Spyder3 Camera Link

User's Manual

S3-10-01k40-00-R
S3-20-01k40-00-R
S3-10-02k40-00-R
S3-20-02k40-00-R
S3-20-04k40-00-R

Camera Link Dual Line Scan Camera

18-Mar-10
03-032-20008-04
www.dalsa.com

With the exception of the RoHS compliance information, the content in this manual also applies to the previous versions of the S3 CL camera: S3-10-0xk40-00-L and S3-20-0xk40-00-L models

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 semiconductor products and services. DALSA's core competencies are in specialized integrated circuit and electronics technology, software, and highly engineered semiconductor wafer processing. Products and services include image sensor components; electronic digital cameras; vision processors; image processing software; and semiconductor wafer foundry services for use in MEMS, high-voltage semiconductors, image sensors and mixed-signal CMOS chips. DALSA is listed on the Toronto Stock Exchange under the symbol "DSA". The Company has its corporate offices in Waterloo, ON and over 1000 employees world-wide.

For further information not included in this manual, or for information on DALSA's extensive line of image sensing products, please call:

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Contents

1 Introduction to the Spyder3 CL Camera

1.1 Camera Highlights

Features

- Broadband responsivity up to 408 ±16 DN(nJ/cm^2) @10dB gain, 8 bit
- 1024, 2048, or 4096 pixels, 14 x 14 µm (1k and 2k) and 10 x 10 µm (4k) pixel pitch, 100% fill factor
- Up to 68 kHz line rates
- Dynamic range up to 1400:1
- Data transmission exceeding 10 meters
- ±50 µm x, y sensor alignment
- Base Camera Link configuration (8 or 12 bit data on 1 or 2 taps depending on camera model)
- RoHS and CE compliant.

Programmability

- Serial interface (ASCII, 9600 baud, adjustable to 19200, 57600, 115200), through Camera Link™.
- Mirroring and forward/reverse control.
- Programmable gain, offset, exposure time and line rate, trigger mode, test pattern output, and camera diagnostics.
- Tall pixel, high sensitivity, or low sensitivity mode available.
- Flat-field correction—minimizes lens vignetting, non-uniform lighting, and sensor FPN and PRNU.

Description

The Spyder3 CL is also DALSA's first dual line scan camera. When operating in high sensitivity (dual line scan) mode, the Spyder3 CL camera has 3x the responsivity of a DALSA's Spyder 2 line scan camera.

Applications

The Spyder3 CL camera is ideal for:

- FPD inspection
- Pick and place
- Container inspection
- Wood/tile/steel inspection
- 100% print inspection (lottery tickets, stamps, bank notes, paychecks)
- Postal sorting
- Glass bottle inspection
- Industrial metrology
- Food inspection
- Web inspection

Models

The Spyder3 CL camera is available in these models.

Table 1: Spyder3 CL Camera Models Overview

Model Number	Description
S3-20-01K40-00-R	1k resolution, 2 sensor taps. Base Camera Link configuration.
S3-20-02K40-00-R	2k resolution, 2 sensor taps. Base Camera Link configuration.
S3-10-01K40-00-R	1k resolution, 1 sensor tap. Base Camera Link configuration.
S3-10-02K40-00-R	2k resolution, 1 sensor tap. Base Camera Link configuration.
S3-20-04k40-00-R	4k resolution, 2 sensor taps. Base Camera Link configuration.

1.2 Camera Performance Specifications

Table 2: Camera Performance Specifications

Feature / Specification	Units	1k	2k	4k
Imager Format		dual line scan	dual line scan	dual line scan
Resolution	pixels	1024	2048	4096
Pixel Fill Factor	%	100	100	100
Pixel Size	µm	14x14	14x14	10x10
Sensitivity Mode		High, low, or tall pixel	High, low, or tall pixel	High, low, or tall pixel
Antiblooming		100x	100x	100x
Gain Range	dB	±10	±10	±10
Optical Interface	**Units**			
Back Focal Distance				
M42x1	mm	6.56±0.25 Lens mount adapters are available. Contact Sales for more information.		
Sensor Alignment				
x	µm	±50		
y	µm	±50		
z	mm	±0.25		
Yz	°	±0.2		
Mechanical Interface	**Units**	**1k and 2k**		**4k**
Camera Size	mm	72(h) x 60(l) x 50(w)		65(h) x 53.7(l) x 85(w)
Mass	g	<300		300
Connectors				
power connector		6 pin male Hirose		
data connector		MDR26 female		
Electrical Interface	**Units**			
Input Voltage	Volts	+12 to +15		
Power Dissipation	W	<5 (1k and 2k)		<7 (4k)
Operating Temperature	°C	0 to 50		
Bit Width	Bits	8 or 12 bit user selectable		
Output Data Configuration		Base Camera Link		
Speed		**1k**	**2k**	**4k**
Maximum Line Rate	2 tap model	68 kHz (80 MHz)	36 KHz (80 MHz)	18.5 kHz
	1 tap model	36 (40 MHz)	18.5 (40 MHz)	

Table 3: Camera Operating Specifications

Specifications	Unit	-10dB			0dB			+10dB		
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max
Broadband responsivity	DN/(nJ/cm^2)									
1k and 2k Dual line			652.8			2064			6528	
1k and 2k Single line			326.4			992			3264	
4k Dual line			431			1363			4310	
4k Single line			216			682			2155	
Random noise rms	DN		3	6.5		9.2	20.5		30	65
Dynamic range	DN:DN									
1k and 2k Dual line		500:1	1400:1		203:1	324:1		59:1	108:1	
1k and 2k Single line		500:1	1400:1		203:1	324:1		59:1	108:1	
4k Dual and Single			1225:1			387:1			122.3:1	
FPN global	DN p-p									
Uncorrected				52.8			169.6			536
Corrected				32			32			64
PRNU ECD										
Uncorrected local	%			8.5			8.5			11.5
Uncorrected global	%			10			10			10
Corrected local	DN p-p			80			80			95
Corrected global	DN p-p			80			80			95
PRNU ECE										
Uncorrected local	%			8.5			12			37
Uncorrected global	%			10			12			37
Corrected local	DN p-p			80			237			752
Corrected global	DN p-p			80			208			752
SEE (calculated)	nJ/cm^2									
Dual line			6.35			1.92			0.61	
Single line			12.2			4.0			1.2	
NEE (calculated)	pJ/cm^2									
Dual line			4.6			4.5			4.6	
Single line			9.2			9.3			9.2	
Saturation output amplitude	DN					3968±80				
DC offset	DN			96			160			336

Test conditions unless otherwise noted:

- 12-bit values, Flat Field Correction (FFC) enabled.
- CCD Pixel Rate: 40 Mega pixels/second per sensor tap.
- Line Rate: 5000 Hz.
- Nominal Gain setting unless otherwise specified.
- Light Source: Broadband Quartz Halogen, 3250k, with 750 nm high pass filter installed.
- Ambient test temperature 25 °C.
- Unless specified, all values are referenced at 12 bit.

- Exposure mode disabled.
- Unless specified, dual line mode.

Notes

1. PRNU measured at 50% SAT.

1.3 Image Sensor

The camera uses DALSA's dual line scan sensor. The camera can be configured to read out in either high or low sensitivity mode, tall pixel mode, and forward or reverse shift direction.

Figure 1: 2 Tap Sensor Block Diagram

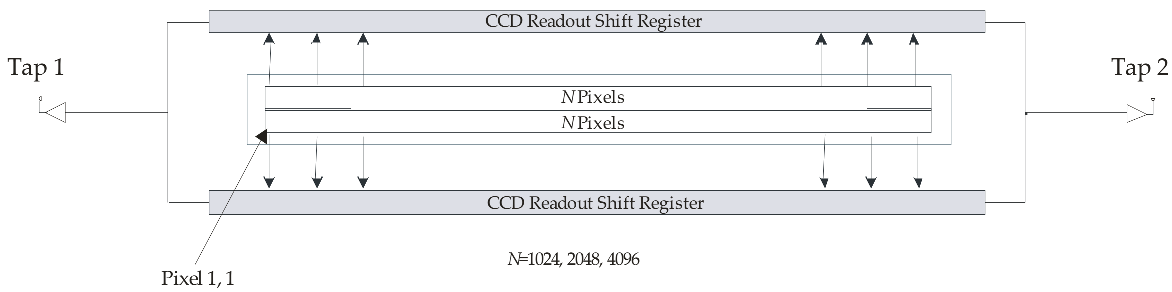
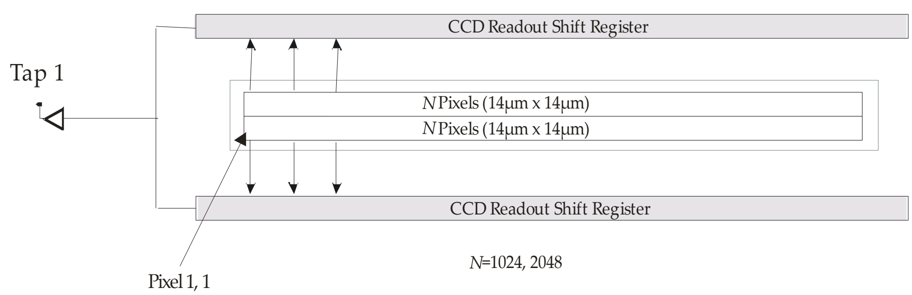


Figure 2: 1 Tap Sensor Block Diagram (1k and 2k only)



Sensitivity Mode and Pixel Readout

The camera has the option to operate in either high sensitivity (dual line) or low sensitivity (single line) modes, or in tall pixel mode.

When in high sensitivity mode, the camera uses both line scan sensors and its responsivity increases accordingly. When in low sensitivity mode, the camera uses the bottom sensor only. When operating in tall pixel mode, the camera operates using both sensors, creating a 28 µm x 14 µm pixel (1k and 2k models), or a 20 µm x 10 µm pixel (4k model).

The sensitivity mode is software-controlled through the ASCII command **`ssm`**.

Figure 3: High Sensitivity Mode

In high sensitivity mode, the camera uses either a 14 µm x 14 µm pixel (1k and 2k models) or a 10 µm x 10 µm pixel (4k model) and captures the same image twice, resulting in a brighter image.

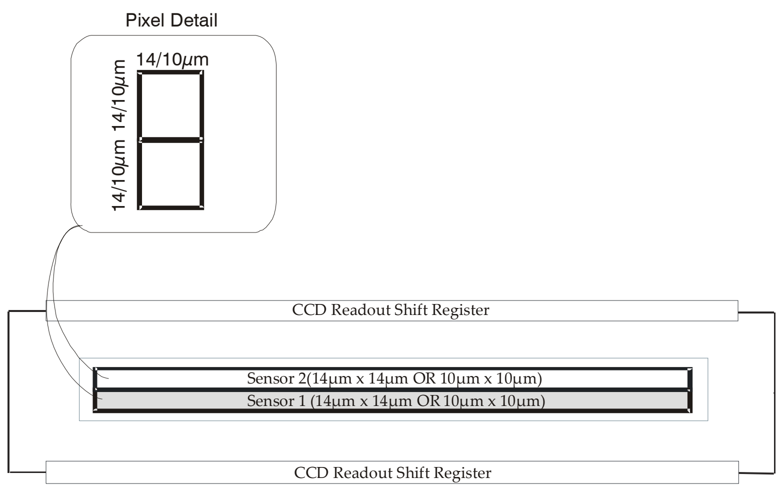


Figure 4: Low Sensitivity Mode

In low sensitivity mode, the camera uses either a 14 µm x 14 µm pixel (1k and 2k models) or a 10 µm x 10 µm pixel (4k model) and captures the image using one sensor (Sensor 1).

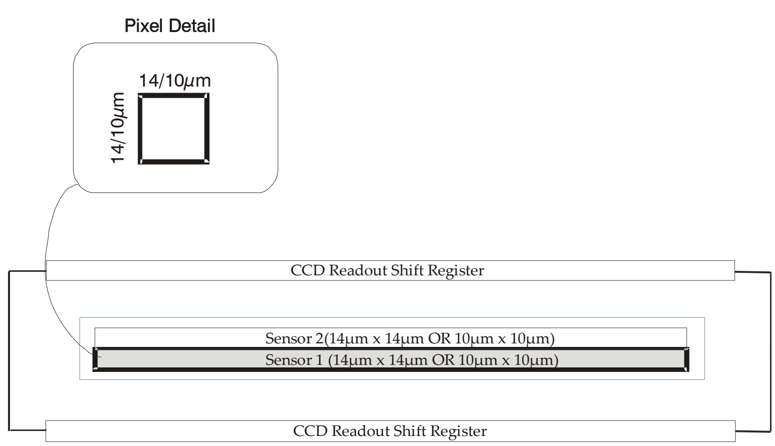
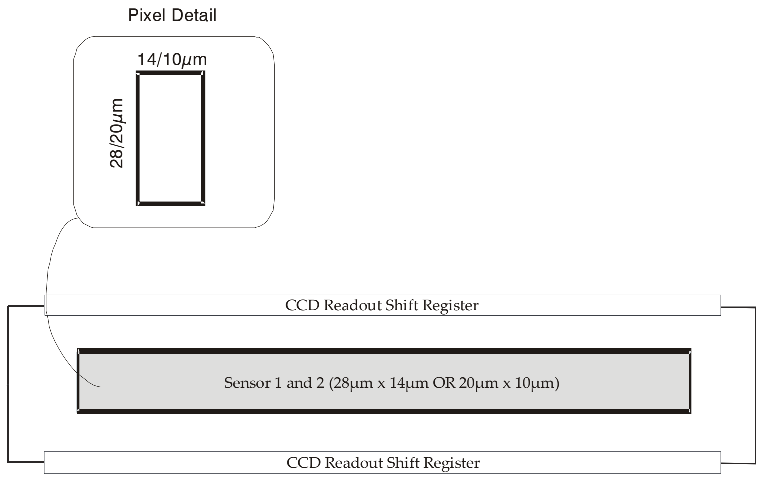


Figure 5: Tall Pixel Mode

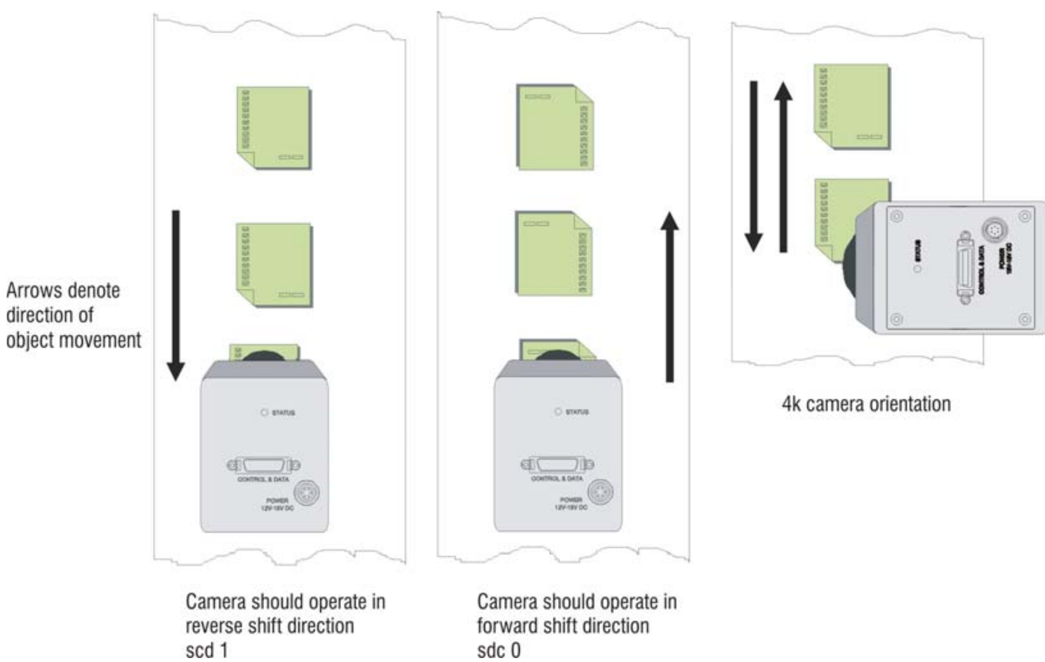
In tall pixel mode, the camera uses a 28 µm x 14 µm pixel (1k and 2k) or a 20 µm x 10 µm pixel (4k model) and captures an image two times taller than in high or low sensitivity modes, resulting in a taller image.



Sensor Shift Direction

When in high sensitivity mode, you can select either forward or reverse CCD shift direction. This accommodates object direction change on a web and allows you to mount the camera "upside down".

Figure 6: Object Movement and Camera Direction Example using an Inverting Lens



Note: You can control the CCD shift direction through the serial interface. Use the software command **scd** to determine whether the direction control is set via software control or via the Camera Link control signal on CC3. Refer to the CCD Shift Direction section of this manual, page 47, for details.

