Pantera SA 4M15

DS-21-04M15

DS-22-04M15

2048 x 2048 Stop Action CCD Camera

DALSA
technology with vision

22-Feb-05
03-32-10062-02
www.dalsa.com

About DALSA

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

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

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

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

DALSA Sales Offices

Waterloo	Europe	Asia Pacific
605 McMurray Rd	Breslauer Str. 34	Space G1 Building, 4F
Waterloo, ON	D-82194 Gröbenzell	2-40-2 Ikebukuro
N2V 2E9	(Munich)	Toshima-ku, Tokyo 171-0014
Canada	Germany	Japan
Tel: 1- 519-886-6000	Tel: +49-8142-46770	+81-3-5960-6353 (phone)
Fax: 1-519-886-8023	Fax: +49-8142-467746	+81-3-5960-6354 (fax)
www.dalsa.com	www.dalsa.com	www.dalsa.com
sales@dalsa.com	europe@dalsa.com	asia@dalsa.com

DALSA Worldwide Operations

Waterloo	Colorado Springs	Europe	Asia Pacific
605 McMurray Rd	4820 Centennial Blvd., Suite 115	Breslauer Str. 34	Space G1 Building, 4F
Waterloo, ON	Colorado Springs, CO 80919	D-82194 Gröbenzell	2-40-2 Ikebukuro
N2V 2E9	USA	(Munich)	Toshima-ku, Tokyo 171-0014
Canada	Tel: 719 599 7700	Germany	Japan
Tel: 1-519-886-6000	Fax: 719 599 7775	Tel: +49-8142-46770	+81-3-5960-6353 (phone)
Fax: 1-519-886-8023	www.dalsa.com	Fax: +49-8142-467746	+81-3-5960-6354 (fax)
www.dalsa.com	sales.americas@dalsa.com	www.dalsa.com	www.dalsa.com
sales@dalsa.com		europe@dalsa.com	asia@dalsa.com

Contents

Introduction to the Pantera SA 4M15 Area Scan Camera 5

1.1 Camera Highlights 5
1.2 Image Sensors 6
1.3 Camera Performance Specifications 8

Camera Hardware Interface 13

2.1 Installation Overview 13
2.2 Input/Output Connectors and LED 14

Software Interface: How to Control the Camera 19

3.1 Communications Protocol Overview 19
3.2 Overview: Setting up the Camera to Send Commands 20
3.3 Startup 21
3.4 Saving and Restoring Settings 21
3.5 Setting Baud Rate 22
3.6 Selecting the Data Output Mode 22
3.7 Setting Frame Rate, Exposure Time, and Exposure Mode 22
3.8 Increasing Sensitivity with Binning (DS-21-04M15 Only) 29
3.9 Defining an Area of Interest (AOI) 30
3.10 Optimizing Offset Performance 33
3.11 Setting Gains 33
3.12 Generating Test Patterns 34
3.13 Monitoring Tasks 35
3.14 Rebooting the Camera 35
3.15 Setting the Pre-trigger 36
3.16 Setting the Video Mode 36

Optical, Mechanical, Thermal, and Handling Considerations 39

4.1 Mechanical Interface 39
4.2 Optical Interface 41

Troubleshooting 45

5.1 Common Solutions 45
5.2 Troubleshooting Using the Serial Interface 46
5.3 Specific Solutions 47
5.4 Product Support 49

Camera Link™ Reference, Timing, and Configuration Table ______ 51

Networking Mode, Error Handling and Command List ______ 57

B1 Networking Mode 57

B2 Error Handling 59

B3 Commands 61

Tap Matching Using Look up Tables (LUTs) ______ 67

C1 Using Factory Calibrated Look Up Tables 67

C2 Creating a Custom LUT 68

C2 Output LUTs 75

C3 All LUT Commands and Examples 75

EMC Declaration of Conformity ______ 81

Revision History ______ 83

Index ______ 85

1

Introduction to the Pantera SA 4M15 Area Scan Camera

1.1 Camera Highlights

Features

- 4-megapixel resolution: 2048 x 2048 pixels, 7.4µm x 7.4µm size
- Frame rates up to 16fps
- 2x40MHz data rate via Camera Link™ high speed serial interface
- Electronic, global non-rolling shutter for "Stop Action" imaging
- Single 12V to 25V power supply
- Binning
- Robust and compact design
- Color option (DS-22-04M15)

Programmability

- Simple ASCII protocol controls gain, offset, frame rates, trigger mode, test pattern output, and camera diagnostics
- Serial interface (ASCII, 9600 baud, adjustable to 19200, 57600, 115200), through Camera Link

Usability

- Programmable gains, offsets, output modes, look up tables and camera controls
- Single input supply (+12V to +25V)
- Compliant with CE

Description

The Pantera SA 4M15 is an exceptional area scan camera for electronics manufacturing inspection, robotics, industrial metrology, and traffic management. The camera uses a 4 megapixel interline transfer CCD capable of running at up to 16 frames per second (fps). It features electronic global shuttering for "Stop Action" (SA) imaging. These features allow for a large field of view, no smear effect, and high throughput.

Programmable features and diagnostics are accessible through the Camera Link™ MDR26 connector.

This camera's small body and robustness make it perfect for the wear and tear of industrial environments.

Applications

The Pantera SA 4M15 is ideal for applications requiring high speed, superior image quality, and high responsivity. Applications include:

- Electronics manufacturing inspection
- Robotics
- Industrial metrology
- Traffic management

Models

The Pantera SA 4M15 cameras are available in two models—monochrome or color.

Table 1: Pantera SA 2M30 Camera Models Overview

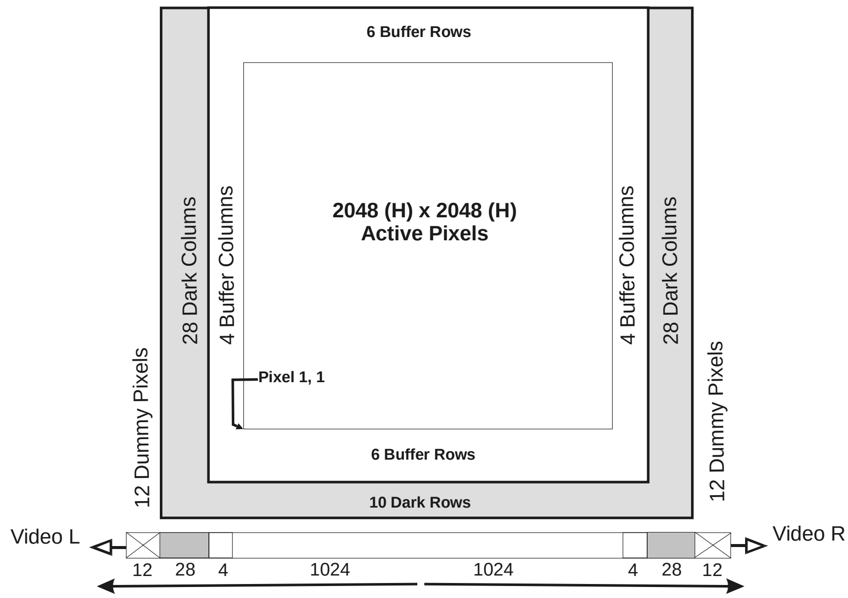
Model Number	Description
DS-21-04M15	Monochrome
DS-22-04M15	Color

1.2 Image Sensors

The Pantera SA 4M15 camera uses a high-performance, dual-output, megapixel interline transfer CCD with 7.4µm square pixels and microlenses.

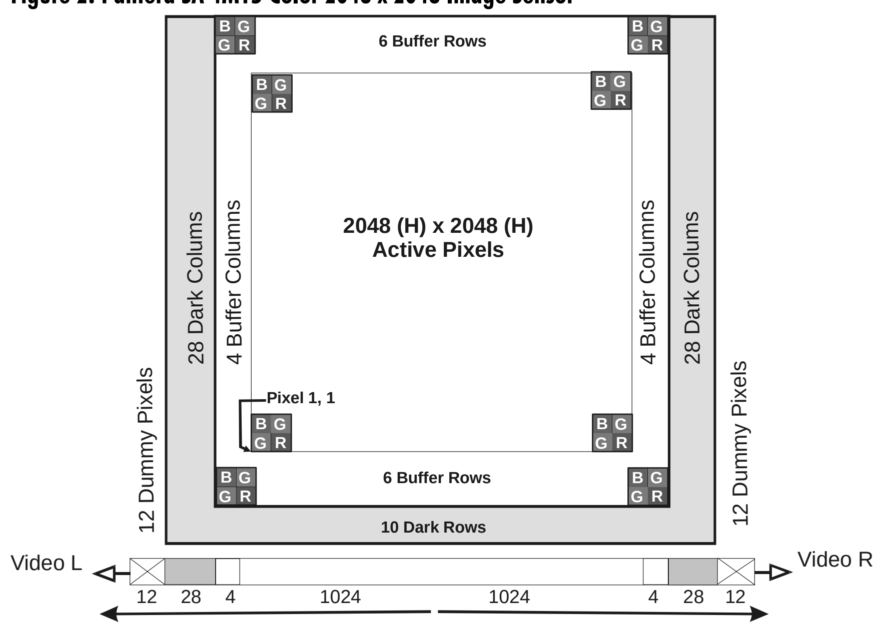
Pantera SA 4M15 Monochrome Sensor

Figure 1: Pantera SA 4M15 Monochrome 2048 x 2048 Image Sensor



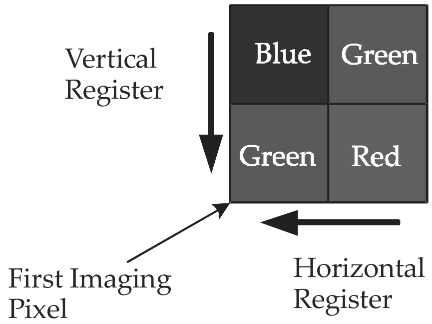
Pantera SA 4M15 Color Sensor

Figure 2: Pantera SA 4M15 Color 2048 x 2048 Image Sensor



Note: The Pantera SA 4M15 is designed to provide dual output only.

Figure 3: Color Filter Array Pattern (Bayer Pattern)



Sensor Characteristics

See Figure 1and Figure 2 for the sensor's layout, including empty, light-shielded, and buffer pixels

While the sensor's right tap gives mirrored output, by default the camera reformats this tap internally—you will not have to reverse the right tap in a framegrabber's line buffer to reconstruct the image. The left half of the image is clocked out Video L (tap 1) and the right half of the image is clocked out Video R (tap 2). Each row consists of 12 empty pixels followed by 28 light shielded pixels followed by 4 buffer pixels and then by 1024 photoactive pixels.

Table 2: Cosmetic Specifications

Type	Definition	Max. Number
Major Defective Pixels	A pixel whose signal deviates by more than 25mV from the mean value of all active pixels under dark field conditions or by more than 15% from the mean value of all active pixels under uniform illumination of 80% of saturation.	20
Minor Defective Pixels	A pixel whose signal deviates by more than 8mV from the mean value of all active pixels under dark field conditions.	200
Cluster	A group of 2 to 20 contiguous major defective pixels with a width no wider than 2 defective pixels.	8
Column	A group of more than 10 contiguous major defective pixels along a single column.	0

1.3 Camera Performance Specifications

Table 3: Pantera SA 4M15 Performance Specifications

Feature / Specification	Units	Value	Notes
Sensor Features			
Resolution	pixels	2048 x 2048	
Pixel Size	µm	7.4 x 7.4	
Output Format (# of taps)		2	

Optical Interface	Units		Notes
Back Focal Distance			
Sensor die to mounting plate	mm	6.56mm ±0.30mm	
Sensor Alignment			
x, y	µm	±300	
z	mm	±0.23	
Θz	°	±2.1	
Parallelism / Tilt	µm	<175	
Die Surface Flatness	µm	100	
Lens Mount		Adapter required	
Camera Thread		M42x1	

Mechanical Interface	Units		Notes
Camera Size	mm	56x56x56	
Mass	Kg	1.25	
Connectors			
data connector		MDR26 (female)	
power connector		Hirose 6-pin (male)	

Electrical Interface	Units	Min	Nom	Max	Notes
Input Voltage	Volts		+12 to +25		
Power Dissipation	W		<7		
Operating Temperature	°C	0	40		Measured at the front plate.
Data Output Format	Bits	8	10	10	

Power Dissipation, typ	W	7 at 24V 6.5 at 12V		
Time to power up, typ	sec.	14		
Data output format	bits	8 or 10 user selectable	Camera Link™	

Camera Performance	Units	Min.	Nom.	Max.	Notes
Frame Rate	fps	1		16	
Data Rate	MHz	2 x 40		2 x 40	
Data Format		8 bit		10 bit	8 or 10 bit user selectable.
Operating Temp	°C	0		40	At front plate.
Nominal Gain Range	dB	0		15	
Dynamic Range	dB	54			
Pixel Response Non-Uniformity (PRNU)	%rms			<5	
FPN	DN rms			1.2	

Camera Performance	Units	Min.	Nom.	Max.	Notes
Random Noise	DN rms			2.0	@0dB gain
Sat. Output Amplitude	DN		1000		
DC Offset	DN		10		
DC Offset Subtraction	DN			up to 50	
Antiblooming				100x	
Responsivity	DN/(nJ/cm^2)	8			@530nm, 0dB
Power Up Duration	sec			16	
SEE	nJ/cm^2		115		@530nm, 0dB
NEE	nJ/cm^2		160		@530nm, 0dB

Regulatory		
Regulatory Compliance	CE	

Operating Ranges	Units	Min	Max	Notes
Data Rate	MHz	40/tap	40/tap	
Temperature	°C	0	40	1
Frame Rate	fps	1	16	

Electro-Optic Specifications	Units	Nom Gain at 0dB	Notes
Responsivity @530nm, typ	DN/(nJ/cm^2)	8	
Dynamic Range Typical	Ratio	449:1	
RMS Noise, typ	DN	1.5	
DC Offset, typ	DN	10	
SEE	nJ/cm^2	115 @ 530nm	
NEE	pJ/cm^2	160 @ 530nm	

Power Supply Current	Units	Typ	Max	Notes
Vin = 25V	A	0.3		
Vin = 12V	A	0.54		

Notes:

DN = Digital Numbers (0-1023); also known as gray levels.

All measurements taken in 10-bit output mode.

All specifications are valid for the front plate temperature range of 0°C to 40°C, in still air.

