DALSTAR 6M18

DS-4x-06M18

18 fps 3k x 2k

CCD Camera

User's Manual and Reference

Document number 03-32-10017

Revision 03

DALSA
technology with vision

About DALSA

DALSA is an international digital imaging solutions company that designs, develops, manufactures, and markets high performance image sensors, electronic cameras, and vision systems. DALSA products are designed to replace human vision and act as high performance "electronic eyes" in machine visions. DALSA's continually expanding markets include Vision for Machines, Life Sciences, Vision Systems, and Digital Cinema. DALSA sells to Original Equipment Manufactures (OEMs), end users, and to the scientific and research communities in Canada, the United States, Europe, Japan, and Asia Pacific. Based in Waterloo, Canada, with operations in Colorado Springs, Tucson, Munich, and Tokyo, DALSA is a public company listed on the Toronto Stock Exchange under the symbol "DSA".

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

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

DALSA Sales Offices

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

DALSA Worldwide Operations

Waterloo	Colorado Springs	Tucson	Europe	Asia Pacific
605 McMurray Rd Waterloo, ON N2V 2E9 Canada Tel: 519 886 6000 Fax: 519 886 8023 www.dalsa.com sales@dalsa.com	5055 Corporate Plaza Drive Colorado Springs, CO 80919 USA Tel: 719 599 7700 Fax: 719 599 7775 www.dalsa.com sales@dalsa.com	3450 S. Broadmont Dr. Suite #128 Tucson, AZ 85713-5245 USA Tel: 520 791 7700 Fax: 520 791 7766 http://lifesciences.dalsa.com sales@dalsa.com	Breslauer Str. 34 D-82194 Gröbenzell (Munich) Germany Tel: +49 - 8142 – 46770 Fax: +49 - 8142 – 467746 www.dalsa.com europe@dalsa.com	Space G1 Building, 4F 2-40-2 Ikebukuro Toshima-ku, Tokyo 171-0014 Japan +81 3 5960 6353 (phone) +81 3 5960 6354 (fax) www.dalsa.com asia@dalsa.com

Camera Link is a trademark registered by PULNiX America Inc., as chair of a committee of industry members including DALSA.

Note: The enclosed information details an engineering model camera that has been made available for initial evaluation and proof of concept for your application. It is not a production model. As such, the current camera configuration may differ from that of a production model.

Contents

1

Introduction to the 6M18 Camera

1.1 Camera Highlights

Features

- 3072 x 2048 resolution, Full-frame CCD architecture.
- 18 fps four channel at full resolution, 4 x 40 MHz data rate
- True 12-bit digitization
- Progressive scan readout
- Asynchronous image capture, externally triggerable to within 200ns.
- Available with F-mount or M72x1 mount.
- Selectable binning
- Programmable operation via RS232, including gain (1x and 10x) , binning, and triggering
- 100% fill factor

Description

The 6M18 digital camera provides high-sensitivity 12-bit images with 3k x 2k spatial resolution at up to 18 frames per second (fps). The 6M18 is a Full Frame CCD camera using a progressive scan CCD to simultaneously achieve outstanding resolution and gray scale characteristics. A square pixel format and high fill factor provide superior, quantifiable image quality even at low light levels.

Applications

The 6M18 is an outstanding performer in fast, very high resolution applications. True 12 bit performance provides up to 4096 distinct gray levels—perfect for applications with large interscene light variations. The low-noise, digitized video signal also makes the camera an excellent choice where low contrast images must be captured in challenging applications.

1.2 Image Sensor

Figure 1: Image Sensor Block Diagram

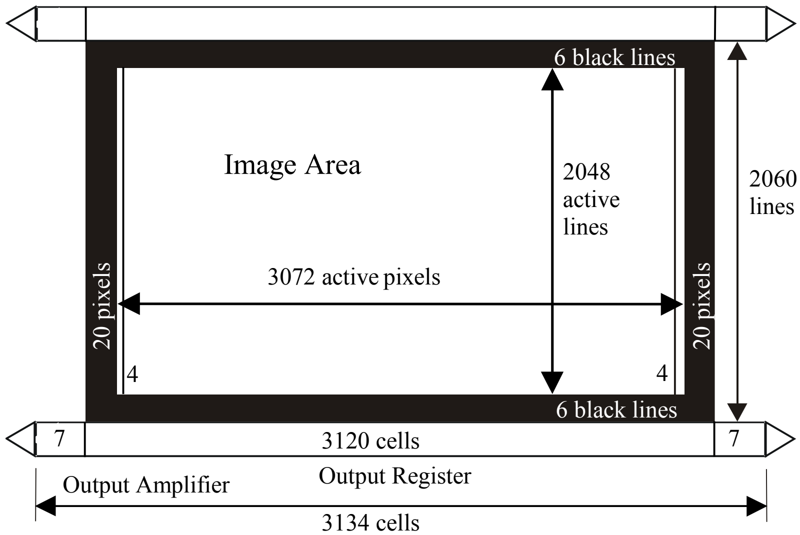


Table 1: Sensor Characteristics

Sensor characteristics	
Optical size	36.864mm (H)x24.576 mm (V)
Chip size	39.148 mm (H)x26.508 mm (V)
Pixel size	12µm x 12µm
Active pixels	3072 (H) x 2048 (V)
Total number of pixels	3120 (H) x 2060 (V)
Optical black pixels	Left: 20 Right: 20
Timing pixels	Left: 4 Right: 4
Dummy register cells	Left: 7 Right: 7
Optical black lines	Bottom: 6 Top: 6

TEST CONDITIONS

Temperature: 35°C

Integration Time: 10 ms

Table 2: Sensor Cosmetic Specifications

Type	Allowable Blemishes
Columns	1
Clusters	6
Pixels	36

Definition of blemishes

Pixel defect

- Pixel whose signal, at nominal light (illumination at 50% of the linear range), deviates more than ±30% from its neighboring pixels.
- Pixel whose signal, in dark, deviates more than 6mV from its neighboring pixels (about 1% of nominal light).

Cluster defect

- A grouping of pixel defects where within a sub area of 3*3 pixels there are at most 5 present.

Column or row defect

- A column or row which has more than 12 pixel defects.
- Column defects must be horizontally separated by 3 columns.
- Row defects are not allowed.

1.3 Camera Performance Specifications

Table 3: 6M18 Camera Performance Specifications

Physical Characteristics	Units		Notes
Resolution	H x V pixels	3072x2048	
Pixel Size	µm	12x12	
Chip Working Area	mm	36.86 x 24.57	
Pixel Fill Factor	%	100	
Image Sensor Grade		Industrial Grade	See Table 2: Sensor Cosmetic Specifications
Size	mm	146x92x105	
Mass	kg	1.05	
Power Dissipation	W	< 27	
Output Data Format	LVDS	4 x 12 Bit, LVDS	1
Serial Port Setup		9600 8N1	
Serial Data Format		Hexadecimal	
Lens Mount		F-mount and M72x1mm	
Cooling Fan		Present	

Operating Ranges	Units	Min.	Max.
Data Rate	MHz	4 x 40	4 x 40
Operating Temp	°C	10	40
+15 Input Voltage	V	+14.25	+15.75
+5 Input Voltage	V	+4.975	+5.25
-5 Input Voltage	V	- 4.75	- 5.25
Nominal Gain Range	X	1x	10x

Binning Modes	Default	Min	Max
Horizontal Binning	1x	2x	4x
Vertical Binning	1x	2x	4x