1.4 Responsivity

Figure 7: Spyder3 CL 1k and 2k Responsivity

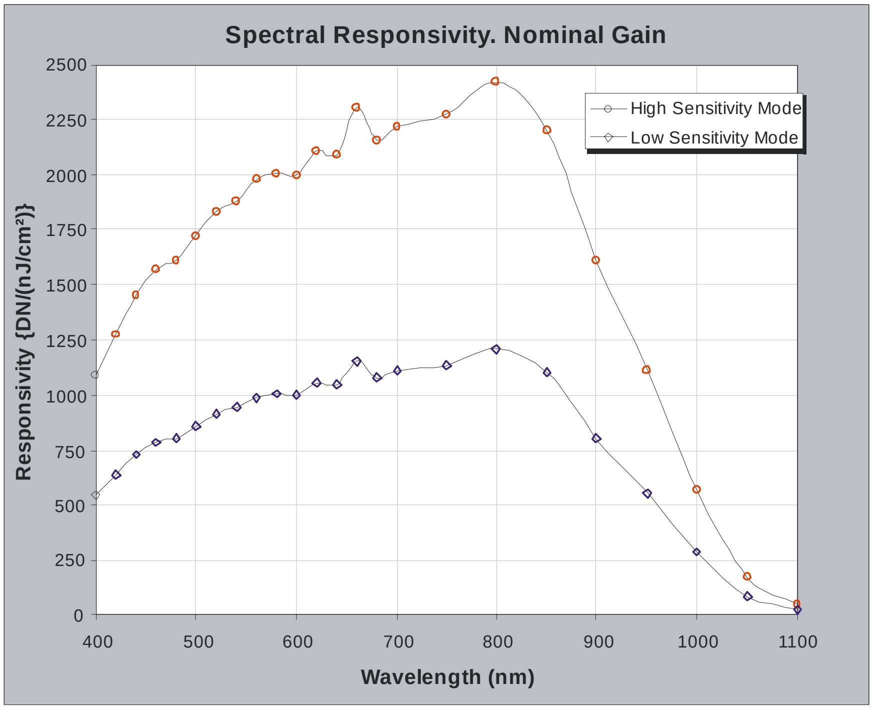
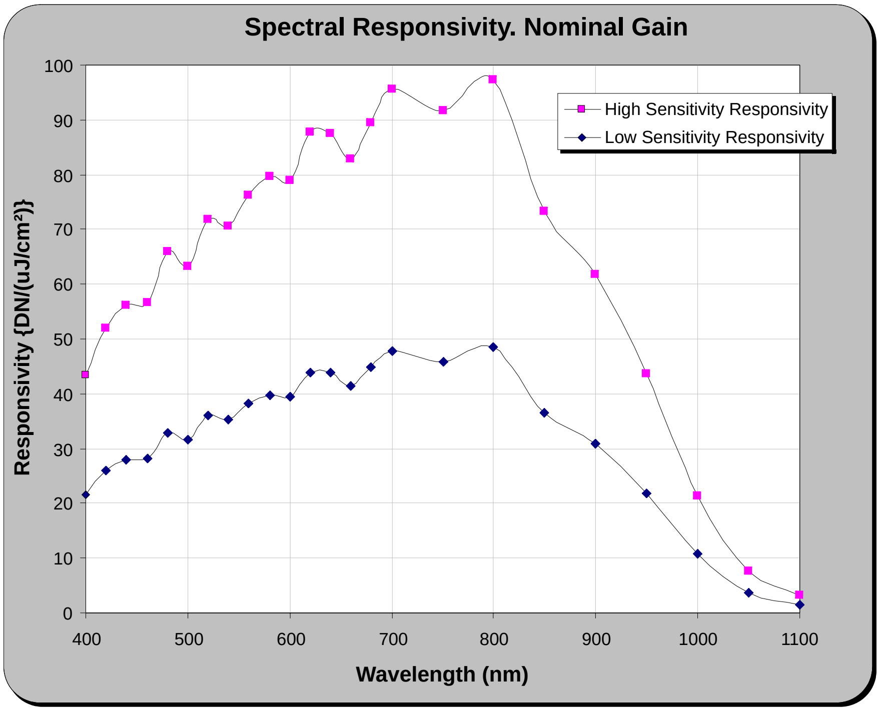


Figure 8: Spyder3 CL 4k Responsivity



1.5 Derating Curves

Figure 9: 1k and 2k Derating Curves

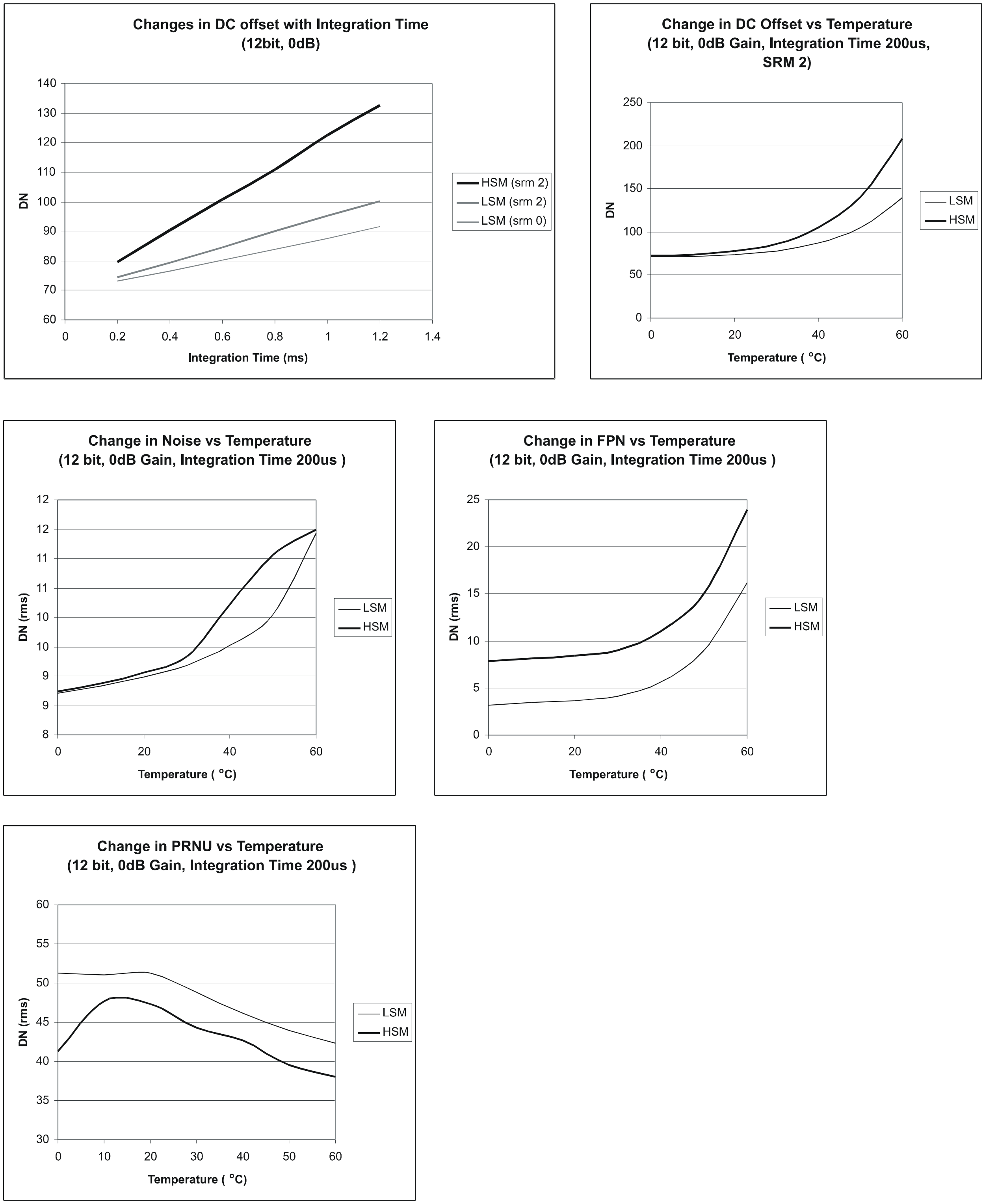
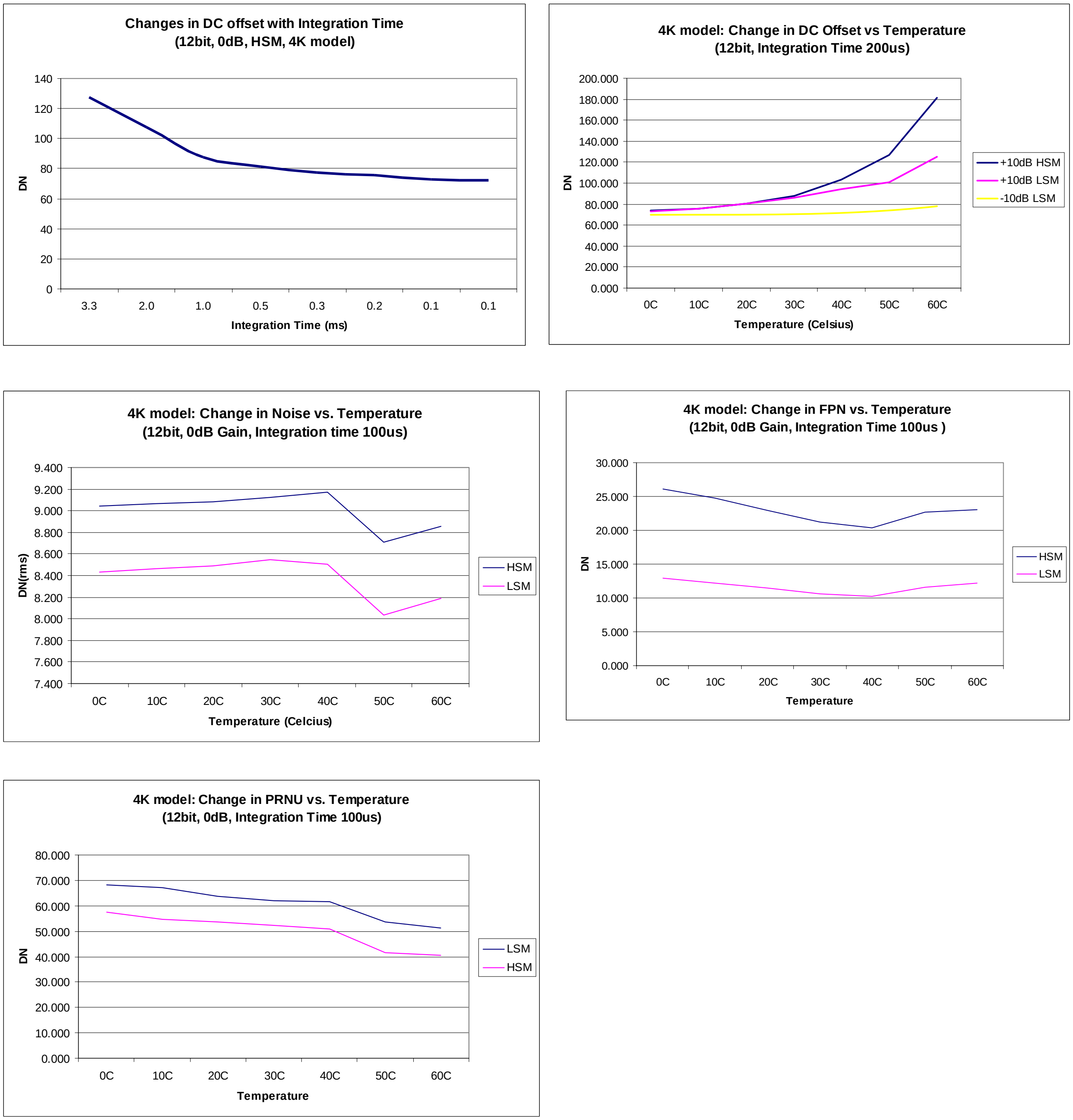


Figure 10: 4k Derating Curves



2 Setting Up the Camera

2.1 Installation Overview

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

When installing your camera, you should take these steps:

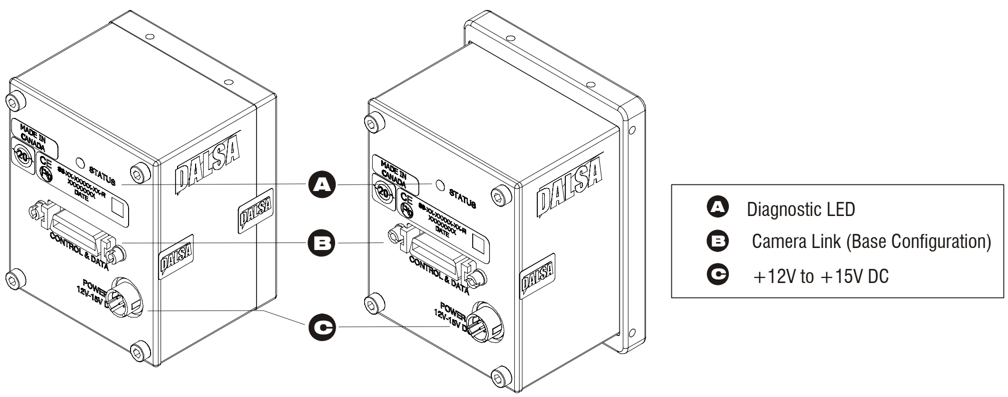
1. Power down all equipment.
2. Follow the manufacturer's instructions and install the frame grabber (if applicable). Be sure to observe all static precautions.
3. Install any necessary imaging software.
4. Before connecting power to the camera, test all power supplies. Ensure that all the correct voltages are present at the camera end of the power cable. Power supplies must meet the requirements defined in section 2.3 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 below for an LED description.

2.2 Input/Output Connectors and LED

The camera uses:

- A diagnostic LED for monitoring the camera. See below for details.
- High-density 26-pin MDR26 connector for Camera Link control signals, data signals, and serial communications. See below for details.
- One 6-pin Hirose connector for power. Refer to the section below for details.
- Camera link connector

Figure 11: Input and Output Connectors



WARNING: It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages may damage the camera. See section 2.4 for more details.

2.3 Power Connector

Figure 12: Hirose 6-pin Circular Male—Power Connector

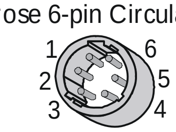


Table 4: Hirose Pin Description

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.

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 Spyder3 CL camera's requirements, but it should not be considered the only choice. Many high quality supplies are available from other vendors. Visit the http://mv.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.

2.4 Camera LED

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.

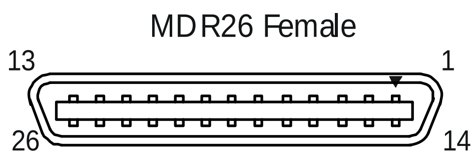
When more than one condition is active, the LED indicates the condition with the highest priority. Error and warning states are accompanied by corresponding messages further describing the current camera status.

Table 5: Diagnostic LED

Priority	Color of Status LED	Meaning
1	Flashing Red	Fatal Error. For example, camera temperature is too high and camera thermal shutdown has occurred.
2	Flashing Green	Camera initialization or executing a long command (e.g., flat field correction commands **`ccp`** or **`ccf`**)
3	Solid Green	Camera is operational and functioning correctly

2.5 Camera Link Data Connector

Figure 13: Camera Link MDR26 Connector



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

**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.

The Camera Link interface is implemented as Base Configuration in the Spyder3 cameras. Refer to section Setting the Camera Link Mode for details on setting the Camera Link configuration.

Table 6: Camera Link Hardware Configuration Summary for Piranha HS-xx Models

Configuration	8 Bit Ports Supported	Serializer Bit Width	Number of Chips	Number of MDR26 Connectors	Applicable Camera Models
Base	A, B, C	28	1	1	The various models

Table 7: Camera Link Connector Pinout

Base Configuration		
One Channel Link Chip + Camera Control + Serial Communication		
Camera Connector	Right Angle Frame Grabber	Channel Link Signal
1	1	inner shield
14	14	inner shield
2	25	X0-
15	12	X0+
3	24	X1-
16	11	X1+
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

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 8: DALSA Camera Control Configuration

Signal	Configuration
CC1	EXSYNC
CC2	PRIN
CC3	Direction
CC4	Spare

See Appendix B for the complete DALSA Camera Link configuration table, and refer to the DALSA Web site, http://mv.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

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 following 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: **0:** Base configuration, 1 taps, 8 bit output **1:** Base configuration, 1 taps, 12 bit output **2:** Base configuration, 2 taps, 8 bit output **3:** Base configuration, 2 taps, 12 bit output
Notes:	• 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	
Example:	**`clm 0`**

7.3 Exposure Mode, Line Rate

for details on how to set frame times, exposure times, and camera modes.

Direction Control

Control the CCD shift direction through the serial interface. Use the software command **`scd`** to determine whether the direction control is set via software control or via the Camera Link control signal on CC3. Refer to the CCD Shift Direction section of this manual, page 47, for details.

Output Signals, 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 http://mv.dalsa.com, for the standard location of these signals.

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

The camera internally digitizes 12 bits and outputs the 8 MSB or all 12 bits depending on the camera's Camera Link operating mode.

2.6 Camera Link Video Timing

Figure 14: Spyder3 Overview Timing Showing Input and Output Relationships

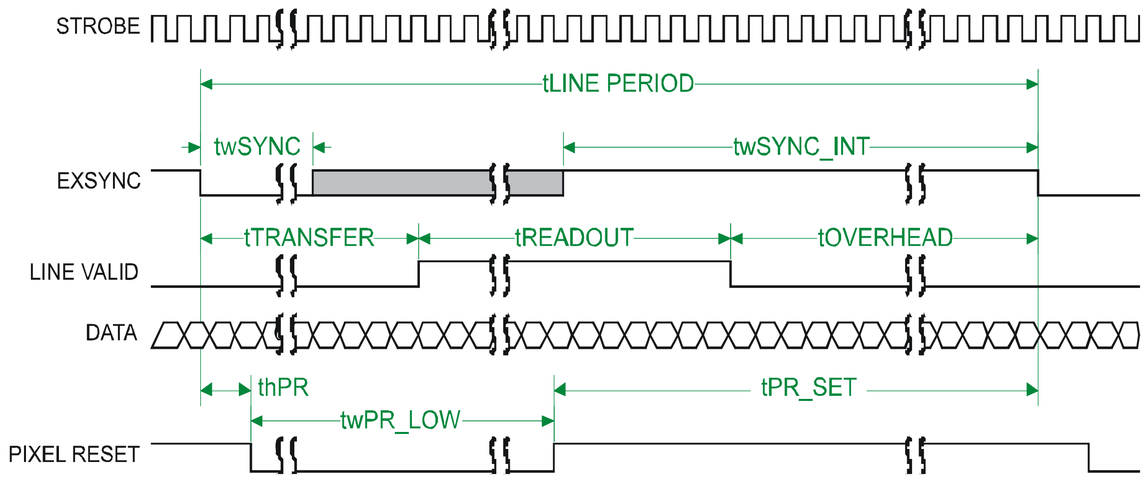


Figure 15: Spyder3 Fixed (Programmed) Integration Timing with External EXSYNC

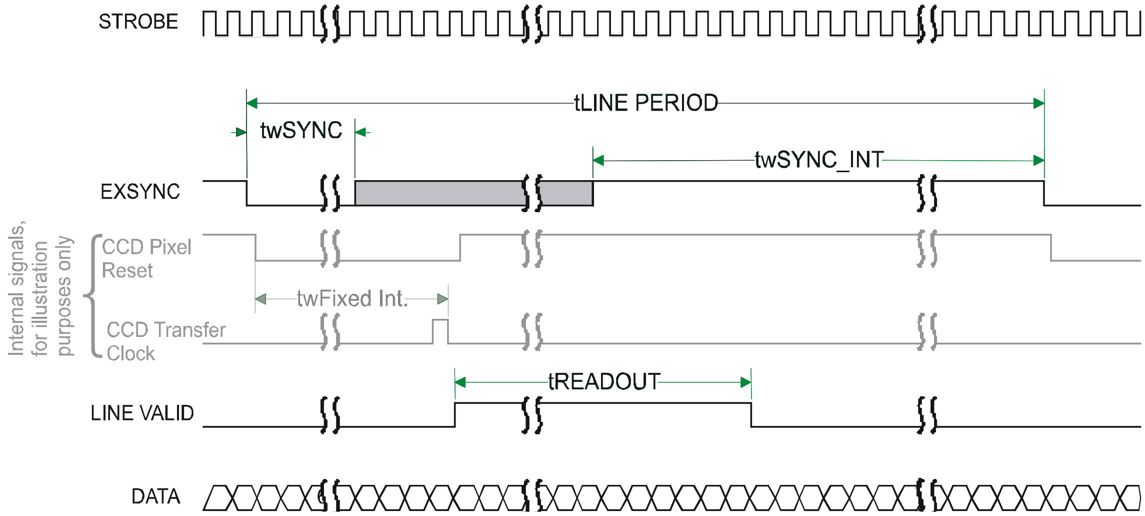


Table 9: Spyder3 Input and Output

Symbol	Definition	Min (ns)	Max (ns)
twSYNC	The minimum low width of the EXSYNC pulse when not in SMART EXSYNC mode.	100	
$twSYNC_{(SMART)}$ *	The minimum low width of the EXSYNC pulse when in SMART EXSYNC modes to guarantee the photosites are reset.	3,000	
twSYNC_INT	The minimum width of the high pulse when the “SMART EXSYNC” feature is turned off	100	
twSYNC_INT (SMART) *	Is the integration time when the “SMART EXSYNC” feature is available and turned on. Note that the minimum time is necessary to guarantee proper operation.	3,000	
tLINE PERIOD (t_{LP})	The minimum and maximum line times made up of tTransfer, tREADOUT plus tOVERHEAD to meet specifications.	14,700 (1k 2 tap) 27,778 (1k 1 tap) 27,778 (2k 2 tap) 54,054 (2k 1 tap) 55,775 (4k 2 tap)	
tTransfer	The time from the reception of the falling edge of EXSYNC to the rising edge of LVAL when pretrigger is set to zero. Pretrigger reduces the number of clocks to the rising edge of LVAL but doesn't change the time to the first valid pixel. If the fixed integration time mode of operation is available and selected then the integration time is added to the specified value.	3,725 ±25 (1k and 2k) 4,100±25 (4k)	
twFixed Int.	Fixed Integration Time mode of operation for variable exsync frequency.	800	
tREADOUT	Is the number of pixels per tap times the readout clock period.	25,600 (1k 1 tap)) 12,800 (1k 2 tap) 51,200 (2k 1 tap) 25,600 (2k 2 tap) 51,200 (4k 2 tap)	
tOVERHEAD	Is the number of pixels that must elapse after the falling edge of LVAL before the EXSYNC signal can be asserted. This time is used to clamp the internal analog electronics	425±25 (All models)	
thPR	Applies when the PRIN exposure control feature is enabled. The PRIN signal must be held a minimum time after the EXSYNC falling edge to avoid losing the integrated charge	To Be Determined	
twPR_LOW	Minimum Low time to assure complete photosite reset	3,000	
tPR_SET	The nominal time that the photo sites are integrating. Clock synchronization will lead to integration time jitter, which is shown in the specification as +/- values. The user should command times greater than these to ensure proper charge transfer from the photosites. Failure to meet this requirement may result in blooming in the Horizontal Shift Register.	3,000	

3 Software Interface: How to Control the Camera

All of the 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 7.17 ASCII Commands: Reference 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 may be different from those used by other DALSA cameras. You should not assume that these commands perform the same as those for 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>

Baud Rate

Purpose:	Sets the speed in bps of the 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**

Select Cable

Purpose:	Sets the cable parameters.
Syntax:	**scb i**
Syntax Elements:	***i***
	Output compare value. Available values are: **0** to **255**.
Notes:	In medium configuration, both cables must be the same length.
	Only one copy of this setting is saved in the camera (rather than with each setting).
	On the **lfs** (load factory settings) command the cable length will be set to the factory default of **100**.
	The cable parameter is a relative value.
	Increase the value for longer cables and decrease it for shorter ones.
	Adjust until test pattern (SVM 1) is clean.
Example:	**scb 75**

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 the Returning Camera Settings section.

