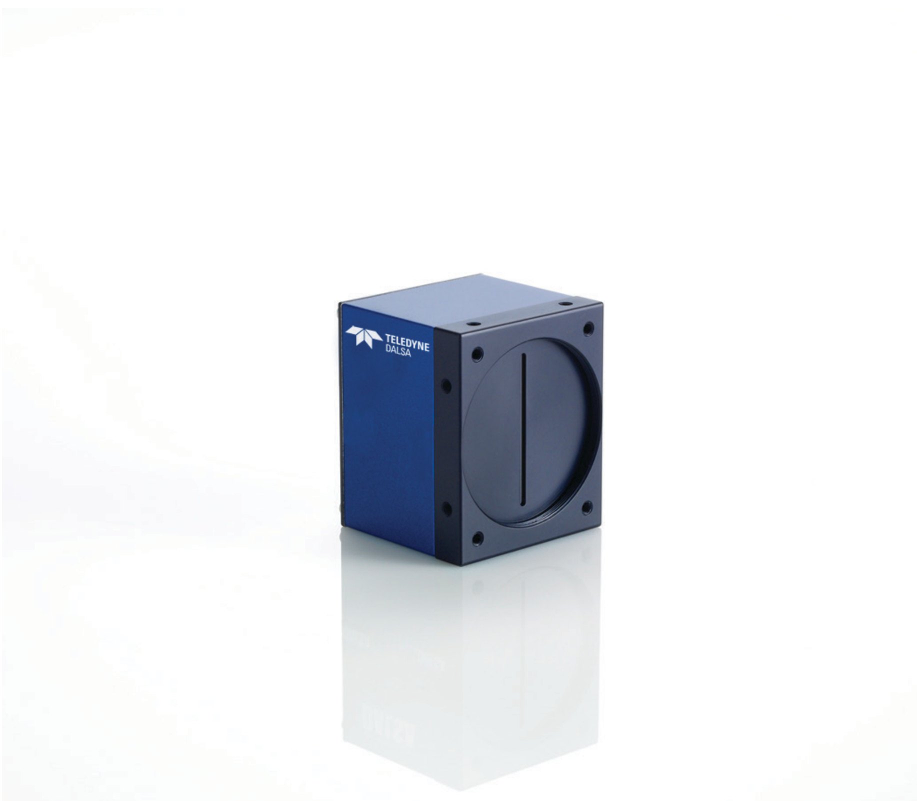
Spyder3

Camera Link Camera User's Manual

S3-14 and S3-24 1K and 2K Monochrome

sensors | **cameras** | frame grabbers | processors | software | vision solutions



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Teledyne DALSA, a Teledyne Technologies company, is an international leader in high performance digital imaging and semiconductors with approximately 1,000 employees worldwide, headquartered in Waterloo, Ontario, Canada. Established in 1980, the company designs, develops, manufactures and markets digital imaging products and solutions, in addition to providing MEMS products and services. For more information, visit Teledyne DALSA's website at www.teledynedalsa.com.

Support

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

North America

700 Technology Park Drive
Billerica, MA
USA, 01821
Tel: 978-670-2000
Fax: 978-670-2010
Email: Sales.Americas@teledynedalsa.com

Europe

Felix-Wankel-Str. 1
82152 Krailling
Germany
Tel: +49 89 89 54 57 3-80
Fax: +49 89 89 54 57 3-46
Email: Sales.Europe@teledynedalsa.com

Asia Pacific

Ikebukuro East 13F
3-4-3 Higashi Ikebukuro, Toshima-ku, Tokyo
Japan
Tel: +81 3 5960 6353
Fax: +81 3 5960 6354
Email: Sales.Asia@teledynedalsa.com

Industry Standards

Teledyne DALSA and this model of the Spyder3 camera support the Camera Link™ communications interface for vision applications. Camera Link is a high speed communications interface for vision applications. It provides a standard method of communication between digital cameras and frame grabbers.

Detailed information on Camera Link is available in the Teledyne DALSA Camera Link Implementation Road Map documentation, available from the Knowledge Center on our Web site: (http://www.teledynedalsa.com/mv/knowledge/appnotes.aspx).

Contents

System Precautions and Cleaning

Precautions

Read these precautions and this manual carefully before using the camera.

Confirm that the camera's packaging is undamaged before opening it. If the packaging is damaged please contact the related logistics personnel.

Do not open the housing of the camera. The warranty is voided if the housing is opened.

Keep the camera housing temperature in a range of 0 °C to 65 °C during operation.

Do not operate the camera in the vicinity of strong electromagnetic fields. In addition, avoid electrostatic charging, violent vibration, and excess moisture.

To clean the device, avoid electrostatic charging by using a dry, clean absorbent cotton cloth dampened with a small quantity of pure alcohol. Do not use methylated alcohol. To clean the surface of the camera housing, use a soft, dry cloth. To remove severe stains use a soft cloth dampened with a small quantity of neutral detergent and then wipe dry. Do not use volatile solvents such as benzene and thinners, as they can damage the surface finish. Further cleaning instructions are below.

This camera does not support hot plugging. Power down and disconnect power to the camera before you add or replace system components.

Electrostatic Discharge and the CMOS Sensor

Image sensors and the camera bodies housing 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. The charge normally dissipates within 24 hours and the sensor returns to normal operation.

Protecting Against Dust, Oil, and Scratches

The sensor 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 an ionized air gun. Oil is usually introduced during handling. Touching the surface of the window barehanded will leave oily residues. Using rubber fingercots and rubber gloves can prevent contamination. However, the friction between rubber and the window may produce electrostatic charge that may damage the sensor. To avoid ESD damage and to avoid introducing oily residues, avoid touching the sensor. 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 will change with the angle of illumination.

Cleaning the Sensor Window

Recommended Equipment

- Glass cleaning station with microscope within clean room.
- 3M ionized air gun 980 (http://solutions.3mcanada.ca/wps/portal/3M/en_CA/WW2/Country/)
- Ionized air flood system, foot operated.
- Swab (HUBY-340CA-003) (http://www.cleancross.net/modules/xfsection/article.php?articleid=24)
- Single drop bottle (FD-2-ESD)
- E2 (Eclipse optic cleaning system (www.photosol.com)

Procedure

- Use localized ionized air flow on to the glass during sensor cleaning.
- Blow off mobile contamination using an ionized air gun.
- Place the sensor under the microscope at a magnification of 5x to determine the location of any remaining contamination.
- Clean the contamination on the sensor using one drop of E2 on a swab.
- Wipe the swab from left to right (or right to left but only in one direction). Do this in an overlapping pattern, turning the swab after the first wipe and with each subsequent wipe. Avoid swiping back and forth with the same swab in order to ensure that particles are removed and not simply transferred to a new location on the sensor window. This procedure requires you to use multiple swabs.
- Discard the swab after both sides of the swab have been used once.
- Repeat until there is no visible contamination present

The Spyder3 S3-14 and S3-24 Cameras

Camera Highlights

The Spyder3 CL surpasses its predecessor, the Spyder2, with 3x more responsivity and 2x the speed. At its core is dual line scan technology that achieves unprecedented responsivity and throughput rates of 80 megapixels per second, without impacting noise.

The Spyder3 CL features the Camera Link™ serial interface and is fully programmable, offering precise control over key performance variables such as gain and offset and improved ease of use and setup.

The temperature range performance of the SC-14 and SC-24 models has increased from an operating temperature of 0 °C to 50 °C to an operating temperature of 0 °C to 65 °C.

Features and Programmability

- Broadband responsivity up to 408 ±16 DN(nJ/cm2) @10 dB gain, 8 bit
- 1024, 2048, or 4096 pixels, 14 µm x 14 µm (1k and 2k) and 10 µm 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)
- 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.

Applications

- 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
S3-24-01K40-00-R	1k resolution, 2 sensor taps. Base Camera Link configuration.
S3-24-02K40-00-R	2k resolution, 2 sensor taps. Base Camera Link configuration.
S3-14-01K40-00-R	1k resolution, 1 sensor tap. Base Camera Link configuration.
S3-14-02K40-00-R	2k resolution, 1 sensor tap. Base Camera Link configuration.
S3-24-04k40-00-R	4k resolution, 2 sensor taps. Base Camera Link configuration.

Camera Performance Specifications

Table 2: Camera Performance Specifications

Feature / Specification	1k	2k	4k
Imager Format	dual line scan		
Resolution	1024 pixels	2048 pixels	4096 pixels
Pixel Fill Factor	100 %		
Pixel Size	14 µm x 14 µm		10 µm x 10 µm
Sensitivity Mode	High, low, or tall pixel		
Antiblooming	100 x		
Gain Range	± 10 dB		

Speed		1k	2k	4k
Data Rate		40 mp / s and 80 mp / s		80 mp / s
Maximum Line Rate	2 tap model	68 kHz (80 MHz)	36 kHz (80 MHz)	18.5 kHz
	1 tap model	36 kHz (40 MHz)	18.5 kHz (40 MHz)	NA

Optical Interface	1k and 2k	4k
Lens Mount	M42 x 1, C and F*	M58 x 0.75, F*
Focal Length	6.56 mm ± 0.25	
Sensor Alignment	x ± 50 µm y ± 50 µm z ± 0.25 mm Θz ± 0.2 º	
Mechanical Interface	**1k and 2k**	**4k**
Camera Size	72 mm (h) x 60 mm (l) x 60 mm (w)	60 mm (h) x 72 mm (l) x 60 mm (w)
Mass	< 300 g	
Connectors	6 pin male Hirose power MDR26 female data connector	
Electrical Interface	**1k and 2k**	**4k**
Input Voltage	+ 12 to +15 Volts DC	
Power Dissipation	< 5 W (1k and 2k)	< 7 W (4k)
Operating Temperature	0 ºC to 65 ºC	

Bit Width	8 or 12 bits user selectable
Output Data Configuration	Base Camera Link

*Lens mount adapters are available. Contact Teledyne DALSA Sales for more information.

Table 3: Camera Operating Specifications

Specifications	Unit		-10dB			0dB			+10dB	
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max
Broadband responsivity	DN / (nJ/cm²)									
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 / cm²									
Dual line			6.35			1.92			0.61	
Single line			12.2			4.0			1.2	
NEE (calculated)	pJ / cm²									
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 megapixels/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.

Certifications

Table 4: EMC Compliance Standards

Compliance
The CE Mark, FCC Part 15, and Industry Canada ICES-003 Evaluation of the DALSA Spyder3 CL S3-14and S3-24 cameras meet the following requirements:
CISPR 22, EN 55022 and EN 61326 Class A Emissions Requirements, EN 55024, and EN 61326 Immunity to Disturbances

