Piranha HS 4x-02K30

HS-40-02K30, HS-41-02K30

High Sensitivity Line Scan CCD Camera

Camera User's Manual

DALSA
technology with vision

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All DALSA products are manufactured using the latest state-of-the-art equipment to ensure product reliability. All electronic modules and cameras are subjected to a 24 hour burn-in test.

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Introduction to the Piranha HS 4x High Sensitivity Line Scan Cameras

1.1 Camera Highlights

- Responsivity up to 1610 DN/(nJ/cm^2)
- 52 kHz line rates
- 2048 pixels, 13µm x 13µm, 100% fill factor
- 120MHz data rate. Selectable Base (2 x 60MHz) or Medium (4x 30MHz) Camera Link™
- 4 taps on sensor
- 100x antiblooming
- 5 independently stage-selectable Time Delay and Integration (TDI) imaging regions for remarkable user-controlled sensitivity
- User-selectable 1x1, 1x2, 2x1, or 2x2 binning
- Compact body with F mount or M42x1 mount interface
- Serial interface (ASCII, 9600 baud, adjustable to 19200, 57600, 115200), through Camera Link
- Selectable 8 or 10 bit output
- Flat-field correction—minimizing sensor FPN and PRNU, lens vignetting and non-uniform lighting

Description

The Piranha HS 4x cameras offer incredible performance at a low cost. Because they use TDI technology, the Piranha HS 4x cameras are highly sensitive—50 times greater responsivity than standard line scan cameras.

With line rates reaching 52kHz and a resolution of 2048 pixels, DALSA's latest high sensitivity camera specifically meets the performance requirements needed in demanding applications such as postal sorting, document scanning, and low light industrial inspection.

The simple ASCII communications protocol allows you to configure and program virtually all camera functions through the asynchronous serial control available through Camera Link.

To speed setup and system debugging, the camera can output a test pattern and end-of-line sequence to help track the path of data through an acquisition system.

Applications

The Piranha HS 4x cameras are ideal for space-constrained applications demanding high performance and low-light or cost-effective lighting. Applications include:

- Postal sorting
- Document scanning
- Web inspection
- Industrial inspection
- Low-light scanning

Part Number Description

The camera part numbers are explained in the table below.

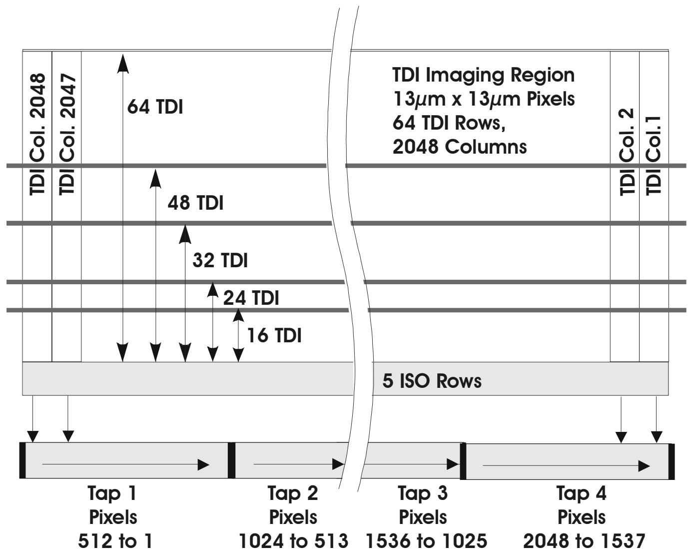
Table 1: Piranha HS 4x Part Number Descriptions

Part Number	Description
HS-40-02K30	No mount
HS-41-02K30	F mount

1.2 Image Sensor

The Piranha HS 4x cameras use DALSA' s 2048 pixel, 4-output, stage selectable, uni-directional TDI IT-E4-2048B sensor.

Figure 1. IT-E4-2048B Image Sensor



1.3 Camera Performance Specifications

Table 2: Piranha HS 4x Camera Performance Specifications

Sensor Features			
Feature / Specification	**Units**	**Value**	**Notes**
Resolution	pixels	2048	
Pixel Fill Factor	%	100	
Pixel Size	µm	13x13	
Output Format (number of taps)		4 adjacent taps of 512 pixels each	
TDI Stage Selection		Select between 16, 24, 32, 48, and 64 TDI stages	Set using the **`stg`** command

Optical Interface			
Feature / Specification	**Units**	**Value**	**Notes**
Back Focal Distance			
F Mount	mm	46.50±0.18	
M42x1 Mount	mm	6.5mm	
Lens Mount		F mount	

Optical Interface			
Feature / Specification	**Units**	**Value**	**Notes**
Sensor Alignment z Θz Parallelism / Tilt	 (F Mount) ° µm	 46.5 ±0.18mm ±0.6 <100 over sensor	

Mechanical Interface			
Feature / Specification	**Units**	**Value**	**Notes**
Camera Size	mm	85x85x50	Excluding lens and connectors
Mass	Kg	1.15	
Connectors		2 x MDR26, Hirose 6-pin	

Electrical Interface				
Feature / Specification	**Units**	**Min**	**Max**	**Notes**
Input Voltage	Volts	12	15	
Power Dissipation	W		8	
Operating Temperature	°C	10	50	Measured at the front plate.
Data Output Format	Bits	8	10	8 or 10 user selectable

Operating Ranges					
Value	**Units**	**Min**	**Nom**	**Max**	**Notes**
Line Rate	kHz	1		52	
Data Rate	MHz		Selectable 2x60 or 4x30		Set using the **sdm** command
Gain	dB	-10	0	+10	Set using the **sg** command
Dynamic Range	Ratio	486	151	48.6	
Random Noise	DN p-p	3	10	30	
Random Noise	DN rms	0.5	1.6	5	
SEE	pJ/cm^2		481 (typ)		
NEE	pJ/cm^2		3.2 (typ)		
Responsivity	DN/nJ/cm^2			1610	
FPN without correction with correction	 DN p-p	 3	 10	 30 2.5	
PRNU (global) without correction with correction	 % of Output			 11 2.5	 @ 64 stages

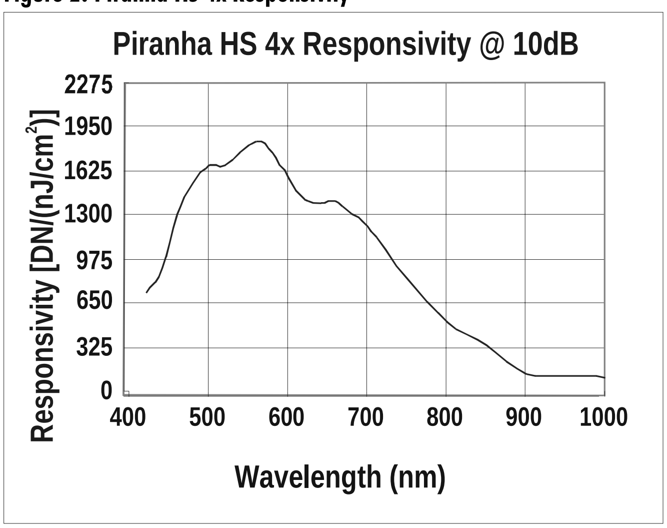
Operating Ranges					
Value	**Units**	**Min**	**Nom**	**Max**	**Notes**
PRNU (pixel to pixel) without correction with correction	% of Output			10 2	@ 64 stages
Saturation Output Amplitude	DN		248 ±2		
Calibrated DC Offset	DN	3	5	7	
Antiblooming			100x		

Regulatory	
EMI	CISPR-22
EMC	EN55024
Shock and Vibration	MIL-STD-810E

Test conditions unless otherwise noted:

1. Data Rate: 30 MHz
2. Line Rate: maximum 52 kHz ±10% (FPN and PRNU measured at minimum 1kHz line rate)
3. Nominal Gain setting.
4. Light Source: Broadband Quartz Halogen, 3250K, with 750nm cutoff filter installed
5. Ambient test temperature 0 to 50°C

Figure 2: Piranha HS 4x Responsivity



2

Camera Hardware Interface

2.1 Installation Overview

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

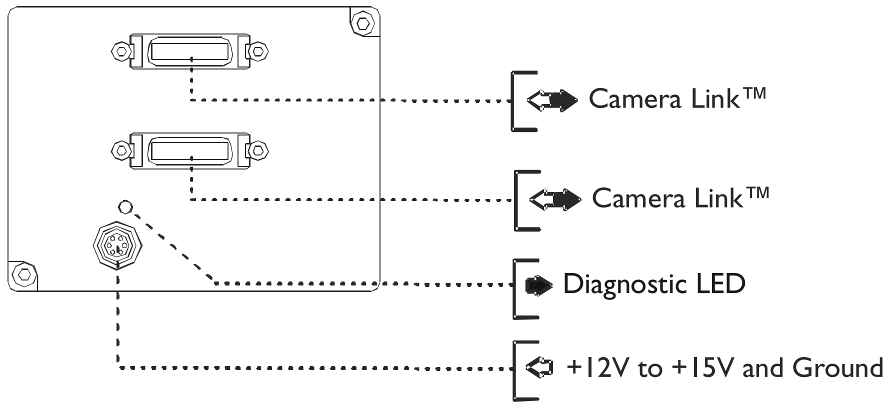
When setting up your camera, you should take these steps:

1. Power down all equipment.
2. Following the manufacturer's instructions, 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. Power supplies must meet the requirements defined in section 2.4.
6. Inspect all cables and connectors prior to installation. Do not use damaged cables or connectors or the camera may be damaged.
7. Connect Camera Link and power cables.
8. After connecting cables, apply power to the camera.
9. Check the diagnostic LED.

