

Spyder3 SC-34

Color Camera User's Manual

SC-34-02K80-00-R

SC-34-04K80-00-R



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TELEDYNE DALSA
A Teledyne Technologies Company

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

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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>).

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The Spyder3 SC-34 Camera

The Spyder3 color Camera Link camera uses Teledyne DALSA's state-of-the-art dual line scan technology in order to deliver high color quality, low-cost and ease of use for color imaging. This camera features 2k and 4k resolutions with a maximum line rate of 18 kHz. The zero gap between the two sensor lines minimizes image artifact. Customer selectable output formats, RGB, RG/ GB, and G, provides greater flexibility to meet many application requirements.

1.1 Camera Highlights

Features

- 2048 or 4096 pixels, 14 μm x 14 μm (2k) and 10 μm x 10 μm (4k) pixel pitch, 100% fill factor
- 80 mega pixels per second throughput
- Up to 18 kHz (2k) or 9 kHz (4k) line rates
- RGB, RG/ GB, or G color output formats
- Dynamic range 60 dB
- Base Camera Link configuration (8 or 12 bit)
- RoHS and CE compliant (pending)
- Pre-calibrated light sources (e.g. white LED)

Programmability

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

Applications

The Spyder3 Color camera is ideal for:

- Cotton and textile inspection
- Food, drug and tobacco inspection
- Wood, tile, and steel inspection
- Postal sorting
- Recycling sorting
- 100 % print inspection (lottery tickets, stamps, bank notes, pay checks, etc.)
- General web inspection

Camera Models

The Spyder3 color camera is available in these models.

Table 1: Camera Models Overview

Model	Description
SC-34-02K80-00-R	2k resolution, 2 sensor taps. Base Camera Link configuration.
SC-34-04K80-00-R	4k resolution, 2 sensor taps. Base Camera Link configuration.

Table 2: Camera Accessories

Accessory	Description
AC-UC-00002-00-R	M42 TO C-MOUNT ADAPTER RH
AC-SU-00113-00-R	TRIPOD MOUNT ROHS SPYDER3
AC-UN-00002-00-R	M42 TO F-MOUNT ADAPTER RH, 2k model
AC-UN-00003-00-R	M42 TO F-MOUNT ADAPTER RH, 4k model

1.2 Camera Performance Specifications

Table 3: Camera Performance Specifications

Feature / Specification	2k	4k
Imager Format	Bilinear CCD	
Resolution	2048 pixels (2046 interpolated)	4096 pixels (4094 interpolated)
Pixel Fill Factor	100%	
Pixel Size	14 μm x 14 μm	10 μm x 10 μm
Antiblooming	100x	
Gain Range	0 to 20 dB	
Optical Interface	2k	4k
Lens Mount	M42 x 1 thread	M58 x 0.75
Lens Mount Adapters*	C and F	F
Back Focal Distance	6.56 \pm 0.25 mm	
Sensor Alignment		
x	\pm 50 μm	
y	\pm 50 μm	
z	\pm 0.25 mm	
Θ_z	\pm 0.2°	
Mechanical Interface	2k	4k
Camera Size	72(h) x 60(w) x 60(l) mm	60 (h) x 72(w) x 60(l) mm
Mass	< 300 g	300 g
Connectors		
power connector	6 pin male Hirose	
data connector	MDR26 female	
Electrical Interface	2k	4k
Input Voltage	+12 to +15 Volts	
Power Dissipation	< 9 W	< 9 W
Operating Temperature	0 °C to 65 °C (measured at front plate)	
Bit Width	8 or 12 bit user selectable Bits	
Output Data Configuration	Base Camera Link	
Speed	2k	4k
Maximum Line Rate	18 000 Hz	9 000 Hz
Minimum line rate	300 Hz	300 Hz

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

Table 4: Camera Operating Specifications (Single Color)

Specs	Unit	0 dB			10 dB			+20 dB		
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max
Broadband responsivity	DN / (nJ / cm ²)									
2k		—	126.4	—	—	400	—	—	1264	—
4k		—	64	—	—	201.6	—	—	784	—
Random noise rms	DN	—	3	6.5	—	9.2	20.5	—	30	65
Dynamic range	DN:DN	—	1300:1	—	—	428:1	—	—	130:1	—
FPN global	DN p-p									
Uncorrected		—	—	52.8	—	—	169.6	—	—	536
Corrected		—	—	32	—	—	32	—	—	64
PRNU ECD										
Uncorrected local	%	—	—	8.5	—	—	8.5	—	—	11.5
Uncorrected global	%	—	—	10	—	—	10	—	—	10
Corrected local	DN p-p	—	—	80	—	—	80	—	—	95
Corrected global	DN p-p	—	—	80	—	—	80	—	—	95
PRNU ECE										
Uncorrected local	%	—	—	8.5	—	—	12	—	—	37
Uncorrected global	%	—	—	10	—	—	12	—	—	37
Corrected local	DN p-p	—	—	80	—	—	237	—	—	752
Corrected global	DN p-p	—	—	80	—	—	208	—	—	752
SEE (calculated)	nJ/cm ²									
2k		—	31	—	—	9.8	—	—	3.1	—
4k		—	62	—	—	20	—	—	6.2	—
NEE (calculated)	pJ/cm ²									
2k		—	23.7	—	—	23.7	—	—	23.7	—
4k		—	46.8	—	—	46.8	—	—	46.8	—
Saturation output amplitude	DN	—	—	—	—	3968±80	—	—	—	—
DC offset	DN	—	—	32	—	—	—	—	—	—

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, 3250 k, with 750 nm high-pass filter and BG38 filter installed.
- Ambient test temperature 25 °C.
- Unless specified, all values are referenced at 12 bit.
- Exposure mode disabled.

Notes

1. PRNU measured at 50% SAT.

Certifications

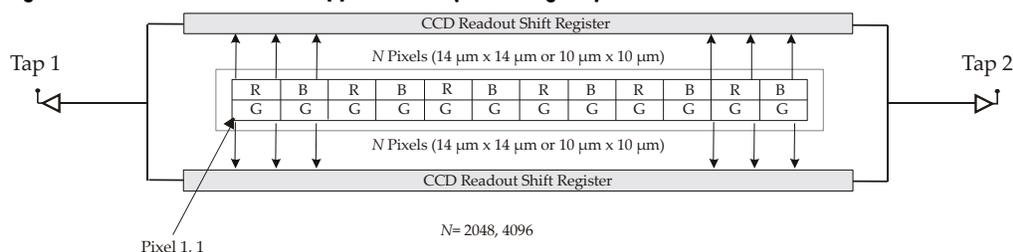
Table 5: EMC Compliance Standards

Compliance
The CE Mark, FCC Part 15, and Industry Canada ICES-003 Evaluation of the DALSA Spyder3 CL SC-34 cameras meet the following requirements:
EN 55022 Class A, EN 55011 Class A, and FCC Part 15 Class A emissions requirements; EN 55024, and EN 61326-1 immunity to disturbances.

1.3 Image Sensor

The Spyder3 Color bilinear camera is based on Teledyne DALSA's dual line scan CCD sensor. The bilinear sensor has two lines. The first line has red (R) and blue (B) pixel alternatively, while the second line has all green (G) pixels. There is no gap in between the two lines and this minimizes any artifact due to spatial correction. The G channel can be used as a monochrome output. The sensor has a 2 tap output.

Figure 1: Bilinear sensor used in Spyder3 Color (block diagram)



1.4 Responsivity

Figure 2: Spyder3 Color 2k Responsivity

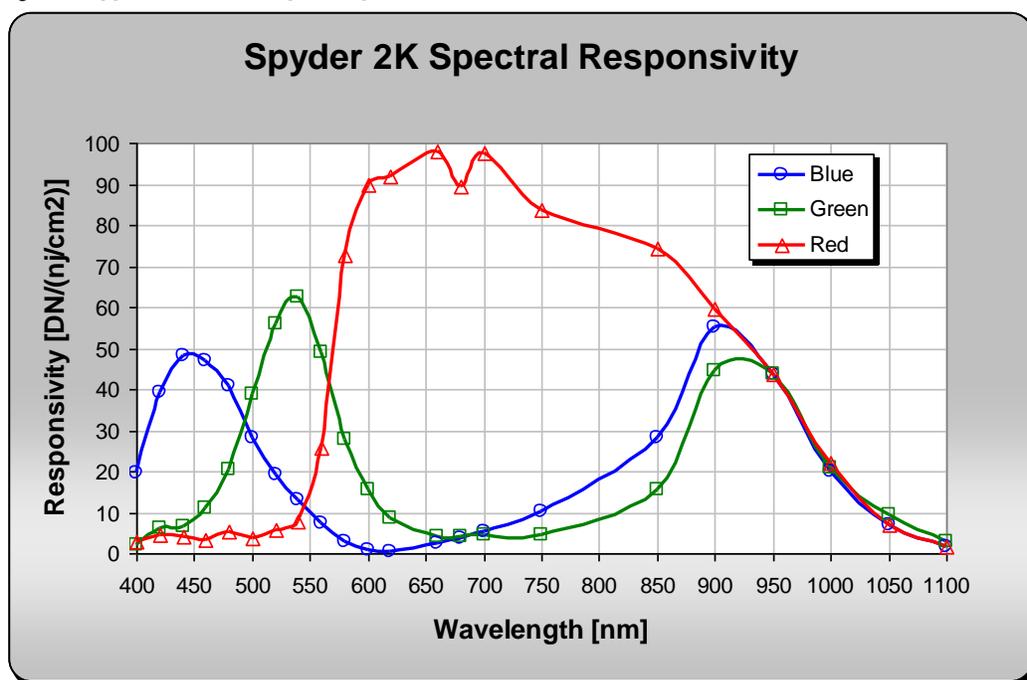
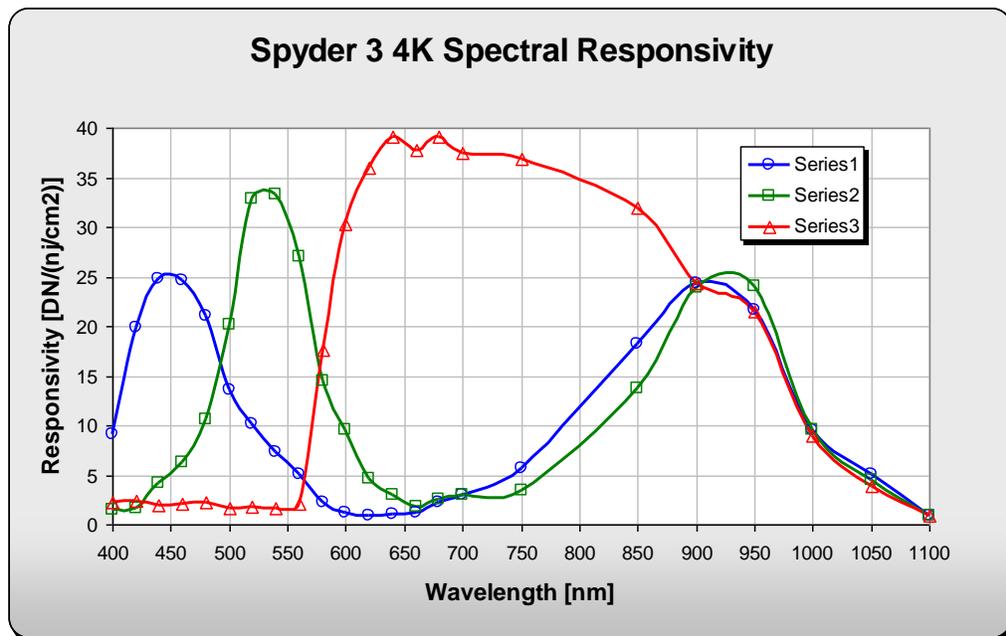


Figure 3: Spyder3 Color 4k Responsivity



Mechanicals

3.1 Mechanical Interface

Figure 4: 2k Mechanical Dimensions

[ADD MECHANICAL PDF HERE]

Figure 5: 4k Mechanical Dimensions

[ADD MECHANICAL PDF HERE]

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.