Responsivity

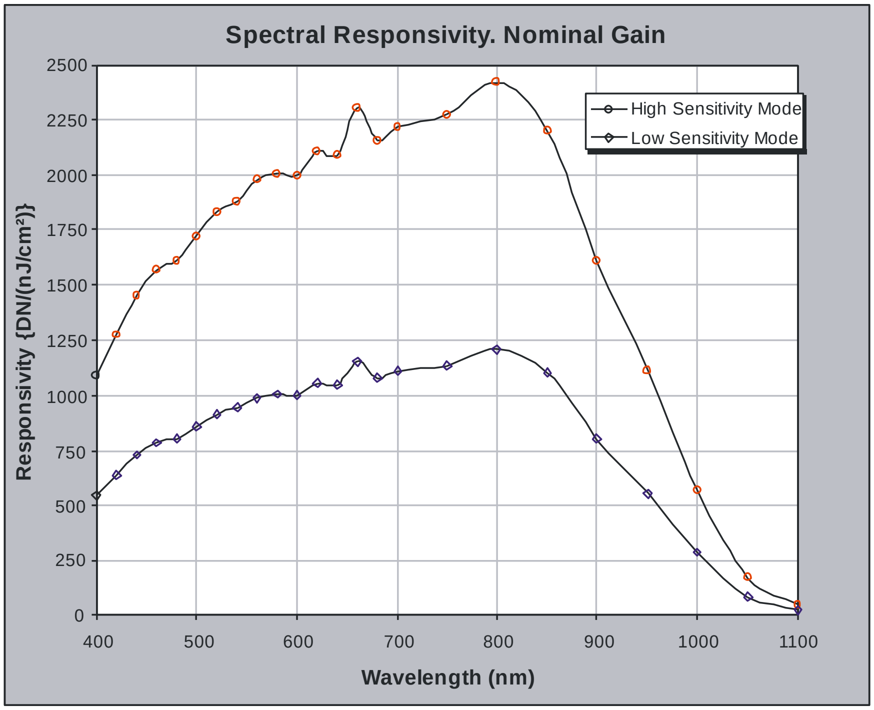


Figure 1: Spyder3 CL 1k and 2k Responsivity

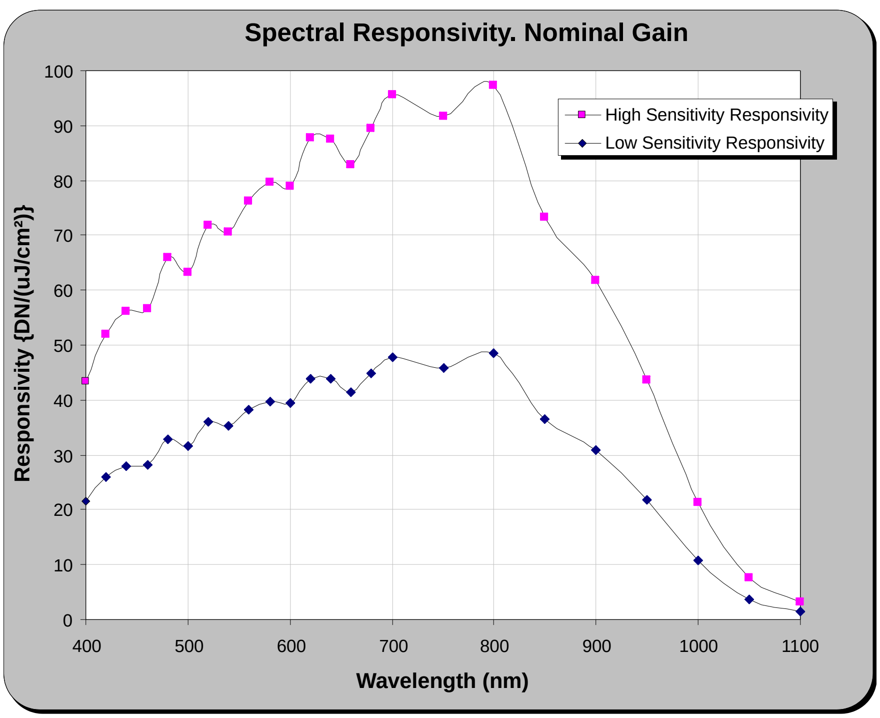


Figure 2: Spyder3 CL 4k Responsivity

Derating Curves

Figure 3: 1k and 2k Derating Curves

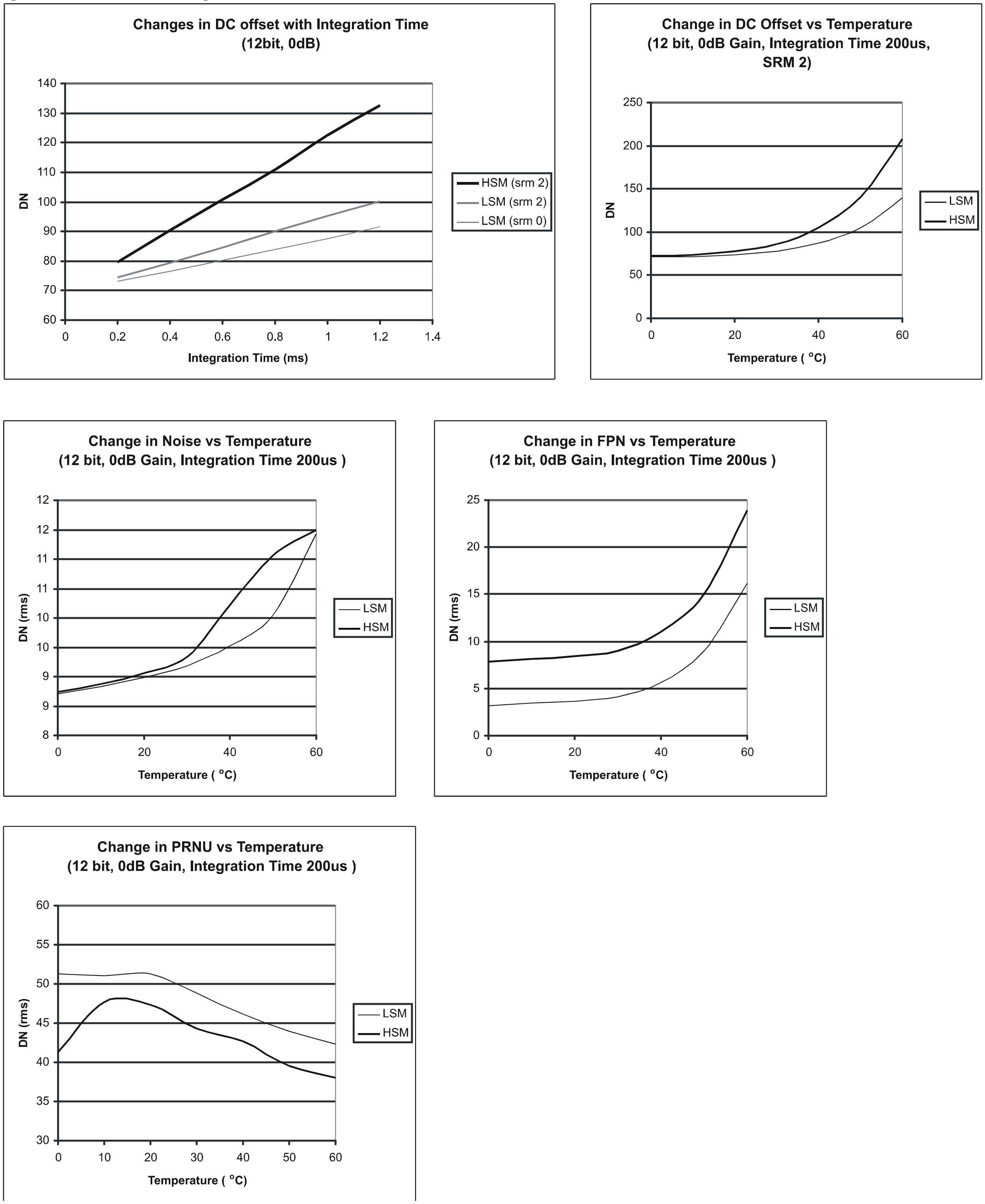
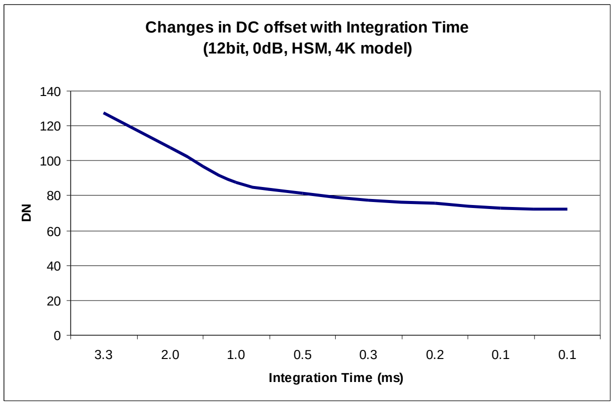
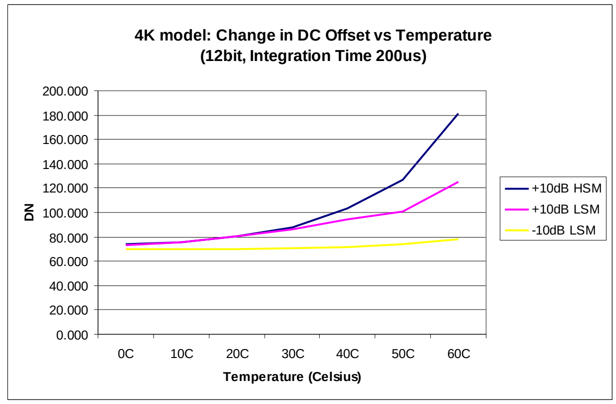
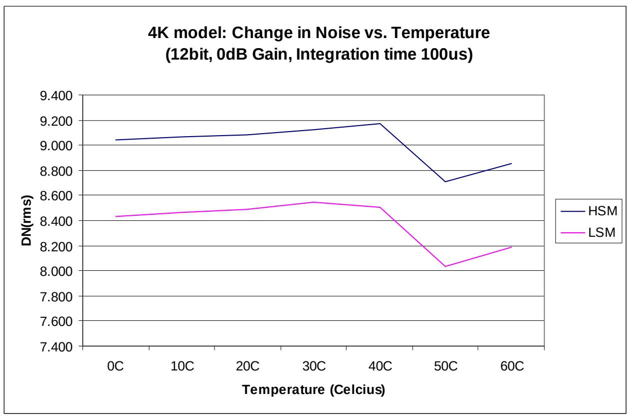
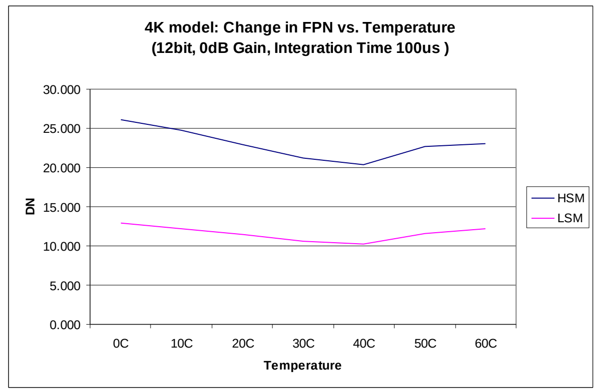


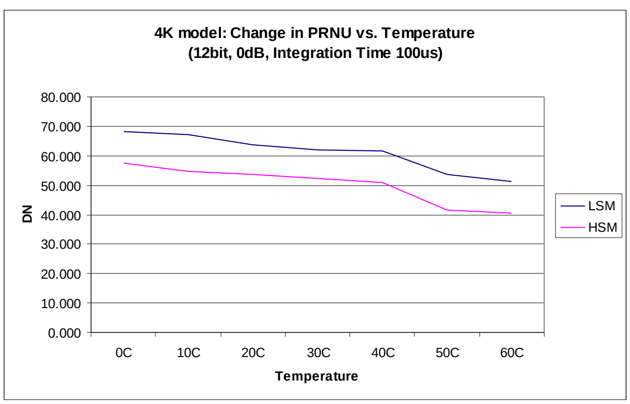
Figure 4: 4k Derating Curves











Mechanicals

Figure 5: 1k and 2k Mechanical Dimensions

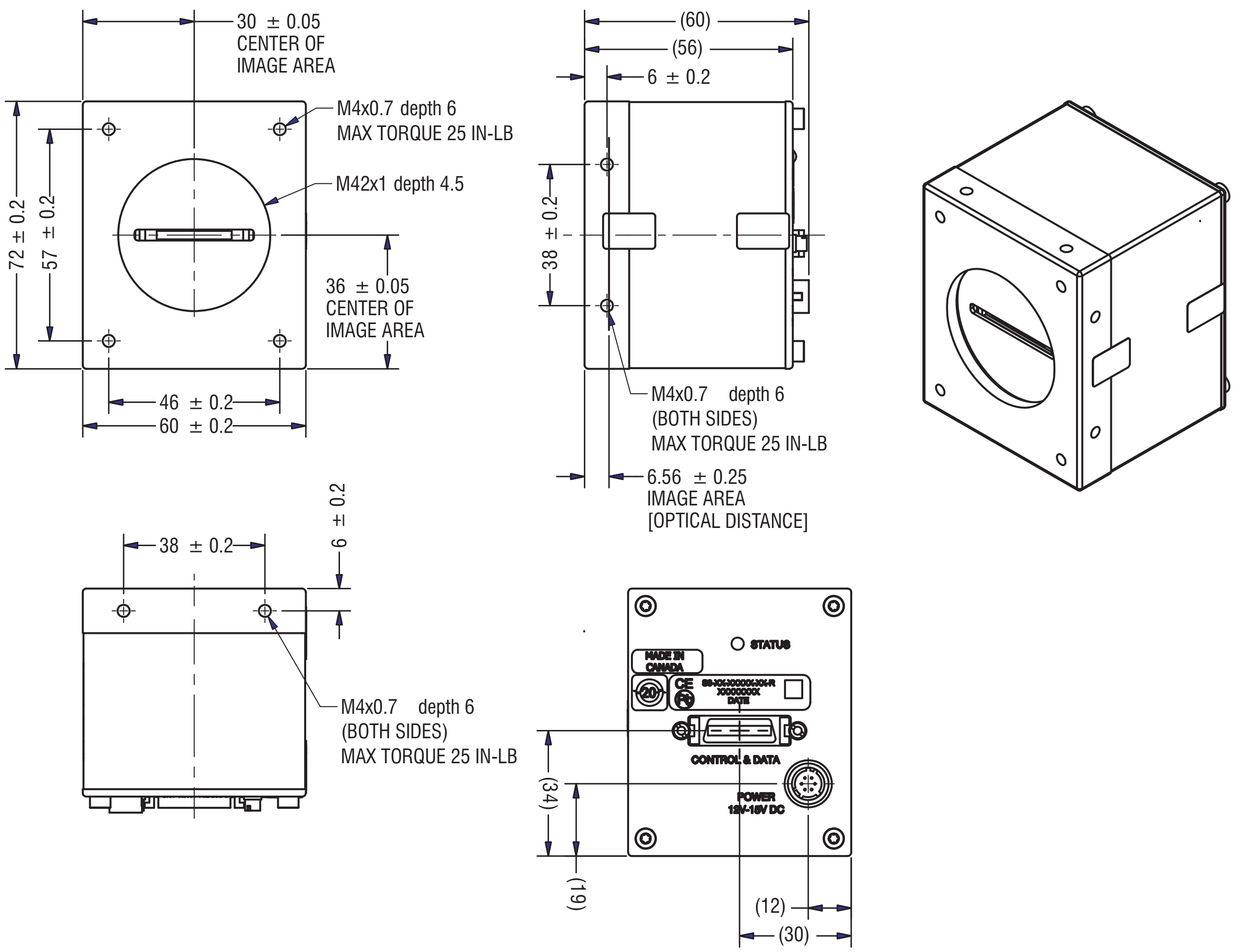
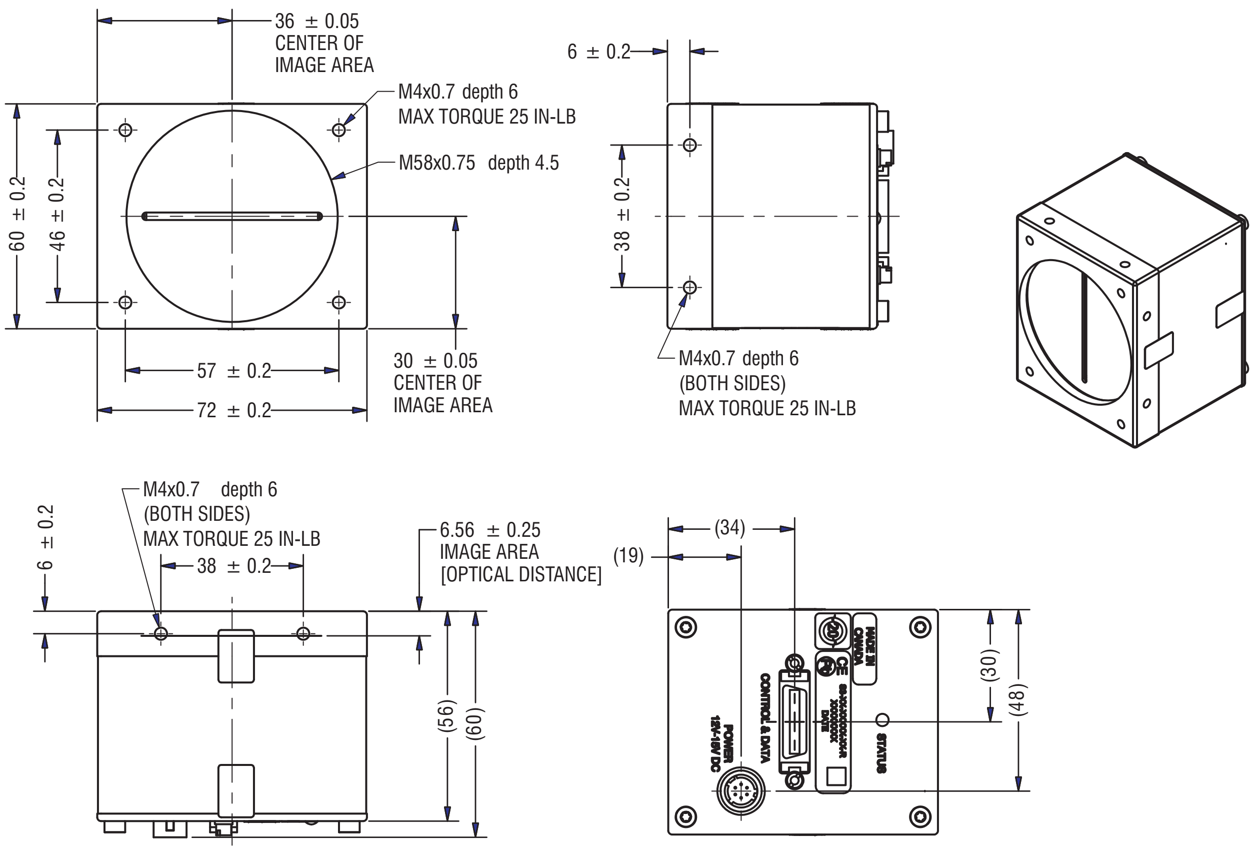