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

Figure 3: Piranha HS 4x Input/Output Connectors

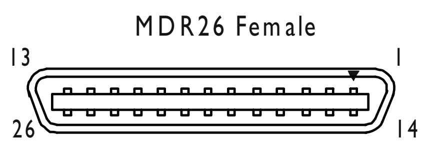


2.3 Connectors, Pinouts, and Cables

The Piranha HS 4x cameras use:

- Two high-density 26-pin MDR26 connectors for Camera Link control signals, data signals, and serial communications. See Figure 4: MDR26 Connector below.
- A Hirose 6 pin power connector. See Figure 5: Hirose 6-pin Circular Male Power Connector on page 13.

Figure 4: MDR26 Connector (Camera Link Connector)



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

Table 3: MDR26 Connector Reference (Camera Link Standard Pinout)

Camera Link Cable						
Medium Configuration Up to an additional 2 Channel Link Chips				Base Configuration One Channel Link Chip + Camera Control + Serial Communication		
Camera Connector	Right AngleFrame Grabber	Channel Link Signal	Cable Name	Camera Connector	Right Angle Frame Grabber	Channel Link Signal
1	1	inner shield	Inner Shield	1	1	inner shield
14	14	inner shield	Inner Shield	14	14	inner shield
2	25	Y0-	PAIR1-	2	25	X0-
15	12	Y0+	PAIR1+	15	12	X0+
3	24	Y1-	PAIR2-	3	24	X1-
16	11	Y1+	PAIR2+	16	11	X1+

Camera Link Cable

Medium Configuration

Up to an additional 2 Channel Link Chips

Camera Connector	Right AngleFrame Grabber	Channel Link Signal	Cable Name
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

Base Configuration

One Channel Link Chip + Camera Control + Serial Communication

Camera Connector	Right Angle Frame Grabber	Channel Link Signal
4	23	X2-
17	10	X2+
5	22	Xclk-
18	9	Xclk+
6	21	X3-
19	8	X3+
7	20	SerTC+
20	7	SerTC-
8	19	SerTFG-
21	6	SerTFG+
9	18	CC1-
22	5	CC1+
10	17	CC2+
23	4	CC2-
11	16	CC3-
24	3	CC3+
12	15	CC4+
25	2	CC4-
13	13	inner shield
26	26	inner shield

*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.

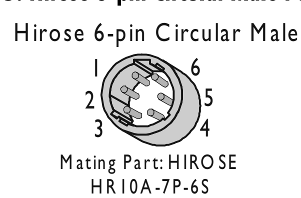
Unused pairs should be terminated in 100 ohms at both ends of the cable.

See Appendix A on page 47 for more information on the DALSA Camera Link configuration table, and refer to the DALSA Vision for Machines Web site, vfm.dalsa.com, for the official Camera Link documents.

Table 4: DALSA Camera Control Configuration

Camera Link Signal	DALSA Configuration
CC1	EXSYNC
CC2	Spare
CC3	Spare
CC4	Spare

Figure 5: Hirose 6-pin Circular Male Power Connector



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

2.4 Power Supplies

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.

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

- 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.

Note: Performance specifications are not guaranteed if your power supply does not meet these requirements. See section 2.3 for more information on the power connector.

WARNING: It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages will damage the camera. Protect the camera with a fast-blow fuse between power supply and camera.

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. Many high quality supplies are available from other vendors. DALSA assumes no responsibility for the use of these supplies.

2.5 Data Bus, Camera Link

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 vfm.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

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

Digital Data

The camera digitizes internally to 10 bits and outputs either all 10 bits or the most significant 8 bits in LVDS format on the Camera Link connector.

2.6 LED Status Indicators

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

Table 5: LED Status Indicators

LED state	Priority	Camera Status	Condition
Blinking RED	1	Error	Fatal hardware failure
Steady RED	2	Warning	Monitoring task failure
Blinking GREEN	3	Progress	Lengthy operation in progress
Steady GREEN	4	OK	Healthy

Note: When more than one condition is active, the LED indicates the condition with highest priority. Error and warning states are accompanied by corresponding messages further describing current camera status. See section B2 Error Handling on page 58 for error message descriptions.

3

Software Interface: How to Control the Camera

This chapter outlines the more commonly used commands. See Appendix B on page 51 for a list of all available commands.

All 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. This chapter explains the most commonly used and important commands, including:

- Saving and restoring settings
- Setting the exposure mode and line rate
- Setting gains
- Setting the number of TDI stages
- Flat field correction

3.1 Overview: Setting up the Camera to Send Commands

The following steps describe how to begin using the Piranha HS 4x commands.

1. If you have not already set up your camera cables, connect your cables as described in section 2.1 Installation Overview.
2. Using a terminal program (e.g., Microsoft HyperTerminal), open a terminal window.

   Note: In order to communicate with the camera, a serial connection in the Camera Link cable needs to be established. The framegrabber manufacturers should be able to provide a solution in order to communicate through this serial link. The terminal software can also be provided by the framegrabber manufacturer. Standard terminal software, such as Microsoft HyperTerminal, can be used if the COM port is allocated by the framegrabber.

   Terminal should be set at 9600 baud during the camera power up.
3. When the terminal window is set up, power on the camera.
4. The boot-up message should appear:

```
Camera Initialization in progress, Please Wait ...

OK>
```

5. Set up the framegrabber to receive the data. Following the framegrabber manufacturer's instructions, set up the parameters described in the Camera Link™ Configuration Table on page 49.
6. Once the framegrabber is set up for data processing and the camera is powered up, run your image processing software. You should be able to see an image from the camera when exposed to a light source.
7. You can now set the other camera parameters described in this chapter.

Online Help

For quick help, the camera can return all available commands and parameters through the serial interface. To generate this list, send the command **h** to the camera.

Retrieving Camera Settings

To read current camera settings, send the command **gcp**.

3.2 Communications Protocol Overview

Serial Protocol Defaults:

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

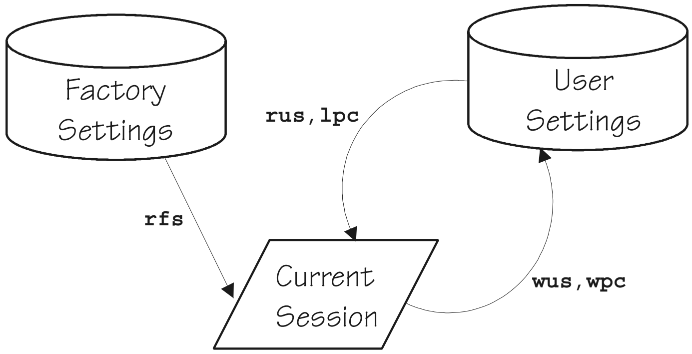
When entering commands, remember that:

- A carriage return (CR) ends each command. The linefeed character is ignored.
- Values in square brackets are optional.
- The camera will answer each command with either a carriage return <CR> and line feed <LF> followed by "OK >" or "Error x: Error Message >". The ">" is always the last character sent by the camera.
- The following parameter conventions are used in the manual:

  t = tap id
  i = integer value
  f = real number
  x1 = pixel start number
  x2 = pixel end number
  [ ] = optional parameter

3.3 Saving and Restoring Settings

Figure 6: Saving and Restoring Overview



Factory Settings

On first initialization, the camera operates using the factory settings. You can restore the original factory settings at any time using the command **rfs**.

User Settings

You can save or restore your user settings to non-volatile memory using the following commands. Pixel coefficients are stored separately from other data.

- To save all current user settings to EEROM, use the command **wus**. The camera will automatically restore the saved user settings when powered up.
- To restore the last saved user settings, use the command **rus**.
- To save the current pixel coefficients, use the command **wpc**.
- To restore the last saved pixel coefficients, use the command **lpc**.

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 to non-volatile memory, use the command **wus**.

3.4 Setting the Baud Rate

To set the speed of the camera's serial communication port, use the command:

Syntax:	**sbr *i***
Syntax Elements:	***i***
	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.
Example:	**sbr 19200**

3.5 Setting the Data Mode

You can configure the camera to output data to your framegrabber using a Camera Link Medium Configuration (4 x 30MHz) or a Camera Link Base Configuration (2 x 60MHz).

To select the camera output mode, use the command:

Syntax:	`sdm i`	
Syntax Elements:	*i*	
	0	8 bit, A/B/C/D ports, single processor. Medium Configuration.
	1	10 bit, A/B/C/D/E/F ports, single processor. Medium Configuration.
	2	8 bit, A/B ports, time multiplexed. Base Configuration.
	3	10 bit A/B/C ports, time multiplexed. Base Configuration.
Notes:	•	To obtain the current data mode, use the command `gcp`.
Example:	`sdm 3`	

Time Multiplexing

Time multiplexing allows the Piranha HS 41 to send data to your framegrabber using a Camera Link Base Configuration. The readout from taps 1 and 2 and taps 3 and 4 are merged into two time slots. Figure 7 and Figure 8 compare camera readout between the Medium Configuration and the Base Configuration. Refer to the Camera Link™ Configuration Table on page 49 for more information on tap reconstruction.