Figure 4: Pantera SA 4M15 Sensor Monochrome Quantum Efficiency

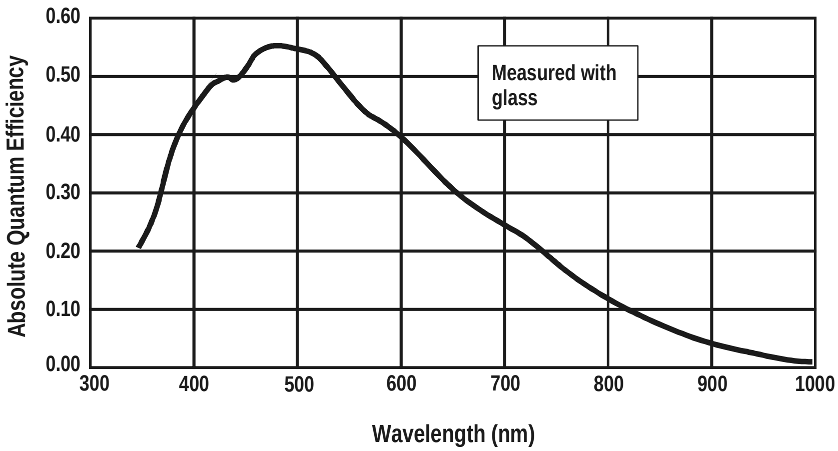


Figure 5: Pantera SA 4M15 Sensor Color Quantum Efficiency (DS-22-04M15 only)

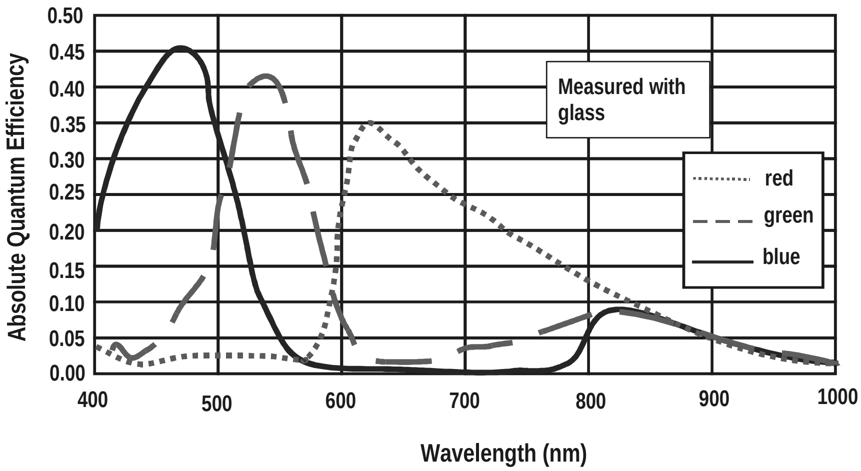
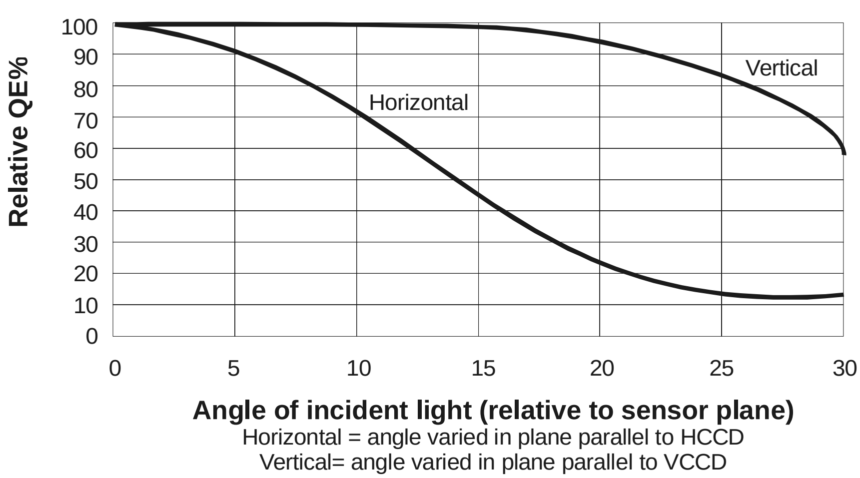


Figure 6: Pantera SA 4M15 Angular Dependence of QE (DS-22-04M15 only)



2

Camera Hardware Interface

2.1 Installation Overview

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

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

1. Power down all equipment.
2. Following the manufacturer's instructions, install the frame grabber (if applicable). Be sure to observe all static precautions.
3. Install any necessary imaging software.
4. Connect camera body and / or front plate to heat sink. Refer to Thermal Management & Dark Current on page 39 for more information. **IMPORTANT: Prior to operation of the camera, refer to Section 4.1 Mechanical Interface, for information regarding Thermal Management and Dark Current.**
5. Before connecting power to the camera, test all power supplies. Ensure that all the correct voltages are present at the camera end of the power. Power supplies must meet the requirements defined in section 2.2.3.
6. Inspect all cables and connectors prior to installation. Do not use damaged cables or connectors or the camera may be damaged.
7. Connect Camera Link and power cables. Refer to section 2.2 for information on camera connectors.
8. After connecting cables, apply power to the camera.
9. Check the diagnostic LED. See 2.2.1 LED Status Indicator on page 14 for LED description.

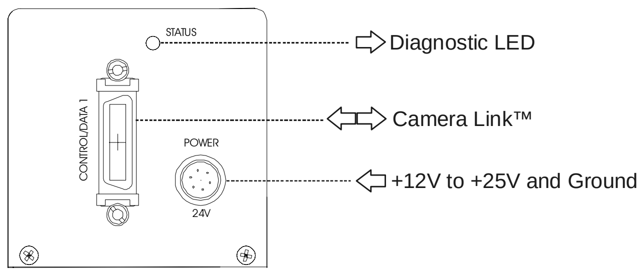
You must also set up the other components of your system, including light sources, camera mounts, host computers, optics, encoders, and so on.

2.2 Input/Output Connectors and LED

The camera uses a:

- high-density 26-pin MDR26 connector for Camera Link control signals, data signals, and serial communications. Refer to Table 5 on page 14 for pin numbers.
- 6-pin Hirose connector for power. Refer to Table 7 on page 16 for pin numbers.
- LED status indicator for camera monitoring. See the following section for details.

Figure 7: Pantera SA 4M15 Input and Output



WARNING: It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages will damage the camera. See section 2.2.3 for details.

2.2.1 LED Status Indicator

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 4: Diagnostic LED

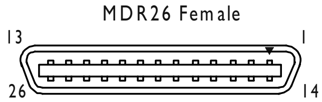
LED state	Priority	Camera Status	Condition
Blinking RED	1	Error	Fatal hardware failure
Steady RED	2	Warning	Monitoring task failure
Blinking GREEN	3	Progress	Lengthy operation in progress
Steady GREEN	4	OK	Healthy

2.2.2 Camera Link Data Connector

The Camera Link interface is implemented as a **Base Configuration** in the Pantera SA cameras. A Base Configuration uses 1 MDR26 connector and 1 Channel Link chip. The main characteristics of the Base Configuration are:

- Ports supported: A, B, C
- Serializer bit width: 28
- Number of chips: 1
- Number of MDR26 connectors: 1

Figure 8: MDR26 Connector



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

Table 5: MDR26 Connector Reference (Camera Link Standard Pinout- Base Configuration)

Item	Value	Item	Value
Pinout	**BASE**	**Pinout**	**BASE**
1	Logic Gnd via 0 ohm resistor	14	Logic Gnd via 0 ohm resistor
2	X0-	15	X0+
3	X1-	16	X1+
4	X2-	17	X2+
5	Xclk-	18	Xclk+
6	X3-	19	X3+
7	SERTC+	20	SERTC-
8	SERTFG-	21	SERTFG+
9	CC1-	22	CC1+
10	CC2+	23	CC2-
11	CC3-	24	CC3+
12	CC4+	25	CC4-
13	Logic Gnd via 0 ohm resistor	26	Logic Gnd via a 0 ohm resistor

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.

Table 6: DALSA Camera Control Configuration

Signal	Configuration
CC1	EXSYNC
CC2	Spare
CC3	Spare
CC4	Spare

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

Control Inputs, Camera Link

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

Note: The camera ships in internal sync, internal programmed integration (Exposure mode 2).

Frame rate can be set internally using the serial interface. The external control signal EXSYNC is optional and enabled through the serial interface.

EXSYNC (Triggers Readout)

EXSYNC is an optional input signal that can be used to trigger the readout rate. This camera uses the **falling edge of EXSYNC** to trigger readout.

Section 3.7 Setting Frame Rate, Exposure Time, and Exposure Mode on page 22 details how to set frame times, exposure times, and camera modes.

Control Outputs, Camera Link

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

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

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

For a Camera Link reference and timing definitions refer to Appendix A on page 51.

2.2.3 Power Connector and Supplies

Figure 9: Hirose 6-pin Circular Male—Power Connector

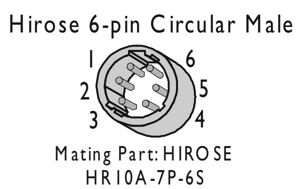


Table 7: Hirose Pin Description

Pin	Description	Pin	Description
1	+12 to +25V	4	GND
2	+12 to +25V	5	GND
3	+12 to +25V	6	GND

The camera requires a single voltage input (+12V to +25V). The camera meets all performance specifications using standard switching power supplies, although well-regulated linear supplies provide optimum performance. See Performance Specifications on page 8 for current requirements.

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

- Protect the camera with a fast-blow fuse between power supply and camera.
- Do not use the shield on a multi-conductor cable for ground.
- Keep leads as short as possible to reduce voltage drop.
- Use high-quality **linear** supplies to minimize noise.

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

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

DALSA offers a power supply with attached 6' power cable that meets the Pantera SA 4M15's requirements, but it should not be considered the only choice. Many high quality supplies are available from other vendors. DALSA assumes no responsibility for the use of these supplies.

Visit the www.dalsa.com Web site for a list of companies that make power supplies that meet the camera's requirements. The companies listed should not be considered the only choices.

3

Software Interface: How to Control the Camera

This chapter details the most commonly used commands. See Appendix B for the complete command list, error handling, and networking instructions.

See Appendix C for instructions on using the camera's look up tables.

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

- Controlling basic camera functions such as gain and choice of sync signal source (internal or external)
- Camera calibration
- Measuring internal temperature and voltages
- Capturing video
- Generating a test pattern for debugging
- Setting an area of interest

The serial interface uses a simple ASCII-based protocol.

Online Help

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

Retrieving Camera Settings

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

3.1 Communications Protocol Overview

Serial Protocol Defaults:

- 8 data bits
- 1 stop bit
- No parity
- No flow control

- 9.6Kbps
- Camera does not echo characters

When entering commands, remember that:

- A carriage return (CR) ends each command. The linefeed character is ignored.
- The camera will answer each command with either "OK >" or "Error x: Error Message >". The ">" is always the last character sent by the camera.
- The following parameters are used throughout the manual:

  `i` = integer
  `f` = float
  `t` = tap
  `[ ]` = optional parameter
  `x` = column identifier
  `y` = row identifier

3.2 Overview: Setting up the Camera to Send Commands

The following steps describe how to begin using the camera commands.

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

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

   Terminal should be set at 9600 baud during the camera power up.