Figure 6: 4k Mechanical Dimensions



Mounting

Heat generated by the camera must be allowed to move away from the camera. Mount the camera on the front plate (using the provided mounting holes) with maximum contact to the area for best heat dissipation.

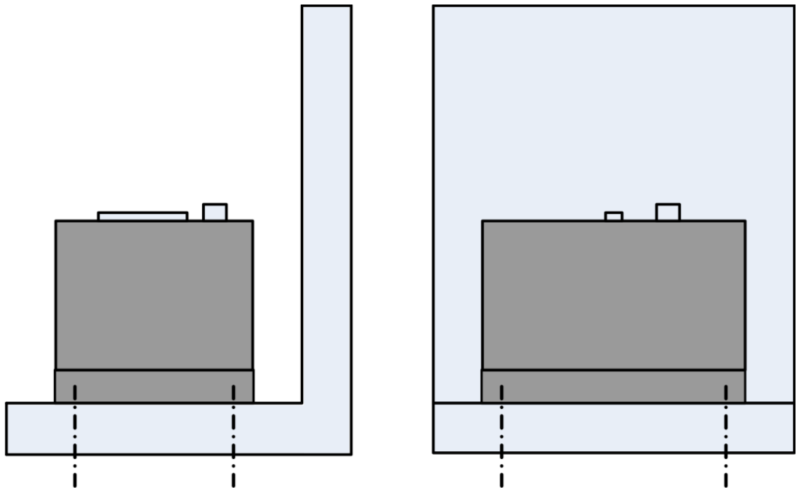


Figure 7: Spyder3 Mounting Example

Image Sensor

The camera uses Teledyne 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 either forward or reverse shift direction.

Figure 8: 2 Tap Sensor Block Diagram

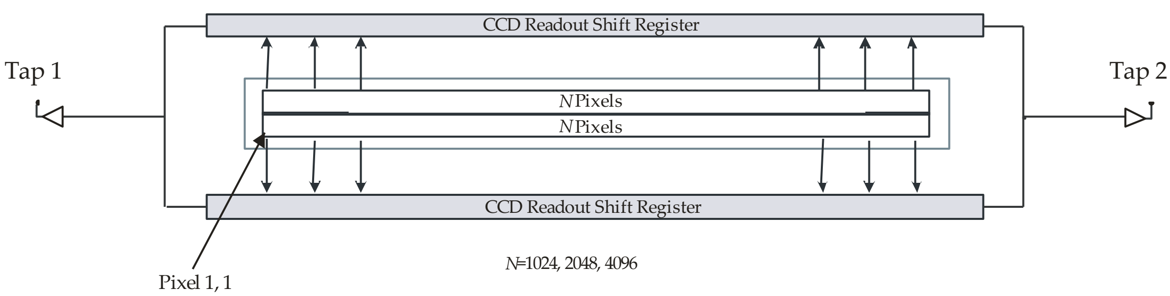
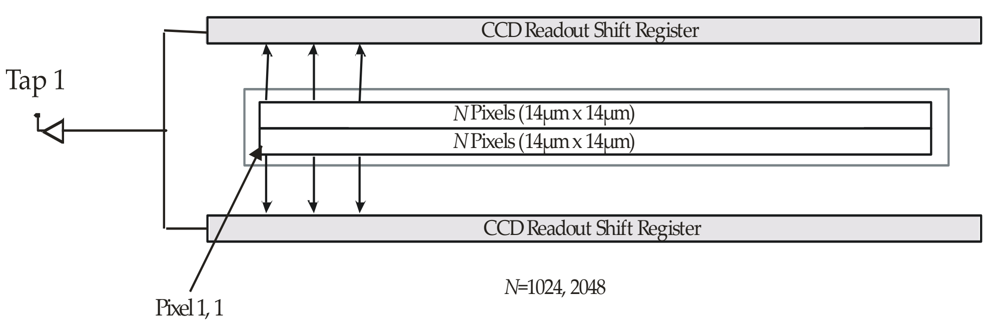


Figure 9: 1 Tap Sensor Block Diagram (1k and 2k only)



Software and Hardware Setup

Host System Requirements

To achieve best system performance, the following minimum requirements are recommended:

- Base Camera Link frame grabber.
- Operating system: Windows XP Professional, Windows Vista, Windows 7 (either 32-bit or 64-bit for all) are supported.

Setup Steps: Overview

Take the following steps in order to setup and run your camera system. They are described briefly below and in more detail in the following sections.

1. Install and Configure Frame Grabber

If your host computer does not have a Base Camera Link frame grabber, or equivalent, then you need to install one.

2. Connect Power, and Camera Link I/O Cables

- Connect a power cable from the camera to a +12 VDC to +15 VDC power supply.
- If using the external signals connect the external control cable to the camera.

3. Establish communicating with the camera

The quickest and easiest way to communicate with the camera is through the use of a terminal program (e.g., Microsoft HyperTerminal is a widely available application).

4. Check camera LED, settings and test pattern

Ensure that the camera is operating properly by checking the LED, the current settings, and by acquiring a test pattern.

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5. Operate the Camera

At this point you will be ready to operate the camera in order to acquire and retrieve images, set camera functions, and save settings.

Step 1. Install and configure the frame grabber and graphics card

Install Frame Grabber

Install a Base Camera Link frame grabber according to the manufacturer's description.

A list of frame grabbers recommended by Teledyne DALSA and supporting the Spyder3 cameras is available on the Teledyne DALSA Web site here:

www.teledynedalsa.com/mv/products/framegrabbers.aspx

Install Graphics Card

Determine the graphics card that supports your selected frame grabber and follow the manufacturer's installation instructions.

Step 2. Connect Power and Camera Link Cables

WARNING! Grounding Instructions
Static electricity can damage electronic components. Please discharge any static electrical charge by touching a grounded surface, such as the metal computer chassis, before performing any hardware installation.

The use of cable types and lengths other than those specified may result in increased emission or decreased immunity and performance of the camera.

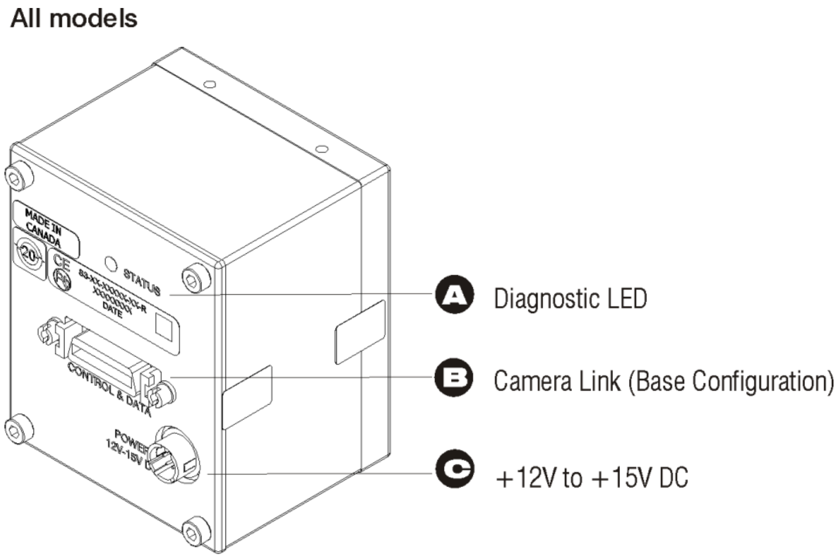


Figure 10: Hirose 6-pin Circular Male—Power Connector

Power Connector

WARNING: It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages may damage the camera. Input voltage requirement: +12 V to +15 V DC.

The camera requires a single 6-pin Hirose connector with a single voltage input +12 VDC to +15 VDC for power. The camera meets all performance specifications using standard switching power supplies, although well-regulated linear supplies provide optimum performance.

Table 5: Hirose Pin Description

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

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

- Apply the appropriate voltages.
- Protect the camera with a 2 amp slow-blow fuse between the power supply and the camera.
- Do not use the shield on a multi-conductor cable for ground.
- Keep leads as short as possible in order to reduce voltage drop.
- Use high-quality linear supplies in order to minimize noise.

Note: If your power supply does not meet these requirements, then the camera performance specifications are not guaranteed.

Status LED

The camera is equipped with a red / green LED used to display the status of the camera's operation. 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 that further describe the current camera status.

Table 6: 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	Solid Red	Loss of functionality.
3	Flashing Green	Camera initialization or executing a long command (e.g., flat field correction commands **ccp** or **ccf**).
4	Solid Green	Camera is operational and functioning correctly.

Returning the LED Status

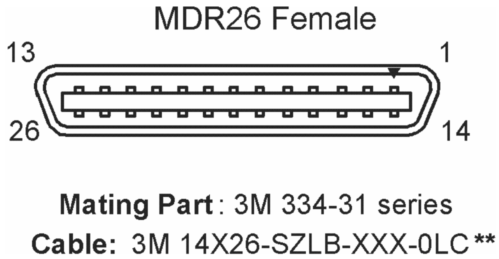
Use the **gsl** command to return the status of the camera's LED.

Camera Link Command

Parameter	Description	Notes
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)	

Camera Link Data Connector

Figure 11: Camera Link MDR26 Connector



**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 7: Camera Link Hardware Configuration Summary

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 8: Camera Link Connector Pin out

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 9: Teledyne DALSA Camera Control Configuration

Signal	Configuration
CC1	EXSYNC
CC2	PRIN
CC3	Direction
CC4	Spare

See Appendix B for the complete Teledyne DALSA Camera Link configuration table, and refer to the Knowledge Center on Teledyne DALSA's Web site, 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.

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.

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 Teledyne DALSA Camera Link Implementation Road Map for the standard location of these signals, available from the Knowledge Center on our Web site: (http://www.teledynedalsa.com/mv/knowledge/appnotes.aspx).

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.