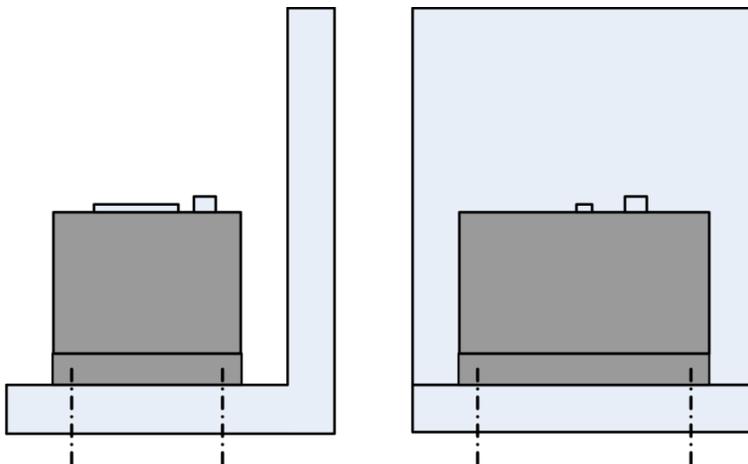


Figure 6: Spyder3 Mounting Example

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.

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.

The camera uses:

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

All models

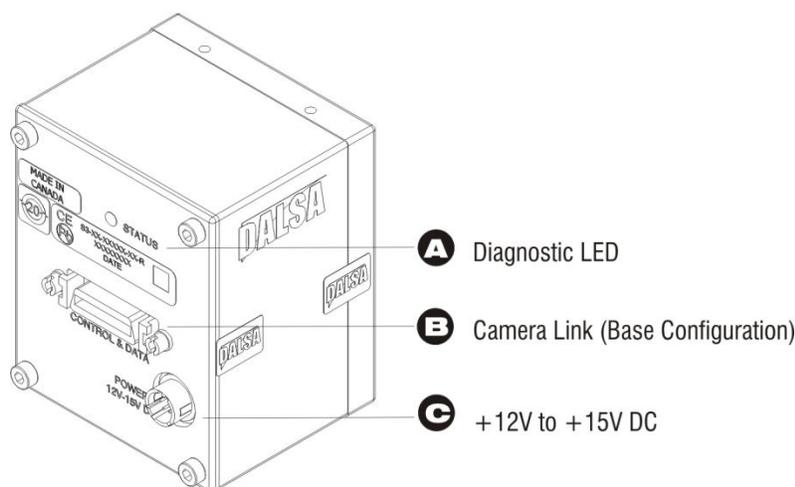


Figure 7: Input and Output Connectors

WARNING: It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages may damage the camera.

2.1 Power Connector

Figure 8: Hirose 6-pin Circular Male—Power Connector and Table 6: Hirose Pin Description

Hirose 6-pin Circular Male



Mating Part: HIROSE
HR10A-7P-6S

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

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

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

- Apply the appropriate voltages. Ensure +12 V to +15 V at the camera power input (after the voltage drop across the power cable). This may mean that the power supply will have to provide a voltage greater than the required one, in order to adjust for this loss. For example, to achieve +12 V at the camera, the power supply may need to supply +12.5 V or greater.
- Protect the camera with a fast-blow fuse between power supply and camera.
- Do not use the shield on a multi-conductor cable for ground.
- Keep leads as short as possible to reduce voltage drop.
- Use high-quality linear supplies to minimize noise.

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

2.2 Camera LED

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

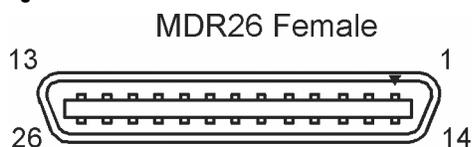
When more than one condition is active, the LED indicates the condition with the highest priority. Error and warning states are accompanied by corresponding messages further describing the current camera status.

Table 7: 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. Warning. Loss of functionality (e.g. external SRAM failure).
2	Flashing Green	Camera initialization or executing a long command
3	Solid Green	Camera is operational and functioning correctly
4	Solid Red	Warning. Loss of functionality.

2.3 Camera Link Data Connector

Figure 9: Camera Link MDR26 Connector



**3M part 14X26-SZLB-XXX-OLC is a complete cable assembly, including connectors. Unused pairs should be terminated in 100 ohms at both ends of the cable.

Mating Part: 3M 334-31 series

Cable: 3M 14X26-SZLB-XXX-OLC **

The Camera Link interface is implemented as Base Configuration in the Spyder3 Color cameras.

Table 8: 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	All models

Table 9: Camera Link Connector Pinout

Base Configuration		
One Channel Link Chip + Camera Control + Serial Communication		
Camera Connector	Right Angle Frame Grabber	Channel Link Signal
1	1	inner shield
14	14	inner shield
2	25	X0-
15	12	X0+
3	24	X1-
16	11	X1+
4	23	X2-
17	10	X2+

5	22	Xclk-
18	9	Xclk+
6	21	X3-
19	8	X3+
7	20	SerTC+
20	7	SerTC-
8	19	SerTFG-
21	6	SerTFG+
9	18	CC1-
22	5	CC1+
10	17	CC2+
23	4	CC2-
11	16	CC3-
24	3	CC3+
12	15	CC4+
25	2	CC4-
13	13	inner shield
26	26	inner shield

Notes:

*Exterior Overshield is connected to the shells of the connectors on both ends.

**3M part 14X26-SZLB-XXX-0LC is a complete cable assembly, including connectors.

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

Inner shield is connected to signal ground inside camera

Table 10: Camera Control Configuration

Signal	Configuration
CC1	EXSYNC
CC2	PRIN
CC3	Direction

See Appendix B for the complete Camera Link configuration table, and refer to the Teledyne DALSA Web site for the official Camera Link documents

(<http://www.teledynedalsa.com/mv/knowledge/appnotes.aspx>).

Input Signals, Camera Link

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

The camera ships in internal sync, maximum exposure time (exposure mode 7).

EXSYNC (Triggers Line Readout)

Line 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. See Setting the Exposure Mode, page 27, for details on how to set line rates, exposure times, and camera modes.

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 Camera Link Implementation Road Map for the standard location of these signals (<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.

2.4 Camera Link Video Timing

Figure 10: Overview Timing Showing Input and Output Relationships

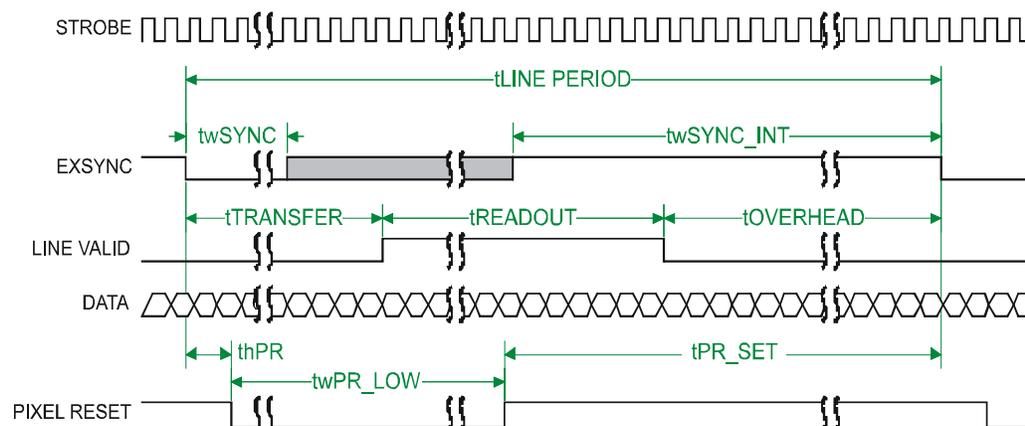


Figure 11: Fixed (Programmed) Integration Timing with External EXSYNC

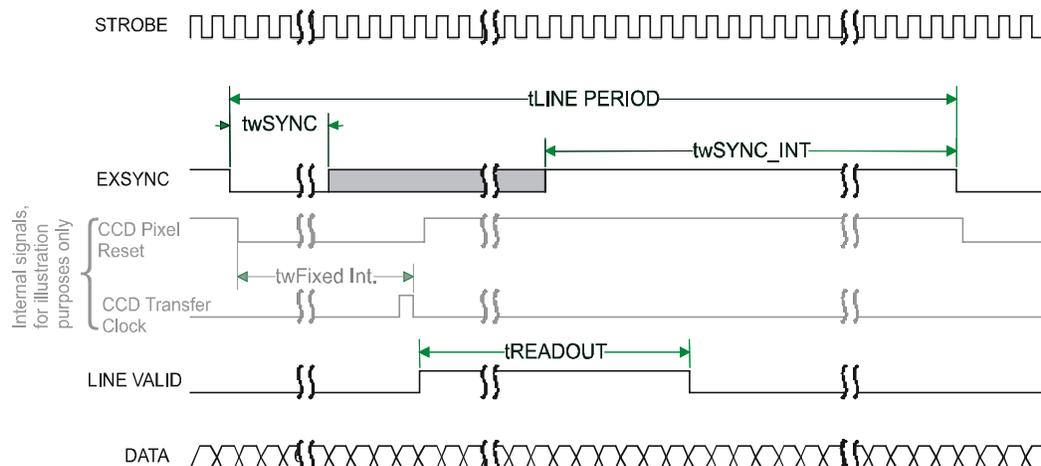


Table 11: Spyder3 Color Input and Output

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.	55,550 (2k 2 tap) 11,1100 (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.	1, 450 ±50 (2k) 1, 650 ±50 (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.	52,975 (2k 2 tap) 104,275 (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	50 ±12 (2k) 210 ±12 (4k)
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

Camera Output Format

There are several color output formats:

RGB mode (interpolation): camera outputs three colors (two native colors, one interpolated color) for each pixel.



RG/ BG mode (native): In this mode the camera outputs two native colors per pixel, (RG or BG depending on the pixel location)

G mode (native): This mode provides 100% fill factor native green color that can be used as a monochrome channel

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 serial interface.

3.1 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 same as those for older cameras.

Complete Command List

A complete list of the ASCII commands and their parameters is available [here](#).

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.

Baud Rate

Purpose: Sets the speed in bps of the serial communication port.

Syntax: **sbr m**

Syntax Elements: **m**

Baud rate. Available baud rates are: **9600** (Default), **19200**, **57600**, and **115200**.

Notes: Power-on rate is always 9600 baud.

The **rc** (reset camera) command will *not* reset the camera to the power-on baud rate and will reboot using the last used baud rate.

Example: **sbr 57600**

3.2 First Power Up Camera Settings

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

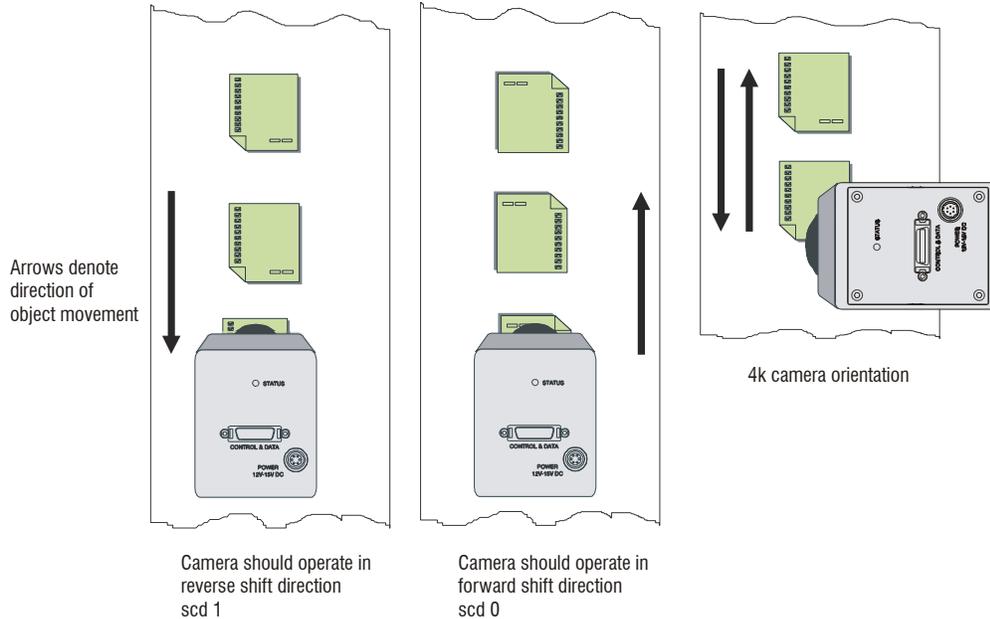
- Forward CCD shift direction
- RGB color output mode (clm 5)
- Exposure mode 7 (Programmable line rate & max exposure time, 625 μ s)
- 1600 Hz line rate
- Readout mode: Auto
- Mirroring mode: 0, left to right
- Factory calibrated analog gain and offset
- 8 bit output

3.3 Sensor Output Format

Sensor Shift Direction

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.” The scan direction has no effect on the color output format.

