DALSTAR 1M60

DS-41-01M60
DS-42-01M60

60 fps 1k x 1k
CCD Camera

User's Manual and Reference

Doc #: C32-10010
Rev: 01

DALSA
technology with vision

1M60 Camera User's Manual Document Number C32-10010-01

About DALSA

DALSA specializes in the manufacture, design, research and development of high performance digital imaging solutions. The DALSTAR 1M60 is part of a product line that provides the highest spatial resolution at the highest data transfer speed of any known products in the industry. DALSA's image sensors and cameras are used worldwide in document scanning, image capture, surveillance, process monitoring and manufacturing inspection. DALSA also develops customized products for specific customers and applications.

All DALSA products are manufactured using the latest state-of-the-art equipment to ensure product reliability.

DALSTAR refers to all DALSA area scan products.

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

DALSA Sales Offices

DALSA Waterloo	DALSA Europe	DALSA 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 Tel: +81 3 5960 6353 Fax: +81 3 5960 6354 www.dalsa.com asia@dalsa.com

DALSA Worldwide Operations

DALSA Waterloo	DALSA Colorado Springs	DALSA Tucson	DALSA Europe	DALSA 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 www.med-optics.com sales@med-optics.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 Tel: +81 3 5960 6353 Fax: +81 3 5960 6354 www.dalsa.com asia@dalsa.com

1M60 USER'S MANUAL

Contents

CHAPTER 1

1.0 Introduction to the 1M60 Camera

1.1 Camera Highlights

Features

- 1024 x 1024 resolution, frame transfer CCD architecture.
- 60 fps four outputs at full resolution, 20 MHz data rate
- True 12-bit digitization
- High sensitivity with low dark current
- Progressive scan readout
- On-chip shutter
- Asynchronous image capture, externally triggerable to within 2 us.
- Selectable binning up to 2 x 2
- Programmable operation via RS232, including gain (1x and 4x), frame rate, offset (-2047 to +2048), binning, and triggering.
- 100% fill factor

Description

The 1M60 digital camera provides high-sensitivity 12-bit images with 1k x 1k spatial resolution at up to 60 frames per second (fps). The 1M60 is a frame transfer 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 1M60 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

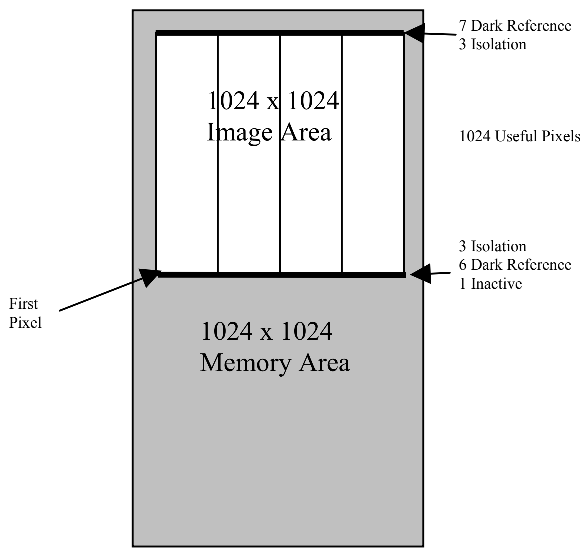


Table 1. Sensor Structure

Sensor characteristics	
Image Zone	14.34 x 14.34 mm
Pixel size	14µm x 14µm
Active pixels	1024 (H) x 1024 (V)
Total number of pixels	1024 (H) x 1044 (V)
Dummy Lines	Top: 1 Bottom: 1
Dark Reference Lines	Top: 7 Bottom: 6
Isolation Lines	Top: 3 Bottom: 3
Inactive Lines	Top: 0 Bottom: 1
Pre-scan Elements (per Zone)	Left: 17

Table 2. Sensor Cosmetic Specifications

Type	Allowable Blemishes	WHITE Vos = 0.7 Vsat	DARK Vos = 0.7Vsat	In Darkness (ref Vo:Average Darkness Signal)
Columns	5	α > 10% Vos	$\|\alpha\|$ 10% Vos	α > 5 mV
Clusters	10	α > 20% Vos	$\|\alpha\|$ 30% Vos	α > 10 mV
Pixels	100	α > 20% Vos	$\|\alpha\|$ 30% Vos	α > 10 mV

