium or Full Camera Link configuration. 7 µm x 7 µm pixel size. 16 or 32 stage TDI.

Throughout the manual, the cameras are refered to as the Piranha ES-xx camera family unless a section is valid to a specific model only where the camera’s model number is used.

1.2 Camera Performance Specifications

Table 2: ES-80-08k80 Camera Performance Specifications

Feature / Specification	Units	
Sensor Features		
Imager Format		Bidirectional TDI
Resolution	pixels	8192
Pixel Fill Factor	%	90
Pixel Size	µm	7 x 7
Output Format (# of Camera Link taps)		4 or 8
Stage Selection		32, 16
Antiblooming		100x
CCD Shift Direction Change	seconds	0.2
Optical Interface	**Units**	
Back Focal Distance		
F Mount	mm	
M42x1 Mount	mm	
M72 Mount	mm	6.56±0.25
Sensor Alignment (aligned to sides of camera)		
x	mm	±0.05
y	mm	±0.05
z	mm	±0.25
Yz	°	±0.2
Lens Mount Hole		M72x0.75
Mechanical Interface	**Units**	
Camera Size	mm lxhxw	80 x 150 x 65
Mass	g	<800
Connectors		
power connector		6 pin male Hirose
data connector		MDR26 female
Electrical Interface	**Units**	
Input Voltage	Volts	+12 to +15 ±5%
Power Dissipation[1]	W	19
Operating Temperature[2]	°C	0 to 50
Bit Width	Bits	8 or 12 bit user selectable

Output Data Configuration		Medium or Full Camera Link

Operating Ranges	Units	
Minimum Line Rate	kHz	3.5
Maximum Line Rate	kHz	68
Throughput	Mpix/sec	640
Gain	dB	-10 to +10

Performance	Units	Min	Typ	Max
Dynamic Range	Ratio			
-10 dB gain		312	500	
0 dB gain		166	357	
+10 dB gain		56	119	
Random Noise	DN rms			
-10 dB gain			.5	.8
0 dB gain			.7	1.5
+10 dB gain			2.1	4.5
SEE	nJ/cm^2			
-10 dB gain			2.13	
0 dB gain			.68	
+10 dB gain			.21	
NEE	pJ/cm^2			
-10 dB gain			4.3	6.8
0 dB gain			1.9	4.1
+10 dB gain			1.8	3.8
Analog Broadband Responsivity	DN/nJ/ cm^2@540nm			
-10 dB gain			39	
0 dB gain		117	123	130
+10 dB gain			390	
FPN with correction	DN p-p			
0 dB gain			.5	2
FPN w/o correction				
-10 dB gain				3
0 dB gain			4.5	3
+10 dB gain				9
PRNU with correction	DN p-p			
0 dB gain			4.0	8
w/o correction				
-10 dB gain				22
0 dB gain				22
+10 dB gain			10	25

Performance	Units	Min	Typ	Max
Saturation Output Amplitude	DN		255	
Calibration Time	seconds	8.5		
DC Offset	DN	3	5	6

Test conditions unless otherwise noted:

- TDI mode of operation. These specifications are not guaranteed for area mode of operation.
- Line Rate: 10kHz
- Nominal Gain setting
- Light Source: Broadband Quartz Halogen, 3250k, with 700 nm IR cutoff filter installed
- All Max specifications are valid over a 0-50°C temperature range
- All Typ specifications are measured at 25°C.
- All values are referenced at 8-bit

1. Maximum using highest Camera Link mode and maximum line rate

2. Measured at the front plate.

Table 3: ES-80-08k40 Camera Performance Specifications

Feature / Specification	Units	
Sensor Features		
Imager Format		Bidirectional TDI
Resolution	pixels	8192
Pixel Fill Factor	%	90
Pixel Size	µm	7 x 7
Output Format (# of Camera Link taps)		4 or 8
Stage Selection		32, 16
Antiblooming		100x
CCD Shift Direction Change	seconds	0.2

Optical Interface	Units	
Back Focal Distance		
F Mount	mm	
M42x1 Mount	mm	
M72 Mount	mm	6.56±0.25

Sensor Alignment (aligned to sides of camera)		
x	mm	±0.05
y	mm	±0.05
z	mm	±0.25
Yz	°	±0.2
Lens Mount Hole		M72x0.75

Mechanical Interface	Units	
Camera Size	mm lxhxw	80 x 150 x 65
Mass	g	<800
Connectors		
power connector		6 pin male Hirose
data connector		MDR26 female

Electrical Interface	Units	
Input Voltage	Volts	+12 to +15 ±5%
Power Dissipation[1]	W	14.4
Operating Temperature[2]	°C	0 to 50
Bit Width	Bits	8 or 12 bit user selectable
Output Data Configuration		Medium or Full Camera Link

Operating Ranges	Units	
Minimum Line Rate	kHz	3.5
Maximum Line Rate	kHz	34
Throughput	Mpix/sec	320
Gain	dB	-10 to +10

Performance	Units	Minimum	Typical	Maximum
Dynamic Range	Ratio			
-10 dB gain		312	500	
0 dB gain		312	500	
+10 dB gain		100	192	
Random Noise	DN rms			
-10 dB gain			0.50	0.8
0 dB gain			0.50	0.8
+10 dB gain			1.3	2.5
SEE	nJ/cm^2			
-10 dB gain			2.13	
0 dB gain			0.65	
+10 dB gain			0.21	

Performance	Units	Minimum	Typical	Maximum
NEE	pJ/cm^2			
-10 dB gain			4.3	6.8
0 dB gain			1.4	2.2
+10 dB gain			1.1	2.1
Analog Broadband Responsivity	DN/nJ/ cm^2@700nm		39	
-10 dB gain		117	123	130
0 dB gain			390	
+10 dB gain				
FPN with correction	DN p-p			
0 dB gain			.5	2
FPN w/o correction				
-10 dB gain				3
0 dB gain			3	3
+10 dB gain				9
PRNU with correction	DN p-p			
0 dB gain			3.2	5.5
w/o correction				
-10 dB gain				22
0 dB gain				22
+10 dB gain			7	25
Saturation Output Amplitude	DN		255	
DC Offset	DN	3	5	6

Test conditions unless otherwise noted:

- TDI mode of operation. These specifications are not guaranteed for area mode of operation.
- Line Rate: 10kHz
- Nominal Gain setting
- Light Source: Broadband Quartz Halogen, 3250k, with 700 nm IR cutoff filter installed
- All Max specifications are valid over a 0-50°C temperature range
- All Typ specifications are measured at 25°C.
- All values are referenced at 8-bit

1. Maximum using highest Camera Link mode and maximum line rate

2. Measured at the front plate.

Table 4: ES-80-04k40 Camera Performance Specifications

Feature / Specification	Units	
Sensor Features		
Imager Format		Bidirectional TDI
Resolution	pixels	4096
Pixel Fill Factor	%	90
Pixel Size	µm	7 x 7
Output Format (# of Camera Link taps)		4 or 8
Stage Selection		32, 16
Antiblooming		100x
CCD Shift Direction Change	seconds	0.2
Optical Interface	**Units**	
Back Focal Distance		
F Mount	mm	
M42x1 Mount	mm	
M72 Mount	mm	6.56±0.25
Sensor Alignment (aligned to sides of camera)		
x	mm	±0.05
y	mm	±0.05
z	mm	±0.25
Yz	°	±0.2
Lens Mount Hole		M72x0.75
Mechanical Interface	**Units**	
Camera Size	mm lxhxw	80 x 150 x 65
Mass	g	<800
Connectors		
power connector		6 pin male Hirose
data connector		MDR26 female
Electrical Interface	**Units**	
Input Voltage	Volts	+12 to +15 ±5%
Power Dissipation[1]	W	14.4
Operating Temperature[2]	°C	0 to 50
Bit Width	Bits	8 or 12 bit user selectable
Output Data Configuration		Medium or Full Camera Link

Operating Ranges	Units	
Minimum Line Rate	kHz	3.5
Maximum Line Rate	kHz	34
Throughput	Mpix/sec	320
Gain	dB	-10 to +10

Performance	Units	Minimum	Typical	Maximum
Dynamic Range	Ratio			
-10 dB gain		312	500	
0 dB gain		312	500	
+10 dB gain		100	192	
Random Noise	DN rms			
-10 dB gain			0.50	0.8
0 dB gain			0.50	0.8
+10 dB gain			1.3	2.5
SEE	nJ/cm^2			
-10 dB gain			2.13	
0 dB gain			0.65	
+10 dB gain			0.21	
NEE	pJ/cm^2			
-10 dB gain			4.3	6.8
0 dB gain			1.4	2.2
+10 dB gain			1.1	2.1
Analog Broadband Responsivity	$DN/nJ/cm^2$@700nm		39	
-10 dB gain		117	123	130
0 dB gain			390	
+10 dB gain				
FPN with correction	DN p-p			
0 dB gain			.5	2
FPN w/o correction				
-10 dB gain				3
0 dB gain			3	3
+10 dB gain				9
PRNU with correction	DN p-p			
0 dB gain			3.2	5.5
w/o correction				
-10 dB gain				22
0 dB gain				22
+10 dB gain			7	25
Saturation Output Amplitude	DN		255	

Performance	Units	Minimum	Typical	Maximum
DC Offset	DN	3	5	6

Test conditions unless otherwise noted:

- TDI mode of operation. These specifications are not guaranteed for area mode of operation.
- Line Rate: 10 kHz
- Nominal Gain setting
- Light Source: Broadband Quartz Halogen, 3250k, with 700 nm IR cutoff filter installed
- All Max specifications are valid over a 0-50°C temperature range
- All Typ specifications are measured at 25°C.
- All values are referenced at 8-bit

1. Maximum using highest Camera Link mode and maximum line rate

2. Measured at the front plate.

Figure 1: PRNU Uncorrected (pk-pk) Forward or Reverse @ 10 kHz line rate and 0 dB Gain over Temperature

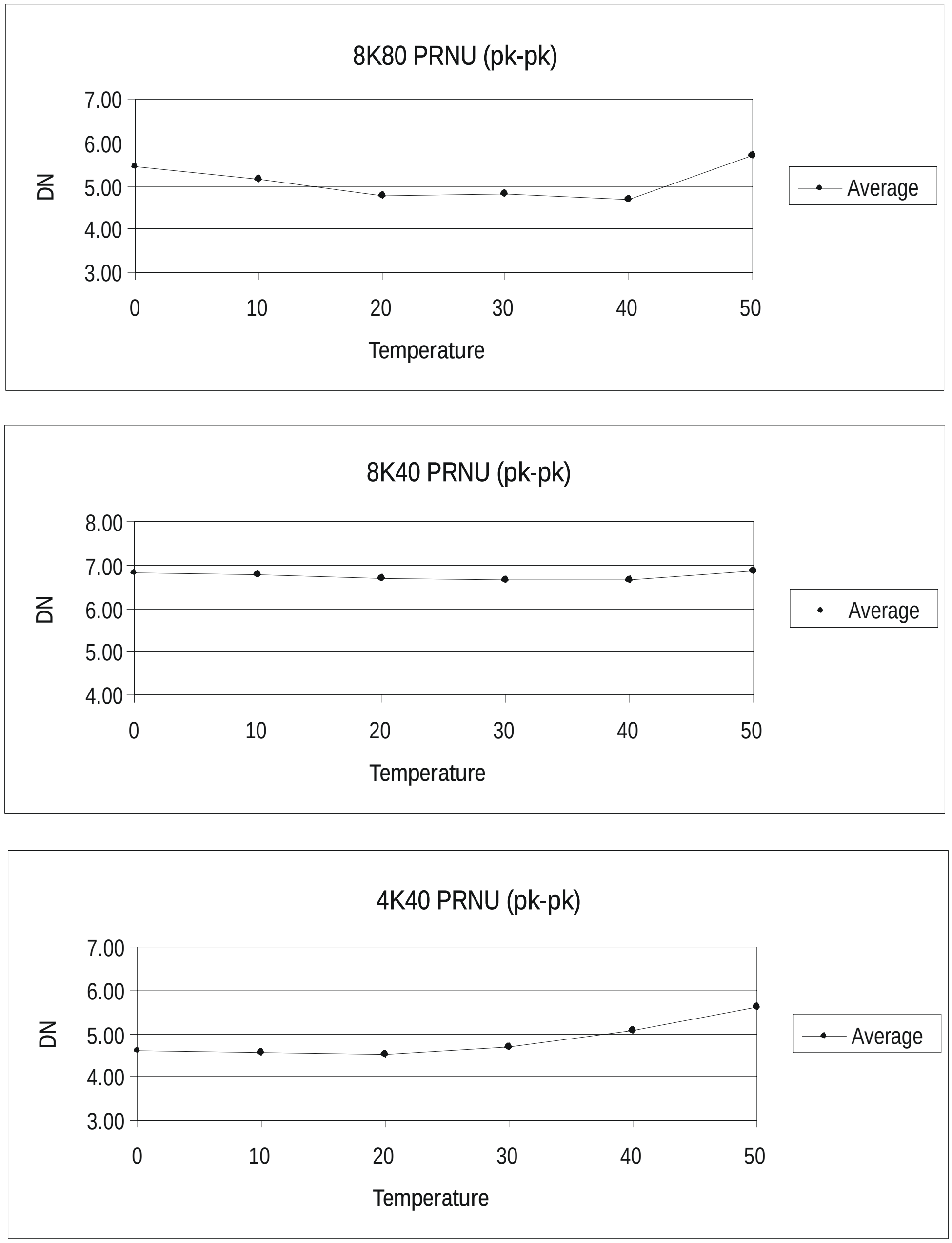
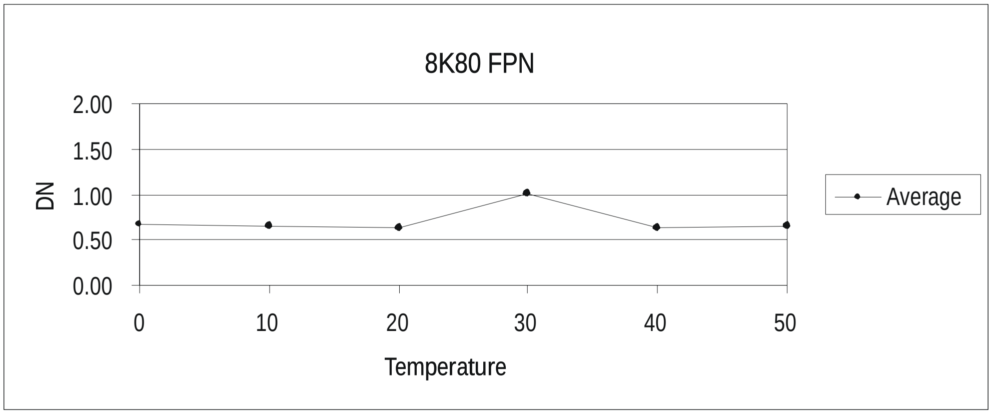
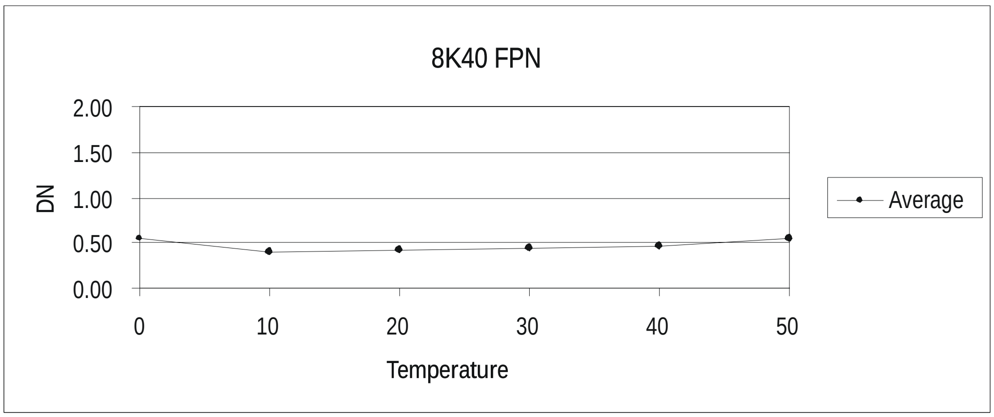


Figure 2: FPN Forward or Reverse @ 10 kHz line rate and 0 dB Gain over Temperature





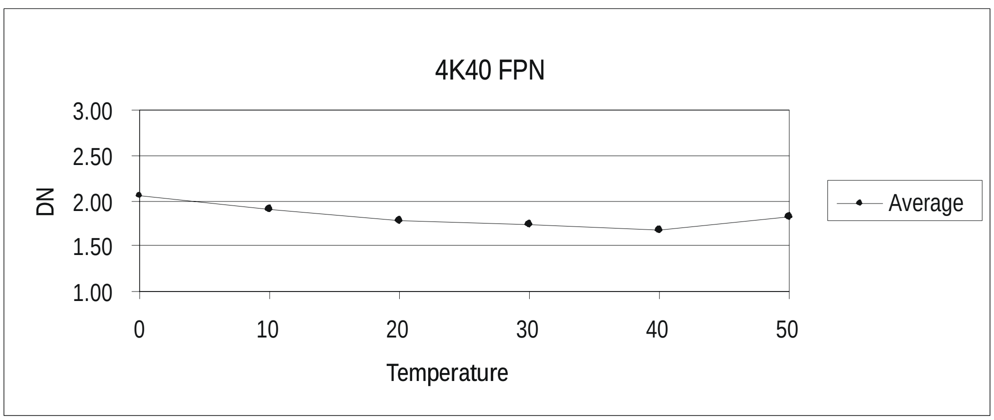
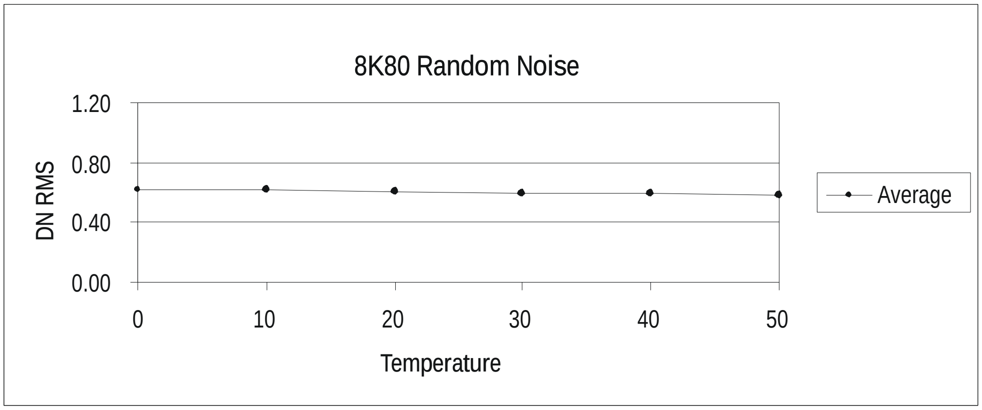
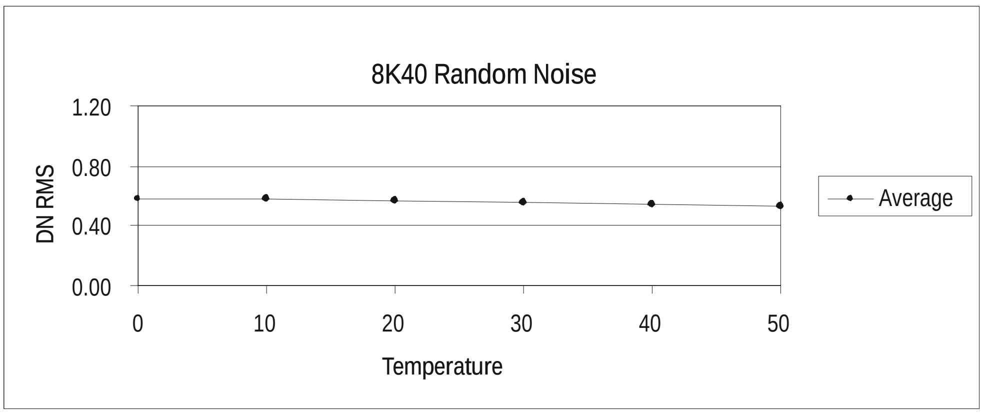


Figure 3: Random Noise Forward or Reverse @ 10 kHz line rate and 0 dB Gain over Temperature