Figure 12: Object Movement and Camera Direction Example using an Inverting Lens



Note: You can control the CCD shift direction through the serial interface. Use the software command `scd` to determine whether the direction control is set via software control or via the Camera Link control signal on CC3. Refer to the CCD Shift Direction section of this manual, page 24, for details.

CCD Shift Direction

Purpose:	Selects the forward or reverse CCD shift direction, internally or externally controlled. This accommodates object direction change on a web and allows you to mount the camera “upside down.”
Syntax:	<code>scd i</code>
Syntax Elements:	<code>i</code>
	Shift direction. Allowable values are: 0 = Internally controlled, forward CCD shift direction. 1 = Internally controlled, reverse CCD shift direction. 2 = Externally controlled CCD shift direction via Camera Link control CC3 (CC3=1 forward, CC3=0 reverse).
Notes:	<ul style="list-style-type: none"> To obtain the current value of the exposure mode, use the command <code>gcp</code> or <code>get scd</code>. Refer to Figure 12: Object Movement and Camera Direction Example using an Inverting Lens, page 24, for an illustration of when you should use forward or reverse shift direction.
Example:	<code>scd 0</code>

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 (`srm`) command to select the camera's pixel readout direction.

Setting the Camera Link Mode

Purpose:	Sets the camera's Camera Link configuration, the number of Camera Link taps, and the data bit depth. Refer to the tables on the previous page to determine which configurations are valid for your camera model and how this command relates to other camera configuration commands.
Syntax:	<code>clm m</code>
Syntax Elements:	<code>m</code>
	Output mode to use: 0 : G only, 8 bit, output as monochrome 1 : G only, 10 bit, output as monochrome 2 : 2 taps (RG/ BG), 8 bit output 3 : 2 taps (RG/ BG), 12 bit output 5 : 3 taps (RGB), 8-bit output 6 : 3 taps (RGB), 12-bit output (time multiplexed) 9 : 4 taps (RGBY), 8-bit output (time multiplexed) 10 : 4 taps (RGBY), 12-bit output (time multiplexed)
Notes:	<ul style="list-style-type: none"> To obtain the current Camera Link mode, use the command <code>gcp</code>

or `get c1m`.

- The bit patterns are defined by the DALSA Camera Link Roadmap, available from <http://mv.dalsa.com>.
- RGBY is RGB output plus the luminance (set with `scx` and `scy` commands)

Example: `c1m 1`

3.4 Exposure Mode, Line Rate and Exposure Time

Overview

You have a choice of operating in one of seven modes. The camera's line rate (synchronization) can be generated internally through the software command `ssf` or set externally with an EXSYNC signal, depending on your mode of operation. To select how you want the camera's line rate to be generated:

You must first set the camera mode using the [sem](#) command.

Next, if using mode 2, 7 or 8 use the commands [ssf](#) and/ or [set](#) to set the line rate and exposure time.

Setting the Exposure Mode

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

Syntax: `sem i`

Syntax Elements: `i`

Exposure mode to use. Factory setting is 7.

- Notes:
- Refer to Table 12: Spyder3 Color Exposure Modes for a quick list of available modes or to the following sections for a more detailed explanation.
 - To obtain the current value of the exposure mode, use the command `gcp` or `get sem`.

Related Commands: [ssf](#), [set](#)

Example: `sem 3`

Table 12: Spyder3 Color Exposure Modes

Mode	Programmable Line Rate		Programmable Exposure Time		Description
	SYNC	PRIN	↓	↓	
2	Internal	Internal	Yes	Yes	Internal line 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.
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

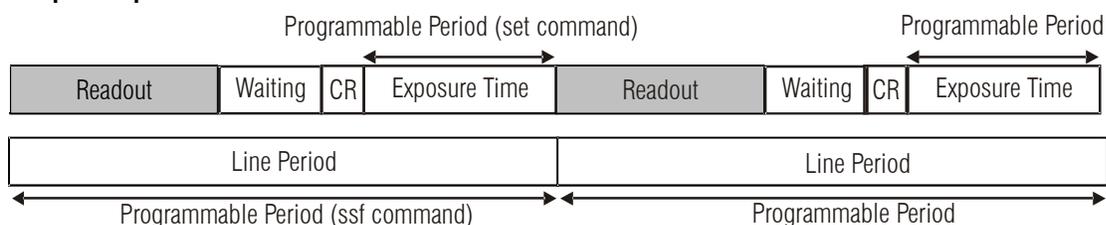
Mode 2: Internally Programmable Line Rate and Exposure Time (Factory Setting)

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

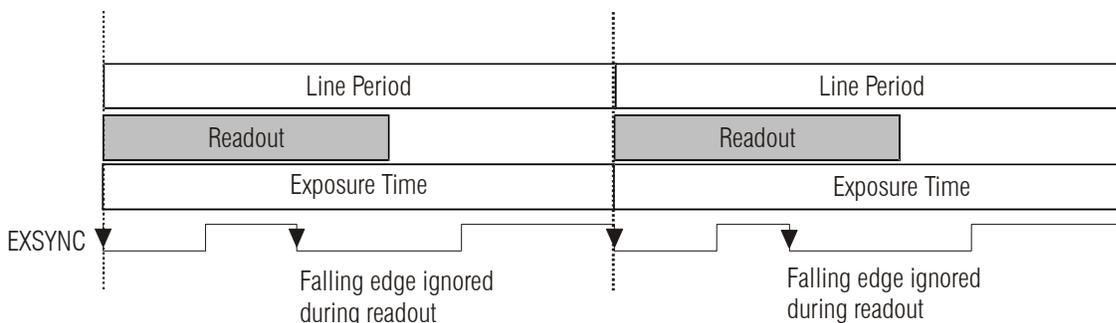


CR = Charge Reset

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.

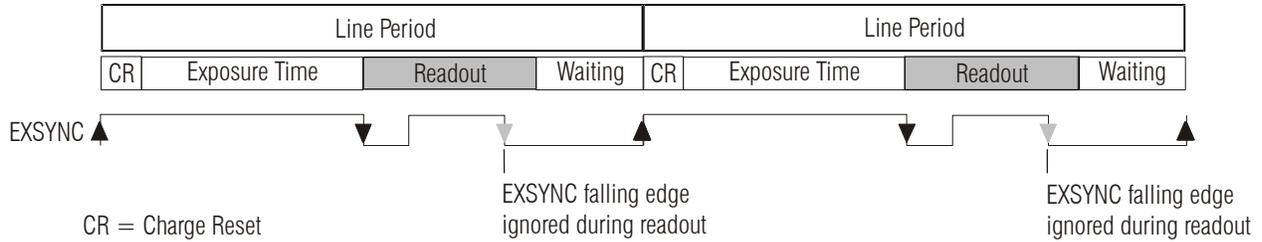
Example 2: Line Rate is set by External Trigger Pulses.



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

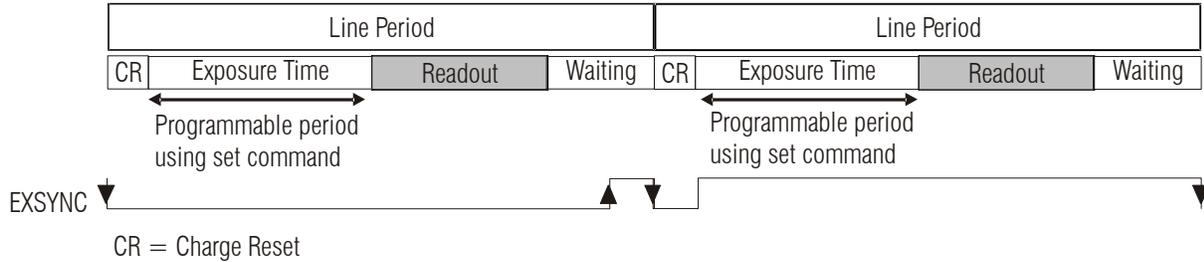
In this mode, EXSYNC sets both the line period and the exposure time. The rising edge of EXSYNC marks the beginning of the exposure and the falling edge initiates readout.

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



Mode 6: External Line Rate and Internally Programmable Exposure Time

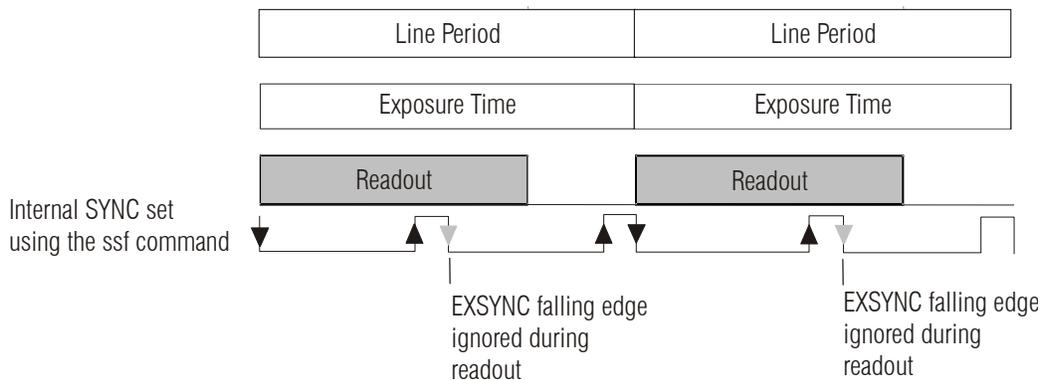
Figure 13: EXSYNC controls Line Period with Internally controlled Exposure Time



Mode 7: Internally Programmable Line Rate, Maximum Exposure Time

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

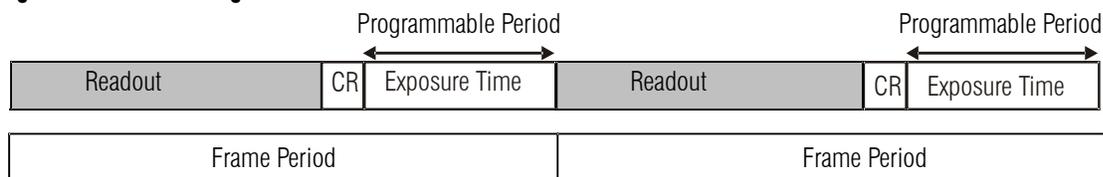
Figure 14: Mode 7 Camera Timing



Mode 8: Maximum Line Rate, Programmable Exposure Time

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

Figure 15: Mode 8 Timing



CR=Charge Reset

Setting the Line Rate



Applies to Modes 2 and 7

Purpose:	Sets the camera's line rate in Hz. Camera must be operating in exposure mode 2 or 7.
Syntax:	ssf f
Syntax Elements:	i
Notes:	<p>Desired line rate in Hz. Allowable values are: 2k 2 tap: 300 - 18000 Hz 4k 2 tap: 300- 9000 Hz</p> <ul style="list-style-type: none"> To read the current line frequency, use the command gcp or get ssf. If you enter an invalid line rate frequency, an error message is returned.
Related Commands:	sem, set
Example:	ssf 10000

Setting the Exposure Time



Applies to Modes 2 and 8

Purpose:	Sets the camera's exposure time is μ s. Camera must be operating in exposure mode 2, 6, or 8.
Syntax:	set f
Syntax Elements:	i
Notes:	<p>Desired exposure time in μs. Allowable range is 3 to 3300 μs.*</p> <ul style="list-style-type: none"> 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. <p>*The exposure time range is based on the current line rate.</p> <ul style="list-style-type: none"> To determine the maximum exposure time allowed for the current line rate, use the command get ger.
Related Commands:	sem, ssf
Example:	set 400.5
Purpose:	Sets the selected pin to use either TTL or LVDS standards.

