

1.4 Megapixel 100 fps CMOS Area Scan Cameras



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Falcon 1.4M100

Camera User's Manual
FA-20-01M1H



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Introduction to the Falcon 1.4M100 Camera

1.1 Camera Highlights

1.1.1 Features

- 1.4 megapixels, 1400(H) x 1024(V) resolution
- Global shutter (non-rolling shutter) for crisp images
- 100 fps model
- Compact camera body – 44mm x 44mm x 44mm – fits into the smallest of places
- Base mini-Camera Link™ SDR26 cable interface for greater ease of use
- Enhanced data drive capability – Achieves 80MHz data with 10m cables
- Vertical windowing for faster frame rate
- 7.4µm x 7.4µm pixel pitch
- Good near-infrared (NIR) response
- 2x80MHz data rates
- 8 or 10 bit selectable output
- Dynamic range of 57dB

1.1.2 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

1.1.3 Description

The Falcon 1.4M100 camera provides 1.4 megapixel image capture at high frame rates of 100fps. The global shutter capability of the sensor makes this camera capable of capturing low smear images at incredibly fast rates. Its small camera body and mini-Camera Link™ cabling allows the camera to fit into space-constrained applications. With its enhanced data drive capability, mini-Camera Link cables up to 10m in length can be used. Programmable features and diagnostics are accessible through the mini-Camera Link SDR26 connector.

1.1.4 Applications

The Falcon 1.4M100 camera is ideal for applications requiring high speed, superior image quality, and high responsiveness, in space constrained areas. These features make the Falcon 1.4M100 applicable to:

- PCB-AOI inspection
- Semiconductor wafer inspection
- Electronics inspection
- Flat panel display inspection
- Industrial metrology
- Traffic management
- General machine vision

1.2 Camera Performance Specifications

Feature / Specification	Units		Notes
Resolution	pixels	1400Hx1024V	
Effective fill factor with microlenses	%	60	
Output Format (# of taps)		2 Tap Interleaved (odd/even)	

Optical Interface	Units		Notes
Back Focal Distance			
Sensor die to mounting plate	mm	17.52	4
Sensor Alignment			
x	mm	+/- 100 microns	
y	mm	+/- 100 microns	
z	mm	+/- 150 microns	
θ_z	°	+/- 0.2	
Lens Mount		C-mount	

	Units		Notes
Camera Size	mm	44 x 44 x 44	
Mass	g	105g	
Connectors			
power connector		6 pin male Hirose	
data connector		SDR26 female - mini Camera Link	

Electrical Interface	Units		Notes
Input Voltage	Volts	+12V to 15V	
Power Dissipation	W	≤ 3	
Operating Temperature	°C	0 to 50	1
Data Output Format	Bits	8 or 10 user selectable	
Output Data Configuration		Base mini-Camera Link	

Operating Ranges	Units		Notes
Minimum Frame Rate	Hz	0	
Maximum Frame Rate	Hz	100	
Data Rate	MHz	2 @ 80	
Dynamic Range (10 bits @ nominal gain)	Ratio	602:1	2
Random Noise	DN rms	1.7	
Broadband Responsivity	DN/(nJ/cm ²)	12	

Operating Ranges	Units		Notes
DC Offset	DN	1	5
Antiblooming		>1000 x Saturation	
FPN	DN rms	1.2	5
PRNU	DN rms	4	5, 6
Integral non-linearity	DN	$\leq 2\%$	3

Test conditions unless otherwise noted:

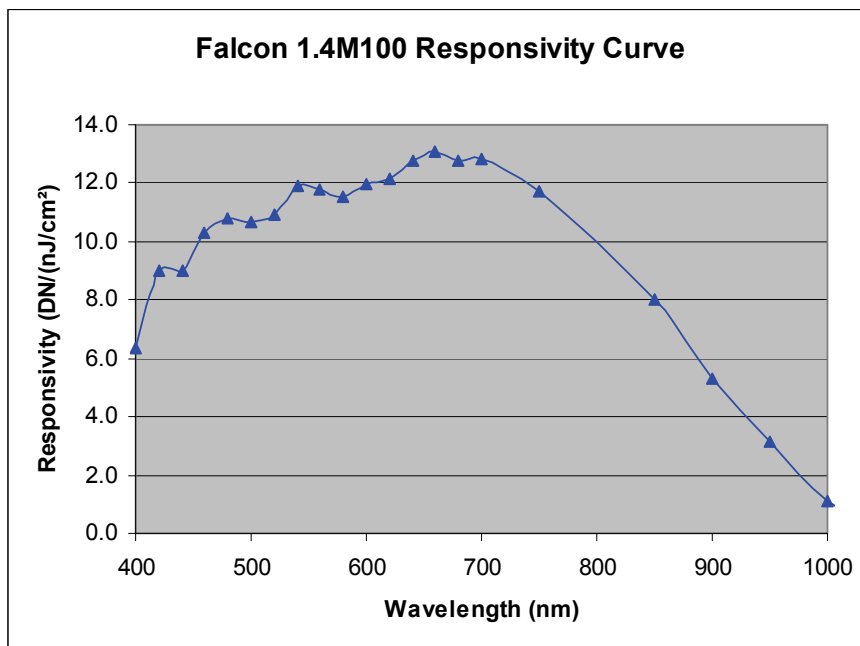
- Exposure mode 2 (sem 2)
- 100 fps (ssf 100)
- 9000 millisecond exposure time (set 9000)
- Light Source: Broadband Quartz Halogen, 3250K, with 750 nm cutoff filter
- Ambient test temperature 25°C
- Full Frame
- 10 bits

Notes:

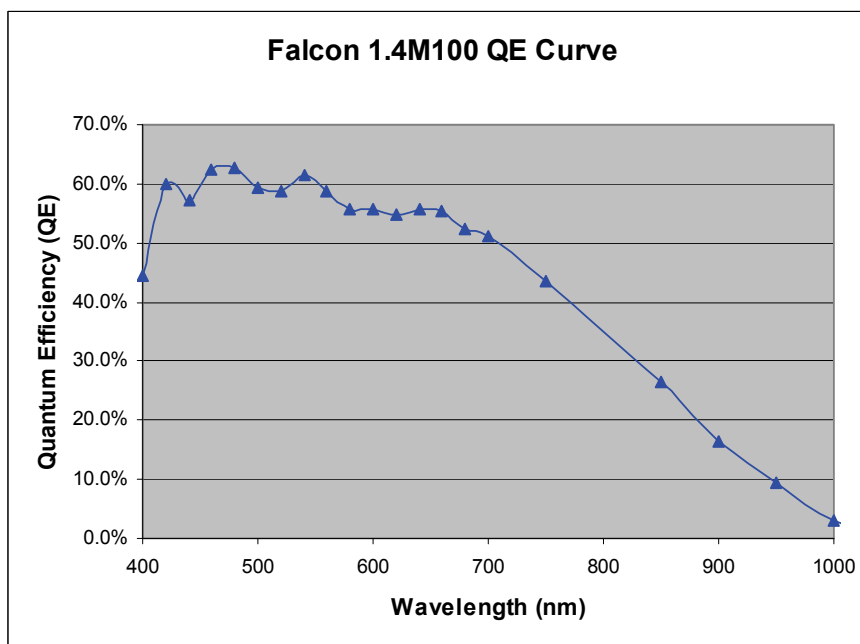
- Measured at the front plate.
- Based on output at 1023DN
- Output over 10-90%
- Optical distance.
- Flat-field correction applied with 9000 ms exposure at 50 fps in sem 2
- At 80% of camera saturation, 1x digital gain

1.3 Responsivity and Quantum Efficiency

The responsivity graph describes the sensor response to different wavelengths of light (excluding lens and light source characteristics). Visible light spans wavelengths between 390-780 nanometers. Wavelengths below 390 nm are ultra-violet while those above 780 nm are termed infra-red.



The quantum efficiency graph describes the fraction of photons at each wavelength that contribute charge to the pixel.



1.4 Camera Cosmetic Specifications

1.4.1 Sensor Cosmetic Specifications

The following table highlights the current cosmetic specifications for the DALSA sensor inside the Falcon 1.4M100 camera. The monochrome sensor has 1.4 megapixels (1400 x 1024) and global shuttering.

Blemish Specifications	Maximum Number of Defects
Hot pixel defects	1
Single pixel defects	100
Clusters defects	No limit (see note)
Spot defects	0
Column defects	0
Row defects	0

Definition of cosmetic specifications

Hot pixel defect

- Pixel whose signal, in dark, deviates by more than 400DN (10-bits) from its neighboring pixels.

Single pixel defect

- Pixel whose signal, at nominal light (illumination at 50% of the linear range), deviates by more than $\pm 30\%$ from its neighboring pixels.

Cluster defect

- A grouping of **at most** 5 pixel defects within an area of 3*3 pixels.

Spot defect

- A grouping of **more than** 5 pixel defects within an area of 3*3 pixels.

Column defect

- A column which has more than 8 pixel defects in a 1*12 kernel.
- Column defects must be horizontally separated by 3 good columns.

Row defect

- A horizontal grouping of more than 3 pixel defects between at least 2 good pixels on both sides, where single good pixels between 2 defective pixels are considered as defective.

Test conditions

- Digital gain – 1X.
- Nominal light = illumination at 50% of saturation.
- Frame Rate = 100fps

- Integration time = 9ms
- Temperature of camera front plate is 25°C

Note: While the number of clusters is not limited by a maximum number, the total number of defective pixels cannot exceed 100. Therefore, you could have 20 clusters of 5 pixels in size ($20 \times 5 = 100$), but you could not have 21 clusters of 5 in size ($21 \times 5 = 105$).

(The probability of 21 clusters of 5 is negligible and is only used as an example.)

1.4.2 Cosmetic Specification

Beyond sensor cosmetic testing, the camera is placed under additional testing to more closely examine potential cosmetic defects due to the sensor glass.

Blemish Specifications	Maximum % deviation below the mean	Size	Maximum Number of Defects
Glass defects	8%	12	0

Definition of cosmetic specifications

Glass defects

- A group of pixels exceeding the maximum % deviation below the mean and the cluster size specifications. Images are taken at nominal light (illumination at 50% of the linear range).

In addition, the camera is examined for the following blemish defects.

Blemish Specifications	Maximum Number of Defects
Hot pixel defects	1
Single pixel defects	100

Test conditions

- Digital gain – 1X.
- Nominal light = illumination at 50% of saturation.
- Frame Rate = 100fps
- Integration time = 9ms
- Temperature of camera front plate is 25°C

Note: All of the above sensor and camera cosmetic specifications are with flat-field correction turned off (**epc 0 0**). There are no post flat-field (**epc 1 1**) camera cosmetic specifications.

2

Camera Hardware Interface

2.1 Installation Overview

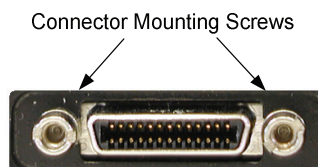
This installation overview assumes you have not installed any system components yet.

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. Before connecting power to the camera, test all power supplies.
5. Inspect all cables and connectors prior to installation. Do not use damaged cables or connectors or camera may be damaged.
6. Connect the mini-Camera Link and power cables.
7. After connecting cables, apply power to the camera.
8. Check the diagnostic LED. If camera is operating correctly, the LED will flash for 10 seconds and then turn solid green. See the section 2.2.1 LED Status Indicator on page 17 for a description of LED states.

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

Note: when unscrewing the mini-Camera Link cable from the Falcon camera, ensure the connector mounting screws do not become attached to the cable thumbscrews; in this case, simply screw the connector mounting screw back into the camera connector mounting.



A note on Camera Link cable quality and length

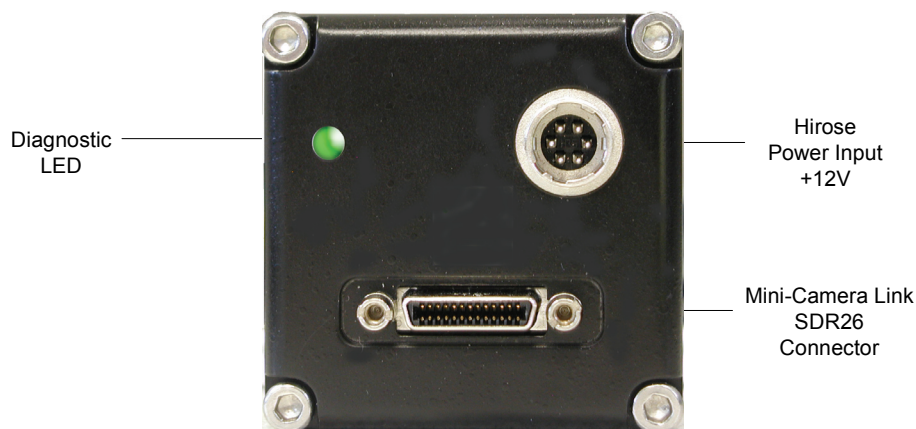
The maximum allowable Camera Link cable length depends on the quality of the cable used and the Camera Link strobe frequency. Cable quality degrades over time as the cable is flexed. As the Camera Link strobe frequency is increased, the maximum allowable cable length will decrease.

DALSA does not guarantee good imaging performance with low quality cables of any length. In general, DALSA recommends the use of high quality cables in lengths less than 10 meters.

2.2 Input/Output Connectors and LED

The camera uses:

- A diagnostic LED for monitoring the camera. See the section 2.2.1 LED Status Indicator on page 17 for details.
- One high-density 26-pin SDR26 connector for Camera Link control signals, data signals, and serial communications. Refer to section 2.2.2 Camera Link Data Connector on page 17 for details.
- One 6-pin Hirose connector for power. Refer to section 2.2.5 Power Connector on page 20 for details.



Input/Output Connectors

WARNING: Ensure that all the correct voltages at full load are present at the camera end of the power (irrespective of cable length) according to the pinout defined in section 2.2.5 Power Connector on page 20. A common system problem is that the voltage drop across the power cable is large enough that the voltage at the camera does not meet the power input voltage specifications.

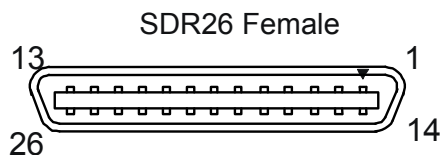
2.2.1 LED Status Indicator

The camera is equipped with an LED to display the operational status of the camera. The table below summarizes the operating states of the camera and the corresponding LED states.

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

Color of Status LED	Meaning
Off	Hardware malfunction or no power
Flashing Red (1 Hz)	Fatal error. Non-recoverable error (such as overheating).
Flashing Red (4 Hz)	Loading backup firmware
Solid Red	Warning. Loss of functionality. Operating condition out of specified range.
Flashing Blue (1 Hz)	Ready to download/Downloading files. Used for firmware update, LUT and FFC coefficients download.
Flashing Blue (4 Hz)	Writing to flash memory, do not power off. Used during firmware update and write user settings.
Flashing Green (1 Hz)	Camera initialization or executing a long command. LED shall flash green at least once each time a serial command is received.
Solid Green	Camera is operational and functioning correctly. Typically outputting images in free-running mode (internal sync, mode 2).