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.

3.1 First Power Up Camera Settings

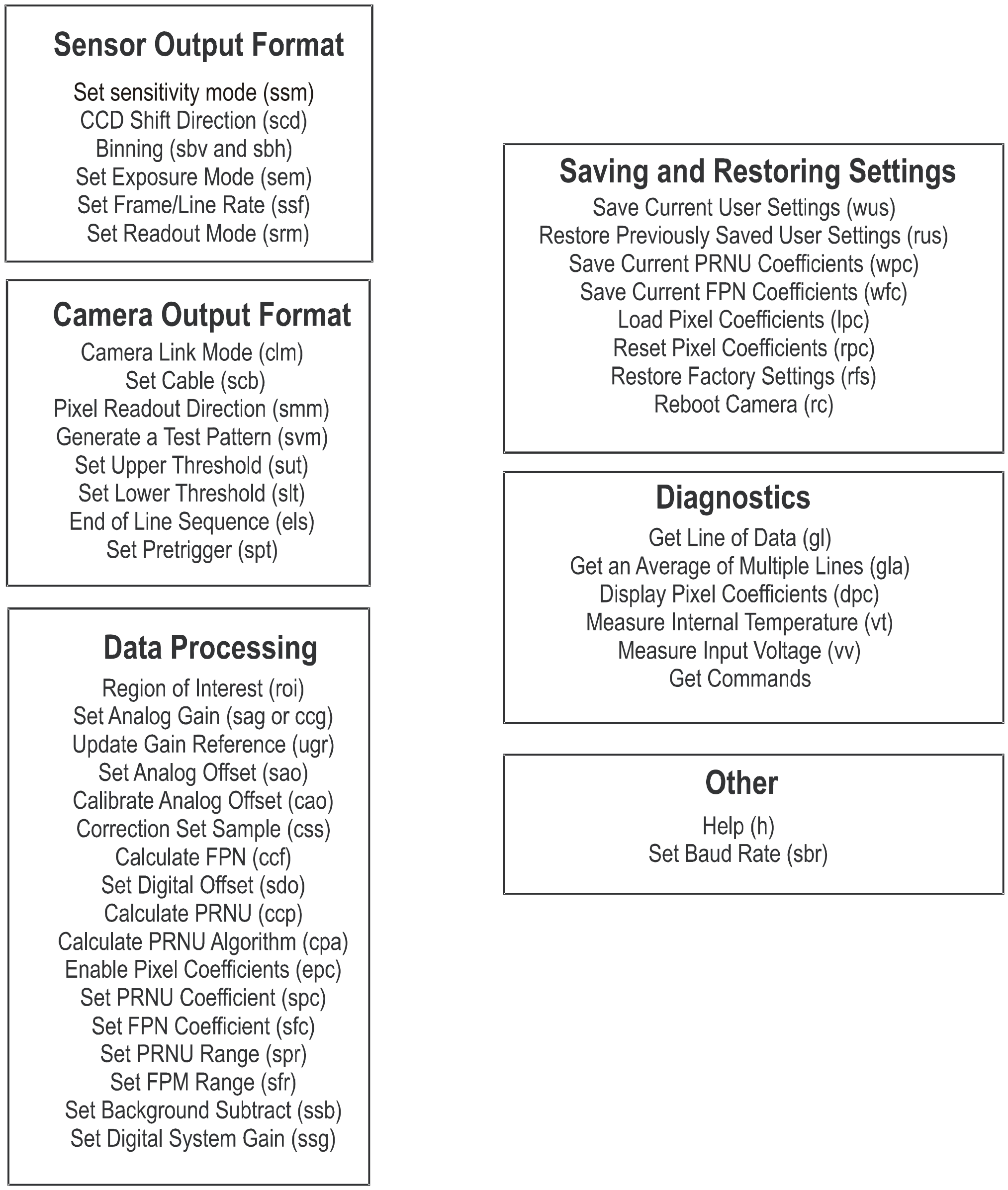
When the camera is powered up for the first time, it operates using the following factory settings:

- High sensitivity mode
- Forward CCD shift direction
- No binning
- Exposure mode 7 (Programmable line rate & max exposure time)
- 5000 Hz line rate
- Readout mode: Off
- Mirroring mode: 0, left to right
- Factory calibrated analog gain and offset
- 8 bit output
- **sag** enabled (1k and 2k use). (It is recommended that you use the **ssg** command with the 4k in order to maintain valid LUT calibration.)
- LUTs enabled (4k default), factory calibrated @ -10dB.

3.2 Command Categories

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

Figure 16: Command Categories



3.3 Camera Output Format

How to Configure Camera Output

Using the camera link mode and pixel readout direction commands

Use the camera link mode (clm) command to determine the camera's Camera Link configuration, the number of output taps, and the bit depth. Use the pixel readout direction (smm) command to select the camera's pixel readout direction.

The following tables summarize the possible camera configurations for each of the S3-xx camera models.

Table 10: Data Readout Configurations

Mode Configuration				Readout Direction
Command	Models	Taps	Bit Depth	smm 0 increment =1 smm 1 increment = -1
clm 0	S3-10-01K40	1	8	smm 0 = CL tap 1 (1-1024) smm 1 = CL tap 1 (1024-1)
	S3-10-02K40			smm 0 = CL tap 1 (1-2048) smm 1 = CL tap 1 (2048-1)
clm 1	S3-10-01K40	1	12	smm 0 = CL tap 1 (1-1024) smm 1 = CL tap 1 (1024-1)
	S3-10-02K40			smm 0 = CL tap 1 (1-2048) smm 1 = CL tap 1 (2048-1)
clm 2	S3-20-01K40	2	8	smm 0 = CL tap 1 (1-512) CL tap 2 (513-1024) smm 1 = CL tap 1 (1024-513) CL tap 2 (512-1)
	S3-20-02K40	2		smm 0 = CL tap 1 (1-1024) CL tap 2 (1025-2048) smm 1 = CL tap 1 (2048-1025) CL tap 2 (1024-1)
	S3-20-04k-40	2		smm 0 = CL tap 1 (1-2048) CL tap 2 (2049-4096) smm 1 = CL tap 1 (4096-2049) CL tap 2 (2048-1)
clm 3	S3-20-01K40	2	12	smm 0 = CL tap 1 (1-512) CL tap 2 (513-1024) smm 1 = CL tap 1 (1024-513) CL tap 2 (512-1)
	S3-20-02K40	2		smm 0 = CL tap 1 (1-1024) CL tap 2 (1025-2048) smm 1 = CL tap 1 (2048-1025) CL tap 2 (1024-1)
	S3-20-04k-40	2		smm 0 = CL tap 1 (1-2048) CL tap 2 (2049-4096) smm 1 = CL tap 1 (4096-2049) CL tap 2 (2048-1)

Setting the Camera Link Mode

Purpose: Sets the camera's Camera Link configuration, the number of Camera Link taps, and the data bit depth. Refer to the tables on the previous page 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:

0: 1 taps, 8 bit output
1: 1 taps, 12 bit output
2: 2 taps, 8 bit output
3: 2 taps, 12 bit output

Notes:

- 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 from http://mv.dalsa.com.

Example: `clm 1`

Setting the Pixel Readout Direction (Mirroring Mode)

Purpose: Sets the tap readout from left to right or from right to left. This command is especially 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 the sensor architecture diagrams that illustrate the sensor readout direction.

Example: `smm 1`

Figure 17: Left to Right Readout (smm 0) Forward Direction Example Output

Figure 18: Right to Left Readout (smm 1) Forward Direction Example Output

Figure 19: Camera Pixel Readout Direction Example using 2k Model with Inverting Lens

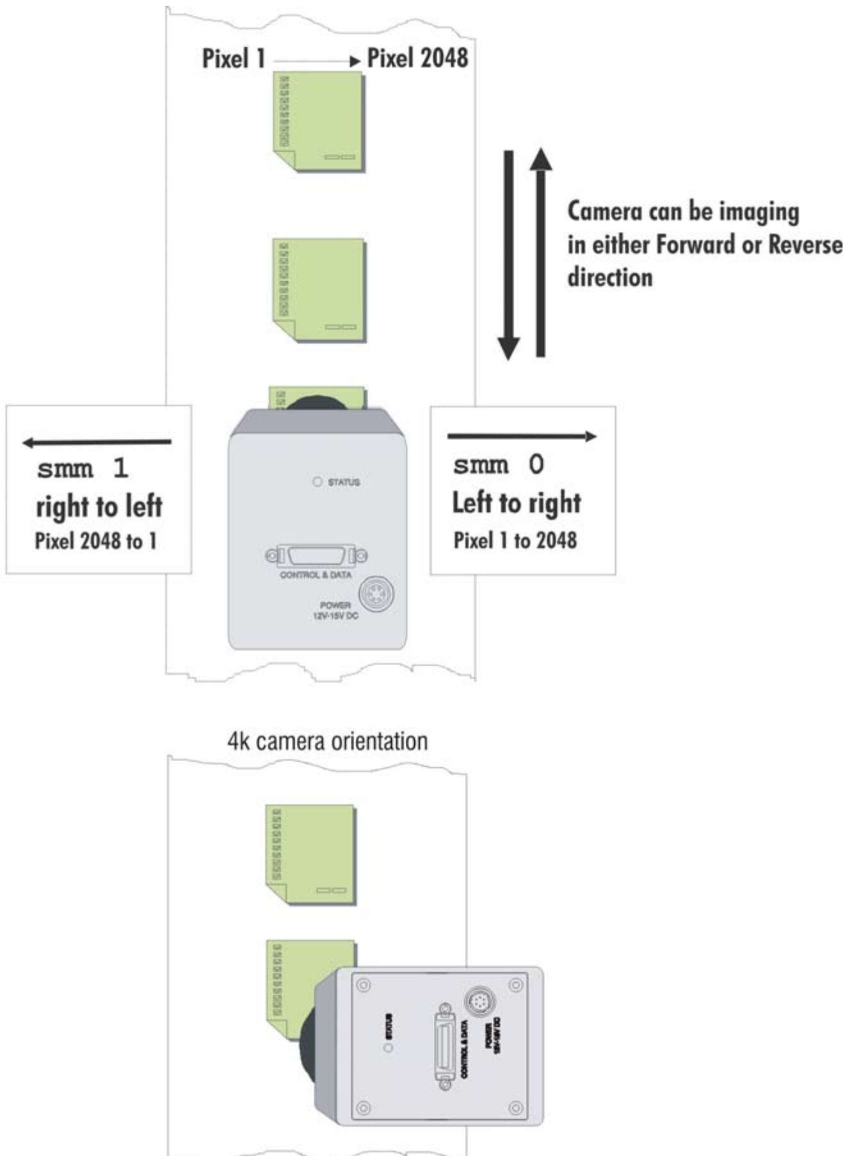


Table 11: Forward or Reverse Pixel Readout

Camera model	Readout direction	Command	Tap 1	Tap 2
S3-10-01k40	Left to Right	`smm 0`	1-1024	n/a
	Right to Left	`smm 1`	1024-1	n/a
S3-20-01K40	Left to Right	`smm 0`	1-512	513-1024
	Right to Left	`smm 1`	1024-513	512-1
S3-10-02K40	Left to Right	`smm 0`	1-2048	n/a
	Right to Left	`smm 1`	2048-1	n/a
S3-20-02K40	Left to Right	`smm 0`	1-1024	1025-2048
	Right to Left	`smm 1`	2048-1025	1024-1
S3-20-04K40	Left to Right	`smm 0`	1-2048	2049-4096
	Right to Left	`smm 1`	4096-2049	2048-1

4 Optical, Mechanical, and Electrical Considerations

4.1 Mechanical Interface

Figure 20: S3 1k and 2k Mechanical Dimensions

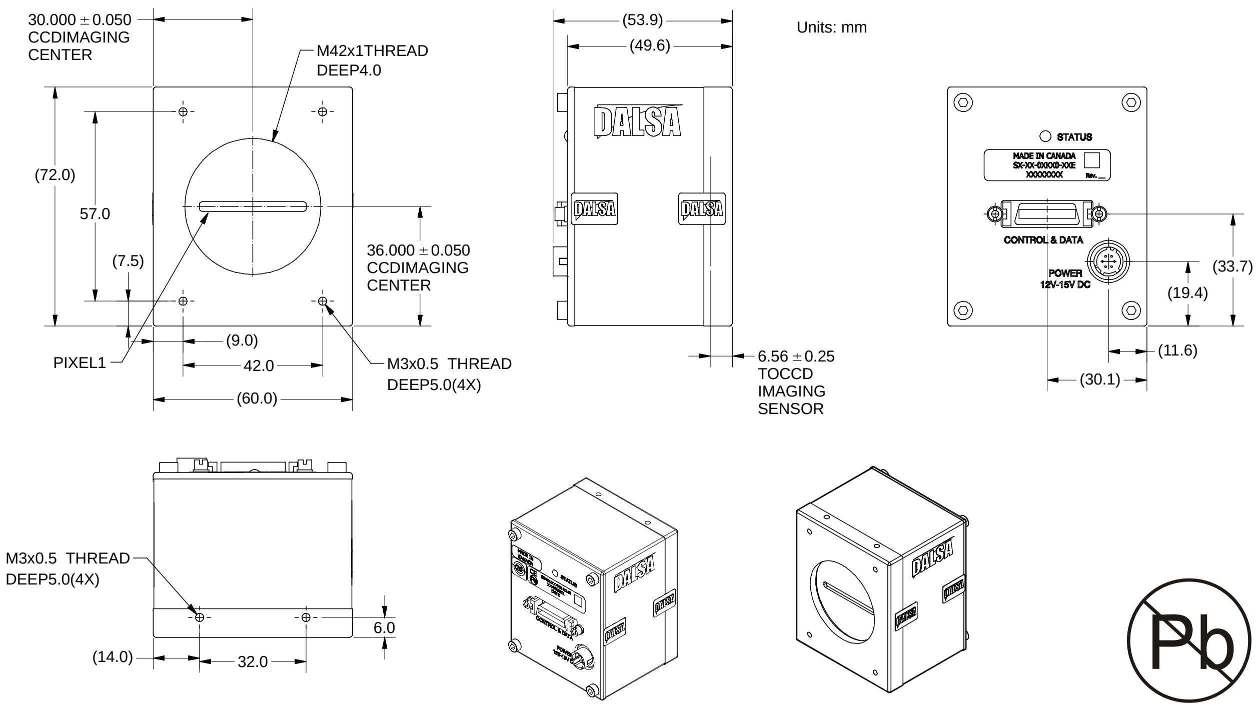
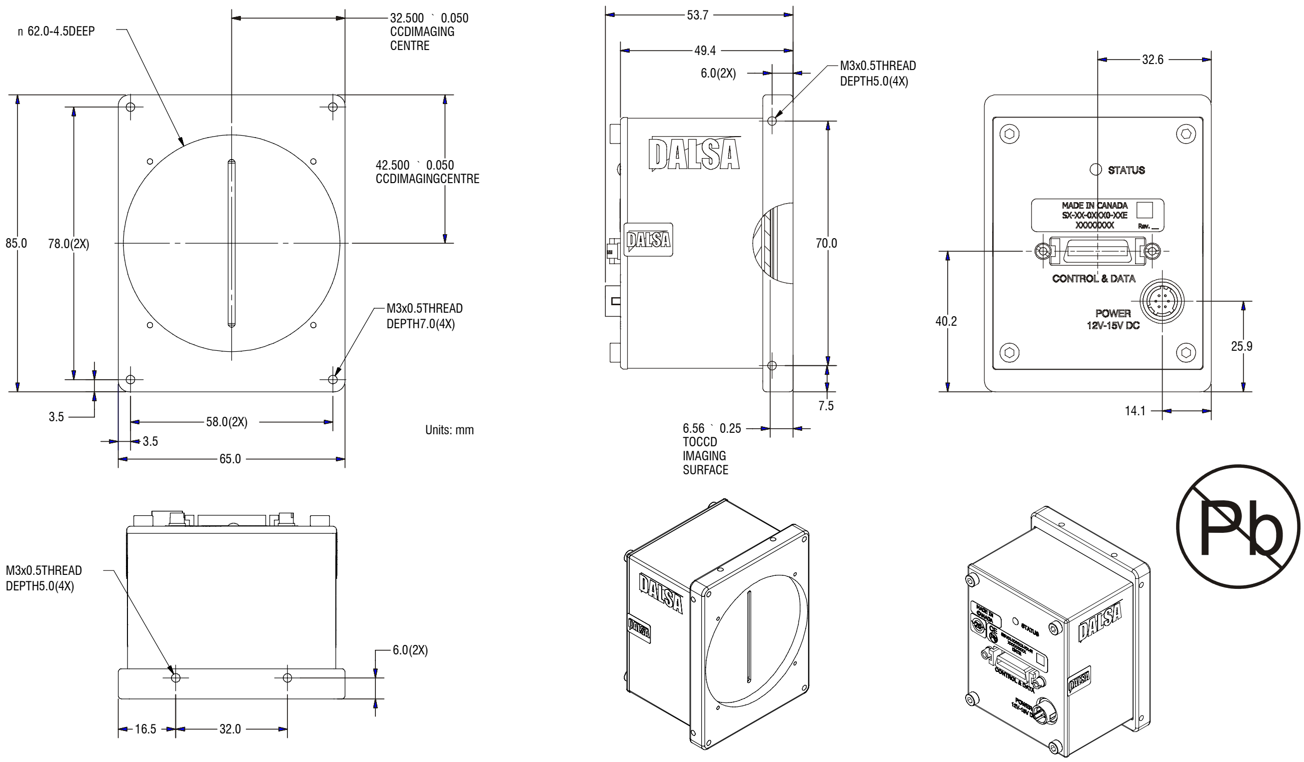


Figure 21: S3-20-04k40 Mechanical Dimensions



4.2 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 sitehttp://mv.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, 5μJ/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 of light, and longer life span compared to other light sources. However, they also require a camera with excellent sensitivity, such as the Spyder3 CL 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

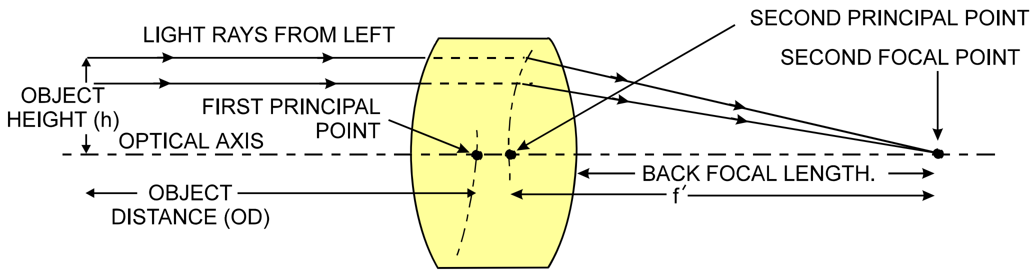
CCD cameras are extremely responsive to infrared (IR) wavelengths of light. To prevent infrared from distorting the images you scan, use a "hot mirror" or IR cutoff filter that transmits visible wavelengths but does not transmit wavelengths over 750nm. Examples are the Schneider Optics™ B+W 489, which 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 22: 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:

Error! Objects cannot be created from editing field codes.	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:

Error! Objects cannot be created from editing field codes.