Blemish Definition

- Pixel: Maximum Blemish area of 2x2 pixels.
- Cluster: Less than 7 contiguous defects in a column
- Column: More than 7 contiguous defects in a column
- Defects measured in darkness at 25 °C
- Light Source: 2854 K with BG38 filter + F/3.5 optical aperture
- α: amplitude of video signal defect with respect to mean output voltage Vos

1.3 Camera Performance Specifications

Table 3. 1M60 Camera Performance Specifications

Physical Characteristics	Units				
Resolution	H x V pixels	1024 x 1024			
Pixel Size	µm	14 x 14			
Pixel Fill Factor	%	73.57			
Size	mm	94x94x102			
Mass	kg	0.85			
Power Dissipation	W	< 17			
Lens Mount		F or C mount			
Aperture	mm	14.34x14.34			
Regulatory Compliance		Pending			
Shock Immunity		Pending			
Vibration Immunity		Pending			
Operating Ranges	**Units**	**Min.**	**Max.**		
Frame Rate	fps	7.5	110		
Data Rate	MHz	10	20		
Data Format	LVDS		12 bit		
Responsivity	DN/(nJ/cm^2)		11@540 nm		
Operating Temp	°C	10	45		
+15 Input Voltage	V	+14.925	+15.075		
+5 Input Voltage	V	+4.975	+5.025		
-5 Input Voltage	V	- 4.975	- 5.025		
Nominal Gain Range		1x	4x		
Calibration Conditions	**Units**	**Setting**	**Min.**	**Max.**	
Data Rate	MHz	20	20	20	
Frame Rate	Hz	2.75			
+15 Input Voltage	V	+15	+14.925	+15.075	
+5 Input Voltage	V	+5	+4.975	+5.025	
-5 Input Voltage	V	- 5	- 4.975	- 5.025	
Ambient Temperature	°C	25			
Binning		1x1			
Gain	X	1			
Electro-Optical Specifications	**Units**	**Min.**	**Typical**	**Max.**	
Dynamic Range	dB	68.5			
Pixel Response Non-Uniformity	%rms		2.5	3.0	
System Noise	DN(rms)		1.0	1.2	

Notes:

CHAPTER 2

2.0 Camera Hardware Interface

2.1 Installation Overview

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

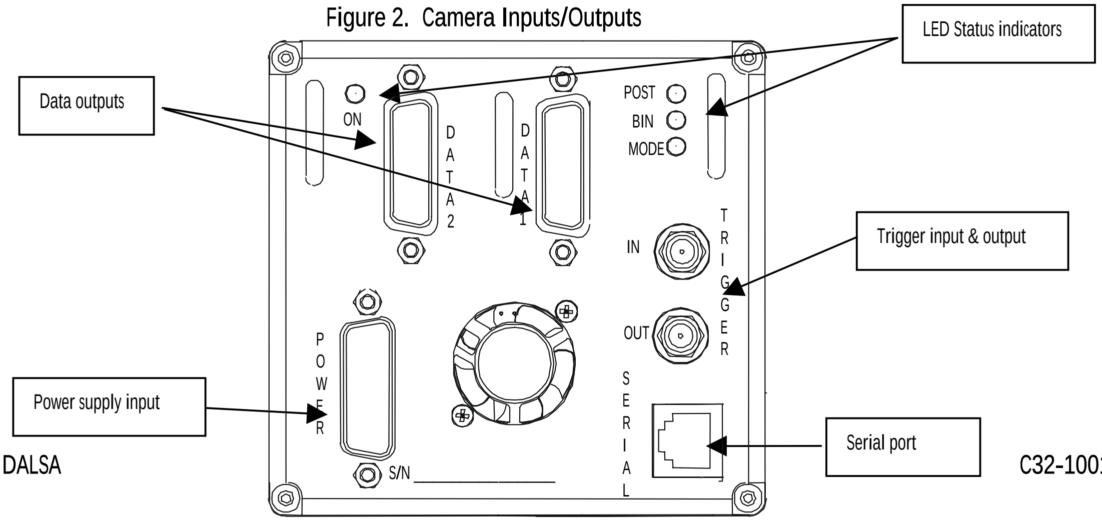
In order to set up your camera, you should take these initial steps:

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. **Ensure that all the correct voltages are present at the camera end of the power cable** (the Camera Performance Specifications earlier in this document list 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 connectors. Camera functions such as frame rate, integration time, binning, camera gain and offset 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 four LED's visible on the rear cover of the camera that indicate the status of the camera.