2.2.2 Camera Link Data Connector



Mini-Camera Link SDR26 Connector

The Camera Link interface is implemented as a Base Configuration in the Falcon cameras. You select the camera configuration with the `clm` command described in section 4.7 Setting Exposure Mode, Frame Rate and Exposure Time on page 33.

The following tables provide this camera's principal Camera Link information. See Appendix A for the complete DALSA Camera Link configuration table, and refer to the DALSA Web site, www.dalsa.com, for the official Camera Link documents.

Camera Link Hardware Configuration Summary

Configuration	8 Bit Ports Supported	Serializer Bit Width	Number of Chips	Number of SDR26 Connectors
Base	A, B, C	28	1	1

BASE Configuration	Port Definition		
Mode (set with <code>c1m</code> command)	Port A Bits 0 thru 7	Port B Bits 0 thru 7	Port C Bits 0 thru 7
Mode 2 2 Tap 8 bit	Tap 1 LSB...Bit 7	Tap 2 LSB...Bit7	xxxxxxx
Mode 3 2 Tap 10 bit	Tap 1 LSB... Bit 7	Tap 1 Bits 8,9 Tap 2 Bits 8,9	Tap 2 LSB..Bit 7

Camera Link Connector Pinout

Base Configuration		
One Channel Link Chip + Camera Control + Serial Communication		
Camera Connector	Right Angle Frame Grabber Connector	Channel Link Signal
1	1	inner shield
14	14	inner shield
2	25	X0-
15	12	X0+
3	24	X1-
16	11	X1+
4	23	X2-
17	10	X2+
5	22	Xclk-
18	9	Xclk+
6	21	X3-
19	8	X3+
7	20	SerTC+
20	7	SerTC-
8	19	SerTFG-
21	6	SerTFG+
9	18	CC1-
22	5	CC1+
10	17	CC2+
23	4	CC2-
11	16	CC3-
24	3	CC3+
12	15	CC4+
25	2	CC4-
13	13	inner shield
26	26	inner shield

Notes:

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

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

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

Inner shield is connected to signal ground inside camera

DALSA Camera Control Configuration

Signal	Configuration
CC1	EXSYNC
CC2	Reserved for future use
CC3	Reserved for future use
CC4	Reserved for future use

2.2.3 Input Signals, Camera Link

The camera accepts control inputs through the Camera Link SDR26F connector. The camera ships in internal sync, internal programmed integration (exposure mode 2), and Camera Link mode 2.

EXSYNC

The EXSYNC signal tells the camera when to integrate and readout the image. It can be either an internally generated signal by the camera, or it can be supplied externally via the serial interface. Depending upon the mode of operation the high time of the EXSYNC signal can represent the integration period.

Section 4.7 Setting Exposure Mode, Frame Rate and Exposure Time on page 33 details how to set frame times, exposure times, and camera modes.

2.2.4 Output Signals, Camera Link

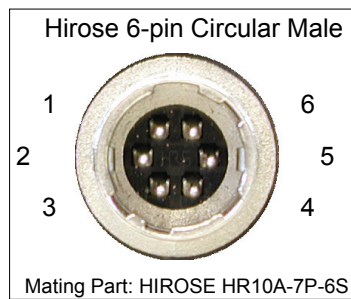
These signals indicate when data is valid, allowing you to clock the data from the camera to your acquisition system. These signals are part of the Camera Link configuration and you should refer to the DALSA Camera Link Implementation Road Map, available at www.dalsa.com, for the standard location of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

Camera Link Clocking Signals

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

- The camera internally digitizes to 10 bits and outputs the 8 most significant bits (MSB's) or all 10 bits depending on the camera's Camera Link operating mode.
- For a Camera Link reference and timing definitions refer to Appendix A on page 69.

2.2.5 Power Connector



Hirose Pin Description

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

The camera requires a single voltage input (12 to 15V). Ensure you measure a minimum of 12V at the camera power connector and not at the power supply. The voltage drop across power cables can be large enough to supply too low of a voltage to the camera for it to operate properly.



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

- Protect the camera with a fast-blow fuse between power supply and camera.
- Power surge limit at 500 mA.
- 12 V power supply. Nominal 0 to 3A load resulting in ~20 A/s current ramp rate
- Power supply current limit needs to be set at >2 A.
- Do not use the shield on a multi-conductor cable for ground.
- Keep leads as short as possible to reduce voltage drop. Long power supply leads may falsely indicate that the power supply is within the recommended voltage range even when the camera at the connector is actually being supplied with much less voltage.
- Use high-quality **linear** supplies to minimize noise.
- Use an isolated type power supply to prevent LVDS common mode range violation.

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.

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


Sapera CamExpert Guide

3.1 Using CamExpert with Falcon Cameras

CamExpert is the camera interfacing tool supported by the Sapera library. When used with a Falcon camera, CamExpert allows a user to test all Falcon operating modes. Additionally CamExpert saves the Falcon user settings configuration to the camera or saves multiple configurations as individual camera parameter files on the host system (*.ccf).

An important component of CamExpert is its live acquisition display window which allows immediate verification of timing or control parameters without the need to run a separate acquisition program.

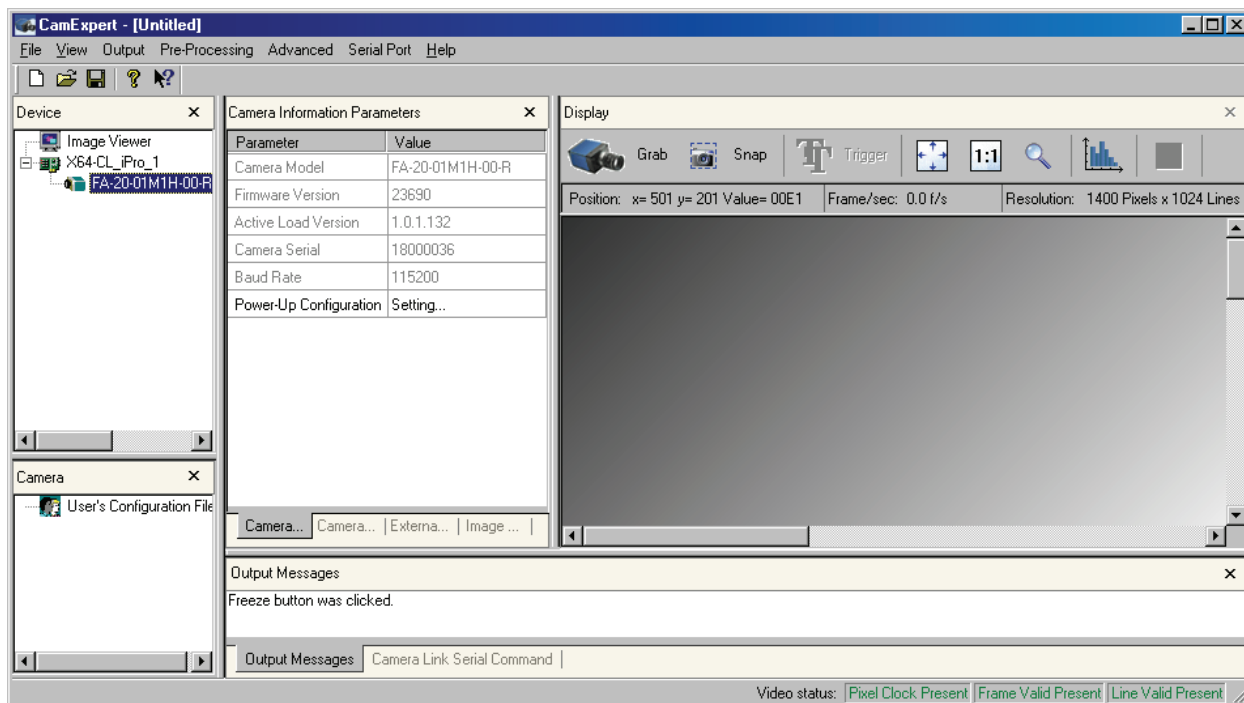
For context sensitive help, click on the  button then click on a camera configuration parameter. A short description of the configuration parameter will be shown in a popup.

Click on the  button to open the help file for more descriptive information on CamExpert.

The central section of CamExpert provides access to the Falcon parameters. Five tabs group Falcon parameters depending on their type as described in the summary below. Each Falcon configuration parameter is described in detail following the summary.






Camera Information	Displays Falcon firmware details such as camera model, version, and serial number. Users can set the User ID and set the power-up configuration mode.
Camera Control	Displays both static and variable sensor parameters that are Falcon model specific. Variable parameters control Falcon exposure, gain and exposure controls. The internal test image is selected here.
External Trigger	Provides controls for trigger source and detection configuration.
Image Buffer and ROI	Provides controls for buffer pixel depth, image size and cropping.


3.1.1 CamExpert User Interface



The CamExpert application uses 5 windows to simplify choosing and configuring camera files or acquisition parameters for the installed device.

- **Device pane:** View and select from any installed Samera acquisition device. After a device is selected, CamExpert only presents acquisition parameters applicable to that device.
- **Camera Information Parameters pane:** Allows viewing or changing all acquisition parameters supported by the acquisition device. CamExpert displays parameters only if those parameters are supported by the installed device. This avoids confusion by eliminating parameter choices when they do not apply to the hardware in use.
- **Display pane:** Provides a live or single frame acquisition display. Frame buffer parameters are shown in an information bar above the image window.
- **Control Buttons:** The Display pane includes CamExpert control buttons. These are:

 Grab  Freeze	Acquisition control button: Click once to start live grab, click again to stop.
 Snap	Single frame grab: Click to acquire one frame from device.
 Trigger	Software trigger button: With the I/O control parameters set to Trigger Enabled / Software Trigger type, click to send a single software trigger command.
	CamExpert display controls: (these do not modify the frame buffer data) Stretch image to fit, set image display to original size, or zoom

the image to any size and ratio.	
	Histogram / Profile tool: Select to view a histogram or line/column profile during live acquisition.

- **Camera pane:** Allows selecting any camera file that is included with the Sapera installation. Only camera files supported by the selected acquisition device are displayed. When there is more than one acquisition server, such as monochrome and RGB, selecting an inappropriate camera file will produce a message prompting you to select the correct acquisition server.
- **Output Messages:** Displays messages from CamExpert or the device driver.
- **Camera Serial Link Command:** Displays commands sent from CamExpert to the Falcon camera. You can also manually enter serial commands at the command prompt in this pane.
- **Video Status bar:** Located on the lower right of the CamExpert window, color coded camera signal status information is displayed. It is green for valid signals detected, and red for missing or incorrect signals. Video status items may differ with different devices.

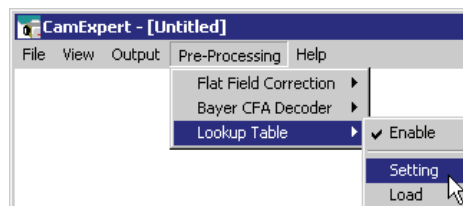
Most of these panes can be hidden via the menu bar view command. Typically after selecting an acquisition device and loading a camera file, the Device and Camera windows can be closed.

3.1.2 CamExpert LUT Controls

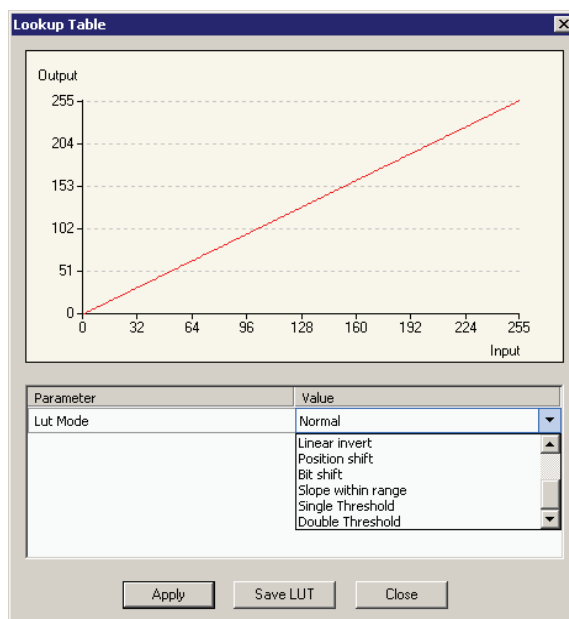
The CamExpert Lookup Table dialog allows you to configure LUTs available on your frame grabber board.

Note: The Falcon on-board LUT can only be configured using the camera serial commands, and not CamExpert; CamExpert configures frame grabber LUTs only (Falcon cameras do not have on-camera LUTs).

To open this dialog, use the **Pre-Processing > Lookup Table > Setting** menu command. Note that you must first enable the Lookup Table, otherwise the Setting command will be grayed-out.



To select the type of LUT to use, click the LUT Mode Value field; a drop-down list box displays the available modes. The Lookup Table dialog displays a graph of the input and output values for the selected LUT. A Sapera application can program the Falcon LUT for any required LUT operation.



CamExpert available LUT examples are briefly described below. The LUT function graphic simplifies understanding the operation especially when user settings modify the LUT function.

- **Normal** (default): modifies all LUT entries using a linear mapping such that a gray level input is equal to the output
- **Arithmetic operation**: modifies all LUT entries using an arithmetic operation
- **Binary pattern**: modifies some LUT entries based on a binary pattern
- **Boolean operation**: modifies all LUT entries using a Boolean operation
- **Gamma correction**: modifies all LUT entries using Gamma correction function
- **Linear invert**: modifies all LUT entries using a linear mapping with a negative slope
- **Position shift**: modifies LUT entries with a zero position offset
- **Bit shift**: modifies LUT entries with a binary bit shift
- **Slope within range**: modifies part of a LUT with a linear mapping
- **Single Threshold**: modifies all LUT entries using a threshold operation
- **Double Threshold**: modifies all LUT entries using a dual level threshold operation

4

Software Interface: How to Control the Camera

In addition to using CamExpert, all camera features can be controlled through the serial interface, which is part of the Camera Link interface standard. 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 sync signal source
- Data readout control
- Generating a test pattern for debugging
- The serial interface uses a simple ASCII-based protocol and the camera does not require any custom software.

Serial Protocol Defaults

- 8 data bits
- 1 stop bit
- No parity
- No flow control
- 9600 Kbps
- Camera does not echo characters

Command Format

When entering commands, remember that:

- A carriage return <CR> ends each command.
- The camera will answer each command with either <CR><LF> **OK** > or **Error x:** **Error Message** >. The > is always the last character sent by the camera.
- The camera accepts both upper and lower case commands.
- The following parameter conventions are used in the manual:

- i = integer value
- f = real number
- m = member of a set. Value must be entered exactly as displayed on help screen.
- s = string
- t = tap id
- x = pixel column number
- y = pixel row number

Example: to retrieve the current camera settings

`gcp <CR>`

4.1 Setting Baud Rate

The baud rate sets the speed in bps of the serial communication port.