Setting the Pixel Readout Direction (Mirroring Mode)

Purpose:	Sets the tap readout from left to right or from right to left. This command is especially useful if the camera must be mounted upside down.
Syntax:	<code>smm i</code>
Syntax Elements:	<i>i</i> Readout direction. Allowable values are: 0 = All pixels are read out from left to right. 1 = All pixels are read out from right to left.
Notes:	<ul style="list-style-type: none"> To obtain the current readout direction, use the command <code>gcp</code> or <code>get smm</code>. 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 the section below for the sensor architecture diagrams that illustrate the sensor readout direction.
Example:	<code>smm 1</code>

Figure 16: Left to Right Readout (smm 0) Forward Direction Example Output

abcdefghijklmnopqrstuvwxyz12345

Figure 17: Right to Left Readout (smm 1) Forward Direction Example Output

zyxwvutsrqponmlkjihgfedcba

Note: In clm 2 and clm 3, the output will be R/ B/ R/ B... for smm 0 and B/ R/ B/ R... for smm 1. The green output remains the same except mirrored.

Figure 18: Camera Pixel Readout Direction Example using 2k Model with Inverting Lens

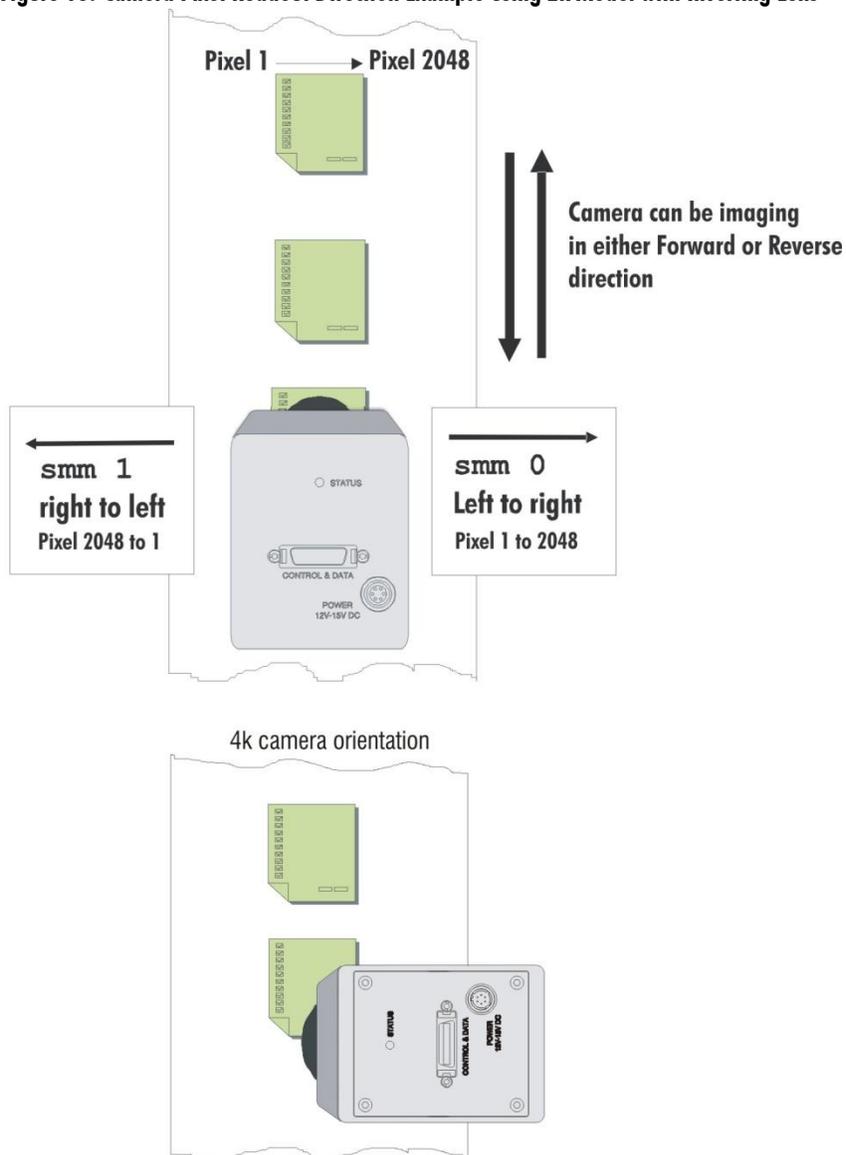


Table 13: Forward or Reverse Pixel Readout

Camera model	Readout direction	Command	Tap 1	Tap 2
SC-34-02K80	Left to Right	smm 0	1-1024	1025-2048
	Right to Left	smm 1	2048-1025	1024-1
SC-34-04K80	Left to Right	smm 0	1-2048	2049-4096
	Right to Left	smm 1	4096-2049	2048-1

Setting the Readout Mode

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

Purpose:	Use this command to clear out dark current charge in the vertical transfer gates immediately before the sensor is read out.
Syntax:	srm
Syntax Elements:	i
	<ul style="list-style-type: none"> 0: Auto. Clears dark current below ~ 45% of the maximum line rate. 1: Dark current clear. Always clears dark. Reduces the maximum line rate. 2: Immediate readout. Does not clear dark current. (Default mode.)
Notes:	<ul style="list-style-type: none"> • The vertical transfer gates collect dark current during the line period. This collected current is added to the pixel charge. The middle two red taps have more vertical transfer gates and, therefore, more charge. This additional charge is especially noticeable at slower line rates. • If the user is in sem 2 or 7 and srm 2, with ssf at 45% of the maximum, and then srm 1 is selected, the following warning will be displayed, but the ssf value will not be changed: Warning 09: Internal line rate inconsistent with readout time> The effect in both internal and external line rate modes is that an EXSYNC is skipped and, therefore, the output will be at least twice as bright. • This value is saved with the camera settings. • This value may be viewed using either the gcp command or the get srm command.
Related Commands:	sem, ssf
Example:	srm 0

Enabling Line Delay

Purpose:	Turning off line delay may result in a better image when you are imaging a web that is moving extremely fast.
Syntax:	eld
Syntax Elements:	i
	<ul style="list-style-type: none"> 0: Off. 1: On.
Example:	eld 0

3.5 Color Commands

Calibrate White Balance

Purpose:	Adjust color digital gain in order to make the color output be a given value while imaging a white reference.
Syntax:	cwb i
Syntax Elements:	i color output in a range 1024 to 4055 .
Example:	cwb 1024

Setting Color Correction

Purpose:	Set the value in the color matrix that is multiplied at the end of the digital processing. This matrix corrects the digital output in order to achieve accurate colors.
Syntax:	scc i
Syntax Elements:	i -8192 to 8191
Related Commands	scx, scy
Example:	scc 4323

Setting Color Gain

Purpose:	Set color gain for the current color in a range of 0 to 20 dB . The current color is set using the scl command.
Syntax:	scg i
Syntax Elements:	i 0 to 20 dB.
Related Commands	scl
Example:	scg 10

Setting Color Selector

Purpose:	Used to select the color for a gain application.
Syntax:	scl m
Syntax Elements:	m rgb/ r/ g/ b
Related Commands	scg
Example:	scl b

Setting Color Correction X Index

Purpose: Set the current color correction X index. This command is used to assist the **scc** command.

Syntax: **sxc m**

Syntax Elements: **m**
o / r / g / b

Related Commands: **scc**

Example: **sxc b**

Setting Color Correction Y Index

Purpose: Set the current color correction Y index. This command is used to assist the **scc** command.

Syntax: **scy m**

Syntax Elements: **m**
r / g / b / y

Related Commands: **scc**

Example:

The following is how the **gcp** table entries look for the **sxc** and **scy** commands:

Color Correction:	o	r	g	b
r	0	4096	0	0
g	0	0	4096	0
b	0	0	0	4096
y	0	0	0	0

The **sxc** command selects the column in the above table (either o/ r/ g/ b). The **scy** command selects the row (either r/ g/ b/ y) in the above table.

The **scc** command is what sets the value at the select x and y position in the table

R_IN, G_IN and B_IN below in the equations are the already digitally processed data.

$$\text{RED PIXEL OUTPUT} = R_IN * (\text{scc \# in position [sxc r, scy r]}) / 4096 + G_IN * (\text{scc \# in position [sxc g, scy r]}) / 4096 + B_IN * (\text{scc \# in position [sxc b, scy r]}) / 4096 + \text{scc \# in position [sxc o, scy r]}$$

$$\text{GREEN PIXEL OUTPUT} = R_IN * (\text{scc \# in position [sxc r, scy g]}) / 4096 + G_IN * (\text{scc \# in position [sxc g, scy g]}) / 4096 + B_IN * (\text{scc \# in position [sxc b, scy g]}) / 4096 + \text{scc \# in position [sxc o, scy g]}$$

$$\text{BLUE PIXEL OUTPUT} = R_IN * (\text{scc \# in position [sxc r, scy b]}) / 4096 + G_IN * (\text{scc \# in position [sxc g, scy b]}) / 4096 + B_IN * (\text{scc \# in position [sxc b, scy b]}) / 4096 + \text{scc \# in position [sxc o, scy b]}$$

$$\text{Y PIXEL OUTPUT} = R_IN * (\text{scc \# in position [sxc r, scy y]}) / 4096 + G_IN * (\text{scc \# in position [sxc g, scy y]}) / 4096 + B_IN * (\text{scc \# in position [sxc b, scy y]}) / 4096 + \text{scc \# in position [sxc o, scy y]}$$

3.6 Data Processing

Setting a Region of Interest (ROI)

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

In most applications, the field of view exceeds the required object size and these extraneous areas should be ignored. It is recommended that you set the region of interest a few pixels inside the actual useable image.

Syntax:

```

srx i
srw i
    
```

Syntax Elements:

`srx` `i`

Starting x position of the ROI, in a value of 1 to `sensor resolution`.

`srw` `i`

Width of the ROI, in a value of 1 to `sensor resolution`.

Notes: To return the current region of interest, use the commands `gcp` or `get srx`, `get srw`.

Related Commands `gl`, `gla`, `ccf`, `cpa`, `els`

3.7 Analog and Digital Signal Processing Chain

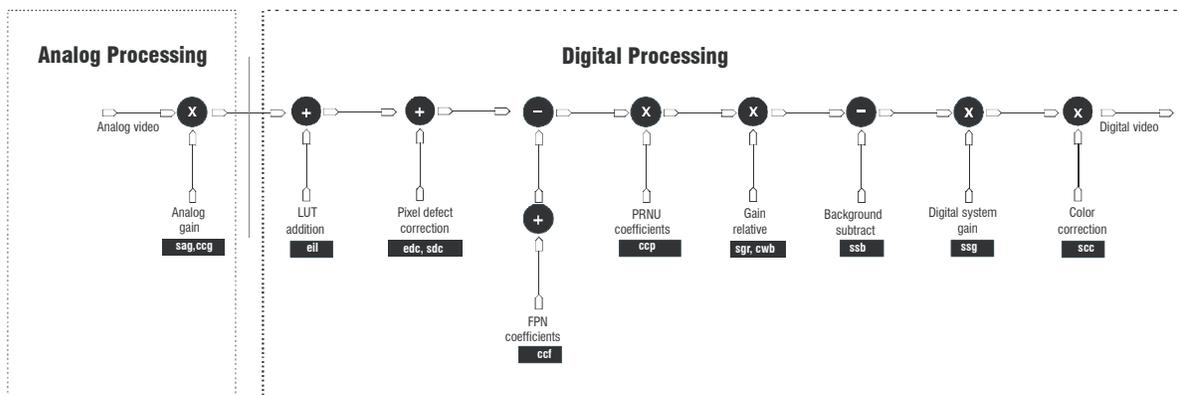
Processing Chain Overview and Description

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 19: 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.