Calibration Conditions	Units	Setting	Min.	Max.	Notes
Data Rate	MHz	4x40	4x40	4x40	
+15 Input Voltage	V	+15	+14.925	+15.075	2
+5 Input Voltage	V	+5	+4.975	+5.025	2
-5 Input Voltage	V	- 5	- 4.975	- 5.025	2
Binning Mode		1x1			
Ambient Temperature	°C	25			
Gain	X	1x			

Electro-Optical Specifications	Units	Min.	Typical	Max.	Notes
Quantum Efficiency @ 530nm	%	20	26		
Dark Current Generation @ 30C	e^-/pix/sec			305	
Dark Offset	DN	40	50	60	
Dynamic Range		1850:1	2500:1		
System Noise	DN(rms)		1.5	2.0	
Saturation Output Amplitude	DN	3700	3800		
Maximum Full frame Rate	Fps			18	
Integration time at Max Frame Rate	mSec			1.4	
FPN	DN(rms)		1.5	2.0	3
PRNU	%		0.5	5	4
Responsivity @ 530nm	DN/(nj/cm^2)	32	36	41	

Notes:

1. Each of the 60 Pin Molex connectors contains 2 12 bit data words synchronized to 1 set of control signals.
2. Max supply ripple for Performance specs <5mV
3. FPN = Fixed Pattern Noise defined by the following equation:

   FPN(DNrms)=Std_dev(Dark_image(i,j))

   Dark_image(i,j)= pixel by pixel average of a statistically significant number of data frames in darkness

   Std_dev= Standard deviation
4. PRNU= Photo Response Nonuniformity defined by the following equation:

   PRNU(%) = [Std_dev (illuminated_50(i,j)) / (mean(Illuminated_sat(i,j))-mean(Dark_average(i,j)))] x 100

   illuminated_50(i,j)= pixel by pixel average image of a statistically significant number of images at 50% illumination

   illuminated_sat(i,j)= pixel by pixel average image a statistically significant number of saturated frames

Dark_average(i,j)= pixel by pixel average image of a statistically significant number of data frames in darkness

Std_dev= standard deviation

mean = mean of all pixels (i,j)

2

Camera Hardware Interface

2.1 Installation Overview

In order to set up your camera, you should take these initial steps:

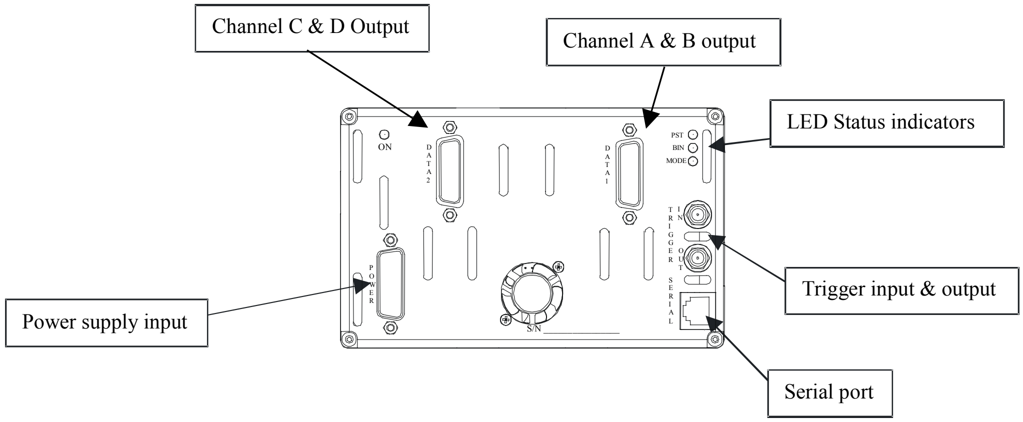
This installation overview assumes you have not installed any system components yet.

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. Ensure that all the correct voltages are present at the camera end of the power cable (the Camera Performance Specifications earlier in this document lists appropriate voltages). Power supplies must meet the requirements defined in section 2.4 Power Input.
5. Inspect all cables and connectors prior to installation. Do not use damaged cables or connectors or the camera may be damaged.
6. Connect data, serial interface, and power cables.
7. After connecting cables, apply power to the camera. The POST (power on self test) LED on the back of the camera should glow green after one second to indicate that the camera is operating and ready to receive commands.

2.2 Input/Output

The camera provides 12-bit LVDS data and synchronization signals through the data output connector. Camera functions such as integration time, binning and camera gain are all controllable by the user via RS232 serial port. The camera is capable of free running operation or may be triggered externally via the input TRIGGER IN. TRIGGER OUT allows the synchronization of shutters or illumination sources in free running or externally triggered modes.

Figure 2: Camera Inputs/Outputs



2.3 LED Status Indicators

There are three LED's visible on the rear cover of the camera that indicate the status of the camera.

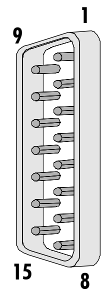
Table 4: LED Functions

LED Label	Color	LED "ON"	LED "OFF"
POST	Green	Camera Power On Self Test successful	Camera failed Power On Self Test
BIN	Green	Camera is operating in a binning mode	Camera is operating unbinned (1x1)
MODE	Green	Camera is in an external trigger mode (uses external signal to trigger image capture)	Camera is triggering image capture internally

2.4 Power Input

Table 5: Power Connector Pinout

Pin	Symbol
1	+5V
2	+5V
3	- 5V
4	+15V
5	NC
6	NC
7	GND
8	GND
9	+5V
10	- 5V
11	+15V
12	+15V
13	NC
14	GND
15	GND



DB15M
(AMP Part # 747236-4 or equivalent)

2.5 Power Supplies

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

- Do not connect or disconnect cable while power is on.
- Do not use the shield on a multi-conductor cable for ground.
- Keep leads as short as possible to reduce voltage drop.
- Use high-quality linear supplies to minimize noise.

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

Table 6: 6M18 Power Requirements

V (DC)	±%	Max Ripple mV	I (A)
+15	0.5	< 5	0.40
+5	0.5	< 5	3.25
-5	0.5	< 5	0.55

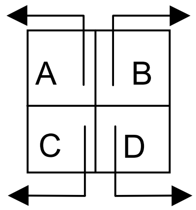
Note: Performance specifications are not guaranteed if your power supply does not meet these requirements.

Many high quality supplies are available from other vendors. DALSA assumes no responsibility for the use of these supplies.

2.6 Data Output

Data channel outputs represent the CCD per the following (Image viewed from the front of the CCD). Arrows indicate channel read out direction.