Serial Command

Purpose:	Sets the speed in bps of the serial communication port.
Syntax:	sbr m
Syntax Elements:	m
	Baud rate. Available baud rates are: 9600 (default), 19200 , 57600 , and 115200 .
Notes:	<ul style="list-style-type: none"> • The rc (reset camera) command will <i>not</i> reset the camera to the power-on baud rate and will reboot using the last used baud rate.
Example:	sbr 57600

CamExpert Parameter

The baud rate is available as a read-only parameter on the Camera Information tab.

4.2 Camera Serial Command Help Screen

For quick help, the camera can retrieve all available serial commands and parameters through the serial interface.

To view the help screen, use the serial command:

Syntax: **h**

The help screen lists all commands available. Parameter ranges displayed are the ranges available under the current operating conditions. Note, that certain parameter settings can limit the available range of other parameters.

Example Help Screen

ccf	Correction calculate FPN		
clm	Set camera link mode	m	2/3/ (8 bits/10 bits)
cpa	Correction PRNU algorithm	ii	2-2:256-1013
csn	Coefficient set number	i	0-1
css	Calibration sample size	m	32/64/128/256/512/1024/
epc	Enable pixel coefficients	ii	0-1:0-1
gcm	Get the camera model		
gcp	Get the camera parameters		
gcs	Get the camera serial number		
gcv	Get the camera versions		
get	Get command ...	s	Command name
gfc	Get FPN coefficient	xy	1-1400:1-1024
gh	Display the get help screen		
gpc	Get PRNU coefficient	xy	1-1400:1-1024
gsf	Get sync. frequency	i	1-1
h	Display this help screen		
lpc	Load pixel coefficients		
rc	Reset the camera		
rfs	Restore fact		
rpc	Reset pixel coefficients		
rus	Restore user settings		
sbh	Set horizontal binning	i	1-2
sbr	Set the UART baud rate	m	9600/19200/57600/115200/
sbv	Set vertical binning	i	1-2
sdo	Set digital offset	ti	0-0:0-1023 DN
sem	Set exposure mode	m	2/4/6/9/10
set	Set exposure time	f	40-9719 (4000000 max)us
sfc	Set FPN coefficient	xyi	1-1400:1-1024:0-255
slc	Set LUT coefficient	ii	0-1023:0-1023
sle	Set LUT enable	i	0-1
smm	Set mirroring mode	i	0-1
sot	Set output throughput	m	80/160/ MHz
spc	Set PRNU coefficient	xyi	1-1400:1-1024:0-255
ssf	Set sync. frequency	f	0.1-101.9 Hz
ssb	Set subtract background	ti	0-0:0-511
ssg	Set system gain	ti	0-0:1024-8191
svm	Set video mode	i	0/4/5/6/7/8/
upd	Upload CBF file		
vt	Verify temperature		
vv	Verify voltage		
wfc	Write FPN coefficients		
wpc	Write PRNU coefficients		
wse	Set window start end	iiixxy	0-0:1-1:0-1399: 0-1023:1-1399:1-1023
wus	Write user settings		

4.3 Retrieving Information About the Camera

Serial Commands

To retrieve the camera model, use the command:

Syntax: **gcm**

To retrieve the camera serial number, use the command

Syntax: **gcs**

To retrieve the camera firmware version, use the command:

Syntax: **gcv**

CamExpert Parameters

The camera model, serial number, and firmware version are available as read-only parameters on the Camera Information tab.

4.3.1 Retrieving Camera Settings

To retrieve current camera settings, use the serial command:

Syntax: **gcp**

To retrieve the value of a specific camera setting, use the command:

Purpose: Displays the value of the specified camera command.

Syntax: **gcp s**

Syntax Elements: **s**

string representing the command

Notes: “Get” supports any command that returns or specifies a setting. Action commands such as “wus” (write user settings) are not supported.

Example: **get svm** – returns the video mode the camera is currently operating in

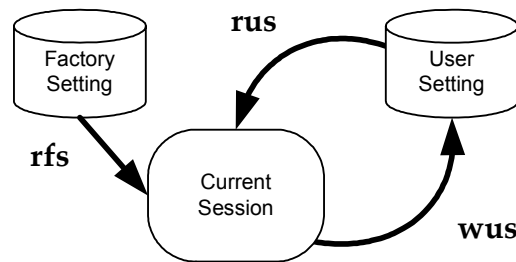
4.4 First Power Up Camera Settings

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

4.4.1 FA-20-01M1H

- Flat field coefficients enabled (Factory FFC coefficients calibrated in exposure mode 2, 10 bit, 50 fps)
- Exposure mode 2
- 100 fps
- 9000 μ s exposure time
- Camera Link mode 2 (Base configuration, 2 taps, 8 bits)
- 80Mpixels/s per tap
- Full window (1400 x 1024)

4.5 Saving and Restoring Settings



Serial Commands for Saving and Restoring Settings

4.5.1 Factory Settings

You can restore the original factory settings at any time using the serial command **rfs**.

Note: This command does not restore flat field coefficients. Refer to **lpc** command.

4.5.2 User Settings

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

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

Note: On power-up the camera will restore the FFC coefficients from the set indicated by the coefficient set number (**csn**); either 0 (factory calibrated set) or 1 (user calibrated set).

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 or issue a reset camera command (**rc**). To save these settings for reuse at power up, use the command **wus**.

CamExpert Parameters

The factory and user settings can be loaded or saved using the Power-Up Configuration dialog, available through the Power-Up Configuration parameter on the Camera Information tab. Set 0 contains the factory settings and Set 1 contains the user settings.

Camera Information Parameters ✕

Parameter	Value
Camera Model	FA-20-01M1H-00-R
Firmware Version	23690
Active Load Version	1.0.1.132
Camera Serial	18000036
Baud Rate	115200
Power-Up Configuration	Setting...

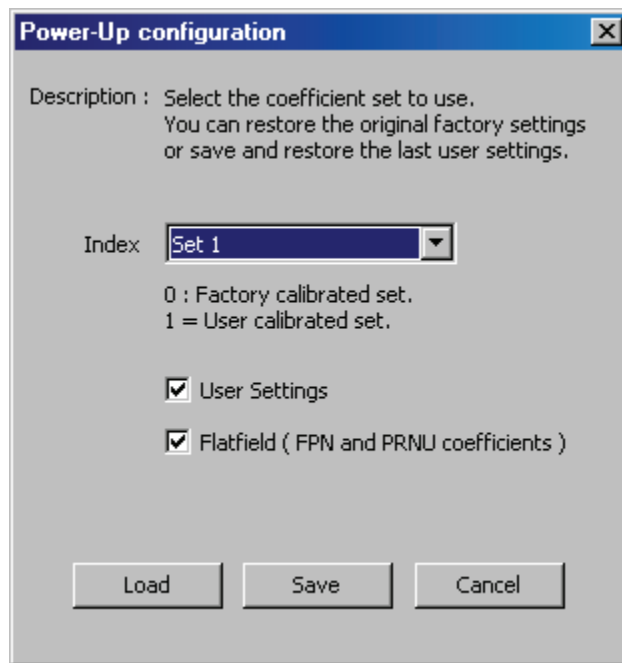
Camera Information

Camera Control

External Trigger

Image Buffer and ROI

Falcon Test Power-Up Configuration – on Camera Information Tab



Falcon Test Power-Up Configuration Dialog

4.6 Camera Output Format

4.6.1 How to Configure Camera Output

The Falcon cameras offer great flexibility when configuring your camera output. Using the **clm** serial command, you determine the camera's Camera Link configuration, number of output taps, and bit depth. Using the **sot** command, you determine the camera's output rate. These two commands work together to determine your final camera output configuration.

Falcon Data Readout Configurations

Camera Link Mode Configuration (Controlled by clm command)				Pixel Rate Configuration (Controlled by sot command)
Mode	Camera Link Configuration	Camera Link Taps	Bit Depth	
2 (clm 2)	Base	2 Camera Link taps	8	40 MHz strobe (sot 80) 80 MHz strobe (sot 160)

Camera Link Mode Configuration (Controlled by clm command)				Pixel Rate Configuration (Controlled by sot command)
Mode	Camera Link Configuration	Camera Link Taps	Bit Depth	
3 (clm 3)	Base	2 Camera Link taps	10	40 MHz strobe (sot 80) 80 MHz strobe (sot 160)

Serial Command

Purpose Sets the camera's Camera Link configuration, number of Camera Link taps and data bit depth.

Syntax: **clm m**

Syntax Elements: **m**

Output mode to use:

2: Base configuration, 2 taps, 8 bit output

3: Base configuration, 2 taps, 10 bit output

- Notes:**
- To retrieve the current Camera Link mode, use the command **gcp**
 - For details on line times and frame readout times when using a window of interest, refer to following table.

Example: **clm 3**

CamExpert Parameters

The factory and user settings can be loaded or saved using the Power-Up Configuration dialog, available through the Power-Up Configuration parameter on the Camera Information tab. Set 0 contains the factory settings and Set 1 contains the user settings.

Camera Information Parameters		X
Parameter	Value	
Camera Model	FA-20-01M1H-00-R	
Firmware Version	23690	
Active Load Version	1.0.1.132	
Camera Serial	18000036	
Baud Rate	115200	
Power-Up Configuration	Setting...	
Camera Information		Camera Control External Trigger Image Buffer and ROI

Falcon Test Power-Up Configuration – on Camera Information Tab

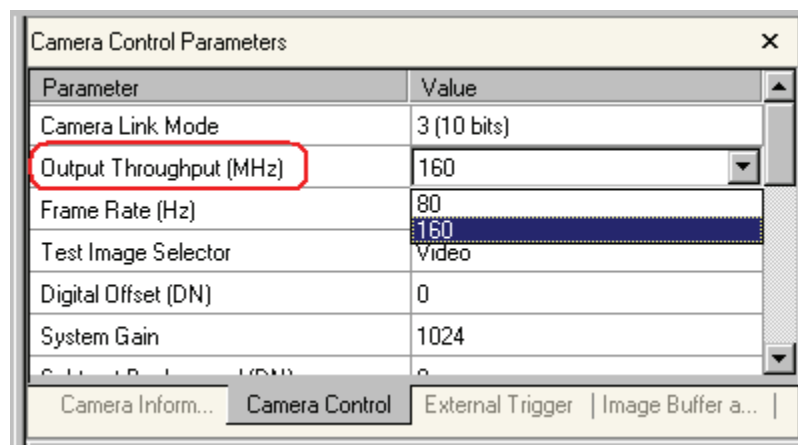
4.6.2 Setting the Camera's Pixel Rate

Serial Command

Purpose:	Sets the camera's pixel rate.
Syntax:	<code>sot m</code>
Syntax Elements:	<code>m</code>
	80: 40 MHz pixel rate with a total throughput of 80 MHz 160: 80 MHz pixel rate with a total throughput of 160 MHz
Notes:	<ul style="list-style-type: none"> To retrieve the current pixel rate, use the command <code>gcp</code> or <code>get sot.</code>
Example:	<code>sot 80</code>

CamExpert Parameter

The camera pixel rate is available through the Output Throughput (MHz) parameter on the Camera Control tab.



Falcon Output Throughput (MHz) – on Camera Control Tab

4.7 Setting Exposure Mode, Frame Rate and Exposure Time

4.7.1 Non-Concurrent vs. Concurrent Modes of Operation

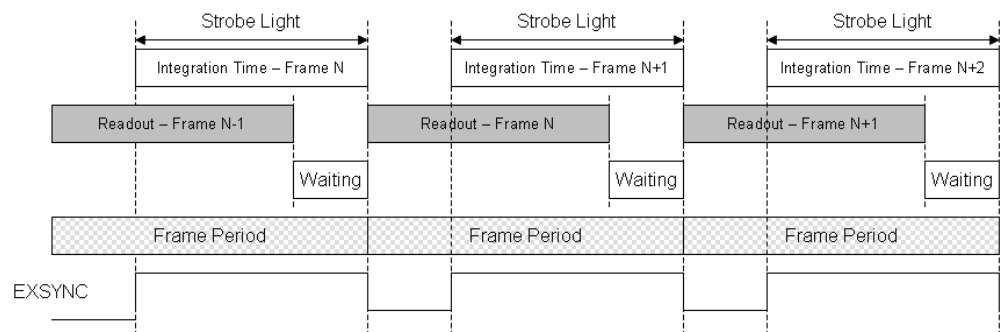
One of the main benefits of global shutter CMOS devices is that you have the choice to operate the camera where integration and readout are concurrent (that is, they overlap for some duration) or where integration and readout are not concurrent (that is, they occur serially). Integration is defined as the time period that the camera can be exposed to light and is often referred to as exposure time. Readout refers to the time it takes to read out

every pixel from the camera. For a 100 fps camera, such as the Falcon 1.4M100, the readout period is around 10.0ms.

Thus, a global shutter CMOS device, as found in the 1.4M100, is capable of running at 100fps even with exposure times up to 10ms. Beyond 10ms, the exposure time dominates and the frame rate drops. With rolling shutter CMOS devices only non-concurrent modes are possible and the integration time immediately impacts the frame rate, thus comparable 1.4 megapixel cameras with a 10ms exposure time would only run at 50fps with a rolling shutter device.

Concurrent mode is when the camera is integrating the current frame (Frame 1) and at the same time is reading out the prior frame (Frame 0). By performing integration and readout in parallel the Falcon 1.4M100 camera is capable of reaching 100fps even with exposure times up to 10ms. A timing diagram helps to explain this mode of operation.

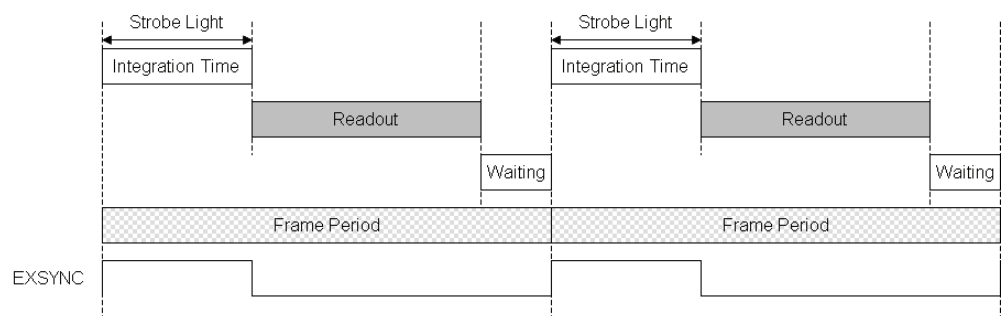
Concurrent Mode Timing Diagram



In concurrent mode, a low-to-high transition in the EXSYNC signal starts the integration time, and a high-to-low transition in the EXSYNC signal starts the readout of image data. As your frame period approaches the readout period, by reducing the Waiting time, the Falcon 1.4M100 camera approaches its maximum frame rate of 100fps.

In non-concurrent mode the integration and readout period do not overlap

Non-concurrent Mode Timing Diagram



In non-concurrent mode, a low-to-high transition in the EXSYNC signal starts the integration time, and a high-to-low transition in the EXSYNC signal starts the readout of image data. This is the same as in concurrent mode. The difference between these two modes is that you do not perform your next low-to-high transition of EXSYNC until readout has completed. The Waiting period can be reduced to 0 seconds by starting the low-to-high transition immediately after readout is complete. The readout time is a fixed amount of time that is dependant upon the mode of operation of the camera, but is typically around 10.0ms.