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

Digital Processing

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

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

Photo-Response Non-Uniformity (PRNU) coefficients (calculated using the [cpa](#) command) 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.

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 DN.

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:

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

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	=	background subtract value

Subtract

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:

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

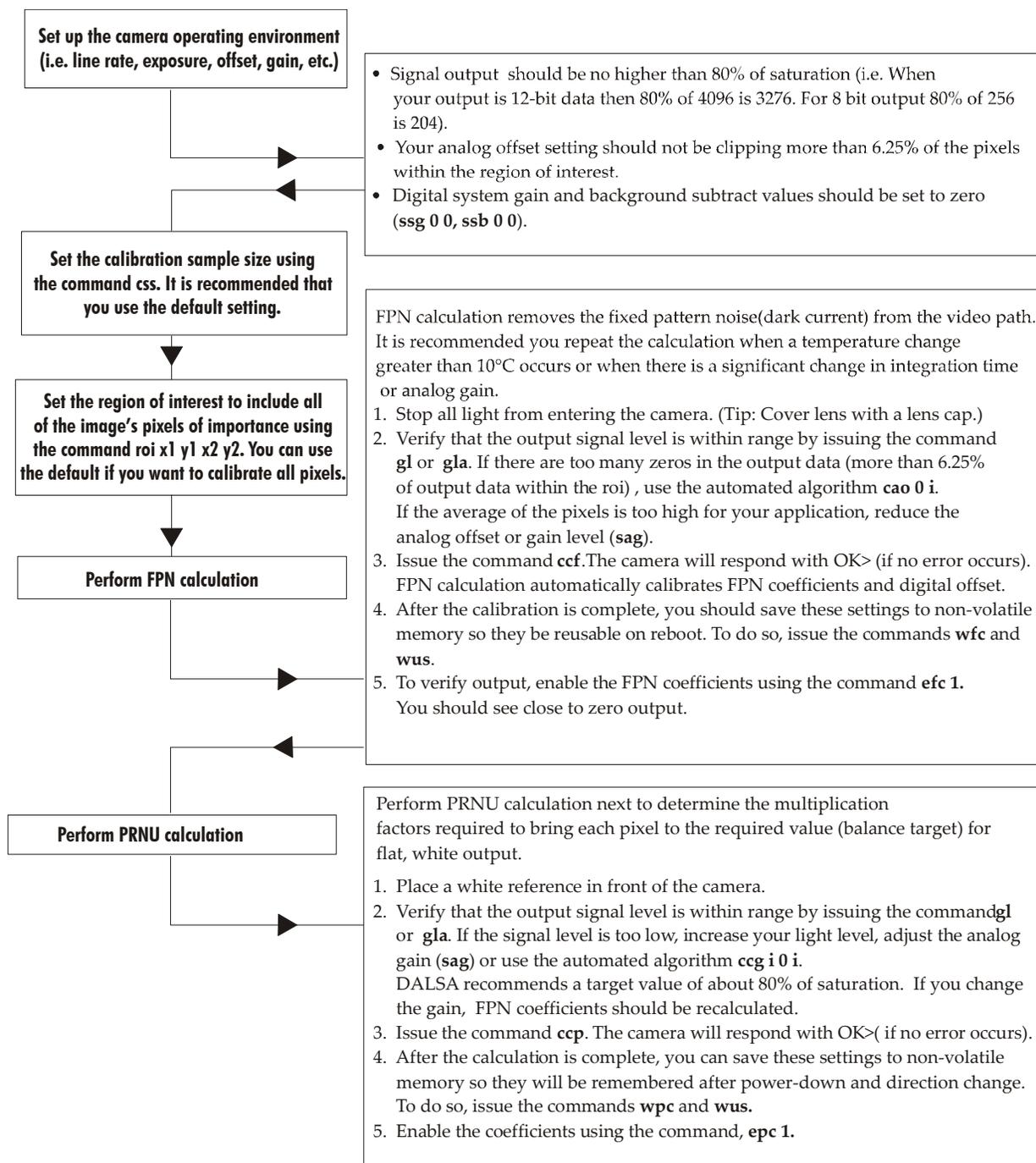
The camera is capable of operating under a range of 8 to 1, but will clip values larger than this ratio.

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.



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

Analog Signal Processing

Black Level Offset Algorithm: Inherent to the A/D is an offset that is added to the video in order to eliminate video clipping in dark (the offset is also affected by temperature). The Spyder3 Color Cameras have an automatic subtraction of this offset, which is called the Black Level Offset Algorithm. This subtraction helps prevent any unwanted color shift. For example, if the offset is 15 DN in 12-bit multiplying by max gain (20 dB) will give 300 DN (12-bit) offset in the final value. With Black Level Offset digital gain only affects the color signal and not the underlining analog offset. The sole job of the Black Level Offset Algorithm is to keep the offset around 0 DN regardless of analog offset setting or the change in dark current (temperature). 0 DN offset is desirable because you do not want your color gains changing your offsets for each color.

Digital Signal Processing

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

FPN Correction

Performing FPN Correction

Syntax:	Performs FPN correction and eliminates FPN noise by removing individual pixel dark current.
Syntax:	ccf
Notes:	<ul style="list-style-type: none"> • Perform all analog and digital adjustments before performing FPN correction. • Perform FPN correction before PRNU correction. • Refer to page 36 for a procedural overview on performing flat field correction. To save FPN coefficients after calibration, use the wfc command. Refer to section 3.10 Saving and Restoring PRNU and FPN Coefficients for details.
Related Commands:	wfc
Example:	ccf

PRNU Correction

Performing PRNU to a user entered value

Purpose:	Performs PRNU calibration to user entered value and eliminates the difference in responsivity between the most and least sensitive pixel, creating a uniform response to light. Using this command, you must provide a calibration target. Executing these algorithms causes the ssb command to be set to 0 (no background subtraction) and the ssg command to 4096 (unity digital gain). The pixel coefficients are disabled (epc 0 0) during the algorithm execution but returned to the state they were in prior to command execution.
Syntax:	cpa i i
Syntax Elements:	i

PRNU calibration algorithm to use:

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

$$\text{PRNU Coefficient}_i = \frac{\text{Target}}{(\text{AVG Pixel Value}_i)}$$

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.

i

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

- Notes:
- Perform all analog adjustments before calibrating PRNU.
 - Calibrate FPN before calibrating PRNU. If you are not performing FPN calibration then issue the rpc (reset pixel coefficients) command.

Example: **cpa 1 600**

Subtracting Background

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

Syntax: **ssb i**

Syntax Elements: **i**

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

- Notes:
- When subtracting a digital value from the digital video signal the output can no longer reach its maximum. Use the **ssg** command to correct for this where:

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

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

Related Commands: **ssg**

Example **ssb 25**

Setting Digital System Gain

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

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

Syntax: **ssg i**

Syntax Elements: **i**

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

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

Use this command in conjunction with the **ssb** command.

Related Commands: **ssb**

Example: **ssg 15**

Returning Calibration Results and Errors

Returning All Pixel Coefficients

- Purpose:** Returns all the current pixel coefficients in the order FPN, PRNU, FPN, PRNU... for the range specified by **spx** and **spw**. The camera also returns the pixel number with every fifth coefficient.
- Syntax:** `dpc`
- Notes:** This function returns all the current pixel coefficients in the order FPN, PRNU, FPN, PRNU... The camera also returns the pixel number with each coefficient.

Enabling and Disabling Pixel Coefficients

Enable FPN coefficients

- Purpose:** Enables and disables FPN coefficients.
- Syntax:** `efc i`
- Syntax Elements:** `i`
- FPN coefficients.
 - 0 = FPN coefficients disabled
 - 1 = FPN coefficients enabled
- Example:** `efc 1`

Enable PRNU coefficients

- Purpose:** Enables and disables PRNU coefficients.
- Syntax:** `epc i`
- Syntax Elements:** `i`
- PRNU coefficients.
 - 0 = PRNU coefficients disabled
 - 1 = PRNU coefficients enabled
- Example:** `epc 0`

3.8 End-of-line Sequence

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

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

Syntax: `els i`

Syntax Elements:

- `i`
- `0` Disable end-of-line sequence
- `3` LVAL extended by 16 (stat) pixels
- `7` LVAL shifted by 16 pixels to encompass stat pixels

Notes: LVAL is 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)	
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

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

Setting a Lower Threshold

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

3.9 Saving and Restoring Settings

For each camera operating mode 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.

Factory Settings

On first initialization, the camera operates using the factory settings. You can restore the original factory settings at any time by setting the user set number to the factory setting (`sus 0`) and then loading the user set (`lus`).

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`.

Current Session Settings

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

3.10 Saving and Restoring PRNU and FPN Coefficients

Saving the Current PRNU Coefficients

Purpose: Saves the current PRNU coefficients set using the **sfs** command.
Syntax: **wpc**
Related command: **sfs**

Saving the Current FPN Coefficients

Purpose: Saves the current FPN coefficients set using the **sfs** command.
Syntax: **wfc**
Related command: **sfs**

Loading a Saved Set of Coefficients

Purpose: Loads a saved set of pixel coefficients.
Syntax: **lpc**
Related commands: **wpc, wfc, sfs**

Resetting the Current Pixel Coefficients

Purpose: Resets the current pixel coefficients to zero. This command does not reset saved coefficients.
Syntax: **rpc**
Notes: The black level offset is not reset.

Rebooting the Camera

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

3.11 Saving and Restoring User Settings Using X-Modem

Use the X-modem feature to save user settings and FPN/ PRNU coefficients to a host PC, and vice-versa.

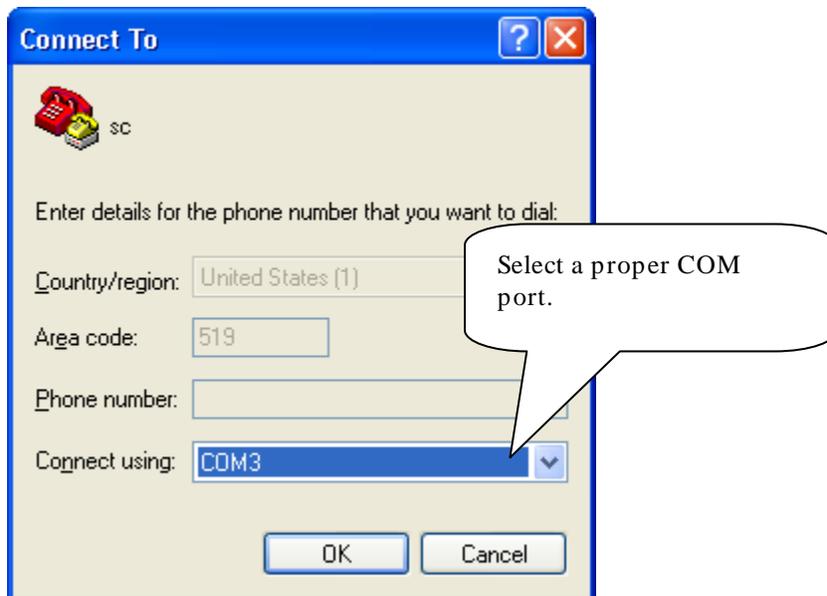
1. HyperTerminal settings

HyperTerminal supports the X-modem communications protocol that is used to upload and download the files. HyperTerminal is the recommended application to use.