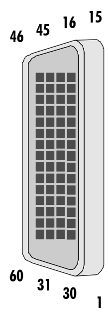
Figure 3: Sensor tap read out direction



The camera back panel output connectors DATA1 and DATA2 utilize differential LVDS signals with pin assignments as follows:

Connector and Pinout

Figure 4: DATA1 Connector Pinout

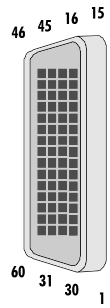


(Molex Part # 70928-2000 or equivalent)

Table 7: DATA1 Connector Pinout

Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol
1	DA0+	16	Reserved	31	DB8-	46	GND
2	DA0-	17	DA7+	32	DB8+	47	DB11-
3	DA1+	18	DA7-	33	DB7-	48	DB11+
4	DA1-	19	DA8+	34	DB7+	49	DB10-
5	DA2+	20	DA8-	35	DB6-	50	DB10+
6	DA2-	21	DA9+	36	DB6+	51	DB9-
7	DA3+	22	DA9-	37	DB5-	52	DB9+
8	DA3-	23	DA10+	38	DB5+	53	Reserved
9	DA4+	24	DA10-	39	DB4-	54	Reserved
10	DA4-	25	DA11+	40	DB4+	55	VSYNC-
11	DA5+	26	DA11-	41	DB3-	56	VSYNC+
12	DA5-	27	DB0+	42	DB3+	57	HSYNC-
13	DA6+	28	DB0-	43	DB2-	58	HSYNC+
14	DA6-	29	DB1+	44	DB2+	59	PIXCLK-
15	Reserved	30	DB1-	45	GND	60	PIXCLK+

Figure 5: DATA2 Connector



(Molex Part # 70928-2000 or equivalent)

Table 8: DATA2 Connector Pinout

Pin	Symbol	Pin	Symbol	Pin	Symbol	Pin	Symbol
1	DC0+	16	Reserved	31	DD8-	46	GND
2	DC0-	17	DC7+	32	DD8+	47	DD11-
3	DC1+	18	DC7-	33	DD7-	48	DD11+
4	DC1-	19	DC8+	34	DD7+	49	DD10-
5	DC2+	20	DC8-	35	DD6-	50	DD10+
6	DC2-	21	DC9+	36	DD6+	51	DD9-
7	DC3+	22	DC9-	37	DD5-	52	DD9+
8	DC3-	23	DC10+	38	DD5+	53	Reserved
9	DC4+	24	DC10-	39	DD4-	54	Reserved
10	DC4-	25	DC11+	40	DD4+	55	VSYNC-
11	DC5+	26	DC11-	41	DD3-	56	VSYNC+
12	DC5-	27	DD0+	42	DD3+	57	HSYNC-
13	DC6+	28	DD0-	43	DD2-	58	HSYNC+
14	DC6-	29	DD1+	44	DD2+	59	PIXCLK-
15	Reserved	30	DD1-	45	GND	60	PIXCLK+

WARNING. Care must be taken when connecting Data cables to the camera to insure proper connection and to prevent damage to the connector.

Data Signals

IMPORTANT:
This camera uses the ***falling*** edge of the pixel clock to register data.

Table 9: Data Signal Definition

Signal	Description
D*0+, D*0-	Data bit 0 true and complement--Output. (Least significant bit)
D*1+, D*1-	Data bit 1 true and complement--Output.
D*2+, D*2-	Data bit 2 true and complement--Output.
D*3-D*10+,-etc.	Etc.
D*11+, D*11-	Data bit 11 true and complement--Output. (Most significant bit)

Digitized video data is output from the camera as LVDS differential signals using two Molex 60-pin connectors on the rear panel (labeled "DATA1" and "DATA2"). The data is synchronous and is accompanied by a pixel clock and clocking signals.

Note: Data frequency is dependent on binning mode. Reference section 3.12 – Triggering, Integration, and Frame Rate Overview.

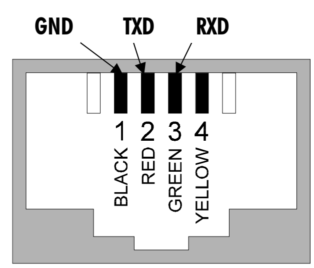
Data Clocking Signals

Table 10: Clock Signal Descriptions

Signal	Description
PIXCLK+, PIXCLK-	Pixel clock true and complement. 40MHz (unbinned) -- Output. Data is valid on the falling edge. Note that data and PIXCLK frequency is dependent on binning mode. Reference section 3.12 – Triggering, Integration, and Frame Rate Overview
HSYNC+, HSYNC-	Horizontal sync, true and complement--Output. HSYNC high indicates the camera is outputting a valid line of data. The number of valid lines in a frame depends on binning mode. Reference section 3.12 – Triggering, Integration, and Frame Rate Overview.
VSYNC+, VSYNC-	Vertical sync, true and complement--Output. VSYNC high indicates the camera is outputting a valid frame of data.

2.7 Serial Communication

Connector and Pinout



RJ-11
View into female jack
6-position with 4 conductors

The serial interface provides control of integration time, video gain, pixel binning, external trigger and external integration (for information on how to control these functions, see section 3.1 How to Control the Camera on page 21). The remote interface consists of a two-wire (plus ground) full duplex RS-232 compatible serial link, used for camera configuration, and two back panel SMA coax connectors used for external trigger input and output

The camera uses an RJ-11 telephone-style connector for serial communications, with four conductors installed in a six-position connector. Note that both four- and six- conductor plugs may be used interchangeably with the RJ-11 jack**.**

IMPORTANT: Both the PC/AT and the camera are configured as "DTE" (Data Terminal Equipment) devices requiring the TXD and RXD lines to be swapped when interconnecting the two (note that pin 4, normally the yellow wire, is not used on the RJ-11.) That is, the TXD pin represents DATA OUT and the RXD pin represents DATA IN on both devices, so that one device's TXD line must connect to the other device's RXD line and vice-versa.

Figure 6: 25 Pin Serial Port Connector to Camera RJ-11 Connector

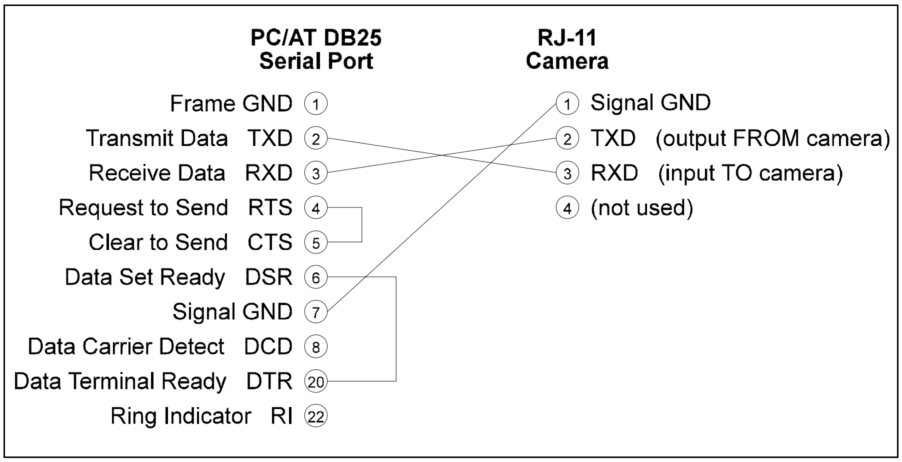
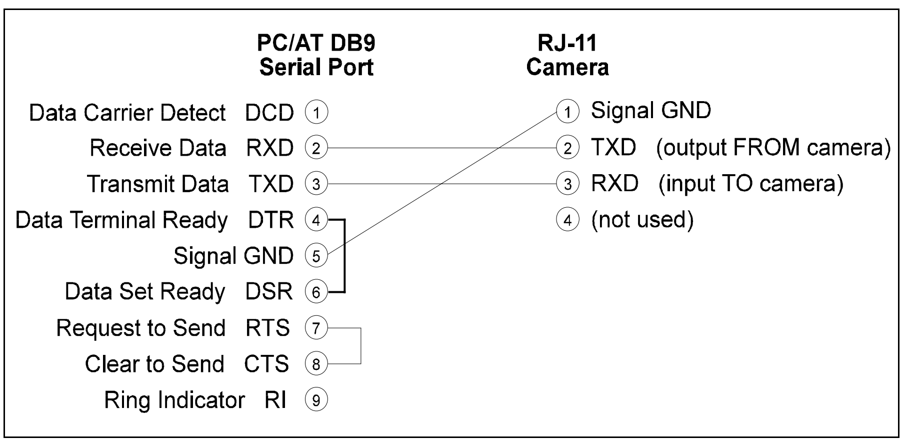


Figure 7: 9 Pin Serial Port Connector to Camera RJ-11 Connector



2.8 Serial Communication Settings

The serial interface operates at RS-232 levels with fixed parameters of 9600 baud, 1 start bit, 8 data bits, 1 stop bit, and no parity. The interface uses only three wires, for received data, transmitted data, and ground. In general writing data must start with a write command byte and be followed by a data byte. Reading a camera register requires only a single read command byte.