Figure 7: sdm 0 and sdm 1 readout (Medium Configuration)

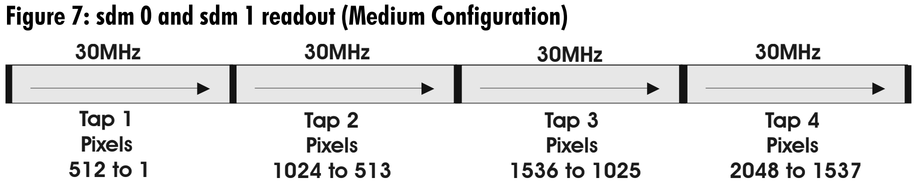
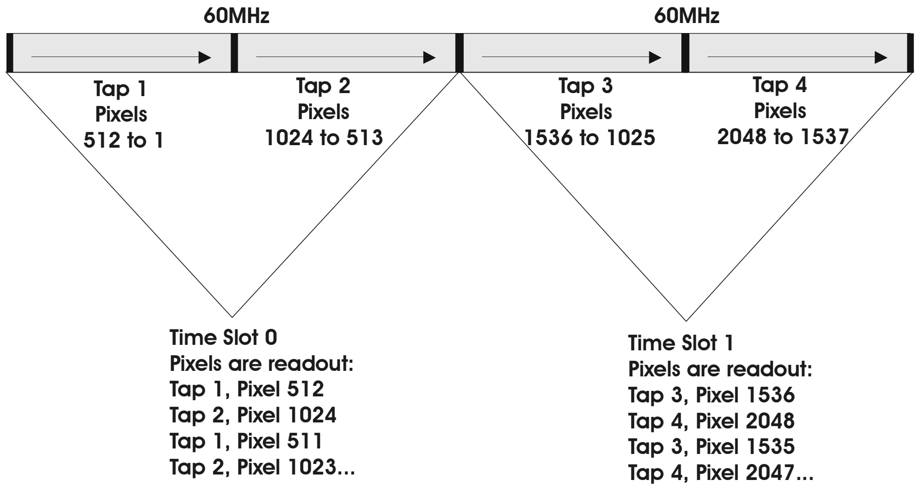


Figure 8: sdm 2 and sdm 3 readout (Base Configuration)



3.6 Selecting the Number of TDI Stages

To set the number of TDI stages, use the command:

Syntax: **`stg i`**

Syntax Elements: ***i***

Number of stages to use. Available values are 16, 24, 32, 48, or 64. Factory setting is 64.

Example: **`stg 32`**

3.7 Setting Exposure Mode and Line Rate

With the Piranha HS 4x cameras, you have a choice of operating in one of two exposure modes. The table below outlines each exposure mode and is followed by instructions on changing the exposure mode and line rate.

Table 6: Piranha HS 4x Exposure Modes

Mode 7 is the factory setting.

Mode	SYNC	Programmable Line Rate	Programmable Exposure Time	Description
3	External	No	No	External SYNC, maximum exposure time (no shuttering)
7	Internal	Yes	No	Internal line rate, no exposure control (factory setting)

To obtain the current value of the exposure mode, use the command **`gcp`**.

Setting Line Rate and Exposure Time

The camera's line rate (synchronization) is generated internally through the software command **ssf** when operating in mode 7, or set externally when operating in mode 3. To select how you want the camera's line rate to be generated:

1. You must first set the camera mode using the **sem** command. Refer to section 3.7.1 Setting the Exposure Mode for details.
2. Next, if using mode 7, use the command **ssf** to set the line rate. Refer to section 3.7.2 Setting Line Rate for details.

3.7.1 Setting the Exposure Mode

Set Exposure Mode Command

To set the exposure mode, use the command:

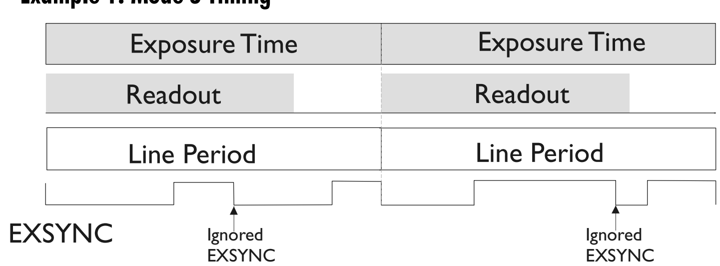
Syntax:	**sem *i***	
Syntax Elements:	***i***	
		Exposure mode to use. Factory setting is 7.
Notes:	•	Refer to Table 6 for a quick list of available modes or to the following sections for a more detailed explanation.
	•	To obtain the current value of the exposure mode, use the command **gcp**.
Related Commands:	**ssf**	
Example:	**sem 3**	

Exposure Modes in Detail

Mode 3: External Trigger with Maximum Exposure

Line 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 beginning of the exposure for the next line.

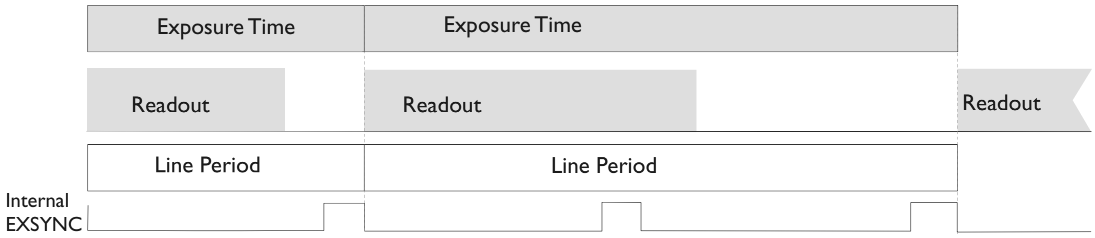
Example 1: Mode 3 Timing



Mode 7: Internal Line Rate, Maximum Exposure Time

In this mode, the line rate is set internally with a maximum exposure time.

Figure 9: Mode 7 Camera Timing



3.7.2 Setting Line Rate

Applies to Mode 7

To set the line rate, use the command:

Syntax:	**`ssf`** ***f***
Syntax Elements:	***i***
	Desired line rate in Hz. Allowable values are 1000 to 51540 if vertical binning is set to 1 (**`sbv 1`**), or 1000 to 48850 if vertical binning is set to 2 (**`sbv 2`**).
Notes:	• To read the current line frequency, use the command **`gcp`**. • If you enter an invalid line rate frequency, an error message is returned.
Related Commands:	**`sem`**
Example:	**`ssf 1005`**

3.8 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.

Setting Horizontal Binning

To set the horizontal binning value, use the command:

Syntax:	**`sbh`** ***i***
Syntax Elements:	***i***
	Horizontal binning value. Available values are 1 (factory setting, no binning) or 2.
Notes:	• If you are using binning (**`sbv 2`** or **`sbh 2`**), the min, max, and mean statistics generated by the **`gl`** or **`gla`** command are for every second pixel only.
Example:	**`sbh 2`**

Setting Vertical Binning

To set the vertical binning value, use the command:

Syntax:	**sbv** ***i***
Syntax Elements:	***i***
	Vertical binning value. Available values are 1 (factory setting, no binning) or 2.
Notes:	• If you are using binning (**sbv 2** or **sbh 2**), the min, max, and mean statistics generated by the **gl** or **gla** command are for every second pixel only.
Example:	**sbv 2**

Figure 10: 2x2 Binning

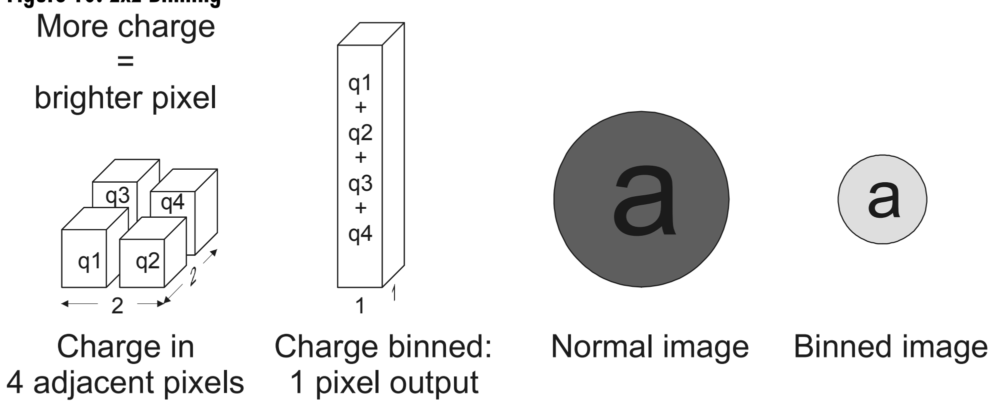


Table 7: Binning vs. Speed

Binning (H x V)	Line Rate (kHz)
1x1	52
1x2	48.5
2x1	52
2x2	48.5

3.9 Setting a Region of Interest

The **roi** command sets the pixel range used to collect the end of line statistic and sets the region of pixels used in the **cag**, **cao**, **gl**, **gla**, **ccf**, and **ccp** commands.

To define a region of interest, use the command:

Syntax: **roi *x1 x2***

Syntax Elements: ***x1***

Pixel start number. Must be an odd number and less than the pixel end number.

x2

Pixel end number. Must be an even number and greater than the pixel start number.

Related Commands

- **cag**, **cao**, **ccf**, **ccp** (see section 3.11 Calibrating the Camera for details on these commands)
- **gl**, **gla** (see section 3.10 Returning Video Information for details on theses commands)

Example: **roi 11 50**

3.10 Returning Video Information

The camera's microcontroller has the ability to read video data. This functionality can be used to verify camera operation and to perform basic testing without having to connect the camera to a framegrabber.

Returning a Single Line of Video

The **gl** command returns a complete line of video (without digital processing or test pattern), displaying one pixel value after another. It also displays the minimum, maximum, and mean value of the line sampled for each tap.

To return a single line of video, use the command:

Syntax: `gl [x1] [x2]`

Syntax Elements:

[*x1*]

Optional parameter. This sets the start pixel to display on screen. Allowable range is 1 to 2048. This parameter does not affect the Min, Max, and Mean statistics generated at the end of the line output.

[*x2*]

Optional parameter. This sets the end pixel to display on screen. Allowable range is (***x1*** + 1) to 2048. This parameter does not affect the Min, Max, and Mean statistics generated at the end of the line output.

Notes:

- If you do not specify a pixel range to display, the line output will display all sensor pixels within the region of interest. The region of interest (**roi**) command is described on page 25.
- If you are using binning (**sbv 2** and / or **sbh 2**), the min, max, and mean statistics are generated for every second pixel only.
- Values returned are in DN.

Example: `gl 10 200`

Returning Multiple Lines of Video

You can also return the average for multiple lines of video data. The number of lines to sample is set and adjusted by the **css** command. The camera displays the Min., Max., and Mean statistics.

To set the number of lines to sample, use the command:

Syntax: `css i`

Syntax Elements:

i

Number of lines to sample. Allowable values are 16, 32, or 64 (factory setting).