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

Error! Objects cannot be created from editing field codes.	This is the governing equation for many object and image plane parameters.

Example: An acquisition system has a 512 x 512 element, 10□m 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).

Error! Objects cannot be created from editing field codes.

4.3 Electrical Interface

The Spyder3 CL cameras have been designed for EMC compliance. The test setup has been verified to the following EMC standards:

- CISPR-11:2004
- EN 55011:2003
- EN 61326:2002

To achieve EMC compliance, follow these specific guidelines:

- Ensure that all cable shields have 360° electrical connection to the connector.
- Fasten and secure all connectors.

5 CCD Handling Instructions

5.1 Electrostatic Discharge and the CCD Sensor

Cameras contain charge-coupled device (CCD) image sensors, which are metal oxide semiconductor (MOS) devices and are susceptible to damage from electrostatic discharge (ESD).

Electrostatic charge introduced to the sensor window surface can induce charge buildup on the underside of the window that cannot be readily dissipated by the dry nitrogen gas in the sensor package cavity. When charge buildup occurs, surface-gated photodiodes (SGPDs) may exhibit higher image lag. Some SGPD sensors, such as the IL-P4 and the IT-P4 used in the Spyder3 CL cameras, may also exhibit a highly non-uniform response when affected by charge buildup, with some pixels displaying a much higher response when the sensor is exposed to uniform illumination. The charge normally dissipates within 24 hours and the sensor returns to normal operation.

WARNING: Charge buildup will affect the camera's flat-field correction calibration. To avoid an erroneous calibration, ensure that you perform flat-field correction only after a charge buildup has dissipated over 24 hours.

5.2 Protecting Against Dust, Oil and Scratches

The CCD window is part of the optical path and should be handled like other optical components, with extreme care.

Dust can obscure pixels, producing dark patches on the sensor response. Dust is most visible when the illumination is collimated. The dark patches shift position as the angle of illumination changes. Dust is normally not visible when the sensor is positioned at the exit port of an integrating sphere, where the illumination is diffuse.

Dust can normally be removed by blowing the window surface using a compressed air blower, unless the dust particles are being held by an electrostatic charge, in which case either an ionized air blower or wet cleaning is necessary.

Oil is usually introduced during handling. Touching the surface of the window barehanded will leave oily residues. Using rubber finger cots and rubber gloves can prevent oil contamination. However, the friction between the rubber and the window may produce electrostatic charge that may damage the sensor. To avoid ESD damage and to avoid introducing oily residues, only hold the sensor from the edges of the ceramic package and avoid touching the sensor pins and the window.

Scratches can be caused by improper handling, cleaning or storage of the sensor. Vacuum picking tools should not come in contact with the window surface. CCDs should not be stored in containers where they are not properly secured and can slide against the container.

Scratches diffract incident illumination. When exposed to uniform illumination, a sensor with a scratched window will normally have brighter pixels adjacent to darker pixels. The location of these pixels changes with the angle of illumination.

5.3 Cleaning the Sensor Window

1. Use compressed air to blow off loose particles. This step alone is usually sufficient to clean the sensor window.
2. If further cleaning is required, use a lens wiper moistened with alcohol or acetone.
3. We recommend using lint-free ESD-safe cloth wipers that do not contain particles that can scratch the window. The Anticon Gold 9"x 9" wiper made by Milliken is both ESD safe and suitable for class 100 environments. Another ESD acceptable wiper is the TX4025 from Texwipe.
4. An alternative to ESD-safe cloth wipers is Transplex swabs that have desirable ESD properties. There are several varieties available from Texwipe. Do not use regular cotton swabs, since these can introduce charge to the window surface.
5. Wipe the window carefully and slowly.
6. When cleaning long linear sensors, it may be easier to wipe along the width (i.e. as opposed to the length) of the sensor.

6 Troubleshooting

6.1 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
- software
- light sources
- operating environment
- cabling
- host computer
- optics
- encoder

LED

When the camera is first powered up, the LED will glow on the back of the camera. Refer to section 2.3 for information on the LED.

Connections

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

Cable Length/Type

Use the **scb** command to select the correct cable parameter for the cable length.

Equipment Requirements

Ensure that you are using compatible equipment.

Power Supply Voltages

Check for the presence of all voltages at the camera power connector. Verify that all grounds are connected. Verify input voltage with the camera's 'vv' serial command.

EXSYNC

When the camera is received from the factory, it defaults (no external input required) to exposure mode 7 (5000 Hz line rate, internal Sync to trigger readout). After a user has saved settings the camera powers up with the saved settings.

If you change to an exposure mode that requires an external sync, ensure that you properly providing an external sync

Camera Operation and Test Patterns

Have the camera send out a test pattern and verify it is being properly received.

Communications

To quickly verify serial communications send the help command. The **`h`** command returns the online help menu. If further problems persist, review Appendix C for more information on communications.

Verify Parameters

To verify the camera parameters, send the **`gcp`** command. A complete explanation of the camera parameters screen follows.

Verify Factory Calibrated Settings

To restore the camera's factory settings and disable the FPN and PRNU coefficients, 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 frame grabber and verify the proper output along the digital processing chain. See below.

Generating Test Patterns

The camera can generate a test pattern to aid in system debugging. Use the command **`svm 1`** to activate the test pattern. The test pattern is a ramp from 0 to 255DN, then starts at 0 again. Use the test pattern to verify the proper timing and connections between the camera and the frame grabber.

- **No test pattern or bad test pattern**— May indicate a problem with the camera (e.g. missing bit) or a system setup problem (e.g. frame grabber or timing). Verify the presence of the LVAL and STROBE signals.

- **Test pattern successful**— Run the **svm 0** command to activate video. Then run the **gl** command under both dark and light conditions to retrieve a line of raw video (no digital processing). Under dark conditions, with factory settings, the analog offset value should be within the specified range (refer to the user specifications). Adjust the analog offset using the **sao** command. Under light conditions, you should receive a value.

Verify Voltage

Use the **vv** command to display the camera's input voltage.

Verify Temperature

To check the internal temperature of the camera, use the **vt** command. 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. If you enter any command other than **vt** or **rc**, the camera responds with:

```
Error 09: The camera's temperature exceeds the specified operating
range>
```

Verify Pixel Coefficients

Use the **dpc** command to display the pixel coefficients in the order FPN, PRNU, FPN, PRNU… The camera also returns the pixel number for each fifth pixel.

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", "pixels below threshold". To activate the end-of-line sequence, use the command **els 1**. To disable the end-of-line sequence, use the command **els 0**.

Use the **sut** and **slt** commands to set threshold values between 0 and 255 for 8 bit data modes, or 0 to 4096 for 12 bit data modes.

6.2 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 in exposure mode that requires external signals).

Line Dropout, Bright Lines, or Incorrect Line Rate

Verify that the frequency of the internal sync is set correctly, or when the camera is set to external sync that the EXSYNC signal supplied to the camera does not exceed the camera's useable Line rate under the current operating conditions.

Noisy Output

Check your power supply voltage outputs for noise. Noise present on these lines can result in poor video quality.

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
5. is approximately one finger-width
6. 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.
7. 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.
8. Repeat steps 2-4 using a clean tissue until the entire window has been cleaned.
9. Blow off any adhering fibers or particles using dry, filtered compressed air.

Horizontal Lines or Patterns in Image

A faulty or irregular encoder 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.

6.3 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** **email**	
Complete Product Model Number **(e.g. S3-10-01k40-00-R...)**	
Complete Serial Number	
Your DALSA Agent or Dealer	
Acquisition System hardware (frame grabber, host computer, light sources, etc.)	
Power supply setting and current draw	
Pixel rate used	
Control signals used in your application, and their frequency or state (if applicable)	EXSYNC BIN LVDS/TTL Other _______
Results when you run an error report	*please attach text received from the camera after initiating an error report*
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
Email:	support@dalsa.com	support@dalsa.com	support@dalsa.com

7 Appendix A

7.1 Spyder3 Camera Link ASCII Commands

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.
- 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 always 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 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**

Select Cable

Purpose: Sets the cable parameters.

Syntax: **scb i**

Syntax Elements: ***i***

Output compare value. Available values are: 0 to 255.

Notes:

- In medium configuration, both cables must be the same length.
- Only one copy of this setting is saved in the camera (rather than with each setting).
- On the **lfs** (load factory settings) command the cable length will be set to the factory default of 100.
- The cable parameter is a relational value. Increase the value for longer cables, and decrease it for shorter ones.
- Adjust the value until the test pattern (svm 1) is clean.

Related command **get scb**

Returns the current cable parameter.

Example: **scb 75**

Camera ASCII Command Help

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 7.16 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 ASCII Command Help Screen (1k 2 Tap Model)

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

```
ccf  correction calibrate fpn
ccg  calibrate camera gain         iti     1-4:0-2:1024-4055
ccp  correction calibrate prnu
clm  camera link mode              m       0/1 or 2/3 depends on model
cpa  calibrate PRNU algorithm      ii      1-3:1024-4055
css  correction set sample         m       256/512/1024/
dpc  display pixel coeffs          xx      1-1024:1-1024
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
gem  get exposure mode
get  get values                    s
gfc  get fpn coeff                 x       1-1024
gh   get help
gl   get line                      xx      1-1024:1-1024
gla  get line average              xx      1-1024:1-1024
gpc  get prnu coeff                x       1-1024
gsf  get signal frequency          i       1-3
gsl  get status led
h    help
lpc  load pixel coefficients       i       0-4
rc   reset camera
rfs  restore factory settings
roi  region of interest            xyxy    1-1024:1-1:1-1024:1-1
rpc  reset pixel coeffs
rus  restore user settings
sag  set analog gain               tf      0-2:-10.0-+10.0
sao  set analog offset             ti      0-2:0-255
sbh  set binning horizontal        m       1/2/
sbr  set baud rate                 m       9600/19200/57600/115200/
scb  set cable parameters          i       0-255
scd  set ccd direction             i       0-2
sdo  set digital offset            ti      0-2:0-2048
sem  set exposure mode             m       2/3/4/5/6/7/8/
set  set exposure time             f       3-1000
sfc  set fpn coeff                 xi      1-1024:0-2047
slt  set lower threshold           i       0-2047
smm  set mirror mode               i       0-1
spc  set prnu coeff                xi      1-1024:0-28671
srm  set readout mode              i       0-2
ssb  set subtract background       ti      0-2:0-2047
ssf  set sync frequency            f       300-68000
ssg  set system gain               ti      0-2:0-65535
ssm  set sensitivity mode          i       0-2
sut  set upper threshold           i       0-4095
svm  set video mode                i       0-2
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

addition of some camera link related commands…
```

7.2 Sensor Output Format

Sensitivity Mode

Purpose:	Sets the camera's sensitivity mode. When using high sensitivity mode, the camera's responsivity increases. High sensitivity mode permits much greater scanning speeds in low light, or allows reduced lighting levels.
Syntax:	**`ssm i`**
Syntax Elements:	***i*** Sensitivity mode to use. **0** = Low sensitivity mode **1** = High sensitivity mode **2** = Tall pixel mode
Notes:	• To obtain the current sensitivity mode, use the command **gcp** or **get ssm**. • The **scd** (set ccd direction) command is not available in low sensitivity mode or tall pixel mode.
Example:	**`ssm 0`**

CCD Shift Direction

Purpose:	When in high sensitivity mode, selects the forward or reverse CCD shift direction, internally or externally controlled. This accommodates object direction change on a web and allows you to mount the camera "upside down".
Syntax:	**`scd i`**
Syntax Elements:	***i*** Shift direction. Allowable values are: **0 =** Internally controlled, forward CCD shift direction. **1 =** Internally controlled, reverse CCD shift direction. **2 =** Externally controlled CCD shift direction via Camera Link control CC3 (CC3=1 forward, CC3=0 reverse).
Notes:	• To obtain the current value of the exposure mode, use the command **gcp** or **get scd.** • Available in high sensitivity mode only. • Refer to Figure 6: Object Movement and Camera Direction Example using an Inverting Lens, page 11, for an illustration of when you should use forward or reverse shift direction.
Related Commands:	**ssm**
Example:	**`scd 0`**

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 following 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: **0**: Base configuration, 1 taps, 8 bit output **1**: Base configuration, 1 taps, 12 bit output **2**: Base configuration, 2 taps, 8 bit output **3**: Base configuration, 2 taps, 12 bit output
Notes:	• 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	
Example:	`clm 0`

7.3 Exposure Mode, Line Rate and Exposure Time

Overview

You have a choice of operating in one of seven modes. The camera's line rate (synchronization) can be generated internally through the software command ssf or set externally with an EXSYNC signal, depending on your mode of operation. 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.
2.	Next, if using mode 2, 7 or 8 use the commands `ssf` and/or `set` to set the line rate and exposure time.

Setting the Exposure Mode

Purpose:	Sets the camera's exposure mode allowing you to control your sync, exposure time, and line rate generation.
Syntax:	`sem i`
Syntax Elements:	*i* Exposure mode to use. Factory setting is **7**.
Notes:	• Refer to Table 12: Spyder3 CL Exposure Modes 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` or `get sem`.

Related Commands: **ssf**, **set**

Example: `sem 3`

Table 12: Spyder3 CL Exposure Modes

Mode	SYNC	PRIN	Programmable Line Rate	Programmable Exposure Time	Description
2	Internal	Internal	Yes	Yes	Internal frame rate and exposure time. Exposure control enabled (ECE).
3	External	Internal	No	No	Maximum exposure time. Exposure control disabled (ECD).
4	External	Internal	No	No	Smart EXSYNC. ECE.
5	External	External	No	No	External sync, external pixel reset. ECE.
6	External	Internal	No	Yes	Fixed integration time. ECE.
7	Internal	Internal	Yes	No	Internal line rate, maximum exposure time. ECD.
8	Internal	Internal	No	Yes	Maximum line rate for exposure time. ECE.

Note: When setting the camera to external signal modes, EXSYNC and/or PRIN must be supplied.

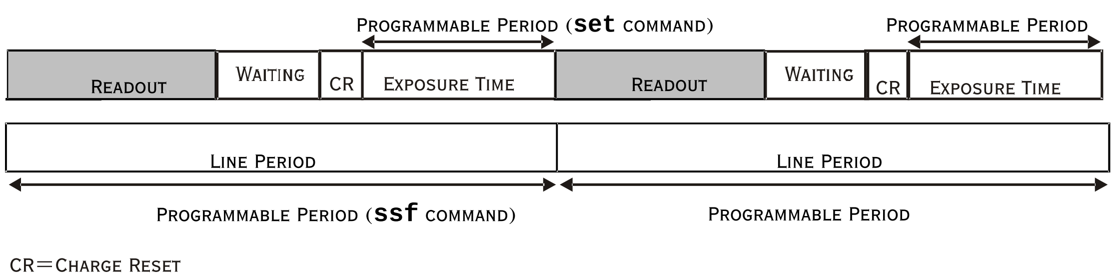
Exposure Modes in Detail

Mode 2: Internally Programmable Line Rate and Exposure Time (Factory Setting)

Mode 2 operates at a maximum line rate and exposure time.

- When setting the line rate (using the **ssf** command), exposure time will be reduced, if necessary, to accommodate the new line rate. The exposure time will always be set to the maximum time (line period – line transfer time – pixel reset time) for that line rate when a new line rate requiring reduced exposure time is entered.
- When setting the exposure time (using the **set** command), line time will be increased, if necessary, to accommodate the exposure time. Under this condition, the line time will equal the exposure time + line transfer time.

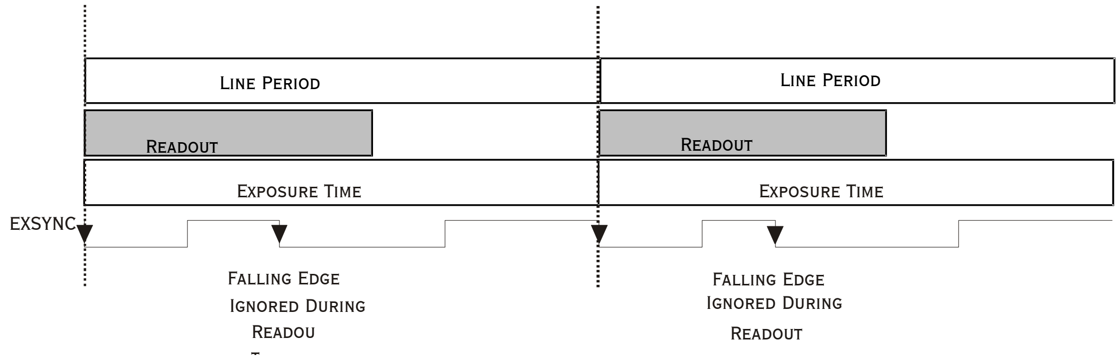
Example 1: Exposure Time less than Line Period



Mode 3: External Trigger with Maximum Exposure

Line rate is set by the period of the external trigger pulses. The falling edge of the external trigger marks the beginning of the exposure.