Camera Link Video Timing

Figure 12: Spyder3 Overview Timing Showing Input and Output Relationships

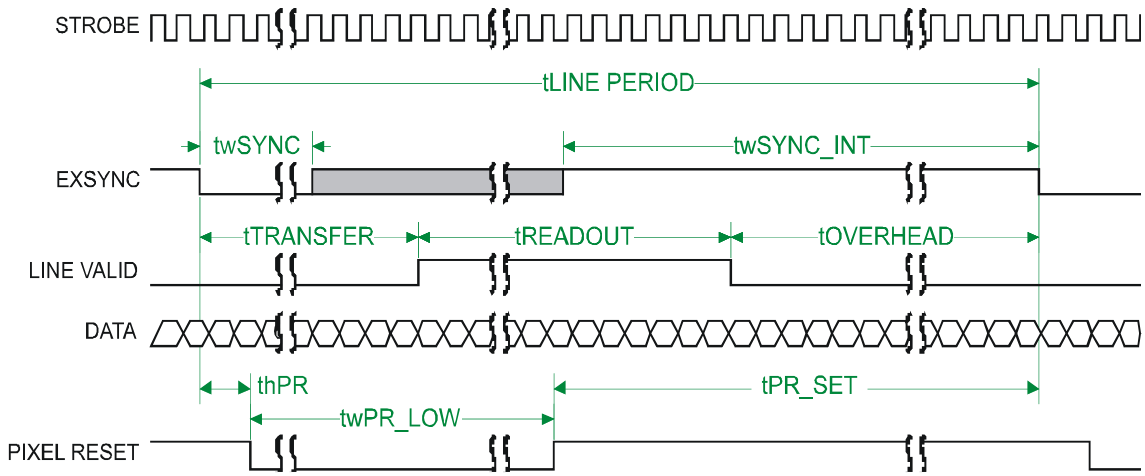


Figure 13: Spyder3 Fixed (Programmed) Integration Timing with External EXSYNC

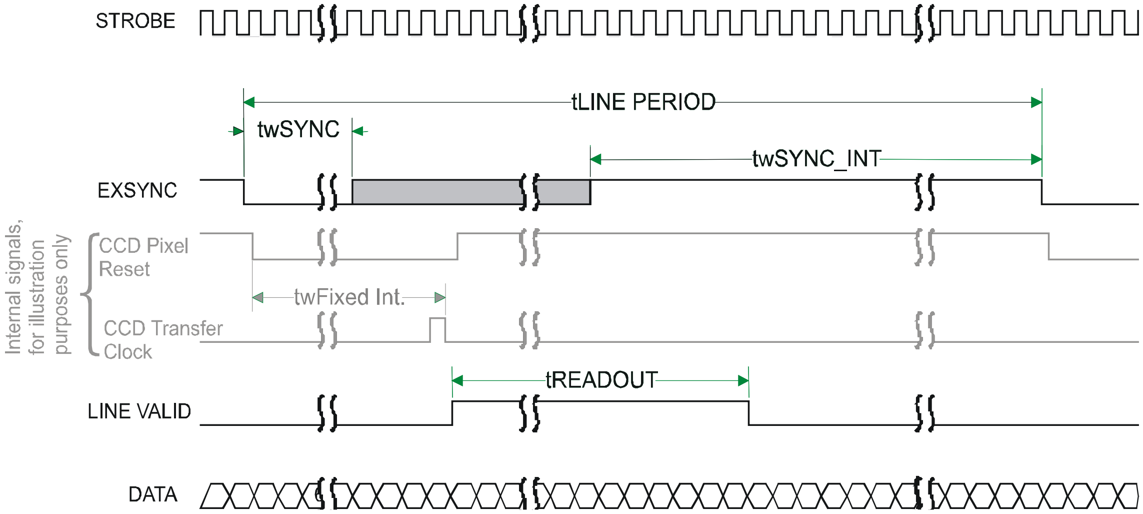


Table 10: Spyder3 Input and Output

Symbol	Definition	Min (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

Step 3. Establish Communication with the Camera

Power on the camera

Turn on the camera's power supply. You may have to wait up to 60 seconds while the camera warms up and prepares itself for operation.

Connect to the camera

In order for you to communicate with the camera, a serial connection in the Camera Link cable needs to be established. The frame grabber manufacturers should be able to provide a solution in order to communicate through this serial link. Terminal software can also be provided by the frame grabber manufacturer. Standard terminal software, such as Microsoft HyperTerminal, can be used if the COM port is allocated by the frame grabber. Start your GUI and establish communication with the camera.

Check LED Status

If the camera is operating correctly at this point, the diagnostic LED will flash for 10 seconds and then turn solid green.

Software Interface

All the camera features can be controlled through the ASCII interface.

Using Camera Link with Spyder3 Cameras

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. For example, functions available include:

- 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 Teledyne DALSA cameras. You should not assume that these commands perform the saI me as those for older cameras.

Complete Command List

A list of all the available commands is included in ASCII Commands: Reference, page 70.

Serial Protocol Defaults

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

Command Format

The camera responds to a simple ASCII-based protocol. 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>

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 **h**.

To view a help screen listing all of the "get" commands, use the command **gh**.

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.

At this point you are ready to start operating the camera in order to acquire images, set camera functions, and save settings.

Camera Operation

Factory 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 @ -10 dB.

Returning Camera Settings

The camera parameter screen (obtained using the **gcp** command) 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:

`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.
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 µSec**	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 End-of-line Sequence for details.
FFC Coefficient Set:	**0**	Current pixel coefficient set loaded. Refer to section 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 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 Analog and Digital Signal Processing Chain for details.
Number of Line Samples:	**1024**	Number of lines samples set with the **css** command. See section Returning Video Information for details.
Upper Threshold	**3600**	Upper threshold value set with the **sut** command. See section End-of-line Sequence for details.
Lower Threshold	**400**	Lower threshold value set with the **slt** command. See section End-of-line Sequence for details.
Analog Gain (dB):	**0.0 0.0**	Analog gain settings set with the **sag** command. See section 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 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 Analog and Digital Signal Processing Chain for details.
Digital Offset:	**0 0**	Digital offset settings set with the **sdo** command. See section Analog and Digital Signal Processing Chain for details.
Background Subtract:	**0 0**	Background subtract settings set with the **ssb** command. See section Analog and Digital Signal Processing Chain for details.
System Gain (DN):	**4096 4096**	Digital gain settings set with the **ssg** command. See section Analog and Digital Signal Processing Chain for details.

Saving and Restoring Settings

Use these commands to select, load, and save factory, user, and coefficient sets.

Camera Link Commands

Parameter	Description
lpc i	Loads your previously saved pixel coefficients from non-volatile memory to active status. 0: factory calibration. 1 – 4: user sets.
rfs	Restores the camera's factory settings. The FPN and PRNU coefficients are reset to 0.
rus	Restores the camera's last saved user settings and FPN and PRNU coefficients.
wfc i	Write all current FPN coefficients to non-volatile memory. 1 – 4 available sets.
wil i	Write current LUT's to non-volatile memory. 1- 4 available sets.
wpc i	Write all current PRNU coefficients to non-volatile memory. 1 – 4 available sets.
wus	Write all of the user settings to non-volatile memory.

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.

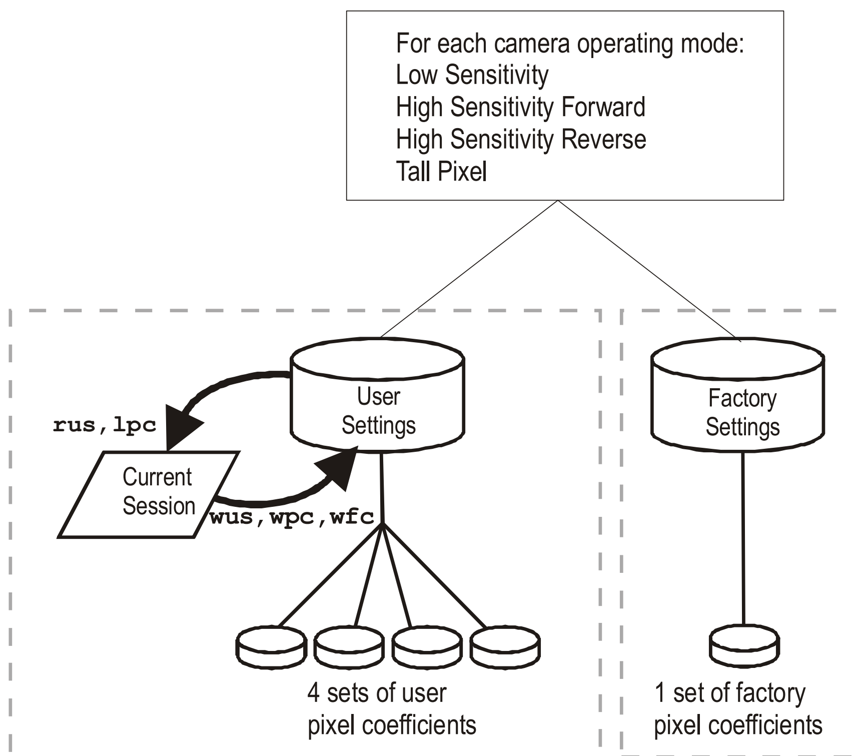


Figure 14: Saving and Restoring Overview

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 LUTs, use the wil command.

Current Session Settings

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

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 11: Data Readout Configurations

Mode Configuration				Readout Direction
Command	**Models**	**Taps**	**Bit Depth**	**smm 0 increment =1** **smm 1 increment = -1**
clm 0	S3-14-01K40	1	8	**smm 0** = CL tap 1 (1-1024) **smm 1** = CL tap 1 (1024-1)
	S3-14-02K40			**smm 0** = CL tap 1 (1-2048) **smm 1** = CL tap 1 (2048-1)
clm 1	S3-14-01K40	1	12	**smm 0** = CL tap 1 (1-1024) **smm 1** = CL tap 1 (1024-1)
	S3-14-02K40			**smm 0** = CL tap 1 (1-2048) **smm 1** = CL tap 1 (2048-1)
clm 2	S3-24-01K40	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)

Mode Configuration				Readout Direction
Command	Models	Taps	Bit Depth	smm 0 increment =1 smm 1 increment = -1
	S3-24-02K40	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)
	S3-24-04k-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	S3-24-01K40	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)
	S3-24-02K40	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)
	S3-24-04k-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

Use the **clm** command to select the 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

Camera Link Command

Parameter	Description	Notes
clm 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	To obtain the current Camera Link mode, use the command **gcp** or **get clm.** The bit patterns are defined by the Teledyne DALSA Camera Link Roadmap, available from the Knowledge Center on Teledyne DALSA website.
Example		
clm 1		

Setting the Pixel Readout Direction (Mirroring Mode)

The **smm** command 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.

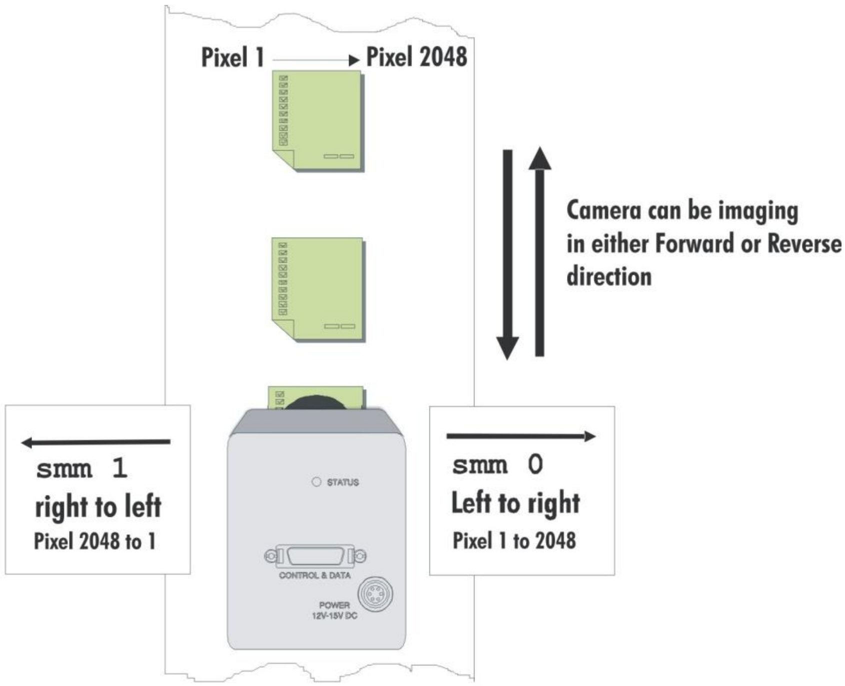
Camera Link Command

Parameter	Description	Notes
smm 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.	• 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 Image Sensor for the sensor architecture diagrams that illustrate the sensor readout direction.
Example		
smm 1		

Figure 15: Left to Right Readout (smm 0) Forward Direction Example Output

Figure 16: Right to Left Readout (smm 1) Forward Direction Example Output

Figure 17: Camera Pixel Readout Direction Example using 2k Model with Inverting Lens



4k camera orientation

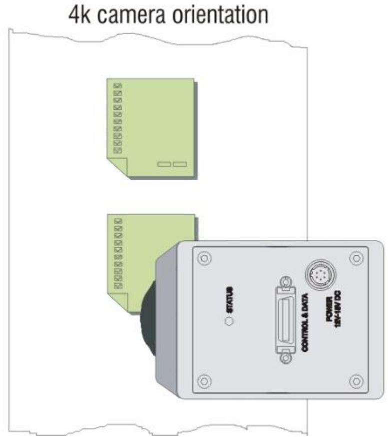


Table 12: Forward or Reverse Pixel Readout

Camera model	Readout direction	Command	Tap 1	Tap 2
S3-14-01k40	Left to Right	`smm 0`	1-1024	n/a
	Right to Left	`smm 1`	1024-1	n/a
S3-24-01K40	Left to Right	`smm 0`	1-512	513-1024
	Right to Left	`smm 1`	1024-513	512-1
S3-14-02K40	Left to Right	`smm 0`	1-2048	n/a
	Right to Left	`smm 1`	2048-1	n/a
S3-24-02K40	Left to Right	`smm 0`	1-1024	1025-2048
	Right to Left	`smm 1`	2048-1025	1024-1
S3-24-04K40	Left to Right	`smm 0`	1-2048	2049-4096
	Right to Left	`smm 1`	4096-2049	2048-1

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 set sensitivity command: **`ssm`**.