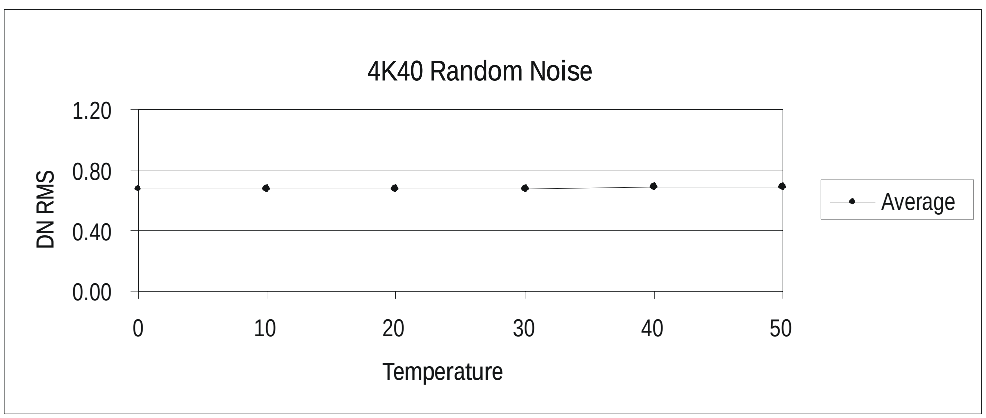
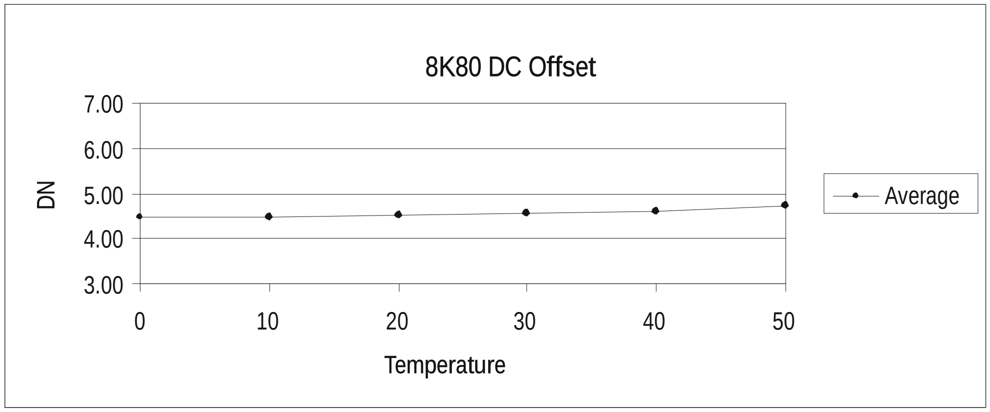
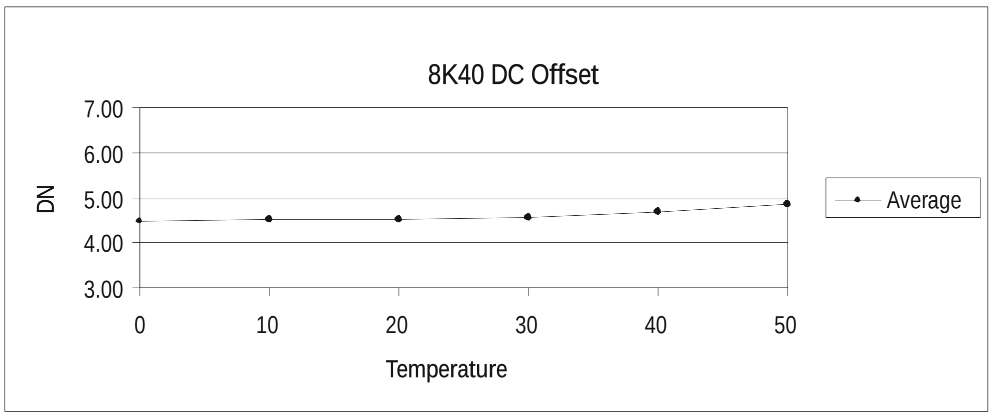
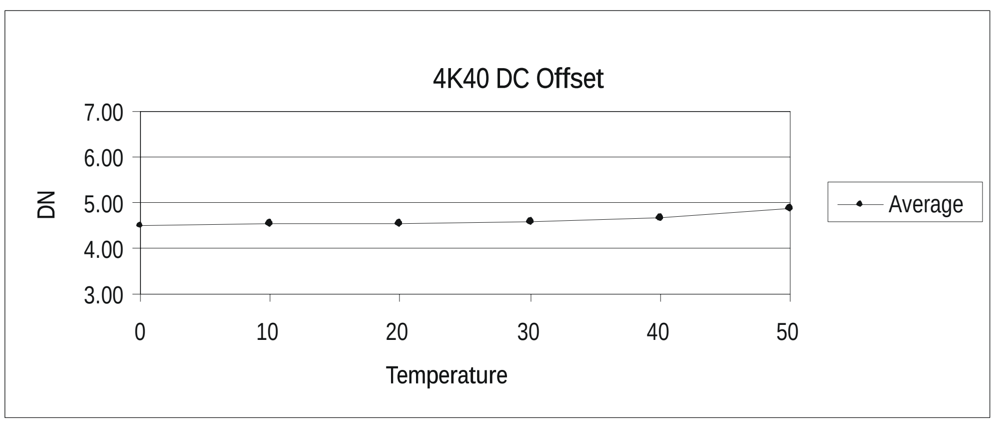


Figure 4: DC Offset Forward or Reverse @ 10 kHz line rate and 0 dB Gain over Temperature



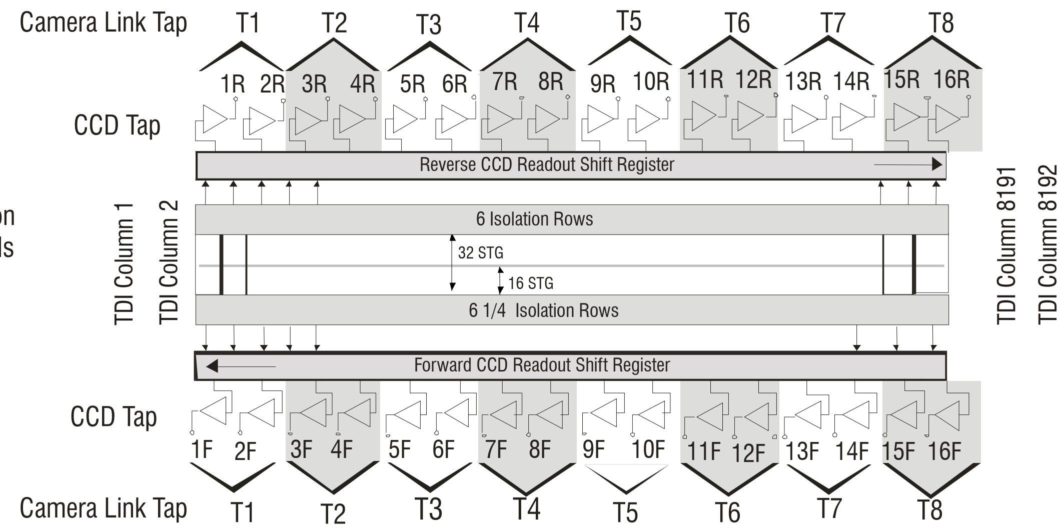




1.3 Image Sensor

The camera uses DALSA's newest bidirectional TDI sensors. The camera can be configured to read out in either Forward or Reverse CCD shift direction. This is controlled by the software command **scd**.

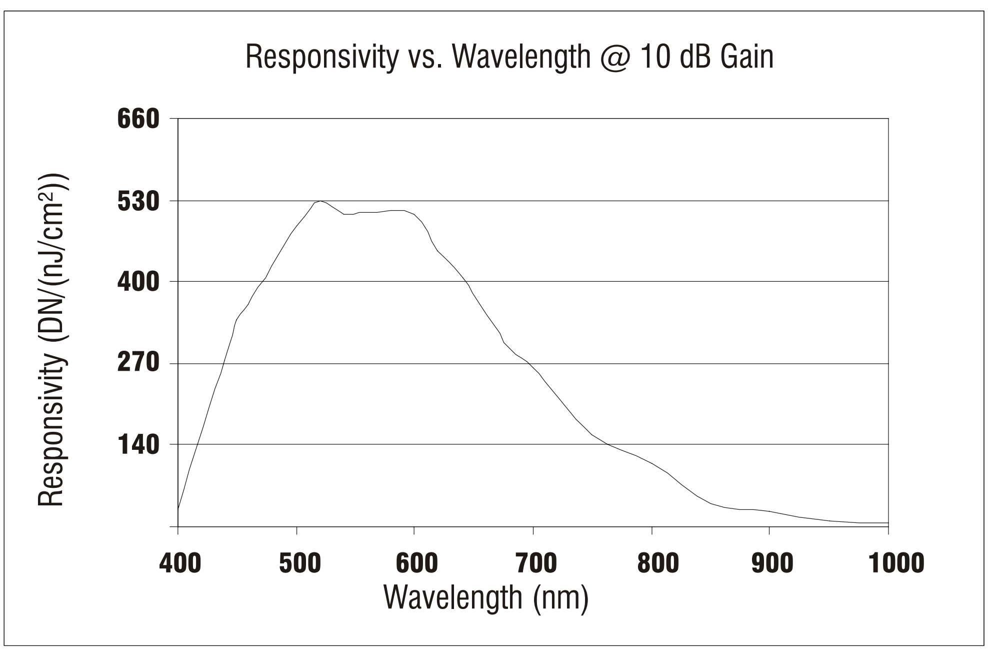
Figure 5: 16 Tap Sensor Block Diagram (ES-80-08kx0)



Note: The ES-80-4k-40 model diagram is TBD.

1.4 Responsivity

Figure 6: Piranha ES Analog Responsivity



2

Camera Hardware Interface

2.1 Installation Overview

When installing your camera, you should take these steps:

This installation overview assumes you have not installed any system components yet.

1. Power down all equipment.
2. Follow the manufacturer's instructions to install the framegrabber (if applicable). Be sure to observe all static precautions.
3. Install any necessary imaging software.
4. Before connecting power to the camera, test all power supplies. Ensure that all the correct voltages are present at the camera end of the power cable. Power supplies must meet the requirements defined in section 2.2.2 Power Connector.
5. Inspect all cables and connectors prior to installation. Do not use damaged cables or connectors or the camera may be damaged.
6. Connect Camera Link and power cables.
7. After connecting cables, apply power to the camera.
8. Check the diagnostic LED. See 2.2.1 LED Status Indicator for an LED description.

You must also set up the other components of your system, including light sources, camera mounts, host computers, optics, encoders, and so on.

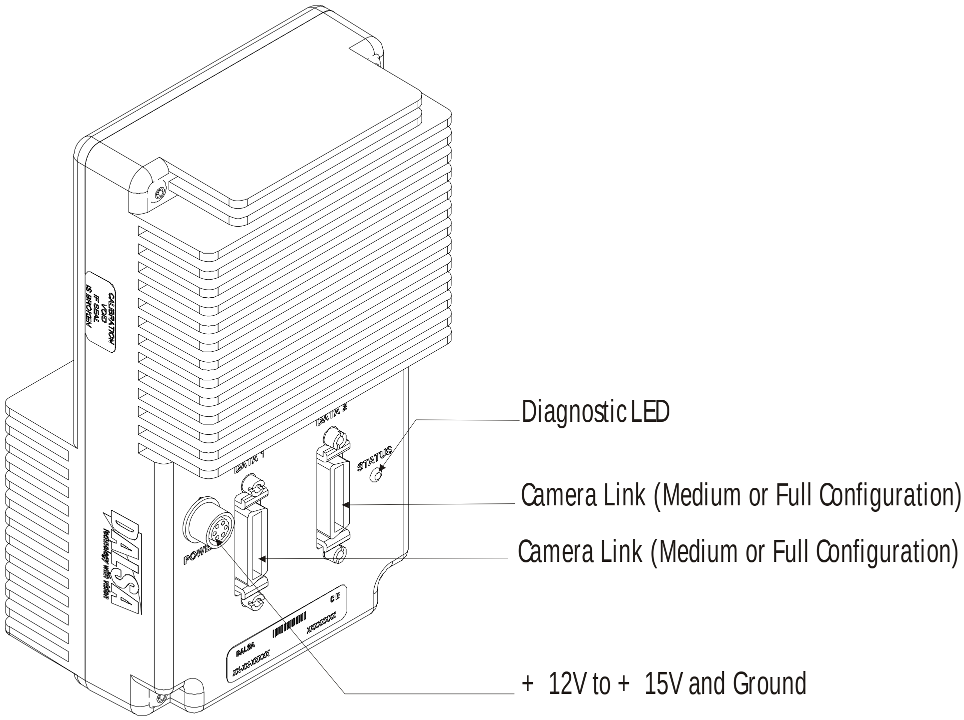
2.2 Input/Output Connectors and LED

The camera uses:

- A diagnostic LED for monitoring the camera. See LED Status Indicator in section 2.2.1 LED Status Indicator for details.

- High-density 26-pin MDR26 connectors for Camera Link control signals, data signals, and serial communications. Refer to section 2.2.3 Camera Link Data Connector for details.
- One 6-pin Hirose connector for power. Refer to section 2.2.2 Power Connector for details.

Figure 7: Piranha ES-8x Input and Output Connectors



WARNING: It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages will damage the camera. See 2.2.2 Power Connector for more details.

2.2.1 LED Status Indicator

The camera is equipped with a red/green LED used to display the operational status of the camera. The table below summarizes the operating states of the camera and the corresponding LED states.

When more than one condition is active, the LED indicates the condition with the highest priority. Error and warning states are accompanied by corresponding messages further describing the current camera status.

Table 5: Diagnostic LED

Priority	Color of Status LED	Meaning
1	Flashing Red	Fatal Error. Camera temperature is too high and camera thermal shutdown has occurred or a power failure has been detected.
2	Solid Red	Warning. Loss of functionality.

Priority	Color of Status LED	Meaning
3	Flashing Green	Camera initialization or executing a long command (e.g., flat field correction commands **ccp** or **ccf**)
4	Solid Green	Camera is operational and functioning correctly.

2.2.2 Power Connector

Figure 8: Hirose 6-pin Circular Male—Power Connector

Table 6: 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

The camera requires a single voltage input (+12 to +15V). The camera meets all performance specifications using standard switching power supplies, although well-regulated linear supplies provide optimum performance.

WARNING: When setting up the camera's power supplies follow these guidelines:

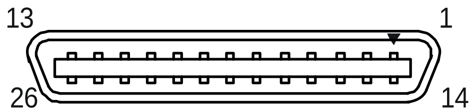
- Apply the appropriate voltages
- Protect the camera with a **fast-blow fuse** between power supply and camera.
- Do not use the shield on a multi-conductor cable for ground.
- Keep leads as short as possible to reduce voltage drop.
- Use high-quality **linear** supplies to minimize noise.
- Use an isolated type power supply to prevent LVDS common mode range violation.

Note: Camera performance specifications are not guaranteed if your power supply does not meet these requirements.

DALSA offers a power supply with attached 6' power cable that meets the Piranha ES camera's requirements, but it should not be considered the only choice. Many high quality supplies are available from other vendors. Visit the www.dalsa.com Web site for a list of companies that make power supplies that meet the camera's requirements. The companies listed should not be considered the only choices.

2.2.3 Camera Link Data Connector

Figure 9: Camera Link MDR26 Connector



Mating Part: 3M 334-31 series
Cable: 3M 14X26-SZLB-XXX-0LC**

A note concerning the length of the Camera Link cables

The length of the cables over which data can be transmitted without loss depends on the data rate and on the quality of the cables.

DALSA tests the cameras using a recognized brand of cable with a length of 5 meters. Data transmission is not guaranteed if you are using a cable greater than 5 meters in length.

Camera Link Configuration

The Camera Link interface is implemented as a Medium or Full Configuration in the Piranha ES cameras depending on the model number. The following table summarizes the different configurations and lists the configurations available to each Piranha ES model number..

Table 7: Camera Link Hardware Configuration Summary for Piranha ES-xx Models

Configuration	8 Bit Ports Supported	Serializer Bit Width	Number of Chips	Number of MDR26 Connectors	Applicable Camera Models
Medium	A, B, C, D, E, F	28	2	2	All
Full	A, B, C, D, E, F, G, H	28	3	2	All

Table 8: Camera Link Connector Pinout

Medium and Full Configurations			
Up to an additional 2 Channel Link Chips			
Camera Connector	Right Angle Frame Grabber	Channel Link Signal	Cable Name
1	1	inner shield	Inner Shield
14	14	inner shield	Inner Shield
2	25	Y0-	PAIR1-
15	12	Y0+	PAIR1+
3	24	Y1-	PAIR2-
16	11	Y1+	PAIR2+
4	23	Y2-	PAIR3-
17	10	Y2+	PAIR3+

5	22	Yclk-	PAIR4-
18	9	Yclk+	PAIR4+
6	21	Y3-	PAIR5-
19	8	Y3+	PAIR5+
7	20	100 ohm	PAIR6+
20	7	terminated	PAIR6-
8	19	Z0-	PAIR7-
21	6	Z0+	PAIR7+
9	18	Z1-	PAIR8-
22	5	Z1+	PAIR8+
10	17	Z2-	PAIR9+
23	4	Z2+	PAIR9-
11	16	Zclk-	PAIR10-
24	3	Zclk+	PAIR10+
12	15	Z3-	PAIR11+
25	2	Z3+	PAIR11-
13	13	inner shield	Inner Shield
26	26	inner shield	Inner Shield

Notes:

*Exterior Overshield is connected to the shells of the connectors on both ends.
**3M part 14X26-SZLB-XXX-0LC is a complete cable assembly, including connectors.
Unused pairs should be terminated in 100 ohms at both ends of the cable.
Inner shield is connected to signal ground inside camera

Table 9: DALSA Camera Control Configuration

Signal	Configuration
CC1	EXSYNC
CC2	Spare
CC3	Forward
CC4	Spare

See Appendix B for the complete DALSA Camera Link configuration table, and refer to the DALSA Web site, vfm.dalsa.com, for the official Camera Link documents.

Input Signals, Camera Link

The camera accepts control inputs through the Camera Link MDR26F connector.

The camera ships in internal sync, internal programmed integration (exposure mode 7) TDI Mode.

EXSYNC (Triggers Frame Readout)

Frame rate can be set internally using the serial interface. The external control signal EXSYNC is optional and enabled through the serial interface. This camera uses the **falling edge of EXSYNC** to trigger pixel readout. Section 3.3.5 Exposure Mode and Line/Frame Rate for details on how to set frame times, exposure times, and camera modes.

Direction Control

You control the CCD shift direction through the serial interface. With the software command, **scd**, you determine whether the direction control is set via software control or via the Camera Link control signal on CC3. Refer to section 3.3.3 Setting the Camera's CCD Shift Direction for details.

Output Signals, Camera Link

IMPORTANT:
This camera's data should be sampled on the rising edge of STROBE.

These signals indicate when data is valid, allowing you to clock the data from the camera to your acquisition system. These signals are part of the Camera Link configuration and you should refer to the DALSA Camera Link Implementation Road Map, available at http://mv.dalsa.com/, for the standard location of these signals.

Clocking Signal	Indicates
LVAL (high)	Outputting valid line
DVAL (high)	Valid data
STROBE (rising edge)	Valid data
FVAL (high)	Outputting valid frame

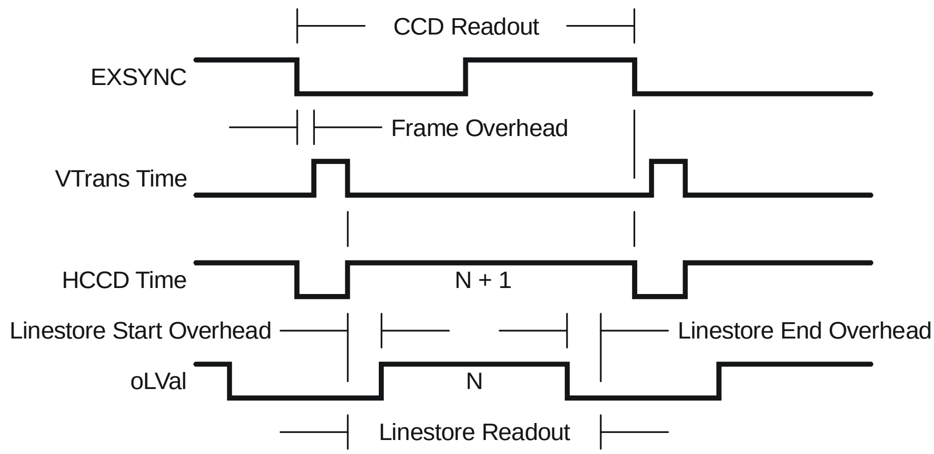
- The camera internally digitizes 12 bits and outputs 8 MSB or all 12 bits depending on the camera's Camera Link operating mode. Refer to 3.4.2 Setting the Camera Link Mode for details.
- For a Camera Link reference refer to Appendix A on page 87.

2.3 Camera Link Video Timing

The Piranha ES-xx camera has two different readout times. The first readout time is the CCD Readout where the camera pixels are read out into the camera's linestore. The second readout is the linestore readout where the linestore pixels are read out to your acquisition system. The camera's minimum readout time is dependant on which of these two readout times are greater where the greater readout time will be the camera's minimum readout time.

The figure below illustrates camera timing when the CCD readout is greater than the linestore readout.

Figure 10: Piranha ES-xx TDI Mode Timing (CCD Limited)



The following figure illustrates camera timing when the linestore readout is greater than the CCD readout.

Figure 11: Piranha ES-xx TDI Mode Timing (Linestore Limited)

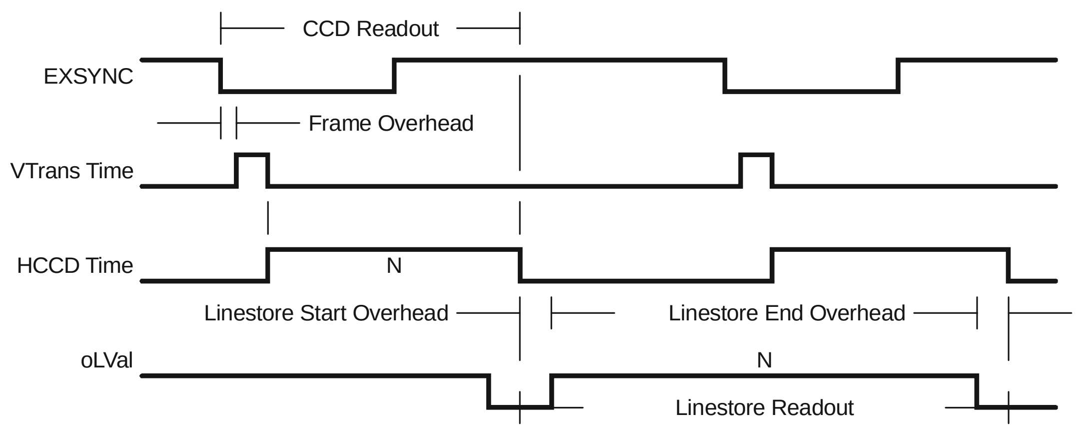


Table 10: Piranha ES-xx Timing Values

Symbol	Time
HCCD Frequency	40 MHz (4k40, 8K80) 20 MHz (8K40)
HCCD Pixels/Tap	512 (4k and 8k camera)
Frame Overhead	$\frac{4}{\text{HCCD Frequency}}$
VTransTime	$\frac{33}{\text{HCCD Frequency}}$
HCCD Read Overhead	ES 4k: and 8k: 34 pixels
HTime	$\text{HTime} = \frac{\text{HCCD Read Overhead} + \text{HCCD Pixels/Tap}}{\text{HCCD Frequency}}$
CCD Readout Time	CCDReadoutTime = FrameOverhead + HTime + VTransTime x Vertical Binning Factor
HCCD Taps	16 (4k and 8k)

Symbol	Time
Linestore Start Overhead	15 clocks
Linestore End Overhead	23 clocks
Linestore Readout Time	$\left[\left(\frac{\text{HCCD Pixels/Tap x HCCD Taps}}{\text{\# Camera Link Taps x Horizontal Binning Factor}}\right)+\text{Linestore Start Overhead}+\text{Linestore End Overhead}\right] \text{ x } \frac{\text{\# Camera Link Taps}}{\text{Throughput (MHz)}}$
Horizontal Binning Factor	Value set with **`sbh`** command
Vertical Binning Factor	Value set with **`sbv`** command
Vertical Readout Rows	Stage selection set with **`stg`** command
# of Camera Link Taps	Value set with the **`clm`** command
Throughput	Value set with **`sot`** command

IMPORTANT:
This camera uses the ***falling*** edge of EXSYNC to trigger line readout, unlike previous DALSA cameras, which used the rising edge.