3. When the terminal window is set up, power on the camera.
4. The boot-up message should appear on the terminal window:

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

   OK>
   ```

   You can now communicate with the camera through the terminal using the software commands described in this manual.

5. Set up the framegrabber to receive the data. Following the framegrabber manufacturer's instructions, set up the parameters described in the Camera Link™ Configuration Table on page 54.
6. Once the framegrabber is set up for data processing and the camera is powered up, run your image processing software. You should be able to see an image from the camera when exposed to a light source.

You can now set the other camera parameters described in this chapter.

3.3 Startup

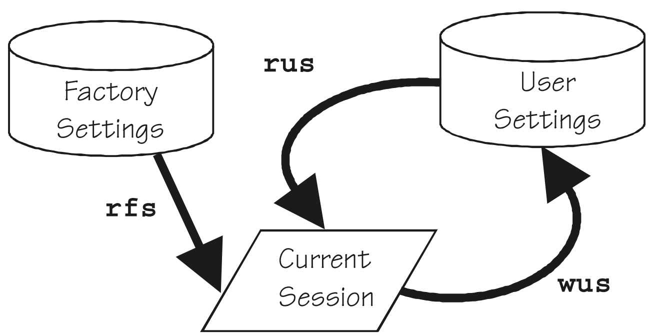
When the camera is first started, it must perform several actions before it is ready for imaging. This startup routine takes approximately 14 seconds, and follows this sequence:

1. Initializes the camera and all internal hardware.
2. Loads the last settings saved to non-volatile memory.
3. Restores user settings if previously saved, otherwise factory settings.
4. Performs a memory test and voltage test and reports an error if any occurred.

After this startup sequence has completed, the camera will return either the prompt "OK>" if no error occurred, or an error code if a problem has been discovered.

3.4 Saving and Restoring Settings

Figure 10: Saving and Restoring Settings Overview



Factory Settings

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

User Settings

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

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

Current Session Settings

These are the current operating settings of your camera. These settings are stored in the camera's volatile memory and will not be restored once you power down your camera. To save these settings to non-volatile memory, use the command **wus**.

3.5 Setting Baud Rate

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

Syntax:	`sbr i`
Syntax Elements:	*i* Baud rate. Available baud rates are: `9600` (Default), `19200`, `57600`, and `115200`.
Notes:	• Power-on rate is always 9600 baud. • The `rc` (reset camera) command will *not* reset the camera to the power-on baud rate.
Example:	`sbr 57600`

3.6 Selecting the Data Output Mode

You can select either 8 or 10-bit output.

To select the camera output mode, use the command:

Syntax:	`sdm i`
Syntax Elements:	*i* `0` 10- bit `1` 8-bit
Notes:	• To obtain the current data mode, use the command `gcp`.
Example:	`sdm 0`

3.7 Setting Frame Rate, Exposure Time, and Exposure Mode

With four different exposure mode settings, the Pantera SA 4M15 delivers many possibilities for flexible camera timing. Table 8 outlines each of these five exposure modes, and is followed by a full explanation on how to set the camera's frame rate and exposure time.

Table 8: Overview of the Pantera SA 4M15 Exposure Modes

Mode 2 is the default

Mode	SYNC	Programmable Frame Rate	Programmable Exposure Time	Description
2	Internal	Yes	Yes	(Factory setting) Internal SYNC , programmable frame time and exposure time using commands **ssf** and **set**. **Note:** The parameter being programmed (i.e. frame rate or exposure time) will be the driving factor so that when setting frame rate, exposure time will change to accommodate the new frame rate and visa-versa.
3	External	No	No	External SYNC, maximum exposure time (no shuttering).
4	External	No	No	"Smart EXSYNC" Mode: external exposure time – high time of external signal is exposure time and 1/period is frame rate.
5	Not Used			
6	External	No	Yes	External SYNC, programmable exposure time. **Note:** You are responsible for not violating timing constraints for the external sync signal used in this mode.

3.7.1 Setting Frame Time and Exposure Time

The camera's frame rate (synchronization) can be generated internally through software commands or input externally from a frame grabber/host system. To select how you want the camera's frame rate to be generated:

1. You must first set the camera mode using the **sem** command. Refer to section 3.7.2 below for details.
2. Then, when applicable, use the commands **ssf** (mode 2 only) to set the frame rate and/or **set** (mode 2 or 6), to set the exposure time. Refer to section 3.7.3 on page 27 for details.

3.7.2 Setting the Exposure Modes

To set the camera exposure mode, use the command:

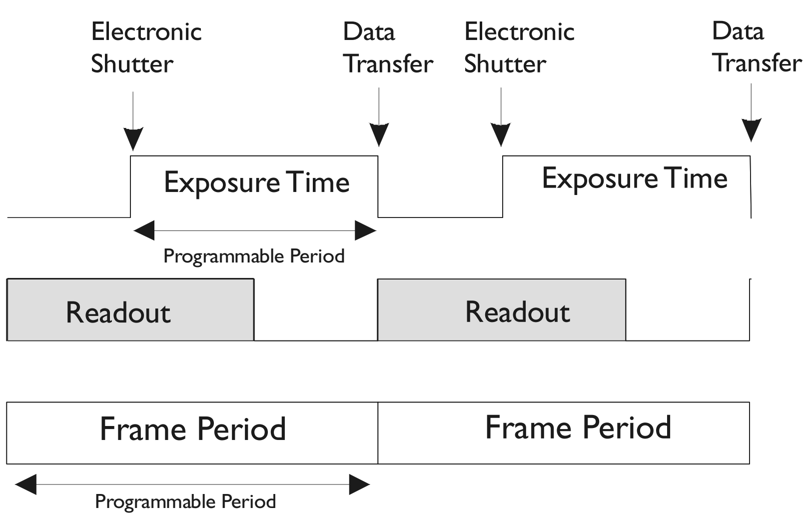
Syntax:	**sem *i***
Syntax Elements:	***i*** Exposure mode to use. Factory setting is **2**.
Notes:	• Refer to Table 8 for a quick list of available modes or to the following sections for a more detailed explanation. • To obtain the current value of the exposure mode, use the command **gcp**.
Related Commands:	**ssf, set**
Example:	**sem 3**

Mode 2: Internally Programmable Frame Rate and Exposure Time (Default)

The parameter being programmed (i.e. frame rate or exposure time) will be the driving factor so that when setting frame rate, exposure time will change to accommodate the new frame rate and visa-versa. If you are using an area of interest while operating in mode 2, see section 3.9 Defining an Area of Interest (AOI) for more timing information.

Note: If the frame period (the period needed to readout one frame) is less than the exposure time entered, the frame period will be set by the exposure time. The camera will use electronic shuttering when the exposure time is less than the frame period.

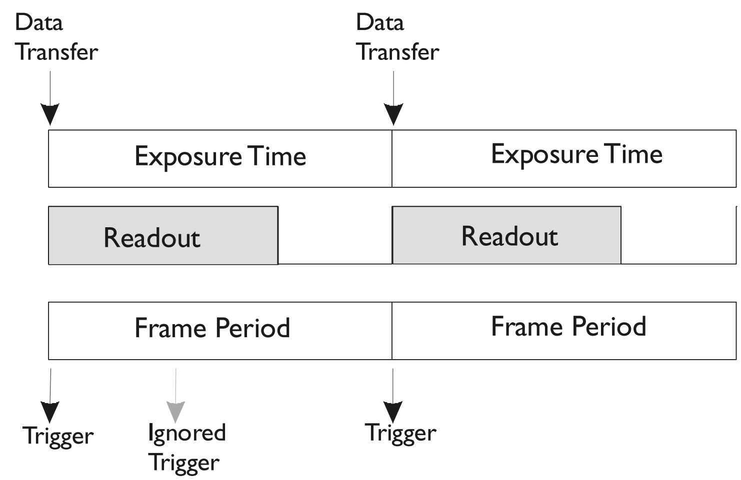
Example 1: Exposure Time less than Frame Period



Mode 3: External Trigger with Maximum Exposure

Frame rate is set by the period of the external trigger pulses. Since there is no electronic shuttering, any trigger pulses faster than the readout time are ignored. The falling edge of the external trigger marks the beginning of the exposure.

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

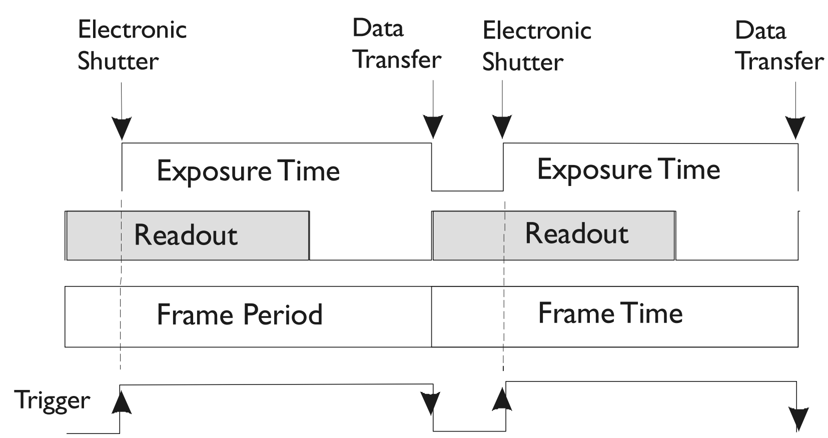


Mode 4: Smart EXSYNC, External Frame Rate and Exposure Time

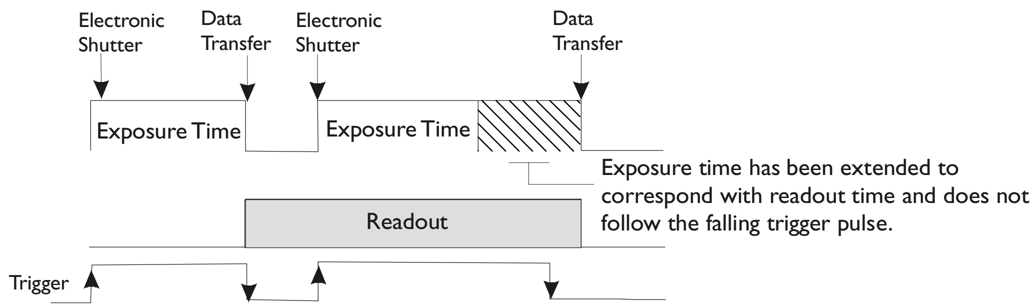
In this mode, the external trigger rate sets both the frame rate and the exposure time. The rising pulse of the external trigger marks the beginning of the exposure.

Note: At the end of the exposure time, the collected data will be transferred to the read out area only if it is not already in the process of reading out. If readout is already in process, the exposure time will be extended until the readout has finished, as is illustrated in Example 4.

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



Example 4: Trigger Period is Intermittent and Occasionally Shorter than Readout Time.

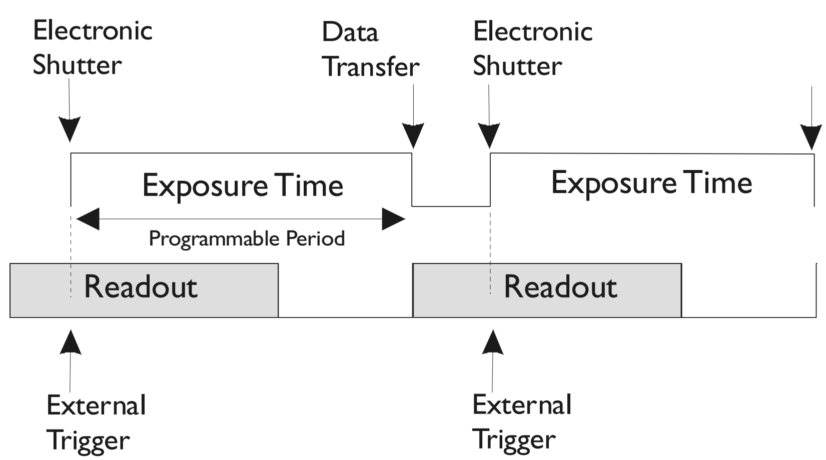


Mode 6: External Frame Rate and Internal Exposure Time

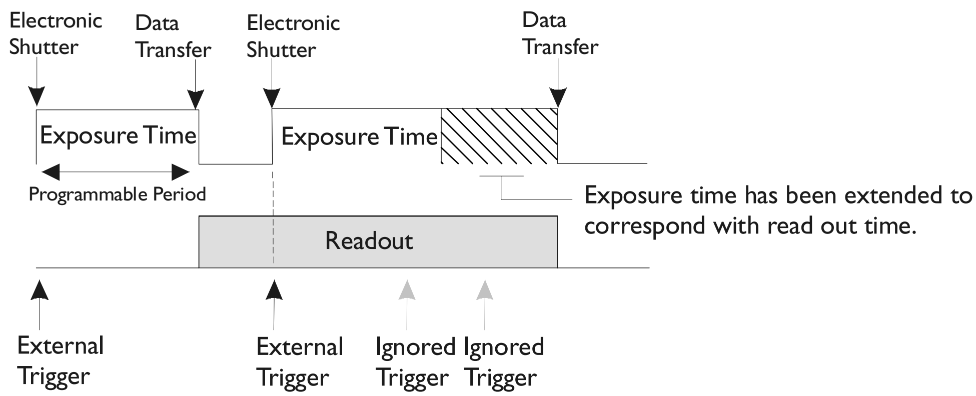
This mode differs according to the trigger rate and the exposure time setting. However, the following rules apply to any condition:

- Any additional external triggers occurring during the exposure time will be ignored.
- All non-ignored external triggers will pulse an electronic shutter to dump any current exposure data at the start of the trigger pulse and start the exposure time.
- At the end of the exposure time, the collected data will be transferred to the readout area **only** if it is **not** already in the process of reading out. If readout is already in process, the exposure time will be extended until the readout is finished, as is illustrated in Example 6.
- If you are using an area of interest while operating in mode 6, see section 3.9 Defining an Area of Interest (AOI) for more timing information.

Example 5: Trigger Period is Repetitive and Greater than Readout Time



Example 6: Trigger period is Nonreptitive and Occasionally Shorter than Readout Time



3.7.3 Setting Frame Rate and Exposure Time

Setting Frame Rate

Camera must be operating in exposure mode 2.

To set the frame rate, use the command:

Syntax:	`ssf i`
Syntax Elements:	*i* Desired frame rate in Hz. Allowable ranges depend on binning mode and size of area of interest.
Notes:	• To read the current frame rate frequency, use the command `gcp`. • If you enter an invalid frame rate frequency, the valid range of values will be displayed.
Related Commands:	`sem, set`
Example:	`ssf 12`

Setting Exposure Time

Camera must be operating in exposure mode 2 or mode 6.

Figure 11: Exposure Mode Time Ranges

Mode	Exposure Time Range
2	Fixed by `ssf` command
6	Limited by current frame rate (EXSYNC frequency)

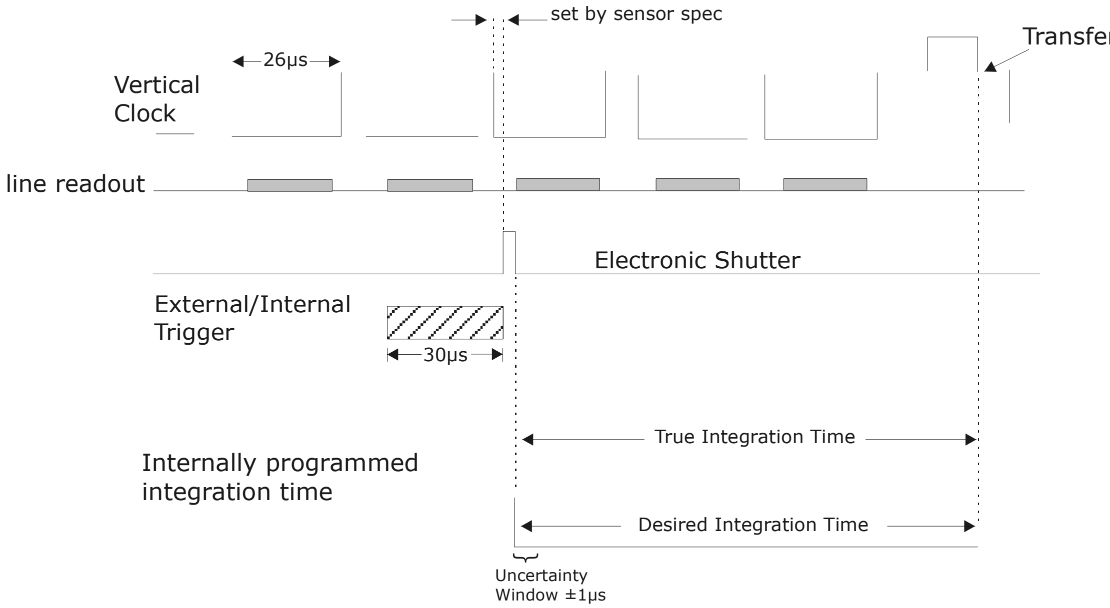
To set the camera exposure time, use the command:

Syntax:	`set i`
Syntax Elements:	*`i`* Fixed point number in µsecs. Allowable range is `68-1000000.00` µsecs.
Notes:	• To read the current exposure time, use the command **`gcp`**. • If you enter an invalid exposure time, the valid range of values will be displayed. •
Related Commands:	`sem, ssf`
Example:	`set 5500`

Shutter/Exposure Timing

Because the camera can be reading out a previous image while shuttering for the next image, there are some timing constrains imposed by the sensor specification on this timing. The result is that the actual frame time of the camera must be synchronized to the vertical clocking. The vertical clocks have a period of about 30µs so this produces an uncertainty window around the desired frame time to what is generated by the camera. The desired integration setting is accurate to +/- 1µs. The figure below shows how this uncertainty window is applied for various operating conditions.

Figure 12: Integration Time Programming



3.8 Increasing Sensitivity with Binning (DS-21-04M15 Only)

Binning increases the camera's light sensitivity by decreasing horizontal and vertical resolution—the charge collected by adjacent pixels is added together.

To set the binning value, use the command:

Syntax: **`sbm i i`**

Syntax Elements:

i

Horizontal binning value. Must be identical to the vertical binning value.

i

Vertical binning value. Must be identical to the horizontal binning value.

Notes:

- Available values are **1**x**1** (factory setting), **2**x**2**, or **4**x**4**.
- To return to 1x1 mode (binning disabled), use the command **`sbm 1 1`**.
- Binning is recommended for the monochrome (DS-21-04M15) 4M15 only. Using binning with the color (DS-22-04M15) 4M15 will cause invalid pixel summations.

Example: **`sbm 2 2`**

Figure 13: 2x2 Binning

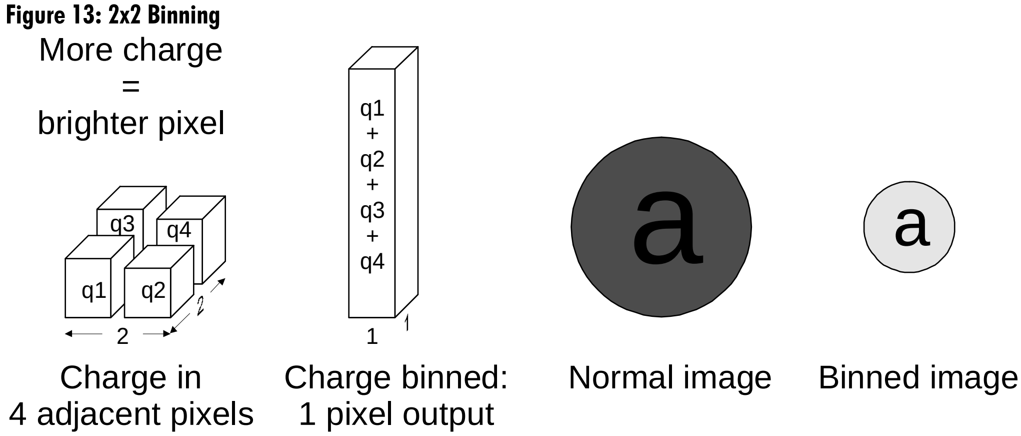


Table 9: Binning vs. Speed

Binning	Read out Time(mS)	Frame Rate	Data Rate (MHz)
1x1	62.5	16	2x40
2x2	34.48	29	2x20
4x4	20.8	48	2x10

3.9 Defining an Area of Interest (AOI)

By default, the Pantera SA 4M15 has an active pixel region of 2048 x 2048. However, using the area of interest command, you can specify a reduced subset of the image to be read out from the sensor. The unwanted data is dumped, resulting in an increased frame rate and a reduction in data volume.

Calculating Frame Rate

Use the following formula to calculate the camera's frame rate:

Maximum Frame Rate (fps)=1000000/[({#Active Lines/Binning Factor + 3} x Step Size) + (#Dumped Lines x 2.8) + 133]

Where Step Size is:

Binning Mode	1 x 1	2 x 2	4 x 4
Step Size (µs)	30	33.1	39.5

Where Dumped Lines are:

Binning Mode	1 x 1	2 x 2	4 x 4
Dumped Lines	2048-Actives+18	2048-Actives+15	2048-Actives+9

Frame Rate Calculation Example

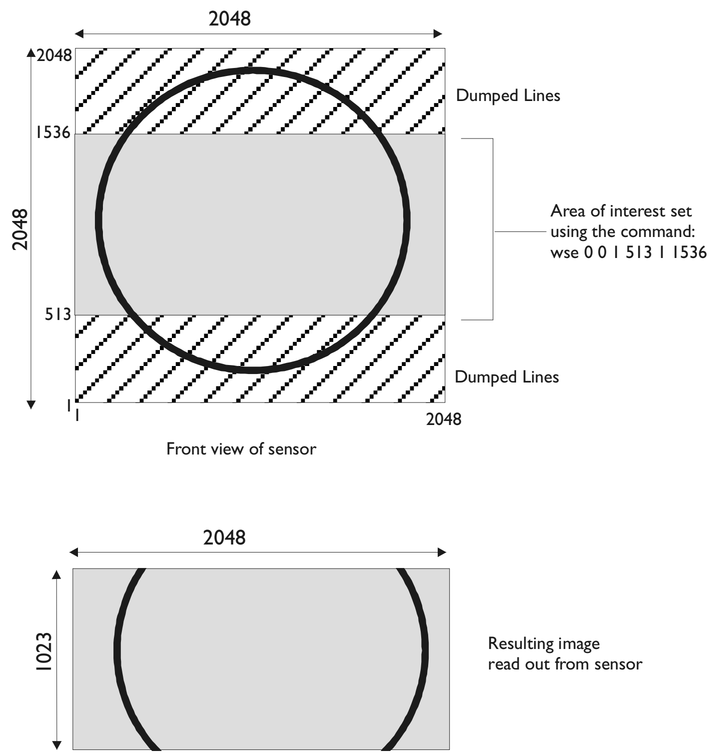
The frame rate for a camera using an area of interest of 200 lines and 1 x 1 binning is:

= 1000000/[(203 x 30) + (1866 x 2.8) + 133]
= 1000000/[6090 + 5224.8 + 133]
= 87

Area of Interest Example

In the example in Figure 14, an area of interest is set to capture 1024 lines of image data—the remaining 1024 lines are dumped through the sensor's fast dump gate. The area of interest begins at line 513 and ends at line 1536. The command syntax for this example is `wse 0 0 1 513 1 1536`.

Figure 14: Area of Interest Example



Guidelines and Rules for Setting the Area of Interest

When setting the area of interest, be aware that:

- Changing the area of interest settings while the camera is operating in mode 2 will also change the **`set`** or **`ssf`** settings. Always re-enter **`set`** and **`ssf`** values after changing the AOI while operating in mode 2. To check settings, enter the command **`gcp`**.
- Changing the area of interest while operating the camera in mode 6 can result in an invalid **`set`** result. Always re-enter your **`set`** value after changing the area of interest when operating in mode 6.
- The camera will ignore any EXSYNC signals that occur quicker than the readout rate.
- The exposure time setting cannot be greater than the frame time. The minimum frame time cannot be less than the readout time. If either of these conditions are violated, the camera will automatically adjust these settings.
- If you are using binning, the window start/end values will be rounded using the following equations:

  Binning Start Value = INT [(Input Value-1)/Binning Factor] x Binning Factor +1

  Binning End Value = [INT {(Input Value-1)/Binning Factor} x Binning Factor +1]+ (Binning Factor –1)
- If you are using the color (DS-22-04M15) 4M15, the resolution of the color filter array Bayer Pattern (2x2) restricts the size and position of the AOI. You must specify an odd number for the start row and an even number for the end row. If you specify an even number for the start row, the Bayer pattern is reversed and the resulting image is corrupted.

Setting the Area of Interest

To set the area of interest, use the command:

Syntax: **wse** ***q i x1 y1 x2 y2***

Syntax Elements:

q

Window sequence id to use. In the 4M15, the sequence id is always `0`.

i

Window id. In the 4M15, the window id is always `0`.

x1

The column start identifier. Since the 4M15 only allows you to set a vertical area of interest, this value is always `1`.

y1

The row start identifier with a range of 1 to an integer less than the row end identifier (**y2**). If you are using the color (DS-22-04M15) 4M15, this value **must be odd** in order to preserve the color filter array Bayer pattern. Otherwise, the image will be corrupted.

x2

The column end identifier. Since the 4M15 only allows you to set a vertical area of interest, this value is always `1`.

y2

The row end identifier with a range greater than the row start identifier (**y1**) to 2048. If you are using the color (DS-22-04M15) 4M15, this value **must be even** in order to preserve the color filter array Bayer pattern. Otherwise, the image will be corrupted.

Example **wse 0 0 1 301 1 900**

Notes:

- Changing AOI settings while in mode 2 or 6 will also change the **set** or **ssf** settings. Also, changing the AOI settings while in modes 2 or 6 may alter camera timing. See Guidelines and Rules for Setting the Area of Interest on page 31 for details.

3.10 Optimizing Offset Performance

Set the analog offset of the camera using the command:

Syntax: `sao t i`

Syntax Elements: *t*

Tap value. Use `0` for all taps or `1` to `2` for individual tap selection.

i

Offset value. Allowable range is from `0` to `1023`.

Notes:

- The offset increases with higher values. The resulting analog offset value depends on other camera parameters such as temperature, frame rate, and gain but will fall somewhere between 1 and 10 DN.

Example: `sao 0 500`

3.11 Setting Gains

Analog Gain

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

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

Syntax: `sg t f`

Syntax Elements: *t*

Tap value. Use `0` for all taps or `1` to `2` for individual tap selection.

f

Gain setting. Allowable range is `0` to `15`dB.

Example: `sg 0 2.5`

Setting Digital Gain for Tap to Tap Matching

The set system gain command allows you to adjust the digital gain in both the left and right channels for control over tap-to-tap matching.

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

Syntax: `ssg t f`

Syntax Elements: *t*

Tap value. Use `0` for all taps or `1` to `2` for individual tap selection.

f

Gain setting. Allowable range is `1`x to `4`x.

Example: `ssg 1 2.5`

3.12 Generating Test Patterns

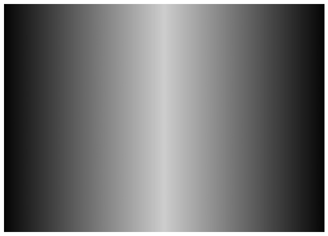
The camera can generate a test pattern to aid in system debugging. To activate the test pattern, use the command **svm *i***. Where *i* is one of three test pattern options. The test pattern is a ramp from 25 to 824DN (on each channel), then starts at 25 again. Use the test pattern to verify the proper timing and connections between the camera and the frame grabber. Table 10 below provides an overview of the three test pattern modes.

Table 10: Test Patterns

Mode	Description
1	Test pattern left side
2	Test pattern right side
3	Test pattern both sides

Figure 15: 8 Bit Test Pattern

Figure 16: 10 Bit Test Pattern



3.13 Monitoring Tasks

The camera enters a warning state when any of camera's continuously running monitoring tasks detects a failure. Use the **`wed i i`** command to display the status of all the defined monitory tasks (if no parameter is passed) and / or to enable / disable specific monitoring tasks. Table 11 below lists the monitoring tasks.

Note: By default all monitoring tasks are enabled.

Table 11: Pantera SA 4M15 Monitoring Tasks

Parameters	Monitoring Task	Description
0 0	All	Disables all monitoring tasks.
0 1	All	Enables all monitoring tasks.
1 0	Voltage	Monitors all camera voltages.
1 1	Voltage	Disables monitoring of camera voltages.
2 0	Gain out of spec	Monitors current setting of analog gain.
2 1	Gain out of spec	Disables monitoring of analog gain setting.

Example:

To enable all monitoring tasks:

```
wed 0 1
```

Voltage Measurement

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

3.14 Rebooting the Camera

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

3.15 Setting the Pre-trigger

A pre-trigger may be required for some frame grabbers.

To set the pre-trigger, use the command:

Syntax: `sp i`

Syntax Elements: *i*

Pretrigger value from `0` to `15`.

Example: `sp 10`

3.16 Setting the Video Mode

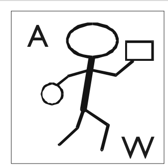
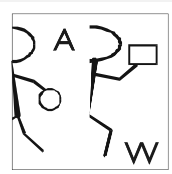
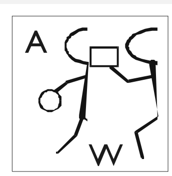
To set the video mode, use the command:

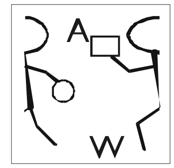
Syntax: `svm i`

Syntax Elements: *i*

Video mode to use. See the table below for mode descriptions

Table 12: Pantera SA 4M15 Video Modes

Mode	Description	Example Image
0	Normal operating mode	
1	Test pattern left side	
2	Test pattern right side	
3	Test pattern both sides	
4	Flip image left side	
5	Flip image left side. Test pattern left side	
6	Flip image left side. Test pattern right side	
7	Flip image left side. Test pattern both sides	
8	Flip image right side	
9	Flip image right side. Test pattern left side	
10	Flip image right side. Test pattern right side	
11	Flip image right side. Test pattern both sides	

Mode	Description	Example Image
12	Flip image both sides	
13	Flip image both sides. Test pattern left side	
14	Flip image both sides. Test pattern right side	
15	Flip image both sides. Test pattern both sides	

4

Optical, Mechanical, Thermal, and Handling Considerations

4.1 Mechanical Interface

Mounting

The camera can be mounted using the M3 holes (metric-threaded) on its base or top, and on its front plate at the corners.

Environment

The camera and cables should be shielded from environmental noise sources for best operation. The camera should also be kept as cool as possible. The specified operating temperature is 0–40°C measured at the bottom plate. Mounting holes (refer above) allow you to attach the necessary heat sinking.

Thermal Management & Dark Current

For any CCD camera optimal performance is achieved by transferring heat away from the sensor. Keeping a sensor "cool" reduces the amount of dark current generated. Dark current is the leading contributor to FPN, PRNU, dark offset, random noise and other performance specifications, especially when a camera is significantly gained (i.e. +10db). Generally, dark current doubles for every 7°C increase in temperature at the sensor and increases linearly with integration time.

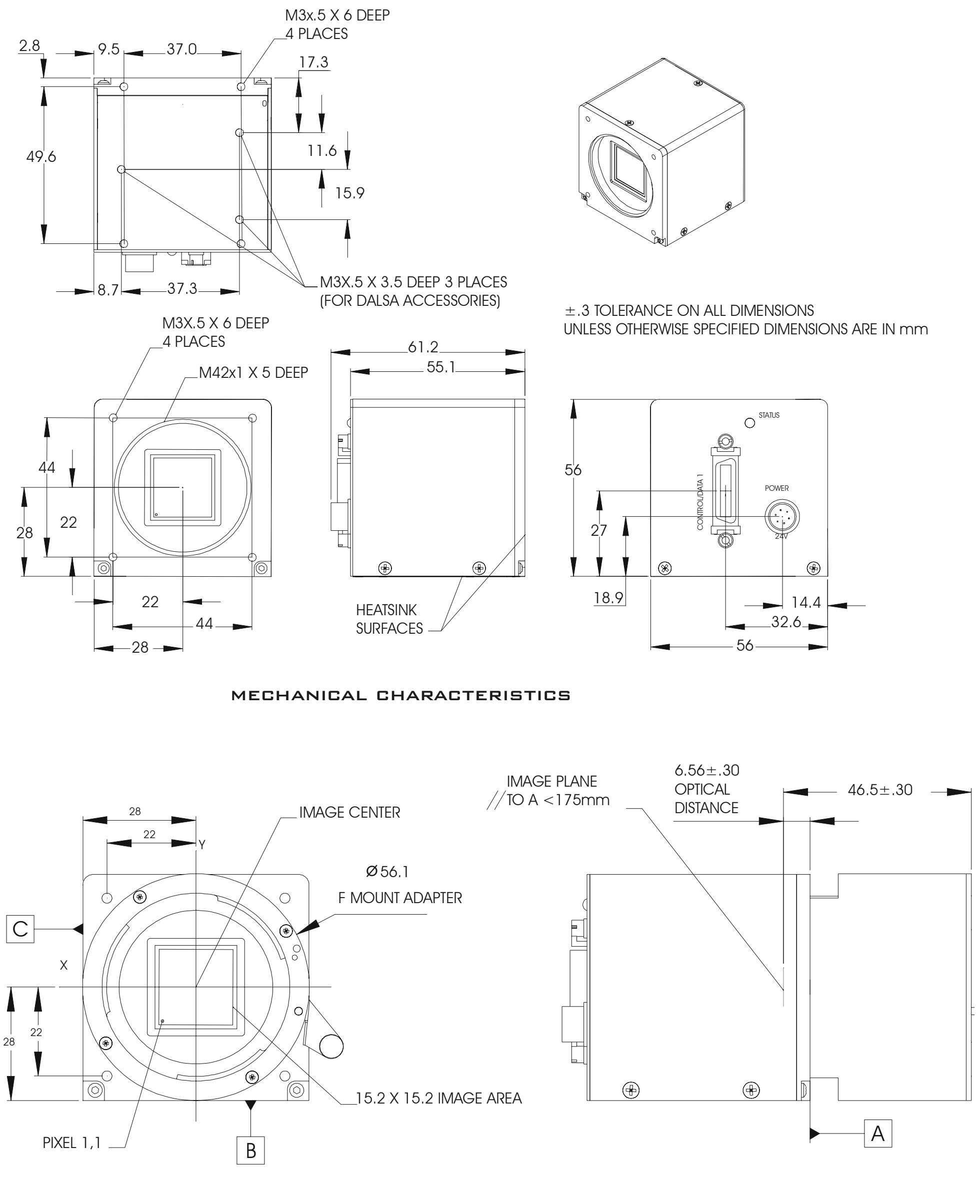
This camera has been optimized to transfer heat from the sensor to the front and base plates. Therefore, to reduce dark current, the front and base plates are the ideal places to mount heat sinks.

Some suggestions for optimizing camera cooling are:

- To minimize power dissipation, keep input voltage as low as possible in the permitted 12 to 25V range.
- Always operate the camera with a lens adapter or lens. The lens transfers a significant amount of heat from the interior of the camera, effectively acting as a heat sink.
- Clamping a metal plate to the base of the camera. Keep in mind that the thicker and wider the metal plate, the more effective the cooling.
- Convection is an ideal method to minimize camera warm-up times and reduce dark current generation. Mount fans away from the camera to avoid vibration, and direct the airflow across the housing to decrease the temperature delta between ambient and bottom plate temperatures.

DALSA also offers a custom heat sink, which can be purchased as a non-standard accessory (contact DALSA for more information).

Figure 17: Mechanical Interface



4.2 Optical Interface

Depending upon resolution, the cameras can be ordered with different lens mounts. The following table provides this information.

Lens Mounts

All C-mount and F-mount adapters have the appropriate back focal distance for the lens type being used. Ensure that the image circle diameter of the lens to be used is as great as the length of the imaging region. The following table provides information regarding the lens mount used and the back focal distance. The M42 lens adapter originated from the high-end photography standard. Distances to its inner flat surface and the outer flat surface are provided.

Table 13: Lens Mounts

Mount	Back Focal Distance (sensor die to adapter)
C-Mount	17.52 ±0.30mm (order as accessory)
F-Mount	46.5 ±0.30mm (order as accessory)
M42	6.56mm ±0.30mm—outer flat surface

Illumination

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

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

Light Sources

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

- LED light sources are relatively inexpensive, provide a uniform field, and longer life span compared to other light sources. However, they also require a camera with excellent sensitivity, such as DALSA's 4M15 camera.
- Halogen light sources generally provide very little blue relative to IR.
- Fiber-optic light distribution systems generally transmit very little blue relative to IR.
- Some light sources age; over their life span they produce less light. This aging may not be uniform—a light source may produce progressively less light in some areas of the spectrum but not others.

Filters

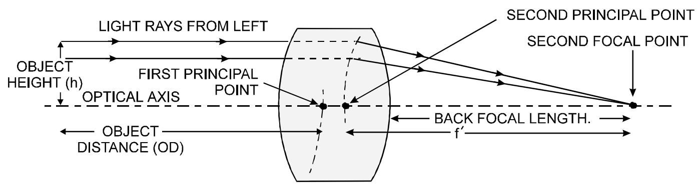
CCD cameras are extremely responsive to infrared (IR) wavelengths of light. To prevent infrared from distorting the images you scan, use a "hot mirror" or IR cutoff filter that transmits visible wavelengths but does not transmit wavelengths over 750nm. Examples are the Schneider Optics™ B+W 489, which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

Lens Modeling

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

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

Figure 18: Primary Points in a Lens System



Magnification and Resolution

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

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

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

By similar triangles, the magnification is alternatively given by:

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

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

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

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

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

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

5

Troubleshooting

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

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

Your steps in dealing with a technical problem should be:

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

5.1 Common Solutions

Connections

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

Power Supply Voltages

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

EXSYNC

When the camera is powered on for the first time, it defaults to exposure mode 2. After a user has saved settings, the camera powers up with the saved settings. **Note:** A warning appears when switching to an exposure mode requiring external signals if external signals are not present (EXSYNC). For more information on setting exposure modes, refer to section 3.7 Setting Frame Rate, Exposure Time, and Exposure Mode.

Data Clocking/Output Signals

To validate cable integrity, have the camera send out a test pattern and verify it is being properly received. Refer to section 3.16 Setting the Video Mode for further information.

5.2 Troubleshooting Using the Serial Interface

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

Communications

To quickly verify serial communications send the help command. The `h` command returns the online help menu.

Verify Parameters

To verify the camera setup, send the `gcp` command.

Verify Factory Calibrated Settings

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

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

Verify Timing and Digital Video Path

Use the test pattern feature to verify the proper timing and connections between the camera and the 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 3` to activate the test pattern, both sides. The test pattern is a ramp from 25 to 824DN, 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 deactivate video correction. Adjust the analog offset using the `sao` commands. Under light conditions, you should receive a value.

Verify Voltage

To check the camera's input voltages and internal voltages, use the `vv` command. If they are within the proper range, the camera returns OK>. Otherwise the camera returns an error message.

LED Status

Located on the back of the camera is a red / green LED used to display the operational status of the camera. Red lights indicate errors or warnings and green lights indicate progress and OKs. Error and warning states are accompanied by corresponding messages further describing current camera status. See section 2.2.1 LED Status Indicator for the complete LED information.

Monitoring Tasks

The camera enters a warning state when any of the camera's continuously running monitoring tasks detects a failure. Use the `wed` command to display the status of all the defined monitory tasks (if no parameter is passed) and / or to enable / disable specific monitoring tasks. See section 3.13 Monitoring Tasks on page 35 for the complete Monitoring Tasks information.

5.3 Specific Solutions

No Output or Erratic Behavior

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

Line Dropout, Bright Lines, or Incorrect Frame 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 maximum specified frame rate.

Noisy Output

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

Dark Patches

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

1. Take standard ESD precautions.

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

Horizontal Lines or Patterns in Image

A faulty or irregular encoder signal 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.

Color Image is Corrupted when Using Binning and/or AOI

If you are using binning:

Invalid pixel summations will occur when you use binning with the color 4M15. Disable binning using the command **`sbm 1 1`**.

If you are using an AOI:

You must preserve the color filter array pattern or the image will be corrupted. To preserve the color filter array pattern, ensure that the row start identifier (**`y1`**) is odd, and the row end (**`y2`**) identifier is even when setting the AOI with the **`wse`** command. See section 3.9 Defining an Area of Interest (AOI) for more information on setting the AOI.

5.4 Product Support

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

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

Customer name	
Organization name	
Customer phone number **fax number**	
Complete Product Model Number (e.g. DS-21-04M15...)	
Complete Serial Number	
Your DALSA Agent or Dealer	
Acquisition System hardware (frame grabber, host computer, light sources, etc.)	
Acquisition System software (version, OS, etc.)	
Power supplies and current draw	
Data rate used	
Control signals used in your application, and their frequency or state (if applicable)	☐ EXSYNC ☐ BIN ☐ MCLK ☐ Other _______
Results when you run the `gcp` command	
Detailed description of problem encountered.	*please attach description with as much detail as appropriate*

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

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

Appendix A

Camera Link™ Reference, Timing, and Configuration Table

Camera Link is a communication interface for vision applications. It provides a connectivity standard between cameras and frame grabbers.

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 on the http://vfm.dalsa.com Web site.

Camera Control Signals

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

- Camera Control 1 (CC1)
- Camera Control 2 (CC2)
- Camera Control 3 (CC3)
- Camera Control 4 (CC4)

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.

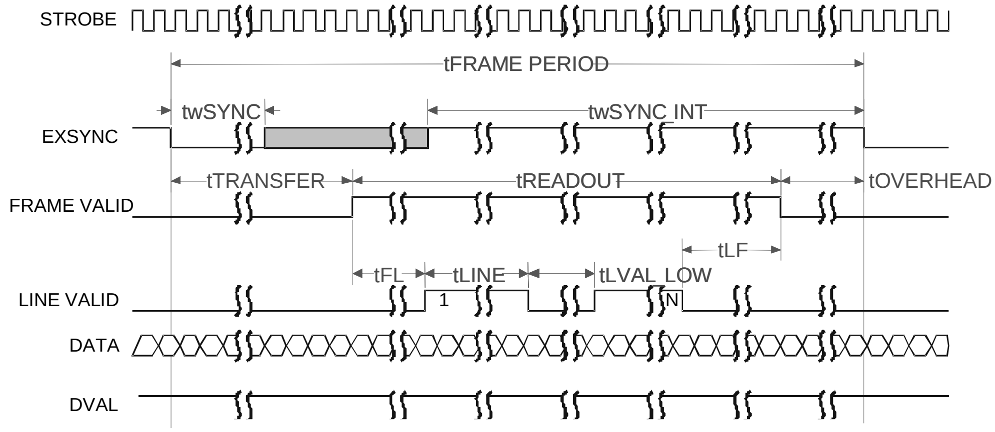
The serial interface will have the following characteristics: one start bit, one stop bit, no parity, and no handshaking. It is recommended that frame grabber manufacturers supply both a user interface and a software application programmming interface (API) for using the asynchronous serial communication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

Power

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

Camera Link Video Timing

Figure 19: Pantera SA 4M15 Timing (Input and Output Relationships)



IMPORTANT:
This camera uses the ***falling*** edge of EXSYNC to trigger line readout.

Table 14: Pantera SA 4M15 Input and Output

	Binning		
Symbol	**1 x 1**	**2 x 2**	**4 x 4**
twSYNC (min sync pulse, not SMART SYNC)	4 strobes (100ns)	4 strobes (100ns)	4 strobes (100ns)
twSYNC (min sync pulse in SMART SYNC)	1200 strobes (30 us)	(33.1 us)	(39.5us)
tTRANSFER (time from falling edge of EXSYNC to start of readout in SMART SYNC, pretrigger=0 – this time includes the transfer state)	2606-2607 strobes (65.15-65.175us)		
Time from Rising edge of EXSYNC to start of Integration in SMART SYNC, Integration during readout pretrigger=0)	230 strobes +up to 30us (5.75-35.75us)	(5.75-38.85us)	(5.75-45.25us)
Time from Rising edge of EXSYNC to start of Integration in SMART SYNC, Integration NOT during readout pretrigger=0)	5.75-5.775us		
tREADOUT (frame readout time, pretrigger=0)	2.488M strobes (62.2ms)	(34.39ms)	(20.6 ms)
tOVERHEAD (time after readout before next EXSYNC)	80K strobes (2ms)	(0.4ms)	(0.3ms)
TwSYNC_INT (min integration pulse, not SMART SYNC)	4 strobes (100ns)	(100ns)	(100ns)
TwSYNC_INT (min integration pulse, in SMART SYNC)	1200 strobes (30 us)	(33.1 us)	(39.5us)

	Binning		
Symbol	**1 x 1**	**2 x 2**	**4 x 4**
tFRAME PERIOD (min frame period)	2.5M strobes (62.5ms)	(34.48ms)	(20.8 ms)
tFL (time from FVAL to first LVAL)	175 strobes (4.375 us)	(7.65 us)	(14.175us)
tLINE (LVAL high time)	1020 strobes (25.5us)	(25.5us)	(25.5us)
tLVAL_LOW (LVAL low time)	175 strobes (4.375 us)	(7.55 us)	(13.875 us)
tLF (time from last LVAL to end of FVAL)	0 strobes (0 ns)	(-125 ns)	(25 ns)

Camera Link™ Configuration Table

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

Pantera SA 4M15 Interface Parameters

Table 15: Frame Grabber Interface Parameters

Item (when programmable configuration the options are separated with a |)	4M15
Imager Dimension <1,2 or 1|2>	2
Imager Columns<number of active columns, X>	2048
Imager Rows<number of active rows, Y> Line Scan/TDI are defined as 1	2048
Number of Imager Taps <1,2,3…..>	2
Tap Clock Rate <xx MHz>	40
Camera Standard <NTSC, PAL, VS, VW, MW>	VS, VW
Variable Window <Column Start, Column End, Row Start, Row End>	(1, 2048, *, *) * Start and end rows are programmable. See Setting the Area of I on page 32 for more details.
Multiple Window Number of Windows, (Column Start 1, Column End 1, Row Start 1, Row End 1) (Column Start 2, Column End2, …	0,(0,0,0,0)
Camera Color <Hybrid, Mono, Pattern, Solid>	DS-21-04M15 Mono DS-22-04M15 Pattern
Pattern Size <(T1,Columns*Rows)(T2, Columns*Rows)(T3,Columns*Rows….>	DS-21-04M15 (T1, 1*1) (T2, 1*1) DS-22-04M15 (T1, 2*2) (T2, 2*2)
Number of Camera Configurations<1,2,3,…>	8

Item (when programmable configuration the options are separated with a |)	4M15
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>	When **svm=0** C1 = Base 2,10,1 C2 = Base, 2 ,8, 1 When **svm=4** C3 = Base, 2, 10, 1 C4 = Base, 2, 8, 1 When **svm=8** C5 = Base, 2, 10, 1 C6 = Base, 2, 8, 1 When **svm=12** C7 = Base, 2, 10, 1 C8 = Base, 2, 8, 1 For details on the **svm** command, see section 3.16 Setting the Video Mode
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>	When **svm=0** C1, T1 (1, 1024, 1, 1, 2048, 1) C1, T2 (1025, 2048, 1, 1, 2048, 1) C2, T1 (1, 1024, 1, 1, 2048, 1) C2, T2 (1025, 2048, 1, 1, 2048, 1) When **svm=4** C3, T1 (1024, 1, -1, 1, 2048, 1) C3, T2 (1025, 2048, 1, 1, 2048, 1) C4, T1 (1024, 1, -1, 1, 2048, 1) C4, T2 (1025, 2048, 1, 1, 2048, 1) When **svm=8** C5, T1 (1, 800, 1, 1, 2048, 1) C5, T2 (2048, 801, -1, 1, 2048, 1) C6, T1 (1, 800, 1, 1, 2048, 1) C6, T2 (2048, 801, -1, 1, 2048, 1) When **svm=12** C7, T1 (800, 1, -1, 1, 2048, 1) C7, T2 (2048, 801, -1, 1, 2048, 1) C8, T1 (800, 1, -1, 1, 2048, 1) C8, T2 (2048, 801, -1, 1, 2048, 1) For details on the **svm** command, see section 3.16 Setting the Video Mode

<table>
<tr><th>Item (when programmable configuration the options are separated with a |)</th><th>4M15</th></tr>
<tr><td>Color Definition
(Column, Row, Color)
Where color is R,G,B</td><td>DS-21-04M15
T1=(1,1,M)
T2=(1,1,M)

DS-22-04M15
When svm=0
T1= (1,1,G) (2,1,R) (1,2,B) (2,2,G)
T2= (1,1,G) (2,1,R) (1,2,B) (2,2,G)
When svm=4
T1= (1,1,R) (2,1,G) (1,2,G) (2,2,B)
T2= (1,1,G) (2,1,R) (1,2,B) (2,2,G)
When svm=8
T1= (1,1,G) (2,1,R) (1,2,B) (2,2,G)
T2= (1,1,R) (2,1,G) (1,2,G) (2,2,B)
When svm=12
T1= (1,1,R) (2,1,G) (1,2,G) (2,2,B)
T2= (1,1,R) (2,1,G) (1,2,G) (2,2,B)</td></tr>
<tr><td>Row Color Offset <0,1,2,3…></td><td>0</td></tr>
<tr><td>Column Color Offset <0,1,2,3…></td><td>0</td></tr>
<tr><td>Row Binning Factor <1,2,3 or 1|2|3></td><td>1|2|4
Note: Row and Column binning values must be identical</td></tr>
<tr><td>Column Binning Factor <1,2,3 or 1|2|3></td><td>1|2|4
Note: Row and Column binning values must be identical</td></tr>
<tr><td>Pretrigger Pixels <0,1,2…or 0..15></td><td>0..15 (programmable)</td></tr>
<tr><td>Pretrigger Lines <0,1,2.. or 0..15></td><td>0</td></tr>
<tr><td>Line/Frame Time Minimum <xx ms></td><td>68</td></tr>
<tr><td>Line/Frame Time Maximum <xx ms></td><td>1000</td></tr>
<tr><td>Internal Line/Frame Time Resolution
<xx ns> 0 if not applicable</td><td>30 µs</td></tr>
<tr><td>Pixel Reset Pulse Minimum Width
<xx ns> 0 if not applicable</td><td>0</td></tr>
<tr><td>Internal Pixel Reset Time Resolution
<xx ns> 0 if not applicable</td><td>0</td></tr>
<tr><td>Pixel Reset to Exsync Hold time <xx ns></td><td>N/A</td></tr>
<tr><td>BAUD Rate <9600….></td><td>9600, 19200, 57600, 115200</td></tr>
<tr><td>CC1 <Exsync></td><td>Exsync</td></tr>
<tr><td>CC2 <Spare></td><td>Spare</td></tr>
<tr><td>CC3 <Forward, Spare></td><td>Spare</td></tr>
<tr><td>CC4 <Spare></td><td>Spare</td></tr>
<tr><td>DVAL out <Strobe Valid, Alternate></td><td>Strobe Valid</td></tr>
<tr><td>FVAL out <Frame Valid, Alternate></td><td>Frame Valid</td></tr>
<tr><td>Spare out <Spare></td><td>Spare</td></tr>
</table>

Appendix B

Networking Mode, Error Handling and Command List

This appendix describes how to configure your camera for networking mode and provides a list of error messages and a complete list of camera commands.

B1 Networking Mode

The camera's network feature provides the capability to connect and control multiple cameras over a multi-drop RS485 link.

The network feature consists of three commands and a set of definitions describing the behavior of the camera when the commands are sent in network mode.

Table 16: Networking Mode Commands

Command	Description
`sci`	Sets camera network ID
`gci`	Reads camera ID
`snm`	0: disable, default (messages enabled) 1: enable (messages disabled)

Camera ID

The camera ID is a single, case insensitive ASCII alphanumeric character: A to Z or 0 to 9.

To change the network ID for a camera, use the command **`sci i i`**. Where the first *i* is an ID of A to Z or 0 to 9, and the second, optional, *i* is the camera's serial number.

To read current camera ID, use the **`gcp`** command.

Changing Network ID of a Camera

Note: Each camera must be polled following use of a broadcast command.

To change the ID of a networked camera, even if some or all of the cameras share the same camera ID, provide the serial number of the camera as the second parameter when sending the broadcast version of the **`sci`** command.

Example:

To change network ID of camera with serial number abcd to 1:

```
sci 1 abcd CR
```

The Network Commands

The network command is an ordinary camera command prefixed by a network prefix. Network prefixes always start with the colon character ":" and are followed immediately by the camera ID (addressing a single camera on the network), or space (addressing all cameras on the network or a Broadcast command).

The camera replies to the network command only if it is addressed directly. The last line of the camera reply (error or OK message) to the network command is prefixed with the ID of the camera.

Example:

To return camera ID for camera a:

```
a gci CR

camera id: a

a OK>
```

Special Case: Empty Network Command

The empty network command is a special case of network commands. If the last command issued was not a Broadcast command, the empty network command will cause the addressed camera to output an "OK" message followed by the ">" prompt and prefixed by the network ID. If the last command issued was a broadcast command, the empty network command is used to query each camera for its READY/BUSY status.

Example:

To empty network command issued:

```
a CR

a OK>
```

Broadcast Commands and READY/BUSY Status

Broadcast commands are commands sent to all cameras on the network at the same time. After a broadcast command is sent, and before issuing the next command, *each* camera on the link must be polled until a READY status is returned. A BUSY status indicates that the camera is not ready to receive the next command.

To poll the status of a networked camera, send an empty network command to each camera until they each return the READY reply.

Both the READY and BUSY reply consist of six characters: Carriage Return (CR), Line Feed (LF), and the network ID of the queried camera, followed by a space and either the BUSY code "0", or the READY code "1" and the prompt character ">".

Example:

To query command followed by a BUSY reply:

```
a CR

<CR><LF>a 0>
```

Example:

To query command followed by a READY reply:

```
a CR

<CR><LF>a 1>
```

Note: The QUERY BUSY mode is active only after a broadcast command, normally the camera does not support this mode of operation. The controlling software must wait for a reply from the camera before sending the next command.

The camera will not reply to the Broadcast command.

Enabling/Disabling Non-Command Messages in the Network Environment

To enable / disable camera messages unrelated to the executed command, such as initialization and monitoring task messages, use the command **`snm i`**.

Table 17: Values for snm

Value	Function
0	Enable messages, default
1	Disable messages

B2 Error Handling

The following tables list the codes for errors, informal messages, and monitoring task messages. (Refer to section B3 on page 61 for a list of all available commands.)

Table 18: Error Codes

Code	Description	Suggested Cause
0	Command executed successfully	Command executed without major error detected
1	Internal camera error (PIXEL INDEX)	Internal software error trap
2	Internal camera error (RESULT CODE)	Internal software error trap
3	Invalid command	Command not recognized
4	Command parameters incorrect or out of range	Command parameters are invalid or out of range
5	Command not available in current exposure mode	**`ssf`** and **`set`** are allowed only in mode 2 (**`ssf`** and **`set`**) and in mode 6 (**`set`**)

Code	Description	Suggested Cause
8	Command not available in VIDEO TEST mode	**sao**, **sg**
10	Camera memory check failure	Memory test of external RAM failed
11	Unable to configure DSP	DSP (FPGA) configuration failure
12	DSP configuration reset failure	DSP (FPGA) could not be placed in configuration mode
14	DSP echo test error	DISC bus communication test failure
15	Invalid sensor configuration (DSP)	Invalid sensor configuration read from DSP (FPGA)
16	Invalid sensor configuration (ADC)	Invalid sensor configuration encoding on the board
17	Sensor configuration mismatch	Sensor configuration read from DSP is different than one encoded on the board
18	One (or more) of the supply voltages is out of specification	vv command result
23	CRC check failure while attempting to restore the camera settings	Camera setting will initialize to default settings, since restore of USER/FACTORY settings failed (internal micro EE memory failure)
24	Camera settings not saved	**rus**, **rfs** attempted but settings were not saved
27	Timeout waiting for DISC SYNC to go LOW	Internal communication protocol error

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

Monitoring Task Message Codes		
Code	**Description**	**Suggested Cause**
1	WARNING: One or more voltages out of specification	At least one of voltages is out of specification
16	WARNING: Current Gain Reference does not support full gain range	Current analog gain setting is out of specification

B3 Commands

As a quick reference, the following table lists all of the commands available to the camera user. For more detail on most of these commands, refer to chapter 3 or for more information on using the look up tables, refer to Appendix C.

Parameters:

`i` = integer
`f` = float
`t` = tap selector
`q` = window sequence
[ ]= optional parameter
x = column identifier
y= row identifier

Table 19: All Available Commands

Command Description	Syntax	Parameters	Description

display input LUT	`dil`	*`t i i`*	Displays the specified input LUT where:
			`i` = Tap number, either `1` or `2`, or `0` for all taps
			`i` = Start Address in a range from `0` to `1023`
			`i` = Stop Address in a range from `0` to `1023`
			See Appendix C for more information on using look up tables.

display output LUT	`dol`	*`i i`*	Displays the specified output LUT where:
			`i` = Start Address in a range from `0` to `1023`
			`i` = Stop Address in a range from `0` to `1023`
			See Appendix C for more information on using look up tables.

enable input LUT	`eil`	*`i`*	Enable or disable the input LUTs. When disabled, the video path is routed around the active LUTs, but the set values remain unchanged where *`i`* is: `0`: Disable input LUT, default `1`: Enable input LUT See Appendix C for more information on using look up tables.
enable output LUT	`eol`	*`i`*	Enable or disable the output LUTs. When disabled, the video path is routed around the active LUTs, but the set values remain unchanged where *`i`* is: `0`: Disable input LUT, default `1`: Enable input LUT See Appendix C for more information on using look up tables.

Command Description	Syntax	Parameters	Description
factory LUT mode	`flm`	*i*	Loads a factory calibrated LUT where *i* is: 0: User LUT mode. Disable factory LUTs. 1: 0dB gain 2: 6dB gain 3: 12dB gain See Appendix C for more information on using look up tables.
get camera id	`gci`		Read the camera ID
get camera model	`gcm`		Read the camera model number
get camera parameters	`gcp`		Read all of the camera parameters. **Note:** Sequence of camera parameters may change as new functionality is added to the camera. When possible, use commands specific to the information you want to retrieve
get camera serial	`gcs`		Read the camera serial number
get camera version	`gcv`		Read the firmware version and FPGA version
get sensor serial	`gss`		Read the sensor serial number
help	`h`		Display the online help
reset camera	`rc`		Reset the entire camera (reboot)
restore factory settings	`rfs`		Restore the camera's factory settings.
restore user settings	`rus`		Restore the camera's last saved user settings.
retrieve input LUT	`ril`	*i*	Retrieves the input LUT where i is the bank number of the LUT to retrieve. Allowable range is 1 to 2.
set analog offset	`sao`	*t i*	Set the analog offset. The first parameter, *t*, is the tap number either 1 or 2, or 0 for all taps. The second parameter, *f*, controls the digital analog convertor (DAC), where allowable input values range from 0 to 1023, resulting in an output between 1 and 10 DN. Offset increases with higher values.
set baud rate	`sbr`	*i*	Set the speed of the camera serial communication port. Available settings are 9600, 19200, 57600, and 115200.

Command Description	Syntax	Parameters	Description
set binning mode	**sbm**	***i i***	Set the binning mode. The first parameter sets the horizontal binning. The second parameter sets the vertical binning. Available modes are **1**x**1**, **2**x**2**, or **4**x**4**. The default value is 1x1.
set camera id	**sci**	***i*** [*i*]	Set the camera ID. The first parameter is an alphanumeric character A to Z, or 0 to 9. The second parameter is optional, this is the serial number of the addressed camera.
set data mode	**sdm**	***i***	Sets the output data mode. Use **0** for 10 bit mode or **1** for 8 bit mode.
set exposure mode	**sem**	***i***	Set the exposure mode: **2**: ***(Factory Setting)*** Internal SYNC, programmable frame rate and exposure time using commands ssf and set **3**: External SYNC,, maximum exposure time **4**: Smart EXSYNC **6**: External SYNC, programmable exposure time
set exposure time	**set**	***i***	Set the exposure time in exposure mode 2 or 6. Where ***i***, is the exposure time set using a fixed point number in µsecs in a range from **68-1000000.00**.
set gain	**sg**	***t f***	Set the analog gain. The first parameter, ***t***, is the tap selection, either **1** or **2**, or **0** for all taps. The second parameter, ***f***, is a gain value specified from **0** to **15**. A gain value of 0 sets the camera to its nominal gain
set netmessage mode	**snm**	***i***	Enable / disable camera messages unrelated to the executed network command: **0**: Enable messages, default **1**: Disable messages
set pretrigger	**sp**	***i***	Set the pretrigger to a value from **0** or **15**
set sync frequency	**ssf**	***i***	Sets the Frame Rate, in exposure mode 2, to a value from **1**Hz to **16**Hz. The actual frame rate will be up to +30µsec of 1/(entered value) when integration overlaps readout, otherwise it will be within +/- 1us. The frame rate can be read back using the command **gcp**.

Command Description	Syntax	Parameters	Description
set video mode	`svm`	*i*	**Set video mode:** `0`: Normal operating mode `1`: Test pattern Left side `2`: Test pattern Right side `3`: Test pattern Both sides `4`: Flip image Left side `5`: Flip image Left side Test pattern Left side `6`: Flip image Left side Test pattern Right side `7`: Flip image Left side Test pattern Both sides `8`: Flip image Right side `9`: Flip image Right side Test pattern Left side `10`:Flip image Right side Test pattern Right side `11`:Flip image Right side Test pattern Both sides `12`:Flip image Both sides `13`:Flip image Both sides Test pattern Left side `14`:Flip image Both sides Test pattern Right side `15`:Flip image Both sides Test pattern Both sides
voltage verify	`vv`		Check the camera voltages and return OK or fail
warning enable disable	`wed`	*i i*	Read enable / disable status of all defined monitoring tasks. Optionally, the first value selects a monitoring task and the second value enables / disable the selected task. See section 3.13 Monitoring Tasks for a list of tasks
write input LUT	`wil`	*i*	Writes the current LUT settings to the bank indicated by *i*. Either `1` for bank one or `2` for bank two.
write output LUT	`wol`	*i*	Writes the current output LUT settings to the bank indicated by *i*. Either `1` for bank one or `2` for bank two.
write user settings	`wus`		Write all of the user settings to EEROM

Command Description	Syntax	Parameters	Description
window start end	**wse**	***q i x1 y1 x2 y2***	Sets the window start and stop pixels where: ***q*** is the window sequence id. It is always **0** in the 4M15. ***i*** is the number of AOIs to set. It is always **0** in the 4M15. ***x1*** is the column start. Since the 4M15 only allows you to set a vertical area of interest, this value is always **1**. ***y1*** is the row start identifier with a range of **1** to an integer less than the row end identifier (**y2**). If you are using the color (DS-22-04M15) 4M15, this value **must be odd** in order to preserve the color filter array Bayer pattern. Otherwise, the image will be corrupted. ***x2*** is the column end identifier. Since the 4M15 only allows you to set a vertical area of interest, this value is always **1**. ***y2*** is the row end identifier with a range greater than the row start identifier (**y1**) to the number of vertical pixels in the sensor. If you are using the color (DS-22-04M15) 4M15, this value **must be even** in order to preserve the color filter array Bayer pattern. Otherwise, the image will be corrupted.

Appendix C

Tap Matching Using Look up Tables (LUTs)

Within a multi-tap camera, each tap response can vary depending on differences in sensor output amplifiers, analog chain components, and analog to digital converters (ADCs). The purpose of using the input LUTs is to improve tap to tap matching over the entire output range of possible values.

The LUT values can be loaded into the camera and then enabled or disabled as desired.

The use of an input LUT on each tap will transform post-ADC image data and improve on the matching between output taps. The output response for a uniformly illuminated and uniformly flat scene in front of the camera will be well matched from tap to tap. If the uniform illumination level were to vary, the tap matching would continue to perform similarly. The range of improved matching is designed to be 10-90% of the output response.

Note: Calibration of the LUTs is based on 10 bits of input image data and 10 bits of output image data. There is the possibility of the existence of missing output codes within the 10 bit image data range as a direct result of improved tap matching.

Note: The use of the input LUT is a purely digital transformation and is constrained by the analog signal processing circuitry left unchanged. Thus, camera performance with the LUT enabled is not able to exceed that which is capable of the analog circuitry.

C1 Using Factory Calibrated Look Up Tables

There are three LUTs that are allocated to the pre-set LUTs calibrated at the factory. Each LUT is directly associated to three different gain settings: 0dB, 6dB, and 12dB.

The gain operating conditions are affected by other conditions such as analog gain, analog offset, and calibration temperature. Best performance of the LUTs requires control of all the supporting conditions. Table 20 outlines the recommended camera operating conditions for each factory calibrated LUT.

Table 20: Pre-Set LUT Overview

	Recommended Camera Operating Conditions				
Load LUT Command	Analog Gain Setting (dB)		Analog Offset (DN)		Front Plate Temp. (°C)
	Tap 1	Tap 2	Tap 1	Tap 2	
`flm 1`	0	0	10	10	25
`flm 2`	6	6	11	11	25
`flm 3`	12	12	21	21	25

To load a pre-set LUT:

1. Perform analog adjustments as recommended in Table 20.
2. Set the factory LUT mode to one of the three settings outlined in Table 20 using the command **`flm i`** where ***i*** is the LUT mode to use.

Once the factory LUTs are enabled, the camera digital gain (**`ssg t i`** command) and background subtract (**`ssb t i`** command) may be used, if desired, but values entered for both taps must be the same. This preserves the tap matching performance while still allowing post-input LUT digital adjustment of gain and offset. Using different values for each tap will degrade tap matching performance.

In addition, while you are using a pre-set LUT, commands for setting analog gain, analog offset, retrieving input LUT, and enabling input LUT are disabled. You can, however, still store factory LUT values as custom LUT values using the input LUT command **`wil i`** where ***i*** is the bank number, either **`1`** or **`2`**.

C2 Creating a Custom LUT

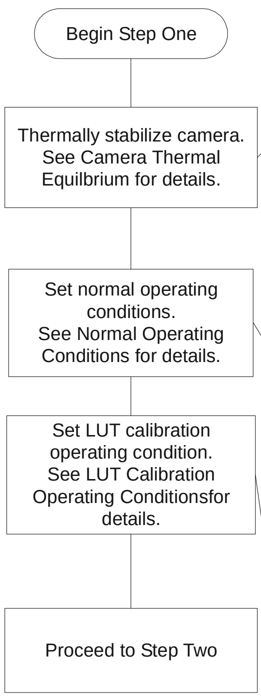