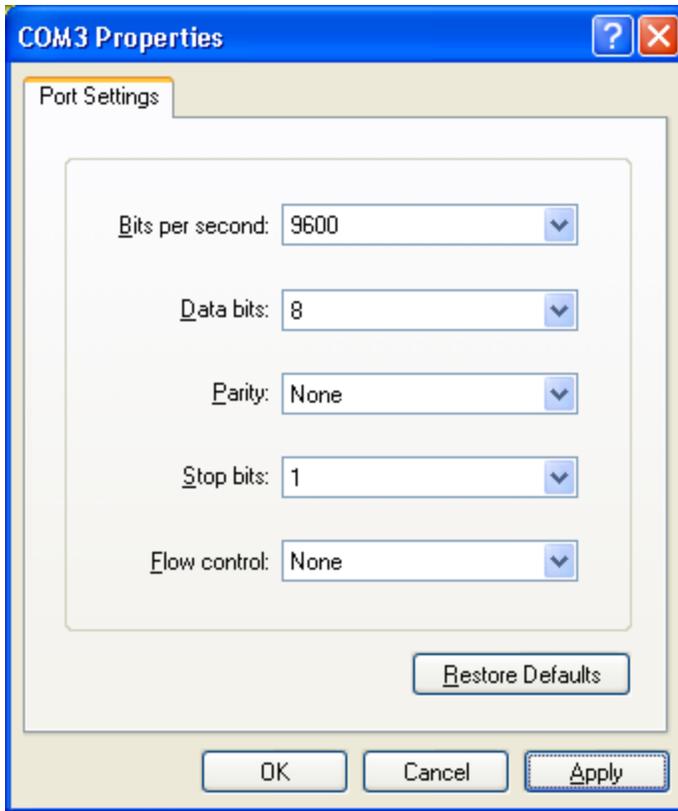
Open HyperTerminal by clicking:

Start→**All Programs**→**Accessories**→**Communications**→**HyperTerminal**.

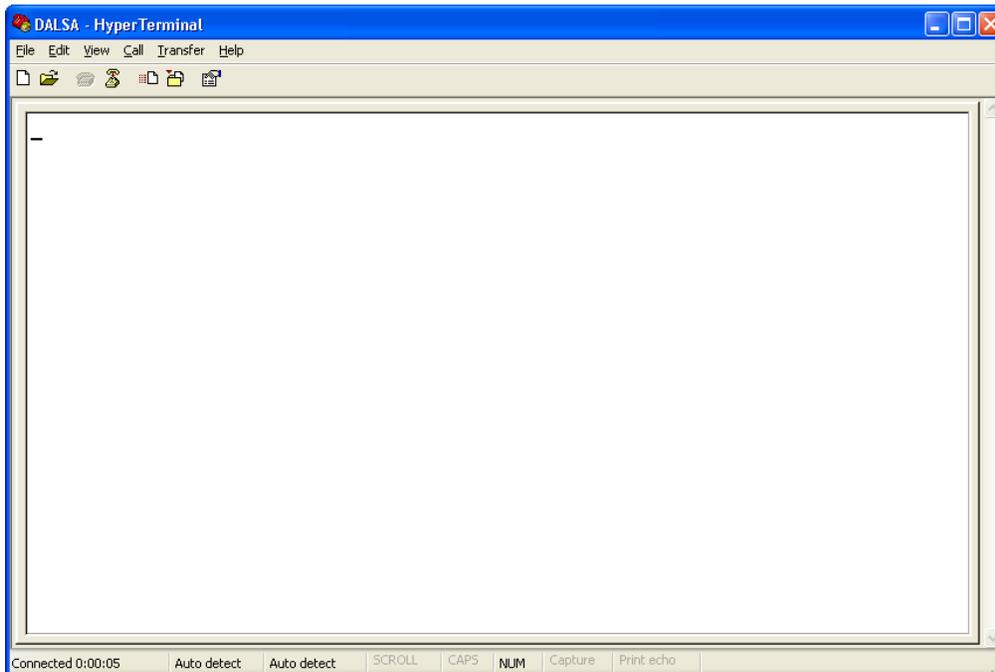
Give your HyperTerminal application a name and click OK. The Connect To dialog box appears.



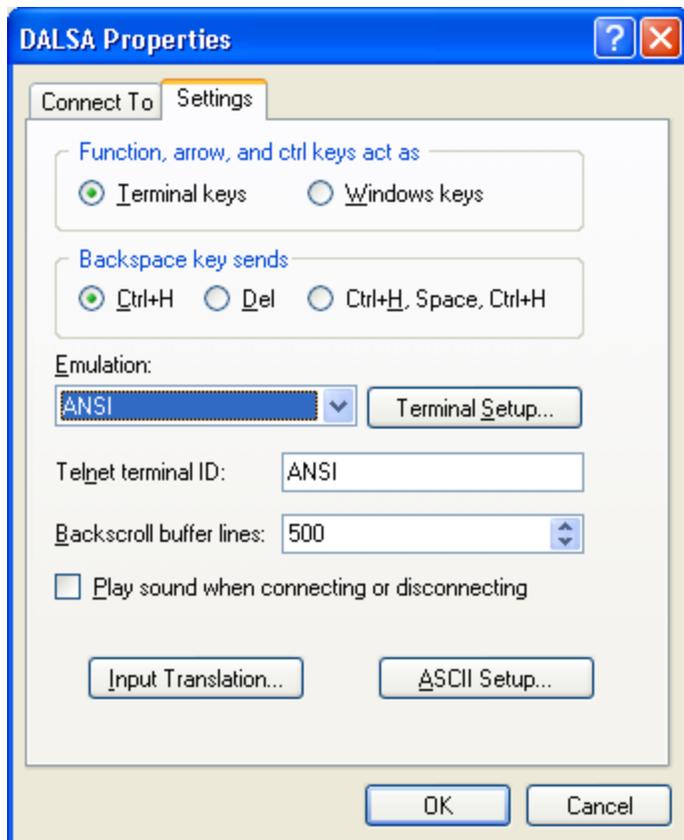
Select a proper COM port and click OK. A COM Properties dialog box appears.



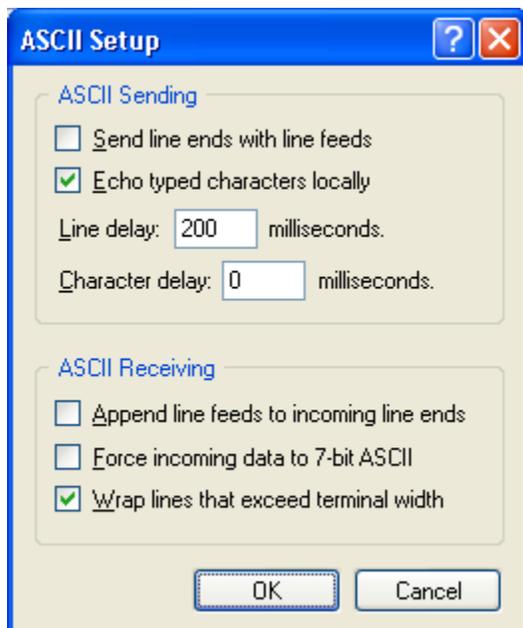
Select each item as shown in the figure above, click Apply, and then OK. The HyperTerminal main dialog box appears.



Select **File** → **Properties**, or click on the Properties icon and select the **Settings** tab.



Select each item as shown in the figure above, and click the **ASCII Setup...** button.



Set each item as shown in above figure and click OK. Click OK again in the Properties dialog box.

2. Transfer User Settings

2-1 Save Settings

OK > sus 99

OK > lus

X-Modem Transfer to Host. Camera is ready for sending...

Click **Receive file...** in the Transfer menu to save a settings.



Make sure to select the Xmodem.

Note that the sus 99 and sfs 99 commands are only communicating to the load commands (lpc and lus) to use the X-Modem transfer. The contents to be transferred are whatever is in the current camera memory (lus) or whatever is transferred to the current camera memory (wus).

For example, if you want to send setting 5 to the host, you communicate: "sus 5", "lus" (these 2 commands load set 5 to memory), and then "sus 99", "lus" (these 2 commands send current set (5) to host). Similarly, if you want to load a settings from a host to set number 5, you communicate: "sus 99", "wus" (these 2 commands load a settings to current camera memory), and then "sus 5", "wus" (these to commands transfer settings in current memory to set number (5)).

The same theory is applied to saving and restoring FPN and PRNU coefficients.

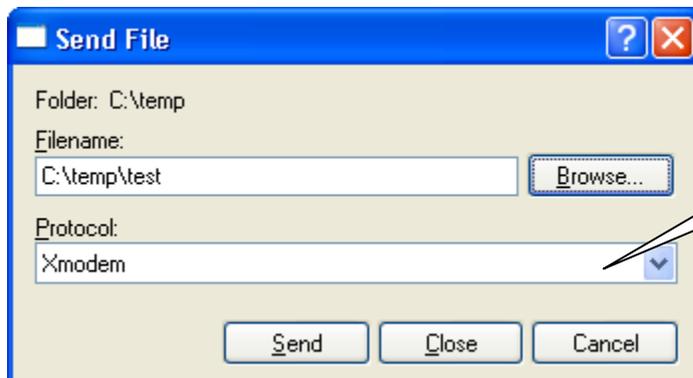
2-2 Restore Settings

OK > sus 99

OK > wus

X-Modem Transfer from Host.

Click **Send file...** in the Transfer menu to load a settings.



Make sure to select the Xmodem

3. Transfer FPN & PRNU Coefficients

3-1 Save FPN & PRNU Coefficients

OK> sfs 99

OK > lpc

X-Modem Transfer to Host. Camera is ready for sending...

Click **Receive file...** in the Transfer menu to save a settings.

3-2 Restore FPN & PRNU Coefficients

OK > sfs 99

OK > wpc

X-Modem Transfer from Host.

Click **Send file...** in the Transfer menu to load a settings.

OK>

3.12 Test Patterns

Generating a Test Pattern

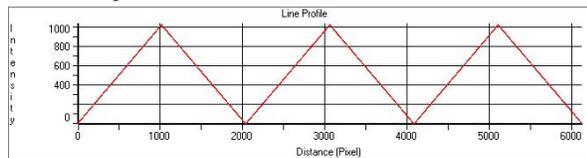
Purpose: Generates a test pattern to aid in system debugging. The test patterns are useful for verifying camera timing and connections. The following tables show each available test pattern.

Syntax: **svm i**

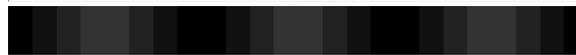
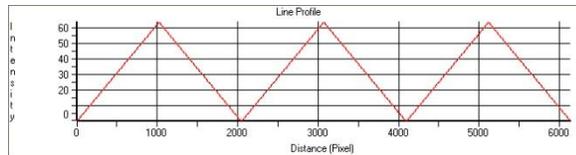
Syntax Elements: **i**

svm **0** Video. Raw .

svm **1** 12-bit test pattern.



svm **1** 8-bit test pattern

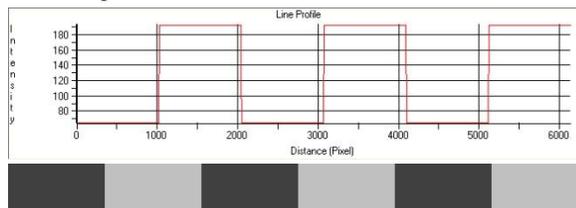
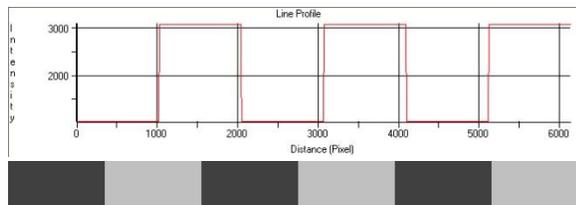


svm **2** 12-bit test pattern

svm

2

8-bit test pattern



Related Commands

sm
m

Use the set mirror mode (smm) command to establish the direction of the pixel readout.

3.13 Returning Video Information

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

Returning a Single Line of Video

Purpose: Returns a complete line of video (without pixel coefficients applied) displaying one pixel value after another. After pixel values have been displayed it also displays the minimum, maximum, and mean value of the line sampled within the region of interest (the region of interest command is explained in section Setting a Region of Interest (ROI)).

Use the **g1** command, or the following **g1a** command, to ensure the proper video input range into the processing chain before executing any pixel calibration commands.