Serial Port Configuration	
Baud	9600, fixed
Start bits	1
Data bits	8
Stop bits	1
Parity	None

WARNING: Due to initialization sequencing after power-up, no commands should be sent to the camera for a minimum of 1 second after power up.

The remote interface connector, on the cameras rear panel, is specified as a low-profile RJ-11 modular connector. The connector is a 6-position model, but only the center four positions are populated with contacts. It will mate with either the 4-position or 6-position cable plugs. This type of connector typically requires special assembly tools; complete cable assemblies are available from suppliers such as Digi-Key:

Serial Cable Source

Digi-Key
701 Brooks Ave. South
Thief River Falls, MN 56701
1-800-344-4539
cable part number:
H2643-14-ND (14 feet)

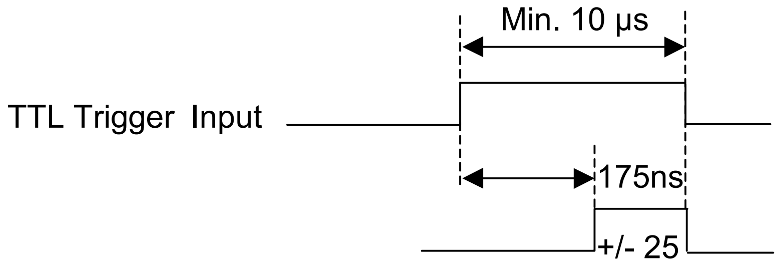
DALSA provides serial cables in 3 lengths: 10', 20' and 50'. Part number CL-31-00004-xx (where xx refers to the cable length in feet).

2.9 TTL Trigger Input and Output

Connector

The camera uses an SMA connector (labeled TRIGGER IN) to allow the user to provide a standard TTL signal to control camera integration and readout. The input is high impedance (>10K) allowing the user to terminate at the SMA input as needed. The camera has another SMA connector (TRIGGER OUT) that provides a standard TTL output which is high whenever the camera is integrating.

Figure 8: Trigger Timing Description



2.10 Integration Time

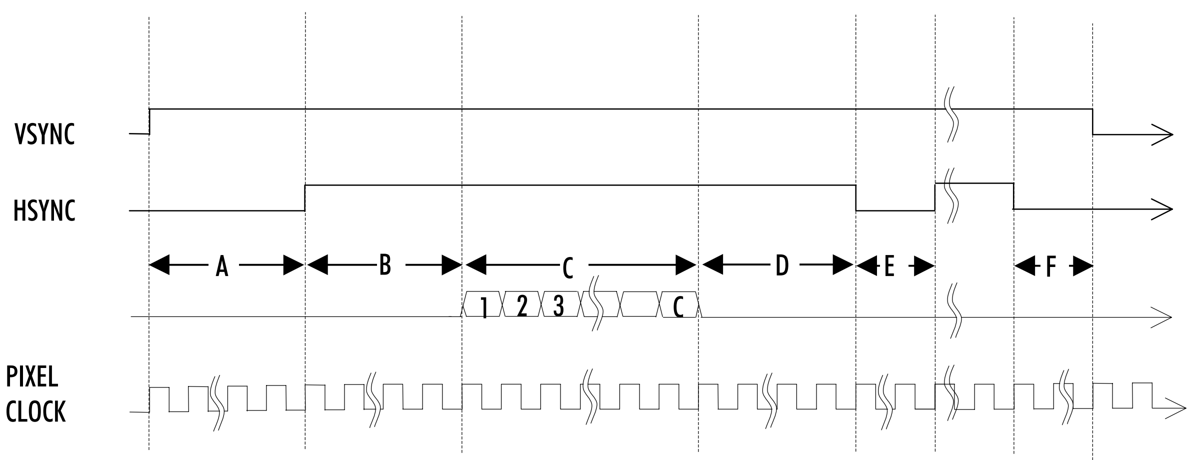
The minimum integration time is 10 µs. As with any full frame imager, the camera will continue to integrate during read out unless externally shuttered or strobed.

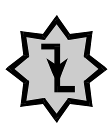
2.11 Timing

The 6M18 pixel clock runs at 40 MHz, so each pixel clock cycle will be 1/40,000,000 or 25 Ns. The following diagram and tables describe the correct timing requirements for the 6M18 camera.

Figure 9: 6M18 Timing

Table 11: HSYNC Pixel Timing





IMPORTANT:
This camera uses the ***falling*** edge of the pixel clock to register data.

Horizontal Binning Mode	A	B	C	D	E	F
1x	11	26	1536	13	518	0
2x	5	16	768	4	539	0
4x	3	6	384	3	550	0

Table 12: VSYNC Pixel Timing (HSYNC falling edges/VSYNC falling edge)

Vertical Binning Mode	Pre-Scan Lines/Frame	Active Lines/Frame	Post Scan Lines/Frame
1x	6	1024	0
2x	3	512	0
4x	2	256	0

"A" represents the number of falling clock edges from the rising edge of VSYNC to the rising edge of HSYNC.

"B" represents the number of falling clock edges prior to the first word. (Pre-Scan pixels)

"C" represents the number of words per line.

"D" represents the number of falling clock edges between the last word and the falling edge of HSYNC. (Post-Scan pixels)

"E" represents the number of falling clock edges between a falling HSYNC and a rising HSYNC.

"F" represents the number of falling clock edges from the falling edge of HSYNC to the falling edge of VSYNC

3

Camera Operation

3.1 How to Control the Camera

The 6M18's RS-232-compatible serial interface allows you to control its configuration and operation, including:

- Triggering Mode
- Binning
- Integration Time
- Gain
- Reset

Command Protocol Overview

The camera accepts 8-bit command/value pairs via its RJ-11 serial port using RS-232 compatible signals.

Serial Port Configuration	
Baud	9600, fixed
Start bits	1
Data bits	8
Stop bits	1
Parity	None

Camera commands are divided into two basic sets:

- "ADC" commands, which apply to the electronics that process and digitize the video. These include gain and offset. ADC commands are board specific, and changing all four channels requires commands to be sent to both ADC boards.
- "Control Register" commands which apply to the electronics that drive the image sensor. These include clock generation, frame rate, integration time, and binning. A single control register command effects the entire camera.

Each set of commands includes read and write variants. With the exception of reset commands, all 8-bit write commands must be followed by an 8-bit data byte. The commands are interpreted as follows:

3.2 ADC Commands

WARNING: Any commands not listed should be considered invalid. Writing to invalid addresses may overwrite camera calibration information, requiring the camera to be returned for recalibration.

The following table defines the ADC command format.

Table 13: ADC Command bit definition

Bit	Function
0:3	ADC Command (Reference Table 12)
4:5	ADC Board Address 00 = ADC Board 1 (Channels A & B) 01 = ADC Board 2 (Channels C & D)
6	Command Type 0 = Write 1 = Read
7	Board Type 0 = ADC Board 1 = Clock Board

WARNING: Due to initialization sequencing after power-up, no commands should be sent to the camera for a minimum of 1 second after power up.