Notes:

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

Example: `css 32`

To return the average of multiple lines of video, use the command:

Syntax: **gla [*x1*] [*x2*]**

Syntax Elements: **[*x1*]**

Optional parameter. This sets the start pixel to display on screen. Allowable range is 1 to 2048. This value does not affect the Min, Max, and Mean statistics generated at the end of the line output.

[*x2*]

Optional parameter. This sets the end pixel to display on screen. Allowable range is (***x1*** + 1) to 2048. This value does not affect the Min, Max, and Mean statistics generated at the end of the line output.

Notes:

- If you do not specify a pixel range to display, the line output will display all sensor pixels within the region of interest. The region of interest (**roi**) command is described on page 25.
- If you are using binning (**sbv 2** and / or **sbh 2**), the min, max, and mean statistics are generated for every second pixel only.
- Values returned are in DN.

Example: **gla 10 200**

3.11 Calibrating the Camera

The Piranha HS 4x cameras have the ability to calibrate themselves in order to remove non-uniformity in the image. 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

The two point correction is implemented such that for each pixel:

$V_{output} = (V_{input}$ - FPN(pixel) - digital offset) * PRNU(pixel)

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

The calibration algorithm is performed in two steps. The fixed offset (FPN) is determined first by performing a calibration 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 (balance target) for flat, white output. Video output is set slightly above the brightest pixel (depending on offset subtracted).

For FPN (dark light) the value of all pixels should be between 1DN and 127DN. For PRNU (white light) the recommended value is between 64DN and 254DN. Use the **gl** command to ensure the proper input to the digital processing, V_{input}.

White light calibration will gain up to maximum white light pixel plus the maximum FPN subtract pixel.

When performing any camera calibration, random noise is minimized by averaging out up to 64 lines of valid data. To adjust the sample line size, use the **css *i*** command, where ***i*** is 16, 32, 64 (factory setting). A lower value reduces the camera's calibration time, at the expense of increased coefficient error.

Calibration Steps Overview

1. Set up the camera operating environment (i.e. line rate, exposure,etc.)
2. Perform all analog and digital adjustments described in section 3.11.1 on page 30.
3. Make sure there are suitable calibration targets. The target to calibrate should be a flat field, e.g. plastic or ceramic for white calibration.
4. Set the calibration sample size using the command **css** (see Returning Multiple Lines of Video page 26).
5. Perform Dark (FPN) calibration (see Dark Calibration on page 28).
6. Perform White (PRNU) calibration (see White Light Calibration on page 29).
7. Save settings and pixel coefficients using the commands **wus** and **wpc**.

Note: It is important to do the FPN calibration first. Results of the FPN calibration are used in the PRNU procedure. We recommend that you repeat the calibration when a temperature change greater than 10°C occurs.

Dark Calibration

Dark calibration is used to remove the fixed analog offset from the video path. It is recommended that you repeat the calibration when a temperature change greater than 10°C occurs.

To perform dark calibration:

1.	Stop all light from entering the camera. (Tip: cover lens with a lens cap.)
2.	Verify that output signal level is within range by issuing the command **gl** or **gla** (recommended range is 1-127). If the signal level is too low, adjust the analog offset (**sao**). If the signal level is too high, ensure that no light is entering the camera, reduce the analog offset or reduce the gain level (**sg**).
3.	Issue the command **ccf**. The camera will respond with OK> if no error occurs. Dark calibration automatically calibrates FPN coefficients and digital offset. **To perform a dark calibration with an analog offset value:** Use the **ccf [*i*]** command, where ***i*** is the analog offset DN. When the optional parameter is provided, this command sets the analog offset first to ***i*** before calculating the FPN coefficients range from 1 to 100DN for 8-bit data mode, and 4 to 400DN for 10-bit data mode for the specified region of interest. If value is left blank, current offset values are used.

4. After the calibration is complete, you can save these settings, and the PRNU coefficients, to non-volatile memory so they will be remembered after power-down. To do so, issue the command **`wpc`**.

White Light Calibration

White light calibration is more complex than dark calibration because the camera attempts to create a flat white image. This calibration corrects PRNU effects as well as non-uniform lighting and lens vignetting affects.

White light calibration 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.

There are several restrictions that must be met in order for the calibration to succeed:

1. The camera is sufficiently sensitive to detect 60 Hz ambient light flicker which may affect camera performance and calibration results.

2. The light level should be set so that all pixels are between 64DN and 254DN, otherwise a warning will be sent stating that the camera could not calibrate all pixels to the same level. Use the **`gl`** command to determine input level. If the signal level is too low or too high, adjust analog gain using the command **`sg`**.

3. The variance in light intensity across the target must not be more than 4 to 1. Because the maximum per-pixel digital gain is 4x, the camera will not be able to compensate for extremely non-uniform light.

These restrictions are all tested within the calibration algorithm and the camera will report an informal message code if any of these conditions could not be met.

To perform a white light calibration:

1. Place a white reference in front of the camera.

2. Verify that output signal level is within range by issuing the command **`gl`** or **`gla`** (recommended range is 128-254). If signal level is too low or too high, adjust the gain using the command **`sg`**.

3. Instruct the camera to perform a white light calibration using the command **`ccp`**. The camera will respond with OK> if no error occurs.

   To perform a white light calibration with an analog gain value:

   Use the **`ccp [i]`** command. When the optional parameter is provided the analog gain is adjusted to produce an average white pixel level that is equivalent to the parameter. This command sets the analog gain first to ***i*** before calculating the PRNU coefficients range from 64 to 251DN for 8-bit data mode, and 256 to 1007DN for 10-bit data mode. If value is left blank, current gain values are used.

4. After the calibration is complete, you can save these settings to non-volatile memory so they will be remembered after power-down. To do so, issue the command **`wpc`**.

Returning Calibration Results and Errors

After calibration, you can retrieve the results using the command **dpc.** This function returns all the pixel coefficients in the order FPN, PRNU, FPN, PRNU… The camera also returns the pixel number with each coefficient.

To set a range for the returned coefficients provide an optional pixel start and end value:

Example: display pixel coefficient from pixel 10 to 20

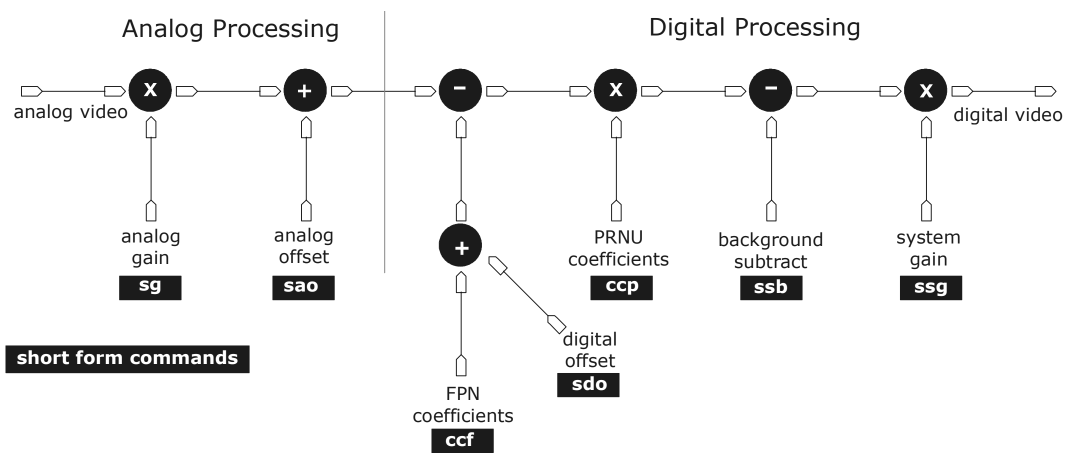
```
dpc 10 20
```

The command **gcp** returns all other settings.

3.11.1 Analog and Digital Processing Chain

The figure below is a simplified block diagram of the camera's processing chain. The analog processing chain contains two elements–a gain stage and an offset stage. The digital processing chain contains the FPN correction, PRNU correction, background subtract, and a system gain stage. The software commands allow you to set and change all the elements of the processing chain. This enables maximum processing flexibility depending on your requirements.

Figure 11: Signal Processing Chain



Analog Signal Processing

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

Setting Analog Gain

To set the analog gain portion of the camera, use the command:

Syntax: `sg t i`

Syntax Elements:

t

Tap value. Use 0 for all taps or 1 to 4 for individual tap selection.

i

Gain setting. Allowable range is –10 to 10dB. For nominal gain, set to 0.

Example: `sg 0 2`

Setting Analog Offset

To set the analog offset of the camera, use the command:

Syntax: `sao t i`

Syntax Elements:

t

Tap selection. Allowable range is 1 to 4, or 0 for all taps.

i

Analog offset value. Allowable range is 0 to 1023.

Notes:

- The offset increases linearly with higher values. A value of 100 does **not** equal an offset of 100DN.
- The resulting analog offset value depends on other camera parameters such as temperature, line rate, and gain.

Example: `sao 0 200`

Subtracting Offset or Background

To subtract the video scene offset or any other background from the output video signal, use the command:

Syntax: `ssb t i`

Syntax Elements:

t

Tap selection. Allowable range is 1 to 4, or 0 for all taps.

i

Subtracted value in a range from 0 to 511.

Notes:

- When subtracting a digital value from the digital video signal the output can no longer reach its maximum. Use the **`ssg`** command to correct for this. See page 32 for details on the **`ssg`** command.

Example: `ssb 0 20`

Digital Signal Processing

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

Setting Digital Gain for Tap to Tap Matching

The set system gain command allows you to adjust all taps at once, or each tap individually for precise control over tap-to-tap matching. For a better signal to noise ratio, perform digital gain adjustments after analog gain adjustments.

To set the digital gain, use the command:

Syntax: `ssg t i`

Syntax Elements: *t*

Tap value. Use 0 for all taps or 1-4 for individual tap selection.

i

0-511. 0 corresponds to low gain (1x). 511 corresponds to high gain (2x).