Figure 18: 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.

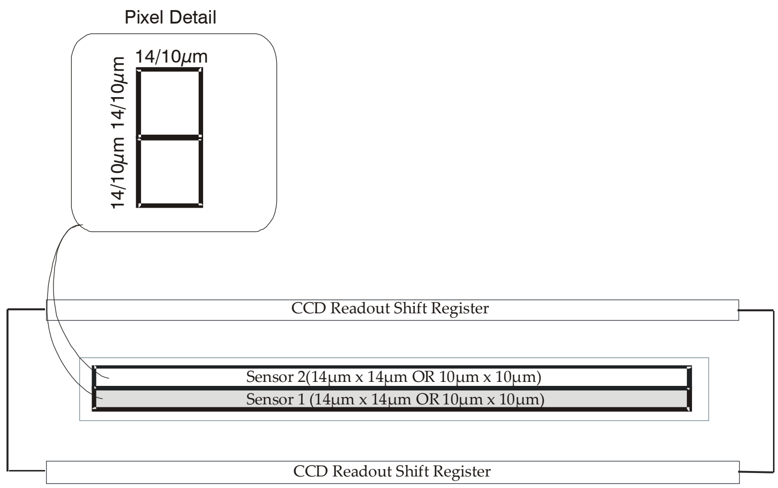


Figure 19: Low Sensitivity Mode

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).

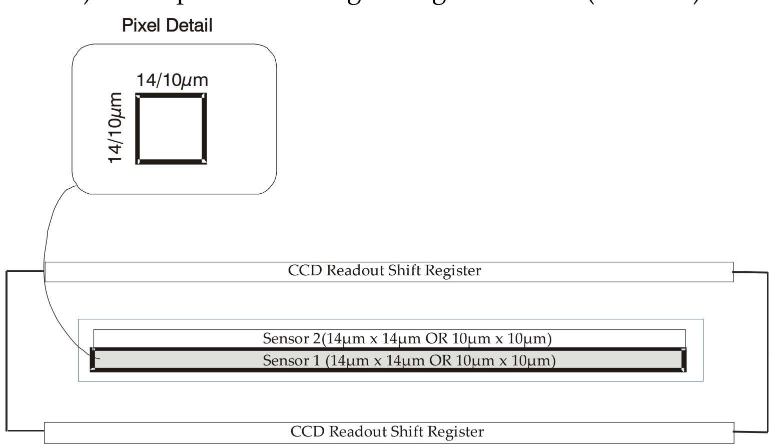
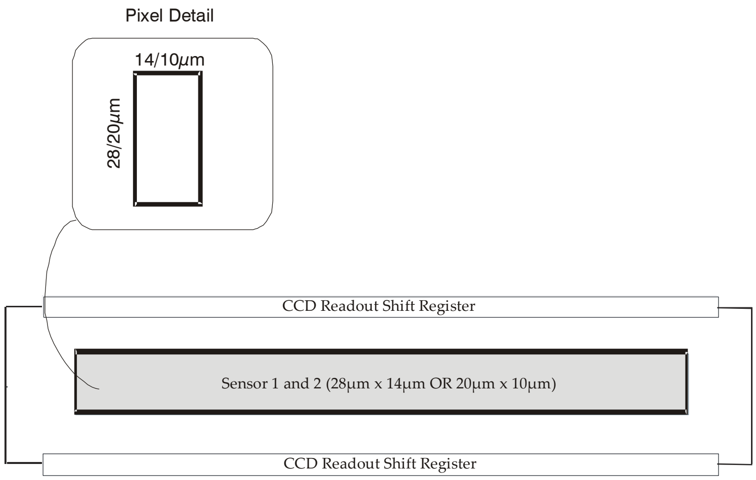


Figure 20: Tall Pixel Mode

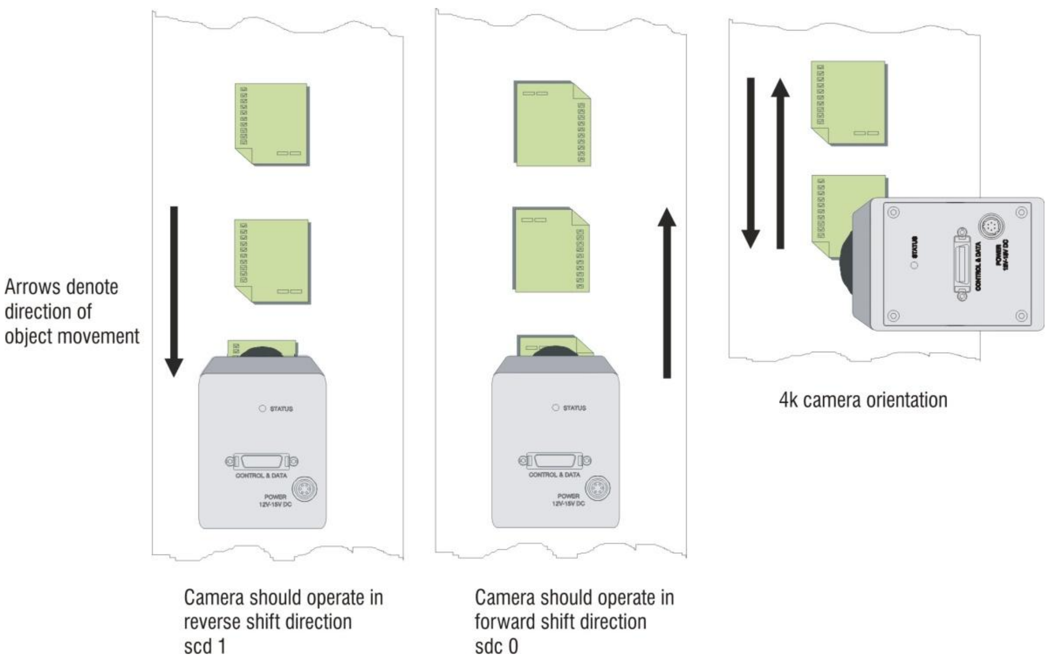
In tall pixel mode, the camera uses a 28 µm x 14 µm pixel (1k and 2k) or a 20 µm x 10 µm pixel (4k model) and captures an image two times taller than in high or low sensitivity modes, resulting in a taller image.



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 21: 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.

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 set sync frequency 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 to one of the 7 available modes 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

Sets the camera's exposure mode allowing you to control your sync, exposure time, and line rate generation.

Camera Link Command

Parameter	Description	Notes
sem i	Sets the exposure mode to use. The factory setting is **7**.	• Refer to • Table 13: 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**.
Example		
sem 3		

Table 13: 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.

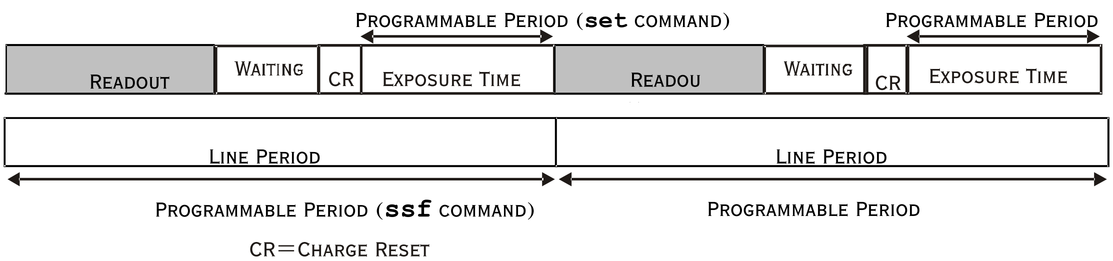
Exposure Modes in Detail

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.

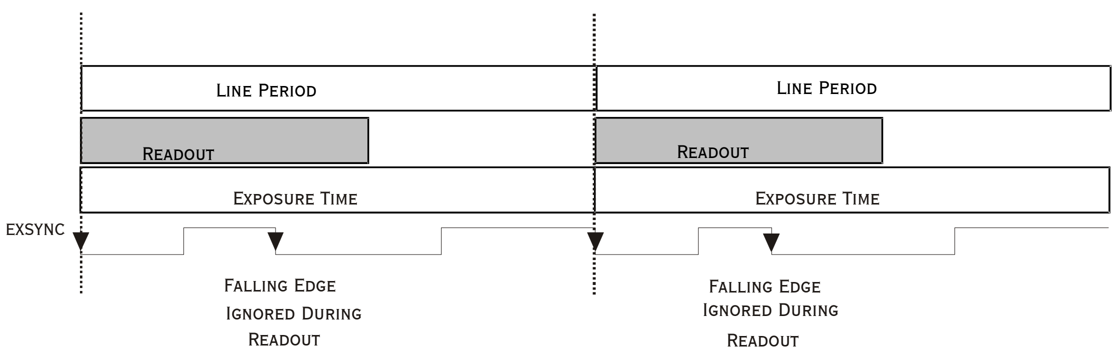
Example 1: Exposure Time less than Line Period



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.

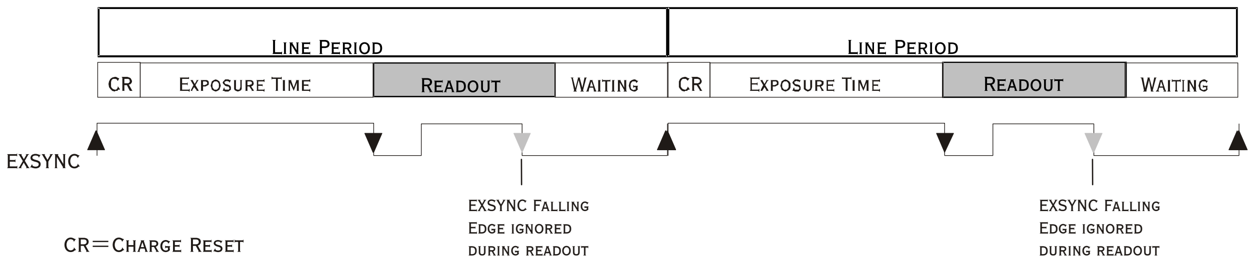
Example 2: Line Rate is set by External Trigger Pulses.



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.

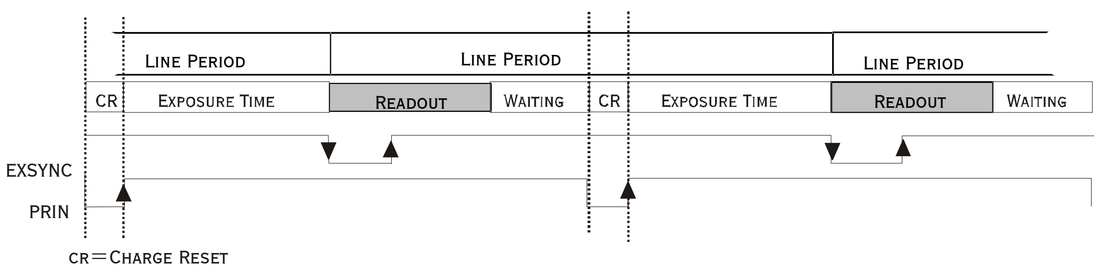
Example 3: Trigger Period is Repetitive and Greater than Read Out Time.



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

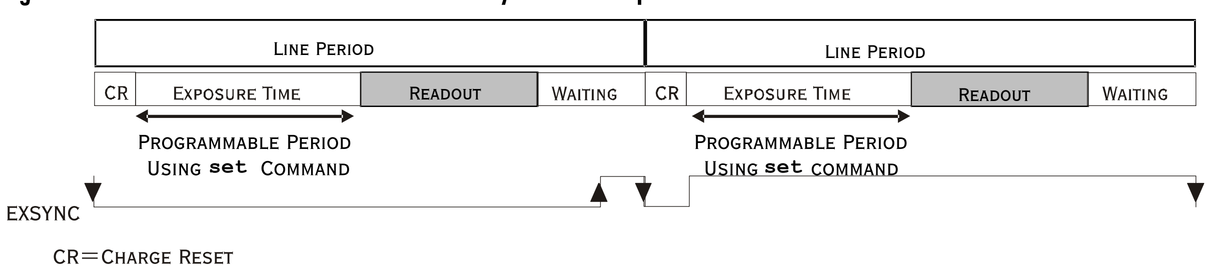
In this mode, the falling edge of EXSYNC sets the line period and the rising edge of PRIN sets the start of exposure time.