The following table lists all valid ADC Commands available to the user. Any commands not listed should be considered invalid to the 6M18 user.

Table 14: Summary of ADC Commands

Control	Write Command		Read Command		Channel	Function
	Hex	Binary	Hex	Binary		
ADC	*0h	00** 0000	NA	NA	A&B or	Resets ADC
Gain	*2h	00** 0010	*2h	01** 0010	A or C	LS byte of 16 bit
	*3h	00** 0011	*3h	01** 0011	A or C	MS byte of 16 bit
	*6h	00** 0110	*6h	01** 0110	B or D	LS byte of 16 bit
	*7h	00** 0111	*7h	01** 0111	B or D	MS byte of 16 bit user controllable gain
AOC	*Ah	00** 1010	*Ah	01** 1010	A&B or C&D	AOC Set Point
	*Bh	00** 1011	*Bh	01** 1011	A&B or C&D	LS byte of AOC initial value
	*Ch	00** 1100	*Ch	01** 1100	A&B or C&D	MS byte of AOC initial value
	*Dh	00** 1101	*Dh	01** 1101	A&B or C&D	AOC Loop Gain

(*) indicates actual value is dependent on the selected channel

The following sections discuss these commands in detail.

3.3 Control Register Reference

A number of functions and modes depend on the control register settings. These settings are detailed in the following sections.

The "Write Control Register" command is used to write a register that controls specific camera triggering and test functions. This command must be followed by a data byte with bits defined as shown in the following table.

The "Read Control Register" command allows interrogation of the camera to determine current configuration of the control register.

Table 15: Control Register Bit Definitions

Register	Write Command	Read Command	Bit	Function	Default
Reset	80h	NA	7:0	Resets all registers to default values	NA
Camera Type	NA	C3h	7:0	Read camera type	4Dh
Firmware Rev	NA	C5h	7:0	Read firmware revision	Fxh
Register 1	82h	C2h	7	Integration Mode 0=Internal 1=External	0
			6:4	Always 0	00
			3	Trigger Mode 0=Internal 1=External	0
			2	Flush Before Integrate 0 = Charge is flushed between frames 1 = Flushing disabled (bit [7] must =1)	0
			1	Always 0	0
			0	Serial Syn Bit	0

Register	Write Command	Read Command	Bit	Function	Default
Register 2	85h	NA	7	Always 0	0
			6:4	Vertical Binning 001 = 1x 010 = 2x 100 = 4x	001
			3	Always 0	0
			2:0	Horizontal Binning 001 = 1x 010 = 2x 100 = 4x	001
Write Integration Time LS	8Ah	NA	7:0	LS byte of 24 bit integration time	2Bh
Write Integration Time 2nd	8Bh	NA	7:0	2nd byte of 24 bit integration time	FCh
Write Integration Time MS	8Ch	NA	7:0	MS byte of 24 bit integration time	00b

3.4 Resetting the ADC boards ("soft" reset)

When this command is issued, the microprocessor on the ADC board will jump to the beginning of code and start execution as if the micro was just powered up. This causes the dark reference control loop to restart at its initial values before settling in to the calibrated dark reference level of approximately 50 counts. This is useful because under some conditions, issuing a soft reset to the ADC board's microprocessor after camera operating conditions have changed will improve the rate at which the offset control loop pulls into the calibrated level. The reset will effect both channels on a single board.

This is one of only two "write" commands that are not followed by a data byte.

Example

Use this command to reset ADC Board 2 (Channels C & D):

	Command	Value
Binary	0001 0000	-
Hex	10h	-

3.5 Adjusting User Gain

Video gain is adjustable from 1x to10x by writing a 16 bit value as an MS and LS byte (only the 14 most significant bits of this value are actually used). The gain for a single channel on an ADC board can be adjusted with a single command set. Adjusting all four ADC channels requires four command sets. The value is calculated according to the following equation:

Value ≅ 32768 × log10(Gain)

Where **1 ≤ Gain ≤ 10**

Example: Set ADC Channel B to 5x Gain

Use these command/value pairs set the camera to 5x gain (you must write both MSB and LSB values).

Value ≅ 32768 × log10(5)

Value = 22903

= 5977h

	Write MSB		Write LSB	
	Command	Value	Command	Value
Binary	0000 0111	0101 1001	0000 0110	0111 0111
Hex	07h	59h	06h	77h

Reading User Gain from ADC Channel C

To read the gain setting from the camera, use these commands:

	Read MSB	Read LSB
Binary	0101 0011	0101 0010
Hex	53	52

Note: At any gain setting, the CCD imager is subject to blooming when it is over illuminated. To remedy over illumination, reduce the integration time or select a higher f-stop value

3.6 Automatic Offset Control (AOC)

The AOC defines the digitized value of black for the camera. An ideal camera (no dark current, no shot noise, etc.) in total darkness produces an image with all pixels equal to the AOC set point value. This command allows you to control the AOC set point of the ADC video board. The two ADC video boards in the 6M18 can each be controlled independently. Both channels on the single board will be affected. Normally both boards are controlled with the same set point value. The default value is 50 DN, or counts.

Example: Set ADC Board 1 (Channel A & B) AOC Set Point to 32 DNs

Value = 32

= 20h

	Command	Value
Binary	0000 1010	0010 0000

Hex	0Ah	20

3.7 Reading the Camera Type

This read command returns an 8-bit value unique to the type of camera interrogated. A 6M18 will return a value of 4Dh when this command is issued. This is useful for applications that need to function with multiple DALSTAR camera types.

Example: Read the camera type

	Command	Value Returned (6M18)
Binary	1100 0011	0100 1101
Hex	C3h	4Dh

3.8 Reading the Firmware Revision

This command returns a byte in which the lower nibble is the revision number for the clock board firmware and the upper nibble is undefined. The ability to read this value may assist in customer support issues.

Example: Read the firmware version

	Command
Binary	1100 0101
Hex	C5h

3.9 Resetting the Camera ("hard" reset)

This is the only other "write" command that is not followed by a data byte. This command resets all clock board and ADC board registers to their default values (the values used at power-up).

Table 16: Default values in effect after reset

Feature	6M18 Default
Frame Rate (fps)	18
Integration Time (ms)	5
Resolution (pixels)	3072x2048
Video Gain	1x
Binning Mode	1x1
Pixel Offset	50
Synchronization	INTERNAL
Integration Control	INTERNAL
Data Rate (MHz)	4x40

Example

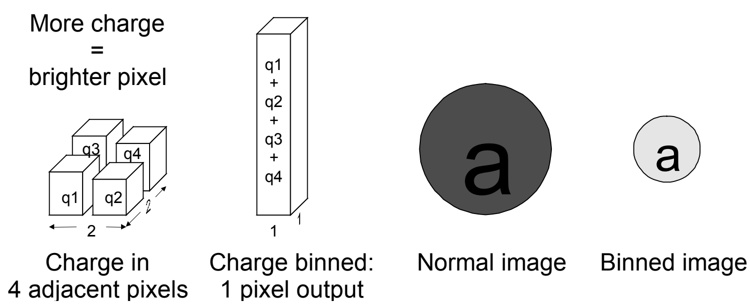
Use this command to reset the camera:

	Command	Value
Binary	1000 0000	-
Hex	80h	-

3.10 Controlling Binning

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

Figure 10: 2x2 Binning



The 6M18 is capable of 1x, 2x, or 4x binning in the horizontal dimension, and 1x, 2x and 4x binning in the vertical dimension. Horizontal and vertical binning can be controlled independently (e.g. this allows combinations such as 2v x 1h or 1v x 4h). The default value for the binning is 1x1.