If you want to operate the camera at a gain setting that is different from those defined in the pre-set factory LUTs, you can optimize tap-matching performance by creating your own LUT.

Calibration of the LUTs takes into account the following operating conditions: analog gain, analog offset, temperature and illumination conditions on two measurement areas for the two taps. Calibration and the resulting camera performance is based solely upon the two measurement areas and is not generalized to the image array outside of such areas.

To create a custom LUT, you will need to complete the steps outlined in the following section. In order to complete the following steps, you require the LUT Calibration spreadsheet available at http://vfm.dalsa.com/docs/docs.asp in the Software folder. Note that if you have not done so already, you must register as a member of the DALSA Web site to access this folder.

Step One: Preparing the Camera for LUT Calibration

In this step, you will be configuring your camera settings to begin the LUT calibration procedure. You will first calibrate your camera to your desired operation conditions and then calibrate the camera in preparation for LUT calibration.
Note: This flowchart assumes you are familiar with using the Pantera SA 4M15 command set. For a detailed explanation of any of the camera commands used in the following procedure, refer to Chapter 3 and Appendix B.



Allow camera to reach thermal equilibrium. The camera should be thermally stable within 45 minutes of operation.

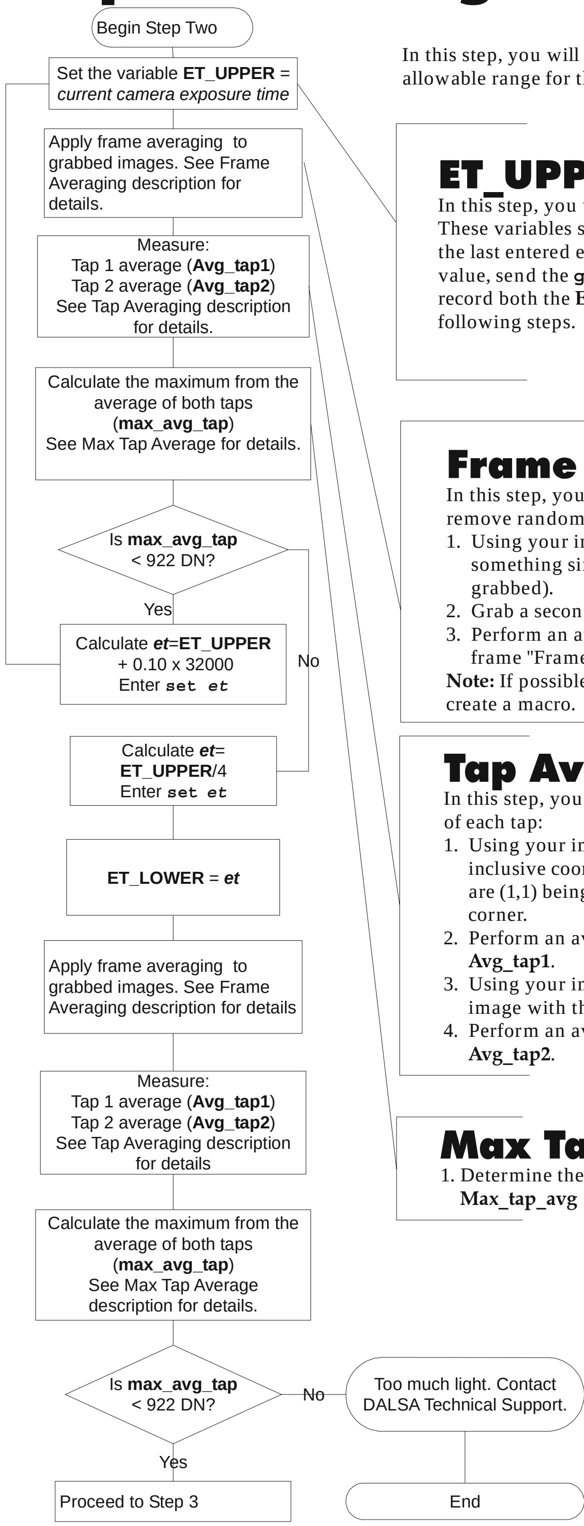
Follow these steps to set camera to your desired operating conditions:

1. Apply your system illumination.
2. Disable factory LUT using the command, **`flm 0`**.
3. Disable output LUT using the command, **`eol 0`**.
4. Set exposure mode using the command **`sem`** ***`i`***.
5. Set frame rate (if applicable to exposure mode) using the command **`ssf`** ***`i`***.
6. Set exposure time (depending on exposure mode) using the command **`set`** ***`i`***.
7. Set background subtract value to 0DN using the command **`ssb 0 0`**.
8. Set digital gain to 1.0x using the command **`ssg 0 1.0`**.
9. Set binning mode using the command **`sbm`** ***`i i`***.
10. Set area of interest using the command **`wse`** ***`q i x1 y1 x2 y2`***.
11. Set any necessary pretrigger using the command **`sp`** ***`i`***.
12. Set analog offset using the command **`sao`** ***`t i`***. Under dark conditions, ensure that the analog offset is matched for both taps within ±1DN. Otherwise, match as best as possible. For best results, there should be no zeros present in the output data. To test for zeros, apply a histogram to the grabbed image.
13. Set analog gain using the command **`sg`** ***`t i`***. Under illuminated conditions, ensure that the analog gain is matched with both taps within ±10DN. Otherwise, match as best as possible.
14. Repeat steps 12 and 13 as necessary.

Follow these steps to configure the camera in preparation for LUT calibration:

1. Apply uniformly white imaging target or defocused columated illumination to front of camera.
2. Set camera to exposure mode 2 using the command **`sem 2`**.
3. Set frame rate to 15 fps using the command **`ssf 15`**.
4. Set exposure time to 32000 µsec using the command **`set 32000`**.
5. Leave camera background subtract set to 0 DN using the command **`ssb 0 0`**.
6. Leave camera analog offset unchanged at your normal operating mode setting.
7. Leave digital gain set to 1.0x (**`ssg 0 1.0`**).
8. Leave the camera analog gain setting unchanged at your normal operating mode setting.
9. Set the video output mode to normal using the command **`svm 0`**.
10. Set the data output mode to 10 bits using the command **`sdm 0`**.
11. Set binning mode to 1x1 using the command **`sbm 1 1`**.
12. Set area of interest to maximum rows using the command **`wse 0 0 1 1 2048 2048`** and ensure that the grabbed image is 2048 rows by 2048 columns.
13 Leave input LUT disabled (**`eil 0`**).
14. Leave output LUT disabled (**`eol 0`**).

Step Two: Testing for Valid Illumination



In this step, you will be testing whether your illumination conditions are within the allowable range for the LUT calibration algorithm.

ET_UPPER and ET_LOWER Variables

In this step, you will be working with an **ET_UPPER** and an **ET_LOWER** variable. These variables store camera exposure times. Here, the **ET_UPPER** variable is set to the last entered exposure time value sent to the camera. If you do not know the value, send the `gcp` command to retreive the exposure time. On a piece of paper, record both the **ET_UPPER** and **ET_LOWER** values for reference during this and the following steps.

Frame Averaging

In this step, you will be performing frame averages on multiple frames in order to remove random noise:

1. Using your imaging software, grab one frame and name it "Frame1" (or something similar that helps you track the frame number you have grabbed).
2. Grab a second frame and name the frame "Frame2".
3. Perform an average function on Frame1 and Frame2 and name the new frame "Frame3".

Note: If possible with your framegrabber, this process can be completed quicker if you create a macro.

Tap Averaging

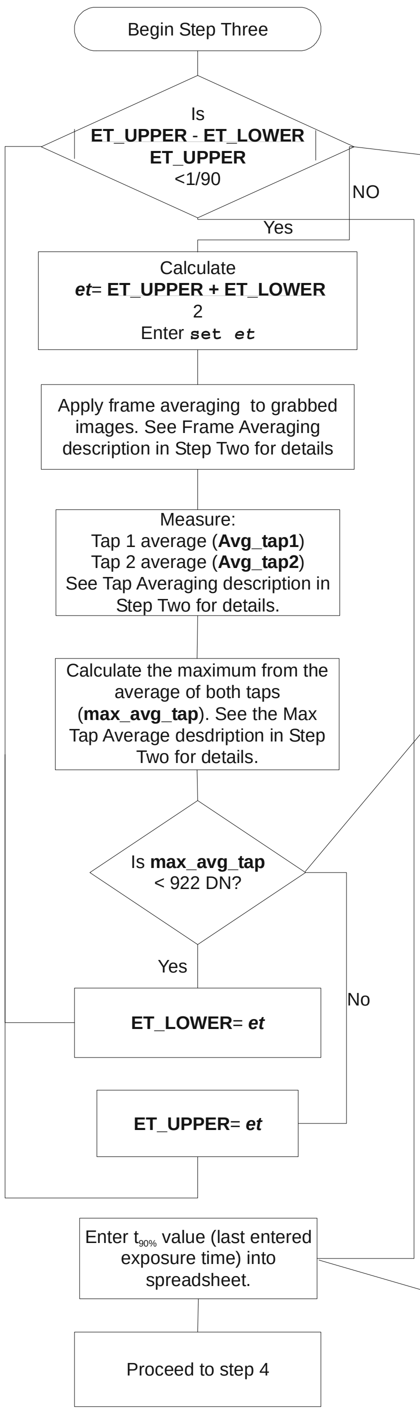
In this step, you will be calculating the average pixel value within a specified area of each tap:

1. Using your imaging software, create a measurement box in tap 1 with the inclusive coordinates of (285, 345) and (796, 856). Origin coordinates of the image are (1,1) being the top left corner and (1600, 1200) being the diagonally opposite corner.
2. Perform an average function on the tap 1 measurement area. Note the value as **Avg_tap1**.
3. Using your imaging software, create a measurement box in tap 2 of the same image with the inclusive coordinates of (805, 345) and (1316, 856).
4. Perform an average function on this tap 2 measurement area. Note the value as **Avg_tap2**.

Max Tap Average

1. Determine the max average value of the two taps, using the formula:
   Max_tap_avg = max (Avg_tap1, Avg_tap2)

Step Three: Determining $t_{90\%}$



In this step, you will be using a bisection method to locate an exposure time within 1% of the $t_{90\%}$ value. It will probably take a number of iterations before you locate the value.

The $t_{90\%}$ value is the required exposure time value in µsec to produce 90% of the full scale output from the camera based on the maximum DN value possible of 1023 and the dark offset value, also in DN.

These are the variables that you recorded in the previous step.

What is so special about 922 DN?

Answer: 922 DN corresponds to 90% of the maximum required input exposure time.

Consider the operating parameters of a 10 bit output and a Desired Response Offset of 10 DN. At 0% input exposure time, the camera output is 10 DN. At 100% input exposure time, the output is ($2^{10\text{ bit}}$-1) DN. If a linear relationship is defined through the two operating points of mininum and maximum exposure time, the equation is represented by the following:

$$output = \frac{(2^{10\text{ bit}} - 1) - DesiredResponseOffset}{t_{100\%}} \times t_{nn\%} + DesiredResponseOffset$$

where:

output *is in units of DN*

DesiredResponseOffse*t is in units of DN*

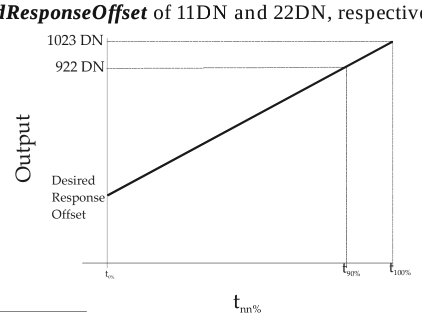
$t_{100\%}$ is the maximum exposure time in units of usec to produce ($2^{10\text{ bit}}$ -1) DN

$t_{nn\%}$ is the input exposure time in units of µsec

The ***DesiredResponseOffse****t* is dependent on the nominal gain used. Thus, at a different gain setting leading to a different ***DesiredResponseOffse****t*, the output value at 90% correspondingly changes.

For example, given a certain amount of illumination, the output is 10 DN, 516.5 DN and 921.7 DN at 0%, 50%, 90% exposure times, respectively. This is assuming a scenario of no FPN, no PRNU, no random noise, perfect linearity, and an infinite resolution analog-digital converter. Note that the value 921.7 DN is rounded to yield the special value of 922 DN.

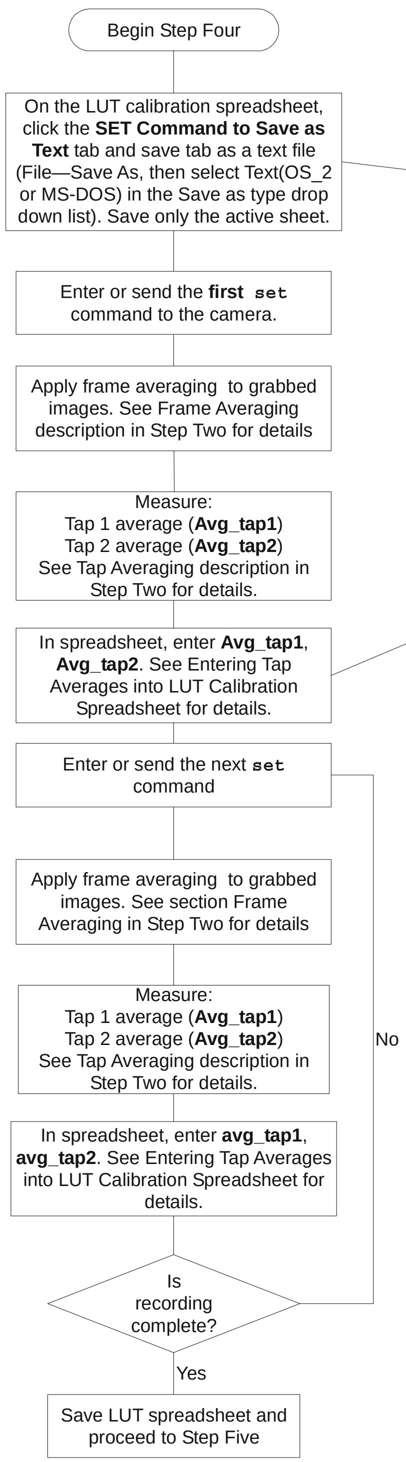
Other examples of output at 90% exposure time include 921.8DN and 922.9DN for ***DesiredResponseOffset*** of 11DN and 22DN, respectively.



1. Open the **LUT Calibrations.xls** spreadsheet if it is not already open. If you require a copy of the spreadsheet, you can download it from the DALSA Web site at http://vfm.dalsa.com/docs/docs.asp in the Software folder.
2. On the **Enter Data Here** tab, in the cell under the title **Enter t90% found from Bisection Method**, enter your $t_{90\%}$ value.

After you have entered the $t_{90\%}$ value, the $t_{1\%}$ to $t_{90\%}$ values are automatically caluculated and populated into the **Exposure Time** column of the spreadsheet.

Step Four: Recording Tap Averages for $t_{nn\%}$ Exposure Times



In this step, you will be recording tap averages for each of the $t_{nn\%}$ exposure times.

Saving Text Files

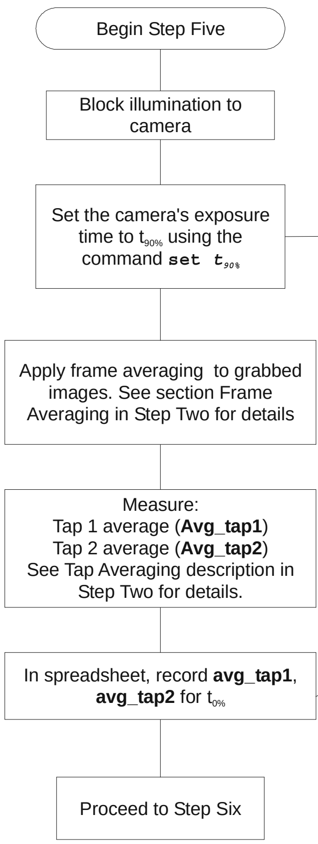
Save the commands as a text file so you can send the commands to the camera through your terminal application rather than having to type in each command individually. For example, to send a file using Microsoft HyperTerminal, select **Transfer** then **Send File**.

Entering Tap Averages into LUT Calibration Spreadsheet

1. Open the **LUT Calibrations.xls** spreadsheet if it is not already open.
2. On the **Enter Data Here** tab, enter the **Avg_tap1**, and **Avg_tap2** beside the corresponding exposure time.

Step Five: Recording Tap Averages for $t_{0\%}$ (Dark Offset)

In this step, you will be recording tap averages while blocking illumination to the camera. Since it is not possible to set the camera to a zero exposure time, an acceptable condition is created by setting the exposure time to $t_{90\%}$ and blocking the illumination to the camera.



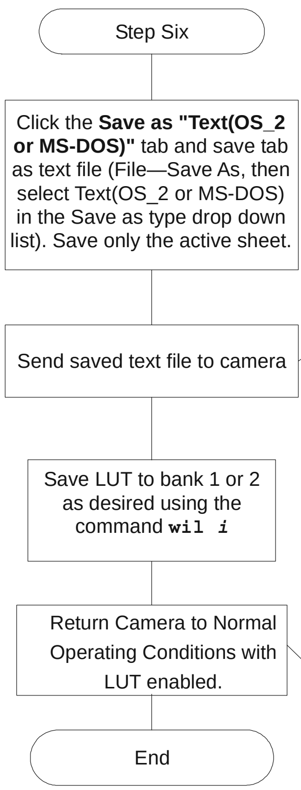
If it is not possible to block light to the camera, enter the minimum allowable Exposure Mode 2 exposure time. See the `set` command for the minimum allowable value.

Entering $t_{0\%}$ Tap Averages into LUT Calibration Spreadsheet

1. Open the **LUT Calibrations.xls** spreadsheet if it is not already open.
2. On the **Enter Data Here** tab, enter the **Avg_tap1**, and **Avg_tap2** beside the $t_{0\%}$ exposure time.

Step Six: Sending LUT Calibration Commands to Camera

In this step, you will be sending the LUT calibration commands to the camera and returning to your normal operating conditions.



Sending Commands to the Camera

This text file contains 2048 **`sil`** commands. To avoid having to enter each command separately, you can send the text file through an application like Microsoft HyperTerminal. In HyperTerminal, select **Transfer** then **Send File**. Note that in order to use this function, your framegrabber must support a virtual COMM port.

Return Camera to Normal Operating Conditions with LUT Enabled

1. Apply system illumination.
2. Set exposure mode (**`sem i`**).
3. Set frame rate (**`ssf i`**).
4. Set exposure time if appropriate (**`set i`**).
5. Set camera background subtract as necessary. To ensure that you retain tap matching keep the subtraction the same for both taps. (**`ssb 0 i`**).
6. Set camera digital gain as necessary. To ensure that you retain tap matching keep the gain the same for both taps. (**`ssg 0 i`**).
7. Set binning mode (**`sbm i`**).
8. Set area of interest (**`wse q i x1 y1 x2 y2`**).
9. Set any necessary pretrigger (**`sp i`**).
10. Enable input LUT (**`eil 1`**).
11. Leave factory LUT mode unchanged (**`flm 0`**)
12. Set output LUT (**`eol i`**).
13. Record Normal Operating Conditions using **`gcp`** and **`dil 0 0 1023.`**

C2 Output LUTs

The output LUTs allow you to apply custom LUTs to the video stream. The output LUTs are a set of general-purpose lookup tables that are applied to the digitized camera data immediately before the data exits the camera. With the output LUTs, you can apply image characterizations such as brightness, contrast, or apply a gamma look-up table. The output LUTs differ from the input LUTs in that a single set of table values is common to all output taps of the camera; there is no mechanism to handle the different taps independently.

You can create a table to generate almost any camera output response desired. Linear functions such as y = mx + b or y = a1 * x^2 + a2 * x + a3 can be easily generated and loaded into the LUT using a scripted macro containing repeated calls to the set output LUT (**`sol`**) command. The following are examples of common applications of LUTs:

Unity LUT (output = input)

LUT = [0, 1, 2, 3… 1020, 1021, 1022, 1023]

Gain of 2 (output = 2 * input) 1

LUT = [0, 2, 4, 6… 1023, 1023, 1023, 1023]

Offset of 2 (output = 2 * input + 2) 1

LUT = [2, 3, 4, 5… 1022, 1023, 1023, 1023]

Or any other desired mapping (e.g. output= 3 * output^2 + 1)

LUT = [1, 4, 13, 28… 1023, 1023, 1023, 1023]

Note: Values loaded into the LUT must be within the valid range for a 10-bit integer (0 <= x <= 1023). If the desired function exceeds either the upper or lower bound, the table output data should be clipped to the valid range.

C3 All LUT Commands and Examples

Display Input LUT (`dil`)

This command is used to retrieve and display the contents of the input LUTs via the serial interface. The expected use of this command is to read back the contents of the selected LUT for verification or archival purposes. Three parameters must be supplied to the command: *tap, start address,* and *stop address.*

In the following example, the **`dil`** command is used to read out the first 12 elements of both taps. Note that the two taps are loaded with identical LUT data.