4.7.2 Setting the Exposure Mode and Time

You have a choice of operating in one of the following exposure modes.

Mode	EXSYNC	Programmable Frame Rate	Programmable Exposure Time	Description	Concurrent / non-concurrent operation
2	Internal	Yes	Yes, minimum 40µs	Internal frame rate and exposure time.	Both
4	External	No	No, minimum 40µs	Smart EXSYNC. High time is the exposure time.	Both
6	External	No	Yes, minimum 40µs	Falling EXSYNC initiates integration. Exposure time is programmed into the camera.	Both
9	External	No	No, minimum 10µs	Smart EXSYNC. High time is the exposure time.	Non-concurrent only
10	External	No	Yes, minimum 7µs	Falling EXSYNC initiates integration. Exposure time is programmed into the camera.	Non-concurrent only

Non-concurrent mode occurs when integration and readout are performed serially. In concurrent mode integration and readout can overlap.

To set the exposure time, the camera must be operating in exposure mode 2, 6 or 10. If you enter an exposure time outside of a valid range, the input will be clipped to the min or max.

If you enter an exposure time which overlaps with the frame readout, the exposure time will automatically adjust to integral units of exposure time increments. The camera sends a warning when this occurs.

To select how you want the camera's frame rate to be generated:

1. You must first set the camera's exposure mode.
2. Next, depending on the specified exposure mode, set the frame rate and set the exposure time.

Exposure Mode Serial Command

Purpose:	Sets the camera's exposure mode allowing you to control your EXSYNC signal, exposure time, and frame rate generation.
Syntax:	sem m
Syntax Elements:	m Exposure mode to use. Factory setting is 2.
Notes:	<ul style="list-style-type: none"> Refer to section 4.7.2 Setting the Exposure Mode and Time on 35 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 4

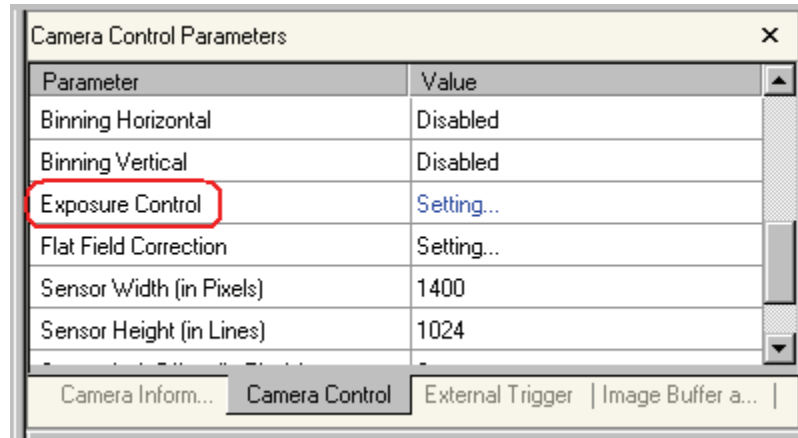
Exposure Time Serial Command

Purpose:	Sets the camera's exposure time in μ s.
Syntax:	set f
Syntax Elements:	f Floating point number in μ s. Allowable range is 40-4000000 μ s.
Notes:	<ul style="list-style-type: none"> Camera must be operating in exposure mode 2, 6 or 10. To retrieve the current exposure time, use the command get set. If you enter an exposure time outside of a valid range, the input will be clipped to the min or max. Refer to the help screen (h command) for the valid range. Changing the exposure time will automatically adjust the frame rate if necessary. The camera sends a warning when this occurs.
Related Commands:	sem, ssf, eec, clm
Example:	set 5500

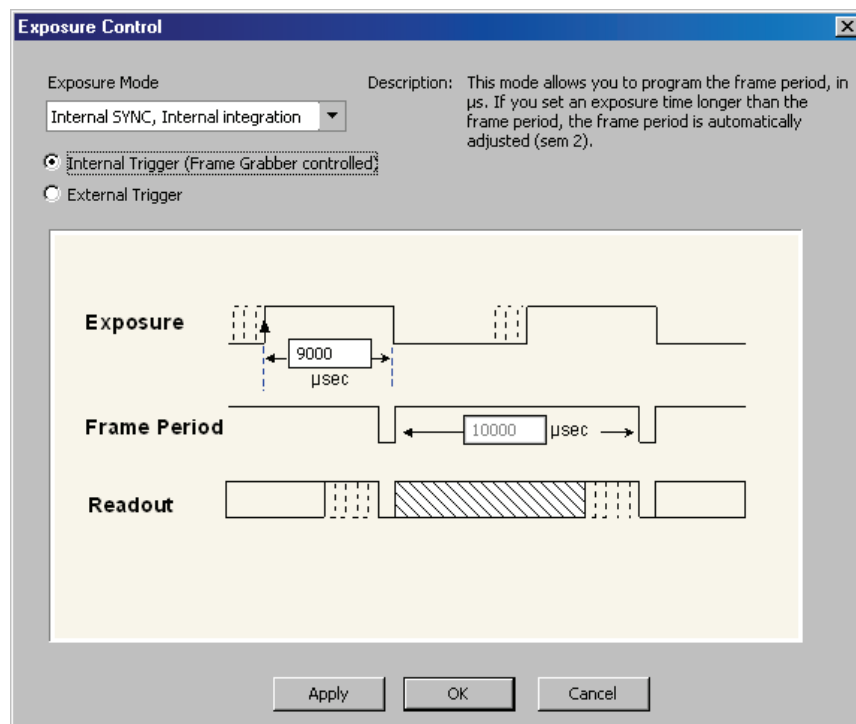
Refer to section 4.6.1 How to Configure Camera Output on page 31 for more information on the **clm** and **set** (sets pixel rate) commands.

CamExpert Parameters

The exposure mode can be specified using the Exposure Control dialog, available through the Exposure Control parameter on the Camera Control tab.



Falcon Exposure Control – on Camera Control Tab

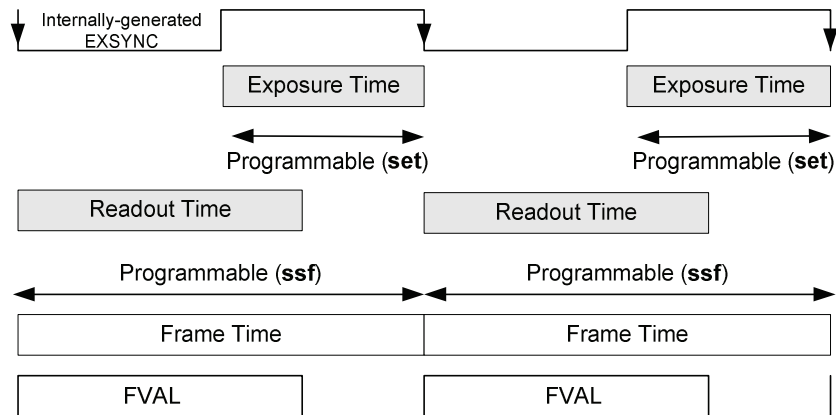


Falcon Exposure Control Dialog

4.7.3 Exposure Modes in Detail

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

The parameter being programmed (that is, frame rate or exposure time) will be the driving factor so that when setting the frame rate, exposure time will decrease, if necessary, to accommodate the new frame rate. In reverse, the frame rate is decreased, if necessary, when the exposure time entered is greater than the frame period.

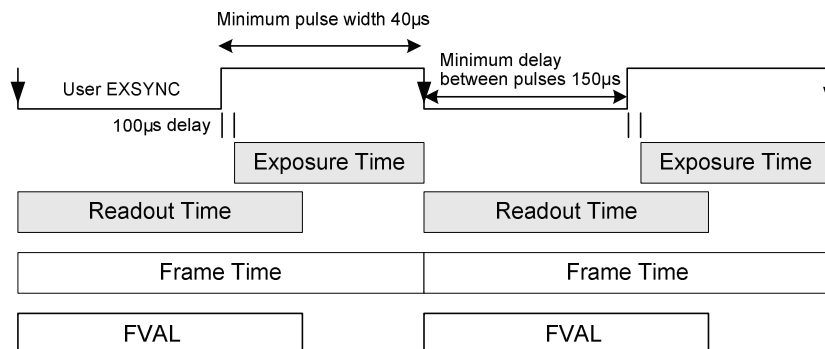


Note: The camera will not set frame periods shorter than the readout period.

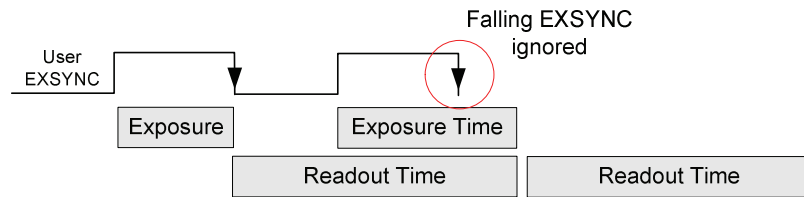
If a frame rate is set (using the **ssf** command) to a time shorter than the readout period, the camera will automatically adjust the frame period to be at least as long as the readout time.

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

In this mode, EXSYNC sets both the frame period and the exposure time. The rising edge of EXSYNC marks the beginning of the exposure and the falling edge initiates readout. There is a 100µs delay between the trigger and the start of the exposure. The minimum delay between consecutive exposure times is 150µs. The minimum pulse width (exposure time) is 40µs.

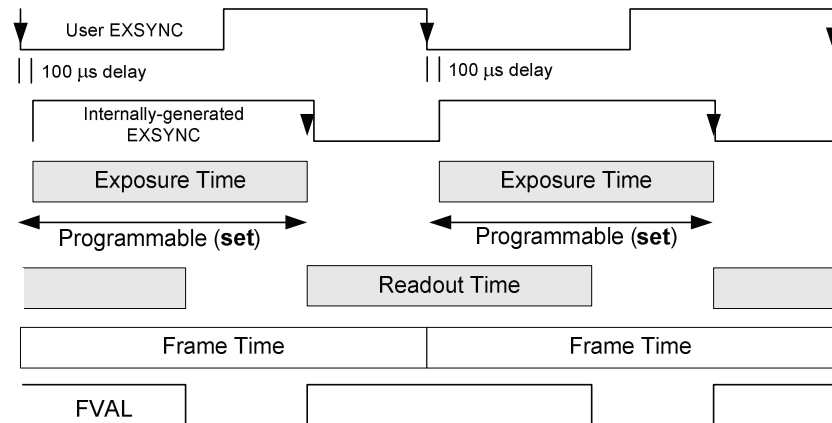


Note that the exposure and readout time can overlap. However, the camera will ignore the falling edge of EXSYNC if the camera is still reading out the prior frame, and extend the exposure time to the end of the readout.



Mode 6: External Frame Rate, Fixed Exposure Time

In this mode, the frame rate is triggered externally with the falling edge of EXSYNC generating the rising edge of a programmable exposure time. There is a 100 μ s delay between the trigger and the start of the exposure. The minimum trigger pulse width is 1 μ s. The minimum exposure time is 40 μ s.



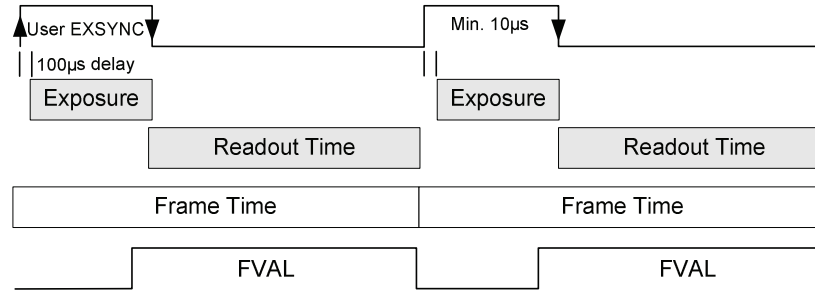
This mode supports both concurrent and non-concurrent operation. If the exposure time is greater than the readout time, it will accept a trigger 1 μ s after the previous exposure is finished.

If the exposure time is less than the readout time, then the minimum delay between consecutive exposure times is 150 μ s. Note that the exposure and readout time can overlap. However, if the camera is still reading out the prior frame, and a trigger is asserted, it will extend the exposure time to the end of the readout.

Mode 9: Sequential Smart EXSYNC, External Frame Rate and Exposure Time

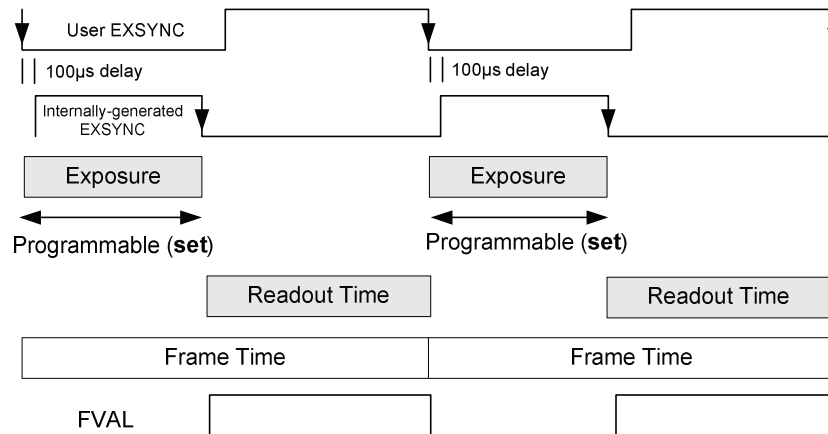
In this mode, EXSYNC sets both the frame period and the exposure time. The rising edge of EXSYNC marks the beginning of the exposure and the falling edge initiates readout. There is a 100 μ s delay between the trigger and the start of the exposure. The minimum exposure time is 10 μ s. The minimum delay between the end of readout and the next EXSYNC is 1 μ s.

Note, the exposure and readout time cannot overlap. In addition, the camera will ignore the falling edge of EXSYNC if the prior frame's integration or readout is not complete.



Mode 10: External Frame Rate, Fixed Exposure Time

In this mode, the frame rate is triggered externally using the EXSYNC falling edge. There is a 100µs delay between the trigger and the start of the exposure. The minimum exposure time is 7µs. The minimum delay between the readout and the next EXSYNC is 1µs. Note, the exposure and readout time cannot overlap.



4.7.4 Setting the Frame Rate

To set the camera frame rate, the camera must be operating in exposure mode 2. Changing the frame rate will automatically adjust the exposure time if necessary. The camera sends a warning when this occurs.

Refer to section 4.6.2 Setting the Camera's Pixel Rate on page 33 for more information on how to set the camera's pixel rate

Allowable range is dependent on the current Camera Link mode and window size. Refer to section 4.6.1 How to Configure Camera Output on page 31 for more information on Camera Link modes and section 4.8 Setting a Vertical Window of Interest on page 42 for more information on setting a window size.

Serial Command

Purpose: Sets the camera's frame rate in Hz.