Figure 22: EXSYNC controls Line Period and PRIN controls Exposure Time



Mode 6: External Line Rate and Internally Programmable Exposure Time

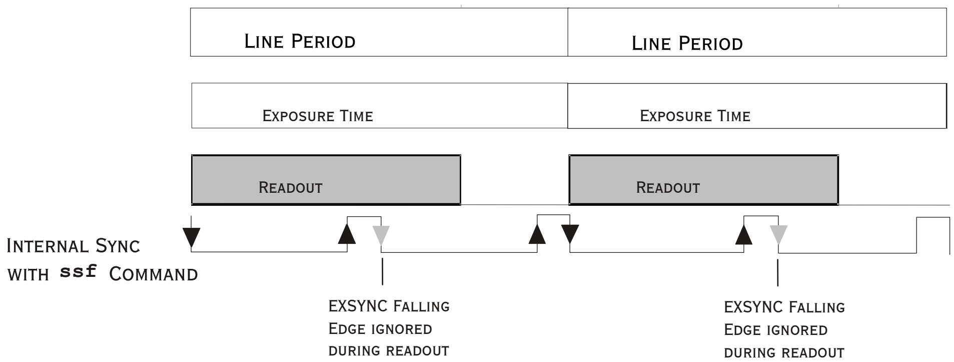
Figure 23: EXSYNC controls Line Period with Internally controlled Exposure Time



Mode 7: Internally Programmable Line Rate, Maximum Exposure Time

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

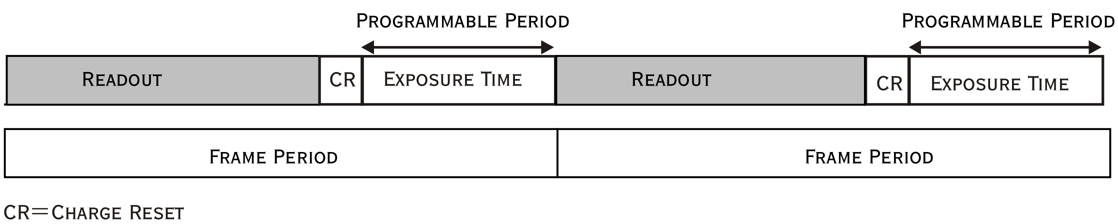
Figure 24: Mode 7 Camera Timing



Mode 8: Maximum Line Rate, Programmable Exposure Time

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

Figure 25: Mode 8 Timing



Setting the Line Rate

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

Camera Link Command

Parameter	Description	Notes
ssf f	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	• 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.
Example		
ssf 10000		

Setting the Exposure Time

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

Camera Link Command

Parameter	Description	Notes
set f	Desired exposure time in µs. Allowable range is `3` to `3300`µs.*	• 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**.
Example		
set 400.5		

Baud Rate

Determines the speed of the serial communication port in bps.

Camera Link Command

Parameter	Description	Notes
sbr m	Baud rate. Available baud rates are: `9600` (Default), `19200`, `57600`, and `115200`.	• 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

Sets the cable parameters.

Camera Link Command

Parameter	Description	Notes
scb i	Output compare value. Available values are: 0 to 255.	• 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. • **get scb** returns the current cable parameter.
Example		
scb 75		

Sensor Output Format

Sensitivity Mode

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.

Camera Link Command

Parameter	Description	Notes
ssm i	Sensitivity mode to use. `0` = Low sensitivity mode `1` = High sensitivity mode `2` = Tall pixel mode	• 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

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".

Camera Link Command

Parameter	Description	Notes
scd *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).	• 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 21: Object Movement and Camera Direction Example using an Inverting Lens, page 38, for an illustration of when you should use forward or reverse shift direction.
Example		
scd 0		

Setting the Camera Link Mode

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.

Camera Link Command

Parameter	Description	Notes
clm 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	• To obtain the current Camera Link mode, use the command **`gcp`** or **`get clm.`** • The bit patterns are defined by the Teledyne DALSA Camera Link Roadmap available here.
Example		
clm 0		

Setting the Mirror Mode

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

Camera Link Command

Parameter	Description	Notes
smm *i*	`0`: Pixels readout left to right. `1`: Pixels readout right to left.	S3-24-01K40 **`smm 0`** = 1-512 (tap 1) or 513-1024 (tap 2) **`smm 1`** = 1024-513 (tap 1) or 512-1 (tap 2) S3-24-02K40 **`smm 0`** = 1-1024 (tap 1) or 1025-2048 (tap 2) **`smm 1`** = 2048-1025 (tap 1) or 1024-1 (tap 2) S3-24-04k-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.

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

Camera Link Command

Parameter	Description	Notes
srm 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.)	• 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.
Example		
srm 0		

Data Processing

Setting a Region of Interest (ROI)

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

Camera Link Command

Parameter	Description	Notes
roi x1 y1 x2 y2	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**.	To return the current region of interest, use the commands **gcp** or **get roi**.
Example		
roi 10 1 50 1		

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.

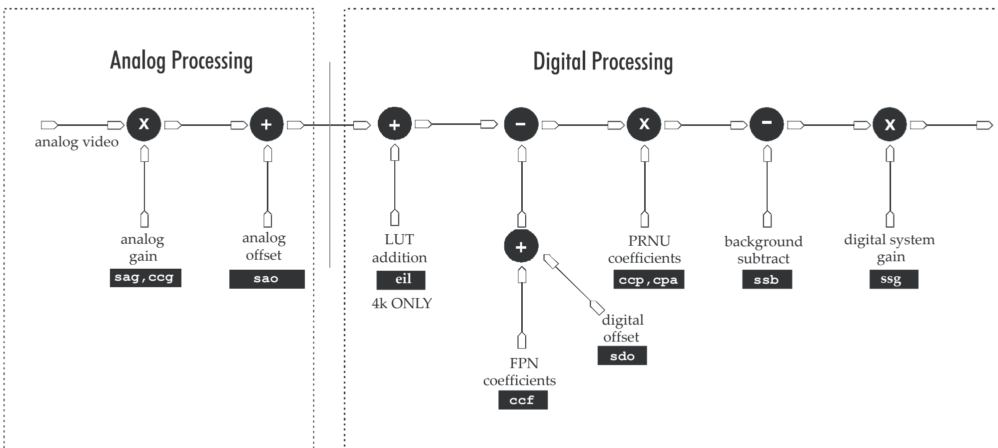


Figure 26: Signal Processing Chain

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

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.

Camera Link Command

Parameter	Description	Notes
sag t f	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.	To return the current analog gain setting, use the command **`gcp`** or **`get sag`**.
Example		
sag 0 5.2		

Calibrating Camera Gain

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.

Camera Link Command

Parameter	Description	Notes
ccg i t i	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).	• 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		

Setting Analog Offset

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. Teledyne 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.

Camera Link Command

Parameter	Description	Notes
sao *t i*	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).	To return the current analog offset value, use the command **`gcp`** or **`get sao`**.

Example
sao 2 35

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:

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

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.

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.

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

Calibration Overview

When a camera images a uniformly lit field, ideally, all of the pixels will have the same gray value. However, in practice, this is rarely the case (see example below) as a number of factors can contribute to gray scale non-uniformity in an image: Lighting non-uniformities and lens distortion, PRNU (pixel response non-uniformity) in the imager, FPN (fixed pattern noise) in the imager, etc.

Figure 27. Image with non-uniformities

By calibrating the camera you can eliminate the small gain difference between pixels and compensate for light distortion. This calibration employs a two-point correction that is applied to the raw value of each pixel so that non-uniformities are flattened out. The response of each pixel will appear to be virtually identical to that of all the other pixels of the sensor for an equal amount of exposure.

Calibration Steps

Step 1: Preparing for Calibration

If you do not want to change the current camera settings, but want to calibrate the camera, skip this step and move to Step 2: PRNU Calibration.

To check the current camera settings, use the get camera parameters (gcp) or the get commands. You can change some or all of the following settings before calibrating:

- Set exposure mode using the command sem m, where m = 2/3/4//6

  For example, `sem 2`
- Set line sync frequency (line rate) using the command ssf f, where f = - 72 kHz

  For example, `ssf 5000`
- Set exposure time using the command set f, where f = 1 - 8888 µs in an available mode.

  For example, `set 100`
- Set gain using command sg t i, where t are the taps 0 to 21 and i = ± 24 db

  For example, `sg t 0`
- Save user settings using command `wus`.

A Note on FPN or Dark Calibration

FPN calibration (also called dark calibration) is done in the factory.

Step 2: PRNU or White Calibration

1. Remove the lens cap and prepare a white, uniform target.

2. Adjust the line rate so that the average output is about 80% of the full output, or below the PRNU target value by:

   Adjusting the lighting, if you are using an internal exposure mode. Or,

   Adjusting the line rate, if you are using the Smart Exsync mode.

3. Calibrate the PRNU using the command **cpa 2 i,** where 2 is the PRNU calculated using the entered target value as shown in the formula on page 56 and i is the target value and the value of i is 1024 to 4055 DN.

For example: cpa 2 3300

4. Save the PRNU coefficients using the command **wpc.**

For example: wpc

Note: Both the FPN and PRNU coefficients are always turned on.

Digital Signal Processing

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

FPN Correction

Performs FPN correction and eliminates FPN noise by removing individual pixel dark current.

Camera Link Command

Parameter	Description	Notes
ccf		• 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 51 for a procedural overview on performing flat field correction. • To save FPN coefficients after calibration, use the **wfc** command. Refer to section Saving and Restoring PRNU and FPN Coefficients for details.
Example		
ccf		

Setting a Pixel's FPN Coefficient

Sets an individual pixel's FPN coefficient.

Camera Link Command

Parameter	Description	Notes
sfc x i	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

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.

Camera Link Command

Parameter	Description	Notes
sdo t i	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)	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.
Example		
sdo 0 100		

PRNU Correction

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.

Camera Link Command

Parameter	Description	Notes
cpa i i	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.	• 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.

	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.	
Example		
cpa 1 600		

Performing PRNU Correction to a Camera Calculated Value

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

Camera Link Command

Parameter	Notes
ccp	• 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 51 for a procedural overview on performing flat field correction. To save FPN coefficients after calibration, use the **`wpc`** command. Refer to section Saving and Restoring PRNU and FPN Coefficients for details.
Example	

Setting a Pixel's PRNU Coefficient

Sets an individual pixel's PRNU coefficient.

Camera Link Command

Parameter	Description	Notes
spc i i	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

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.

Camera Link Command

Parameter	Description	Notes
ssb t i	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**.	• 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: $\text{ssg value} = \frac{\text{max output value}}{\text{max output value - ssb value}}$
Example		
ssb 0 25		

Setting Digital System Gain

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:

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

Camera Link Command

Parameter	Description	Notes
ssg *t i*	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.	
Example		
ssg 1 15		

Returning Calibration Results and Errors

Returning All Pixel Coefficients

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.

Camera Link Command

Parameter	Description	Notes
dpc x1 x2	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**.	▪ 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

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

Camera Link Command

Parameter	Description	Notes
gfc i	The pixel number to read in a range from **1** to **sensor pixel count**.	
Example		
gfc 10		

Returning PRNU Coefficients

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

Camera Link Command

Parameter	Description	Notes
gpc *i*	i The pixel number to read in a range from **1** to **sensor pixel count**.	
Example		
gpc 10		

Enabling and Disabling Pixel Coefficients

Enables and disables FPN and PRNU coefficients

Camera Link Command

Parameter	Description	Notes
epc i i	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		

End-of-line Sequence

To aid in debugging, the camera can produce 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.

Camera Link Command

Parameter	Description	Notes
els i	0 Disable end-of-line sequence 1 Enable end-of-line sequence	LVAL is not high during the end-of-line statistics.
Example		
els 1		

Table 14: 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)	

Location	Value	Description
8	Line sum (31…24)	
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

Sets the upper threshold limit to report in the end-of-line sequence.

Camera Link Command

Parameter	Description	Notes
sut *i*	Upper threshold limit in range from **0** to **4095**.	LVAL is not high during the end-of-line statistics.
Example		
sut 1024		

Setting a Lower Threshold

Sets the lower threshold limit to report in the end-of-line sequence.

Camera Link Command

Parameter	Description	Notes
slt i	Upper threshold limit in range from **0** to **4095**.	LVAL is not high during the end-of-line statistics.
Example		
slt 1024		

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

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

Camera Link Command

Parameter	Description	Notes
`cil`	0 to 1. 0 for dark, 1 for light. 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

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

Camera Link Command

Parameter	Description	Notes
`eil flag`	`0` Disable 1 Enable	▪ Coefficients must be created first with the cil command. ▪ Setting saved with the wfs and wus commands.
Example		

Write Input LUT

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

Camera Link Command

Parameter	Description	Notes
`wil`	`0` = Factory set `1` to `4` = User sets	• LUT use is enabled or disabled with the EIL command. • Set 0 can only be written from factory mode.
Example		

Saving and Restoring PRNU and FPN Coefficients

Saving the Current PRNU Coefficients

The **wpc** command saves the current PRNU coefficients. You can save up to four sets of pixel coefficients.

Camera Link Command

Parameter	Description	Notes
wpc 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

The **wfc** command saves the current FPN coefficients. You can save up to four sets of pixel coefficients

Camera Link Command

Parameter	Description	Notes
wfc 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

The **lpc** command Loads one of the 4 saved sets of pixel coefficients. In addition, a factory calibrated set of coefficients is available.

Camera Link Command

Parameter	Description	Notes
lpc 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

The **rpc** command resets the current pixel coefficients to zero. This command does not reset saved coefficients.