Table 4. LED Functions

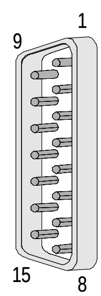
LED Label	Color	LED "ON"	LED "OFF"
ON	Green	Camera is receiving power	There is no camera power
POST	Green	Camera Power On Self Test successful	Camera failed Power On Self Test
BIN	Red	Camera is operating in a binning mode	Camera is operating unbinned (1x1)
MODE	Red	Camera is in an external trigger mode (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	NC
13	NC
14	GND
15	GND

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



DB15M
(AMP Part # 747236-4 or equivalent)

The camera has the following input power requirements.

V (DC)	±%	Max Ripple mV	A
+15	0.5	< 5	0.45
+5	0.5	< 5	1.88
-5	0.5	< 5	0.58

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

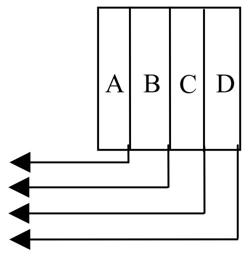
Many high quality supplies are available from other vendors. DALSA assumes no responsibility for the use of these supplies.

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.

2.5 Data Output

Data channel outputs represent the CCD per the following (Image viewed from the front of the CCD).

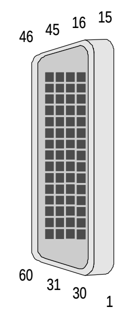


The camera back panel output connectors DATA1 and DATA2 utilize differential LVDS signals with pin assignments as follows:

Connector and Pinout

Table 6. 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+

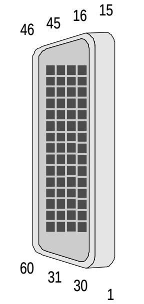


(Molex Part # 70928-2000 or equivalent)

NC = No Connect. These pins are unused.

Table 7. 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+



(Molex Part # 70928-2000 or equivalent)

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 8. 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 3.10 – Triggering, Integration, and Frame Rate Overview.

Data Clocking Signals

Table 9. Clock Signal Descriptions

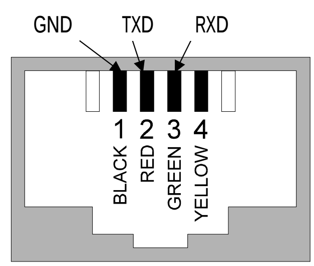
Signal	Description
PIXCLK+, PIXCLK-	Pixel clock true and complement. 20MHz (unbinned) -- Output. Data is valid on the falling edge. Note that data and PIXCLK frequency is dependent on binning mode. Reference section 3.10 – Triggering, Integration, and Frame Rate Overview
HSYNC+, HSYNC-	Horizontal sync, 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 3.10 – 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.

2.6 Serial Communication

Connector and Pinout

The serial interface provides control of frame rate, integration time (shuttering), video gain and offset, pixel binning, external trigger and external integration (for information on how to control these functions, see "Operating the Camera" later in this document). 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.



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

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 3. 25 Pin Serial Port Connector to Camera RJ-11 Connector