Example: `ssg 0 20`

Subtracting Digital Offset

To subtract the A/D offset from the video signal, use the command:

Syntax: `sdo t i`

Syntax Elements: *t*

Tap selection. Allowable range is 1 to 4, or 0 for all taps.

i

Subtracted offset value in a range from 0 to 511.

Notes:

- When subtracting a digital value from the digital video signal, the output can no longer reach its maximum
- Digital offset is recalculated after sending the **ccf** command. See the Dark Calibration description on page 28 for more information on the **ccf** command.

Example: `sdo 0 100`

3.11.2 Calibrating Analog Offset and Analog Gain Values

Instead of manually setting the analog offset to a specific value, you can have the camera determine the offset value by providing the camera with an average output level to use.

Calibrating Gains

To calibrate the analog gain, use the command:

Syntax: `cag t i`

Syntax Elements: *t*

Tap value. Use 0 for all taps or 1 to 4 for individual tap selection.

i

Line average in a range dependent on the current camera data mode setting. See table below.

Notes:

- See section 3.10 Returning Video Information for more information on line averages
- This function requires constant light input while executing.

Example: `cag 0 155`

Table 8: Data Mode Line Averages

Data Mode	Line Average Value Range
8-bit	64 to 251DN
10-bit	256 to 1007DN

Calibrating Analog Offset

To calibrate the analog offset:

Syntax: `cao t i`

Syntax Elements: *t*

Tap selection. Allowable range is 1 to 4, or 0 for all taps.

i

The line average in a range from 0 to 1023DN.

Notes:

- See section 3.10 Returning Video Information for more information on line averages

Related Commands: `gla, gl`

Example: `cag 1 156`

3.11.3 Loading, Resetting, Enabling, and Disabling Pixel Coefficients

After pixel coefficients have been saved to non-volatile memory using the **`wpc`** command, you can reload them. This is useful when you have made unwanted changes to pixel coefficients.

To load the FPN and PRNU coefficients, use the command:

Syntax: **`lpc`**

You can also reset all pixel coefficients to zero.

To reset pixel coefficients to zero, use the command:

Syntax: **`rpc`**

You can also disable or enable PRNU and / or FPN pixel coefficients.

To enable or disable PRNU and/or FPN coefficients, use the command:

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 1 0`**

3.11.4 Setting and Reading a Pixel's PRNU and FPN Coefficient

You can set or read an individual pixel's PRNU and FPN coefficient

PRNU Coefficients

To set the PRNU coefficient, use the command:

Syntax: `spc` *`i i`*

Syntax Elements: *`i`*

The pixel number from 1 to 2048.

`i`

Coefficient value in a range from 0 to 1023.

Example: `spc 10 50`

To read the PRNU coefficient, use the command:

Syntax: `gpc` *`i`*

Syntax Elements: *`i`*

The pixel number to read in a range from 1 to 2048.

Example: `gpc 10`

FPN Coefficients

To set the FPN coefficient, use the command:

Syntax: `sfc` *`i i`*

Syntax Elements: *`i`*

The pixel number from 1 to 2048.

`i`

Coefficient value in a range from 0 to 63.

Example: `sfc 10 50`

To read the FPN coefficient, use the command:

Syntax: `gfc` *`i`*

Syntax Elements: *`i`*

The pixel number to read in a range from 1 to 2048.

Example: `gfc 10`

3.12 System Debugging

Setting the Video Mode and Displaying a Test Pattern

Use the test pattern to verify the proper timing and connections between the camera and the framegrabber.

The test patterns are:

- With 8 bit data, each tap has two ramps from 0 to 255 starting with pixel 1.
- With 10 bit data, each tap has two ramps from 0 to 255 starting with pixel 1 with a unique offset for each tap.

  Tap 1 offset is 0 DN

  Tap 2 offset is 256 DN

  Tap 3 offset is 512 DN

  Tap 4 offset is 768 DN

To set the video mode, use the command:

Syntax:	**svm** ***i***	
Syntax Elements:	***i***	
	0	Video mode
	1	Generate a test pattern

End-of-line Sequence

To further aid debugging, the camera can generate an end-of-line sequence. The end-of-line sequence outputs "aa", "55", "line counter", "line average", "pixels above threshold", and "pixels below threshold".

To activate or deactivate the end-of-line sequence, use the command:

Syntax:	**els** ***i***	
Syntax Elements:	***i***	
	0	Deactivate the end-of-line sequence.
	1	Activate the end-of-line sequence.
Example:	**els 1**	

Setting Thresholds

To set a lower threshold value that is checked for and reported in the end-of-line statistic, use the command:

Syntax: `slt i`

Syntax Elements: *i*

Lower threshold value. Available values are 0 to 255 for 8 bit more or 0 to 1023 for 10 bit mode.

Example: `slt 550`

To set an upper threshold value that is checked for and reported in the end-of-line statistic, use the command:

Syntax: `sut i`

Syntax Elements: *i*

Upper threshold value. Available values are 0 to 255 for 8 bit mode or 0 to 1023 for 10 bit mode.

Example: `sut 1000`

3.13 Monitoring Tasks

The camera enters a warning state when any of the camera's continuously running monitoring tasks detect a failure. Use the **wed** command to display the status of all the defined monitory tasks (if no parameter is passed) and / or to enable / disable specific monitoring tasks. Table 9 below lists the monitoring tasks.

Note: By default, all monitoring tasks are disabled.

Table 9: Piranha HS 4x Monitoring Tasks

Parameters	Monitoring Task	Description
0 0	All	Disables all monitoring tasks.
0 1		Enables all monitoring tasks.
1 0	Voltage	Monitors all camera voltages.
1 1		Disables monitoring of camera voltages.
2 0	Temperature	Monitors camera temperature.
2 1		Disables monitoring of camera temperature.
3 0	External Sync	Monitors the external sync signal.
3 1		Disables monitoring of the external sync signal.
4 0	Gain out of spec	Monitors current setting of analog gain.
4 1		Disables monitoring of analog gain setting.

Example:

To enable all monitoring tasks:

```
wed 0 1
```

Voltage Measurement

The command **vv** checks some of the camera's input voltages and internal voltages during power-up. If they are within the proper range, the camera returns OK>. Otherwise, the camera returns an error message. Note that the voltage measurement feature of the camera provides only approximate results (typically within 10%). They should not be used to set the applied voltage to the camera. The purpose of this test is to isolate gross problems with the supply voltages.

Temperature Measurement

The command **vt** measures and displays the temperature of the inside of the camera. It helps to determine whether the camera is operating within the recommended front plate temperature range of 10 to 50°C.

3.14 Rebooting the Camera

The command **rc** reboots the camera. The camera starts up with the last saved settings.

4

Optical and Mechanical Considerations

4.1 Mechanical Interface

Figure 12: Piranha HS 4x Mechanical Drawing

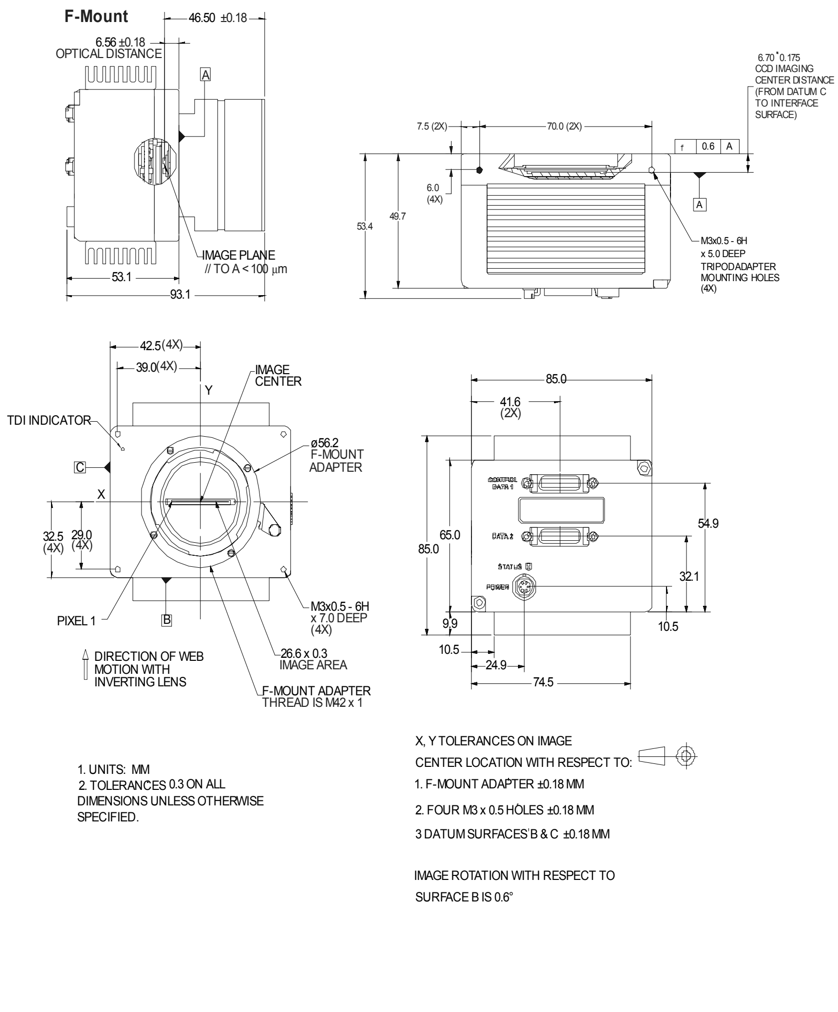
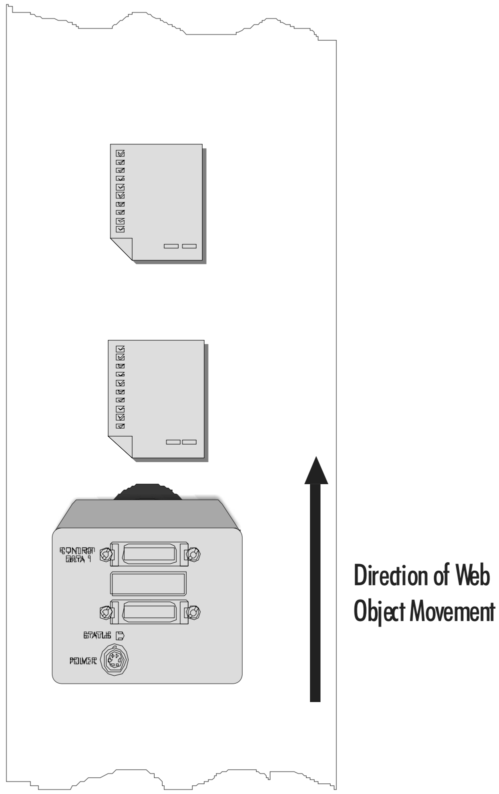


Figure 13: Direction of Web Movement using an Inverting Lens



4.2 Optical Interface

Lens Mounts

All F-mount adapters have the appropriate back focal distance for the lens type being used. Ensure that the image circle diameter of the lens to be used is as great as the length of the imaging region. The following table provides information regarding the lens mount used and the back focal distance. Distances to its inner flat surface and the outer flat surface are provided.