Syntax: **g1**

Notes:

- Range defined using the **spx** and **spw** commands.
- Default settings: **spx 1** and **spw 2**.
- Values returned are in 12-bit DN.

Related Commands **spw**, **spx**

Example: **g1**

Returning Averaged Lines of Video

Setting the Number of Lines to Sample

Purpose: Sets the number of lines to sample when using the **g1a** command or when performing FPN and PRNU calibration.

Syntax: **css m**

Syntax Elements: **m**

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

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

Related Commands: `gla, ccf, cpa`

Example: `css 1024`

Returning the Average of Multiple Lines of Video

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

Syntax: `gla`

Notes:

- Range defined using the `spx` and `spw` commands.
- Analog gain, analog offset, digital offset, background subtract, and digital system gain are applied to the data. FPN and PRNU coefficients are not included in the data.
- Values returned are in 12 bit DN.

Related Commands: `spw, spx`

Example: `gla`

3.14 Temperature Measurement

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

Note: If the camera reaches 75°C, the camera will 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.

3.15 Voltage Measurement

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

3.16 Camera Frequency Measurement

Purpose: Returns the frequency for the requested Camera Link control signal

Syntax: `gsf i`

Syntax Elements: `i`

Camera Link control signal to measure:

1: CC1 (EXSYNC)

2: CC2 (PRIN)

3: CC3 (CCD Direction)

Note:

- Camera operation may be impacted when entering the `gsf` command (i.e., poor time response to direction change or video may have artifacts (gain changes) for several lines while the camera returns signal information)

- This command is not available when operating the camera with external CCD direction control (scd 2).

Example: `gsf 1`

3.17 Returning the LED Status

Purpose: Returns the status of the camera's LED.

Syntax: `gs1`

The camera returns one of the following values:

1 = red (loss of functionality)

2 = green (camera is operating correctly)

5 = flashing green (camera is performing a function)

6 = flashing red (fatal error)

Notes: Refer to section

2.2 Camera LED for more information on the camera LED

3.18 Returning Camera Settings

Returning All Camera Settings with the Camera Parameter Screen

The camera parameter (gcp) screen returns all of the camera's current settings. The table below lists all of the gcp screen settings.

To read all current camera settings, use the command: gcp

GCP Screen		
GENERAL CAMERA SETTINGS		
Camera Model No.:	SC-34-0xK80-00-R	Camera model number
Camera Serial No.:	xxxxxxx	Camera serial number
Firmware Version:	xx-xxx-xxxx-xx	Firmware design revision number
CCI Version:	xx-xxx-xxxx-xx	CCI version number
FPGA Version:	xx-xxx-xxxx-xx	FPGA revision number
Set Number:	1	Last user set loaded, set with sus command
UART Baud Rate:	9600	Serial communication connection speed set with the sbr command
Camera Link Mode:	clm:2 (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
Exposure Mode:	7	Current exposure mode value set with the sem command
SYNC Frequency:	1600.00 Hz	Current line rate. Value is set with the ssf command
Exposure Time:	200.00 uSec	Current exposure time setting. Value is set with the set command
CCD Direction:	internal/ forward	Current direction setting set with scd command

Video Mode:	video	Current video mode value set with the svm command
Region Of Interest X:	1	The starting horizontal position of Region Of Interest. Set with srx command
Region Of Interest Width:	2048 or 4096	Width of Region Of Interest in pixel. Set with srw command
End-Of-Line Sequence:	off	States whether an end of line sequence is turned on or off. Set using the els command
FFC Coefficient Set:	1	Current pixel coefficient set loaded, set with sfs command
FPN Coefficients:	on	States whether FPN coefficients are on or off. Set with the epc command
PRNU Coefficients:	on	States whether PRNU coefficients are on or off. Set with the epc command.
Input LUT:	off	States whether LUT correction is on or off. Set with eil command
Input LUT Coefficients Set:	0	Current LUT coefficient set loaded
Number Of Line Samples:	1024	Number of lines samples set with the css command
Upper Threshold:	3600	Upper threshold value set with the sut command
Lower Threshold:	400	Lower threshold value set with the slt command
Current Tap:	0	Current tap, set with sct command
Colour:	RGB	Current color, set with scl command
Current Light:	unadjusted	Current light source, set with sls command
Color Gain(dB):	Red 7.36 7.48	Current color gain, set with scl, sct, scg commands
	Green 17.23 17.37	
	Blue 18.56 21.19	
Color Reference(dB):	Red 0.00 0.00	Current color reference level, update with ucr command
	Green 0.00 0.00	
	Blue 0.00 0.00	
Total Color Gain(dB):	Red 7.36 7.48	Total color gain in DB, read only value
	Green 17.23 17.37	
	Blue 18.56 21.19	
Total Color Gain(DN):	Red 9563 9689	Total color gain in DN, read only value
	Green 29778 30276	
	Blue 34704 46988	
Color Correction:	O r g b	Color correction matrix, set with scx, sey and scc commands.
	r 0 4096 0 0	
	g 0 0 4096 0	
	b 0 0 0 4096	
	y 0 0 0 0	
Black Level Offset:	12 11	Current amount of black level correction
Background Subtract:	0	Background subtract settings set with the ssb command
System Gain (DN):	4096	Digital gain settings set with the ssg command

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 get commands, use the command **gh**.

3.19 ASCII Commands: Reference

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

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

Table 15: Command Quick Reference

Mnemonic	Syntax	Parameters	Description
Help, single command	?	s	Returns help on a single command
correction calibrate fpn	ccf		Performs FPN calibration and eliminates FPN noise by subtracting away individual pixel dark current
Camera Link mode	clm	i	Sets the camera’s bit width where: 0 = GREEN, 8 bits, 1 tap, monochrome 1 = GREEN, 12 bits, 1 tap, monochrome 2 = Mono, 8 bits, 2 taps 3 = Mono, 12 bits, 2 taps 5 = RGB, 8 bit, 3 taps 6 = RGB, 12 bits, 3 taps 9 = RGBY, 8 bits, 4 taps 10 = RGBY, 12 bits, 4 taps
calculate PRNU algorithm	cpa	i i	Performs PRNU calibration according to the selected algorithm. The parameter is the target value to use in a range from 1024 to 4055 DN. $\text{PRNU Coefficient}_i = \frac{\text{Target}}{(\text{AVG Pixel Value}_i)}$ 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.
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
calibrate white balancing	cwb	i	Adjust color digital gain to make the color output to the given value while imaging a white reference
display pixel coeffs	dpc		Displays the pixel coefficients in the order FPN, PRNU, FPN, PRNU, ...

Mnemonic	Syntax	Parameters	Description
enable FPN coeffs	efc	i	Sets whether FNU coefficients are enabled or disabled. Where i is: 0 = FPN coefficients disabled 1 = FPN coefficients enabled
enable input LUT	eil	i	Enable input LUT, where: 0 : Off 1 : On
enable 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 3 : LVAL extended by 16 (stat) pixels 7 : LVAL shifted by 16 pixels to encompass stat pixels
enable noise filter coefficients	enc	i	0 – 1. Enables FIR filter in the output. The first two pixels are not filtered.
enable PRNU coefficients	epc	i	Sets whether PRNU coefficients are enabled or disabled. Where i is: 0 = PRNU coefficients disabled 1 = PRNU coefficients enabled
enable watchdog	ewd	i	0 – 1. The watchdog subtracts excessive dark current at line rates below 10 Hz.
get command log	gcl		Returns list of commands sent.
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 value	get	s	Returns the value of the parameter specified.
get help	gh		Returns all of the available “get” commands.
get line	gl		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.
get line average	gla		Read the average of line samples.
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.

Mnemonic	Syntax	Parameters	Description
load pixel coefficients	lpc		Loads the previously saved pixel coefficients from non-volatile memory
Load user settings	lus		Load the settings saved using the lus command at set specified in sus command
reset camera	rc		Resets the entire camera (reboot). Baud rate is not reset and reboots with the value last used.
reset pixel coeffs	rpc		Resets the pixel coefficients to 0.
set baud rate	sbr	i	Set the speed of camera serial communication port. Baud rates: 9600, 19200, 57600, and 115200 . Default: 9600.
set color correction	scc	i	Set the values in the color matrix that is multiplied at the end of the digital processing.
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 color gain	scg	i	Set color gain for current color in a range of 0 to 65535 . The current color is set from scl command.
set color selector	scl	m	Selects color for gain application. Used prior to the scg command
Set current tap	set	t	Selects tap for color gain application. Used prior to the scg command.
set color correction matrix X index	scx	m	Set current color correction x index in a range of o/r/g/b .
set color correction matrix Y index	scy	m	Set current color correction y index in a range of r/g/b/y .
Set exposure control	sec	m	This command combined with the slm command is equivalent to the sem command. Set exposure control mode. If input is t , this mode uses the value set by the “set” command for the exposure time If input is w , this mode uses the width of the line trigger pulse. If the user tries to set this mode while “ slm ” is set to internal, then they will receive an error: not available in this mode. If the user sets the “ slm ” to internal while the “ sec ” value is set to width. The camera will return a warning message and change the exposure control to maximum. If input I is m . The camera uses the maximum possible exposure time for the given line rate.

Mnemonic	Syntax	Parameters	Description
set exposure mode	sem	m	Sets the exposure mode: 2 = Internal SYNC, internal PRIN, programmable line rate and exposure time using commands ssf and set 3 = External SYNC, internal PRIN, maximum exposure time 4 = Smart EXSYNC 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 FFC set number	sfs	i	Set to load/ save using the lpc , wpc , wfc commands.
set line mode	slm	m	Set the line trigger mode as either external or internal: e —external line trigger i —internal line trigger.
set light source	sls	i	Set current light source in a range of 0 to 5 .
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	Set tap readout direction: left to right, or right to left
set pixel window width	spw	i	Set horizontal width used in gl , gla , dpc commands.
set pixel X position	spx	i	Set horizontal starting position used in gl , gla , dpc commands.
set readout mode	srn	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.
set ROI width	srw	i	Specify the width of the ROI.
set ROI X	srx	i	Specify the starting X position of the ROI.
set subtract background	ssb	i	Subtract the input value from the output signal. 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 18000 Hz (2k model). Value rounded up/ down as required.
set system gain	ssg	i	Set the digital gain. i = Digital gain in a range from 0 to 65535 . The digital video values are multiplied by this number.
set user set number	sus	i	
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 .

Mnemonic	Syntax	Parameters	Description
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 color reference	ucr		Set the color reference value to the current color gain value.
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		Write all current FPN coefficients to non-volatile memory.
write PRNU coeffs	wpc		Write all current PRNU coefficients to non-volatile memory.
write user settings	wus		Write all of the user settings to non-volatile memory.

3.20 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 0 to +20 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>	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>	Unsupported number of parameters entered.

Message	Description
Error 04: Incorrect parameter value>	This response returned for <ul style="list-style-type: none"> · 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.

Clearing Dark Current

Gate Dark Current Clear

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.

Auto Mode (srm 0)

Note: Teledyne DALSA recommends Auto mode for most users. In this mode camera will automatically start and stop dark current clear based on the line rate.

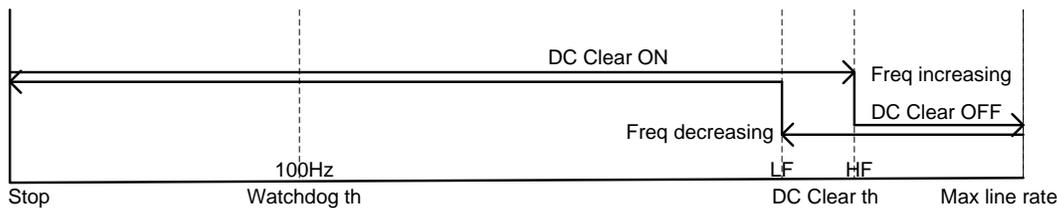


Figure 20: Gate Dark Current Clear in the Auto Mode.

To avoid corrupted lines due to jitter in External Trigger mode, the dark current clear switchover is controlled by hysteresis thresholds. Thresholds (LF and HF) are set to higher frequencies, below $\frac{1}{2}$ of the maximum line rate, so that switchover will be transparent in an image.