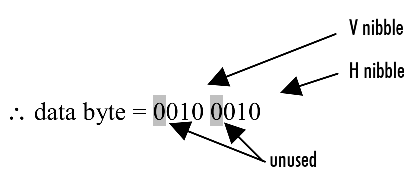
To enable binning, you must write a command (85h) to Register 2, followed by a data byte that defines how many horizontal and vertical pixels to bin.

The binning command must be followed by a data byte where bits 0 through 2 (H nibble) define the vertical binning mode and bits 4 through 6 (V nibble) define the horizontal binning mode. Bits 3 and 7 are unused. Reference Table 13 for valid data bits. All invalid commands will default to 1x1 binning.

Example: Setting the camera to 2x2 binning mode

H nibble = 2 = 010

V nibble = 2 = 010



	Command	Value
Binary	1000 0101	0010 0010
Hex	85h	22h

Whenever the camera is in binning mode, the **BIN** LED on the right side of the rear cover will light to indicate other than 1x1 binning.

Lines per image

Vertical binning affects the number of lines per image. The following table summarizes the total number of lines per frame versus the total number of usable lines per frame as a function of the vertical binning mode.

Table 17: Lines per Frame Versus Vertical Binning

Vertical binning	1x	2x	4x
Total lines per frame	1030	515	258
Usable image lines per frame	1024	512	256

The difference between the total number of lines and the uesable image lines is a result of 6 masked (dark) lines at the top of each channel the CCD array. These lines must be read out to completely clear the CCD for the next integration. In all cases the first lines read out are the valid image lines and the remainder are invalid.

3.11 Flush Before Integrate

There is no way to prevent the CCD imager from integrating (accumulating charge due to light falling on the imager). Under some conditions this will cause the image to show smearing in the vertical direction unless something is done to prevent this. In order to prevent this, by default, the camera flushes the image area clean by performing a rapid transfer of the charge out of the imaging area of the CCD immediately before the start of each integration period. This transfer requires approximately 1.2 mS of time.

Under some conditions, this 1.2 mS time delay before the start of the integration period is undesirable. An example would be when the user desires to synchronize the integration to an external event. This mode is only functional when in External Integration mode. In external Integration Modes, the user can disable the Flush Before Integrate Mode by setting bit 2 in Register 1 = 1.

3.12 Triggering, Integration, and Frame Rate Overview

Image capture triggering, integration, and frame rate are closely related.

- You can program fixed integration and frame rates (or use defaults) and let the camera "free run."
- You can program fixed integration time and supply a (asynchronous) trigger signal to control frame rate by supplying a TTL pulse on the SMA connector. This is referred to as "Programmed Integration/External Trigger Mode."
- You can also have the camera integrate as long as an asynchronous TTL pulse is held high. This pulse will therefore control both integration time and frame rate. This is also known as "External Integrate Mode."

For a given frame rate, the maximum integration time is limited to the frame period less an overhead factor required for proper operation of the CCD. Maximum integration time is defined by this equation:

`Integration Time < (1/Frame Rate) – Readout Time`

This equation is valid for all binning modes, free running, external trigger and external integrate modes.

Note that binning mode impacts the Read Time and limits Integration Time.

WARNING: Do not set integration time higher than the limits of the equation above. Unpredictable operation may result

Table 18: Integration/Frame Rate Limits

Vertical Binning	Read out Time (mS)	Max Frame Rate	Data Rate (MHz)
1 x	53.8	18	4 x 40
2 x	34.2	28	4 x 20
4 x	24.2	39	4 x 10

The default integration time was chosen to give a frame rate of 18 fps (see section *3.14 Controlling Frame Rate*). Changing the integration time involves writing to the three integration time registers.

3.13 Controlling Integration

The 6M18 allows you to control integration (also known as exposure time) in five ways.

- **Programmed Integration/Free Running:** (default) The camera free runs with the internally programmed integration time and frame rate
- **Programmed Integration/SMA Trigger:** The camera will integrate for the internally programmed time when triggered by a TTL high pulse on the SMA connector.
- **Programmed Integration/Serial trigger:** The camera will integrate for the internally programmed time when triggered by high signal on the serial interface.
- **External Integration/SMA Trigger:** The camera will integrate as long as the TTL pulse on the TRIGGER IN SMA connector is high. The integration time is effectively the input pulse width. In this mode, TRIGGER IN also controls the frame rate.
- **External Integration/Serial Trigger:** The camera will integrate as long as the serial bit is held high. The integration time is effectively the input pulse width. In this mode, the serial signal also controls the frame rate. Due to variation in the host operating system, this mode is generally used only for camera setup and functional testing.

The register settings required for each mode are defined in the following table.

Table 19: Integration/Trigger Modes

Mode	Control Register Bit [7] INTEGRATE	Control Register Bit [3] EXT Trigger
Programmed Integration/Free Running	0	0
Programmed Integration/SMA Trigger	0	1
Programmed Integration/Serial Trigger	0	1
External Integration/SMA Trigger	1	1
External Integration/Serial Trigger	1	1

Whenever the Integrate Mode or External Trigger Mode bits are set the **MODE** LED on the right side of the rear cover will light to indicate that an externally synchronized mode is active.

Free Running (Programmed Integration):

This mode is the camera's default. The camera speed is controlled by writing a 3-byte integration time value (in µs) to the three Integration Time registers. These three bytes are then combined to form a 24 bit integration time. The number represents the integer number of microseconds the camera will collect light. The number programmed in the three registers should not be below 10 µS (0000Ah). The camera will run at maximum speed for the programmed integration time.

The camera's default integration time value is 5 ms which achieve 18 fps.

Example: Set integration time to 1000ms

1. Using the command 82h, set bit [7] of the data byte to 0 (Integration Mode = Internal) and bit [3] of the data byte to 0 (Trigger Mode = Internal).

   NOTE: All bits within the register are written at one time. Ensure the correct value for all bits are used when changing camera modes.

2. Use commands 8Ah, 8Bh, 8Ch to set the 24-bit integration time value.

   Value = 1000ms

   = 1000000µs

   = 0F4240h.

	Write Integration LS Byte		Write Integration Center Byte		Write Integration MS Byte	
	Command	**Value**	**Command**	**Value**	**Command**	**Value**
Binary	1000 1010	0100 0000	1000 1011	0100 0010	1000 1100	0000 1111
Hex	8Ah	40h	8Bh	42h	8Ch	0Fh

Programmed Integration/SMA Trigger

For external SMA controlled triggering with a programmed integration time, a TTL rising edge on the **TRIGGER IN** (or SYNC) signal triggers the camera to acquire one frame of data. Integration begins within 200ns after the rising edge and stops when the programmed integration time has completed. After that single frame acquisition, the camera outputs the just acquired frame and "re-arms", thus waiting for a new External Trigger signal to trigger a new frame acquisition. The camera is "armed" when the read out of the acquired frame is completed. *No additional rising edges, or triggers, should be allowed during the image acquisition or frame read out*.

When the camera is in External Trigger Mode, the Frame LED will be illuminated on the camera back to indicate the camera is expecting a signal on the SMA connector or serial bit [0] of register 1.