Camera Link Command

Parameter	Description	Notes
rpc		The digital offset is not reset.
Example		

Rebooting the Camera

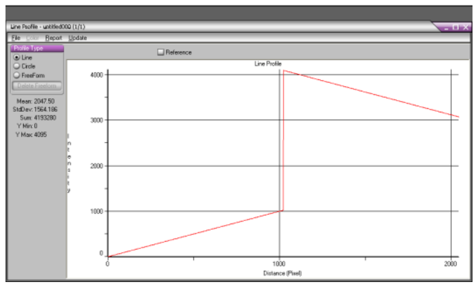
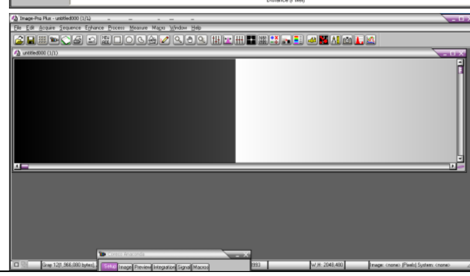
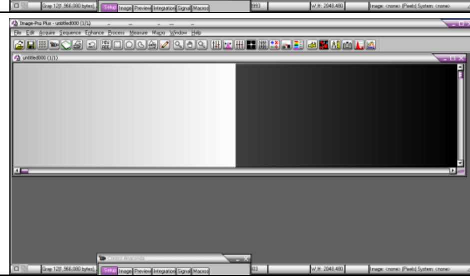
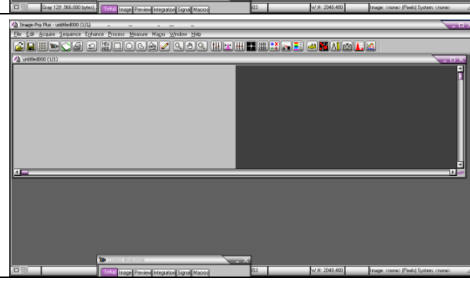
The command **`rc`** reboots the camera. The camera starts up with the last saved settings and the baud rate used before the reboot order. Previously saved pixel coefficients are also restored.

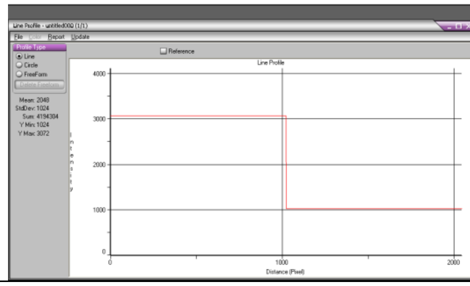
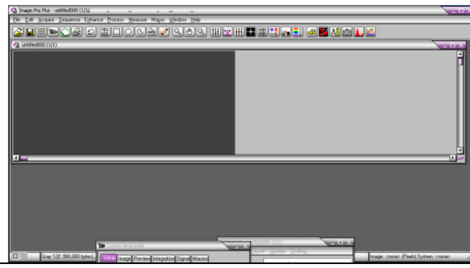
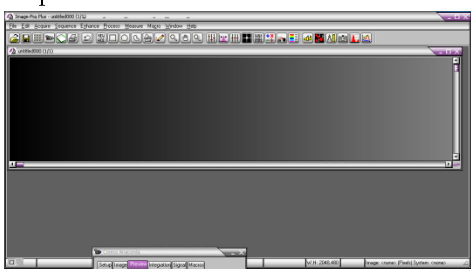
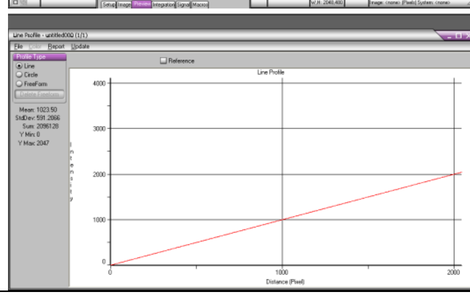
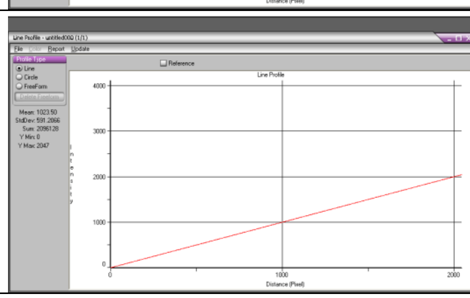
Diagnostics

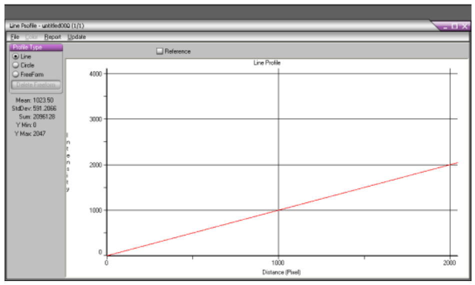
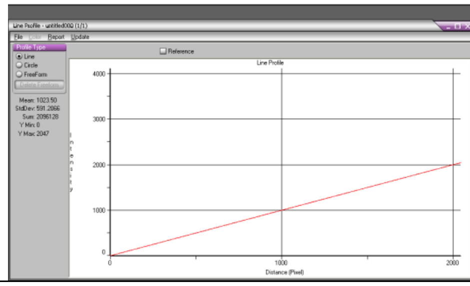
Generating a Test Pattern

Use the **svm** command to generate 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.

Camera Link Command

Parameter		Description
svm	0	Video.
svm smm	1 0	12 bit test pattern. 2 tap model:  
svm smm	1 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 smm	1 1	
svm smm	2 1	8 bit test pattern t tap model:

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 can also be used to collect line statistics for calibrating the camera.

Returning a Single Line of Video

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.

Camera Link Command

Parameter	Description	Notes
gl x1 x2	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**.	• If **x2** ≤ **x1** then **x2** is forced to be **x1**. Values returned are in 12-bit DN.
Example		
gl 10 20		

Returning Averaged Lines of Video

Setting the Number of Lines to Sample

The **css** command sets the number of lines to sample when using the **gla** command or when performing an FPN or PRNU calibration.

Camera Link Command

Parameter	Description	Notes
css m	Number of lines to sample. Allowable values are **256**, **512**, or **1024** (factory setting).	To return the current setting, use the **gcp** command or **get css**.
Example		
css 1024		

Returning the Average of Multiple Lines of Video

The **gla** command 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)).

Camera Link Command

Parameter	Description	Notes
gla x1 x2	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.	• 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.
Example		
gla 10 20		

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 65 °C.

Note: If the camera reaches 65 °C, the camera will shut down 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 shut down again. The camera allows you to send the **vt** (verify temperature) command while it is in this state.

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.

Camera Frequency Measurement

Returns the frequency for the requested Camera Link control signal

Camera Link Command

Parameter	Description	Notes
gsf i	Camera Link control signal to measure: 1: CC1 (EXSYNC) 2: CC2 (PRIN) 3: CC3 (CCD Direction)	• 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		

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. To view a help screen listing the following get commands, use the command **gh**.

ASCII Commands: Reference

Parameters:
t = tap id
f = float
s = string
y = pixel row number
i = integer value
m = member of a set
x = pixel column 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
Camera Link mode	**clm**	**i m**	Sets the camera's bit width where: *For S3-1x-01K40 and S3-1x-02K40* **0 =** 8 bits, 1 tap **1 =** 12 bits, 1 tap *For S3-2x-01K40 and S3-2x-02K40* **2** = 8 bits, 2 taps **3** = 12 bits, 2 taps
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.
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**
display gpio configuration	**dgc**		Display the current configuration of the GPIO connector
display input lut	**dil**	**t a a**	0 – 2 : 0 – 1023 : 0 - 1023
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

Mnemonic	Syntax	Parameters	Description
enable (EXSYNC) jitter	**ejt**	**i**	0 – 1. This feature will prevent line-to-line output variations due to EXYNC jitter at the maximum line rate.
end of line sequence	**els**	**i**	Sets the end-of-line sequence: **0**: Off **1**: On
enable noise correction	**enc**	**i**	0 – 1. Enables FIR filter in the output. The first two pixels are not filtered.
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
enable shaft encoder	**ese**	**i**	0 - 1
enable watchdog	**ewd**	**i**	0 – 1. The watchdog subtracts excessive dark current at line rates below 10 Hz.
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 exposure range	**ger**		
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**.
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**.

Mnemonic	Syntax	Parameters	Description
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.
single command help	`?`	`s`	
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
load user set	`lus`		
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.
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.

Mnemonic	Syntax	Parameters	Description
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.
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 mirroring mode	**smm**	**i**	0 - 1
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
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.

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>	
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.

Appendix A

Clearing Dark Current

Gate Dark Current Clear

Note: This feature is not available for the S3-24-04k40 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.

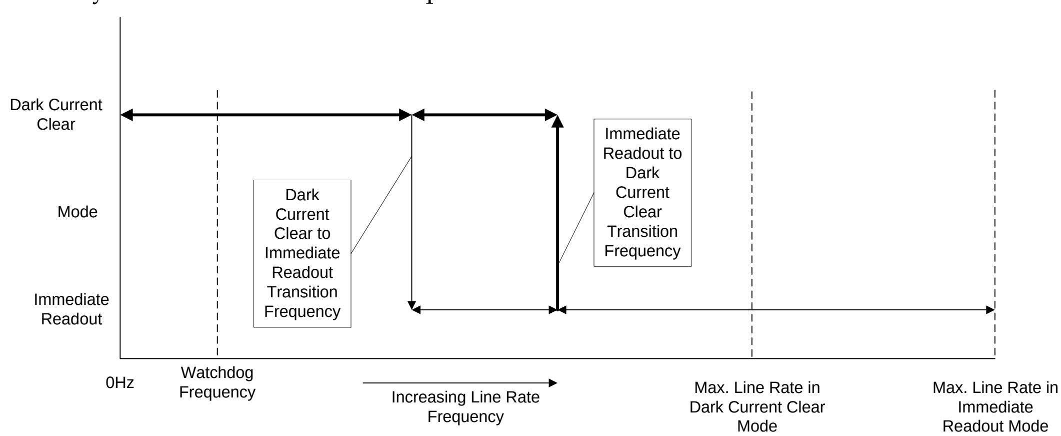


Figure 28: Gate Dark Current Clear

Table 17.

	Transition Frequencies	
Model	**Dark Current Clear to Immediate Readout Transition**	**Immediate Readout to Dark Current Clear Transition**
S3-14-01k40	13.6KHz	16.4KHz
S3-24-01k40	25.1KHz	30.4KHz

S3-14-02k40	7.05KHz	8.52KHz
S3-24-02k40	13.6KHz	16.4KHz
S3-24-04k40	4.4KHz	7.24KHz

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**
S3-14-01k40	36 KHz	18KHz
S3-24-01k40	68 KHz	34 KHz
S3-14-02k40	18.5KHz	9.25KHz
S3-24-02k40	36 KHz	18 KHz
S3-24-04k40	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
S3-14-01k40	27.5 µs
S3-24-01k40	14.75 µs
S3-14-02k40	53.1µs
S3-24-02k40	27.5 µs
S3-24-04k40	53.1µs

Auto Mode (srm 0)

Note: This feature is not available for the S3-24-04k40 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.

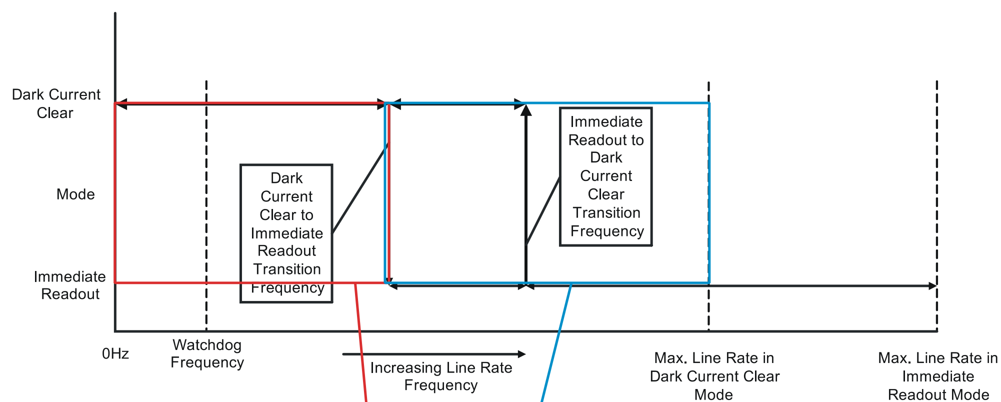
In the case of a slow transition (that is, when the EXSYNC line rate increases by less than 10% of the previous line rate) a line readout will not become corrupt.

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: Teledyne DALSA recommends Auto mode for most users.

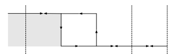
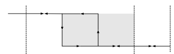
For information on artifacts that may be experienced while using this mode, see the Artifacts section below.

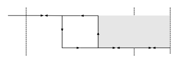
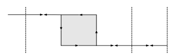
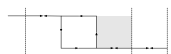
Please note: The graphic below explains the relationship between the following tables and the preceding Figure 28. The operating regions described in the tables refer to a specific region of Figure 28.