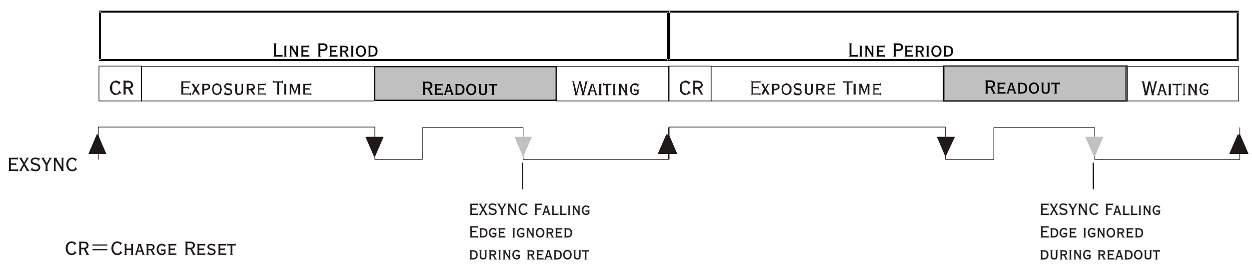
Example 2: Line Rate is set by External Trigger Pulses.



Mode 4: Smart EXSYNC, External Line Rate and Exposure Time

In this mode, EXSYNC sets both the line period and the exposure time. The rising edge of EXSYNC marks the beginning of the exposure and the falling edge initiates readout.

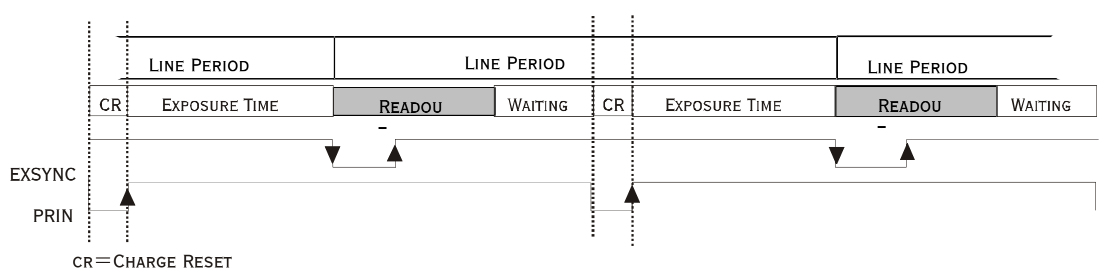
Example 3: Trigger Period is Repetitive and Greater than Read Out Time.



Mode 5: External Line Rate (EXSYNC) and External Pixel Reset (PRIN)

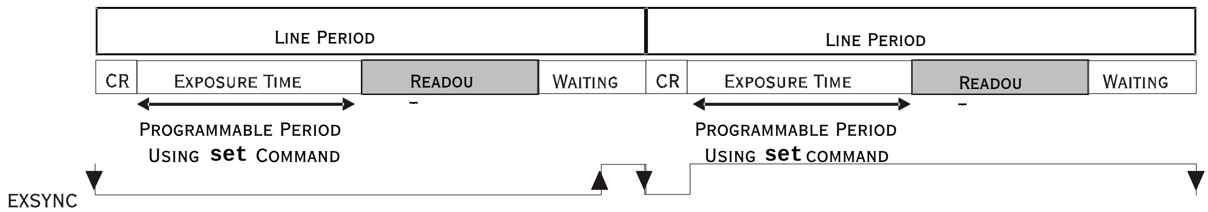
In this mode, the falling edge of EXSYNC sets the line period and the rising edge of PRIN sets the start of exposure time.

Figure 23: EXSYNC controls Line Period and PRIN controls Exposure Time



Mode 6: External Line Rate and Internally Programmable Exposure Time

Figure 24: EXSYNC controls Line Period with Internally controlled Exposure Time

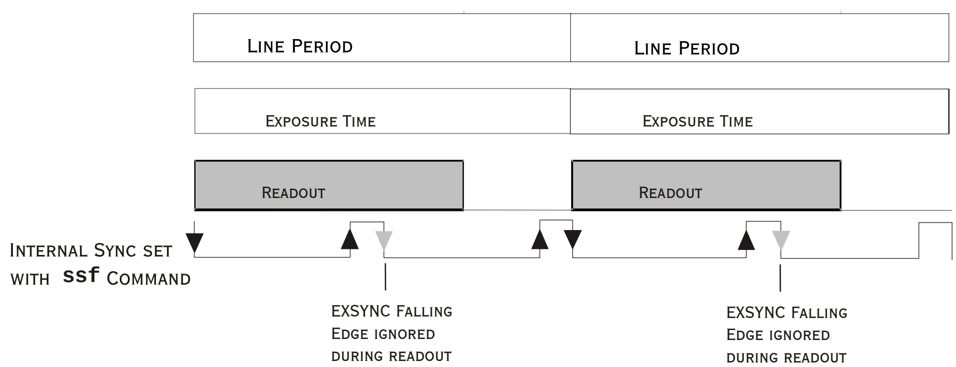


CR=CHARGE RESET

Mode 7: Internally Programmable Line Rate, Maximum Exposure Time

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

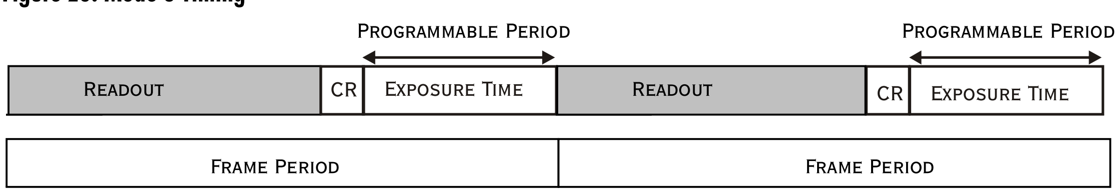
Figure 25: Mode 7 Camera Timing



Mode 8: Maximum Line Rate, Programmable Exposure Time

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

Figure 26: Mode 8 Timing



CR=CHARGE RESET

Setting the Line Rate

Applies to Modes 2 and 7

Purpose: Sets the camera's line rate in Hz. Camera must be operating in exposure mode 2 or 7.

Syntax: **`ssf f`**

Syntax Elements: **`i`**

Desired line rate in Hz. Allowable values are:
1k 1 tap: **`300-36000`** Hz
1k 2 tap: **`300-68000`** Hz
2k 1 tap: **`300-18500`** Hz
2k 2 tap: **`300-36000`** Hz
4k 2 tap: **`300-18500`** Hz

Notes:
- To read the current line frequency, use the command **`gcp`** or **`get ssf`**.
- If you enter an invalid line rate frequency, an error message is returned.

Related Commands: **`sem`**, **`set`**

Example: **`ssf 10000`**

Setting the Exposure Time

Applies to Modes 2 and 8

Purpose: Sets the camera's exposure time is µs. Camera must be operating in mode 2, 6, or 8.

Syntax: **`set f`**

Syntax Elements: **`i`**

Desired exposure time in µs. Allowable range is **`3`** to **`3300`**µs.*

Notes:
- To read the current line frequency, use the command **`gcp`** or **`get set`**.
- If you enter an invalid line rate frequency, an error message is returned.
- *The exposure time range is based on the current line rate.
- To determine the maximum exposure time allowed for the current line rate, use the command **get ger**.

Related Commands: **`sem`**, **`ssf`**

Example: **`set 400.5`**

Setting the Mirror Mode

Purpose: Sets the camera's mirror mode. Set the pixel readout as either left to right, or right to left.

Syntax: **`smm i`**

Syntax Elements: **`i`**

`0`: Pixels readout left to right.
`1`: Pixels readout right to left.

Notes:	S3-20-01K40	**smm 0** = 1-512 (tap 1) or 513-1024 (tap 2)
		smm 1 = 1024-513 (tap 1) or 512-1 (tap 2)
	S3-20-02K40	**smm 0** = 1-1024 (tap 1) or 1025-2048 (tap 2)
		smm 1 = 2048-1025 (tap 1) or 1024-1 (tap 2)
	S3-20-04k-40	**smm 0** = 1-2048 (tap 1) or 2049-4096 (tap 2)
		smm 1 = 4096-2049 (tap 1) or 2048-1 (tap 2)
Example:	**smm 1**	

Setting the Readout Mode

See also, the Clearing Dark Current section in Appendix A for more information on this mode.

Purpose: Use this command to clear out dark current charge in the vertical transfer gates immediately before the sensor is read out.

Syntax: **srm**

Syntax Elements: **i**

0: Auto. Clears dark current below ~ 45% of the maximum line rate.

1: Dark current clear. Always clears dark. Reduces the maximum line rate.

2: Immediate readout. Does not clear dark current. (Default mode.)

Notes:

- The vertical transfer gates collect dark current during the line period. This collected current is added to the pixel charge. The middle two red taps have more vertical transfer gates and, therefore, more charge. This additional charge is especially noticeable at slower line rates.
- If the user is in **sem 2** or **7** and **srm 2**, with **ssf** at 45% of the maximum, and then srm 1 is selected, the following warning will be displayed, but the ssf value will not be changed: Warning 09: Internal line rate inconsistent with readout time> The effect in both internal and external line rate modes is that an EXSYNC is skipped and, therefore, the output will be at least twice as bright.
- This value is saved with the camera settings.
- This value may be viewed using either the **gcp** command or the get **srm** command.

Related Commands: **sem, ssf**

Example: **srm 0**

7.4 Data Processing

Setting a Region of Interest (ROI)

Purpose:	Sets the pixel range used to collect the end-of-line statistics and sets the region of pixels used in the **ccg**, **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`** Pixel start number. Must be less than the pixel end number in a range from **`1`** to **`sensor resolution`**. ***`y1`*** Column start number. Since the Spyder3 CL is a line scan camera, this value must be **`1`**. ***`x2`*** Pixel end number. Must be greater than the pixel start number in a range from **`1`** to **`sensor resolution`**. ***`y2`*** Column end number. Since the Spyder3 CL is a line scan camera, this value must be **`1`**.
Notes:	• To return the current region of interest, use the commands **gcp** or **get roi**.
Related Commands	**ccg**, **gl**, **gla**, **ccf**, **ccp**, **cpa**, **els**
Example:	**`roi 10 1 50 1`**

7.5 Analog and Digital Signal Processing Chain

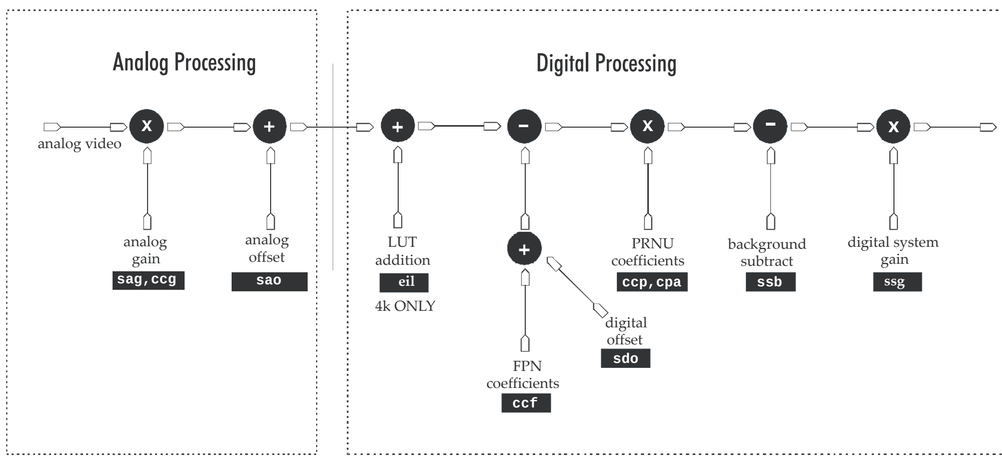
Processing Chain Overview and Description

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. Non-linearity look-up table (LUT) correction is available for the 4k model of camera.

All of these elements are user programmable.

Figure 27: 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 (**sag** or **ccg** command.) 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. Note: To maintain valid LUT calibration do not use the **sag** command with the 4k model. Instead, use the **ssg** command.

2. The analog offset (**sao** command) or black level is an "artificial" offset introduced into the video path to ensure that the A/D is functioning 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 (calculated using the **ccp** or **cpa** commands) 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 may 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.
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 255 DN(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.

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.

Note: This command will invalidate the LUT calibration for the 4k model of camera. Use the **ssg** command instead.

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 **2** for individual tap selection. ***f*** Gain value in a range from **–10** to **+10**dB.
Notes:	• To return the current analog gain setting, use the command **gcp** or **get sag**.

Example:	**`sag 0 5.2`**
Related Commands:	**`ccg`**

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 region of interest (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 **`2`** for individual tap selection if you are using the two tap model. **`i`** Calculation target value in a range from **`1024`** to **`4055`**DN (12 bit LSB).
Notes:	• This function requires constant light input while executing. • 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. • All digital settings affect the analog gain calibration. If you do not want the digital processing to have any effect on the camera gain calibration, then turn off all digital settings by sending the commands: **`sdo 0 0`**, **`epc 0 0`**, **`ssb 0 0`**, and **`ssg 0 4096`**
Example:	**`ccg 2 0 3040`**
Related Commands:	**`sag`**, **`ssg`**

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 **`2`** for individual tap selection if you are using the two tap model.

`i`

Offset value in a range from **`0`** to **`255`**DN (12 bit LSB).

Notes:

- To return the current analog offset value, use the command **`gcp`** or **`get sao`**.

Example: **`sao 2 35`**

Related Commands:

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. 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 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 (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, or line rate.

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:

- 50 or 60 Hz ambient light flicker is sufficiently low not to affect camera performance and calibration results.
- 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.
- The brightest pixel should be slightly below the target output.
- When 6.25% of pixels from a single row within the region of interest are clipped, flat field correction results may be inaccurate.
- 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.

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

- Signal output should be no higher than 80% of saturation (i.e. When your output is 12-bit data then 80% of 4096 is 3276. For 8 bit output 80% of 256 is 204).
- Your analog offset setting should not be clipping more than 6.25% of the pixels within the region of interest.
- Digital offset and digital system gain, and background subtract values should be set to zero (**ssb 0 0**, **sdo 0 0**, **ssg 0 0**)

Set the calibration sample size using the command css. It is recommended that you use the default setting.

Set the region of interest to include all of the image's pixels of importance using the command roi x1 y1 x2 y2. You can use the default if you want to calibrate all pixels.

Perform FPN calculation

FPN calculation removes the fixed pattern noise(dark current) from the video path. It is recommended you repeat the calculation 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 0 *i***. If the average of the pixels is too high for your application, reduce the analog offset or gain level (**sag**).
3. Issue the command **ccf**. The camera will respond with OK> (if no error occurs). FPN calculation automatically calibrates FPN coefficients and digital offset.
4. After the calibration is complete, you should save these settings to non-volatile memory so they be reusable on reboot. To do so, issue the commands **wfc** and **wus**.
5. To verify output, enable the FPN coefficients using the command **epc 1 0**. You should see close to zero output.

Perform PRNU calculation

Perform PRNU calculation 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.
2. Verify that the output signal level is within range by issuing the command **gl** or **gla**. If the signal level is too low, increase your light level, adjust the analog gain (**sag**) or use the automated algorithm **ccg i 0 i**.
   DALSA recommends a target value of about 80% of saturation. If you change the gain, FPN coefficients should be recalculated.
3. Issue the command **ccp**. The camera will respond with OK>(if no error occurs).
4. After the calculation is complete, you can save these settings to non-volatile memory so they will be remembered after power-down and direction change. To do so, issue the commands **wpc** and **wus.**
5. Enable the coefficients using the command, **epc 1 1**.

Note: All commands listed above are described in detail in the following sections.

Digital Signal Processing

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

FPN Correction

Performing FPN Correction

Syntax:	Performs FPN correction and eliminates FPN noise by removing individual pixel dark current.
Syntax:	**`ccf`**
Notes:	• Perform all analog and digital adjustments before performing FPN correction. • Perform FPN correction before PRNU correction. • Refer to Calibrating the Camera to Remove Non-Uniformity (Flat Field Correction) on page 59 for a procedural overview on performing flat field correction. • To save FPN coefficients after calibration, use the **`wfc`** command. Refer to section 7.9 Saving and Restoring PRNU and FPN Coefficients for details.
Related Commands:	**`ccp`**, **`wfc`**
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`** to **`2047`** (12 bit LSB).
Example:	**`sfc 10 50`**

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 **`2`** depending on camera model, or **`0`** for all taps. ***`i`*** Subtracted offset value in a range from **`0`** to **`2048`** where FPN Coefficient= *i* (12 bit LSB Justified)
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`**
Example:	**`sdo 0 100`**

PRNU Correction

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 in 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. It 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 the 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.

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`**

Performing PRNU Correction to a Camera Calculated Value

Purpose: Performs PRNU correction and eliminates the difference in responsivity between the most and least sensitive pixel creating a uniform response to light.

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 wfc command. You can then adjust the digital offset (**`sdo`** command) to remove some of the FPN.
- Ensure camera is operating at its expected analog gain, integration time, and temperature.
- Refer to Calibrating the Camera to Remove Non-Uniformity (Flat Field Correction)on page 59 for a procedural overview on performing flat field correction.
- To save FPN coefficients after calibration, use the **`wpc`** command. Refer to section 7.9 Saving and Restoring PRNU and FPN Coefficients for details.

Related Commands: **`ccf`**, **`cpa`**

cpa i i

i

- 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.
- Note: Refer to Calibrating the Camera to Remove Non-Uniformity (Flat Field Correction)on page 59 for a procedural overview on performing flat field correction.

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:

$$\text{PRNU coefficient } 1 + \frac{i}{4096}$$

Example: **spc 1024 10000**

Subtracting Background

Purpose: Use the background subtract command after performing flat field correction if you want to improve your image in a low contrast scene. It is useful for systems that process 8 bit data but want to take advantage of the camera's 12 bit digital processing chain. You should try to make your darkest pixel in the scene equal to zero.

Syntax: **ssb *t i***

Syntax Elements: **t**

Tap selection. Allowable range is **1** to **2** depending on camera model, or **0** for all taps.

i

Subtracted value in a range in DN from **0** to **4095**.

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 where: $$\text{ssg value} = \frac{\text{max output value}}{\text{max output value - ssb value}}$$ See the following section for details on the **ssg** command.
Related Commands:	**ssg**
Example	**ssb 0 25**

Setting Digital System 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 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 **2**, 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: $$\text{Digital Gain} = \frac{i}{4096}$$ Use this command in conjunction with the **ssb** command.
Related Commands:	**ssb**
Example:	**ssg 1 15**

Returning Calibration Results and Errors

Returning All Pixel 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`**.

`x2`

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

Notes:

- This function returns all the current pixel coefficients in the order FPN, PRNU, FPN, PRNU… The camera also returns the pixel number with each coefficient.

Example: **`dpc 10 20`**

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`**.

Example: **`gfc 10`**

Returning PRNU Coefficients

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

Syntax: **`gpc`** ***`i`***

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

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

Example: **`gpc 10`**

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**

7.6 End-of-line Sequence

Purpose: Produces an end-of-line sequence that provides basic calculations including "line counter", "line sum", "pixels above threshold", "pixels below threshold", and "derivative line sum" within the region of interest. These calculations can be used to perform **aoc** algorithms or indicate objects of interest.

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 are calculated for the 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 13: 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	Counter increments by 1. Use this value to verify that every line is output
5	Line sum (7…0)	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)	

Location	Value	Description
9	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)
10	Pixels above threshold (15…8)	
11	Pixels below threshold (7…0)	
12	Pixels below threshold (15…8)	
13	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.
14	Differential line sum (15…8)	
15	Differential line sum (23…16)	
16	Differential line sum (31…24)	

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**

7.7 Look-Up Tables

Note: This information only applies to the 4k model camera.