Syntax: **ssf f**

Syntax Elements: **f**

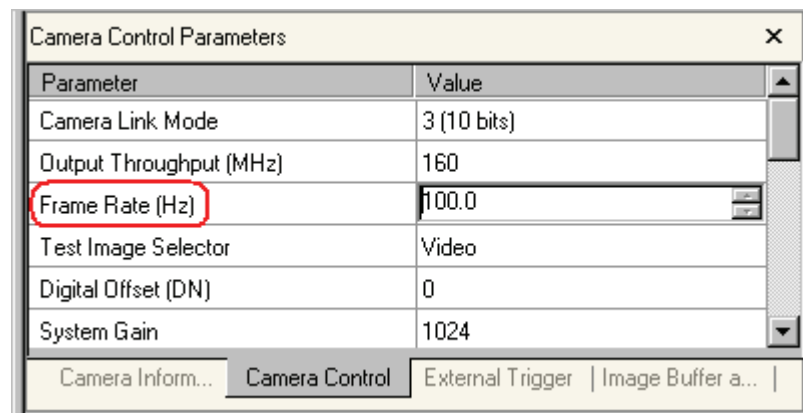
Set the frame rate in Hz in a range from **0.1–101.9** (full frame, 80 MHz pixel rate) or **0.1–51.1** (full frame, 40 MHz pixel rate). Range increases when using a window of interest.

Related Commands: **sem, set**

Example: **ssf 25.0**

CamExpert Parameter

The frame rate can be specified using the Frame Rate (Hz) parameter available through the Camera Control tab.



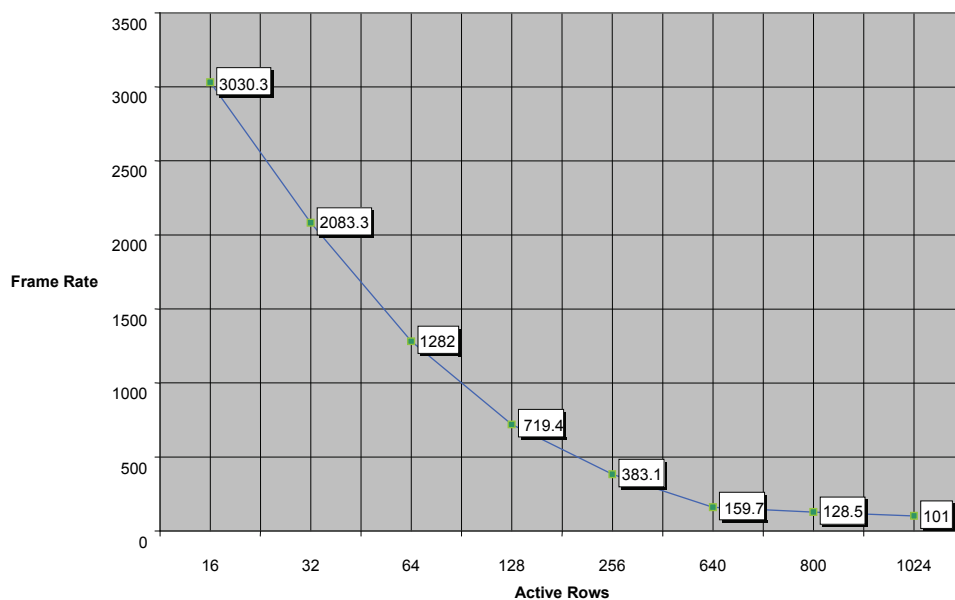
Falcon Frame Rate (Hz) – on Camera Control Tab

4.8 Setting a Vertical Window of Interest

A window of interest is a subset of a full frame image that is desired as output from the camera. Because the sensor is outputting only the designated window of interest, the benefit is an increase in frame rate and a reduction in data volume. You can set both the horizontal and vertical window, however only decreasing the vertical window increases the frame rate.

4.8.1 Frame Rate vs. Active Lines

The following chart describes the frame rate vs. active rows achieved using a 80 MHz pixel clock and an exposure time of 40 μ s.



The equation used to determine the frame rate from active rows is:

$$\text{Frame rate} = \frac{10^6}{(9.5 \times \# \text{ of rows}) + 71}$$

Serial Command

To set a window of interest:

- Set the window coordinates, using the window start end command:
`wse 0 1 x y x y.`

The maximum frame rate increases as you decrease the sequence size.

Purpose: Sets a window of interest.

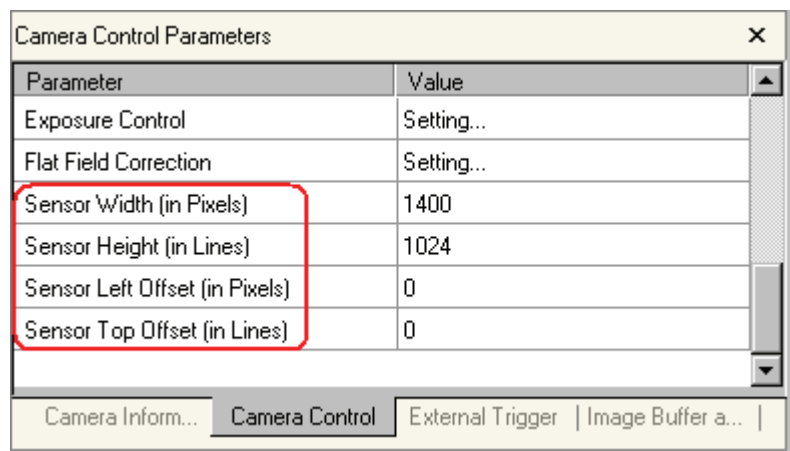
Syntax: **wse q i x1 y1 x2 y2**

Syntax Elements:	q	Window sequence id to use. In this camera, the sequence id is always 0.
	i	Window to set. You can only set one window, so this is always 1.
	x1	Window horizontal start corner pixel number, in a range from 0 – 1399 and must belong to the following set: 1, 5, 9, ... 1399.
	y1	Window vertical start corner pixel number, in a range from 0-1023.
	x2	Window horizontal end corner pixel number, in a range from 15-1399 must belong to the following set: 15, 19, ... 1399.. The minimum window width is 16 pixels.
	y2	Window vertical end pixel number in range from 1-1023.

Example: **wse 0 1 1 13 1399 1023**

CamExpert Parameter

The serial (ASCII) commands let you set the x and y coordinates of the top left and lower right corners of the window. Through CamExpert, the window is defined by its size and of offset of the top left corner of the window. The sensor window size and offset can be specified using the Sensor Width, Sensor Height, Sensor Left Offset, and Sensor Top Offset parameters available through the Camera Control tab.



Sensor Parameters – on Camera Control Tab

After adjusting the window size, you can change the frame rate for improved performance. In general, the smaller the window size, the higher the possible frame rate. The frame rate can be specified using the Frame Rate (Hz) parameter available through the Camera Control tab.

4.9 Flat Field Correction

This camera has the ability to calculate correction coefficients in order to remove non-uniformity in the image. This video correction operates on a pixel-by-pixel basis and implements a two point correction for each pixel. This correction can reduce or eliminate image distortion caused by the following factors:

- Fixed Pattern Noise (FPN)
- Photo Response Non Uniformity (PRNU)
- Lens and light source non-uniformity

The camera is shipped with pre-set factory correction coefficients in both the factory and user sets, such that in most applications there is no need to perform flat field correction. Note that factory calibration is performed with an exposure time of 9ms. However, if you are using a different exposure time and your application is sensitive to small pixel variations, it is recommended that you perform flat field correction at your typical exposure time.

Correction is implemented such that for each pixel:

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

where	V_{output}	=	digital output pixel value
	V_{input}	=	digital input pixel value from the sensor
	$\text{PRNU}(\text{pixel})$	=	PRNU correction coefficient for this pixel
	$\text{FPN}(\text{pixel})$	=	FPN correction coefficient for this pixel
	Background Subtract	=	background subtract value
	System Gain	=	digital gain value

The algorithm is performed in two steps. The fixed offset (FPN) is determined first by performing a calculation without any light. This calibration determines exactly how much offset to subtract per pixel in order to obtain flat output when the sensor is not exposed.

The white light (PRNU) calibration is performed next to determine the multiplication factors required to bring each pixel to the required value (target) for flat, white output. Video output is set slightly above the brightest pixel (depending on offset subtracted).

It is important to do the FPN correction first. Results of the FPN correction are used in the PRNU procedure. We recommend that you repeat the correction when a temperature change greater than 10°C occurs or if you change the frame rate or integration time.

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

PRNU correction requires a clean, white reference. The quality of this reference is important for proper calibration. White paper is often not sufficient because the grain in the white paper will distort the correction. White plastic or white ceramic will lead to better balancing.

For best results, ensure that:

1. 60 Hz ambient light flicker is sufficiently low not to affect camera performance and calibration results.
2. The brightest pixel should be slightly below the target output. If the target is too close, then some pixels may not be able to reach their full swing (1023 DN dynamic range) due to the correction applied by the camera.
3. When 6.25% of pixels from a single row within the region of interest are clipped, flat field correction results may be inaccurate.
4. Correction results are valid only for the current analog offset values.

Flat Field Calibration Example Procedure

The following is a flat field calibration example, using serial commands:

1. The camera is placed in **sem 2**.
2. Settings such as frame rate, exposure time, and so forth, are set as close as possible to actual operating conditions. Set the digital gain to 1 x gain (**sbg 0 1024**) and background subtract to 0 (**ssb 0 0**) as these are the defaults during FFC calibration. In addition, ensure that you are in non-concurrent operation. In non-concurrent mode, readout and integration do not overlap, thus eliminating some residual artifacts associated with concurrent operation.
3. Place the camera in the dark and send the **ccf** command. This performs the FPN correction and automatically saves the FPN coefficients to non-volatile memory.
4. Set **epc 1 0**, which enables the FPN correction and verify the signal output is close to 0 DN. Leave **epc 1 0** for the next step since the **cpa** target assumes there is no FPN.
5. Illuminate the sensor, such that with **epc 1 0**, it reaches 50%-70% saturation.
6. Send **cpa 2 T** where T is typically 1.3 x the average output level. This is important since if the target is too low ($< 1.1 \times$), then some pixels may not be able to reach full swing (1023 DN) due to corrections applied by the camera.
7. If satisfied by the results write the FPN coefficients and PRNU coefficients to memory (**wfc** and **wpc**).

How can one match gain and offset values on multiple cameras?

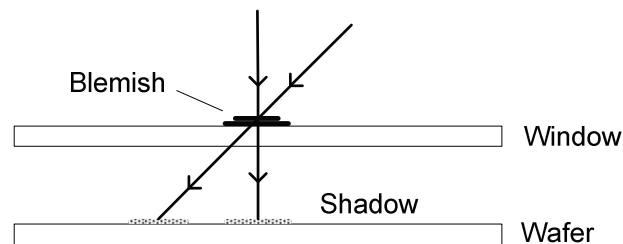
One way is of course to use flat field correction. All cameras would be set up under the same conditions including lighting and then calibrated with **ccf** and **cpa**. This can be time-consuming and complicated (especially the white target). Another way is to use analog offset and system gain (digital gain):

1. Starting from factory settings (**sao 0 0**, **sbg 0 1024**, **epc 1 1**), take note what the highest dark offset is among the set of cameras. If the highest dark offset is higher than about 16 DN (10 bit) you might want to consider recalibrating the FPN correction (**ccf**). Large differences in dark offset between the factory and user are typically caused by differences in temperature from factory to user. Large dark offsets will result in PRNU-correction-induced FPN and should therefore be avoided.
2. Increase the offset (camera in dark) on all cameras (**sao** command) until they are the same and reach at least 4 DN (10 bit).

3. Illuminate to about 80% saturation (820 DN, 10 bit) and note the highest signal level among the set of cameras.
4. Increase the digital gain (**ssg**) on the cameras until they all reach the same output level of the camera with the highest output found in step 3.
5. Place camera in the dark and repeat steps 2 to 4 until both dark offset and 80% saturation signal levels are equal on all cameras.
6. If satisfied by the results write the FPN coefficients and PRNU coefficients to memory (**wfc** and **wpc**).

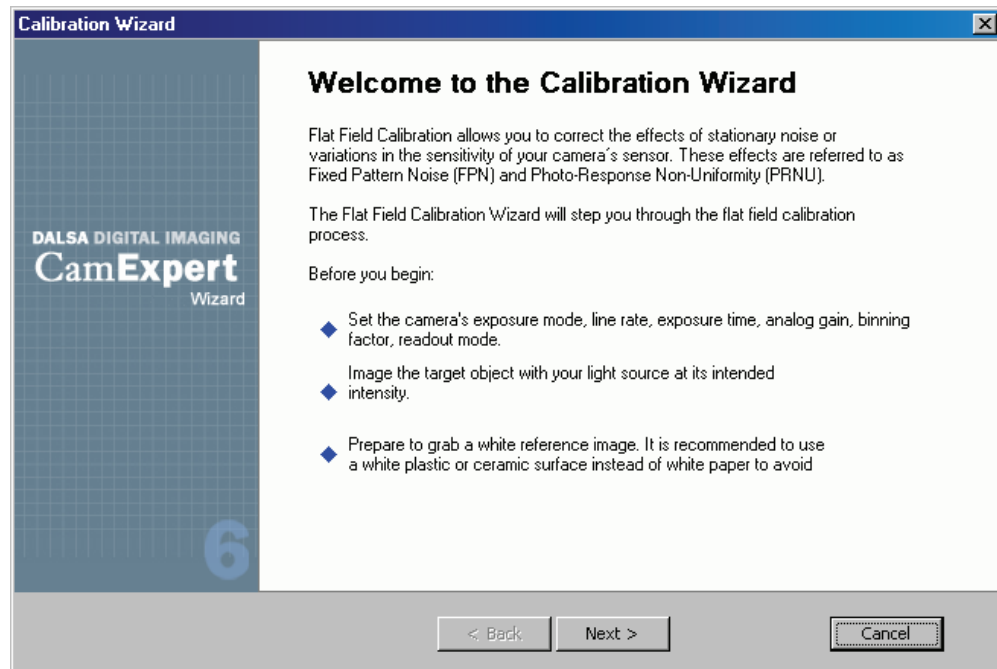
An important note on window blemishes:

When flat field correction is performed, window cleanliness is paramount. The following figure shows an example of what can happen if a blemish is present on the sensor window when flat field correction is performed. The blemish will cast a shadow on the wafer. FFC will compensate for this shadow by increasing the gain. Essentially FFC will create a white spot to compensate for the dark spot (shadow). As long as the angle of incident light remains unchanged then FFC works well. However when the angle of incidence changes significantly (for example, when a lens is added) then the shadow will shift and FFC will make things worse by not correcting the new shadow (dark spot) and overcorrecting where the shadow used to be (white spot). While the dark spot can be potentially cleaned, the white spot is an FFC artifact that can only be corrected by another FFC calibration.