Figure 12: Piranha ES-xs Area Mode Timing (CCD Limited)

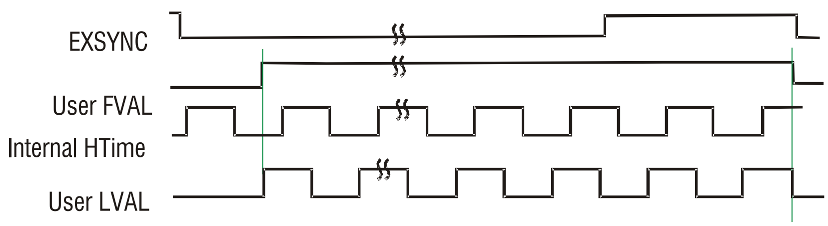


Figure 13: Piranha ES-xx Area Mode Timing (Linestore Limited)

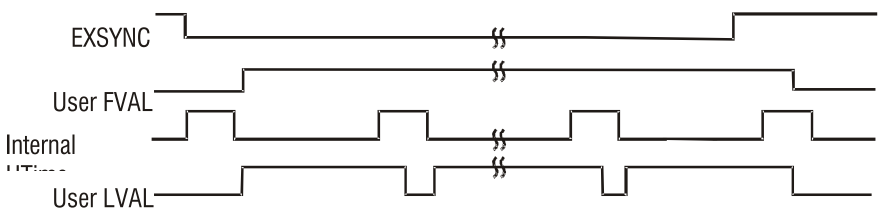


Table 11: Piranha Input and Output

Symbol	Time
CCD Readout Time (Area Mode)	$\text{CCD ReadoutTime}=\frac{\text{Frame Overhead}}{\text{HCCD Frequency}}+\left[\text{HTime}+\text{VTransTime} \text{ x Remainder}\left(\frac{\text{Vertical readout rows}+\text{ISORows}}{\text{Vertical Binning Factor}}\right)\right]+\left[\left(\text{HTime}+\text{VTrans} \text{ x Vertical Binning Factor}\right) \text{ x Integer}\left(\frac{\text{Vertical readout rows}+\text{ISORows}}{\text{Vertical Binning Factor}}\right)\right]$

3

Software Interface: How to Control the Camera

All Piranha ES-xx camera features can be controlled through the serial interface. The camera can also be used without the serial interface after it has been set up correctly. Functions available include:

This chapter outlines the more commonly used commands. See section A2 Commands for a list of all available commands.

- Controlling basic camera functions such as gain and sync signal source
- Flat field correction
- Mirroring and readout control
- Generating a test pattern for debugging

The serial interface uses a simple ASCII-based protocol and the PC does not require any custom software.

Note: This command set has changes from previous DALSA cameras. Do not assume that the Piranha ES commands perform similarly to older cameras.

Serial Protocol Defaults

- 8 data bits
- 1 stop bit
- No parity
- No flow control
- 9.6kbps
- Camera does not echo characters

Command Format

When entering commands, remember that:

- A carriage return <CR> ends each command.
- A space or multiple space characters separate parameters. Tabs or commas are invalid parameter separators.
- Upper and lowercase characters are accepted
- The backspace key is supported
- The camera will answer each command with either <CR><LF> "OK >" or <CR><LF>"Error xx: Error Message >" or "Warning xx: Warning Message >". The ">" is used exclusively as the last character sent by the camera.

The following parameter conventions are used in the manual:

- ***i*** = integer value
- ***f*** = real number
- ***m*** = member of a set
- ***s*** = string
- ***t*** = tap id
- ***x*** = pixel column number
- ***y*** = pixel row number

Example: to return the current camera settings

gcp <CR>

Setting Baud Rate

Purpose:	Sets the speed in bps of the camera serial communication port.
Syntax:	**sbr *m***
Syntax Elements:	***m*** Baud rate. Available baud rates are: **9600** (Default), **19200**, **57600**, and **115200**.
Notes:	• Power-on rate is always 9600 baud. • The **rc** (reset camera) command will *not* reset the camera to the power-on baud rate and will reboot using the last used baud rate.
Example:	**sbr 57600**

Camera Help Screen

For quick help, the camera can return all available commands and parameters through the serial interface.

There are two different help screens available. One lists all of the available commands to configure camera operation. The other help screen lists all of the commands available for retrieving camera parameters (these are called "get" commands).

To view the help screen listing all of the camera configuration commands, use the command:

Syntax: **h**

To view a help screen listing all of the "get" commands, use the command:

Syntax: **gh**

Notes: For more information on the camera's "get" commands, refer to section 3.7.6 Returning Camera Settings.

The camera configuration command help screen lists all commands available. Parameter ranges displayed are the extreme ranges available. Depending on the current camera operating conditions, you may not be able to obtain these values. If this occurs, values are clipped and the camera returns a warning message.

Some commands may not be available in your current operating mode. The help screen displays NA in this case.

Example Help Screen for ES-80-08k80 TDI Mode Operation

```
cag  calibrate analog gain        ti      0-16:1024-4055
cao  calibrate analog offset      ti      0-16:0-255
ccf  correction calibrate fpn
ccg  calibrate camera gain       iti      1-4:0-16:1024-4055
ccp  correction calibrate prnu
clm  camera link mode             m       15/16/21/
cpa  calculate prnu algorithm     ii     1-4:1024-4055
css  correction set sample        m       256/512/1024/
dpc  display pixel coeffs         xx      1-8191:2-8192
els  end of line sequence         i       0-1
epc  enable pixel coefficients    ii      0-1:0-1
gcm  get camera model
gcp  get camera parameters
gcs  get camera serial
gcv  get camera version
get  get values                   s
get  fpn coeff                    x       1-8192
gh   get help
gl   get line                     xx      1-8191:2-8192
gla  get line average             xx      1-8191:2-8192
gpc  get prnu coeff               x       1-8192
gsf  get signal frequency         i       0-0
gss  get sensor serial
h    help
lpc  load pixel coefficients        i      0-4
rc   reset camera
rfs  restore factory settings
roi  region of interest           xyxy    1-8192:1-8192:1-1:1-1
rpc  reset pixel coeffs
rus  restore user settings
sag  set analog gain              tf      0-16:-10.0-+10.0
sao  set analog offset            ti      0-16:0-255
sbh  set binning horizontal       m       1/2/4/8/
sbr  set baud rate                m       9600/19200/57600/115200/
sbv  set binning vertical         i       1-8
scd  set ccd direction            i       0-2
sdo  set digital offset           ti      0-16:0-511
sem  set exposure mode            m       3/7/
set  set exposure time            f       NA
```

Command

Parameters
i = integer
f = floating point number
m = member of a set
s = string
t = tap
x = pixel column number
y = pixel row number

Parameter Range
- = range
: = multiple parameter separator
/ = member of a set separator
NA = command not available in current operating mode

sfc	set fpn coeff	xi	1-8192:0-511
sfr	set fpn range	xxi	1-8192:1-8192:0-2048
slt	set lower threshold	i	0-4095
smm	set mirroring mode	i	0-1
sot	set output throughput	m	320
spc	set prnu coeff	xi	1-8192:0-28671
spr	set prnu range	xxi	1-8192:1-8192:0-28671
ssb	set subtract background	ti	0-16:0-4095
ssf	set sync frequency	f	3499.87-68610.6 [Hz]
ssg	set system gain	ti	0-16:0-65535
stg	set stage	m	16, 32
spt	set pretrigger	i	0-16
suf	set upgrade feature	s	
sut	set upper threshold	i	0-4095
svm	set video mode	i	0-3
tdi	set TDI or area mode	i	0-1
ugr	update gain reference		
vt	verify temperature		
vv	verify voltage		
wfc	write FPN coefficients	i	1-4
wpc	write PRNU coefficients	i	1-4
wus	write user settings		

Example Help Screen for ES-80-08k80 Area Mode Operation

cao	calibrate analog offset	ti	0-16:0-255
ccf	correction calibrate fpn		NA
ccg	calibrate camera gain	iti	0-1:0-16:1024-4055
ccp	correction calibrate prnu		NA
clm	camera link mode	m	5/16/21/
cpa	calculate prnu algorithm	ii	NA
css	correction set sample	m	NA
dpc	display pixel coeffs	xx	NA
els	end of line sequence	i	0-1
epc	enable pixel coefficients	ii	NA
gcm	get camera model		
gcp	get camera parameters		
gcs	get camera serial		
gcv	get camera version		
get	get values	s	
gfc	get fpn coeff	x	NA
gh	get help		
gl	get line	xx	NA
gla	get line average	xx	NA
gpc	get prnu coeff	x	NA
gsf	get signal frequency	i	0-0
gss	get sensor serial		
h	help		
lpc	load pixel coefficients		NA
rc	reset camera		
rfs	restore factory settings		
roi	region of interest	xyxy	1-8192:1-96:1-8192:1-96
rpc	reset pixel coeffs		NA
rus	restore user settings		
sag	set analog gain	tf	0-16:-10.0-+10.0
sao	set analog offset	ti	0-16:0-255
sbh	set binning horizontal	m	1/2/4/8/
sbr	set baud rate	m	9600/19200/57600/115200/
sbv	set binning vertical	i	1-8
scd	set_ccd_direction	i	0-1
sdo	set digital offset	ti	0-16:0-511
sem	set exposure mode	m	2/3/4/5/6/7/8/

```
set  set exposure time          f         3-1000 [uSec]
sfc  set fpn coeff              xi        NA
slt  set lower threshold        i         0-4095
smm  set mirroring mode         i         0-1
sot  set output throughput      m         320
spc  set prnu coeff             xi        NA
ssb  set subtract background    ti        0-4:0-4095
ssf  set sync frequency         f         1-6169.03 [Hz]
ssg  set system gain            ti        0-4:0-65535
stg  set stage                  m         16, 32
spt  set pretrigger             i         0-16
suf  set upgrade feature        s
sut  set upper threshold        i         0-4095
svm  set video mode             i         0-3
tdi  set TDI or area mode       i         0-1
ugr  update gain reference
vt   verify temperature
vv   verify voltage
wfc  write FPN coefficients               NA
wpc  write PRNU coefficients              NA
wus  write user settings
```

3.1 First Power Up Camera Settings

When the camera is powered up for the first time, it operates using the following factory settings:

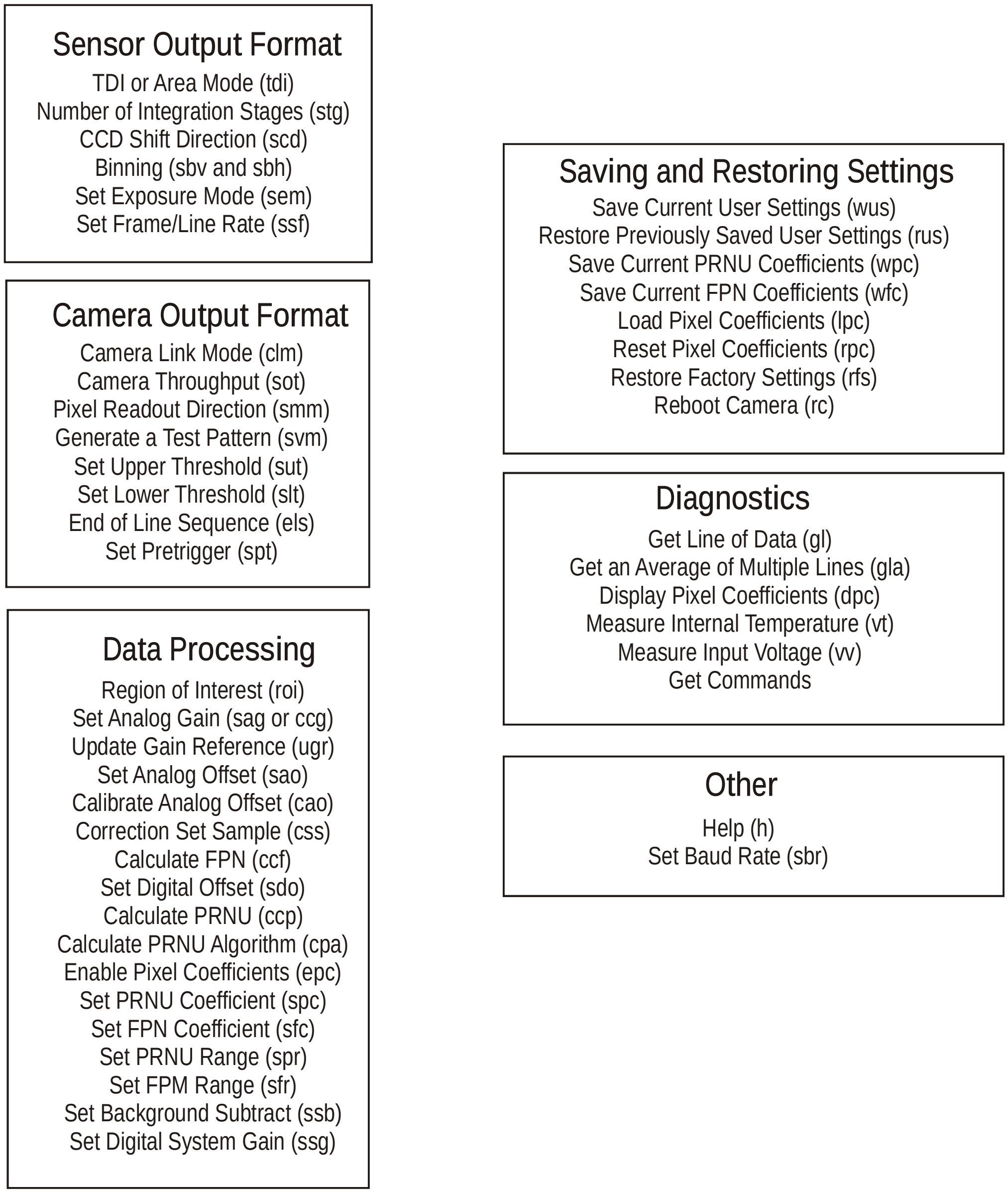
- TDI mode
- Left to right pixel readout
- Forward CCD shift direction
- 32 integration stages
- No binning
- Camera Link Mode: 21 (8 bit, 8 taps, 40MHz strobe rate)
- Exposure mode 7
- 10 kHz line rate
- 320 throughput
- Factory calibrated analog gain and offset
- Factory calibrated FPN and PRNU coefficients using the following process:

1. **ssf 10000** (line rate of 10000Hz)
2. **ccg 2 0 3280** (analog gain calibrated to an average pixel value of 3280)
3. **ccf** (fpn calibration)
4. **ccp** (prnu calibration)
5. **ssg 0 0**

3.2 Command Categories

The following diagram categorizes and lists all of the camera's commands. This chapter is organized by command category.

Figure 14: Command Categories



3.3 Sensor Output Format

3.3.1 Selecting TDI or Area Mode Operation

The Piranha ES-xx cameras have the ability to operate in both TDI and Area Mode.

In Area Mode, the camera operates as an area array camera using a two dimensional array of pixels. Area Mode is useful for aligning the camera to your web direction or when you need a rectangular 2D image and the lighting supports a full frame imager.

In TDI Mode, the camera operates as a TDI high sensitivity line scan camera and combines multiple exposures of an object into one high-resolution result.

The camera stores user settings for Area Mode and TDI Mode separately, allowing you to switch between Area and TDI mode without losing settings specific to each mode. See section 3.6 Saving and Restoring Settings for an explanation on how user settings are stored and retrieved.

NOTE: Sensor cosmetic specifications for Area Mode of operation are neither tested nor guaranteed

Purpose: Selects the camera's operating mode. Area Mode is useful for aligning and focusing your camera.

Syntax: **`tdi`** ***`i`***

Syntax Elements: ***`i`***

- **`0`** Area mode
- **`1`** TDI mode

Notes:

- Remember to save your user settings before changing mode. Sending the **`tdi`** command **always** restores your last saved user settings for the mode of operation requested even if you are already operating in the requested mode. See section 3.6 Saving and Restoring Settings for an explanation on how user settings are stored and retrieved for each mode.
- Flat field correction is not available in Area Mode

Example **`tdi 1`**

3.3.2 Selecting the Number of CCD Integration Stages

Purpose: In TDI Mode, this command adjusts the sensitivity level in your camera by setting the number of CCD integration stages. In Area Mode, the vertical height of the image sensor is controlled by the number of stages.

Syntax: **`stg`** ***`m`***

Syntax Elements: ***`m`***

Number of stages to use. Available values are **`16`** and **`32`**. Area mode is restricted to **32** stages.

Example **`stg 32`**

3.3.3 Setting the Camera's CCD Shift Direction

Purpose: When in TDI Mode, selects the forward or reverse CCD shift direction or external direction control. This accommodates object direction change on a web and allows you to mount the camera "upside down".

In Area Mode, selects the vertical readout direction. This allows you to mirror the image vertically or mount the camera "upside down".

Syntax: **scd *i***

Syntax Elements: ***i***

Readout direction. Allowable values are:

0 = Forward CCD shift direction.

1 = Reverse CCd shift direction.

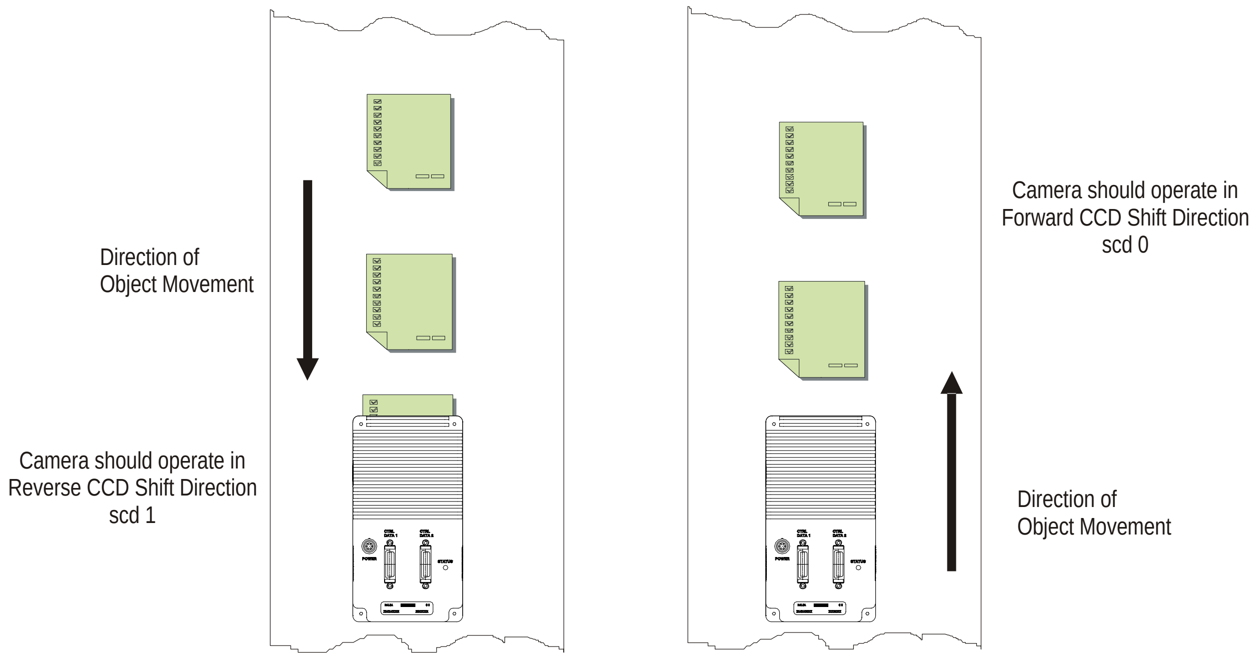
2 = Externally controlled direction control via Camera Link control CC3 (CC3=1 forward, CC3=0 reverse). Available only in TDI Mode.

Notes:

- The following user settings are stored separately for forward and reverse direction; analog gain, analog offset, digital gain, digital offset, background subtract, and pixel coefficients. These settings are automatically loaded when you switch direction. All other settings are common to both directions.
- See the following figures for an illustration of CCD shift direction in relation to object movement.
- Note that some commands that require longer processing time, like **ccg**, delay implementation of an external direction change.

Example **scd 1**

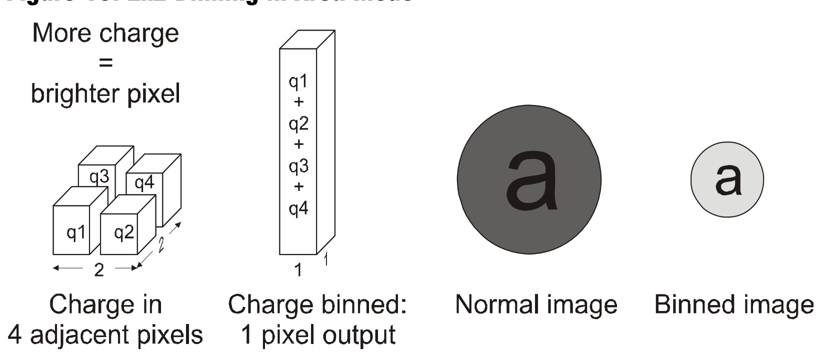
Figure 15: Object Movement and Camera Direction Example using 8k Model and an Inverting Lens



3.3.4 Increasing Sensitivity with Binning

Binning increases the camera's light sensitivity by decreasing horizontal and/or vertical resolution—the charge collected by adjacent pixels is added together. Binning is also useful for increasing frame rate (vertical binning) or increasing the pixel pitch. For example, if you set your vertical binning to 2 and your horizontal binning to 2, your pixel size increases from 7µm x 7µm (no binning) to 14µm x 14µm (2x2 binning).