The flat field corrections FPN and PRNU assume a linear response to the amount of light by the sensor, output node, analog amplifier, and analog to digital converter. To correct any non-linearity in this system of components a Look-Up Table (LUT) has been implemented in the FPGA for each tap immediately after the ADC. The LUT adds a signed value (-256 to +255) indexed by the 10 MSB of the input value.

Calibrate Input LUT

Purpose: Calibrates the current input look-up table for correcting non-linearity in the analog chain (CCD sense node and analog-to-digital conversion).

Syntax: **`cil`**

Syntax Elements:

Notes: This command calibrates all taps within the ROI.

To calibrate:

Place a white reference in front of the camera. This is similar to a PRNU calibration.

In addition:

Use the **`wil`** command to write the LUT to non-volatile memory.

Use the **`eil`** command to enable use of the LUT.

Use the **`roi`** command to limit the taps calibrated and to limit which pixels are used for calibration. If a tap is not in the region of interest, then it will not be calibrated and left at current values.

Press spacebar to abort this command.

Rerun this command if the analog gain or operating temperature changes.

Example:

Enable Input LUT

Purpose: Enables or disables the use of the input look-up tables for the correction of the analog chain non-linearity.

Syntax: **`eil`** ***`flag`***

Syntax Elements: ***`0`***

Disable

`1`

Enable

Notes: Coefficients must be created first with the **cil** command.
Setting saved with the **wfs** and **wus** commands.

Example:

Write Input LUT

Purpose: Saves current values of input LUT that are in FPGA SDRAM to Flash memory or a PC file.

Syntax: **`wil`**

Syntax Elements:

Example: **`wil`**

Notes: **`0`** = Factory set
`1` to **`4`** = User sets

Input LUT is loaded by LIL, and automatically at power-up.
LUT use is enabled or disabled with the EIL command.
Set 0 can only be written from factory mode.

Load Input LUT

Purpose: Load previously stored LUT from non-volatile memory to FPGA SDRAM.

Syntax: **`lil`**

Syntax Elements:

Example: **`lil`**

Notes: **`0`** = Factory set
`1` to **`4`** = User sets

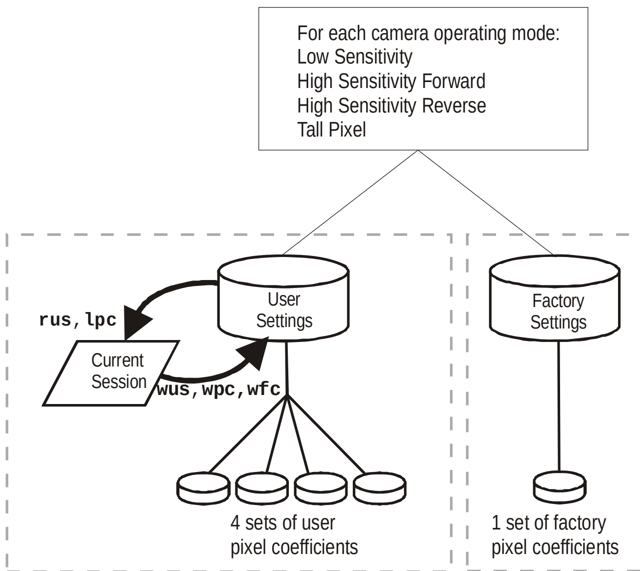
LUTs are only loaded from non-volatile memory on: power-up, LIL.

Related Commands: **`wil`**

7.8 Saving and Restoring Settings

For each camera operating mode (high sensitivity forward direction, high sensitivity reverse direction, low sensitivity, or tall pixel), the camera has distinct factory settings, current settings, and user settings. In addition, there is one set of factory pre-calibrated pixel coefficients and up to four sets of user created pixel coefficients for each operating mode.

Figure 28: 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 and LUTs are stored separately from other data.

- To save all current user settings to non-volatile memory, use the command **`wus`**. The camera will automatically restore the saved user settings when powered up. **Note:** 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, use the command **`rus`**.
- To save the current pixel coefficients, use the command **`wpc`** and **`wfc`**.
- To restore the last saved pixel coefficients, use the command **`lpc`**.
- To write and load LUTs, use the **`wil`** and **`lil`** commands, respectively.

Current Session Settings

These are the current operating settings of your camera. To save these settings to non-volatile memory, use the command **`wus`**.

7.9 Saving and Restoring PRNU and FPN Coefficients

Saving the Current PRNU Coefficients

Purpose: Saves the current PRNU coefficients. You can save up to four sets of pixel coefficients

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

Example: **wpc 2**

Saving the Current FPN Coefficients

Purpose: Saves the current FPN coefficients. You can save up to four sets of pixel coefficients

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

Example: **wfc 2**

Loading a Saved Set of Coefficients

Purpose: Loads a saved set of pixel coefficients. 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

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.

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.

7.10 Diagnostics

Generating a Test Pattern

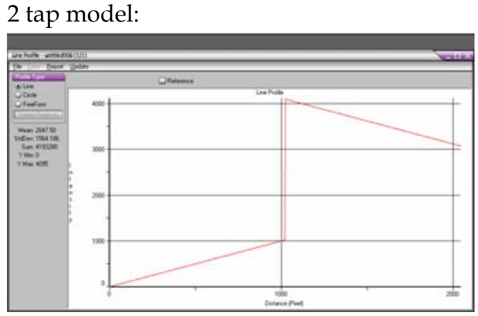
Purpose: Generates a test pattern to aid in system debugging. The test patterns are useful for verifying camera timing and connections. The following tables show each available test pattern.

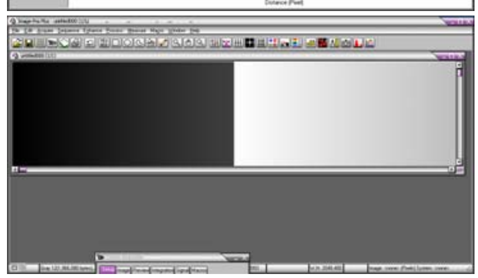
Syntax: **svm *i***

Syntax Elements: ***i***

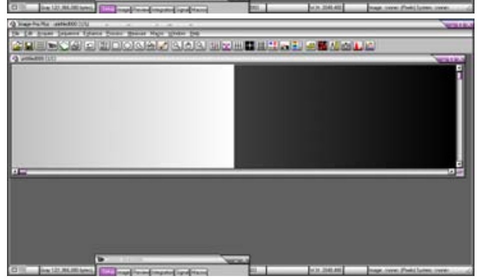
svm **0** Video.

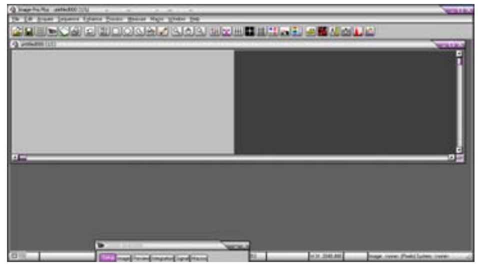
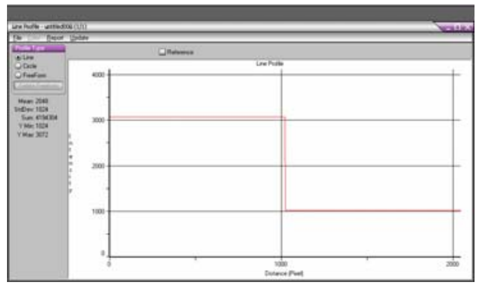
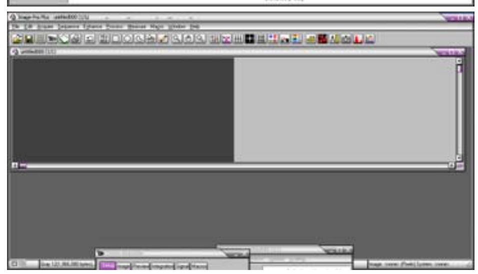
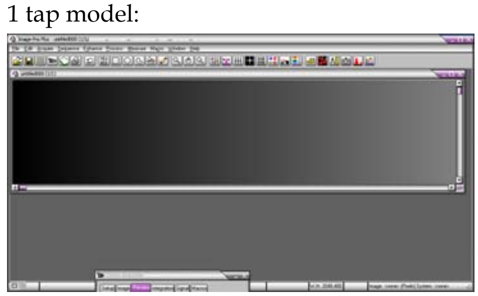
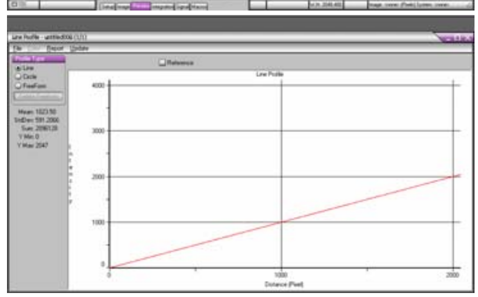
svm **1** 12 bit test pattern.
smm **0** 2 tap model:

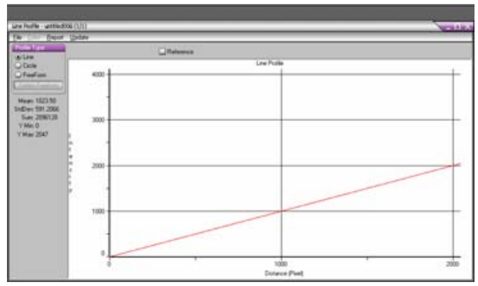


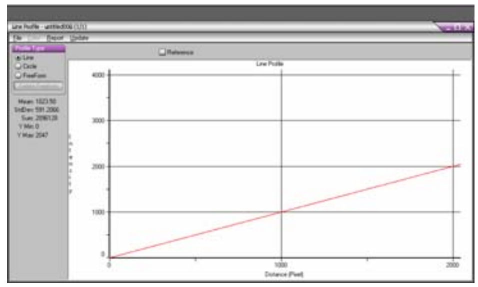


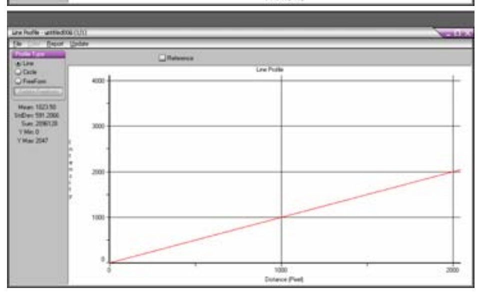
svm **1**
smm **1**



svm smm	2 1	
svm smm	2 0	8 bit test pattern 2 tap model: 
svm smm	2 1	
svm smm	1 0	12 bit test pattern 1 tap model:  

svm	**1**	
smm	**1**	
svm	**2**	8 bit test pattern
smm	**1**	t tap model:





7.11 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 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 applied) displaying one pixel value after another. After pixel values have been displayed 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 (ROI)).

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`***

Pixel start number. Must be less than the pixel end number in a range from **1** to **sensor resolution**.

x2

Pixel end number. Must be greater than the pixel start number in a range from **2** to **sensor resolution**.

Notes:
- If **x2**≤**x1** then **x2** is forced to be **x1**.
- Values returned are in 12-bit DN.

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 when performing FPN and PRNU calibration.

Syntax: **css *m***

Syntax Elements: **m**

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

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

Related Commands: **gla**, **ccf**, **ccp**, **cpa**

Example: **css 1024**

Returning the Average of Multiple Lines of Video

Purpose: Returns the average for multiple lines of video data (without pixel coefficients applied). 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 (ROI)).

Syntax: **gla x1 x2**

Syntax Elements: ***x1***

Pixel start number. Must be less than the column end number in a range from **1** to sensor **resolution**.

x2

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

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

Example: **gla 10 20**

7.12 Temperature Measurement

The temperature of the camera can be determined by using the **vt** command. This command will return the internal chip case 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 not be able to restart the camera until the temperature is less than 65°C. You will have to correct the temperature problem or the camera will shutdown again. The camera allows you to send the **vt** (verify temperature) command while it is in this state.

7.13 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.

7.14 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 (PRIN) **3**: CC3 (CCD Direction)
Note:	• Camera operation may be impacted when entering the gsf command (i.e., poor time response to direction change or video may have artifacts (gain changes) for several lines while the camera returns signal information) • This command is not available when operating the camera with external CCD direction control (**scd 2**)
Example:	**gsf 1**

7.15 Returning the LED Status

Purpose:	Returns the status of the camera's LED.
Syntax:	**`gsl`**
	The camera returns one of the following values: **1** = red (loss of functionality) **2** = green (camera is operating correctly) **5** = flashing green (camera is performing a function) **6** = flashing red (fatal error)
Notes:	• Refer to section 2.4 Camera LED for more information on the camera LED

7.16 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. The table below lists all of the gcp screen settings.

To read all current camera settings, use the command:

Syntax: **`gcp`**

GCP Screen		Description
GENERAL CAMERA SETTINGS		
Camera Model No.:	**S3-x0-0xK40-00-R**	Camera model number.
Camera Serial No.:	**xxxxxxxxx**	Camera serial number.
Firmware Version:	**xx-xx-xxxxx-xx**	Firmware design revision number.
CCI Version:	**xxxxx.xx**	CCI version number.
FPGA Version:	**xxx.xx**	FPGA revision number.
UART Baud Rate:	**9600**	Serial communication connection speed set with the **sbr** command. See Setting Baud Rate on page 44 for details.
Dual Scan Mode:	**High Sensitivity**	Current sensitivity mode set with the **smm** command. See section Sensitivity Mode for details.
Camera Link Mode:	**2 taps, 8 bits**	Current bit depth setting set with the clm command.

`Mirroring Mode`	`0, left to right`	Tap readout direction: left to right, or right to left. Set with the **smm** command.
`Readout Mode`	`Off`	Current readout mode status. Set using the **srm** command.
`Cable Parameter`	`200`	The cable parameter. Set using the **scb** command.
`Exposure Mode:`	`2`	Current exposure mode value set with the **sem** command. See the Setting the Camera Link Mode section for details.
`SYNC Frequency:`	`5000 Hz`	Current line rate. Value is set with the **ssf** command. See the Setting the Camera Link Mode section for details.
`Exposure Time:`	`200 uSec`	Current exposure time setting. Value is set with the **set** command. See the Setting the Camera Link Mode section for details.
`CCD Direction:`	`internal/forward`	Current direction setting set with scd command. Refer to section CCD Shift Direction for details.
`Horizontal Binning:`	`1`	Current horizontal binning factor set with the **sbh** command.
`Video Mode:`	`video`	Current video mode value set with the **svm** command. See section Generating a Test Pattern for details.
`Region of Interest:`	`(1,1) to (1024, 1)`	Region of interest size set with the **roi** command. See section Setting a Region of Interest (ROI) for details.
`End-Of-Line Sequence:`	`on`	States whether an end of line sequence is turned on or off. Set using the **els** command. See section 7.6 End-of-line Sequence for details.
`FFC Coefficient Set:`	`0`	Current pixel coefficient set loaded. Refer to

		section 7.9 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 7.5 Analog and Digital Signal Processing Chain for details.
PRNU Coefficients:	**off**	States whether PRNU coefficients are on or off. Set with the **epc** command. Refer to section 7.5 Analog and Digital Signal Processing Chain for details.
Number of Line Samples:	**1024**	Number of lines samples set with the **css** command. See section 7.11 Returning Video Information for details.
Upper Threshold	**3600**	Upper threshold value set with the **sut** command. See section 7.6 End-of-line Sequence for details.
Lower Threshold	**400**	Lower threshold value set with the **slt** command. See section 7.6 End-of-line Sequence for details.
Analog Gain (dB):	**0.0 0.0**	Analog gain settings set with the **sag** command. See section 7.5 Analog and Digital Signal Processing Chain for details.
Analog Gain Reference(dB):	**0.0 0.0**	Analog reference gain set with the **ugr** command. See section 7.5 Analog and Digital Signal Processing Chain for details.
Total Analog Gain (dB):	**5.5 5.5**	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:	**70 70**	Analog offset settings set with the **sao** command. See section 7.5 Analog and Digital Signal Processing Chain for details.
Digital Offset:	**0 0**	Digital offset settings set with the **sdo** command. See section 7.5 Analog and Digital Signal Processing Chain for details.
Background Subtract:	**0 0**	Background subtract settings set with the **ssb** command. See section 7.5 Analog and Digital Signal Processing Chain for details.
System Gain (DN):	**4096 4096**	Digital gain settings set with the **ssg** command. See section 7.5 Analog and Digital Signal Processing Chain 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 14 below for a list of available commands. To view a help screen listing the following get commands, use the command **gh**.

Table 14: Get Commands

Syntax	Parameters	Description
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 configuration where: **0 =** 8 bits, 1 tap **1 =** 12 bits, 1 tap **2** = 8 bits, 2 taps **3** = 12 bits, 2 tap

Syntax	Parameters	Description
`get dil`	`t a a`	Displays LUT values: **t** = Tap dependent: 0 for all. 1 and 2 for individual. **a1** = Start LUT address. In a range from 0 to 1023. **a2** = Stop LUT address, a1 < a2
`get dpc`	`x1 x2`	Returns pixel coefficients without formatting.
`get eil`		Returns LUTs status. **0**: Off **1**: On
`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 ger`		Returns the maximum exposure time for the current line rate.
`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 gpc`	`x`	Returns the PRNU pixel coefficient for the pixel indicated.
`get gsf`	`i`	Returns the frequency of the Camera Link control signal indicated, either **1**, **2**, or **3**.
`get gsl`		Returns the led status where:
`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.

Syntax	Parameters	Description
`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** to **2** for individual tap selection.
`get sao`	`t`	Returns the analog offset for the tap indicated. **t = 0** for all taps or **1** to **2** for individual tap selection.
`get sbh`		Returns the horizontal binning factor.
`get sbr`		Returns the speed of camera serial communication port.
`get scb`		Returns the set cable parameter.
`get scd`		Returns the ccd shift direction where: **0 =** Forward CCD shift direction. **1 =** Reverse CCD shift direction. **2 =** Externally controlled, forward direction, via CC3. **3 =** Externally controlled, reverse direction, via CC3.
`get sdo`	`t`	Returns the digital offset value in DN for the tap indicated. **t** = Tap value. **0** for all taps or **1** to **2** for individual tap selection.
`get sem`		Returns the current exposure mode: **2 =** Internal SYNC, internal PRIN, programmable line rate and exposure time using commands **ssf** and **set** **3 =** External SYNC, internal PRIN, maximum exposure time **4** = Smart EXSYNC **5** = External SYNC and PRIN **6** = External SYNC, internal PRIN, programmable exposure time **7 =** Internal programmable SYNC, maximum exposure time. Factory setting. **8** = Internal SYNC, internal PRIN, programmable exposure time. Maximum line rate for exposure time.
`get set`		Returns the current exposure time in µs.
`get sfc`	`x`	Returns the FPN coefficient for the pixel number indicated. **x** =pixel number within the range **1** to **sensor pixel count**.
`get slt`		Returns the current lower threshold value.
`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 srm`		Returns the readout mode: **0** = Auto. **1** = Dark current clear. **2** = Immediate readout. Does not clear dark current.
`get ssb`	`t`	Returns the current background subtract value. **t** = Tap value. **0** for all taps or **1** to **2** for individual tap selection depending on camera model.
`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 **2** depending on camera model, or **0** for all taps
`get ssm`		Returns the current sensitivity mode where: **0** = Low sensitivity mode **1** = High sensitivity mode **2** = Tall pixel mode
`get sut`		Returns the current upper threshold value.
`get svm`		Returns the current video mode. **0**: Normal video mode **1**: Test pattern **2**: Test pattern
`get ugr`	`t`	Returns the gain reference value. **t** = tap selection, either **1** to **2** depending on camera model, or **0** for all taps
`get vt`		Returns the camera's internal chip temperature in degrees Celsius.
`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

7.17 ASCII Commands: 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

The following table lists all of the camera's available ASCII commands. Refer to Appendix A for detailed information on using these ASCII commands.