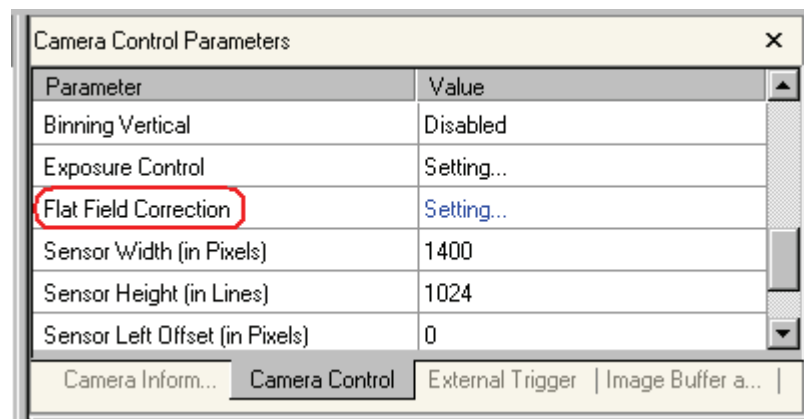
4.9.1 CamExpert Calibration Wizard

CamExpert includes a Calibration Wizard which is designed to guide you through the flat field calibration process, without having to directly use serial commands. Simply follow the instructions provided by the wizard.



Note: The CamExpert Pre-Processing menu includes commands to perform flat field correction on the hardware (frame grabber) or software (host PC), however, to use the camera's flat field correction capability, use the Calibration Wizard or the camera serial commands.

To launch the Calibration Wizard, click on the Flat Field Correction parameter "Setting..." field, available on the Camera Control tab.



Falcon Flat Field Correction – on Camera Control Tab

4.9.2 Selecting Factory or User Coefficients

Serial Command

Purpose:	Selects the coefficient set to use. The camera ships with a factory calibrated set of FPN and PRNU coefficients. The factory coefficients cannot be erased or modified.
Syntax:	csn i
Syntax Elements:	i Coefficient set to use. 0 = Factory calibrated set of FPN and PRNU coefficients. These coefficients cannot be erased or modified. 1 = User calibrated set of FPN and PRNU coefficients. These coefficients can be deleted or modified.
Notes:	<ul style="list-style-type: none"> ▪ The camera ships with the factory calibrated FPN and PRNU coefficients saved to both set 0 and set 1. When you first boot up the camera, the camera operates using set 1 (csn 1) enabled. ▪ To retrieve the current coefficient set number, use get csn.
Example:	csn 0

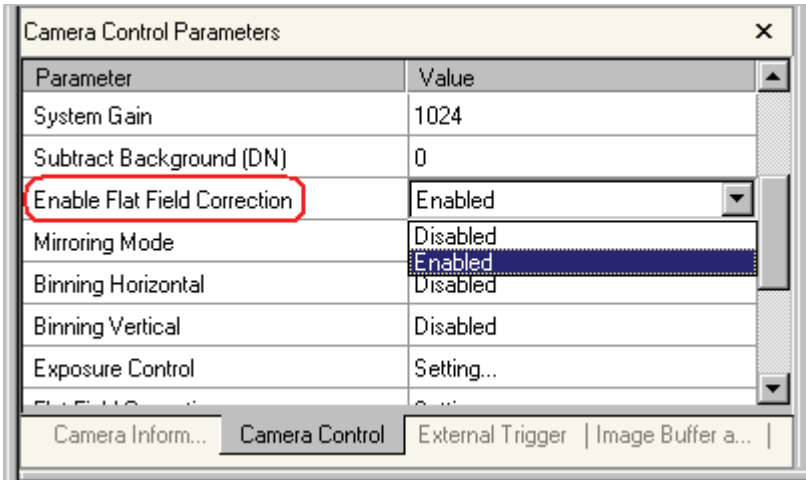
4.9.3 Enabling Pixel Coefficients

Serial Command

Purpose:	The camera ships with the FPN and PRNU coefficients enabled, but you can enable and disable FPN and PRNU coefficients whenever necessary.
Syntax:	epc i i
Syntax Elements:	i FPN coefficients. 0 = FPN coefficients disabled 1 = FPN coefficients enabled i PRNU coefficients. 0 = PRNU coefficients disabled 1 = PRNU coefficients enabled
Notes:	<ul style="list-style-type: none"> ▪ The coefficient set that you are enabling or disabling is determined by the csn value. Refer to the previous section for an explanation of the csn command.
Example:	epc 1 1

CamExpert Parameter

The pixel coefficients are enabled using the Frame Rate (Hz) parameter available through the Camera Control tab. This parameter enables both FPN and PRNU coefficients.



Enable Flat Field Correction – on Camera Control Tab

4.9.4 Selecting the Calibration Sample Size

Serial Command

Setting the Number of Frames to Sample

- Purpose: Sets the number of frames to sample when performing pixel coefficient calculations. Higher values cause calibration to take longer but provide the most accurate results.
- Syntax: `css i`
- Syntax Elements: `i`
Number of frames to sample. Allowable values are 32 (default), 64, 128, 256, 512, or 1024.
- Notes:
 - To return the current setting, use the `gcp` command.
- Example: `css 1024`

4.9.5 Performing FPN Calibration

Serial Commands

Calibrating All Camera Pixels

Purpose:	Performs FPN calibration and eliminates FPN noise by subtracting away individual pixel dark current.
Syntax:	ccf
Notes:	<ul style="list-style-type: none"> ▪ Before performing this command, stop all light from entering the camera. (Tip: cover lens with a lens cap.) ▪ The goal is to subtract all non-uniformities and offsets to obtain a 0 DN output in dark. Analog offset should be set to 0 since it gets subtracted out during FPN calibration. ▪ Set the digital gain to 1 x gain (ssg 0 4096) since during calibration it is forced to 1 x gain. ▪ Perform FPN correction before PRNU correction. ▪ The ccf command is not available when the camera is using the factory calibrated coefficients (csn 0). You must select the user coefficient set (csn 1) before you can perform FPN calibration. An error message is returned if you attempt to perform FPN calibration when using csn 0. ▪ If you are operating the camera in test pattern mode (svm 1-8), you must turn off exposure correction (eec 0) prior to running the ccf command. ▪ The LED flashes green while coefficients are computed. After completion, the LED should return to solid green, unless an error occurred during calibration.
Example:	ccf <ul style="list-style-type: none"> ▪ FPN correction can only be performed in exposure modes sem 2, sem 9 and sem 10.

Calibrating Individual Pixels

Purpose: Sets an individual pixel's FPN coefficient.

Syntax **sfc x y i**

Syntax Elements: **x**

The pixel column number from **1** to **1400**.

y

The pixel row number from **1** to **1024**.

i

Coefficient value in a range from **0** to **255**.

Notes:

- The **sfc** command is not available when the camera is using the factory calibrated coefficients (**csn 0**). You must select the user coefficient set (**csn 1**) before you can perform FPN calibration. An error message is returned if you attempt to perform FPN calibration when using **csn 0**.

Example: **sfc 10 50**

4.9.6 Performing PRNU Calibration

Serial Command

Purpose: Performs PRNU calibration to a targeted, user defined value and eliminates the difference in responsivity between the most and least sensitive pixel creating a uniform response to light. To use this command, you must provide a calibration target.

Executing these algorithms causes the **ssb** command to be set to 0 (no background subtraction) and the **ssg** command to 4096 (unity digital gain). The pixel coefficients are disabled (**epc 0 0**) during the algorithm execution but returned to the state they were prior to command execution.

Syntax: **cpa i i**

Syntax Elements: **i**

PRNU calibration algorithm to use:

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

$$\text{PRNU Coefficient}_i = \frac{\text{Target}}{(\text{AVG Pixel Value}_i) - (\text{FPN}_i + \text{sdo value})}$$

The calculation is performed for all sensor pixels but warnings are only applied to pixels in the region of interest. This algorithm is useful for achieving uniform output across multiple cameras. It is important that the target value (set with the next parameter) is set to be at least equal to the highest pixel across all cameras so that all pixels can reach the highest pixel value during calibration.

i

Peak target value in a range from **256 to 1013** DN. The target value must be greater than the current peak output value.

Notes:

- PRNU correction can only be performed in exposure mode **sem 2**, **sem 9** or **sem 10**.
- Calibrate FPN before calibrating PRNU. If you are not performing FPN calibration then issue the **rpc** (reset pixel coefficients) command and set the **sdo** (set digital offset) value so that the output is near zero under dark.
- The **cpa** command is not available when the camera is using the factory calibrated coefficients (**csn 0**). You must select the user coefficient set (**csn 1**) before you can perform PRNU calibration. An error message is returned if you attempt to perform PRNU calibration when using **csn 0**.

Example: **cpa 2 700**

Calibrating Individual Pixels

Purpose:	Sets an individual pixel's PRNU coefficient.
Syntax	spc x y i
Syntax Elements:	<p>x</p> <p>The pixel column number from 1 to 1400.</p> <p>y</p> <p>The pixel row number from 1 to 1024.</p> <p>i</p> <p>Coefficient value in a range from 0 to 255 where</p> $\text{PRNU coeff} = 1 + \left(\frac{i}{256} \right)$
Notes:	<ul style="list-style-type: none"> The spc command is not available when the camera is using the factory calibrated coefficients (csn 0). You must select the user coefficient set (csn 1) before you can perform PRNU calibration. An error message is returned if you attempt to perform PRNU calibration when using csn 0. To return the current csn number, send the command get csn.
Example:	spc 10 50 200

4.9.7 Saving, Loading and Resetting Coefficients

Saving the Current PRNU Coefficients

Purpose:	Saves the current PRNU coefficients to non-volatile memory.
Syntax:	wpc
Notes:	<ul style="list-style-type: none"> The wpc command is not available when the camera is using the factory calibrated coefficients (csn 0). You must select the user coefficient set (csn 1) before you can perform PRNU calibration. An error message is returned if you attempt to perform PRNU calibration when using csn 0. To return the current csn number, send the command get csn.
Example:	wpc

Saving the Current FPN Coefficients

Purpose:	Saves the current FPN coefficients to non-volatile memory.
Syntax:	wfc
Notes:	<ul style="list-style-type: none"> The wfc command is not available when the camera is using the factory calibrated coefficients (csn 0). You must select the user coefficient set (csn 1) before you can save FPN coefficients. An error message is returned if you attempt to save FPN coefficients when using csn 0. To return the current csn number, send the command get csn.
Example:	wfc

Loading Pixel Coefficients

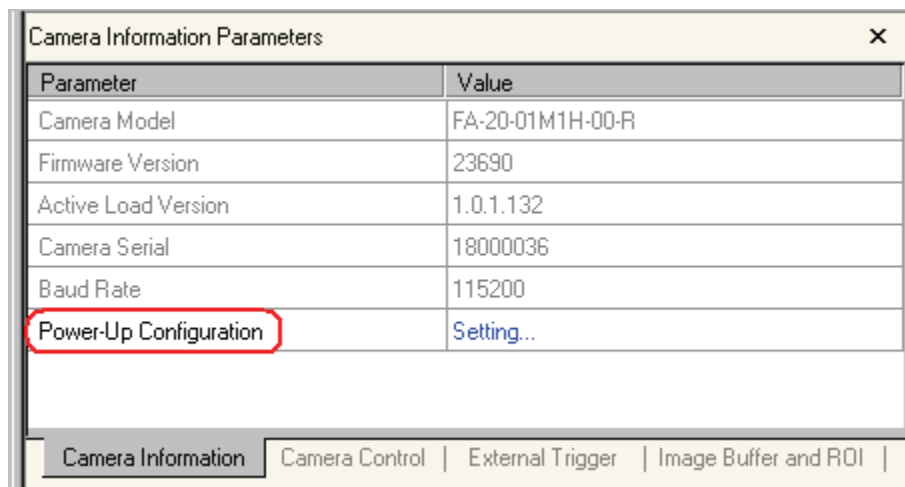
Purpose:	Loads the last saved user coefficients or original factory coefficients from non-volatile memory.
Syntax:	lpc
Notes:	<ul style="list-style-type: none"> The coefficient set that you are loading is determined by the csn value. Refer to the section, Selecting Factory or User Settings, for an explanation of the csn command. To return the current csn number, send the command get csn.
Example:	lpc

Resetting the Current Pixel Coefficients

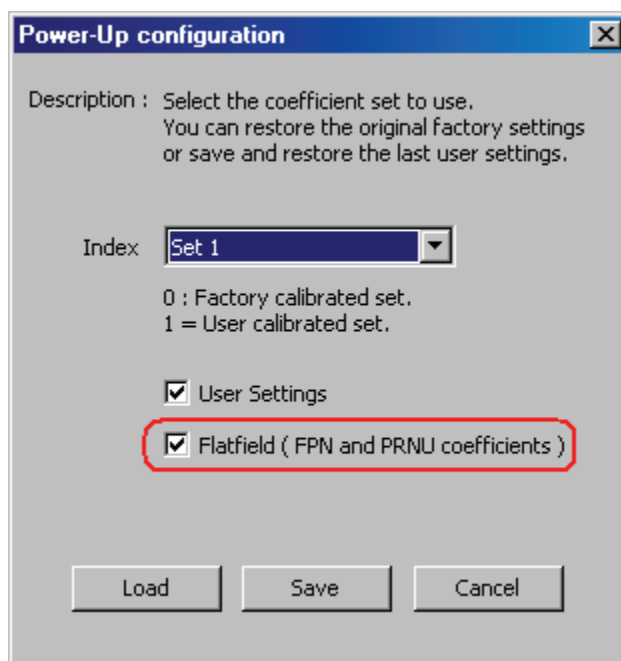
Purpose:	Resets the current user coefficients to zero. This command also resets saved coefficients to zero, resulting in raw video without correction being output from the camera.
Syntax:	rpc
Notes:	<ul style="list-style-type: none"> The rpc command is not available when the camera is using the factory calibrated coefficients (csn 0). You must select the user coefficient set (csn 1) before you can reset pixel coefficients. An error message is returned if you attempt to reset pixel coefficients when using csn 0. To return the current csn number, send the command get csn.

CamExpert Parameters

The user flat field coefficient settings can be loaded or saved using the Power-Up Configuration dialog, available through the Power-Up Configuration parameter on the Camera Information tab.



Falcon Test Power-Up Configuration – on Camera Information Tab



Falcon Test Power-Up Configuration Dialog

Set 0 contains the factory settings and Set 1 contains the user settings. Enable the Flatfield FPN and PRNU coefficients checkbox to load or save the user flat field coefficients.

4.10 Gain Adjustments

4.10.1 Factory Calibrated Analog Gains

The camera has a factory calibrated analog gain setting. Adjustment of analog gain is not available to the user, however, digital gain is available using the set system gain serial command, **ssg**.

4.10.2 Setting Digital System Gain

Serial Command

Purpose:

- 1) Increases the overall gain of the camera.
- 2) Improves signal output swing after a background subtract. When subtracting a digital value from the digital video signal, using the **ssb** command, the output can no longer reach its maximum. Use this command to correct for this where:

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

Syntax:

ssg t i

Syntax Elements:

t

Sensor tap selection. This is always **0** for all taps.

i

Gain setting. The gain ranges are **1024** to **8191**. The digital video values are multiplied by this value where:

$$\text{Digital Gain} = \frac{i}{1024}$$

For example, to set a digital gain of 2.0, **i** equals 2048.