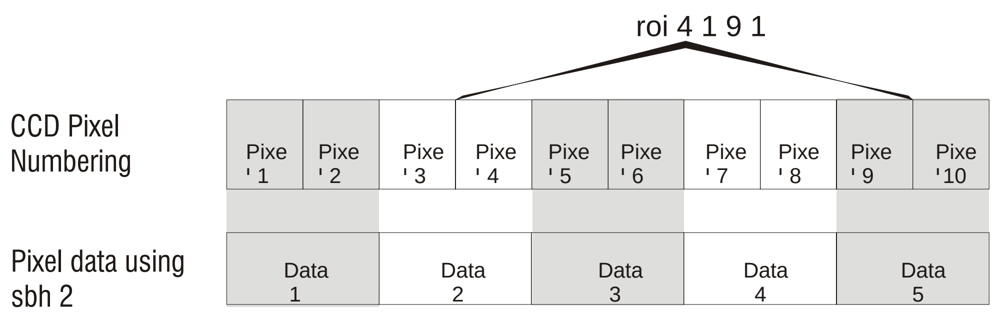
Figure 16: 2x2 Binning in Area Mode



Setting Horizontal Binning

Purpose:	Increases the horizontal pixel pitch and light sensitivity by decreasing horizontal resolution. The amount of data being sent from the camera is reduced by the horizontal binning factor. Different framegrabber files are needed for different horizontal binning factors.
Syntax:	**sbh** *m*
Syntax Elements:	**m** Horizontal binning value. Available values are **1** (factory setting, no binning) **2**, **4**, or **8**.
Notes:	• If you are using horizontal binning, the min, max, and mean statistics generated by the **gl** or **gla** command are for every second pixel (or valid data) only (e.g., if **sbh 2**, every second pixel). • For optimal flat field correction, you should rerun the **ccp** and **ccf** commands after changing binning values. • Changing binning values does not automatically alter gain, frame rate generation, or other functions of the camera. • Pixel numbering remains unchanged for the **roi**, **gl**, **gla**, **dpc**, **gfc**, **sfc**, **gpc**, and **spc** commands. Refer to Figure 17 for an explanation of pixel numbering and pixel start and stop values when using a region of interest.
Example:	**sbh 2**

Figure 17: Binning Start and End Values when using a Region of Interest



In this example a region of interest is set to include pixels 4 to 9 and horizontal binning is set to 2. Because pixel 3 is now included in the same data group as pixel 4, the region of interest will now include the data from pixel 3. Also, pixel 10 is included in the same data group as pixel 9, so pixel 10 is now part of the region of interest. To see how the region of interest start and stop values have been rounded, use the command **get roi**.

Setting Vertical Binning

Syntax:	Increases the vertical pixel pitch and light sensitivity by decreasing vertical resolution. Vertical binning is also useful for increasing frame rate in Area Mode. Vertical binning in TDI Mode should only be used if your web's shaft encoder provides a reduced ratio of pulses to match web speed.
Syntax:	**sbv *i***
Syntax Elements:	**i** Vertical binning value. Available values are **1** (factory setting, no binning) to **8**.
Notes:	• You will have to recalibrate the camera after changing binning values. • Increasing the vertical binning, decreases the maximum allowable line rate. You may have to enter a new camera frame rate after changing vertical binning values if the current value becomes invalid. The camera sends a warning message in this situation.
Example:	**sbv 2**

3.3.5 Exposure Mode and Line/Frame Rate

How to Set Exposure Mode and Line/Frame Rate

You have a choice of operating the camera in one of two exposure modes. Depending on your mode of operation, the camera's line/frame rate (synchronization) can be generated internally through the software command **ssf** or set externally with an EXSYNC signal (CC1). When operating in TDI Mode, it is important that the line rate used matches the web speed. Failure to match the web speed will result in smearing. Refer to the DALSA application note, "Line Scan/TDI Line Scan Calculation Worksheet" located on the http://mv.dalsa.com/ site, if you require further explanation on how to synchronize your web speed.

To select how you want the camera's line/frame rate to be generated:

1. You must first set the camera's exposure mode using the **sem** command. Refer to section Setting the Exposure Mode below for details.
2. Next, if using mode 7, use the command **ssf** to set the line/frame rate. Refer to section
3. Setting Frame Rate for details.

Setting the Exposure Mode

Purpose:	Sets the camera's exposure mode allowing you to control your sync and line/frame rate generation.
Syntax:	**sem** ***m***
Syntax Elements:	**m** Exposure mode to use. Factory setting is **7**.
Notes:	• Refer to Table 12: Piranha ES Exposure Modes for a quick list of available modes or to the following sections for a more detailed explanation including timing diagrams. • To obtain the current value of the exposure mode, use the command **gcp** or **get sem**. • When setting the camera to external signal modes, EXSYNC must be supplied. • Refer to section 3.5.1 for more information on how to operate your camera in TDI or Area Mode. • Exposure Modes are saved separately for TDI Mode and Area Mode. Refer to section 3.6 Saving and Restoring Settings for more information on how to save camera settings.
Related Commands:	**ssf**
Example:	**sem 3**

Table 12: Piranha ES Exposure Modes

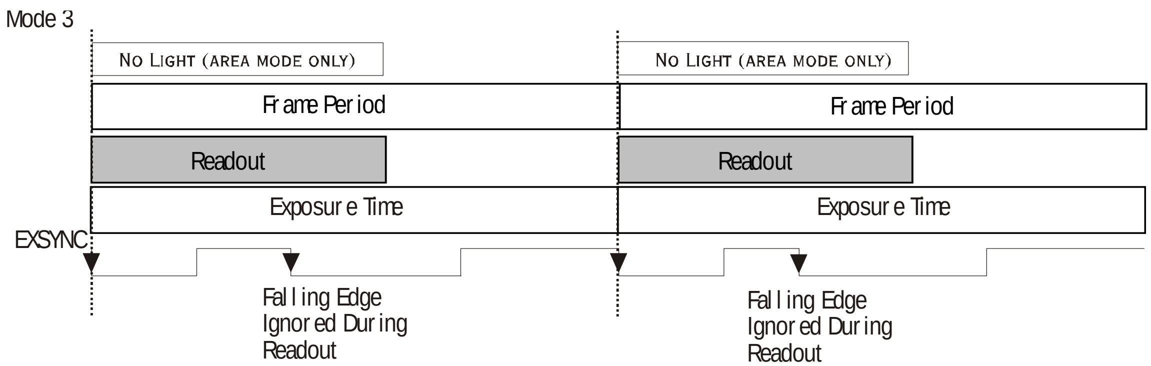
Mode	SYNC	Programmable Frame Rate	Programmable Exposure Time	Description
3	External	No	No	Maximum exposure time with no charge reset.
7	Internal	Yes	No	Internal sync, maximum exposure time with no charge reset.

Exposure Modes in Detail

Frame rate is set by the period of the external trigger pulses. EXSYNC pulses faster than the read out time are ignored. The falling edge of EXSYNC marks the start of readout.

Note: In TDI mode the frame period equals the line period.

Figure 18: Mode 3 Timing

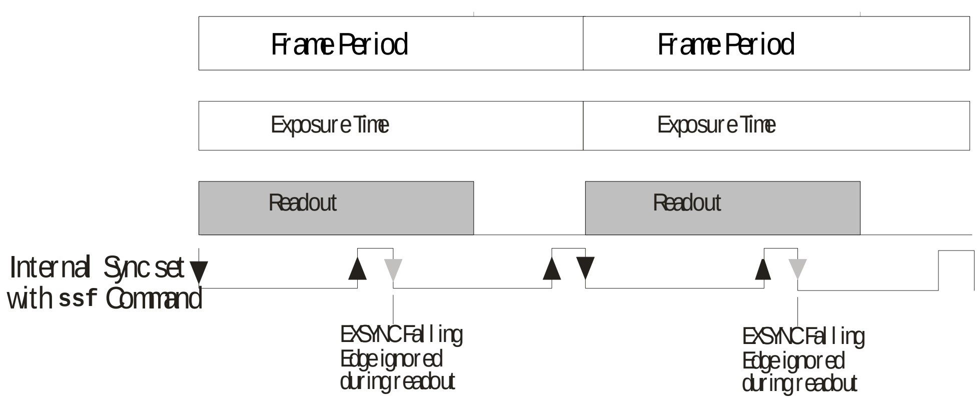


Mode 7: Internal Frame Rate, Maximum Exposure Time

In this mode, the frame rate is set internally using the **ssf** command with a maximum exposure time.

Note: In TDI mode the frame period equals the line period.

Figure 19: Mode 7 Camera Timing



Setting Frame Rate

Purpose: Sets the camera's frame rate in Hz. Camera must be operating in exposure mode 7.

Syntax: **ssf *f***

Syntax Elements: **f**

Set the frame rate to a value from:

TDI

ES-80-8k40: 3499.56-34305.3
ES-80-8k80: 3499.87-68610.6
ES-80-4k40: 3499.87-68610.6

Area

ES-80-8k40: 1-3084.52
ES-80-8k80: 1-6169.03
ES-80-4k40: 1-6169.03

Value rounded up/down as required. The maximum line/frame rate is affected by horizontal and vertical binning factors, throughput setting, Camera Link mode, and number of CCD integration stages.

Notes:

- If you enter an invalid frame rate frequency the value, the camera clips the frame rate to be within the current operating range and a warning message is returned.
- If you enter a frame rate frequency out of the range displayed on the help screen, an error message is returned and the frame rate remains unchanged.
- The camera does not automatically change the frame rate after you change binning or stage selection values. You may have to adjust your frame rate to avoid ignored syncs.
- To return the camera's frame rate, use the commad **gcp** or **get ssf**.

Related Commands: **sem**

Example: **ssf 10000**

3.4 Camera Output Format

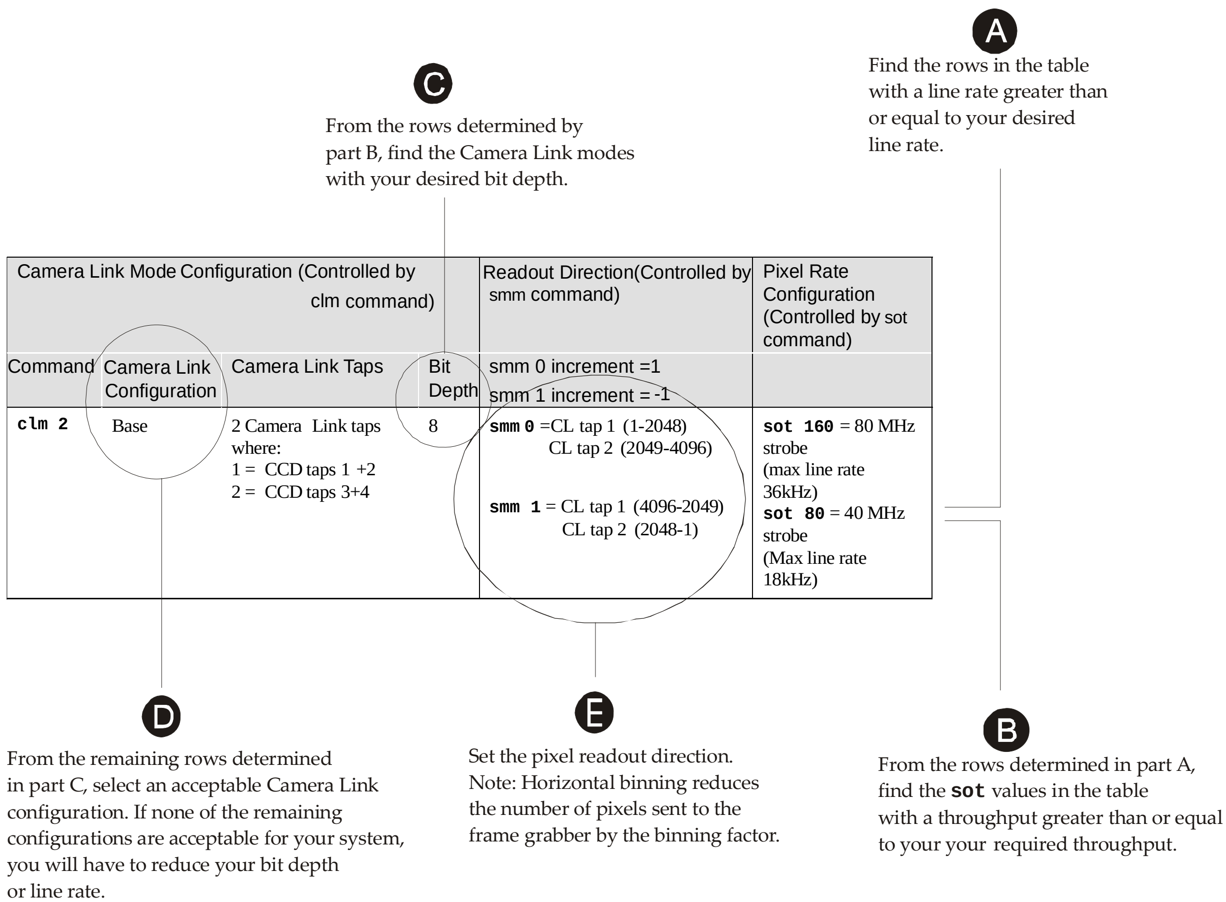
3.4.1 How to Configure Camera Output

The Piranha ES cameras offer great flexibility when configuring your camera output. Using the **clm** command, you determine the camera's Camera Link configuration, number of output taps, and bit depth. Using the **sot** command, you determine the camera's output rate. These two commands work together to determine your final camera output configuration.

You can further configure your readout using the **smm** command to select the camera's pixel readout direction.

The following tables summarize the possible camera configurations for each of the ES-xx camera models. Refer to the figure below for a description on how to select your camera output.

Figure 20: How to Read the Camera Link Tables



Note: In the following tables, a CCD tap refers to the actual physical taps on the sensor, while the Camera Link taps refer to the way the data is configured for output over Camera Link. For a diagram illustrating sensor taps, see section 1.3 Image Sensor.

Table 13: ES-80-04k40 Configurations

Camera Link Mode Configuration (Controlled by clm command)				Readout Direction (Controlled by smm command)	Pixel Rate Configuration (Controlled by sot command)
Command	**Camera Link Configuration**	**Camera Link Taps**	**Bit Depth**		
`clm 15`	Medium	4 Camera Link taps where: 1 = CCD tap 1 + 2 2 = CCD tap 3 + 4 3 = CCD tap 5 + 6 4 = CCD tap 7 + 8	8	`smm 0` = CL tap 1 (1-1024) CL tap 2 (1025-2048) CL tap 3 (2049-3072) CL tap 4 (3073-4096) `smm 1` = CL tap 1 (4096-3073) CL tap 2 (3072-2049) CL tap 3 (2048-1025) CL tap 4 (1024-1)	`sot 320` = 80 MHz strobe (max rate 68610 Hz) `sot 160` = 40 MHz strobe (max line rate 37629 Hz)
`clm 16`	Medium	4 Camera Link taps where: 1 = CCD tap 1 + 2 2 = CCD tap 3 + 4 3 = CCD tap 5 + 6 4 = CCD tap 7 + 8	12	`smm 0` = CL tap 1 (1-1024) CL tap 2 (1025-2048) CL tap 3 (2049-3072) CL tap 4 (3073-4096) `smm 1` = CL tap 1 (4096-3073) CL tap 2 (3072-2049) CL tap 3 (2048-1025) CL tap 4 (1024-1)	`sot 320` = 80 MHz strobe (max line rate 68610 Hz) `sot 160` = 40 MHz strobe (max line rate 37629 Hz)
`clm 21`	Full	8 Camera Link taps where: 1 = CCD tap 1 2 = CCD tap 2 3 = CCD tap 3 4 = CCD tap 4 5 = CCD tap 5 6 = CCD tap 6 7 = CCD tap 7 8 = CCD tap 8	8	`smm 0` = CL tap 1 (1-512) CL tap 2 (513-1024) CL tap 3 (1025-1536) CL tap 4 (1537-2048) CL tap 5 (2049-2560) CL tap 6 (2561-3072) CL tap 7 (3073-3584) CL tap 8 (3585-4096) `smm 1` = CL tap 1 (4096-3585) CL tap 2 (3584-3073) CL tap 3 (3072-2561) CL tap 4 (2560-2049) CL tap 5 (2048-1537) CL tap 6 (1536-1025) CL tap 7 (1024-513) CL tap 8 (512-1)	`sot 320` = 40 MHz strobe (max line rate 68610 Hz)

Table 14: ES-80-08k40 Configurations

Camera Link Mode Configuration (Controlled by clm command)				Readout Direction (Controlled by smm command)	Pixel Rate Configuration (Controlled by sot command)
Command	**Camera Link Configuration**	**Camera Link Taps**	**Bit Depth**		
clm 15	Medium	4 Camera Link taps where: 1 = CCD tap 1+2+3+4 2 = CCD tap 5+6+7+8 3 = CCD tap 9+10+11+12 4 = CCD tap 13+14+15+16	8	**smm 0** = CL tap 1(1-2048) CL tap 2(2049-4096) CL tap 3(4097-6144) CL tap 4(6145-8192) **smm 1** = CL tap 1(8192-6145) CL tap 2(6144-4097) CL tap 3(4096-2049) CL tap 4(2048-1)	**sot 80** = 20 MHz strobe (max line rate 9583Hz) **sot 160** = 40 MHz strobe (max line rate 19157Hz)
clm 16	Medium	4 Camera Link taps where: 1 = CCD tap 1+2+3+4 2 = CCD tap 5+6+7+8 3 = CCD tap 9+10+11+12 4 = CCD tap 13+14+15+16	12	**smm 0** = CL tap 1(1-2048) CL tap 2(2049-4096) CL tap 3(4097-6144) CL tap 4(6145-8192) **smm 1** = CL tap 1(8192-6145) CL tap 2(6144-4097) CL tap 3(4096-2049) CL tap 4(2048-1)	**sot 80** = 20 MHz strobe (max line rate 9583Hz) **sot 160** = 40 MHz strobe (max line rate 19157Hz)
clm 21	Full	8 Camera Link taps where: 1 = CCD tap 1+2 2 = CCD tap 3+4 3 = CCD tap 5+6 4 = CCD tap 7+8 5 = CCD tap 9+10 6 = CCD tap 11+12 7 = CCD tap 13+14 8 = CCD tap 15+16	8	**smm 0** = CL tap 1(1-1024) CL tap 2(1025-2048) CL tap 3(2049-3072) CL tap 4(3073-4096) CL tap 5(4097-5120) CL tap 6(5121-6144) CL tap 7(6145-7168) CL tap 8(7169-8192) **smm 1** = CL tap 1(8192-7169) CL tap 2(7168-6145) CL tap 3(6144-5121) CL tap 4(5120-4097) CL tap 5(4096-3073) CL tap 6(3072-2049) CL tap 7(2048-1025) CL tap 8(1024-1)	**sot 160** = 20 MHz strobe (max line rate 18814Hz) **sot 320** = 40 MHz strobe (max line rate 34305Hz)

Table 15: ES-80-08k80 Configurations

Camera Link Mode Configuration (Controlled by clm command)				Readout Direction (Controlled by smm command)	Pixel Rate Configuration (Controlled by sot command)
Command	**Camera Link Configuration**	**Camera Link Taps**	**Bit Depth**		
`clm 15`	Medium	4 Camera Link taps where: 1 = CCD tap 1+2+3+4 2 = CCD tap 5+6+7+8 3 = CCD tap 9+10+11+12 4 = CCD tap 13+14+15+16	8	`smm 0` = CL tap 1(1-2048) CL tap 2(2049-4096) CL tap 3(4097-6144) CL tap 4(6145-8192) `smm 1` = CL tap 1(8192-6145) CL tap 2(6144-4097) CL tap 3(4096-2049) CL tap 4(2048-1)	`sot 320` = 80 MHz strobe (max rate 38314Hz) `sot 160` = 40 MHz strobe (max line rate 19166Hz)
`clm 16`	Medium	4 Camera Link taps where: 1 = CCD tap 1+2+3+4 2 = CCD tap 5+6+7+8 3 = CCD tap 9+10+11+12 4 = CCD tap 13+14+15+16	12	`smm 0` = CL tap 1(1-2048) CL tap 2(2049-4096) CL tap 3(4097-6144) CL tap 4(6145-8192) `smm 1` = CL tap 1(8192-6145) CL tap 2(6144-4097) CL tap 3(4096-2049) CL tap 4(2048-1)	`sot 320` = 80 MHz strobe (max line rate 38314Hz) `sot 160` = 40 MHz strobe (max line rate 19166Hz)
`clm 21`	Full	8 Camera Link taps where: 1 = CCD tap 1+2 2 = CCD tap 3+4 3 = CCD tap 5+6 4 = CCD tap 7+8 5 = CCD tap 9+10 6 = CCD tap 11+12 7 = CCD tap 13+14 8 = CCD tap 15+16	8	`smm 0` = CL tap 1(1-1024) CL tap 2(1025-2048) CL tap 3(2049-3072) CL tap 4(3073-4096) CL tap 5(4097-5120) CL tap 6(5121-6144) CL tap 7(6145-7168) CL tap 8(7169-8192) `smm 1` = CL tap 1(8192-7169) CL tap 2(7168-6145) CL tap 3(6144-5121) CL tap 4(5120-4097) CL tap 5(4096-3073) CL tap 6(3072-2049) CL tap 7(2048-1025) CL tap 8(1024-1)	`sot 640` = 80 MHz strobe (ES-80-08k80 only) (max line rate 68610Hz) `sot 320` = 40 MHz strobe (max line rate 37629Hz)

3.4.2 Setting the Camera Link Mode

Purpose: Sets the camera's Camera Link configuration, number of Camera Link taps and data bit depth. Refer to the tables on the previous pages to determine which configurations are valid for your camera model and how this command relates to other camera configuration commands.

Syntax: **`clm`** ***m***

Syntax Elements: ***m***

Output mode to use:

15: Medium configuration, 4 taps, 8 bit output
16: Medium configuration, 4 taps, 12 bit output
21: Full configuration, 8 taps, 8 bit output

Notes:

- When you change the Camera Link mode (**`clm`** command), the camera attempts to maintain the current **`sot`** throughput (pixels/sec). If the current throughput is too slow or too fast for the current Camera Link mode, the camera will automatically adjust the throughput value and will return a warning message that a related parameter was adjusted.
- To obtain the current Camera Link mode, use the command **`gcp`** or **`get clm`**.
- The bit patterns are defined by the DALSA Camera Link Roadmap available at http://mv.dalsa.com/.

Related Commands **`sot`**

Example: **`clm 15`**

3.4.3 Setting the Camera Throughput

Purpose:	Works in conjunction with the `clm` command (see previous) and determines the throughput of the camera. Refer to the tables in section 3.4.1 How to Configure Camera Output to determine which configurations are valid for your camera model and how this command relates to other camera configuration commands.
Syntax:	**`sot`** ***`m`***
Syntax Elements:	***`m`*** Output throughput. Allowable values are: **`80 =`** 4 taps at 20MHz or 2 taps at 40MHz **`160 =`** 2 taps at 80MHz or 4 taps at 40MHz **`320 =`** 4 taps at 80MHz or 8 taps at 40MHz **`640 =`** 8 taps at 80MHz
Notes:	▪ Throughput is calculated as: **Throughput= (Number of Camera Link Taps) x (Camera Link Pixel Rate in MHz)** • To obtain the throughput setting, use the command `gcp` or `get clm`. • Throughput values are clipped if the camera is unable to maintain the current throughput setting and a warning message is displayed. • Refer to the tables in section 3.4.1 How to Configure Camera Output to determine which configurations are valid for your camera model.
Related Commands	`clm`
Example:	**`sot 160`**

3.4.4 Setting the Pixel Readout Direction

Purpose:	Sets the tap readout from left to right or from right to left. This command is useful if the camera must be mounted upside down.
Syntax:	**`smm`** ***`i`***
Syntax Elements:	***`i`*** Readout direction. Allowable values are: **`0 =`** All pixels are read out from left to right. **`1 =`** All pixels are read out from right to left.
Notes:	• To obtain the current readout direction, use the command `gcp` or `get smm`. • This command is available in both TDI and Area Mode. • Refer to the following figures and tables for an explanation of pixel readout and mirror direction. • Refer to section 1.3 Image Sensor for sensor architecture diagrams that illustrate sensor readout direction.