However, if the external trigger frequency jumps back and forth over both thresholds in three consecutive lines, a corrupted line will occur.

Threshold frequencies for each model are outlined in the tables below.

Auto Mode	Transition Frequencies (kHz)		
Model	LF	HF	Maximum Line Rate
SC-34-02K80-00-R	7433	8993	18000
SC-34-04K80-00-R	4000	4400	9000

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.

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

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

The watchdog will start DC clear at frequencies = or < 10 Hz, where dark current is significant.

A small DN step will be visible in the image where the watchdog turns on and off.

The watchdog operates on the single threshold. If sync frequency is not in the sharp transition watchdog may cause corrupted lines crossing the threshold.

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 1/2 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 17.

Model	Max. Line Rate	
	Immediate Readout Mode	Dark Current Clear Mode
SC-34-02K80	18000 Hz	9000 Hz
SC-34-04K80	9000 Hz	4500 Hz

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 18.

Model	Exposure Delay and Max Exposure Time in Auto Mode
SC-34-02K80	55.5 μs
SC-34-04K80	111 μs

Setting the Readout Mode

Use this command to control dark current in the vertical transfer gates.

Camera Link Command

Parameter	Description	Notes
srm	0: Auto. Clears dark current below ~ 30-45% of the maximum line rate. 1: Dark current clear. Always clears	<ul style="list-style-type: none"> The vertical transfer gates collect dark current during the line period. This collected current is added to the pixel charge.

	<p>dark. Reduces the maximum line rate.</p> <p>2: Immediate readout. Does not clear dark current.</p>	<ul style="list-style-type: none"> • 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. <p>This value may be viewed using either the gcp command or the get srm command.</p> <p>Readout Mode defaults srm 0, SC-34-02K80-00-R model srm 2, SC-34-04K80-00-R model</p>
Example		
srm 0		

Appendix A

Camera Link™ Reference, Timing, and Configuration Table

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

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

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

LVDS Technical Description

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

Camera Signal Requirements

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

Video Data

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

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

All four enable signals must be provided by the camera on each Channel Link chip. All unused data bits must be tied to a known value by the camera. For more information on image data bit allocations, refer to the official Camera Link specification located at [http:// mv.dalsa.com](http://mv.dalsa.com).

Camera Control Signals

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

- Camera Control 1 (CC1)
- Camera Control 2 (CC2)
- Camera Control 3 (CC3)

The camera uses the following control signals:

Table 19: DALSA Camera Control Configuration

CC1	EXSYNC, negative edge active
CC2	PRIN
CC3	Direction

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 Mode	T0			T1 (Note: Entries imply double frequency pixel rate data transmission)		
	PORT A Bits 0 thru 7	PORT B Bits 0 thru 7	PORT C Bits 0 thru 7	PORT A Bits 0 thru 7	PORT B Bits 0 thru 7	PORT C Bits 0 thru 7
Mode 0, 1	G	G				
1 Tap n bit Where Mode 0 = 8 bit	LSB....Bit 7	Bit 8....MSB xxxx	xxxxxxx x= don't care	N/A	N/A	N/A

Mode 1 = 12 bit			for unused bits			
Mode 2						
2 Tap 8 bit	RBRBRB... LSB..Bit 7	GGGGGG... LSB..Bit 7	xxxxxxx	N/A	N/A	N/A
Mode 3						
2 Tap n bit Where n= 12	RBRB... LSB.. Bit 7	RBRB... Bits 8,9,10,11, G Bits 8,9,10,11	G LSB..Bit 7	N/A	N/A	N/A
Mode 5						
RGB 8 bit	R LSB...Bit 7	G LSB...Bit 7	B LSB...Bit 7	N/A	N/A	N/A
Mode 6						
RGB 12 bit	R LSB.. Bit 7	R Bits 8,9,10,11, B Bits 8,9,10,11	B LSB...Bit 7	G LSB... Bit 7	G Bits 8,9,10,11 xxxx	xxxxxxx
Mode 9						
Color RGBY 8 bit	R LSB..Bit 7	B LSB..Bit 7	xxxxxxx	G LSB..Bit 7	Y LSB..Bit 7	xxxxxxx
Mode 10						
Color RGBY 12 bit	R LSB..Bit 7	R Bits 8, 9,10, 11 B Bits 8, 9,10, 11	B LSB..Bit 7	G LSB...Bit 7	G Bits 8, 9,10, 11 Y Bits 8, 9,10, 11	Y LSB..Bit 7

Table 20:Camera Lnk Bit Definitions

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 Web site and view the DALSA Camera Link Implementation Road Map document for further details (<http://www.dalsa.com/mv/knowledge/appnotes.aspx>).

Camera Interface Parameters

Table 21: Frame Grabber Interface Parameters

Item (when programmable configuration the options are separated with a)	SC-34-02k80	SC-34-04k80
Imager Dimension <1,2 or 1 2>	1	1
Imager Columns<number of active columns, X>	2048	4096
Imager Rows<number of active rows, Y> Line Scan/ TDI are defined as 1	1	1

Item (when programmable configuration the options are separated with a)	SC-34-02k80	SC-34-04k80
Number of CCD Taps <1,2,3.....>	2	2
Sensor Tap Clock Rate <xx MHz>	40	40
Camera Standard <NTSC, PAL, VS, VW, MW>	VS	VS
Variable Window <Column Start, Column End, Row Start, Row End>	(0,0,0,0) All zeros indicates an unsupported feature	(0,0,0,0) All zeros indicates an unsupported feature
Multiple Window Number of Windows (Column Start 1, Column End 1, Row Start 1, Row End 1) (Column Start 2, Column End 2,...)	0, (0,0,0,0) All zeros indicates an unsupported feature	0, (0,0,0,0) All zeros indicates an unsupported feature
Number of Camera Configurations<1,2,3,...>	2	2
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, 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) 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
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
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
Row Color Offset <0,1,2,3...>	0	0

Item (when programmable configuration the options are separated with a)	SC-34-02k80	SC-34-04k80
Column Color Offset <0,1,2,3...>	0	0
Row Binning Factor <1,2,3 or 1 2 3>	1	1
Column Binning Factor <1,2,3 or 1 2 3>	1 2	1 2
Pretrigger Pixels <0,1,2...or 0..15>	0	0
Pretrigger Lines <0,1,2.. or 0..15>	0	0
Frame Time Minimum <xx μs>	55.55	111.1
Frame Time Maximum <xx μs>	3333	3333
Internal Line/ Frame Time Resolution <xx ns> 0 if not applicable	25	25
Pixel Reset Pulse Minimum Width <xx ns> 0 if not applicable	3000	3000
Internal Pixel Reset Time Resolution <xx ns> 0 if not applicable	25	25
Pixel Reset to Exsync Hold time <xx ns>		
BAUD Rate <9600....>	9600, 19200, 57600, 115200	9600, 19200, 57600, 115200
CC1 <Exsync>	EXSYNC	EXSYNC
CC2 <PRIN>	PRIN	PRIN
CC3 <Forward, Reverse>	Forward/ Reverse	Forward/ Reverse
CC4 <Spare>	Spare	Spare
DVAL out <Strobe Valid, Alternate>	Strobe Valid	Strobe Valid
Spare out <Spare> (For future use)	Spare	Spare

Appendix B

EMC Declaration

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

Declare under sole responsibility that the cameras:

Brand Name: Spyder3 CL

Models: SC-34-04K80-00-R and SC-34-02k80-00-R

The CE Mark, FCC Part 15, and Industry Canada ICES-003, CISPR 22 and CISPR 11, evaluation of the Teledyne DALSA Spyder3 CL cameras, which are manufactured by Teledyne DALSA Inc., satisfied the following requirements:

EN 55022 Class A (2006), EN 55011 Class A (2003) and EN 61326-1 (2006) Emissions Requirements
EN 55024 (1998) and EN 61326-1 (2006) Immunity to Disturbances

Place of issue: Waterloo, Ontario, Canada

Date of Issue: June 29, 2009

Hank Helmond
Director of Quality, TELEDYNE DALSA Corp.



Appendix C

Troubleshooting

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

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

LED

When the camera is first powered up, the LED will glow on the back of the camera. Refer to section 2.4 for information on the LED.

Connections

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

For information, refer to the section detailing the camera connections: [Step 2. Connect Power and Camera Link Cables](#).

Equipment Requirements

Ensure that you are using compatible equipment. For example, in order 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.

Power Supply Voltages

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

EXSYNC

When the camera is received from the factory, it defaults (no external input required) to exposure mode 7 (1600 Hz line rate, internal Sync to trigger readout). After a user has saved settings the camera powers up with those saved settings.

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

Camera Operation and Test Patterns

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

Communications

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

Verify Parameters

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

Verify Timing and Digital Video Path

Use the test pattern feature to verify the proper timing and connections between the camera and the frame grabber and verify the proper output along the digital processing chain. See below.

Generating Test Patterns

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

- **No test pattern or bad test pattern**— May indicate a problem with the camera (e.g. missing bit) or a system setup problem (e.g. frame grabber or timing). Verify the presence of the LVAL and STROBE signals.
- **Test pattern successful**— Run the **svm 0** command to activate video. Then run the **gl** command under both dark and light conditions to retrieve a line of raw video (no digital processing). Under dark conditions, with factory settings, the analog offset value should be within the specified range (refer to the user specifications).

Verify Voltage

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

Verify Temperature

To check the internal temperature of the camera, use the **vt** command. For proper operation, this value should not exceed 65 °C, measured at the front camera plate.

Note: If the camera reaches 65 °C, the camera **will shutdown and the LED will flash red**. If this occurs, the camera **must be rebooted** using the command, [rc](#) or can be powered down manually. You will have to correct the temperature problem or the camera will shut down again. If you enter any command other than **vt** or **rc**, the camera responds with:

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

Verify Pixel Coefficients

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

End-of-line Sequence

To further aid debugging, the camera can generate an end-of-line sequence. The end-of-line-sequence outputs "aa", "55", "line counter", "line average", "pixels above threshold", "pixels below threshold". To activate the end-of-line sequence, use the commands `els 3 (LVAL extended by 16 (stat) pixels)` or `els 7 (LVAL shifted by 16 pixels to encompass stat pixels)`. To disable the end-of-line sequence, use the command `els 0`.

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

Specific Solutions

No Output or Erratic Behavior

If your camera provides no output or behaves erratically, it may be picking up random noise from long cables acting as antennae. Do not attach wires to unused pins. Verify that the camera is not receiving spurious inputs (e.g. EXSYNC if camera is in exposure mode that requires external signals).

Line Dropout, Bright Lines, or Incorrect Line Rate

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

Noisy Output

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

Dark Patches

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

1. Take standard ESD precautions.
2. Wear latex gloves or finger cots
3. Blow off dust using a filtered blow bottle or dry, filtered compressed air.
4. Fold a piece of optical lens cleaning tissue (approx. 3" x 5") to make a square pad that
5. is approximately one finger-width
6. Moisten the pad on one edge with 2-3 drops of clean solvent—either alcohol or acetone. Do not saturate the entire pad with solvent.
7. Wipe across the length of the window in one direction with the moistened end first, followed by the rest of the pad. The dry part of the pad should follow the moistened end. The goal is to

prevent solvent from evaporating from the window surface, as this will end up leaving residue and streaking behind.

8. Repeat steps 2-4 using a clean tissue until the entire window has been cleaned.
9. Blow off any adhering fibers or particles using dry, filtered compressed air.

Horizontal Lines or Patterns in Image

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

Appendix D

Electrostatic Discharge and the CCD Sensor

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

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

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

Protecting Against Dust, Oil and Scratches

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

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

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

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

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

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

Cleaning the Sensor Window

1. Use compressed air to blow off loose particles. This step alone is usually sufficient to clean the sensor window.

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

Revision History

Rev	Change Description	Date
00	Preliminary release.	March 21, 2012
01	Revision to the Clearing Dark Current section. Revised EMC Declaration section.	May 31, 2013

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