Notes:

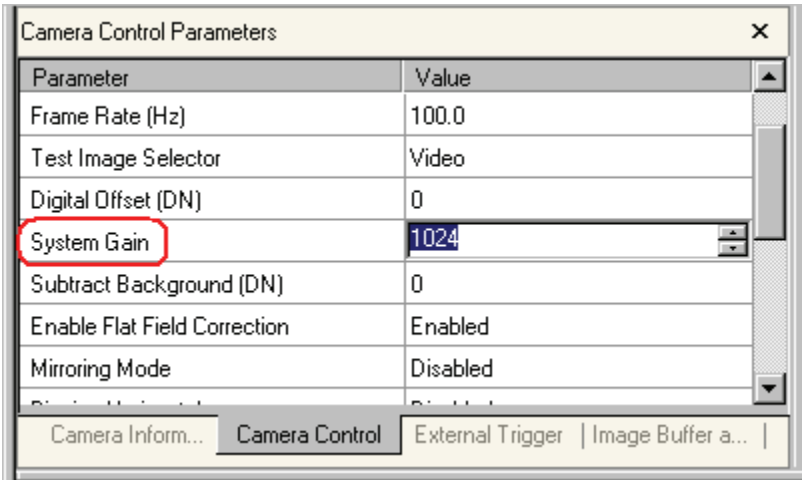
- Entering a large value gain will cause the camera to digitally saturate the output image

Example:

ssg 0 1024

CamExpert Parameters

The digital system gain is set using the System Gain parameter, available on the Camera Control tab.



Falcon System Gain – on Camera Control Tab

4.10.3 Subtracting Background

Serial Command

Purpose: Use the background subtract command after performing flat field correction if you want to improve your image in a low contrast scene. It is useful for systems that process 8 bit data but want to take advantage of the camera’s 10 bit digital processing chain. You should try to make your darkest pixel in the scene equal to zero.

Syntax: `ssb t i`

Syntax Elements: `t` Tap selection. This is always set to 0 (all taps).
`i`

Notes: Subtracted value in a range in DN from 0 to 511.
When subtracting a digital value from the digital video signal the output can no longer reach its maximum. Use the **ssg** command to correct for this where:

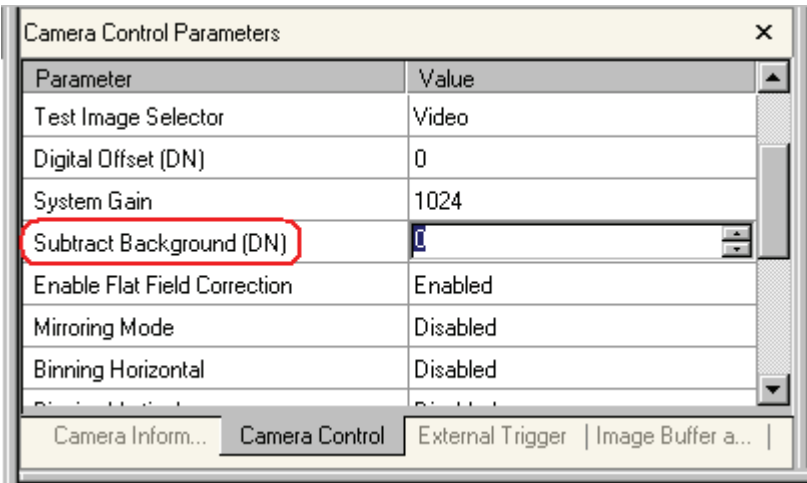
$$\text{ssg value} = \frac{\text{max output value}}{\text{max output value} - \text{ssb value}}$$

Related Commands: `ssg`

Example `ssb 0 25`

CamExpert Parameters

The background subtraction is set using the Subtract Background (DN) parameter, available on the Camera Control tab.



Falcon Subtract Background – on Camera Control Tab

4.11 Generating a Test Pattern

The Falcon camera includes a built in test pattern generator that can be used to confirm camera connections or driver installations, without the need for a camera lens or proper lighting. The pattern generator inserts video just after the sensor A/D converter, therefore Falcon processing such as the LUT act on the generator images or on sensor images.

Serial Command

Purpose: Generates a test pattern to aid in system debugging. The test patterns are useful for verifying proper timing and connections between the camera and the frame grabber. The following table shows each available test pattern.

Syntax: `svm i`


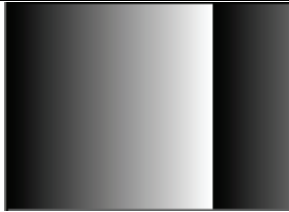




Syntax Elements: `i`

- 0 Video.
- 4 Test pattern horizontal ramp
- 5 Test pattern vertical ramp
- 6 Test pattern diagonal ramp:
- 7 Reserved for DALSA product support.
- 8 Reserved for DALSA product support.

When switching the camera from video mode (`svm 0`) to one of the test pattern modes (`svm 4` thru `8`), the camera "turns off" any digital gain (`sbg`), and background subtract

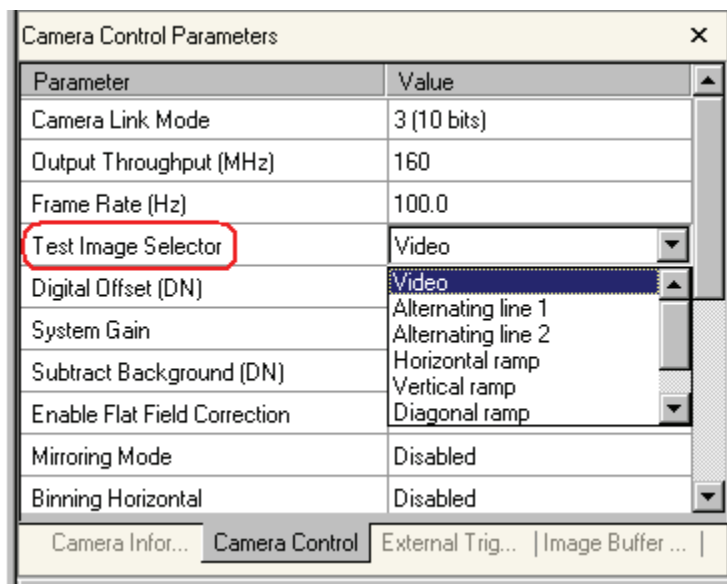
(**ssb**) settings currently being used. The **gcp** screen does not turn off these settings and displays the settings used prior to switching to test pattern mode. When returning to video mode (**svm 0**), the digital gain, background subtract and exposure control settings are returned to their prior state.

Example: **svm 5**

Test Pattern	8-Bit	10-Bit
Horizontal Ramp (svm 4)		
Vertical Ramp (svm 5)		
Diagonal Ramp (svm 5)		

CamExpert Parameter

CamExpert is used to easily enable and select the Falcon test patterns. As shown in the following figure, select the Camera Control tab, then select one of the available patterns from the Test Image Selector drop menu. Select live grab to see the pattern output.

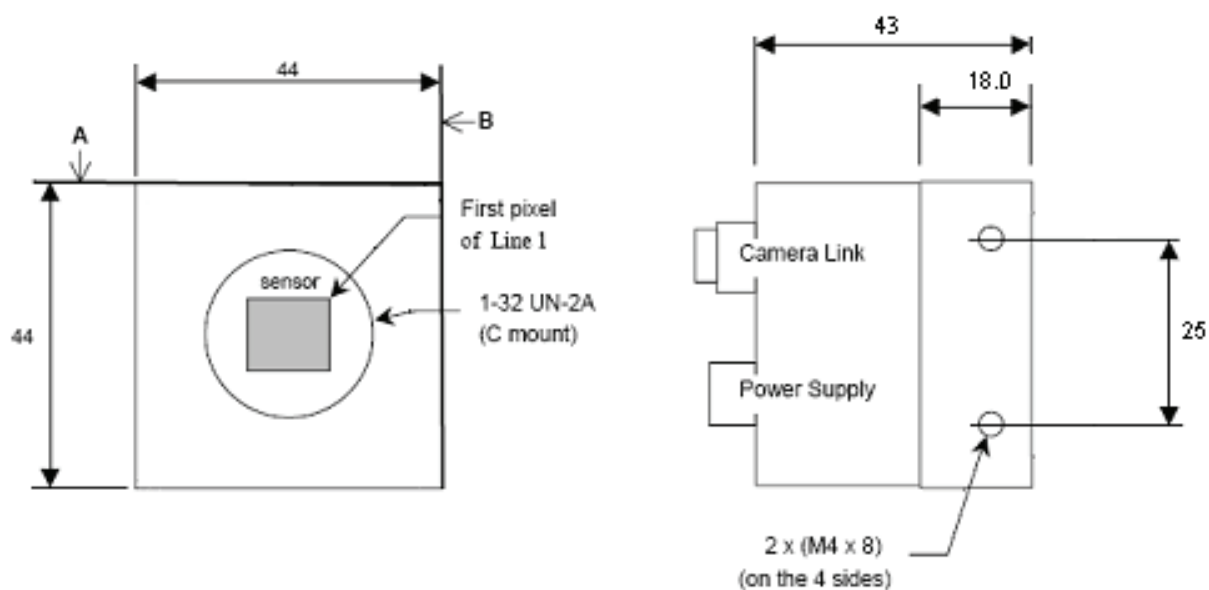


Falcon Test Image Selector – on Camera Control Tab

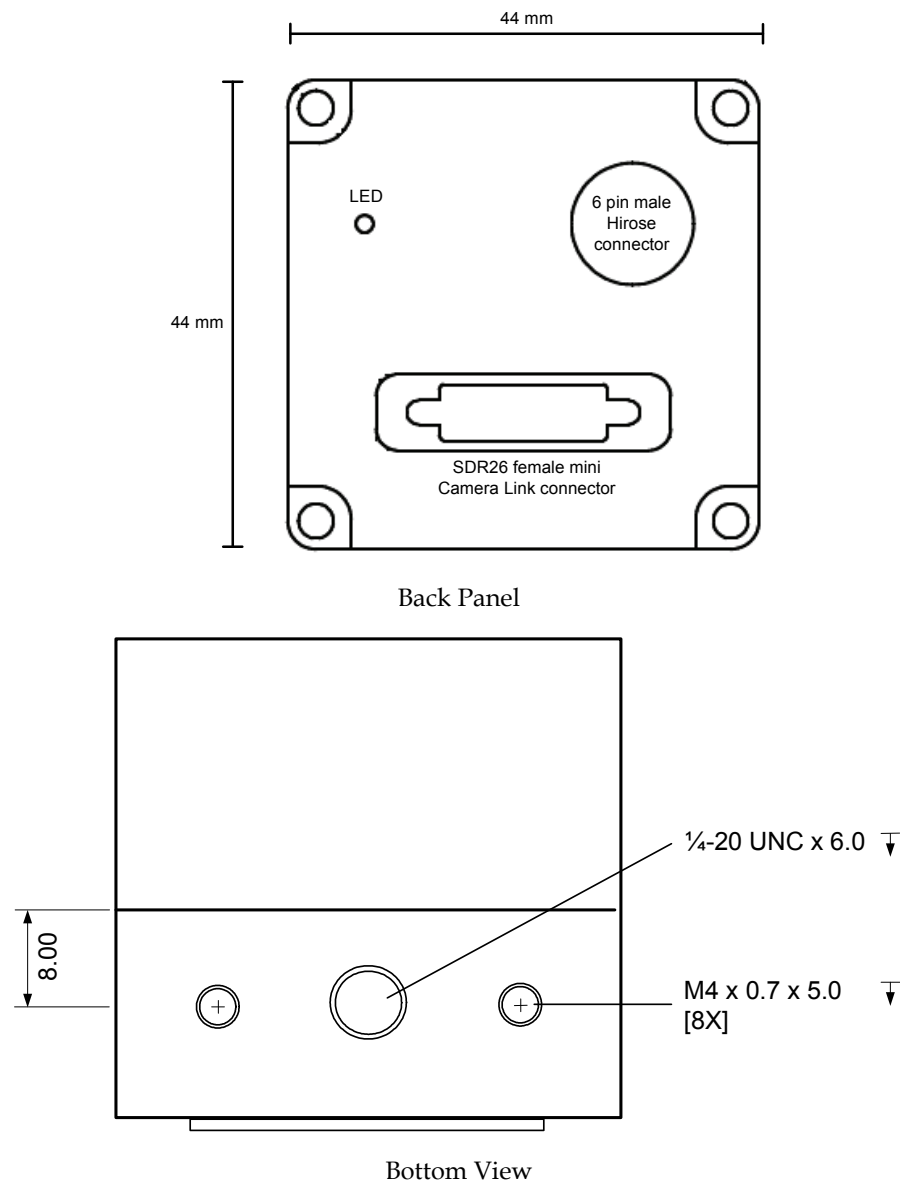
5

Optical and Mechanical Considerations

5.1 Mechanical Interface



Camera Mechanical Dimensions (in mm)



For optimal camera performance, the camera can be cooled by applying forced air flow or by attaching the camera to a material that can conduct heat away from the camera.

5.2 Lens Mounts

Configuration	Flange Back Focal Length (sensor die to adapter)
C-Mount	17.52

Note that the use of certain C-Mount lenses will cause vignetting due to the size of the image sensor. The full resolution of the CMOS sensor is between 2/3 inch and 1 inch C-Mount standards

5.3 Optical Interface

5.3.1 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, www.dalsa.com, provides an introduction to this potentially complicated issue. See "Practical Radiometry" in the Application Notes and Technology Primers found under the Knowledge Center 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). For example, $5\mu\text{J}/\text{cm}^2$ can be achieved by exposing $5\text{mW}/\text{cm}^2$ for 1ms just the same as exposing an intensity of $5\text{W}/\text{cm}^2$ for $1\mu\text{s}$.

5.3.2 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. Compared to Halogen light sources, LED's provide more blue and less red photons.
- 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.

5.3.3 Filters

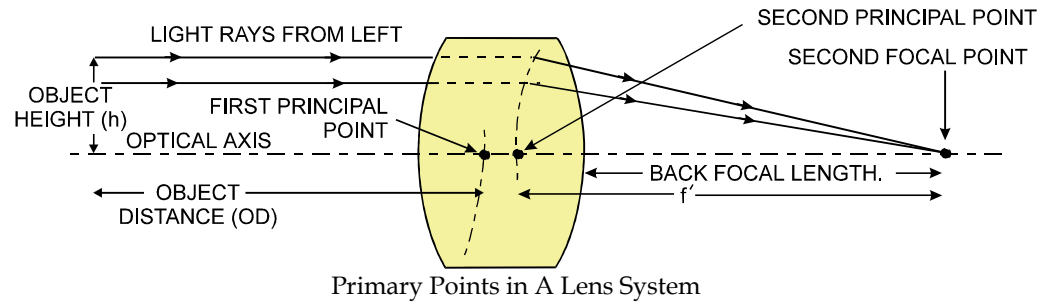
Digital cameras are extremely responsive to infrared (IR) wavelengths of light. To prevent infrared from distorting the images you scan, use a "hot mirror" or IR cutoff filter that transmits visible wavelengths but does not transmit wavelengths over 750nm. Examples are the Schneider Optics™ B+W 489,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

5.3.4 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.