Because this signal is internally OR'ed with the Serial Trigger input, care must be taken to ensure the serial bit [0] of register 1 is equal to a logic 0 while in SMA Trigger mode.

Programmed Integration/Serial Trigger

For external serial controlled triggering with a programmed integration time, a TTL rising edge on bit [0] of serial register 1 triggers the camera to acquire one frame of data. Integration begins within 200ns after the rising edge and stops when the programmed integration time has completed. After that single frame acquisition, the camera outputs the just acquired frame and "re-arms", thus waiting for a new External Trigger signal to trigger a new frame acquisition. The camera is "armed" when the read out of the acquired frame is completed. *No additional rising edges, or triggers, should be allowed during the image acquisition or frame read out*.

When the camera is in External Trigger Mode, the Frame LED will be illuminated on the camera back to indicate the camera is expecting a signal on the SMA connector or serial bit [0] of register 1.

Because this signal is internally OR'ed with the TRIGGER IN Sync input, care must be taken to ensure the TRIGGER IN signal is equal to a logic 0 while in Serial Trigger mode.

External Integration/SMA Trigger

When in External Integrate/SMA mode, a TTL rising edge on the **TRIGGER IN** (or SYNC) signal triggers the camera to acquire one frame of data. Integration begins within 200 ns after the rising edge and stops within 550 ns after the falling edge. After that single frame acquisition, the camera outputs the just acquired frame and "re-arms", thus waiting for a new External Trigger signal to trigger a new frame acquisition. The camera is "armed" when the read out of the acquired frame is completed. *No additional rising edges, or triggers, should be allowed during the image acquisition or frame read out*. This means in this mode TRIGGER IN necessarily controls both integration and frame rate.

When the camera is in External Trigger Mode, the Frame LED will be illuminated on the camera back to indicate the camera is expecting a signal on the SMA connector or serial bit [0] of register 1.

Because this signal is internally OR'ed with the Serial Trigger input, care must be taken to ensure the serial bit [0] of register 1 is equal to a logic 0 while in SMA Trigger mode.

External Integration/Serial Trigger

When in External Integration/Serial mode, a TTL rising edge on serial bit [0] of register 1 triggers the camera to acquire one frame of data. Due to variation in the host operating system, this mode is generally used only for camera setup and functional testing. Integration begins within 200 ns after the rising edge and stops within 550 ns after the falling edge. After that single frame acquisition, the camera outputs the just acquired frame and "re-arms", thus waiting for a new External Trigger signal to trigger a new frame acquisition. The camera is "armed" when the read out of the acquired frame is completed. *No additional rising edges, or triggers, should be allowed during the image acquisition or frame read out*.

This means in this mode TRIGGER IN necessarily controls both integration and frame rate.

When the camera is in External Trigger Mode, the Frame LED will be illuminated on the camera back to indicate the camera is expecting a signal on the SMA connector or serial bit [0] of register 1.

Because this signal is internally OR'ed with the TRIGGER IN Sync input, care must be taken to ensure the TRIGGER IN signal is equal to a logic 0 while in Serial Trigger mode.

3.14 Controlling Frame Rate

The 6M18 allows you to control frame rate in three ways.

- **Free Running:** (default) The camera free runs with the internally programmed integration time.
- **External Trigger/Internal Integration:** The camera frame rate will be controlled by the TTL pulse on the TRIGGER IN SMA connector. The camera will integrate for the programmed integration time. (*Reference section 3.13 Controlling Integration Mode*)
- **External Integration:** The camera frame rate will be controlled by the TTL pulse on the TRIGGER IN SMA connector. The camera will integrate fas long as the pulse is held high. In this mode, TRIGGER IN also controls integration. (*Reference section 3.13 Controlling Integration Mode*)

Free Running

This mode is the camera's default. The camera will operate at the maximum frame rate for the programmed integration time. Reference section 3.13 – Controlling Integration.

External Trigger/Programmed Integration

This is the same as External Integrate/SMA Trigger Mode. Reference to section 3.13 Controlling Integration Mode.

Example: Set the Frame Rate to 2.5 fps

1 . Reference section 3.12 Triggering, Integration, and Frame Rate Overview to ensure the desired frame rate can be supported for the selected binning and integration modes.

2. Using the command 81h, set bit [0] of the data byte to 0 (Integration Mode = Internal) and bit [3] of the data byte to 1 (Trigger Mode = External).

   NOTE: All bits within the register are written at one time. Ensure the correct value for all bits are used when changing camera modes.

3 Set the desired integration time per section 3.13 – Controlling Integration.

4 Each TTL rising edge on the SMA connector will initiate a new frame of data, using the programmed integration time. To achieve 2.5 fps, a TTL pulse must be sent to the camera every 400 ms (1/2.5).

External Trigger/Serial Connector

This is the same as External Integrate/External Trigger Mode. Refer to section 3.13 Controlling Integration Mode.

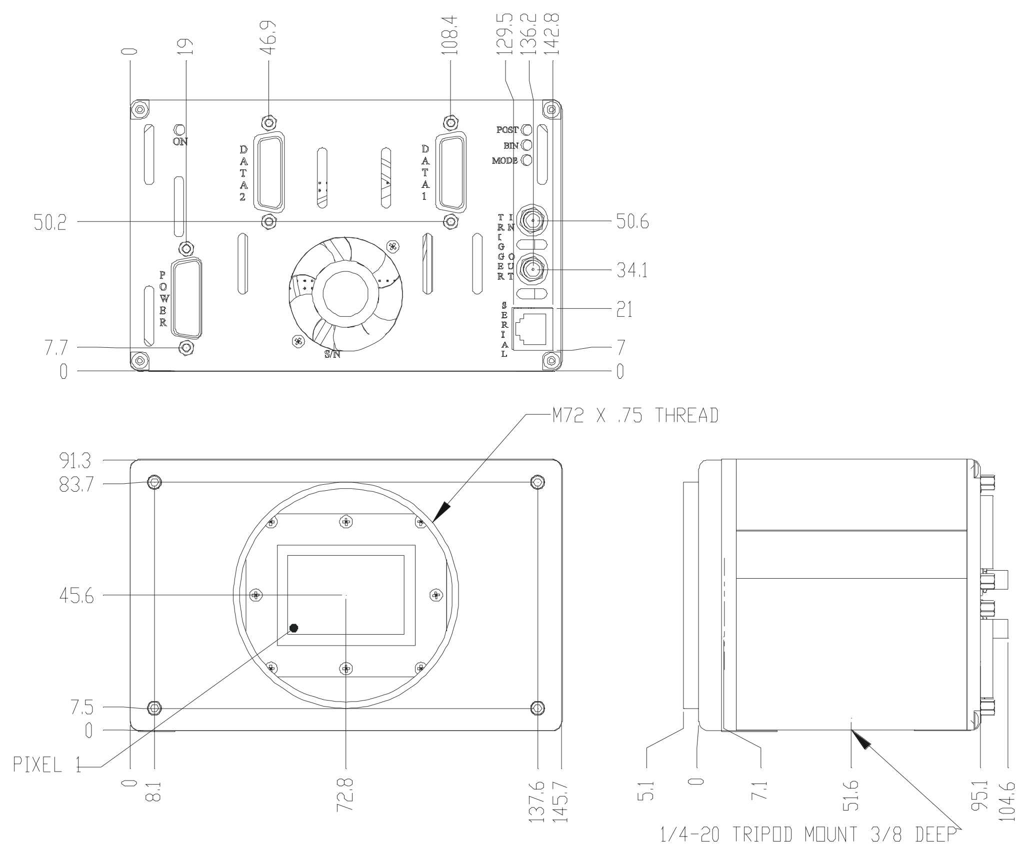
4

Optical and Mechanical Considerations

4.1 Mechanical Interface

An M72-F mount adapter is available from DALSA. Contact DALSA sales for more information.