Table 10: Lens Mounts

Mount	Back Focal Distance (sensor die to adapter)
F-Mount	46.50 ±0.18
M42 x 1	6.56mm ±0.18—outer flat surface

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 Vision for Machines 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 HS-41 camera.
- Halogen light sources generally provide very little blue relative to 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

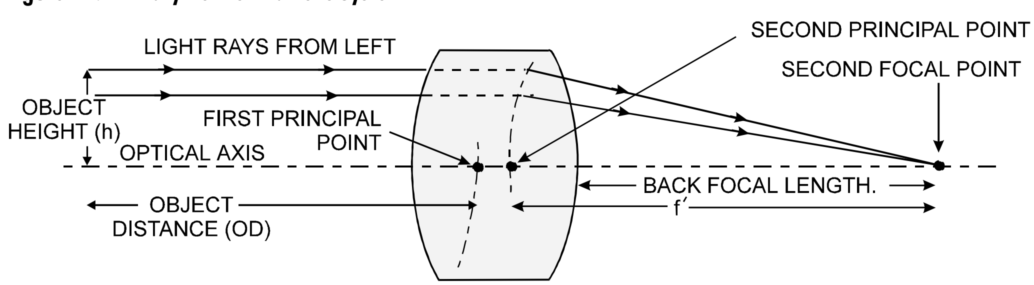
CCD cameras are extremely responsive to infrared (IR) wavelengths of light. To prevent infrared from distorting the images you scan, use a "hot mirror" or IR cutoff filter that transmits visible wavelengths but does not transmit wavelengths over 750nm. Examples are the Schneider Optics™ B+W 489, which 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 14: Primary Points in a Lens System



Magnification and Resolution

The magnification of a lens is the ratio of the image size to the object size:

$$m = \frac{h'}{h}$$

where m is the magnification, h' is the image height (pixel size) and h is the object height (desired object resolution size).

By similar triangles, the magnification is alternatively given by:

$$m = \frac{f'}{OD}$$

These equations can be combined to give their most useful form:

$$\frac{h'}{h} = \frac{f'}{OD}$$

This is the governing equation for many object and image plane parameters.

Example: An acquisition system has a 512 x 512 element, 10µm pixel pitch area scan camera, a lens with an effective focal length of 45mm, and requires that 100µm in the object space correspond to each pixel in the image sensor. Using the preceding equation, the object distance must be 450mm (0.450m).

$$\frac{10\mu m}{100\mu m} = \frac{45mm}{OD} \qquad OD = 450mm\,(0.450m)$$

5

Troubleshooting

The information in this chapter can help you solve problems that may occur during the setup of your camera. Remember that the camera is part of the entire acquisition system. You may have to troubleshoot any or all of the following:

- power supplies
- framegrabber hardware & software
- light sources
- operating environment
- cabling
- host computer
- optics
- encoder

Your steps in dealing with a technical problem should be:

1. Try the general and specific solutions listed in sections 5.1, 5.2 and 5.3.
2. If these solutions do not resolve your problem, see section 5.4 on getting product support.

5.1 Common Solutions

Connections

The first step in troubleshooting is to verify that your camera has all the correct connections.

Power Supply Voltages

Check for the presence of all voltages at the camera power connector. Verify that all grounds are connected.

Data Clocking/Output Signals

To validate cable integrity, have the camera send out a test pattern and verify it is being properly received. Refer to section 3.12 for further information.

5.2 Troubleshooting Using the Serial Interface

The following commands can aid in debugging. (The complete command protocol is described in Appendix B.)

Communications

To quickly verify serial communications send the **h** (help) command. By sending the **h** and receiving the help menu, the serial communications are verified. If further problems persist, review Appendix B for more information on communications.

Verify Parameters

To verify the camera setup, send the **gcp** (get camera parameters) command.

Verify Factory Calibrated Settings

To restore the camera's factory settings, send the **rfs** command.

After executing this command, send the **gcp** command to verify the factory settings.

Verify Timing and Digital Video Path

Use the test pattern feature to verify the proper timing and connections between the camera and the framegrabber and verify the proper output along the digital processing chain.

Verify Voltage

To check the camera's input voltages and internal voltages, use the **vv** command. If they are within the proper range, the camera returns OK>. Otherwise, the camera returns an error message. If an error occurs, verify the input voltage at the camera. If a problem still persists, contact Technical Support. See section 5.4 Product Support for contact information.

5.3 Specific Solutions

No Output or Erratic Behavior

If your camera provides no output or behaves erratically, it may be picking up random noise from long cables acting as antennae. Do not attach wires to unused pins. Verify that the camera is not receiving spurious inputs (e.g. EXSYNC, if camera is using an internal signal for synchronization).

Line Dropout, Bright Lines, or Incorrect Line rate

Verify that the frequency of the internal sync is set correctly.

Noisy Output

Check your power supply voltage outputs for noise. Noise present on these lines can result in poor video quality. Low quality or non-twisted pair cable can also add noise to the video output.

Dark Patches

If dark patches appear in your output, the optics path may have become contaminated. Clean your lenses and sensor windows with extreme care.

1. Take standard ESD precautions.
2. Wear latex gloves or finger cots.
3. Blow off dust using a filtered blow bottle or dry, filtered compressed air.
4. Fold a piece of optical lens cleaning tissue (approx. 3" x 5") to make a square pad that is approximately one finger-width.
5. Moisten the pad on one edge with 2-3 drops of clean solvent—either alcohol or acetone. Do not saturate the entire pad with solvent.
6. Wipe across the length of the window in one direction with the moistened end first, followed by the rest of the pad. The dry part of the pad should follow the moistened end. The goal is to prevent solvent from evaporating from the window surface, as this will end up leaving residue and streaking behind.
7. Repeat steps 2-4 using a clean tissue until the entire window has been cleaned.
8. Blow off any adhering fibers or particles using dry, filtered compressed air.

Horizontal Lines or Patterns in Image

A faulty or irregular encoder signal that is applied as the EXSYNC signal may result in horizontal lines due to exposure time fluctuations; ensure that your exposure time is regular. If you have verified that your exposure time is consistent and patterns of low frequency intensity variations still occur, ensure that you are using a DC or high frequency light source.

5.4 Product Support

If there is a problem with your camera, collect the following data about your application and situation and call your DALSA representative.

Note: You may also want to photocopy this page to fax to DALSA.

Customer name	
Organization name	
Customer phone number **fax number**	
Complete Product Model Number (e.g. HS-41-02K30...)	
Complete Serial Number	
Your DALSA Agent or Dealer	
Acquisition System hardware (framegrabber, host computer, light sources, etc.)	
Acquisition System software (version, OS, etc.)	
Power supplies and current draw	
Data rate used	
Control signals used in your application, and their frequency or state (if applicable)	☐ EXSYNC ☐ BIN ☐ MCLK ☐ Other _______
Results when you run the `gcp` command	*please attach text received from the camera after initiating the command*
Detailed description of problem encountered.	*please attach description with as much detail as appropriate*

In addition to your local DALSA representative, you may need to call DALSA Technical Sales Support:

	North America	Europe	Asia
Voice:	519-886-6000	+49-8142-46770	519-886-6000
Fax:	519-886-8023	+49-8142-467746	519-886-8023

Appendix A

Camera Link™ Reference and Configuration Table

Camera Link is a communication interface for vision applications.

For years, the scientific and industrial digital video market has lacked a standard method of communication. Both framegrabber and camera manufacturers developed products with different connectors, making cable production difficult for manufacturers and very confusing for consumers. Increasingly diverse cameras and advanced signal and data transmissions have made a connectivity standard like Camera Link a necessity.

LVDS Technical Description

Low Voltage Differential Signaling (LVDS) is a high-speed, low-power general purpose interface standard. The standard, known as ANSI/TIA/EIA-644, was approved in March 1996. LVDS uses differential signaling, with a nominal signal swing of 350mV differential. The low signal swing decreases rise and fall times to achieve a theoretical maximum transmission rate of 1.923 Gbps into a loss-less medium. The low signal swing also means that the standard is not dependent on a particular supply voltage. LVDS uses current-mode drivers, which limit power consumption. The differential signals are immune to ±1 V common volt noise. Camera Link uses an implementation of LVDS technology called Channel Link®.

Camera Signal Requirements

This section provides definitions for the signals used in the Camera Link interface. The standard Camera Link cable provides camera control signals, serial communication, and video data.

Video Data

The Channel Link technology is integral to the transmission of video data. Image data and image enable signals are transmitted on the Channel Link bus. Four enable signals are defined as:

- FVAL—Frame Valid (FVAL) is defined LOW for valid lines.
- LVAL—Line Valid (LVAL) is defined HIGH for valid pixels.
- DVAL—Data Valid (DVAL) is defined HIGH when data is valid.
- Spare— A spare has been defined for future use.