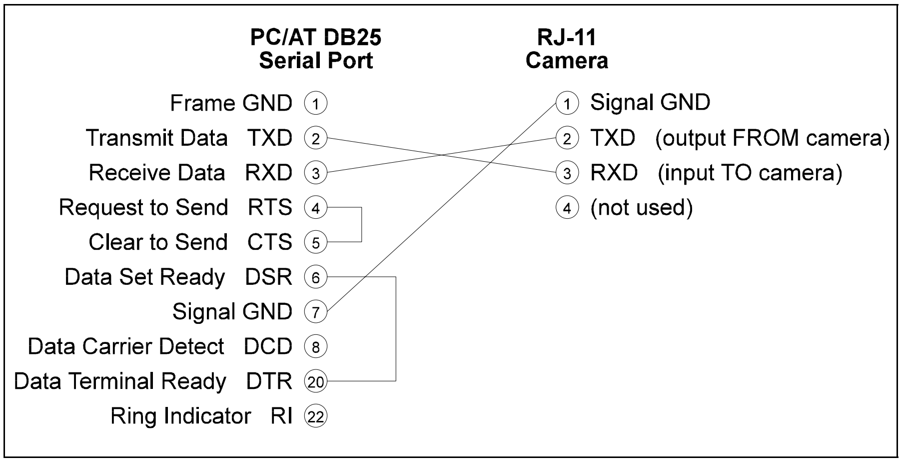
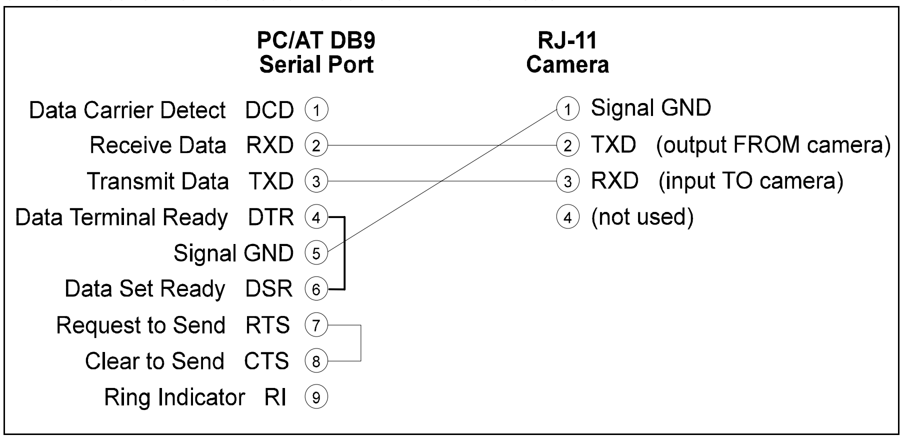


Figure 4. 9 Pin Serial Port Connector to Camera RJ-11 Connector



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)

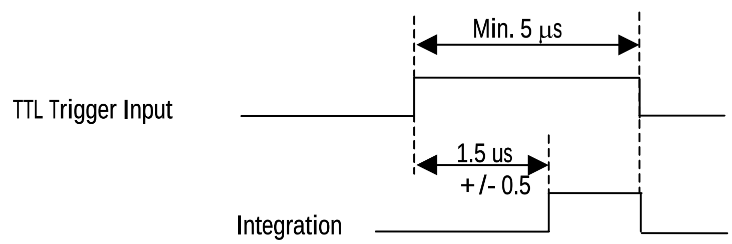
DALSA provides serial cables in 3 lengths: 10', 20' and 50'. Part number CL-31-00004-xx (where xx refers to the cable length in feet).

2.7 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 5. Trigger Timing Description



2.8 Integration Time

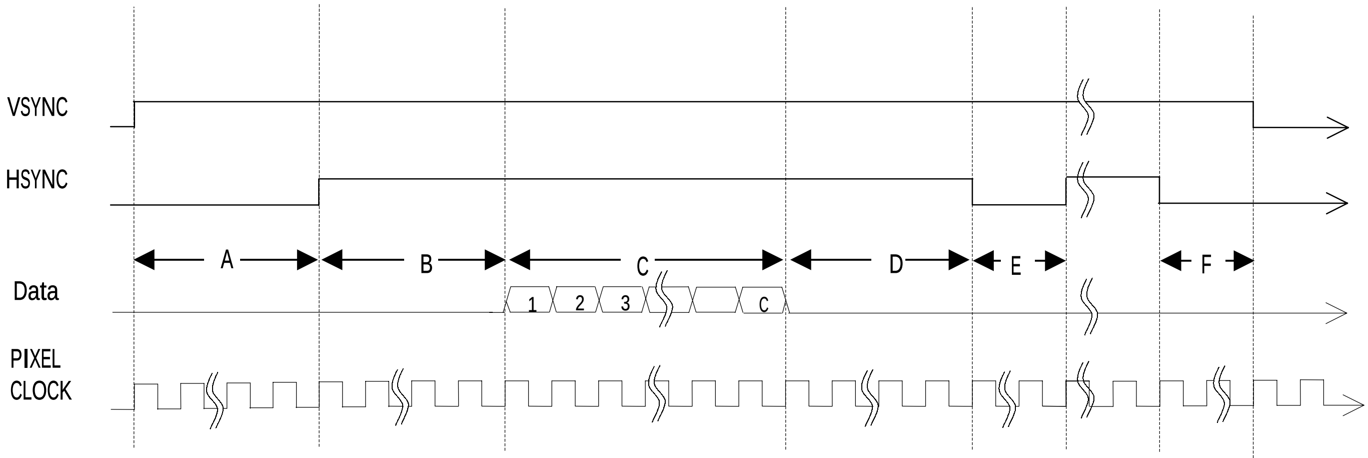
The minimum integration time (or shutter time) is 5 μs. As with any full frame imager, the camera will continue to integrate during read out unless externally shuttered or strobed.