Figure 11: Camera Dimensions



4.2 Mechanical Tolerances

Table 20: Mechanical Tolerances

Additional Dimensions	
Center of sensor with respect to lens mount	<.025
Planarity of lens flange to sensor	<.010
Rotation of sensor	<.3°

4.3 Mounting the Camera

The 6M18 can be mounted via the3/8" deep, 1/4"-20 threaded tripod mount located on the bottom of the camera.

5

Cleaning and Maintenance

5.1 Cleaning

Electrostatic Discharge and the CCD Sensor

Charge-coupled device (CCD) image sensors are metal oxide semiconductor (MOS) devices and are susceptible to damage from electrostatic discharge (ESD). Although many sensor pins have ESD protection circuitry, the ESD protection circuitry in CCDs is typically not as effective as those found in standard CMOS circuits.

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

Preventing ESD Damage

To prevent ESD damage, DALSA advises you to take the following handling precautions.

1. Ground yourself prior to handling CCDs.
2. Ensure that your ground and your workbench are also properly grounded. Install conductive mats if your ground or workbench is non-conductive.
3. Use bare hands or non-chargeable cotton gloves to handle CCDs. NOTE: Rubber fingercots can introduce electrostatic charge if the rubber comes in contact with the sensor window.
4. Handle the CCD from the edge of the ceramic package and avoid touching the sensor pins.
5. Do not touch the window, especially in the region over the imaging area.
6. Ground all tools and mechanical components that come in contact with the CCD.
7. DALSA recommends that CCDs be handled under ionized air to prevent static charge buildup.

8. Always store the devises in conductive foam. Alternatively, clamps can be used to short all the CCD pins together before storing.

The above ESD precautions need to be followed at all times, even when there is no evidence of CCD damage. The rate which electrostatic charge dissipates depends on numerous environmental conditions and an improper handling procedure that does not appear to be damaging the CCDs immediately may cause damage with a change in environmental conditions.

Protecting Against Dust, Oil, and Scratches

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

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

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

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

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

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

Cleaning the Sensor Window

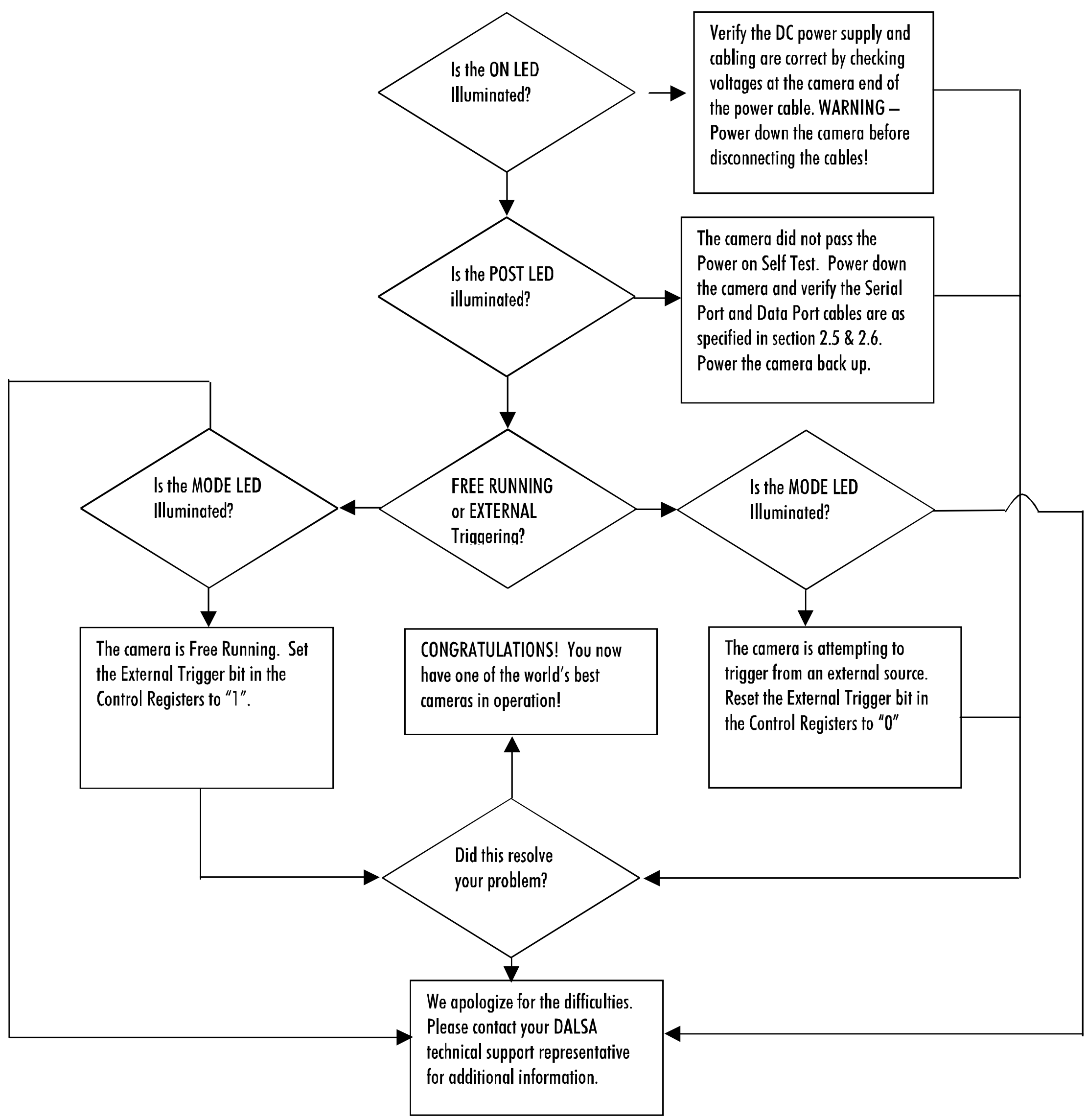
1. Use clean, dry, compressed air to blow off loose particles. This step alone is usually sufficient to clean the sensor window.
2. If further cleaning is required, use a lens wiper moistened with alcohol.
3. We recommend using lint free, ESD safe cloth wipers that do not contain particles that can scratch the window.
4. Wipe the window carefully and slowly.

5.2 Maintenance

There are no user serviceable parts on this camera. Please contact DALSA service.

6

Troubleshooting



7

Warranty

7.1 Limited One-Year Warranty

What We Do

This product is warranted by DALSA for one year from date of original purchase. Please refer to your Purchase Order Confirmation for details.

What is Not Covered

This warranty does not apply if the product has been damaged by accident or misuse, or as a result of service or modification by other than DALSA, or by hardware, software, interfacing or peripherals not provided by DALSA. DALSA shall have no obligation to modify or update products once manufactured. This warranty does not apply to DALSA Software Products.

Note: if the camera has a non-standard cover glass (e.g. taped) the warranty is void on the CCD.

How to Obtain Service for Your Equipment

If you want to return your product for repair, contact DALSA Technical Support in order to obtain a Return Goods Authorization form. Repair cannot begin until the form is issued, completed, and returned to DALSA.

DALSA Technical Support
Phone: 519 886 6000
Fax: 519 886 8023
email: support@DALSA.com

Index

V

W