All four enable signals must be provided by the camera on each Channel Link chip. All unused data bits must be tied to a known value by the camera. For more information on image data bit allocations, refer to the official Camera Link specification on the vfm.dalsa.com Web site.

Camera Control Signals

Four LVDS pairs are reserved for general-purpose camera control. They are defined as camera inputs and framegrabber outputs. Camera manufacturers can define these signals to meet their needs for a particular product. DALSA has defines these signals

Table 11: Standard DALSA Naming Conventions

DALSA Standard	Camera Link Name	HS-41 Configuration
EXSYNC	CC1	EXSYNC
PRIN	CC2	SPARE
FORWARD	CC3	SPARE
SPARE	CC4	SPARE

Communication

Two LVDS pairs have been allocated for asynchronous serial communication to and from the camera and framegrabber. Cameras and framegrabbers must support 9600 baud, as a minimum requirement. These signals are

• SerTFG—Differential pair with serial communications to the framegrabber.

• SerTC—Differential pair with serial communications to the camera.

The serial interface will have the following characteristics: one start bit, one stop bit, no parity, and no handshaking. It is recommended that framegrabber manufacturers supply both a user interface and a software application programming interface (API) for using the asynchronous serial communication port. The user interface will consist of a terminal program with minimal capabilities of sending and receiving a character string and sending a file of bytes. The software API will provide functions to enumerate boards and send or receive a character string. See Appendix B in the Official Camera Link specification on the vfm.dalsa.com Web site.

Power

Power will not be provided on the Camera Link connector. The camera will receive power through a separate cable. DALSA defines our own power connector, current, and voltage requirements.

Camera Link Video Timing

Figure 15. HS-41 Overview Timing Showing Input and Output Relationships

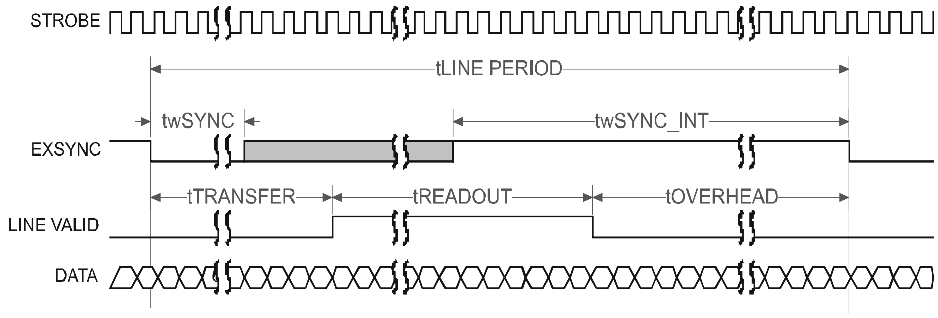


Table 12: HS-41 Timing Values

Symbol	Definition	Value (µs)
twSYNC	The minimum low width of the EXSYNC pulse.	0.33
twSYNC_INT	The minimum width of the high pulse	0.33
tLINE PERIOD (t LP)	The minimum and maximum line times made up of tTransfer, tREADOUT plus tOVERHEAD to meet specifications.	18.83
tTransfer	The time from the reception of the falling edge of EXSYNC to the rising edge of LVAL.	1.2
tREADOUT	Is the number of pixels per tap times the readout clock period.	17.060
tOVERHEAD	Is the number of pixels that must elapse after the falling edge of LVAL before the EXSYNC signal can be asserted.	0.57

Camera Link™ Configuration Table

The following table provides tap reconstruction information. DALSA is working with the machine vision industry to use this table as the basis for auto configuration. Visit the http://vfm.dalsa.com Web site and view the DALSA Camera Link Implementation Road Map document, 03-32-00450, for further details.

Piranha HS 4x Interface Parameters

Table 13: Framegrabber Interface Parameters

Item (when programmable configuration the options are separated with a |)	Piranha HS 4x
Imager Dimension <1,2 or 1|2>	1
Imager Columns<number of active columns, X>	2048
Imager Rows<number of active rows, Y> Line Scan/TDI are defined as 1	1
Number of Imager Taps <1,2,3…..>	4
Tap Clock Rate <xx MHz>	30

Item (when programmable configuration the options are separated with a |)	Piranha HS 4x
Camera Standard <NTSC, PAL, VS, VW, MW>	VS
Number of Camera Configurations<1,2,3,…>	4
Configuration Definition Cx= HDW, Number of Output Taps, Bit Width, Number of Processing Nodes where Cx is the configuration ID x is <1,2,3…> HDW is <Base, Medium, Full> Number of Output Taps is <1,2,3…> Bit width is <8, 10,12…> Number Processing Nodes is <1 or 2>	C1 = Base 4, 8,1 C2 = Base, 4 , 10, 1 C3 = Medium, 4, 8, 1 C4 = Medium, 4 , 10, 1 See section 3.5 Setting the Data Mode for details on changing the camera configuration.
Tap Reconstruction In some configurations the reconstruction may change. C0 is the default output format and must be listed. Output configurations that don't conform are listed separately. <Cx,Tn (Column Start, Column End, Column Increment, Row Start, Row End, Row Increment>	C0, T1 (512, 1, -1, 1, 1, 1) C0, T2 (1024, 513, -1, 1, 1, 1) C0, T3 (2047, 1536, -1, 1, 1, 1) C0, T4 (2048, 1537, -1, 1, 1, 1)
Camera Color <Hybrid, Mono, Pattern, Solid>	Mono
RGB Pattern Size <(T1,Columns*Rows)(T2, Columns*Rows)(T3,Columns*Rows….>	(T1, 1*1) (T2, 1*1) (T3, 1*1) (T4, 1*1)
Color Definition (Column, Row, Color) Where color is R,G,B	T1=(1,1,M) T2=(1,1,M) T3=(1,1,M) T4=(1,1,M)
Row Color Offset <0,1,2,3…>	0
Column Color Offset <0,1,2,3…>	0
Row Binning Factor <1,2,3 or 1|2|3>	1|2
Column Binning Factor <1,2,3 or 1|2|3>	1|2
Pretrigger Pixels <0,1,2…or 0..15>	0
Pretrigger Lines <0,1,2.. or 0..15>	0
Line Time Minimum <xx ms>	1
Line Time Maximum <xx µs>	19.2
Internal Line/Frame Time Resolution <xx ns> 0 if not applicable	33.3
Pixel Reset Pulse Minimum Width <xx ns> 0 if not applicable	N/A
Internal Pixel Reset Time Resolution <xx ns> 0 if not applicable	N/A
Pixel Reset to Exsync Hold time <xx ns>	N/A
BAUD Rate <9600….>	9600, 19200, 57600, 115200
CC1 <Exsync>	Exsync
CC2 <Spare>	Spare
CC3 <Forward, Spare>	Spare

<table>
<tr><th>Item (when programmable configuration the options are separated with a |)</th><th>Piranha HS 4x</th></tr>
<tr><td>CC4 <Spare></td><td>Spare</td></tr>
<tr><td>DVAL out <Strobe Valid, Alternate></td><td>Strobe Valid</td></tr>
<tr><td>LVAL out <Frame Valid, Alternate></td><td>Line Valid</td></tr>
<tr><td>Spare out <Spare></td><td>Spare</td></tr>
<tr><td>FVAL out</td><td>Tied High</td></tr>
</table>

Appendix B

Command Reference

When entering commands, remember that:

- A carriage return (CR) ends each command. The linefeed character is ignored.
- Values in square brackets are optional.
- The camera will answer each command with either a carriage return <CR> and line feed <LF> followed by "OK >" or "Error x: Error Message >". The ">" is always the last character sent by the camera.
- The following parameter conventions are used:

  t = tap id
  i = integer value
  f = real number
  x1 = pixel start number
  x2 = pixel end number
  [ ] = optional parameter

Serial Protocol Defaults:

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

B1 All Available Commands

Parameters:
t = tap id
i = integer value
f = real number
x1 = pixel start number
x2 = pixel end number
[ ] = optional parameter

Table 14: All Available Commands

Command Function	Syntax	Parameters	Command and Parameter Description
calibrate analog gain	**cag**	**t i**	Calibrates the analog offset. **t** = Tap value. **0** for all taps or **1-4** for individual tap selection. **i**= Line average in a range dependent on the current camera data mode. **64** to **251** DN for 8 bit mode or **256** to **1007** DN for 10 bit mode.
calibrate analog offset	**cao**	**t i**	Calibrates the analog offset. **t** = Tap value. **0** for all taps or **1-4** for individual tap selection. **i**= Target value from **1** to **100** DN for 8 bit mode and **4** to **400** DN for 10 bit mode.
correction calibrate FPN	**ccf**	**[i]**	Start FPN coefficient calibration. Use **css** to set sample size. Values range from **1** to **100** DN for 8-bit mode and **4** to **400** DN for 10-bit.
correction calibrate PRNU	**ccp**	**[i]**	Start PRNU coefficient calibration. Use **css** to set sample size. Values range from **64** to **251** DN for 8-bit mode and **256** to **1007** DN for 10-bit.
correction set sample	**css**	**i**	Sets the number of line samples averaged when using the **gl** and **gla** commands. **i**= **16**, **32**, **64** (factory setting)
display pixel coefficients	**dpc**	**[i i]**	Display the pixel coefficients in the order FPN, PRNU, FPN, PRNU, … Optional pixel start and end values in a range from 1 to sensor pixel count.
end of line sequence	**els**	**i**	Sets whether to use an end of line sequence where **i** is: **0** = End of line sequence disabled **1** = End of line sequence enabled (factory setting)
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

Command Function	Syntax	Parameters	Command and Parameter Description
get camera model	**gcm**		Returns the camera's model.
get camera parameters	**gcp**		Read 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 FPN coefficient	**gfc**	**i**	Read the FPN coefficient.
get line	**gl**	**[x1 x2]**	Get 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. **[x1]** = Optional pixel start number to display on screen. Allowable range is **1** to **2048**. **[x2]** = Optional pixel end number to display on screen. Allowable range is **x1+1** to **2048**.
get line average	**gla**	**[x1 x2]**	Read the average of multiple line samples. Use **css** to set sample size. **[x1]** = Optional pixel start number to display on screen. Allowable range is **1** to **2048**. **[x2]** = Optional pixel end number to display on screen. Allowable range **x1+1** to **2048**.
get PRNU coefficient	**gpc**	**i**	Read the PRNU coefficient.
get sensor serial	**gss**		Display the sensor's serial number.
help	**h**		Display the online help.
load pixel coefficients	**lpc**		Loads the previously saved pixel coefficients from non-volatile memory.
reset camera	**rc**		Reset the entire camera (reboot).
restore factory settings	**rfs**		Restore the camera's factory settings.
region of interest	**roi**	**x1 x2**	Set the pixel range for reading end-of-line statistic and for the region of pixels used in the **cag**, **cao**, **gl**, **gla**, **ccf**, and **ccp** commands. The parameters are the pixel start (**x1**) and end (**x2**) values in a range from 1 to sensor pixel count.
reset pixel coefficients	**rpc**		Resets all pixel coefficients to zero.
restore user settings	**rus**		Restore the camera's last saved user settings.