Figure 21: Left to Right Readout (smm 0) Forward Direction Example Output

Figure 22: Right to Left Readout (smm 1) Forward Direction Example Output

Figure 23: Camera Pixel Readout Direction Example using 8k Model with Inverting Lens

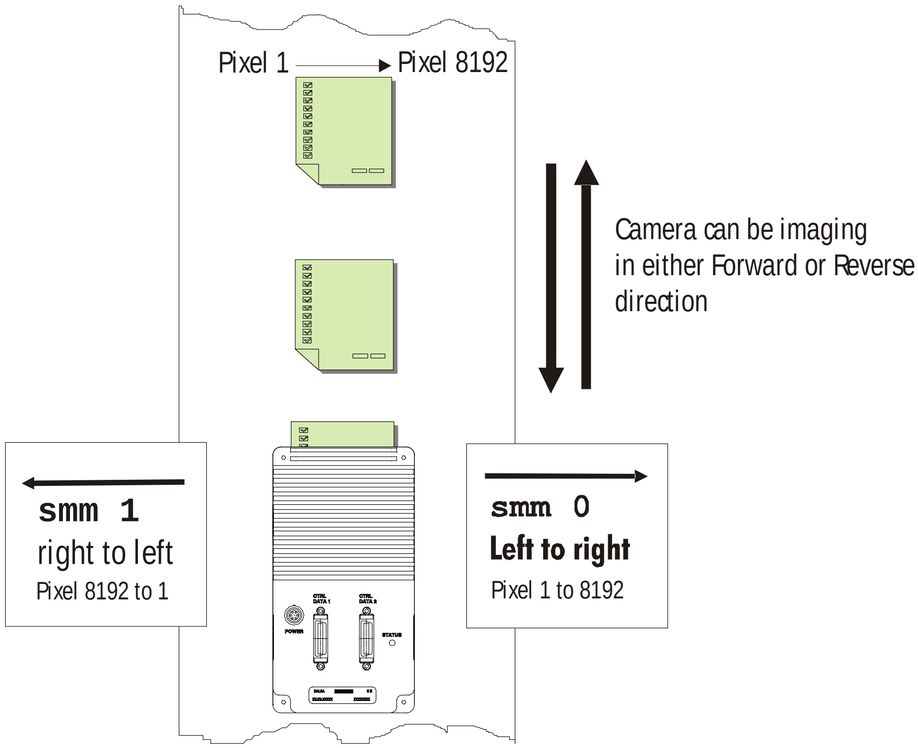


Table 16: HS-80-04k40 Forward or Reverse Pixel Readout

Camera Link Readout Direction	Tap 1	Tap 2	Tap 3	Tap 4
Left to Right Software command `smm 0`	1-1024	1025-2048	2049-3072	3073-4096
Right to Left Software command `smm 1`	4096-3073	3072-2049	2048-1025	1024-1

Table 17: Forward or Reverse Pixel Readout

Readout Direction	Tap 1	Tap 2	Tap 3	Tap 4	Tap 5	Tap 6	Tap 7	Tap 8
Left to Right Software command `smm 0`	1-1024	1025-2048	2049-3072	3073-4096	4097-5120	5121-6144	6145-7168	7169-8192
Right to Left Software command `smm 1`	8192-7169	7168-6145	6144-5121	5120-4097	4096-3073	3072-2049	2048-1025	1024-1

3.4.5 Setting a Pretrigger

Purpose: A pretrigger may be required for some frame grabbers.

Syntax: **spt *i***

Syntax Elements: ***i***

Pretrigger in a range from **0** to **16**.

3.5 Data Processing

3.5.1 Setting a Region of Interest

Purpose: Sets the pixel range used to collect the end-of-line statistics and sets the region of pixels used in the **ccg**, **cao**, **cpa**, **gl**, **gla**, **ccf**, and **ccp** commands.

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 of interest a few pixels inside the actual useable image.

Syntax: **roi x1 y1 x2 y2**

Syntax Elements: **x1**

Column start number. Must be less than or equal to the column end number in a range from **1** to (column resolution – 1).

y1

Row start number. Must be less than or equal to the row end number in a range from **1** to (row end number – 1) except in TDI Mode where ***y1*** must be **1**.

x2

Column end number. Must be greater than or equal to the column start number in a range from **2** to column resolution.

y2

Row end number. Must be greater than or equal to the row start number in a range from **2** to number of stages except in TDI Mode where ***y2*** must be **1**.

Notes:

- If you are using binning, the start pixel is rounded down to the beginning of binned area and end pixel is rounded up to the end of the binned area.
- In Area Mode, the roi must be within the stage. If the requested roi is above the stage, the roi rows will be clipped. The start and end rows will be clipped to the stage selection if necessary. A “clipped to max” warning message is returned.

Related Commands **ccg**, **cao**, **cpa**, **gl**, **gla**, **ccf**, **ccp**, **els**

Example: **roi 10 1 50 1** (TDI Mode)

3.5.2 Analog and Digital Signal Processing Chain

Processing Chain Overview and Description

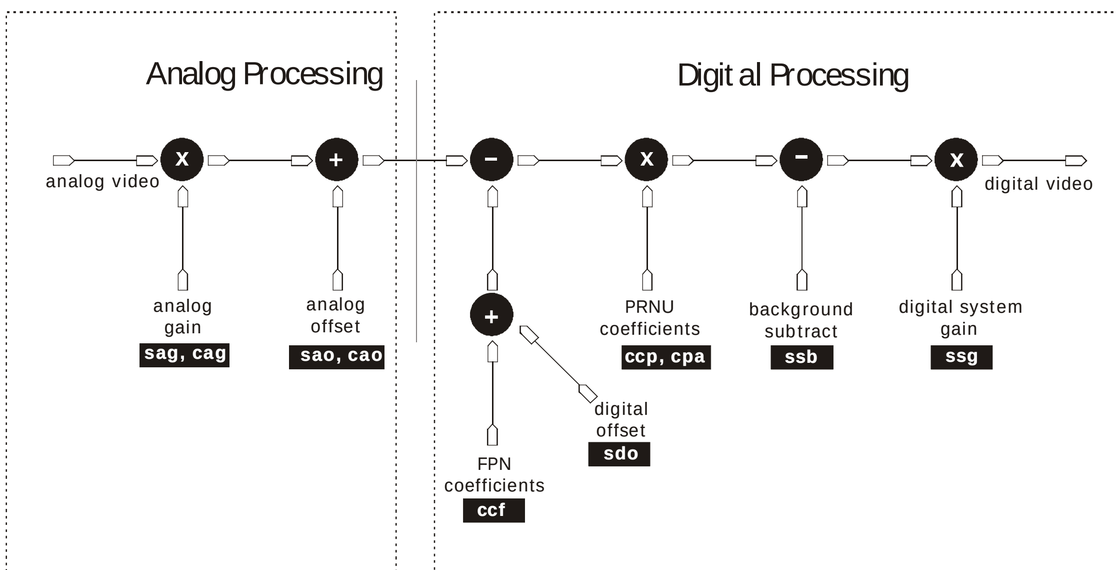
The following diagram shows a simplified block diagram of the camera's analog and digital processing chain. The analog processing chain begins with an analog gain adjustment, followed by an analog offset adjustment. These adjustments are applied to the video analog signal prior to its digitization by an A/D converter.

The digital processing chain contains the FPN correction, the PRNU correction, the background subtract, and the digital gain and offset. All of these elements are user programmable.

Notes:

- FPN and PRNU correction is not available when operating the camera in Area Mode. For details on how to switch camera operation modes, refer to section 3.5.1 .
- The following user settings are stored separately for forward and reverse direction; analog gain, analog offset, digital gain, digital offset, and background subtract. They are saved using the `wus` command. For details on changing camera shift direction, refer to section 3.3.3 Setting the Camera's CCD Shift Direction.
- FPN and PRNU coefficients are stored separately for forward and reverse direction. To save the current PRNU coefficients, use the command `wpc`. To save the current FPN coefficients, use the command `wfc`. Settings are saved for the current direction only.

Figure 24: Signal Processing Chain



Analog Processing

Optimizing offset performance and gain in the analog domain allows you to achieve a better signal-to-noise ratio and dynamic range than you would achieve by trying to optimize the offset in the digital domain. As a result, perform all analog adjustments prior to any digital adjustments.

1. Analog gain is multiplied by the analog signal to increase the signal strength before the A/D conversion. It is used to take advantage of the full dynamic range of the A/D converter. For example, in a low light situation the brightest part of the image may be consistently coming in at only 50% of the DN. An analog gain of 6 dB (2x) will ensure full use of the dynamic range of the A/D converter. Of course the noise is also increased.

2. The analog offset or black level is an "artificial" offset introduced into the video path to ensure that the A/D will function properly. The analog offset should be set so that it is at least 3 times the rms noise value at the current gain.

Digital Processing

To optimize camera performance, digital signal processing should be completed after any analog adjustments.

1. Fixed pattern noise (FPN) calibration (calculated using the **ccf** command) is used to subtract away individual pixel dark current.

2. The digital offset (**sdo** command) enables the subtraction of the "artificial" A/D offset (the analog offset) so that application of the PRNU coefficient doesn't result in artifacts at low light levels due to the offset value. You may want to set the **sdo** value if you are not using FPN correction but want to perform PRNU correction.

3. Photo-Response Non-Uniformity (PRNU) coefficients are used to correct the difference in responsivity of individual pixels (i.e. given the same amount of light different pixels will charge up at different rates) and the change in light intensity across the image either because of the light source or due to optical aberrations (e.g. there many be more light in the center of the image). PRNU coefficients are multipliers and are defined to be of a value greater than or equal to 1. This ensures that all pixels will saturate together. When using PRNU correction, it is important that the A/D offset and Fixed Pattern Noise (FPN) or per pixel offsets are subtracted prior to the multiplication by the PRNU coefficient. The subtraction of these 2 components ensure that the video supplied to the PRNU multiplier is nominally zero and zero multiplied by anything is still zero resulting in no PRNU coefficient induced FPN. If the offset is not subtracted from the video then there will be artifacts in the video at low light caused by the multiplication of the offset value by the PRNU coefficients.

4. Background subtract (**ssb** command) and system (digital) gain (**ssg** command) are used to increase image contrast after FPN and PRNU calibration. It is useful for systems that process 8-bit data but want to take advantage of the camera's 12-bit digital processing chain. For example, if you find that your image is consistently between 128 and 255DN(8-bit), you can subtract off 128 (**ssb 2048**) and then multiply by 2 (**ssg 0 8192**) to get an output range from 0 to 255.

The following sections are organized as follows:

1. Section Analog Signal Processing provides a detailed description of all analog processing chain commands.

2. Section Calibrating the Camera to Remove Non-Uniformity (Flat Field Correction) provides an overview of how to perform flat field calibration.

3. Section Digital Signal Processing provides a detailed description of all digital processing chain commands.

Analog Signal Processing: Setting Analog Gain and Offset

All analog signal processing chain commands should be performed prior to FPN and PRNU calibration and prior to digital signal processing commands.

Setting Analog Gain

Purpose:	Sets the camera's analog gain value. Analog gain is multiplied by the analog signal to increase the signal strength before the A/D conversion. It is used to take advantage of the full dynamic range of the A/D converter.
Syntax:	**sag *t f***
Syntax Elements:	***t***
	Tap selection. Use **0** for all taps or **1** to number of CCD taps for individual tap selection.
	f
	Gain value in a range from **–10** to **+10**dB.
Example:	**sag 0 5.2**

Calibrating Camera Gain

Purpose: Instead of manually setting the analog gain to a specific value, the camera can determine appropriate gain values. This command calculates and sets the analog gain according to the algorithm determined by the first parameter.

Syntax: **`ccg i t i`**

Syntax Elements:

`i`

Calibration algorithm to use.

`1` = This algorithm adjusts analog gain so that 8% to 13% of tap ROI pixels are above the specified target value.

`2` = This algorithm adjusts analog gain so that the average pixel value in tap's ROI is equal to the specified target value.

`3` = This algorithm adjusts digital gain so that the average pixel value in tap's ROI is equal to the specified target.

`4` = This algorithm adjusts the analog gain so that the peak tap ROI pixels are adjusted to the specified target.

`t`

Tap value. Use **`0`** for all taps or **`1`** to number of CCD taps for individual tap selection.

`i`

Calculation target value in a range from **`1024`** to **`4055`**DN (12 bit LSB).

Notes:

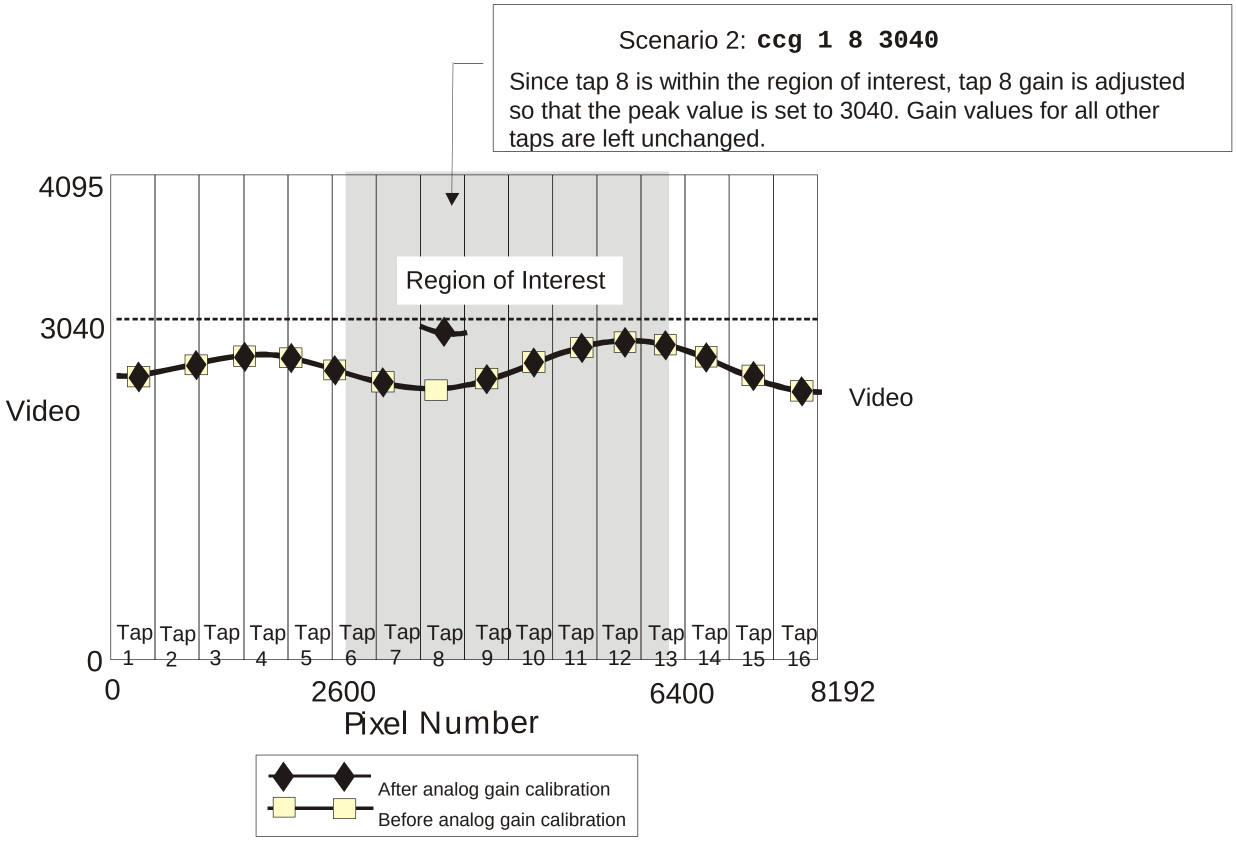
- All digital settings (digital offset, FPN and PRNU coefficients), digital gain, background subtract) should be turned off before calibrating analog gain to avoid unpredictable results.
- This function requires constant light input while executing.
- To use this command, the CCD shift direction (**`scd`**) should be set to forward (**`0`**) or reverse (**`1`**).
- If very few tap pixels are within the ROI, gain calculation may not be optimal.
- When all taps are selected, taps outside of the ROI are set to the average gain of the taps that are within the ROI.
- Perform analog gain algorithms before performing FPN and PRNU calibration.

Example: **`ccg 2 0 3040`**

The following diagrams summarize and provide an example of how analog gain is calibrated when using a region of interest.

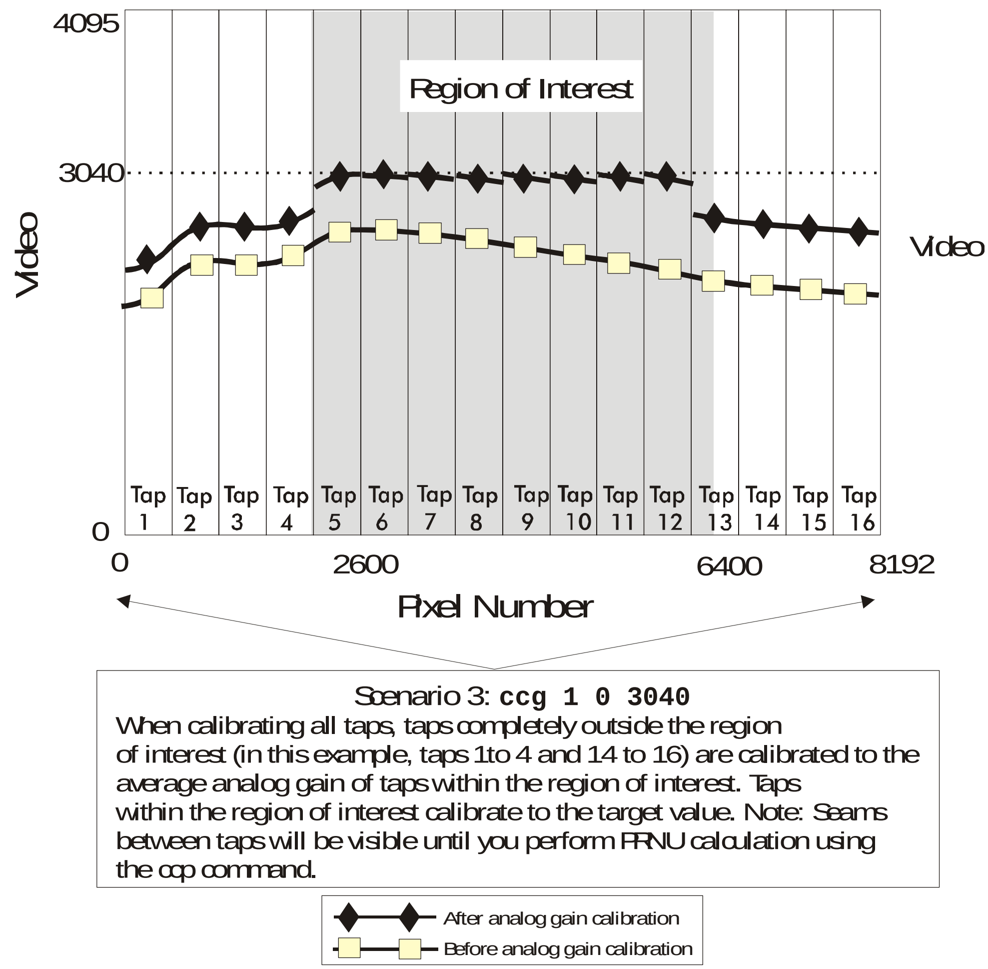
In the following example, analog gain is being set for a tap inside the region of interest. The peak value of the tap is calibrated to the specified target value and all other taps remain unchanged.

Figure 25: Calculating Analog Gain for a Tap inside the Region of Interest



In the following example, analog gain is set for all taps. The peak value of each tap within the region of interest is calibrated to the specified target value. All taps completely outside the region of interest are calibrated to the average analog gain value of the taps inside the region of interest.

Figure 26: Calculating Analog Gain for all Taps



Setting Analog Offset

Purpose:	Sets the analog offset. The analog offset should be set so that it is at least 3 times the rms noise value at the current gain. DALSA configures the analog offset for the noise at the maximum specified gain and as a result you should not need to adjust the analog offset.
Syntax:	**sao *t i***
Syntax Elements:	***t*** Tap selection. Use **0** for all taps or **1** to number of CCD taps for individual tap selection. ***i*** Offset value in a range from **0** to **255**DN (12 bit LSB).
Example:	**sao 3 35**

Calibrating Analog Offset

Purpose:	Instead of manually setting the analog offset to a specific value, the camera can determine appropriate offset values.This command calculates and averages each tap's pixels within the ROI and sets the offset to achieve the specified average target value.
Syntax:	**cao** ***t i***
Syntax Elements:	***t*** Tap selection. Use **0** for all taps or **1** to number of CCD taps for individual tap selection. ***i*** Average target value in a range from **1** to **255**DN (12 bit LSB).
Notes:	• Perform analog offset calibration before performing FPN and PRNU coefficients. • To use this command, CCD shift direction should be controlled internally, either **scd** **0** or **1**
Example:	**cao 1 50**

Updating the Gain Reference

To update the analog gain reference:

Purpose:	Sets the current analog gain setting to be the 0dB point. This is useful after tap gain matching allowing you to change the gain on all taps by the same amount.
Syntax:	**ugr**

Calibrating the Camera to Remove Non-Uniformity (Flat Field Correction)

Flat Field Correction Overview

This camera has the ability to calculate correction coefficients in order to remove non-uniformity in the image when operating in TDI Mode. This video correction operates on a pixel-by-pixel basis and implements a two point correction for each pixel. This correction can reduce or eliminate image distortion caused by the following factors:

- Fixed Pattern Noise (FPN)
- Photo Response Non Uniformity (PRNU)
- Lens and light source non-uniformity

Correction is implemented such that for each pixel:

$$V_{output} = [(V_{input} - FPN(pixel) - digital\ offset) * PRNU(pixel) – Background\ Subtract] \times System\ Gain$$

where V_{output} = digital output pixel value

V_{input}	=	digital input pixel value from the CCD
PRNU(pixel)	=	PRNU correction coefficient for this pixel
FPN(pixel)	=	FPN correction coefficient for this pixel
Background Subtract	=	background subtract value
System Gain	=	digital gain value

The algorithm is performed in two steps. The fixed offset (FPN) is determined first by performing a calculation without any light. This calibration determines exactly how much offset to subtract per pixel in order to obtain flat output when the CCD is not exposed.