Table 15: Command Quick Reference

Mnemonic	Syntax	Parameters	Description
correction calibrate fpn	**ccf**		Performs FPN calibration and eliminates FPN noise by subtracting away individual pixel dark current.
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** or **2** for individual tap selection depending on camera model. **i** = Calibration target value in a range from **1024** to **4055**DN (12 bit LSB).
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.
calibrate input LUT	**cil**		Calibrates the input lookup table (LUT). The LUTs are used to remove nonlinearity from the analog chain.

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. The second parameter is the target value to use in a range from **1024** to **4055**DN.
Camera Link mode	**clm**	**i**	Sets the camera's bit width where: *For S3-10-01K40 and S3-10-02K40* **0 =** 8 bits, 1 tap **1 =** 12 bits, 1 tap *For S3-20-01K40 and S3-20-02K40* **2** = 8 bits, 2 taps **3** = 12 bits, 2 taps
correction set sample	**css**	**m**	Sets the number of lines to sample when using the **gla** command or when performing FPN and PRNU calibration where m is **256**, **512**, or **1024**

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 **x2**= Pixel end number in a range from **1** to **1024** or **2048**
enable input LUT	**eil**	**i**	Enable input LUT, where: **0**: Off **1**: On
end of line sequence	**els**	**i**	Sets the end-of-line sequence: **0**: Off **1**: On
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
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**.
get help	**gh**		Returns all of the available "get" commands.
get input LUT	**gil**		Display the current LUT set number.
get line	**gl**	**x x**	Gets a line of video (without pixel coefficients applied) 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**.

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**.
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
get status led	**gsl**		Returns the current state of the camera's LED where: **1** = Red **2** = Green **5** = Blinking green **6** = Blinking red
help	**h**		Display the online help. Refer to the Select Cable Camera ASCII Command Help for details.
load input LUT	**lil**	**i**	Load input LUT's from non-volatile memory to current. In range of 0 to 4.
load pixel coefficients	**lpc**	**i**	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**		Resets the entire camera (reboot). Baud rate is not reset and reboots with the value last used.
restore factory settings	**rfs**		Restores the camera's factory settings. FPN and PRNU coefficients reset to 0.
reset input LUT	**ril**		Sets the value of the current LUT to zero. Use **wil** to save this setting.
region of interest	**roi**	**x y x y**	Sets the pixel range affected by the **cag**, **gl**, **gla**, **ccf**, 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**.
reset pixel coeffs	**rpc**		Resets the pixel coefficients to 0.

Mnemonic	Syntax	Parameters	Description
restore user settings	**rus**		Restores the camera's last saved user settings and FPN and PRNU coefficients.
set analog gain	**sag**	**t f**	Sets the analog gain in dB. **t** = tap selection, either **1** or **2** depending on camera model, or **0** for all taps. **f**= gain value specified from **–10** to **+10**
set analog offset	**sao**	**t i**	Sets the analog offset. **t =** tap selection, either **1** or **2** depending on camera model, or **0** for all taps. **i**= Offset value in a range from **0** to **255** (12-bit LSB). Offset increases with higher values.
set binning horizontal	**sbh**	**m**	Sets the horizontal binning value. Available values are **1** and **2**.
set baud rate	**sbr**	**i**	Set the speed of camera serial communication port. Baud rates: **9600**, **19200**, **57600**, and **115200**. Default: 9600.
set cable parameter	**scb**	**i**	Set the cable parameter. Output compare value. Available values are: 0-255.
set ccd direction	**scd**	**i**	Sets the CCD shift direction where: **0 =** Forward CCD shift direction. **1 =** Reverse CCD shift direction. **2 =** Externally controlled direction control via CC3. (CC3=1 forward, CC3=0 reverse.)
set digital offset	**sdo**	**t i**	Subtracts the input value from the video signal prior to FPN correction. **t** = tap selection, either **1** or **2** depending on camera model, or **0** for all taps. **i** = Offset in a range from **0** to **2048**DN.

Mnemonic	Syntax	Parameters	Description
set exposure mode	**sem**	**m**	Sets the exposure mode: **2 =** Internal SYNC, internal PRIN, programmable line rate and exposure time using commands **ssf** and **set** **3 =** External SYNC, internal PRIN, maximum exposure time **4** = Smart EXSYNC **5** = External SYNC and PRIN **6** = External SYNC, internal PRIN, programmable exposure time **7 =** Internal programmable SYNC, maximum exposure time. Factory setting. **8** = Internal SYNC, internal PRIN, programmable exposure time. Maximum line rate for exposure time.
set exposure time	**set**	**f**	Sets the exposure time. Refer to the camera help screen (**h** command) for allowable range.
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 **2047** (12-bit LSB).
set input LUT	**sil**	**t i**	Set a single value in a LUT. **t**=Tap: 1 or 2. **i**=Value within the range -255 to +256.
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**.
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 readout mode	**srm**	**i**	Set the readout mode in order to clear out dark current charge in the vertical transfer gates before the sensor is read out. **0** = Auto. **1** = Dark current clear. **2** = Immediate readout. Does not clear dark current.

Mnemonic	Syntax	Parameters	Description
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 camera taps* for individual tap selection. **i** = Subtracted value in a range from **0** to **4095**.
set sync frequency	**ssf**	**i**	Set the frame rate to a value from **300**Hz to **36000**Hz (2k model) or **300**Hz to **68000**Hz (1k model). Value rounded up/down as required.
set system gain	**ssg**	**t i**	Set the digital gain. **t** = tap selection, either **1** to **2**, or **0** for all taps **i** = Digital gain in a range from **0** to **65535**. The digital video values are multiplied by this number.
set sensitivity mode	**ssm**	**i**	Sets the camera's sensitivity mode where i is: **0** = Low sensitivity mode **1** = High sensitivity mode **2** = Tall pixel mode
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**.
set video mode	**svm**	**i**	Switch between normal video mode and camera test patterns: **0**: Normal video mode **1**: Camera test pattern **2**: Camera test pattern
update gain reference	**ugr**		Changes 0dB gain to equal the current analog gain value set with the **sag** command.
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 non-volatile memory, where ***i*** is: **1** = FPN coefficient set one **2** = FPN coefficient set two **3** = FPN coefficient set three **4** = FPN coefficient set four
write input LUT	**wil**	**i**	Write current LUT's to non-volatile memory. **i**=1 to 4

Mnemonic	Syntax	Parameters	Description
write PRNU coeffs	**wpc**	**i**	Write all current PRNU coefficients to non-volatile memory, where ***i*** is: **1** = PRNU coefficient set one **2** = PRNU coefficient set two **3** = PRNU coefficient set three **4** = PRNU coefficient set four
write user settings	**wus**		Write all of the user settings to non-volatile memory.

7.18 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 16: Warning and Error Messages

Message	Description
OK>	SUCCESS
Warning 01: Outside of specification>	Parameter accepted was outside of specified operating range (e.g. gain greater than ±10 dB of factory setting).
Warning 02: Clipped to min>	Parameter was clipped to the current operating range. Use **gcp** to see value used.
Warning 03: Clipped to max>	Parameter was clipped to the current operating range. Use **gcp** to see value used.
Warning 04: Related parameters adjusted>	Parameter was clipped to the current operating range. Use **gcp** to see value used.
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>	A FPN/PRNU has been calculated to be greater than the maximum allowable 511 (8).
Warning 09: Internal line rate inconsistent with readout time>	
Message	**Description**
Error 02: Unrecognized command>	Command is not available in the current access level or it is not a valid command.
Error 03: Incorrect number of parameters>	

Message	Description
Error 04: Incorrect parameter value>	This response returned for · Alpha received for numeric or vice versa · Not an element of the set of possible values. E.g., Baud Rate · Outside the range limit
Error 05: Command unavailable in this mode>	Command is valid at this level of access, but not effective. Eg line rate when in smart Exsync mode
Error 06: Timeout>	Command not completed in time. Eg FPN/PRNU calculation when no external Exsync is present.
Error 07: Camera settings not saved>	Tried saving camera settings (`rfs/rus)` but they cannot be saved.
Error 08: Unable to calibrate - tap outside ROI>	Cannot calibrate a tap that is not part of the region of interest.
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.

7.19 Clearing Dark Current

Gate Dark Current Clear

Note: This feature is not available for the S3-20-04k40 camera model.

Image sensors accumulate dark current while they wait for a trigger signal. If the readout is not triggered in a reasonable amount of time, then this dark current accumulation may increase to an excessive amount. The result of this happening will be that the first row, and possibly additional rows (frames), of the image will be corrupt.

The sensor used in this camera contains two sources of dark current that will accumulate with time: 1) in the photo sensitive area, and 2) in the gates used to clock-out the charge.

The gate dark current can account for approximately 20% of the total dark current present. While the exposure control has direct control over the amount of dark current in the photo sensitive area, it has no control over the charge accumulated in the gates. Even with exposure control on, at low line rates, this gate charge can cause the camera to saturate.

Using the `Set Readout Mode (srm)` command, the camera user can control the camera's behavior in order to minimize the dark current artifact.

The modes of operation selected by the `srm` command are: Auto, On, or Off.

Note: This command is only available in low sensitivity and tall pixel modes. High sensitivity mode operates only in the immediate read out position.

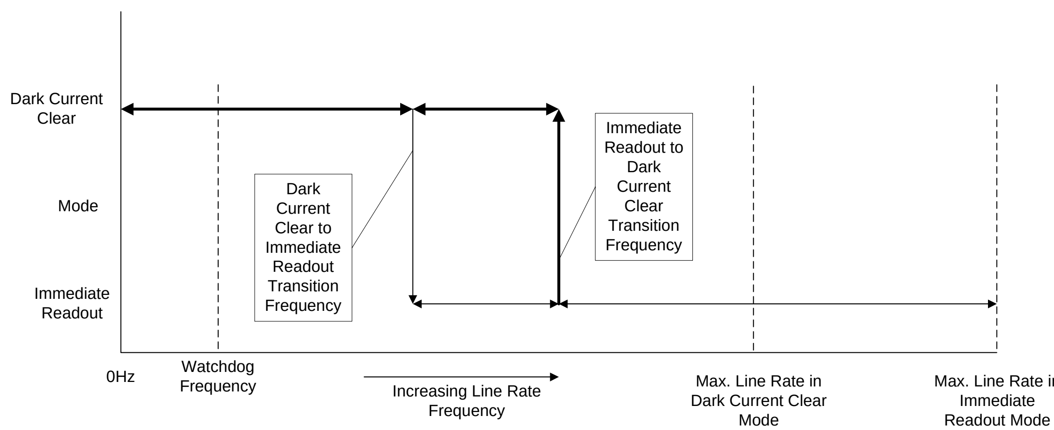


Figure 29: Gate Dark Current Clear

Table 17.

	Transition Frequencies	
Model	**Dark Current Clear to Immediate Readout Transition**	**Immediate Readout to Dark Current Clear Transition**
S3-10-01k40	13.6KHz	16.4KHz
S3-20-01k40	25.1KHz	30.4KHz

S3-10-02k40	7.05KHz	8.52KHz
S3-20-02k40	13.6KHz	16.4KHz
S3-20-04k40	7.05KHz	8.52KHz

Immediate read out mode (default, srm 2)

In this mode the image is read out, including accumulated dark current, immediately following the trigger or the EXSYNC falling edge.

There are no line rate limitations other than the amount of gate dark current that can be tolerated at low line rates.

There are no timing or exposure anomalies other than situations where EXSYNC is removed from camera. In this case, the camera will operate in a "watchdog" state.

For information on artifacts that may be experienced while using this mode, see the Artifacts section below.

Gate dark current clear mode (always on, srm 1)

In this mode the gate dark current will be cleared continuously.

After the trigger (EXSYNC) is received, the dark current is cleared from the image sensor before the image is acquired. The line rate is limited to ½ the maximum line rate available for that model of camera.

For information on artifacts that may be experienced while using this mode, see the Artifacts section below.

Table 18.

	Max. Line Rate	
Model	**Immediate Readout Mode**	**Dark Current Clear Mode**
S3-10-01k40	36 KHz	18KHz
S3-20-01k40	68 KHz	34 KHz
S3-10-02k40	18.5KHz	9.25KHz
S3-20-02k40	36 KHz	18 KHz
S3-20-04k40	18.5KHz	9.25KHz

When operating in the dark current clear mode, there will be a slight delay, equivalent to one readout time, before the actual exposure is implemented. The actual exposure time will not be altered.

Table 19.

Model	**Exposure Delay and Max Exposure Time in Auto Mode**
S3-10-01k40	27.5 μs
S3-20-01k40	14.75 μs
S3-10-02k40	53.1μs
S3-20-02k40	27.5 μs
S3-20-04k40	53.1μs

Auto Mode (srm 0)

Note: This feature is not available for the S3-20-04k40 camera model.

In this mode the line rate from the camera will automatically cause a switch between the gate dark current clear mode and non gate dark current clear mode.

The frequency of when this mode switchover occurs depends on the camera model.

In cases where the line rate is rapidly increased from below the Dark Current Clear to Immediate Readout Transition Frequency to above the Immediate Readout to Dark Current Clear Transition Frequency, the first line following this transition will likely be corrupted.

The table below outlines the artifacts that may be seen during this transition period. All subsequent lines after this occurrence will be as expected.

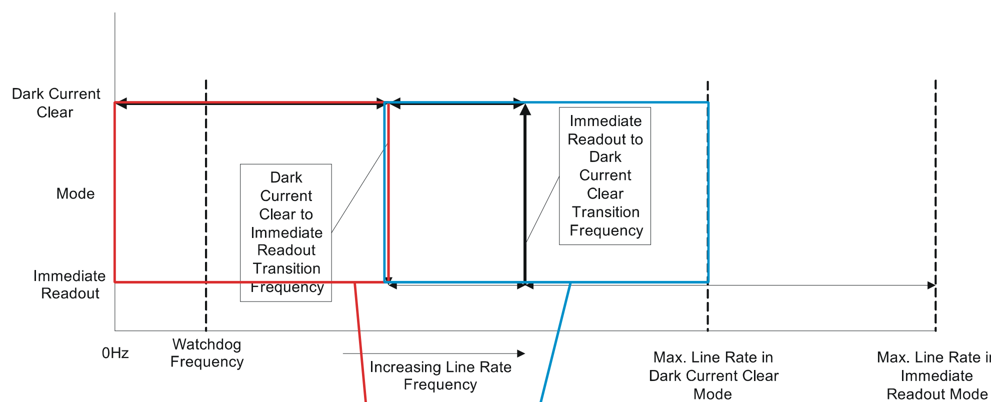
In the case of a slow transition (that is, when the EXSYNC line rate increases by less than 10% of the previous line rate) a line readout will not become corrupt.

There are also limitations on the exposure time when operating in auto mode: If the line rate exceeds half the maximum line rate, then the exposure time cannot exceed the time stated in Table 19.

Note: DALSA recommends Auto mode for most users.

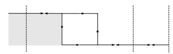
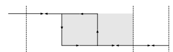
For information on artifacts that may be experienced while using this mode, see the Artifacts section below.

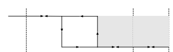
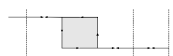
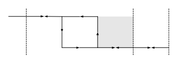
Please note: The graphic below explains the relationship between the following tables and the preceding Figure 29. The operating regions described in the tables refer to a specific region of Figure 29.

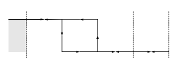
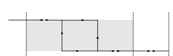


SRM 0, Auto Mode		
Time Period	Operating Region Refer to the above figure	Operating Mode
T0		Dark Current Dump state
T1		Immediate Readout state

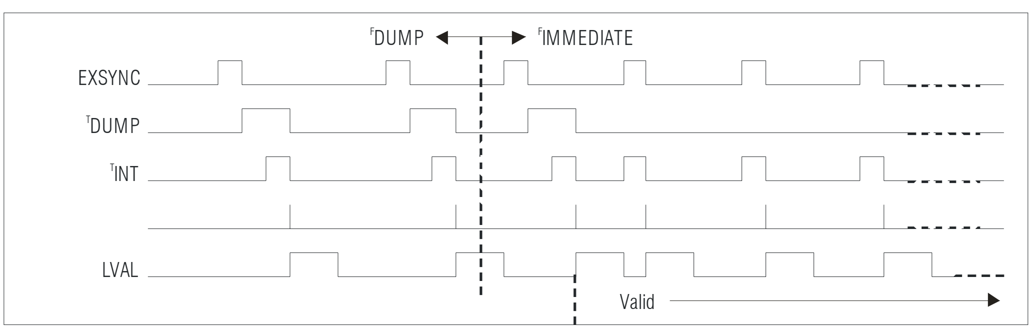
Dark Current Dump to Immediate Readout: Multi-Line Artifacts.