Command Function	Syntax	Parameters	Command and Parameter Description
set analog offset	**sao**	**t i**	Sets the analog offset. **t** = Tap value. **0** for all taps or **1-4** for individual tap selection. **i**= Controls the digital analog converter (DAC) in a range from **0** to **1023**, that sets analog offset. Offset increases with higher values.
set binning horizontal	**sbh**	**i**	Sets the horizontal binning factor. **i** = **1** (factory setting) or **2**
set binning vertical	**sbv**	**i**	Sets the vertical binning factor. **i** = **1** (factory setting) or **2**
set baud rate	**sbr**	**i**	Sets the speed (baud rate) of the camera serial communication port. **i**= **9600**, **19200**, **57600**, and **115200**. Power up baud is always 9600.
set data mode	**sdm**	**i**	Sets the data mode of the camera where **i** is: **0** = 8 bit, A/B/C/D ports, single processor **1** = 10 bit, A/B/C and D/E/F ports, single processor **2** = 8 bit, A/B, time multiplexed **3** = 10 bit A/B/C, time multiplexed
set digital offset	**sdo**	**t i**	Subtracts the input value from the video signal prior to the PRNU correction. The first parameter is the tap selection **1** to **4**, **0** for all taps. The second parameter is the offset in a range from **0** to **511**.
set exposure mode	**sem**	**i**	Sets the exposure mode to use where **i** is: **3 =** External SYNC, maximum exposure time (no shuttering). **7 =** Internal programmable SYNC, maximum exposure time. Factory setting.
Set FPN coefficient	**sfc**	**i i**	Sets an individual pixel's coefficient value. **i** = The pixel to set in range from **1** to **2048**. **i** = The coefficient value to set in a range from **0** to **63**.
set gain	**sg**	**t f**	Sets the analog gain. **t**= Tap value. 0 for all taps or **1-4** for individual tap selection. **f**= Analog gain setting in a range from **–10** to **10**dB.

Command Function	Syntax	Parameters	Command and Parameter Description
set lower threshold	**slt**	**i**	Sets the lower threshold value that is checked for and reported in the end-of-line statistic. **i**= Lower threshold value with a range from **0** to **255** DN for 8 bit data modes, and **0** to **1023** DN for 10 bit data modes.
set prnu coeff	**spc**	**i i**	Set the PRNU coefficient. The first parameter is the pixel number within the range **1 to 2048**. The second parameter is a specified value within the range **0 to 511** DN.
set subtract background	**ssb**	**t i**	Subtracts the input value from the output signal. **t**= Tap value. **0** for all taps or **1-4** for individual tap selection. **i**= The second parameter is the subtracted value in a range from **0** to **511**.
set sync frequency	**ssf**	**f**	Sets the line rate, in exposure mode 7, to a value from **1000** to **51540** Hz when operating in **sbv 1** or **1000** to **48850** Hz when operating in **sbv 2**.
set system gain	**ssg**	**t i**	Sets the digital gain. **t**= Tap value. **0** for all taps or **1-4** for individual tap selection. **i**= Gain value in a range from **0** to **511**.
stage select	**stg**	**i**	Sets the number of TDI stages to use. **i** = **16**, **24**, **32**, **48**, or **64**. Factory setting is 64.
set upper threshold	**sut**	**i**	Sets the upper threshold value that is checked for and reported in the end-of-line statistic. **i**= **0** to **255** DN in 8 bit mode, or **0** to **1023** DN in 10 bit mode.
set video mode	**svm**	**i**	Sets the video mode, where **i** is: **0**= Video mode **1**= Test pattern
verify temperature	**vt**		Checks the internal temperature of the camera.
verify voltage	**vv**		Checks the camera voltages and returns OK or error message.
warning enabled disabled	**wed**	**[i i]**	Reads or enables / disables the status of all defined monitoring tasks. **[i]** = Selects a specific monitoring task. **[i]** = Enables or disables the selected task. For more information, see section 3.13 Monitoring Tasks.

Command Function	Syntax	Parameters	Command and Parameter Description
write pixel coeffs	`wpc`		Write all current pixel coefficients to EEPROM.
write user settings	`wus`		Writes all of the user settings to the EEPROM.

B2 Error Handling

The following tables list the codes for errors, informal messages, and monitoring task messages.

Error Codes		
Code	**Description**	**Suggested Cause**
0	Command executed successfully	Command executed without major error detected
1	Internal camera error (PIXEL INDEX)	Internal software error trap
2	Internal camera error (RESULT CODE)	Internal software error trap
3	Invalid command	Command not recognized
4	Command parameters incorrect or out of range	Command parameters are invalid or out of range
5	Command not available in current mode	ssf is unavailable in mode 3
8	Command not available in VIDEO TEST mode	sao, sg
10	Camera memory check failure	Memory test of external RAM failed
11	Unable to configure DSP	DSP (FPGA) configuration failure
12	DSP configuration reset failure	DSP (FPGA) could not be placed in configuration mode
13	Get line process command timed out, check for the presence of external signals	gl,gla,cao,cag timed out. Current exposure mode requires external SYNC, however SYNC signal not present
14	DSP echo test error	DISC bus communication test failure
15	Invalid sensor configuration (DSP)	Invalid sensor configuration read from DSP (FPGA)
16	Invalid sensor configuration (ADC)	Invalid sensor configuration encoding on the board
17	Sensor configuration mismatch	Sensor configuration read from DSP is different than one encoded on the board
18	One (or more) of the supply voltages is out of specification	vv command result
19	The camera's temperature is outside the specified operating range	vt command result
21	Analog offset calibration failure	Analog offset calibration failure (could not tune the analog offset to obtain targeted

Error Codes		
Code	**Description**	**Suggested Cause**
		video level)
22	Analog gain calibration failure	Analog gain calibration failure (could not tune the analog gain to obtain targeted video level)
23	CRC check failure while attempting to restore the camera settings	Camera setting will initialize to default settings, since restore of USER/FACTORY settings failed (internal micro EE memory failure)
24	Camera settings not saved	rus, rfs attempted but settings were not saved
26	I2C communication fault while accessing temperature sensor	Serial communication fault (I2C) while accessing temperature sensor
27	Timeout waiting for DISC SYNC to go LOW	Internal communication protocol error

Informal Message Codes		
Code	**Description**	**Suggested Cause**
4	INFO: Flash memory ID error	Reported from boot process, only if DSP configuration fails (possible cause: communication error with serial flash memory)
8	INFO: DSP configuration file missing or corrupt	Reported from boot process, only if DSP configuration fails (possible cause)
16	INFO: Serial communication failure while accessing external ADC chip	Reported from boot process if communication verification fails with external ADC chip (camera voltage measurement, SPI)

Monitoring Task Message Codes		
Code	**Description**	**Suggested Cause**
1	WARNING: One or more voltages out of specification	At least one of voltages is out of specification
2	WARNING: Camera temperature exceeds specified limit	Current camera temperature exceeds specification limit
4	WARNING: External SYNC not detected	Exposure Mode 3: external SYNC not detected
16	WARNING: Analog gain is over/under the specification	Current analog gain setting is out of specification

Appendix C

EMC Declaration of Conformity

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

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

HS-4x-02K30

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:1995** **EN 61000-4-4; 500V, 1100V:1995** **EN 61000-4-6; 3V:1996**

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	September 25, 2003
Name and Signature of authorized person	**Hank Helmond** **Quality Manager, DALSA Corp.**

This Declaration corresponds to EN 45 014.

Appendix D

Revision History

Revision Number	Change Description
00	Preliminary release
01	Added flat field correction commands: • ROI Region of Interest • CCF Correction Calibrate FPN • CCP Correction Calibrate PRNU • GFC Get FPN Coefficient • SFC Set FPN Coefficient • GPC Get PRNU Coefficient • SPC Set PRNU Coefficient • WPC Write Pixel Coefficients • RPC Reset Pixel Coefficients • DPC Display Pixel Coefficients • LPC Load Pixel Coefficients • EPC Enable Pixel Coefficients • SDO Set Digital Offset Added Time Multiplexing Information and diagrams in section 3.5 Updated FPN and PRNU specs: • FPN with correction Max value from 2 to 2.5 • PRNU with correction Max value from 3 to 2.5 • PRNU pixel to pixel without correction max value from 8 to 10 • PRNU pixel to pixel with correction max value from TBD to 2
02	Updated mechanical drawing to include a side view of the camera (including mounting holes M3x0.5) Added the Piranha HS name
03	Added Figure 13: Direction of Web Movement using an Inverting Lens Added Camera Link Video Timing, page 49 Added Revision History.

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