The white light calibration is performed next to determine the multiplication factors required to bring each pixel to the required value (target) for flat, white output. Video output is set slightly above the brightest pixel (depending on offset subtracted).

Flat Field Correction Restrictions

It is important to do the FPN correction first. Results of the FPN correction are used in the PRNU procedure. We recommend that you repeat the correction when a temperature change greater than 10°C occurs or if you change the analog gain, integration time, binning, or number of integration stages.

Note: If your illumination or white reference does not extend the full field of view of the camera, the camera will send a warning.

PRNU correction requires a clean, white reference. The quality of this reference is important for proper calibration. 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.

For best results, ensure that:

1. 60 Hz ambient light flicker is sufficiently low not to affect camera performance and calibration results.
2. For best results, the analog gain should be adjusted for the expected operating conditions and the ratio of the brightest to darkest pixel in a tap should be less than 3 to 1 where:

$$3 > \frac{\text{Brightest Pixel (per tap)}}{\text{Darkest Pixel (per tap)}}$$

The camera is capable of operating under a range of 8 to 1, but will clip values larger than this ratio.

3. The brightest pixel should be slightly below the target output.
4. When 6.25% of pixels from a single row within the region of interest are clipped, flat field correction results may be inaccurate.
5. Correction results are valid only for the current stage selection. If you change the number of stages, it is recommended that you recalculate your coefficients.
6. Correction results are valid only for the current analog gain and offset values. If you change these values, it is recommended that you recalculate your coefficients.

How to Perform Flat Field Correction

❶ Set up the camera operating environment (i.e. line rate, CCD shift direcion, exposure, offset, gain, etc.)

- Analog gain should be no higher than 80% of the maximum signal output (i.e. When your output is 12-bit data then 80% of 4096 is 3276. For 8 bit output 80% of 256 is 204). Gain is reduced to ensure that there are no pixels at or above the maximum signal output with a PRNU of 10%.
- Your analog offset setting should not be clipping more than 6.25% of the pixels within the region of interest.
- Digital offset and gain, and background subtract values should be set to zero (**ssb 0 0**, **sdo 0 0**, **ssg 0 4096, epc 0 0**) Note: **ssg** is a linear function and 4096 is equal to a gain of 1.

❷ Set the calibration sample size using the command css

❸ Set the region of interest to include all of the image's pixels of importance using the command roi x1 y1 x2 y2.

❹ Perform FPN correction. FPN correction should be performed before PRNU correction.

FPN correction removes the fixed analog offset from the video path.
Repeat the correction when a temperature change greater than 10°C occurs or when there is a significant change in integration time or analog gain.

1. Stop all light from entering the camera. (Tip: Cover lens with a lens cap.)
2. Verify that the output signal level is within range by issuing the command **gl** or **gla**. If there are too many zeros in the output data (more than 6.25% of output data within the roi) , increase the analog offset (**sao**) or use the automated algorithm **cao *t i***. If the average of the pixels is more than 25% of the maximum signal swing, ensure that no light is entering the camera and reduce the analog offset or gain level (**sag**).
3. Issue the command **ccf**. The camera will respond with OK> if no error occurs. FPN correction automatically calibrates FPN coefficients.
4. After the correction is complete, you must save these settings to non-volatile memory so they will be remembered and be reusable. To do so, issue the commands **wfc *i*** where ***i*** is the coefficient set to save and **wus**.
   Forward and reverse direction settings are stored separately and coefficients must be saved before switching direction.
5. If you will be operating the camera in the opposite camera shift direction, repeat steps 2 through 4 after changing direction.
6. To verify output, enable the FPN coefficients using the command **epc 1 0**. You should see close to zero output.

❺ Perform PRNU correction

Perform PRNU correction next to determine the multiplication factors required to bring each pixel to the required value (balance target) for flat, white output.

1. Place a white reference in front of the camera and remove lens cap.
2. Verify that the output signal level is within range by issuing the command **gl** or **gla**. If the signal level is too low, adjust the analog gain (**sag**) or use the automated algorithm **ccg *i* 0 *i***.
   DALSA recommends a target value of about 80% of maximum signal swing per tap. If you change the gain, FPN coefficients should be recalculated.
3. Issue the command **ccp** or **cpa 2 *i*** where i is equal to or greater than the maximum pixel in the image. The camera will respond with OK> if no error occurs.
4. After the correction is complete, you must save these settings to non-volatile memory so they will be remembered and be reusable. To do so, issue the commands **wpc *i*** where ***i*** is the coefficient set to save and **wus**.
   Forward and reverse direction settings are stored separately and coefficients must be saved before switching direction.
5. If you will be operating the camera in the opposite camera shift direction, repeat steps 2 through 4 after changing direction.
6. Enable the coefficients using the command, **epc 1 1**. You should see a flat line with a couple of DN peak to peak residual patterns. It is necessary to average many lines to see the residual FPN/PRNU.

Digital Signal Processing

Subtracting Background

Purpse: Use the background subtract command after performing flat field correction if you want to improve your image in a low contrast scene. You should try to make your darkest pixel in the scene equal to zero.

Sytax: **ssb t i**

Syntax Elements:

t

Tap selection. Allowable range is 1 to number of CCD taps, or 0 for all taps.

i

Subtracted value in a range in DN from 0 to 4095 (12 bit LSB).

Notes:

- See the following section for details on the **ssg** command.

Related Commands: **ssg**

Example: **ssb 0 500**

Setting Digital Gain

Purpose: Improves signal output swing after a background subtract. When subtracting a digital value from the digital video signal, using the **ssb** command, the output can no longer reach its maximum. Use the this command to correct for this where:

$$\text{ssg value} = \frac{\text{max output value}}{\text{max output value - ssb value}}$$

Syntax: **ssg t i**

Syntax Elements:

t

Tap selection. Allowable range is 1 to number of CCD taps, or 0 for all taps.

i

Gain setting. The gain ranges are 0 to 65535. The digital video values are multiplied by this value where:

$$\text{Digital Gain} = \frac{i}{4096}$$

Notes:

- Use this command in conjunction with the **ssb** command (described above).
- DALSA recommends that i is never set below 4096. Setting **i** to 0 will result in only 0 output data.
- Digital offset is set to zero after sending the **ccf** command

Related Commands: **ssb**, **sdo**

Example: **ssg 1 4500**

Setting Digital Offset

Purpose:	Sets the digital offset. Digital offset is set to zero when you perform FPN correction (**ccf** command). If you are unable to perform FPN correction, you can partially remove FPN by adjusting the digital offset.
Syntax:	**sdo *t i***
Syntax Elements:	***t*** Tap selection. Allowable range is 1 to number of CCD taps, or 0 for all taps. ***i*** Subtracted offset value in a range from 0 to 511 (12-bit LSB).
Notes:	• When subtracting a digital value from the digital video signal, the output can no longer reach its maximum unless you apply digital gain using the **ssg** command. See the previous section for details on the **ssg** command.
Related Commands:	**ssg**, **ccf**
Example:	**sdo 0 100**

FPN Correction

Performing FPN Correction

Syntax:	Performs FPN correction and eliminates FPN noise by subtracting away individual pixel dark current. For a complete description on how to use this command, see the Flat Field Correction Overview on page 57.
Syntax:	**ccf**
Notes:	• Before performing this command, stop all light from entering the camera. (Tip: cover lens with a lens cap.) • Perform all analog and digital adjustments before performing FPN correction. • Perform FPN correction before PRNU correction. • The **ccf** command is not available when the CCD direction is externally controlled (**scd 2**) (see Direction Control on page 26). Direction control must be stable while the camera is calculating coefficients. • Available in TDI Mode only. • Save coefficients before changing directions, changing operating mode, or powering off.
Related Commands:	**ccp**, **cpa**
Example:	**ccf**

Setting a Pixel's FPN Coefficient

Purpose: Sets an individual pixel's FPN coefficient.

Syntax **sfc *x i***

Syntax Elements: ***x***

The pixel number from 1 to sensor pixel count.

i

Coefficient value in a range from 0-511 (12-bit LSB).

Notes:
- Available in TDI Mode only.

Example: **sfc 10 50**

Returning FPN Coefficients

Purpose: Returns a pixel's FPN coefficient value in DN (12-bit LSB)

Syntax: **gfc *i***

Syntax Elements: ***i***

The pixel number to read in a range from 1 to sensor pixel count.

Notes:
- Available in TDI Mode only.

Example: **gfc 10**

Setting a Range of FPN Coefficients

Purpose: Sets a range of pixel FPN coefficients.

Syntax **sfr *x x i***

Syntax Elements: ***x***

The first pixel number of the range.

x

The last pixel number of the range.

i

Coefficient value in a range from 0-2048.

Notes:
- The first pixel of the range must be less than the last.

Example: **sfr 1 100 80**

PRNU Correction

Performing PRNU Correction

Purpose: Performs PRNU correction to a camera calibrated peak value and eliminates the difference in responsivity between the most and least sensitive pixel creating a uniform response to light. For a complete description on how to use this command, see the Flat Field Correction Overview on page 57.

Syntax **ccp**

Notes:

- Perform all analog adjustments before calculating PRNU.
- Perform FPN correction before PRNU correction.
- If FPN cannot be calibrated, use the **rpc** command to reset all coefficients to zero, and save them to memory with the **wpc** command. You can then adjust the digital offset (**sdo** command) to remove some of the FPN.
- The **ccp** command is not available when the camera shift direction is externally controlled. Direction control must be stable while the camera is calculating coefficients (see Direction Control on page 26).
- Ensure camera is operating at its expected analog gain, integration time, and temperature.
- To avoid losing your current direction coefficients, you must save the PRNU coefficients using the command **wpc** before changing camera shift direction or changing from TDI to Area Mode.
- Available in TDI Mode only.
- Executing these algorithms causes the **ssb** command to be set to 0 (no background subtraction) and the **ssg** command to 4096 (unity digital gain). The pixel coefficients are disabled (epc 0 0) during the algorithm execution but returned to the state they were prior to command execution.

Performing PRNU to a user entered value

Purpose: Performs PRNU calibration to user entered value and eliminates the difference in responsivity between the most and least sensitive pixel creating a uniform response to light. Using this command, you must provide a calibration target.

Executing these algorithms causes the **ssb** command to be set to 0 (no background subtraction) and the **ssg** command to 4096 (unity digital gain). The pixel coefficients are disabled (epc 0 0) during the algorithm execution but returned to the state they were prior to command execution.

Syntax: **cpa i i**

Syntax Elements: ***i***

PRNU calibration algorithm to use:

1 = This algorithm first adjusts each tap's analog gain so that 8-13% of pixels within a tap are above the value specified in the target value parameter. PRNU calibration then occurs using the peak pixel in the region of interest.

This algorithm is recommended for use only when FPN is negligible and FPN coefficients are set to zero. Since this algorithm adjusts the analog gain, it also affects FPN. If FPN is calibrated prior to running this algorithm, FPN will be observable in dark conditions and an incorrect FPN value will be used during PRNU calibration resulting in incorrect PRNU coefficients.

2 = Calculates the PRNU coefficients using the entered target value as shown below:

$$\text{PRNU Coefficient}_i = \frac{\text{Target}}{(\text{AVG Pixel Value}_i) - (\text{FPN}_i + \textbf{sdo} \text{ value})}$$

The calculation is performed for all sensor pixels but warnings are only applied to pixels in the region of interest. This algorithm is useful for achieving uniform output across multiple cameras. Is is important that the target value (set with the next parameter) is set to be at least equal to the highest pixel across all cameras so that all pixels can reach the highest pixel value during calibration.

3 = This algorithm includes an analog gain adjustment prior to PRNU calibration. Analog gain is first adjusted so that the peak pixel value in tap's ROI is within 97 to 99% of the specified target value. It then calculates the PRNU coefficients using the target value as shown below:

$$\text{PRNU Coefficient}_i = \frac{\text{Target}}{(\text{AVG Pixel Value}_i) - (\text{FPN}_i + \textbf{sdo} \text{ value})}$$

The calculation is performed for all sensor pixels but warnings are only applied to pixels in the region of interest. This algorithm is useful for achieving uniform output across multiple cameras.

This algorithm is useful for achieving uniform output across multiple cameras by first adjusting analog gain and then performing PRNU calibration. This algorithm is recommended for use only when FPN is negligible and FPN coefficients are set to zero. Since this algorithm adjusts the analog gain, it also affects FPN. If FPN is calibrated prior to running this algorithm, FPN will be observable in dark conditions and an incorrect FPN value will be used during PRNU calibration resulting in incorrect PRNU coefficients.

This algorithm is more robust and repeatable than algorithm 1 because it uses an average pixel value rather than a number above target. However, this algorithm is slower.

4 = Calculates the PRNU coefficient in the same way as **cpa 2** with the exception that this command only calculates PRNU for pixels within the current Region of Interest (ROI).

i

Peak target value in a range from 1024 to 4055DN. The target value must be greater than the current peak output value.

Notes:

- Perform all analog adjustments before calibrating PRNU.
- This command performs the same function as the **cpp** command but forces you to enter a target value.
- Calibrate FPN before calibrating PRNU. If you are not performing FPN calibration then issue the **rpc** (reset pixel

coefficients) command and set the **sdo** (set digital offset) value so that the output is near zero under dark.

Example: `cpa 1 600`

Setting a Pixel's PRNU Coefficient

Purpose: Sets an individual pixel's PRNU coefficient.

Syntax: **spc *i i***

Syntax Elements:

i

The pixel number from 1 to sensor pixel count.

i

Coefficient value in a range from 0 to 28671 where:

$$\text{prnu coefficient} = 1 + \frac{i}{4096}$$

Setting a range of Pixel PRNU Coefficients

Purpose: Sets a range of pixel PRNU coefficients.

Syntax: **spr *i i x***

Syntax Elements:

i

The first pixel number of the range.

i

The last pixel number of the range.

x

Coefficient value in a range from 0 to 28671 where:

$$\text{prnu coefficient} = 1 + \frac{i}{4096}$$

Notes:

- The first pixel of the range must be less than the last.

Example: `spr 4001 4096 0`

Returning FPN and PRNU Coefficients

Purpose: Returns all the current pixel coefficients in the order FPN, PRNU, FPN, PRNU… for the range specified by ***x1*** and ***x2***. The camera also returns the pixel number with every fifth coefficient.

Syntax: **dpc x1 x2**

Syntax Elements:

x1

Start pixel to display in a range from 1 to (sensor pixel count-1).

x2

End pixel to display in a range from **x1** +1 to sensor pixel count.

Notes: • If **x2<x1** then **x2** is forced to be **x1**.

Example: **dpc 10 20**

Enabling and Disabling Pixel Coefficients

Purpose: Enables and disables FPN and PRNU coefficients.

Syntax: **epc *i i***

Syntax Elements: ***i***

FPN coefficients.
0 = FPN coefficients disabled
1 = FPN coefficients enabled

i

PRNU coefficients.
0 = PRNU coefficients disabled
1 = PRNU coefficients enabled

Example: **epc 0 1**

3.5.3 End-of-line Sequence

Purpose: Produces an end-of-line sequence that provides basic calculations including "frame counter", "line sum", "pixels above threshold", "pixels below threshold", and "derivative line sum" within the region of interest. These basic calculations are used to calibrate analog offset (**cao**) and calibrate analog gain (**ccg**).

To further aid in debugging and cable/data path integrity, the first three pixels after Line Valid are "aa", "55", "aa". Refer to the following table. These statistics refer only to pixels within the region of interest.

Syntax: **els *i***

Syntax Elements: **i**

0 Disable end-of-line sequence

1 Enable end-of-line sequence

Notes: • LVAL is not high during the end-of-line statistics.

Example: **els 1**

Table 18: End-of-Line Sequence Description

Location	Value	Description
1	A's	By ensuring these values consistently toggle between "aa" and "55", you can verify cabling (i.e. no stuck bits)
2	5's	
3	A's	
4	4 bit counter LSB justified (Upper 4 bits are row counter in Area Mode)	Counter increments by 1. Use this value to verify that every line is output

Location	Value	Description
5	Line sum (7…0)	LSB justified. Use these values to help calculate line average and gain
6	Line sum (15…8)	
7	Line sum (23…16)	
8	Line sum (31…24)	
9	Line sum (39…32)	
10	Pixels above threshold (7…0)	Monitor these values (either above or below threshold) and adjust camera digital gain and background subtract to maximize scene contrast. This provides a basis for automatic gain control (AGC)
11	Pixels above threshold (15…8)	
12	Pixels above threshold (23…16)	
13	Pixels below threshold (7…0)	
14	Pixels below threshold (15…8)	
15	Pixels below threshold (23…16)	
16	Differential line sum (7..0)	Use these values to focus the camera. Generally, the greater the sum the greater the image contrast and better the focus.
17	Differential line sum (15…8)	
18	Differential line sum (23…16)	
19	Differential line sum (31…24)	
20	Differential line sum (39…32)	

Setting Thresholds

Setting an Upper Threshold

Purpose:	Sets the upper threshold limit to report in the end-of-line sequence.
Syntax:	**sut *i***
Syntax Elements:	**i** Upper threshold limit in range from **0** to **4095**.
Notes:	• LVAL is not high during the end-of-line statistics.
Related Commands:	**els**, **slt**
Example:	**sut 1024**

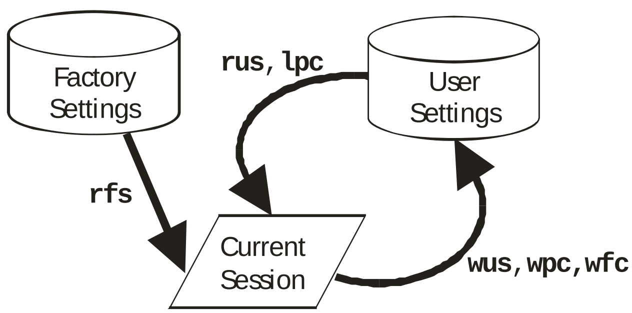
Setting a Lower Threshold

Purpose:	Sets the lower threshold limit to report in the end-of-line sequence.
Syntax:	**slt *i***
Syntax Elements:	**i**
	Upper threshold limit in range from **0** to **4095**.
Notes:	• LVAL is not high during the end-of-line statistics.
Related Commands:	**els**, **sut**
Example:	**slt 1024**

3.6 Saving and Restoring Settings

3.6.1 Saving and Restoring Factory and User Settings

Figure 27: Saving and Restoring Overview



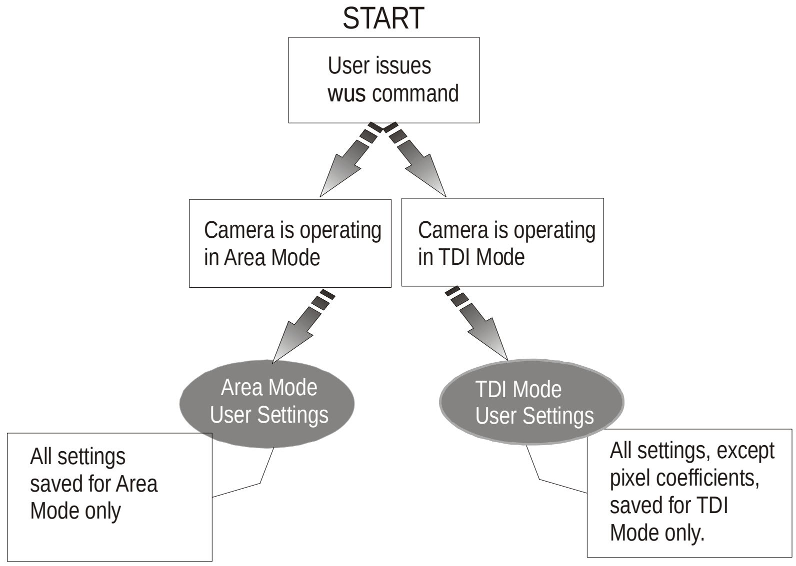
Factory Settings

You can restore the original factory settings, including the factory calibrated pixel coefficient set, at any time using the command **rfs**.

User Settings

There are two main sets of user settings: Area Mode user settings and TDI Mode user settings. After issuing the user settings save command, **wus**, settings are saved depending on which mode the camera is operating in when the command is issued. Also, when operating in TDI Mode, analog gain and offset, digital gain and offset, and background subtract values are saved as distinct values for Forward and Reverse directions. In other words, you can program the camera to operate with an analog gain value of +5db in Forward direction and an analog gain value of +3db in Reverse direction. Forward and Reverse direction settings are saved simultaneously with the **wus** command. Note that when you switch directions, the settings saved for that direction are automatically loaded.

Figure 28: How User Settings are Stored in the ES-xx Cameras after issuing the wus Command



You can save or restore your user settings to non-volatile memory using the following commands.

- To save all current user settings to EEPROM for the current mode for both TDI shift directions, use the command **wus**. The camera will automatically restore the saved user settings when powered up.

  WARNING: While settings are being written to nonvolatile memory, do not power down camera or camera memory may be corrupted.

- To restore the last saved user settings, including the last used pixel coefficient set, for the current mode, use the command **rus**.

Current Session Settings

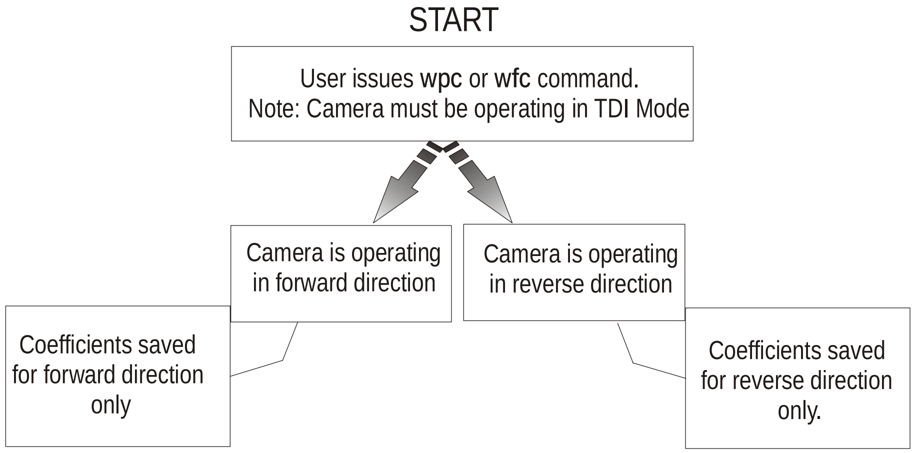
These are the current operating settings of your camera. These settings are stored in the camera's volatile memory and will not be restored once you power down your camera. To save these settings for reuse at power up, use the command **wus**. Settings are saved for the current operating mode (TDI or Area) only.