5.3.5 Magnification and Resolution

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

$$m = \frac{h'}{h} \quad \text{where } m \text{ is the magnification, } h' \text{ is the image height (pixel size) and } h \text{ is the object height (desired object resolution size).}$$

By similar triangles, the magnification is alternatively given by:

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

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

$$\frac{h'}{h} = \frac{f'}{OD} \quad \text{This is the governing equation for many object and image plane parameters.}$$

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

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

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 6.1, 6.2, and 6.3.
2. If these solutions do not resolve your problem, see section 6.4 on getting product support.

6.1 Common Solutions

6.1.1 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 the connector pinout and that all grounds are connected. Refer to section 2.2.5 Power Connector on page 20 for details.

Note: Avoid hot plugging long power cables into the camera.

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 4.11 Generating a Test Pattern for further information on running test patterns.

6.2 Troubleshooting Using the Serial Interface

6.2.1 Communications

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

6.2.2 Verify Parameters

To verify the camera setup, send the **gcp** (get camera parameters) command. To retrieve valid parameter ranges, send the **h** (help) command.

6.2.3 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.

6.2.4 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.

6.3 Specific Solutions

6.3.1 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 (for example EXSYNC, if camera is using an internal signal for synchronization).

6.3.2 Line Dropout, Bright Lines, or Incorrect Frame rate

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

6.3.3 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.

6.3.4 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 2-6 using a clean tissue until the entire window has been cleaned.
8. Blow off any adhering fibers or particles using dry, filtered compressed air.

6.4 Product Support

If there is a problem with your camera, collect the following data about your application and situation and call your DALSA representative. In most cases, providing the output from executing the 'gcp' command will give our Product Support Team with a large amount of information to help you solve your problem.

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 (for example, FA-20-01M1H-00-R)	
Complete Camera 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)	<div> <div>✎ EXSYNC</div> <div>✎ MCLK</div> </div> <div> <div>✎ BIN</div> <div>✎ Other _____</div> </div>
Results when you run the gcp command	<i>please attach text received from the camera after initiating the command</i>
Detailed description of problem encountered.	<i>please attach description with as much detail as appropriate</i>

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

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

The DALSA Camera Link Implementation Road Map (available in the Knowledge Center at www.dalsa.com) details how DALSA standardizes its use of the Camera Link interface.

LVDS Technical Description

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

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 www.dalsa.com Web site.

DALSA Camera Control Configuration

Falcon Stop Action Cameras	Camera Link Name
EXSYNC	CC1
Reserved for future use	CC2
Reserved for future use	CC3
Reserved for future use	CC4

Communication

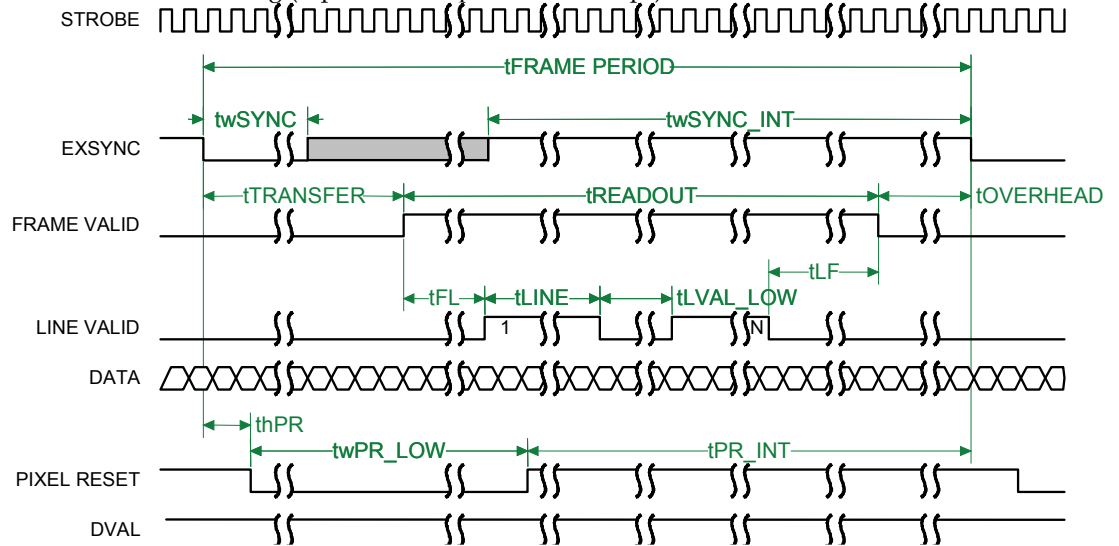
Two LVDS pairs have been allocated for asynchronous serial communication to and from the camera and frame grabber. Cameras and frame grabbers should support at least 9600 baud. These signals are

- 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 programming interface (API) for using the asynchronous serial communication port. The user interface will consist of a terminal program with minimal capabilities of sending and receiving a character string and sending a file of bytes. The software API will provide functions to enumerate boards and send or receive a character string. See Appendix B in the Official Camera Link specification on the www.dalsa.com Web site.

Camera Link Video Timing

Falcon Standard Timing (Input and Output Relationships)



Symbol	Definition	Units	Min.	Typ.	Max.
t_{wSYNCR}	The minimum width of the EXSYNC pulse. When in SMART EXSYNC mode, the minimum width is greater to allow for the photosites to be properly reset.	μs	12		
t_{wSYNCR_INT}	Te integration time when the "SMART EXSYNC" feature is available and turned on. Note, the minimum time is necessary to guarantee proper operation.	μs	10		
$t_{FRAME PERIOD}$	The minimum frame time made up of $t_{TRANSFER}$, $t_{READOUT}$ plus $t_{OVERHEAD}$	ms	16.129		1000.0
$t_{TRANSFER}$	The time from the reception of the falling edge of EXSYNC to the rising edge of FVAL.	μs	*	82 (c1m 2/3)	
$t_{READOUT}$	The time that frame valid is high	μs	*	(c1m 2/3) (c1m 2/3, sot 80)	
$t_{OVERHEAD}$	The number of pixels that must elapse after the falling edge of FVAL before the EXSYNC falling edge can occur.	ns	*		
t_{LINE}	The line time	μs	*	(c1m 2/3, sot 80)	

Symbol	Definition	Units	Min.	Typ.	Max.
tFL	Number strobes between FVAL rising and the first LVAL rising edge.	clocks		0	
tLVAL_LOW	Number strobes that LVAL is low during readout	μs	*		
tLF	Number of strobes between last LVAL falling and FVAL falling edge.	clocks		0	
thPR	N/A	ns			
twPR_LOW	N/A	ns			
tPR_INT	N/A	ns			

* Information not available at printing.

Bit Assignments According to Configuration

The following table describes the bit assignments for both 8-bit and 10-bit 2 tap base configuration (clm 2 and clm 3). The two taps are interleaved and provide consecutive pixels simultaneously (for example, with the 8-bit configuration, port A starts with pixel 0 and port B pixel 1, and so on).

Port/bit	8-bit	10-bit
Port A0	A0	A0
Port A1	A1	A1
Port A2	A2	A2
Port A3	A3	A3
Port A4	A4	A4
Port A5	A5	A5
Port A6	A6	A6
Port A7	A7	A7
Port B0	B0	A8
Port B1	B1	A9
Port B2	B2	Not used
Port B3	B3	Not used
Port B4	B4	B8
Port B5	B5	B9
Port B6	B6	Not used
Port B7	B7	Not used
Port C0	Not used	B0
Port C1	Not used	B1
Port C2	Not used	B2
Port C3	Not used	B3
Port C4	Not used	B4
Port C5	Not used	B5
Port C6	Not used	B6
Port C7	Not used	B7

Appendix B

Error Handling and Command List

All Available Commands

As a quick reference, the following table lists all of the commands available to the camera user. For detailed information on using these commands, refer to [Chapter 4](#).

	Command	Syntax	Parameters	Description
Parameters: t = tap id i = integer value f = real number s = string m = member of a set	correction calibrate FPN	ccf		Performs FPN calibration and eliminates FPN by subtracting away individual pixel dark current.
	camera link mode	clm	m	Output mode to use: 2 : Base configuration, 2 taps, 8 bit output 3 : Base configuration, 2 taps, 10 bit output
	calculate PRNU algorithm	cpa	i i	Performs PRNU calibration according to the selected algorithm. The first parameter is the algorithm where i is: 2 = Calculates the PRNU coefficients using the entered target value $\text{PRNU Coefficient}_i = \frac{\text{Target}}{(\text{AVG Pixel Value}_i) - (\text{FPN}_i + \text{sdo value})}$ This algorithm is useful for achieving uniform output across multiple cameras.
	coefficient set number	csn	i	Selects the coefficient set to use, either: 0 = Factory calibrated set of FPN and PRNU coefficients. These coefficients cannot be erased or modified. 1 = User calibrated set of FPN and PRNU coefficients. These coefficients can be deleted or modified.
	calibration sample size	css	m	Sets the number of lines to sample when performing FPN and PRNU calibration where m is 32 (factory setting), 64 , 128 , 256 , 512 , or 1024

Parameters:
t = tap id
i = integer value
f = real number
s = string
m = member of a set

Command	Syntax	Parameters	Description
enable pixel coefficients	epc	i i	Enables or disables FPN and PRNU coefficients. The first parameter sets the FPN coefficients where i is: 0 = FPN coefficients disabled 1 = FPN coefficients enabled The second parameter sets the PRNU coefficients where i is: 0 = PRNU coefficients disabled 1 = PRNU coefficients enabled
get camera model	gcm		Read the camera model number.
get camera parameters	gcp		Read all of the camera parameters.
get camera serial	gcs		Read the camera serial number.
get camera version	gcv		Read the firmware version and FPGA version.
get command parameter	get	s	Display value of camera command s
Get FPN Coefficient	gfc	x y	x = 1-1400 y = 1-1024
get help	gh		Display the get help screen
get sync frequency	gsf	i	Displays the frames per second. (i = 1)
help	h		Display the online help
Load pixel coefficients	lpc		
reset camera	rc		Reset the entire camera (reboot).
restore factory settings	rfs		Restore the camera's factory settings.
reset pixel coefficients	rpc		Resets the pixel coefficients to factory settings.
restore user settings	rus		Restore the camera's last saved user settings.
set horizontal binning	sbh	i	Sets the horizontal binning. 1 : no binning 2 : each pixel value is formed from 2 adjacent pixels, effectively reducing the frame width in half.
set baud rate	sbr	m	Set the speed of the serial communication port. Baud rates: 9600 , 19200 , 57600 , and 115200 . Default baud: 9600.

	Command	Syntax	Parameters	Description
Parameters: t = tap id i = integer value f = real number s = string m = member of a set	set vertical binning rate	sbv	i	Sets the vertical binning. 1: no binning 2: each pixel value is formed from 2 adjacent pixels on consecutive lines, effectively reducing the frame height in half.
	set digital offset	sdo	t i	Set the digital offset as a DN, which is added to the digital video signal. t: tap selector: this is always 0 (all taps) i: the digital offset (0-1023 DN)
	Set exposure mode	sem	m	Set the exposure mode. Available values are: 2: Internal SYNC, programmable frame rate and exposure time using commands ssf and set . 4: Smart EXSYNC. 6: External frame rate, fixed exposure time 9: Sequential Smart EXSYNC. 10: Sequential external frame rate, fixed exposure time
	set exposure time	set	f	Sets the exposure time to a floating point number in μs . Allowable range is 250–4194303 μs .
	Set FPN Coefficient	sfc	x y i	x = 1-1400 y = 1-1024 i = 0-255
		sfc	x y z	
	set LUT coefficient	slc	i i	Specifies the LUT input pixel value and output value. All other pixel values are then calculated linearly. i :Input pixel value. Possible values are 0–1023 . i : Output pixel value. Possible values are 0–1023 .
	set LUT enable	sle	i	Enables or disables the camera LUT. 0: LUT disabled 1: LUT enabled
	set mirroring mode"	smm	i	Enables or disables mirroring mode: 0: disabled 1: enabled
	set output throughput	sot	m	Sets the output throughput. Possible values are 80 or 160 MHz.
	Set PRNU coefficient	spc	x y i	x = 1-1400 y = 1-1024 i = 0-255

	Command	Syntax	Parameters	Description
Parameters: t = tap id i = integer value f = real number s = string m = member of a set	Set subtract background	ssb	t i	t = 0-0 i = 0-511
	set sync frequency	ssf	f	Sets the frame rate in Hz to a value from 0.095 to 102.354 .
	set system gain	ssg	t i	Sets the digital gain. t = Tap selection. Allowable value is 0 for all taps. i = Gain value is specified from 0 to 65535 . The digital video values are multiplied by this number.
	set video mode	svm	m	Sets the camera's video mode. 0 : Video mode 4 : Test pattern horizontal ramp 5 : Test pattern vertical ramp 6 : Test pattern diagonal ramp 7 : Test pattern FPN 8 : Test pattern PRNU
	upload CBF file	upd		
	verify temperature	vt		Returns the current temperature of the camera.
	verify voltage	vv		Returns the 1.2 V, 2.5V, and 3.3V measurements.
	window start end	wse	i i x1 y1 x2 y2	Sets the window start and stop pixels where: i is the window sequence id. It is always 0 in this camera. i is the number of windows to set. It is always 1 in this camera. x1 is window start corner value. Ranges from 0-1399 . y1 is window start pixel number. Ranges from 0-1023 . x2 is window end corner value. Ranges from 15-1399 . y2 is window end pixel number . Ranges from 1-1023 .
	write FPN coefficients	wfc		Saves the FPN coefficients
	write PRNU coefficients	wpc		Saves the PRNU coefficients
	write user settings	wus		Write all of the user settings to non-volatile memory.

Appendix C

EMC Declaration of Conformity



EC & FCC DECLARATION OF CONFORMITY

We : DALSA Montreal Inc.
7075 Place Robert-Joncas, Suite 142,
St. Laurent, Quebec, Canada H4M 2Z2

Declare under sole legal responsibility that the following products conform to the protection requirements of council directive 89/336 EEC on the approximation of the laws of member states relating to electromagnetic compatibility, as amended by directive 93/68/EEC:

VIDEO CAMERA: FALCON 1.4M100 & VGA295

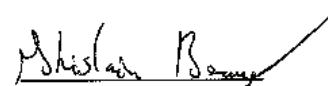
The products to which this declaration relates are in conformity with the following relevant harmonized standards, the reference numbers of which have been published in the Official Journal of the European Communities:

EN55022:1998- Residential, Commercial and Light Industry
ENV50204: 1995
EN61000-4: 1995, 1996, 1998, 2001

Further declare under our sole legal responsibility that the product listed conforms to the code of federal regulations CFR 47 part 15 (2006) subpart B. Measurement of radiated emissions; Class A.

St. Laurent, Canada
Location

July 17, 2007
Date


Ghislain Beaupré
Vice-President,
Research & Development

Appendix D

Revision History

Revision Number	Change Description
00	Preliminary release
01	First release edition

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