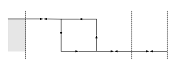
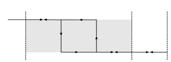


SRM 0, Auto Mode		
Time Period	Operating Region Refer to the above figure	Operating Mode
T_0		Dark Current Dump state
T_1		Immediate Readout state

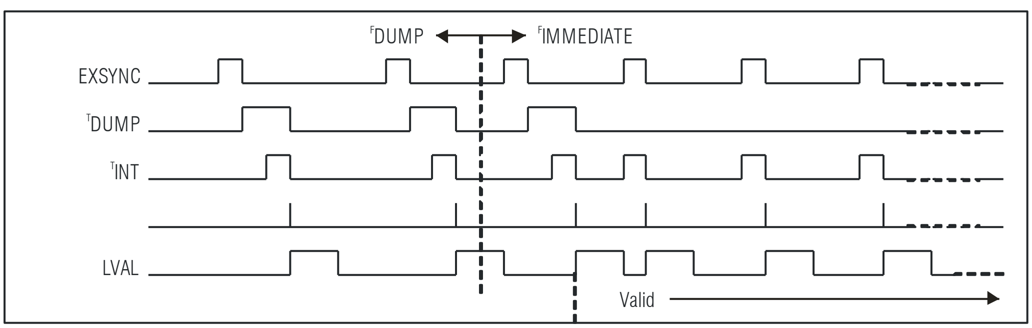
Dark Current Dump to Immediate Readout: Multi-Line Artifacts.

SRM 0, Auto Mode.		
Time Period	**Operating Region Refer to Figure 28.**	**Operating Mode**
T_0		Dark Current Dump state
T_1		Immediate Readout state

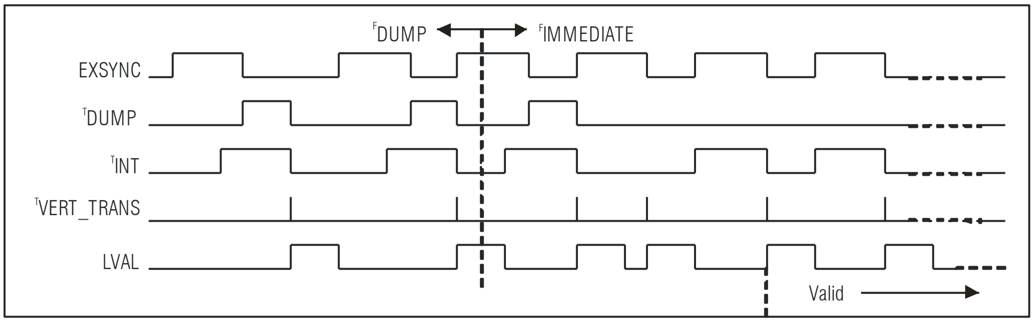
SRM 0, Auto Mode.		
Time Period	**Operating Region Refer to Figure 28.**	**Operating Mode**
T_0		Immediate Readout state
T_1		Dark Current Dump state
T_2		Immediate Readout state

SRM 2, Immediate Readout Mode.		
Time Period	**Operating Region Refer to Figure 28.**	**Operating Mode**
T_0		Dark Current Dump state
T_1		Immediate Readout state

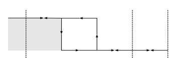
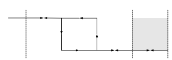
Dark Current Dump to Immediate Readout (T_{INT} < #)

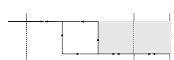
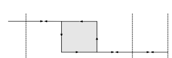
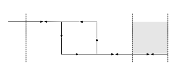


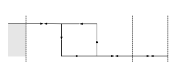
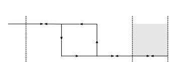
Dark Current Dump to Immediate Readout (T_{INT} > #)



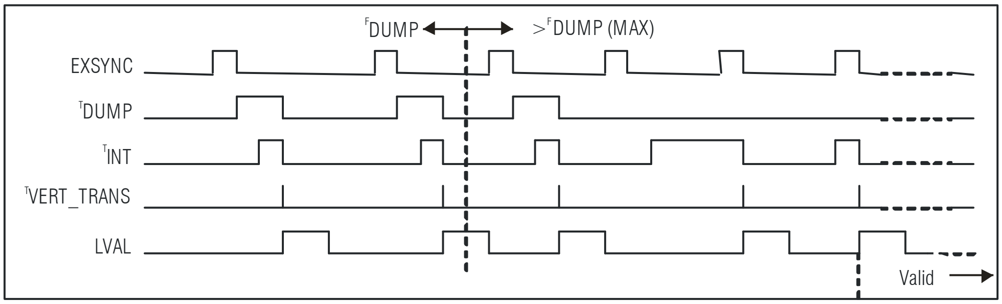
Dark Current Dump to Immediate Readout: Multi-Line Artifacts

SRM 0, Auto Mode.		
Time Period	**Operating Region Refer to Figure 28.**	**Operating Mode**
T_0		Dark Current Dump state
T_1		Immediate Readout state

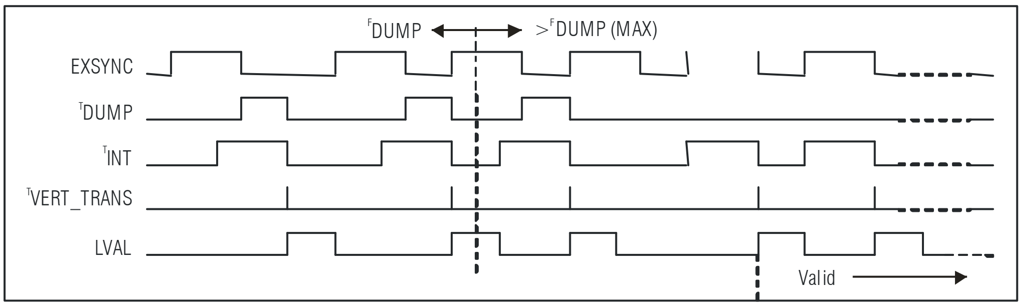
SRM 0, Auto Mode.		
Time Period	**Operating Region Refer to Figure 28.**	**Operating Mode**
T_0		Immediate Readout state
T_1		Dark Current Dump state
T_2		Immediate Readout state

SRM 2, Immediate Readout Mode.		
Time Period	**Operating Region Refer to Figure 28.**	**Operating Mode**
T_0		Dark Current Dump state
T_1		Immediate Readout state

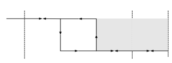
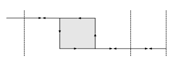
Dark Current Dump to Immediate Readout (T_{INT} < #)

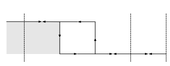
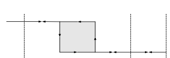
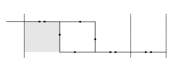


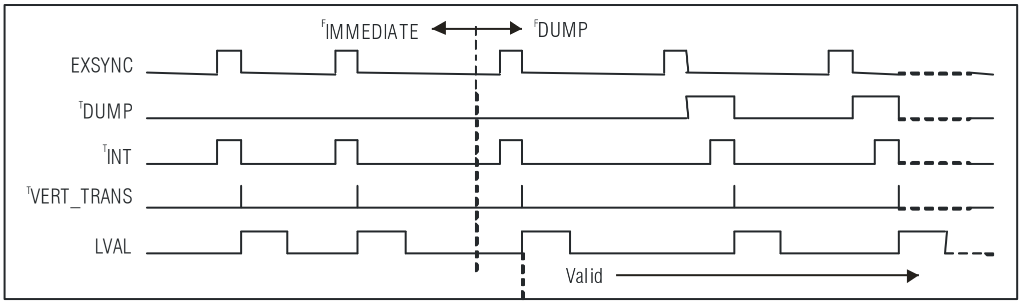
Dark Current Dump to Immediate Readout (T_{INT} > #)



Immediate Readout to Dark Current Dump: Hysteresis Artifacts

SRM 0, Auto Mode.		
Time Period	**Operating Region Refer to Figure 28.**	**Operating Mode**
T_0		Immediate Readout state
T_1		Dark Current Dump state

SRM 0, Auto Mode.		
Time Period	**Operating Region Refer to Figure 28.**	**Operating Mode**
T_0		Dark Current Dump state
T_1		Immediate Readout state
T_2		Dark Current Dump state



Setting the Readout Mode

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

Camera Link Command

Parameter	Description	Notes
srm	`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.)	• 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.
Example		
srm 0		

Appendix B

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 Teledyne DALSA Camera Link Implementation Road Map (available here) details how Teledyne 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 in the Knowledge Center on Teledyne DALSA's website.

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: Teledyne 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.

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

Camera Link Configuration Tables

The following table provides tap reconstruction information. Teledyne DALSA is working with the machine vision industry to use this table as the basis for auto configuration. Visit the Knowledge Center on our website, and view the Teledyne DALSA Camera Link Implementation Road Map document, 03-32-00450, for further details.

Camera Interface Parameters (PRELIMINARY)

Table 21: Frame Grabber Interface Parameters

<table>
<tr><th>Item (when programmable configuration the options are separated with a |)</th><th>S3-14-01k40</th><th>S3-24-01k40</th><th>S3-14-02k40</th><th>S3-24-02k40</th><th>S3-24-04k-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>
</table>

Item (when programmable configuration the options are separated with a |)	S3-14-01k40	S3-24-01k40	S3-14-02k40	S3-24-02k40	S3-24-04k-40
Configuration Definition Cx= HDW, Number of Output Taps, Bit Width, Number of Processing Nodes where Cx is the configuration ID x is <1,2,3…> HDW is <Base, Medium, Full> Number of Output Taps is <1,2,3…> Bit width is <8, 10, 12…> Number Processing Nodes is <1 or 2>	C1 = Base, 1, 8, 1 C2 = Base, 1, 12, 1	C1 = Base, 2, 8, 1 C2 = Base, 2, 12, 1	C1 = Base, 1, 8, 1 C2 = Base, 1, 12, 1	C1 = Base, 2, 8, 1 C2 = Base, 2, 12, 1	C1 = Base, 2, 8, 1 C2 = Base, 2, 12, 1
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

Item (when programmable configuration the options are separated with a |)	S3-14-01k40	S3-24-01k40	S3-14-02k40	S3-24-02k40	S3-24-04k-40
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
Row Binning Factor <1,2,3 or 1|2|3>	1	1	1	1	1
Column Binning Factor <1,2,3 or 1|2|3>	1| 2	1| 2	1| 2	1| 2	1| 2
Pretrigger Pixels <0,1,2…or 0..15>	0	0	0	0	0
Pretrigger Lines <0,1,2.. or 0..15>	0	0	0	0	0
Frame Time Minimum <xx µs>	27.78	14.7	54.05	27.78	54.05
Frame Time Maximum <xx µs>	3333	3333	3333	3333	3333
Internal Line/Frame Time Resolution <xx ns> 0 if not applicable	25	25	25	25	25
Pixel Reset Pulse Minimum Width <xx ns> 0 if not applicable	3000	3000	3000	3000	3000
Internal Pixel Reset Time Resolution <xx ns> 0 if not applicable	25	25	25	25	25
Pixel Reset to Exsync Hold time <xx ns>	TBD				
BAUD Rate <9600….>	9600, 19200, 57600, 115200	9600, 19200, 57600, 115200	9600, 19200, 57600, 115200	9600, 19200, 57600, 115200	9600, 19200, 57600, 115200
CC1 <Exsync>	EXSYNC	EXSYNC	EXSYNC	EXSYNC	EXSYNC
CC2 <PRIN>	PRIN	PRIN	PRIN	PRIN	PRIN

Item (when programmable configuration the options are separated with a |)	**S3-14-01k40**	**S3-24-01k40**	**S3-14-02k40**	**S3-24-02k40**	**S3-24-04k-40**
CC3 <Forward, Reverse>	Forward/ Reverse	Forward/ Reverse	Forward/ Reverse	Forward/ Reverse	Forward/ Reverse
CC4 <Spare>	Spare	Spare	Spare	Spare	Spare
DVAL out <Strobe Valid, Alternate>	Strobe Valid	Strobe Valid	Strobe Valid	Strobe Valid	Strobe Valid
Spare out <Spare> (For future use)	Spare	Spare	Spare	Spare	Spare

Appendix C

EMC Declaration of Conformity

We, TELEDYNE DALSA
605 McMurray Road
Waterloo, Ontario
CANADA N2V 2E9

Declare under sole responsibility that the CE Mark, FCC Part 15, and Industry Canada ICES-003 evaluation of the Spyder 3 CL cameras--model numbers S3-14-01K40-00-R, S3-24-01K40-00-R, S3-14-02K40-00-R, S3-24-02K40-00-R, and S3-24-04k40-00-R--manufactured by Teledyne DALSA Inc., produced the following results:

EN 55011 Class A (2010), EN 55022 Class A (2006), EN61326 Class A (1997) Emissions Requirements--Pass
EN 55024 (1998), and EN 61326 (1997) Immunity to Disturbances--Pass

IEC 61000-4-2 (1996)--Pass
IEC 61000-4-3 (2006)--Pass
IEC 61000-4-4 (2004)--Pass
IEC 61000-4-6 (1996)--Pass

The cameras met the requirements outlined above which satisfy the regulations for FCC Part 15 Class A, Industry Canada ICES-003 Class A, the 2004/108/EC EMC Directive for CE Marking, and the 2006/95/EC Low Voltage Directive exemption due to low operating voltage, and carry the CE marking accordingly.

Place of issue: Waterloo, Ontario, Canada

Date of Issue: March 27, 2007 (1k and 2k models) and March 13, 2008 (4k model).

Hank Helmond

Director of Quality, TELEDYNE DALSA Corp.

H. Helmond

Revision History

Number	Description	Date
00	Preliminary release.	23 February 2012
01	Revision to the Clearing Dark Current section. Revised EMC Declaration section.	June 10, 2013
02	Revised EMC Declaration. Added recent EN 55011 emissions testing.	December 4, 2014

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