3.6.2 Saving and Restoring PRNU and FPN Coefficients

Note: Available in TDI Mode only.

Pixel coefficient sets are saved separately for Forward and Reverse direction, depending on which direction the camera is operating in when the **wpc** or **wfc** command is issued. It is important that you save pixel coefficients before switching CCD shift direction or current coefficient values will be lost.

Figure 29: How Pixel Coefficients are saved in the ES-xx Cameras after issuing the wpc or wfc Command



Saving the Current PRNU Coefficients

Purpose: Saves the current PRNU coefficients for the current direction.

Syntax: **`wpc i`**

Syntax Elements: ***i***

PRNU coefficients set to save.
1 = Coefficient set one
2 = Coefficient set two
3 = Coefficient set three
4 = Coefficient set four

Notes:
- Available in TDI mode only.
- Available only when operating the camera in internal direction contol (`scd 0` or `1`)

Example: **`wpc 2`**

Saving the Current FPN Coefficients

Purpose: Saves the current FPN coefficients for the current direction.

Syntax: **`wfc i`**

Syntax Elements: ***i***

FPN coefficients set to save.
1 = Coefficient set one
2 = Coefficient set two
3 = Coefficient set three
4 = Coefficient set four

Notes:
- Available in TDI mode only.
- Available only when operating the camera in internal direction contol (`scd 0` or `1`)

Example: **`wfc 2`**

Loading a Saved Set of Coefficients

Purpose: Loads a saved set of pixel coefficients for the current direction. A factory calibrated set of coefficients is available.

Syntax: **`lpc i`**

Syntax Elements: ***`i`***

FPN coefficients set to save.

0 = Factory calibrated pixel coefficients.

1 = Coefficient set one

2 = Coefficient set two

3 = Coefficient set three

4 = Coefficient set four

Notes:

- Available in TDI mode only.
- Available only when operating the camera in internal direction contol (**`scd 0`** or **`1`**). When operating in external direction control, you must switch to internal direction control, load the coefficient set, and then return to external direction contol.

Example: **`lpc 0`**

Resetting the Current Pixel Coefficients

Purpose: Resets the current pixel coefficients to zero. This command does not reset saved coefficients.

Syntax: **`rpc`**

Notes: The digital offset is not reset.

3.6.3 Rebooting the Camera

The command **`rc`** reboots the camera. The camera starts up with the last saved settings and the baud rate used before reboot. Previously saved pixel coefficients are also restored.

3.7 Diagnostics

3.7.1 Generating a Test Pattern

Purpose:	Generates a test pattern to aid in system debugging. The test patterns are useful for verifying proper timing and connections between the camera and the frame grabber. The following tables show each available test pattern.
Syntax:	**`svm i`**
Syntax Elements:	**`i`** **`0`** Video. **`1`** 12 bit test pattern 1 (ramp) **`2`** 8 bit test pattern 2 (step)
Notes:	• When returning to video (svm 0) after viewing a test pattern, the camera restores the saved user settings for digital offset (**`sdo`**), enable pixel coefficients (**`epc`**), set subtract background (**`ssb`**), and set system digital gain (**`ssg`**). • 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.
Example:	**`svm 2`**

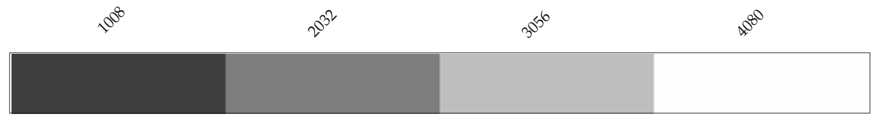
Table 19: Test Patterns

4k Camera Operating Mode	Test Pattern
TDI Mode Forward, **`smm 0, svm 1`**	
TDI Mode Reverse, **`smm 0, svm 1`**	
TDI Mode Forward, **`smm 1, svm 1`**	
TDI Mode Reverse, **`smm 1, svm 1`**	
Area Mode Forward, **`smm 0, svm 1`**	

Area Mode Reverse, **smm 0**, **svm 1**

Area Mode Forward, **smm1**, **svm 1**

Area Mode Reverse, **smm1**, **svm 2**



TDI or Area Mode, **smm 0**, **svm 2**

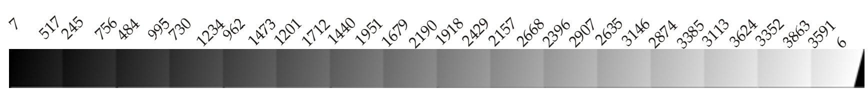
8k Camera Operating Mode	**Test Pattern**

TDI Mode Forward, **smm 0**, **svm 1**

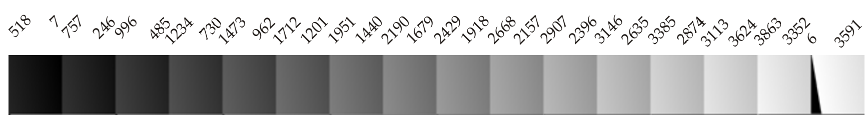
TDI Mode Forward, **smm 1**, **svm 1**

TDI Mode Reverse, **smm 1**, **svm 1**

Area Mode Forward, **smm 0**, **svm 1**



Area Mode Reverse, **smm 0**, **svm 1**

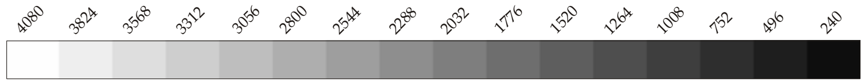


Area Mode Forward, **smm 1**, **svm 1**

Area Mode Reverse, **smm 1**, **svm 1**

TDI or Area Mode, **smm 1** or **2**, **svm 2**

TDI or Area Mode, Forward or Reverse, smm 1, svm 2



3.7.2 Returning Video Information

The camera's microcontroller has the ability to read video data when operating the camera in TDI Mode. This functionality can be used to verify camera operation and to perform basic testing without having to connect the camera to a frame grabber. This information is also used for collecting line statistics for calibrating the camera.

Returning a Single Line of Video

Purpose: Returns a complete line of video (without pixel coefficients or test pattern) displaying one pixel value after another. It also displays the minimum, maximum, and mean value of the line sampled within the region of interest (the region of interest command is explained in section Setting a Region of Interest).

Use the **`gl`** command, or the following **`gla`** command, to ensure the proper video input range into the processing chain before executing any pixel calibration commands.

Syntax: **`gl x1 x2`**

Syntax Elements:

`x1`

Column start number. Must be less than the column end number in a range from **`1`** to (**`column resolution – 1`**).

`x2`

Column end number. Must be greater than the column start number in a range from **`2`** to sensor resolution.

Notes:

- If **`x2`** ≤ **`x1`** then **`x2`** is forced to be **`x1`**.
- Analog gain, analog offset, digital offset, background subtract, and digital system gain are applied to the data. FPN and PRNU coefficients are not included in the data.
- Values returned are in 12 bit DN.
- Available in TDI Mode only.

Related Commands: **`roi`**

Example: **`gl 10 20`**

Returning Averaged Lines of Video

Setting the Number of Lines to Sample

Purpose: Sets the number of lines to sample when using the **gla** command or for pixel coefficient calculations.

Syntax: **css *i***

Syntax Elements: **i**

Number of lines to sample. Allowable values are **256**, **512**, or **1024** (factory setting).

Notes:
- To return the current setting, use the **gcp** command.

Related Commands: **gla**

Example: **css 1024**

Returning the Average of Multiple Lines of Video

Purpose: Returns the average for multiple lines of video data (without pixel coefficients or test pattern). The number of lines to sample is set and adjusted by the **css** command. The camera displays the Min., Max., and Mean statistics for the pixels in the region of interest (the region of interest command is explained in section Setting a Region of Interest).

Syntax: **gla x1 x2**

Syntax Elements: ***x1***

Column start number. Must be less than the column end number in a range from **1** to (**column resolution – 1**).

x2

Column end number. Must be greater than the column start number in a range from **2** to column resolution.

Notes:
- If **x2**$\leq$**x1** then **x2** is forced to be **x1**.
- Analog gain, analog offset, digital offset, background subtract, and digital system gain are applied to the data. FPN and PRNU coefficients are not included in the data.
- Values returned are in 12 bit DN.
- Available in TDI Mode only.

Related Commands: **css**, **roi**

Example: **gla 10 20**

3.7.3 Temperature Measurement

The temperature of the camera can be determined by using the **vt** command. This command will return the internal chip temperature in degrees Celsius. For proper operation, this value should not exceed 75°C.

Note: If the camera reaches 75°C, the camera **will shutdown and the LED will flash red**. If this occurs, the camera **must be rebooted** using the command, **rc** or can be powered down manually. You will have to correct the temperature problem or the camera will shutdown again.

3.7.4 Voltage Measurement

The command **vv** displays the camera's input voltage. Note that the voltage measurement feature of the camera provides only approximate results (typically within 10%). The measurement should not be used to set the applied voltage to the camera but only used as a test to isolate gross problems with the supply voltage.

3.7.5 Camera Frequency Measurement

Purpose:	Returns the frequency for the requested Camera Link control signal
Syntax:	**gsf *i***
Syntax Elements:	***i*** Camera Link control signal to measure: **1**: CC1 (EXSYNC) **2**: CC2 (Spare) **3**: CC3 (Forward) **4**: CC4 (Spare)
Example:	**gsf 1**

3.7.6 Returning Camera Settings

Returning All Camera Settings with the Camera Parameter Screen

The camera parameter (GCP) screen returns all of the camera's current settings. Figure 30 below describes the GCP screen for the Piranha ES-4k camera.

To read all current camera settings, use the command:

Syntax: **gcp**

Figure 30: Example GCP Screen for ES-40-08k40 TDI Mode Operation

GCP Screen		Description
C A M E R A S E T T I N G S		
Camera Model No.:	**ES-xx-xxxxx**	Camera model number.
Sensor Serial No.:	**xxxxxxxxx**	Sensor serial number.
Firmware Design Rev.:	**xx-xx-xxxxx-xx**	Firmware design revision number.
FPGA Version:	**xx-xx-xxxx-xx**	DSP design revision number.
UART Baud Rate:	**9600**	Serial communication connection speed set with the **sbr** command. See section Setting Baud Rate for details.
TDI Mode:	**tdi**	Current operating mode, either TDI or Area set with

GCP Screen		Description
		the **tdi** command. See section 3.5.1 for details.
Exposure Mode:	**7**	Current exposure mode value set with the **sem** command. See section 3.3.5 Exposure Mode and Line/Frame Rate for details.
SYNC Frequency:	**10000.00 Hz**	Current line rate. Value is set with the **ssf** command. See section 3.3.5 Exposure Mode and Line/Frame Rate for details.
Internal Exposure Time:	**100.00µs**	Current exposure time setting if internal. If external, “external” is displayed. Value is set with the **set** command. See section 3.3.5 Exposure Mode and Line/Frame Rate for details.
CCD Direction:	**internal/forward**	CCD shift direction set with the **scd** command. See section 3.3.3 Setting the Camera’s CCD Shift Direction for details.
Stage Selection	**16, 32**	Number of integration stages set with the **stg** command. See section 3.3.2 Selecting the Number of CCD Integration Stages for details.
Horizontal Binning	**1**	Horizontal binning value set with the **sbh** command. See section 3.3.4 Increasing Sensitivity with Binning for details.
Vertical Binning	**1**	Vertical binning value set with the **sbv** command. See section 3.3.4 Increasing Sensitivity with Binning for details.
Video Mode:	**video**	Current video mode value set with the **svm** command. See section 3.7.1 Generating a Test Pattern for details.
Background Subtract:	**0 0 0 0**	Background subtract value set with the **ssb** command. See section Digital Signal Processing for details.
Region of Interest:	**(1,1)to(8192,1)**	Region of interest size set with the **roi** command. See section Setting a Region of Interest for

GCP Screen		Description
		details.
`End-Of-Line Sequence:`	`on`	States whether an end-of-line sequence is turned on or off. Set using the **eol** command. See section 3.5.3 End-of-line Sequence for details.
`FFC Coefficient Set:`	`0`	Current pixel coefficient set loaded. Refer to section 3.6.2 Saving and Restoring PRNU and FPN Coefficients for details.
`FPN Coefficients:`	`off`	States whether FPN coefficients are on or off. Set with the **epc** command. Refer to section Digital Signal Processing for details.
`PRNU Coefficients:`	`off`	States whether PRNU coefficients are on or off. Set with the **epc** command. Refer to section Digital Signal Processing for details.
`Number of Line Samples:`	`1024`	Number of lines sample with the **gla** command set with the **css** command. See section 3.7.2 Returning Video Information for details.
`Lower Threshold:`	`400`	Lower threshold value set with the **slt** command. See section 3.5.3 End-of-line Sequence for details.
`Upper Threshold:`	`3600`	Upper threshold value set with the **sut** command. See section 3.5.3 End-of-line Sequence for details.
`Camera Link Mode:`	`15, Medium, 4 taps, 8 bits, no time MUX`	Camera Link configuration set with the clm command. See 3.4.2 Setting the Camera Link Mode for details.
`Output Throughput:`	`320`	Camera throughput value set with the **sot** command. See section 3.4.3 Setting the Camera Throughput for details.
`Pretrigger`	`0`	Pretrigger set with the **spt** command. See section 3.4.5 Setting a Pretrigger.

GCP Screen					Description
Mirroring Mode:	**left to right**				Readout direction set with the **smm** command. See section 3.4.4 Setting the Pixel Readout Direction for details.
Analog Gain (dB):	**3.0**	**3.0**	**3.0**	**3.0**	Analog gain settings set with the **sag** command. See section Analog Signal Processing for details.
Analog Reference Gain (dB):	**3.0**	**3.0**	**3.0**	**3.0**	Analog reference gain set with the **ugr** command. See section Analog Signal Processing for details.
Total Analog Gain (dB):	**6.0**	**6.0**	**6.0**	**6.0**	This is the sum of the analog gain and analog gain reference values and is the total analog gain being used by the camera.
Analog Offset:	**100**	**100**	**100**	**100**	Analog offset settings set with the **sao** command. See section Analog Signal Processing for details.
Digital Offset:	**50**	**50**	**50**	**50**	Digital offset settings set with the **sdo** command. See section Digital Signal Processing for details.
Background Subtract:	**150**	**150**	**150**	**150**	Background subtract settings set with the **ssb** command. See section Digital Signal Processing for details.
System Gain:	**4096**	**4096**	**4096**	**4096**	Digital gain settings set with the **ssg** command. See section Digital Signal Processing for details.

Returning Camera Settings with Get Commands

You can also return individual camera settings by inserting a "**get**" in front of the command that you want to query. If the command has a tap or pixel number parameter, you must also insert the tap number or pixel number that you want to query. Refer to Table 20 below for a list of available commands. To view a help screen listing the following get commands, use the command **gh**.

Table 20: Get Commands

Syntax	Parameters	Description
get cao	**t**	Returns the analog offset for the tap indicated **t** = tap selection, either **1** to **number of CCD taps**, or **0** for all taps
get ccf	**x1 x2**	Returns the FPN pixel coefficients for the pixel range indicated. **x1** = Pixel start number **x2**= Pixel end number
get ccp	**x1 x2**	Returns the PRNU pixel coefficients for the pixel range indicated. **x1** = Pixel start number **x2**= Pixel end number
get clm		Returns the current Camera Link mode.
get css		Returns the number of line samples averaged for pixel coefficient calculations or for output of **gla** command.
get els		Returns whether the end-of-line statistics are turned off or on. **0**: Off **1**: On
get epc		Returns whether pixel coefficients are enabled or disabled. The first parameter returns the FPN coefficients setting where: **0** = FPN coefficients disabled **1** = FPN coefficients enabled The second parameter returns the PRNU coefficients setting where: **0** = PRNU coefficients disabled **1** = PRNU coefficients enabled
get gcm		Returns the camera's model number
get gcs		Returns the camera's serial number
get gcv		Returns the camera's software version.
get gfc	**x**	Returns the FPN pixel coefficient for the pixel indicated.
get gl	**x1 x2**	Returns pixel values for the pixel range specified.
get gla	**x1 x2**	Returns the average of the pixel range indicated.
get gsf	**i**	Returns the frequency of the Camera Link control signal indicated, either **1**, **2**, **3**, or **4**.

Syntax	Parameters	Description
`get lpc`		Returns the current coefficient set number.
`get rfs`		Returns whether factory settings have been saved. The camera always returns **1** (factory settings have been saved).
`get roi`		Returns the current region of interest.
`get rus`		Returns whether user settings have been saved. **0** = No user settings saved **1** = User settings have been saved
`get sag`	**t**	Returns the analog gain in dB for the tap indicated **t** = Tap value. **0** for all taps or **1-number of CCD taps** for individual tap selection.
`get sao`	**t**	Returns the analog offset for the tap indicated. **t = 0** for all taps or **1** to **number of CCD taps** for individual tap selection.
`get sbh`		Returns the horizontal binning value.
`get sbr`		Returns the speed of camera serial communication port.
`get sbv`		Returns the vertical binning value.
`get scd`		Returns the CCD shift direction where: **0 =** Forward TDI shift direction. **1 =** Reverse TDI shift direction. **2 =** Externally controlled direction control via Camera Link control CC3.
`get sdo`	**t**	Returns the digital offset value in DN for the tap indicated. **t** = Tap value. **0** for all taps or **1-number of CCD taps** for individual tap selection.
`get sem`		Returns the current exposure mode: **3 =** External SYNC, maximum exposure time **7 =** Internal programmable SYNC, maximum exposure time. Factory setting.
`get sfc`	**x**	Returns the FPN coefficient for the pixel number idicated. **x** =pixel number within the range **1** to **sensor pixel count**.
`get sgr`		Returns the current analog gain reference value in dB.
`get slt`		Returns the current lower threshold value.
`get smm`		Returns the camera's mirror mode: **0**: Pixels readout left to right (1 to 4096 or 8192) **1**: Pixels readout right to left (8092 or 4096 to 1)
`get sot`		Returns the Camera Link strobe rate.
`get spc`	**x**	Returns the PRNU coefficient for the specified pixel number. **x**=pixel number within the range **1** to **sensor pixel count**.

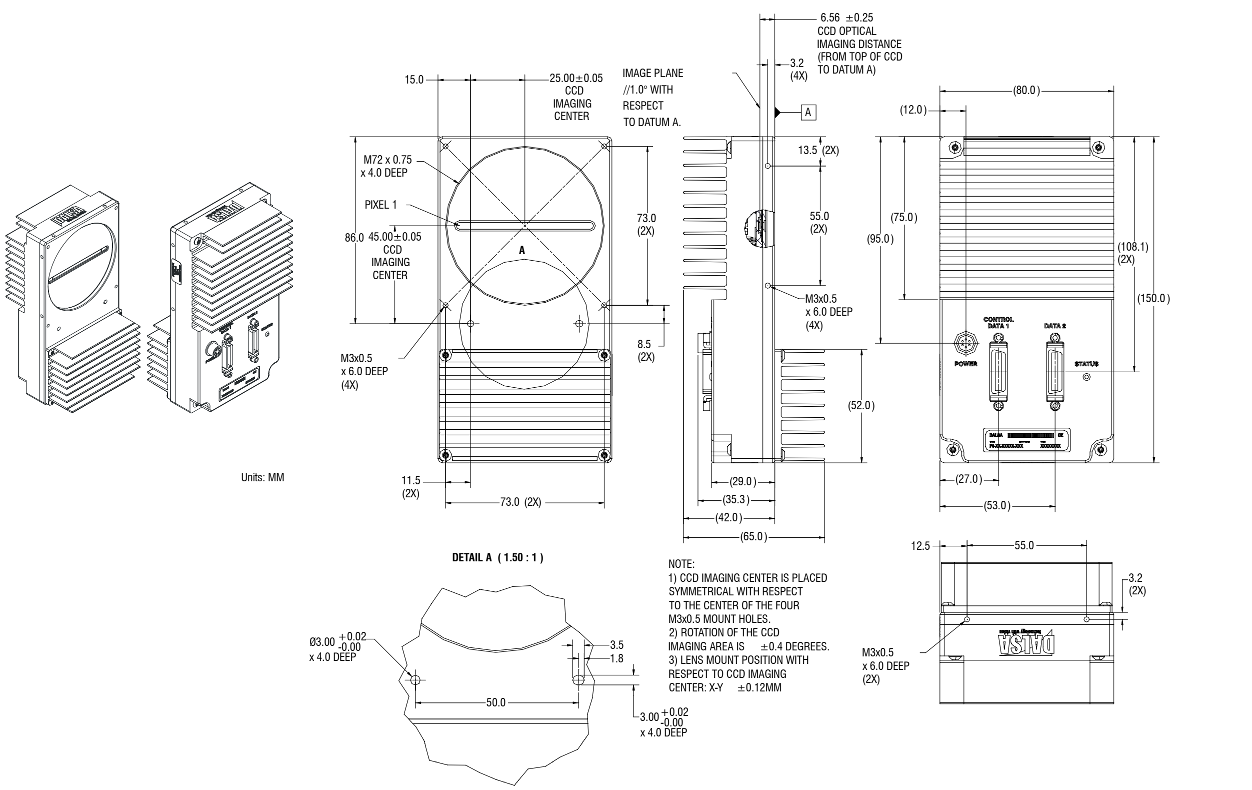
Syntax	Parameters	Description
`get spt`		Returns the current pretrigger setting.
`get ssb`	`t`	Returns the current background subtract value. **`t`** = Tap value. **`0`** for all taps or **`1`** to **`number of CCD taps`** for individual tap selection.
`get ssf`		Returns the current line/frame rate in Hz.
`get ssg`	`t`	Returns the current digital gain setting. **`t`** = tap selection, either **`1`** to **`number of CCD taps`**, or **`0`** for all taps
`get stg`		Returns the current number of CCD integration stages.
`get sut`		Returns the current uppder threshold value.
`get svm`		Returns the current video mode. **`0`**: Normal video mode **`1`**: Test pattern **`2`**: Test pattern **`3`**: Test pattern
`get tdi`		Returns the camera's current operating mode. **`0`**: Area Mode **`1`**: TDI Mode
`get ugr`		Returns the gain reference value
`get vt`		Returns the camera's internal chip temperature in degrees Celcius.
`get vv`		Returns the camera's supply voltage.
`get wfc`		Returns whether FPN coefficients have been saved. **`0`** = No FPN coefficients saved **`1`** = Pixel coefficients have been saved
`get wpc`		Returns whether PRNU coefficients have been saved. **`0`** = No PRNU coefficients saved **`1`** = Pixel coefficients have been saved
`get wus`		Returns whether user settings have been saved. **`0`** = No user settings saved **`1`** = User settings have been saved

4

Optical and Mechanical Considerations

4.1 Mechanical Interface

Figure 31: Piranha ES-xx Mechanical Dimensions



4.2 Lens Mounts

Model Number	Lens Mount Options
All models	M72x0.75 thread.