```
OK>
OK>dil 0 0 11
TAP 1
956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967,
TAP 2
956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967,
OK>
```

Retrieve Input LUT (`ril`)

This command loads a given bank (or set) of LUTs from nonvolatile storage into active LUT memory. The inverse of this command is "Write Input LUT" which stores the active LUTs to nonvolatile memory.

In the following example, the input LUTs from bank 2 are recalled into active memory.

```
OK>
OK>ril 2
OK>
```

Set Input LUT Value (`sil`)

This command allows manipulation of the values stored in an input LUT. Users wanting to load an entire LUT from the host pc to the camera will need to call this function up to 2048 times – once for each table (1024 locations) per tap (2 taps).

In the following example, three calls to *sil* are made. The first sets the first cell of both taps to a value of ten, the second sets element 511 of the tap 1 input LUT to 123, and the third sets the element 1023 of tap 2 to a value of 768.

```
OK>
OK>sil 0 0 10       // Sets Taps 1 & 2, Addr 0 to 10
OK>sil 1 511 123          // Sets Tap 1, Addr 511 to 123
OK>sil 2 1023 768         // Sets Tap 2, Addr 1023 to 768
OK>
```

Write Input LUT (`wil`)

Stores the current contents of the active input LUTs to the given bank of nonvolatile memory. The information for both taps is automatically stored. The inverse function "Retrieve Input LUT" loads the stored data to active memory.

The following example stores the contents of the input LUTs to bank 3.

```
OK>
OK>wil 3
OK>
```

Enable Input LUTs (`eil`)

This command enables or disables the input LUTs. When disabled, video is routed through bypass circuitry allowing it to circumvent the input LUT logic. When enabled, video is routed through the input lookup tables.

The following example disables and then re-enables the LUTs.

```
OK>
OK>eil 0                    // Disables input LUTs
OK>eil 1                    // Enables input LUTs
OK>
```

Display Output LUT (`dol`)

This command is used to retrieve and display the contents of the output LUT via the serial interface. The expected use of this command is to read back the contents of the selected LUT for verification or archival purposes.

In the following example, the *dol* command is used to read out the first 12 elements of the output LUT. Note that a single table is shared between both taps.

```
OK>
OK>dol 0 0 11
956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967,
OK>
```

Retrieve Output LUT (`rol`)

This command loads the output LUT stored ine the given bank to the active output LUT.. The inverse of this command is "Write Output LUT" which stores the active LUT to nonvolatile memory.

In the following example, the output LUT from bank 2 is recalled into active memory.

```
OK>
OK>rol 2
OK>
```

Set Output LUT Value (`sol`)

This command allows manipulation of the values stored in an input LUT.

In the following example, element 0 of the output LUT is set to ten.

```
OK>
OK>sol 0 10                // Sets Output LUT, Addr 0 to 10
OK>
```

Write Output LUT (`wol`)

Stores the current contents of the active output LUT to the given bank of nonvolatile memory. The inverse function "Retrieve Output LUT" loads the stored data to active memory.

The following example stores the contents of the output LUT to bank 3.

```
OK>
OK>wol 3
OK>
```

Enable Output LUTs (`eol`)

This command enables or disables the output LUTs. When disabled, video is routed through bypass circuitry allowing it to circumvent the output LUT logic. When enabled, video is routed through the output lookup tables.

The following example disables and then re-enables the LUT.

```
OK>
OK>eol 0                    // Disables output LUT
OK>eol 1                    // Enables output LUT
OK>
```

Set System Gain (ssg)

Provides the mechanism for setting the digital gain used within the camera. Each tap can be independently controlled or both can be set together to match. Gain is adjustable from 1.000 to 4.0000.

The following example sets both camera taps to 1x gain and then sets one tap to 3.3x gain.

```
OK>
OK>ssg 0 1   // Sets the gain for both taps to 1x.
OK>ssg 1 3.3        // Sets the gain for tap1 to 3.3x (approx)
OK>
```

Set Subtract Background (ssb)

Provides the means for adjusting the subtracted background option in the camera. The background value can be any integer between 0 and 1023. For normal operation, a typical value of zero is used.

In the following example, the background value is set to zero and then the value for tap 1 is changed to ten.

```
OK>
OK>ssb 0 0          // Sets the background to 0 for both taps
OK>ssb 1 10         // Sets the background to 10 for tap 1
OK>
```

Appendix D

EMC Declaration of Conformity

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

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

DS-2x-04M15

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

EMC: **EN 61326:2001**

EN55011 Class A
EN61000-3-2
EN61000-3-3
EN61000-4-2
EN61000-4-3
EN61000-4-4
EN61000-4-5
EN61000-4-6
EN61000-4-11

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

Place of Issue	Waterloo, ON, CANADA
Date of Issue	February 2005
Name and Signature of authorized person	**Hank Helmond** **Quality Manager, DALSA Corp.**

This Declaration corresponds to EN 45 014.

Appendix E

Revision History

Revision Number	Change Description
00	Preliminary release.
01	Updated Back Focal Distance on page 8 from 6mm±0.30 to 6.56±0.30. Was incorrect. Made the same correction on page 39 for M42 spec. On page 59 in table 18 the second parameter for the sg command changed to f (float) from i (integer) On page 52 in table 14 on line Internal Line / Frame Rate resolution changed from 26µs to 30µs.
02	Updated power supply input voltage range from 11-25V to 12-25V. Changes made to page 5 (2x), page 9 and 10 (table 3), page 14 (figure 7), page 16 (figure 9) and page 40. Updated Appendix D: EMC Declaration of Conformity with new codes.

Index

A

analog gain, 33
AOI. *See* area of interest
applications, 6
area of interest, 30
  frame rate calculation, 30
  rules, 31
  setting, 32

B

base configuration, 14
baud rate, 22
bayer pattern, 8
binning, 29
  frame rate calculation, 30
bright lines, 45

C

cables, 16
calculating frame rate, 30
camera
  cooling, 39
  features, 5
  models, 6
  mounting, 39
camera control signals, 15, 50
Camera Link
  base configuration, 14
  connector, 14
  input signals, 15
  output signals, 16
  pinout, 15
clock signals, 16
color
  array pattern, 8
  image corruption, 46
command protocol, 19
commands, 59
  networking, 55
  overview table, 59
  reference, 55
connectors
  Hirose, 16
  power, 16
cooling, 39
current camera settings
  reading, 19
  saving, 21
custom LUTs, 66

D

dark patches, 45
data mode, 22
data rate, 9
DC Offset, 10
digital gain, 34
DVAL, 49
dynamic range, 9, 10

E

electrical
  specs, 9
EMC Declaration of Conformity, 79
environmental considerations, 39
error messages, 55, 57
exposure mode
  setting, 23
exposure modes, 23
exposure time
  setting, 23, 27
EXSYNC, 16
  troubleshooting, 43
external trigger, 16

F

factory LUTs, 65
features, 5
fiber-optic light sources, 41
filters, 42
frame rate, 9
  calculation, 30
  setting, 23, 27
FVAL, 49

G

gain
  analog, 33
  digital, 34
  range, 9
graph
  angular dependnece of QE, 11

quantum efficiency, 11

H

halogen light sources, 41
heatsinking, 39
help, 19
Hirose connector, 16
hot mirror, 42

I

illumination, 41
image readout, 36
incorrect line rate, 45
input signals, 15
installation, 13
integration time, 28
interface
electrical, 9
mechanical, 9, 39
optical, 9, 41
parameters, 52
internal sync
mode, 24
setting, 27

L

LED, 14
lens
C-Mount, 41
F-Mount, 41
M42, 41
modeling, 42
mounts, 41
light sources, 41
line dropout, 45
look up tables. *See* LUTs
LUTs
calibrated, 65
custom, 66
factory, 65
user defined, 66
LVAL, 49
LVDS, 49
pairs, 50

M

magnification, 42
MDR26 connector, 14, 15
mechanical interface, 13, 39
mechanical specs, 9
mirroring, 36
model numbers, 6
modes
default, 24
exposure, 23
networking, 55
operating, 23
video, 36
monitoring tasks, 35
mounting, 39

N

NEE, 10
networking, 55
no output, 45
noisy output, 45

O

offset
analog, 33
optimizing, 33
online help, 19
operating temp, 9
optical
interface, 41
specs, 9
output
mode, 22
signals, 16

P

power
connectors, 16
supplies, 16
supply current, 10
pretrigger, 36
PRNU, 9

Q

quantum efficiency
angular dependence, 11
sensor, 11

R

rate
data, 10
frame, 10
rebooting, 35
resolution, 8
responsivity, 10
RMS noise, 10

S

SEE, 10
sensitivity, increasing, 29

sensor, 6
  alignment, 9
  color, 7, 8
  cosmetic specifications, 8
  monochrome, 7
  output, 8
  quantum efficiency, 11
  readout settings, 36
serial interface, 19
settings
  factory, 21
  reading, 19
  restoring, 21
  saving, 21
  saving and restoring, 21
  user, 21
signals
  input, 15
  output, 16
specifications
  electro-optical, 9
  sensor cosmetic, 8
startup, 21
startup sequence, 20
support, 47
sync, setting, 23

T

tap reconstruction, 52
Technical Sales Support, 47
temperature, 9, 39
test patterns
  description, 34
  generating, 34, 44
  setting, 36
timing, 51
  camera, 51
  Camera Link, 51
  constrains, 28
  exposure, 27
  factory, 24
  integration, 28
  mode 2 (programmable), 24
  mode 3 (exsync, max exposure time), 25
  mode 4 (smart exsync), 25
  mode 6(exsync, programmable exposure), 26
trigger
  external, 16
  internal, 24
troubleshooting, 43
  serial interface, 44
  STROBE, 44

V

video
  data, 49
  modes, 36
voltage
  measurement, 35

W

warning messages, 58