SRM 0, Auto Mode.		
Time Period	**Operating Region Refer to Figure 29.**	**Operating Mode**
T_0		Dark Current Dump state
T_1		Immediate Readout state

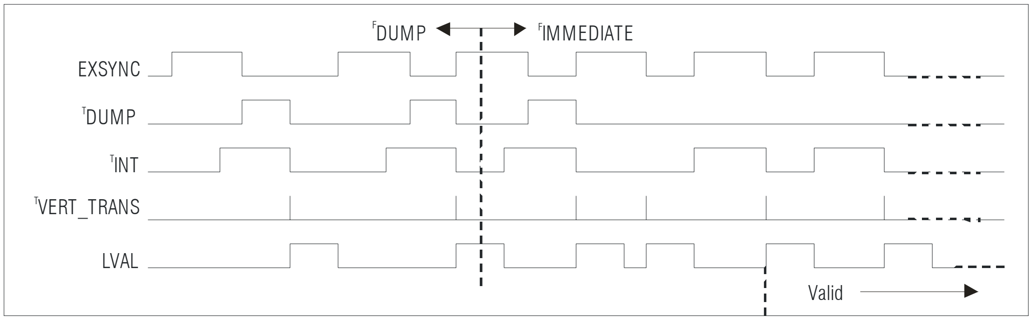
SRM 0, Auto Mode.		
Time Period	**Operating Region Refer to Figure 29.**	**Operating Mode**
T_0		Immediate Readout state
T_1		Dark Current Dump state
T_2		Immediate Readout state

SRM 2, Immediate Readout Mode.		
Time Period	**Operating Region Refer to Figure 29.**	**Operating Mode**
T_0		Dark Current Dump state
T_1		Immediate Readout state

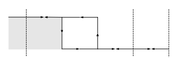
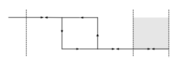
Dark Current Dump to Immediate Readout (T_{INT} < #)

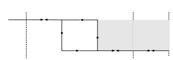
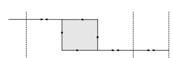
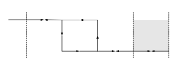


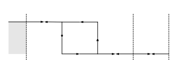
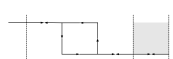
Dark Current Dump to Immediate Readout (T_{INT} > #)



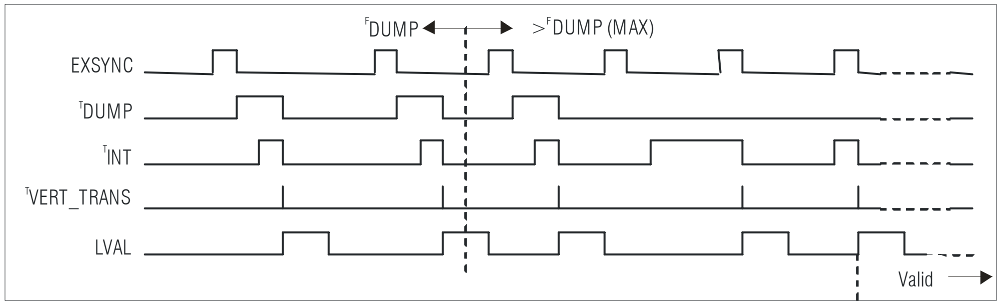
Dark Current Dump to Immediate Readout: Multi-Line Artifacts

SRM 0, Auto Mode.		
Time Period	**Operating Region Refer to Figure 29.**	**Operating Mode**
T_0		Dark Current Dump state
T_1		Immediate Readout state

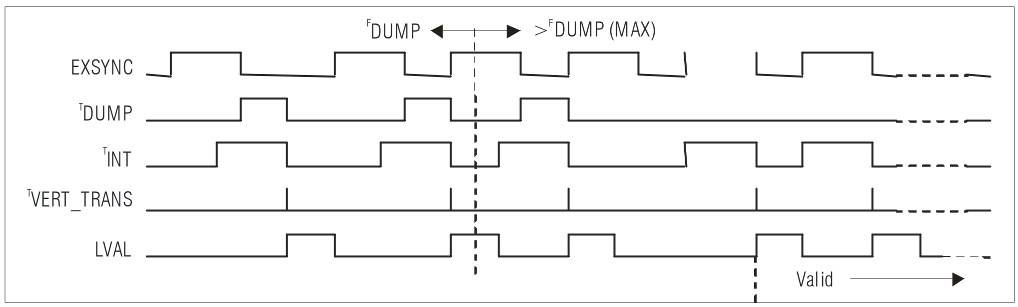
SRM 0, Auto Mode.		
Time Period	**Operating Region Refer to Figure 29.**	**Operating Mode**
T_0		Immediate Readout state
T_1		Dark Current Dump state
T_2		Immediate Readout state

SRM 2, Immediate Readout Mode.		
Time Period	**Operating Region Refer to Figure 29.**	**Operating Mode**
T_0		Dark Current Dump state
T_1		Immediate Readout state

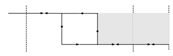
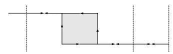
Dark Current Dump to Immediate Readout (T_{INT} < #)

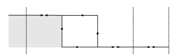
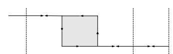
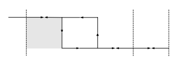


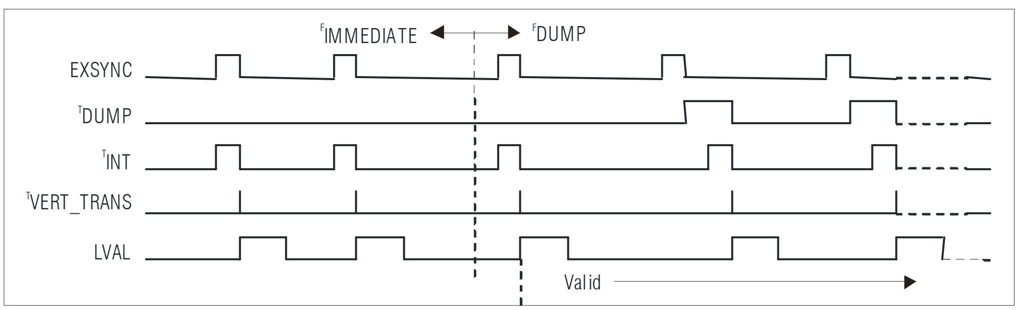
Dark Current Dump to Immediate Readout (T_{INT} > #)



Immediate Readout to Dark Current Dump: Hysteresis Artifacts

SRM 0, Auto Mode.		
Time Period	**Operating Region Refer to Figure 29.**	**Operating Mode**
T_0		Immediate Readout state
T_1		Dark Current Dump state

SRM 0, Auto Mode.		
Time Period	**Operating Region Refer to Figure 29.**	**Operating Mode**
T_0		Dark Current Dump state
T_1		Immediate Readout state
T_2		Dark Current Dump state



Setting the Readout Mode

Purpose:	Use this command to clear out dark current charge in the vertical transfer gates immediately before the sensor is read out.
Syntax:	**`srm`**
Syntax Elements:	**`i`** **`0`**: Auto. Clears dark current below ~ 45% of the maximum line rate. (1k and 2k camera models only.) **`1`**: Dark current clear. Always clears dark. Reduces the maximum line rate. (1k and 2k camera models only.) **`2`**: Immediate readout. Does not clear dark current. (Default mode.)
Notes:	• Modes 0 and 1 are not available to the 4k camera model. • The vertical transfer gates collect dark current during the line period. This collected current is added to the pixel charge. The middle two red taps have more vertical transfer gates and, therefore, more charge. This additional charge is especially noticeable at slower line rates. • If the user is in **`sem 2`** or **`7`** and **`srm 2`**, with **`ssf`** at 45% of the maximum, and then srm 1 is selected, the following warning will be displayed, but the ssf value will not be changed: Warning 09: Internal line rate inconsistent with readout time> The effect in both internal and external line rate modes is that an EXSYNC is skipped and, therefore, the output will be at least twice as bright. • This value is saved with the camera settings. • This value may be viewed using either the **`gcp`** command or the get **`srm`** command.
Related Commands:	**`sem, ssf`**
Example:	**`srm 0`**

8 Appendix B

8.1 Camera Link™ Reference, Timing, and Configuration Table

Camera Link is a communication interface for vision applications. It provides a connectivity standard between cameras and frame grabbers. A standard cable connection will reduce manufacturers' support time and greatly reduce the level of complexity and time needed for customers to successfully integrate high speed cameras with frame grabbers. This is particularly relevant as signal and data transmissions increase both in complexity and throughput. A standard cable/connector assembly will also enable customers to take advantage of volume pricing, thus reducing costs.

The camera link standard is intended to be extremely flexible in order to meet the needs of different camera and frame grabber manufacturers.

The DALSA Camera Link Implementation Road Map (available at from http://mv.dalsa.com) details how DALSA standardizes its use of the Camera Link interface.

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 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 HIGH 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 located at http://mv.dalsa.com.

Camera Control Signals

Four LVDS pairs are reserved for general purpose camera control. They are defined as camera inputs and frame grabber outputs. Camera manufacturers can define these signals to meet their needs for a particular product. The signals are:

• Camera Control 1 (CC1)

• Camera Control 2 (CC2)

• Camera Control 3 (CC3)

• Camera Control 4 (CC4)

The S3-xx uses the following camera control signals:

Table 20: DALSA Camera Control Configuration

CC1	EXSYNC, negative edge active
CC2	PRIN
CC3	Direct in High Sensitivity mode
CC4	Not Used

Communication

Two LVDS pairs have been allocated for asynchronous serial communication to and from the camera and frame grabber. Cameras and frame grabbers should support at least 9600 baud. These signals are

• SerTFG—Differential pair with serial communications to the frame grabber.

• 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 frame grabber 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.

Power

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

8.2 Camera Link Bit Definitions

BASE Configuration	**T0**		
Mode	**Port A Bits 0 thru 7**	**Port B Bits 0 thru 7**	**Port C Bits 0 thru 7**
Mode 0 1 Tap 8 bit	Tap 1 LSB..Bit 7	xxxxxxx	xxxxxxx
Mode 1 1 Tap n bit Where n=10,12	Tap 1 LSB..Bit 7	Tap 1 Bits 8,9,10,11,	xxxxxxx
Mode 2 2 Tap 8 bit	Tap 1 LSB..Bit 7	Tap 2 LSB..Bit7	xxxxxxx
Mode 3 2 Tap n bit Where n=10,12	Tap 1 LSB..Bit 7	Tap 1 Bits 8,9,10,11, Tap 2 Bits 8,9,10,11	Tap 2 LSB..Bit 7

8.3 Camera Link Configuration Tables

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://mv.dalsa.com Web site and view the DALSA Camera Link Implementation Road Map document, 03-32-00450, for further details.

S3-x0-0xk40 Interface Parameters (PRELIMINARY)

Table 21: Framegrabber Interface Parameters

<table>
<tr><th>Item (when programmable configuration the options are separated with a |)</th><th>S3-10-01k40</th><th>S3-20-01k40</th><th>S3-10-02k40</th><th>S3-20-02k40</th><th>S3-20-04k-40</th></tr>
<tr><td>Imager Dimension <1,2 or 1|2></td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Imager Columns<number of active columns, X></td><td>1024</td><td>1024</td><td>2048</td><td>2048</td><td>4096</td></tr>
<tr><td>Imager Rows<number of active rows, Y> Line Scan/TDI are defined as 1</td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Number of CCD Taps <1,2,3…..></td><td>1</td><td>2</td><td>1</td><td>2</td><td>2</td></tr>
<tr><td>Sensor Tap Clock Rate <xx MHz></td><td>40</td><td>40</td><td>40</td><td>40</td><td>40</td></tr>
<tr><td>Camera Standard <NTSC, PAL, VS, VW, MW></td><td>VS</td><td>VS</td><td>VS</td><td>VS</td><td>VS</td></tr>
<tr><td>Variable Window
<Column Start, Column End, Row Start, Row End></td><td>(0,0,0,0)
All zeros indicates an unsupported feature</td><td>(0,0,0,0)
All zeros indicates an unsupported feature</td><td>(0,0,0,0)
All zeros indicates an unsupported feature</td><td>(0,0,0,0)
All zeros indicates an unsupported feature</td><td>(0,0,0,0)
All zeros indicates an unsupported feature</td></tr>
<tr><td>Multiple Window
Number of Windows (Column Start 1, Column End 1, Row Start 1, Row End 1) (Column Start 2, Column End 2,...)</td><td>0, (0,0,0,0)
All zeros indicates an unsupported feature</td><td>0, (0,0,0,0)
All zeros indicates an unsupported feature</td><td>0, (0,0,0,0)
All zeros indicates an unsupported feature</td><td>0, (0,0,0,0)
All zeros indicates an unsupported feature</td><td>0, (0,0,0,0)
All zeros indicates an unsupported feature</td></tr>
<tr><td>Number of Camera Configurations<1,2,3,…></td><td>2</td><td>2</td><td>2</td><td>2</td><td>2</td></tr>
<tr><td>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></td><td>C1 = Base, 1, 8, 1
C2 = Base, 1, 12, 1</td><td>C1 = Base, 2, 8, 1
C2 = Base, 2, 12, 1</td><td>C1 = Base, 1, 8, 1
C2 = Base, 1, 12, 1</td><td>C1 = Base, 2, 8, 1
C2 = Base, 2, 12, 1</td><td>C1 = Base, 2, 8, 1
C2 = Base, 2, 12, 1</td></tr>
</table>

Item (when programmable configuration the options are separated with a |)	S3-10-01k40	S3-20-01k40	S3-10-02k40	S3-20-02k40	S3-20-04k-40
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>	Horizontal mirroring is supported. Mirror "on" changes the following unmirrored values to: • The sign of the column increment is inverted. • Column Start becomes the Column End value • Column End becomes the Column Start value Direction left to right readout C0, T1 (1, 1024, 1, 1, 1, 1)	Horizontal mirroring is supported. Mirror "on" changes the following unmirrored values to: • The sign of the column increment is inverted. • Column Start becomes the Column End value • Column End becomes the Column Start value Direction left to right readout C0, T1 (1, 512, 1, 1, 1, 1) C0, T2 (513, 1024, 1, 1, 1, 1)	Horizontal mirroring is supported. Mirror "on" changes the following unmirrored values to: • The sign of the column increment is inverted. • Column Start becomes the Column End value • Column End becomes the Column Start value Direction left to right readout C0, T1 (1, 2048, 1, 1, 1, 1)	Horizontal mirroring is supported. Mirror "on" changes the following unmirrored values to: • The sign of the column increment is inverted. • Column Start becomes the Column End value • Column End becomes the Column Start value Direction left to right readout C0, T1 (1, 1024, 1, 1, 1, 1) C0, T2 (1025, 2048, 1, 1, 1, 1)	Horizontal mirroring is supported. Mirror "on" changes the following unmirrored values to: • The sign of the column increment is inverted. • Column Start becomes the Column End value • Column End becomes the Column Start value Direction left to right readout C0, T1 (1, 2048, 1, 1, 1, 1) C0, T2 (2049, 4096, 1, 1, 1, 1)
Camera Color <Hybrid, Mono, Pattern, Solid>	Mono	Mono	Mono	Mono	Mono
RGB Pattern Size < (T1, Columns*Rows) (T2, Columns*Rows) (T3, Columns*Rows….>	(T0, 1*1) where 0 is reserved for the default case and individual taps don't need to be articulated	(T0, 1*1) where 0 is reserved for the default case and individual taps don't need to be articulated	(T0, 1*1) where 0 is reserved for the default case and individual taps don't need to be articulated	(T0, 1*1) where 0 is reserved for the default case and individual taps don't need to be articulated	(T0, 1*1) where 0 is reserved for the default case and individual taps don't need to be articulated
Color Definition (Column, Row, Color) Where color is R,G,B	T0 = (1, 1, M) where 0 is reserved for the default case and individual taps don't need to be defined	T0 = (1, 1, M) where 0 is reserved for the default case and individual taps don't need to be defined	T0 = (1, 1, M) where 0 is reserved for the default case and individual taps don't need to be defined	T0 = (1, 1, M) where 0 is reserved for the default case and individual taps don't need to be defined	T0 = (1, 1, M) where 0 is reserved for the default case and individual taps don't need to be defined
Row Color Offset <0,1,2,3…>	0	0	0	0	0
Column Color Offset <0,1,2,3…>	0	0	0	0	0

<table>
<tr><th>Item (when programmable configuration the options are separated with a |)</th><th>S3-10-01k40</th><th>S3-20-01k40</th><th>S3-10-02k40</th><th>S3-20-02k40</th><th>S3-20-04k-40</th></tr>
<tr><td>Row Binning Factor <1,2,3 or 1|2|3></td><td>1</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Column Binning Factor <1,2,3 or 1|2|3></td><td>1| 2</td><td>1| 2</td><td>1| 2</td><td>1| 2</td><td>1| 2</td></tr>
<tr><td>Pretrigger Pixels <0,1,2…or 0..15></td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Pretrigger Lines <0,1,2.. or 0..15></td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Frame Time Minimum <xx μs></td><td>27.78</td><td>14.7</td><td>54.05</td><td>27.78</td><td>54.05</td></tr>
<tr><td>Frame Time Maximum <xx μs></td><td>3333</td><td>3333</td><td>3333</td><td>3333</td><td>3333</td></tr>
<tr><td>Internal Line/Frame Time Resolution
<xx ns> 0 if not applicable</td><td>25</td><td>25</td><td>25</td><td>25</td><td>25</td></tr>
<tr><td>Pixel Reset Pulse Minimum Width
<xx ns> 0 if not applicable</td><td>3000</td><td>3000</td><td>3000</td><td>3000</td><td>3000</td></tr>
<tr><td>Internal Pixel Reset Time Resolution
<xx ns> 0 if not applicable</td><td>25</td><td>25</td><td>25</td><td>25</td><td>25</td></tr>
<tr><td>Pixel Reset to Exsync Hold time <xx ns></td><td>TBD</td><td></td><td></td><td></td><td></td></tr>
<tr><td>BAUD Rate <9600….></td><td>9600, 19200, 57600, 115200</td><td>9600, 19200, 57600, 115200</td><td>9600, 19200, 57600, 115200</td><td>9600, 19200, 57600, 115200</td><td>9600, 19200, 57600, 115200</td></tr>
<tr><td>CC1 <Exsync></td><td>EXSYNC</td><td>EXSYNC</td><td>EXSYNC</td><td>EXSYNC</td><td>EXSYNC</td></tr>
<tr><td>CC2 <PRIN></td><td>PRIN</td><td>PRIN</td><td>PRIN</td><td>PRIN</td><td>PRIN</td></tr>
<tr><td>CC3 <Forward, Reverse></td><td>Forward/ Reverse</td><td>Forward/ Reverse</td><td>Forward/ Reverse</td><td>Forward/ Reverse</td><td>Forward/ Reverse</td></tr>
<tr><td>CC4 <Spare></td><td>Spare</td><td>Spare</td><td>Spare</td><td>Spare</td><td>Spare</td></tr>
<tr><td>DVAL out <Strobe Valid, Alternate></td><td>Strobe Valid</td><td>Strobe Valid</td><td>Strobe Valid</td><td>Strobe Valid</td><td>Strobe Valid</td></tr>
<tr><td>Spare out <Spare> (For future use)</td><td>Spare</td><td>Spare</td><td>Spare</td><td>Spare</td><td>Spare</td></tr>
</table>

9 Appendix C

9.1 EMC Declaration of Conformity

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

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

S3-10-01K40-00-R
S3-20-01K40-00-R
S3-10-02K40-00-R
S3-20-02K40-00-R
S3-20-04k40-00-R

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

EMC: **CISPR 22**
EN 55022 Class A, EN61326 Class A
EN 55024, and EN 61326

This product meets the requirements outlined above which will satisfy the regulations for FCC Part 15 Class A, Industry Canada ICES-003 Class A, and the EMC Directive for CE Marking.

Place of Issue Waterloo, ON, CANADA

Date of Issue March 2008

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

10 Appendix D

10.1 Revision History

Revision Number	Change Description
00	Preliminary release.
01	-Revised CCD Shift Direction section. The get scd 3 command added to the list of get commands, page 83. The command scd 3: externally controlled/reverse direction. -Responsivity, random noise, SEE and NEE specifications revised. Previous specifications cited 8 bit numbers, not the correct 12 bit. Page 7. -Revised responsivity graph added, page 12.
02	-Page 11: Added the following note to the Sensor Shift Direction section: Note: The CCD shift direction is controlled through the serial interface. Use the software command **scd** to determine whether the direction control is set via software control or via the Camera Link control signal on CC3. Refer to the CCD Shift Direction section in this manual, page 49, for details. -Page 20: Revised Table 7 to the following: CC1: EXSYNC, CC2: PRIN, CC3: Direction, CC4: Spare. -4k model, S3-20-04k40-00-R, added to manual. Including all specs and mechanicals, etc.
03	-4k mechanical in the performance spec revised to the correct: 65(h) x 53.7(l) x 85(w). -Dark current diagrams in Appendix A were missing labels. Labels restored. -Mechanicals updated to show RoHS-compliant stickers, p. 17, 31, 32. -LUT information for the 4k model added: pages 25 and 26, 55 and 56, 70 to 72, and 83.
04	-Reference to Medium and Full camera link configurations removed from page 17. This camera operates in Base configuration. -4k single and dual line responsivity and dynamic range values revised, page 8. -Preliminary stamp removed.

11 Index

S

T

V

W