4.3 Optical Interface

Illumination

The amount and wavelengths of light required to capture useful images depend on the particular application. Factors include the nature, speed, and spectral characteristics of objects being imaged, exposure times, light source characteristics, environmental and acquisition system specifics, and more. DALSA’s Web site, http://vfm.dalsa.com/, provides an introduction to this potentially complicated issue. See “Radiometry and Photo Responsivity” and "Sensitivities in Photometric Units" in the CCD Technology Primer found under the Application Support link.

It is often more important to consider exposure than illumination. The total amount of energy (which is related to the total number of photons reaching the sensor) is more important than the rate at which it arrives. For example, $5\mu J/cm^2$ can be achieved by exposing $5mW/cm^2$ for 1ms just the same as exposing an intensity of $5W/cm^2$ for 1µs.

Light Sources

Keep these guidelines in mind when setting up your light source:

- LED light sources are relatively inexpensive, provide a uniform field, and longer life span compared to other light sources. However, they also require a camera with excellent sensitivity, such as the ES-xx camera.
- Halogen light sources generally provide very little blue relative to infrared light (IR).
- Fiber-optic light distribution systems generally transmit very little blue relative to IR.
- Some light sources age; over their life span they produce less light. This aging may not be uniform—a light source may produce progressively less light in some areas of the spectrum but not others.

Filters

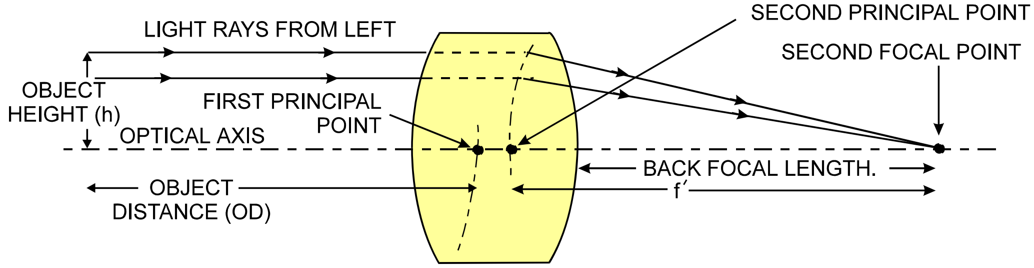
CCD cameras are extremely responsive to infrared (IR) wavelengths of light. To prevent infrared from distorting the images you scan, use a “hot mirror” or IR cutoff filter that transmits visible wavelengths but does not transmit wavelengths over 750nm. Examples are the Schneider Optics™ B+W 489, which includes a mounting ring, the CORION™ LS-750, which does not include a mounting ring, and the CORION™ HR-750 series hot mirror.

Lens Modeling

Any lens surrounded by air can be modeled for camera purposes using three primary points: the first and second principal points and the second focal point. The primary points for a lens should be available from the lens data sheet or from the lens manufacturer. Primed quantities denote characteristics of the image side of the lens. That is, *h* is the object height and *h′* is the image height.

The *focal point* is the point at which the image of an infinitely distant object is brought to focus. The *effective focal length (f′)* is the distance from the second principal point to the second focal point. The *back focal length (BFL)* is the distance from the image side of the lens surface to the second focal point. The *object distance (OD)* is the distance from the first principal point to the object.

Figure 32: Primary Points in a Lens System



Appendix A

Error Handling and Command List

A1 Error Handling

The following table lists warning and error messages and provides a description and possible cause. Warning messages are returned when the camera cannot meet the full value of the request; error messages are returned when the camera is unable to complete the request.

Table 21: Warning and Error Messages

Warning Messages	
Camera Response	**Comment**
OK>	Camera executed command
Warning 01: Outside of specification>	Parameter accepted was outside of specified operating range (e.g. gain greater than ±10 dB of factory setting, or SSF below specification).
Warning 02: Clipped to min>	Parameter was clipped to the current operating range. Use GCP or GET to see value used.
Warning 03: Clipped to max>	Parameter was clipped to the current operating range. Use GCP or GET to see value used.
Warning 04: Related parameters adjusted>	Internal operating condition is adjusted to accommodate the entered command. E.g. requesting exposure time longer than line time automatically adjusts the line time to meet the exposure time requirement.
Warning 07: Coefficient may be inaccurate A/D clipping has occurred>	In the region of interest (ROI) greater than 6.251% single or 1% of averaged pixel values were zero or saturated.
Warning 08: Greater than 1% of coefficients have been clipped	Greater than 1% of FPN or PRNU coefficients have been calculated to be greater than the maximum allowable and so were clipped.
Warning 09: Internal line rate inconsistent with read out time>	Changing this parameter (e.g. vertical binning) has changed read out time and that is greater than the *internal* SYNC

Error Messages

Camera Response	Comment
Error 01: Internal error xx>	Where xx is a code list below. Only output during power up. Customer should contact DALSA customer support.
Error 02: Unrecognized command>	Command is not valid.
Error 03: Incorrect number of parameters>	Too many or too few parameters.
Error 04: Incorrect parameter value>	This response returned for ▪ Alpha received for numeric or visa versa ▪ Float where integer expected ▪ Not an element of the set of possible values. E.g., Baud Rate ▪ Outside the range limit
Error 05: Command unavailable in this mode>	E.g. SSF when in SEM 3
Error 06: Timeout>	Command not completed in time. E.g. CCF or CCP in SEM 3 when no external EXSYNC is present.
Error 07: Camera settings not saved>	Indicates that user settings have been corrupted by turning off the power while executing the WUS command. Must build up new settings from factory and re-save with WUS.
Error 08: Unable to calibrate - tap outside ROI>	Cannot calibrate a tap that is not part of the end of line statistics.
Error 09: The camera's temperature exceeds the specified operating range>	Indicates that the camera has shut itself down to prevent damage from further overheating. (flashing red) Shuts down at internal temperature of 75˚C and will not restart until below 65˚C (equivalent to 50˚C at front plate).
Error 10: FPGA Flash Program Failed	FCS failed either because of communication error or a bad file was sent.

A2 Commands: Quick Reference

Parameters:
t = tap id
i = integer value
f = float
m = member of a set
s = string
x = pixel column number
y = pixel row number

As a quick reference, the following table lists all of the camera configuration commands available to the camera user. For detailed information on using these commands, refer to Chapter 3. Note: This table does not list "get" commands. Refer to section 3.7.6 Returning Camera Settings for a list of these commands.

Table 22: Command Quick Reference

Mnemonic	Syntax	Parameters	Description
calibrate analog offset	**cao**	**t i**	Calibrates the analog gain and averages each tap's pixels within the ROI to the specified average target value. **t** = tap selection, either **1** to **number of CCD taps**, or **0** for all taps **i** = target value in a range from **0** to **255**DN (12-bit LSB) Refer to Analog Signal Processing: Setting Analog Gain and Offset for details.
correction calibrate fpn	**ccf**		Performs FPN calibration and eliminates FPN noise by subtracting away individual pixel dark current. Refer to Digital Signal Processing and Processing Chain Overview and Description for details.

Mnemonic	Syntax	Parameters	Description
calculate camera gain	`ccg`	`i t i`	Calculates the camera gain according to the selected algorithm. `i` = Calibration algorithm to use. `1` = This algorithm adjusts analog gain so that 8% to 13% of tap ROI pixels are above the specified target value. `2` = This algorithm adjusts analog gain so that the average pixel value in tap's ROI is equal to the specified target value. `3` = This algorithm adjusts digital gain so that the average pixel value in tap's ROI is equal to the specified target. `4` = This algorithm adjusts the analog gain so that the peak tap ROI pixels are adjusted to the specified target. `t =` Tap value. Use `0` for all taps or `1` to number of CCD taps for individual tap selection. `i` = Calibration target value in a range from: Algorithm 1 and 2: `1024` to `4055`DN (12 bit LSB). Algorithm 3: `4095` to `65535.` The digital video values are multiplied by this value where: $\text{Digital Gain} = \frac{i}{4096}$
correction calibrate prnu	`ccp`		Performs PRNU calibration and eliminates the difference in responsivity between the most and least sensitive pixel creating a uniform response to light. Refer to Digital Signal Processing and Processing Chain Overview and Description for details.
camera link mode	`clm`	`m`	Sets the Camera Link configuration, number of Camera Link taps, and data bit depth. `15`: Medium configuration, 4 taps, 8 bit output `16`: Medium configuration, 4 taps, 12 bit output `21`: Full configuration, 8 taps, 8 bit output Refer to section 3.4.2 Setting the Camera Link Mode for details.

Mnemonic	Syntax	Parameters	Description
calculate PRNU algorithm	**cpa**	**i i**	Performs PRNU calibration according to the selected algorithm. The first parameter is the algorithm where **i** is: **1** = This algorithm first adjusts each tap's analog gain so that 8-13% of pixels within a tap are above the value specified in the target value parameter. PRNU calibration then occurs using the peak pixel in the region of interest. (Identical to **ccp**) **2** = Calculates the PRNU coefficients using the entered target value as shown below: $\text{PRNU Coefficient} = \frac{\text{Target}}{(\text{AVG Pixel Value}) - (\text{FPN}+\textbf{sdo}\ \text{value})}$ The calculation is performed for all sensor pixels but warnings are only applied to pixels in the region of interest. This algorithm is useful for achieving uniform output across multiple cameras. **3** = This algorithm includes an analog gain adjustment prior to PRNU calibration. Analog gain is first adjusted so that the peak pixel value in tap's ROI is within 97 to 99% of the specified target value. It then calculates the PRNU coefficients using the target value as shown below: $\text{PRNU Coefficient}_i = \frac{\text{Target}}{(\text{AVG Pixel Value}_i) - (\text{FPN}_i + \textbf{sdo}\ \text{value})}$ The calculation is performed for all sensor pixels but warnings are only applied to pixels in the region of interest. This algorithm is useful for achieving uniform output across multiple cameras. **4** = This algorithm is the same as 2 with the exception that it only calculates PRNU for the pixels within the current Region of Interest (ROI). The second parameter is the target value to use in a range from **1024** to **4055**DN.
correction set sample	**css**	**m**	Set number of line samples averaged for pixel coefficient calculations or for output of **gla** command. Values: **256**, **512**, **1024**. Factory setting: **1024** Refer to Returning Averaged Lines of Video on page 75 for details.

Mnemonic	Syntax	Parameters	Description
display pixel coeffs	**dpc**	**x1 x2**	Displays the pixel coefficients in the order FPN, PRNU, FPN, PRNU, … **x1** = Pixel start number **x** 2= Pixel end number in a range from **1** to **sensor pixel count**.
end of line sequence	**els**	**i**	Sets the end-of-line sequence: **0**: Off **1**: On Refer to Refer to 3.5.3 End-of-line Sequence for details.
enable pixel coefficients	**epc**	**i i**	Sets whether pixel coefficients are enabled or disabled. The first parameter sets the FPN coefficients where **i** is: **0** = FPN coefficients disabled **1** = FPN coefficients enabled The second parameter sets the PRNU coefficients where **i** is: **0** = PRNU coefficients disabled **1** = PRNU coefficients enabled Refer to section Enabling and Disabling Pixel Coefficients on page 66 for details.
get camera model	**gcm**		Reads the camera model number.
get camera parameters	**gcp**		Reads all of the camera parameters.
get camera serial	**gcs**		Read the camera serial number.
get camera version	**gcv**		Read the firmware version and FPGA version.
get exposure mode	**gem**		Retrieves the current camera exposure mode.
get fpn coeff	**gfc**	**x**	Read the FPN coefficient **x** = pixel number to read in a range from **1** – **sensor pixel count**. Refer to Returning FPN Coefficients on page 61 for details.
get line	**gl**	**x x**	Gets a line of raw video (no digital processing or test pattern) displaying one pixel value after another and the minimum, maximum, and mean value of the sampled line. **x** = Pixel start number **x** = Pixel end number in a range from **1** to **sensor pixel count**. Refer to Returning a Single Line of Video on page 74 for details.

Mnemonic	Syntax	Parameters	Description
get line average	**gla**	x x	Read the average of line samples. **x** = Pixel start number **x** = Pixel end number in a range from **1** to **sensor pixel count**. Refer to Returning Averaged Lines of Video on page 75 for details.
get prnu coeff	**gpc**	x	Read the PRNU coefficient. **x** = pixel number to read in a range from **1** – **sensor pixel count**.
get signal frequency	**gsf**	i	Reads the requested Camera Link control frequency. **1** = EXSYNC frequency **2** = Spare **3** = Direction (1 = forward, 2 = reverse) **4** = Spare
help	**h**		Display the online help. Refer to section for details.
load pixel coefficients	**lpc**		Loads the previously saved pixel coefficients from non-volatile memory where ***i*** is: **0** = Factory calibrated coefficients **1** = Coefficient set one **2** = Coefficient set two **3** = Coefficient set three **4** = Coefficient set four
reset camera	**rc**		Reset the entire camera (reboot). Baud rate is not reset and reboots with the value last used.
restore factory settings	**rfs**		Restore the camera's factory settings. FPN and PRNU coefficients reset to 0. Refer to section 3.6 Saving and Restoring Settings for details.
region of interest	**roi**	x y x y	Sets the pixel range affected by the **cag**, **cao**, **gl**, **gla**, **ccf**, **cpa** and **ccp** commands. The parameters are the pixel start and end values (**x**) and the column start and end values (**y**) in a range from **1** to **sensor pixel count**. Refer to section 3.5.1 Setting a Region of Interest for details.
reset pixel coeffs	**rpc**		Reset the pixel coefficients to 0. Refer to section Enabling and Disabling Pixel Coefficients on page 66 for details.
restore user settings	**rus**		Restore the camera's last saved user settings and FPN and PRNU coefficients. Refer to section 3.6 Saving and Restoring Settings for details.

Mnemonic	Syntax	Parameters	Description
set analog gain	**`sag`**	**`t f`**	Sets the analog gain in dB. **`t`** = Tap value. **`0`** for all taps or **`1-number of CCD taps`** for individual tap selection. **`f`**= gain value specified from **`–10`** to **`+10`** Refer to Analog Signal Processing: Setting Analog Gain and Offset on page 53 for details.
set analog offset	**`sao`**	**`t i`**	Sets the analog offset. **`t = 0`** for all taps or **`1`** to **`number of CCD taps`** for individual tap selection. **`i`**= Offset value in a range from **`0`** to **`255`** (12-bit LSB). Offset increases with higher values. Refer to Analog Signal Processing: Setting Analog Gain and Offset for details.
set binning horizontal	**`sbh`**	**`m`**	Sets the horizontal binning value. Available values are **`1`**, **`2`**, **`4`**, or **`8`**. Refer to section 3.3.4 Increasing Sensitivity with Binning on page 37 for details.
set baud rate	**`sbr`**	**`i`**	Set the speed of camera serial communication port. Baud rates: **`9600`**, **`19200`**, **`57600`**, and **`115200`**. Default: 9600. Refer to section Setting Baud Rate on page 30 for details.
set binning vertical	**`sbv`**	**`m`**	Sets the vertical binning value. Available values are **`1`** to **`8`**. Refer to section 3.3.4 Increasing Sensitivity with Binning on page 37 for details.
set ccd direction	**`scd`**	**`i`**	Sets the CCD shift direction where: **`0 =`** Forward TDI shift direction. **`1 =`** Reverse TDI shift direction. **`2 =`** Externally controlled direction control via Camera Link control CC3. Available only in TDI Mode
set digital offset	**`sdo`**	**`t i`**	Subtracts the input value from the video signal prior to FPN correction. **`t`** = Tap value. **`0`** for all taps or **`1-number of CCD taps`** for individual tap selection. **`i`** = Offset in a range from **`0`** to **`511`**DN. Refer to Setting Digital Offset on page61 for details.

Mnemonic	Syntax	Parameters	Description
set exposure mode	**sem**	m	Set the exposure mode: **3 =** External SYNC, maximum exposure time **7 =** Internal programmable SYNC, maximum exposure time. Factory setting.
set exposure time	**set**	f	Sets the exposure time. Refer to the camera help screen (**h** command) for allowable range. Not available in TDI Mode.
set fpn coeff	**sfc**	x i	Set the FPN coefficient. **x** =pixel number within the range **1** to **sensor pixel count**. **i**= FPN value within the range **0** to **511** (12-bit LSB). Refer to Performing FPN Correctionon page 61 for details.
set fpn range	**sfr**	x x i	Set a range of pixel FPN coefficients **x**=first pixel number of the range. **x**=last pixel number of the range **i**=coefficient value in a range from **0** to **2048**. Refer to Setting a Range of FPN Coefficients on page 62 for details.
set lower threshold	**slt**	i	The pixels below the lower threshold are checked for and reported in the end-of-line sequence in a range from **0-4095**. Refer to section 3.5.3 End-of-line Sequence for details.
set mirror mode	**smm**	i	Set the camera's mirror mode: **0**: Pixels readout left to right (1 to 4096 or 8192) **1**: Pixels readout right to left (8092 or 4096 to 1) Refer to 3.4.4 Setting the Pixel Readout Direction for details.
set output throughput	**sot**	m	This command works in conjunction with the **clm** command and determines the Camera Link strobe rate. **80 =** 4 taps at 20MHz or 2 taps at 40MHz **160 =** 2 taps at 80MHz or 4 taps at 40MHz **320 =** 4 taps at 80MHz or 8 taps at 40MHz **640 =** 8 taps at 80MHz Refer to section 3.4.3 Setting the Camera Throughput for details on using this command. Available settings are dependent on your camera model.

Mnemonic	Syntax	Parameters	Description
set pretrigger	**spt**	**i**	Set the pretrigger to a value from **0** to **16**.
set prnu coeff	**spc**	**x i**	Set the PRNU coefficient. **x**=pixel number within the range **1** to **sensor pixel count**. **i**= PRNU value within the range **0** to **28671**.
set prnu range	**spr**	**i i x**	Set a range of pixel PRNU coefficients **i**=first pixel number of the range **i**=last pixel number of the range **x**=coefficient value in a range from **0** to **28671**. Refer to Setting a Range of PRNU Coefficients on page 65 for details.
set subtract background	**ssb**	**t i**	Subtract the input value from the output signal. **t** = Tap value. **0** for all taps or **1** to **number of CCD taps** for individual tap selection. **i** = Subtracted value in a range from **0** to **4095**. Refer to Subtracting Background on page 60 for details.
set sync frequency	**ssf**	**i**	Set the frame rate to a value from: TDI ES-80-8k40: **3499.56-34305.3** ES-80-8k80: **3499.87-68610.6** Area ES-80-8k40: **1-3084.52** ES-80-8k80: **1-6169.03** Value rounded up/down as required. Refer to Setting Frame Rate on page 42 for details.
set system gain	**ssg**	**t i**	Set the digital gain. **t** = tap selection, either **1** to **number of CCD taps**, or **0** for all taps **i** = Digital gain in a range from **0** to **65535**. The digital video values are multiplied by this number. Refer to Setting Digital Gain on page 60 for details.
stage select	**stg**	**i**	Sets the number of TDI stages. Allowable values are: **16 or 32.** Refer to 3.3.2 Selecting the Number of CCD Integration Stages for details.

Mnemonic	Syntax	Parameters	Description
set upgrade feature	**suf**	s	Allows you to upgrade from an ES-80-08k40 to an ES-80-08k80. Contact DALSA Sales for an upgrade string.
set upper threshold	**sut**	i	The pixels equal to or greater than the upper threshold are checked for and reported in the end-of-line sequence in a range from **0-4095**. Refer to 3.5.3 End-of-line Sequence for details.
set video mode	**svm**	i	Switch between normal video mode and test patterns: **0**: Normal video mode **1**: Test pattern **2**: Test pattern **3**: Test pattern Refer to section 3.7.1 Generating a Test Pattern for details.
set TDI mode	**tdi**	i	Set the camera's operating mode. **0**: Area Mode **1**: TDI Mode Refer to section 3.5.1 for details.
update gain reference	**ugr**		Changes 0dB gain to equal the current analog gain value set with the **sag** command. Refer to section Analog Signal Processing: Setting Analog Gain and Offset for details.
verify temperature	**vt**		Check the internal temperature of the camera
verify voltage	**vv**		Check the camera's input voltages and return OK or fail
write FPN coefficients	**wfc**	i	Write all current FPN coefficients to EEROM where ***i*** is: **1** = FPN coefficient set one **2** = FPN coefficient set two **3** = FPN coefficient set one **4** = FPN coefficient set two Refer to section 3.6.2 Saving and Restoring PRNU and FPN Coefficients for details.
write PRNU coeffs	**wpc**	i	Write all current PRNU coefficients to EEROM where ***i*** is: **1** = PRNU coefficient set one **2** = PRNU coefficient set two **3** = PRNU coefficient set one **4** = PRNU coefficient set two Refer to section 3.6.2 Saving and Restoring PRNU and FPN Coefficients for details.

Mnemonic	Syntax	Parameters	Description
write user settings	**wus**		Write all of the user settings to EEROM. Refer to section 3.6.1 Saving and Restoring Factory and User Settings for details.

Appendix B

EMC Declaration of Conformity

NOTE: PENDING

We, **DALSA**
605 McMurray Rd.,
Waterloo, ON
CANADA N2V 2E9

declare under sole responsibility, that the product(s):

ES-80-04k40
ES-80-08k40
ES-80-08k80

fulfill(s) the requirements of the standard(s)

EMC: **CISPR-22:1997**
EN 50082-1:1997
EN 61000-4-2; +/- 6kV CD, +/-8kV AD:1995
EN 61000-4-3; 3V/m:1996
EN 61000-4-4; 500V, 1100V:1995

This product complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carries the CE mark accordingly.

Place of Issue Waterloo, ON, CANADA

Date of Issue April 2005

Name and Signature of authorized person **Hank Helmond**
Quality Manager, DALSA Corp.

This Declaration corresponds to EN 45 014.

Appendix C

Revision History

Rev Number	Change Description	Date
00	Preliminary release	April 30, 2009

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