2.9 Timing

Programmed Integration

The 1M60 pixel clock runs at 20 MHz, so each pixel clock cycle will be 1/20,000,000 or 50 ns. The following diagram and tables describe the correct timing requirements for the 1M60 camera.

Figure 6. 1M60 Timing



"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

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

Table 10. HSYNC Pixel Timing

Horizontal Binning Mode	A	B	C	D	E	F
1x	68	14	256	2	24	2
2x	42	12	128	1	15	1

Table 11. VSYNC Pixel Timing (HSYNC falling edges/VSYNC falling edge)

Vertical Binning Mode	Pre-Scan Lines/Frame	Active Lines/Frame	Post Scan Lines/Frame
1x	10	1024	10
2x	5	512	5

CHAPTER 3

3.0 Camera Operation

3.1 How to Control the Camera

The 1M60's RS-232-compatible serial interface allows you to control its configuration and operation, including:

- Triggering Mode
- Binning
- Integration Time
- Gain
- Offset

Command Protocol Overview

The camera accepts 8-bit command/value pairs via its RJ-11 serial port using RS-232 compatible signals. Camera commands are "clock" commands which apply to the electronics that drive the image sensor. These include clock generation, frame rate, integration time, and binning. 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:

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

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.**

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.**

3.2 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 12. Control Register Bit Definitions

Register	Write Command	Read Command	Bit	Function	Default
Reset	80h		7:0	Resets all registers to default values	NA
Camera Type	NA	C3h	7:0	Read camera type	02h
Firmware Rev	NA	C5h	7:0	Read firmware revision	NA
Register 1	82h	C2h	7	Integration Mode 0 = Internal 1 = External	0
			6	Video Gain 0 = 1x 1 = 4x	0
			5	Anti-Blooming 0 = Anti-Blooming Enabled 1 = Anti-Blooming Disabled	0
			4	Binning Mode 0 = 1x1 1 = 2x2	0
			3	Trigger Mode 0 = Internal 1 = External	00
			2:0	Shutter Control 000 = None (Frame Rate Controlled) 100 = 8 ms (1/125) 101 = 4 ms (1/250) 110 = 2 ms (1/500) 111 = 1 ms (1/1000)	000
Register 2	84h	C4h	7:0	User Offset MS Byte (Bits 11-4 of 12 bits)	00h
Register 3	88h	C8h	7	Serial Trigger (If Integrate mode = 1)	0
			6:4	Frame Rate 000 = 60 fps 001 = 30 fps 010 = 15 fps 011 = 7.5 fps 100 = 110 fps (2x2 binninf only)	000
			3:0	Pixel Offset LS nibble	000

3.3 Reading the Camera Type

This read command returns an 8-bit value unique to the type of camera interrogated. A 1M60 will return a value of 02h 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 (1M60)
Binary	1100 0011	0000 0010
Hex	C3h	02h

3.4 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

3.5 Resetting the Camera

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

Table 13. Default values in effect after reset

Feature	1M60 Default
Frame Rate (fps)	60
Integration Time (ms)	15.8
Resolution (pixels)	1024 x 1024
Video Gain	1x
Binning Mode	1x1
Pixel Offset	0
Triggering	INTERNAL
Integration Control	INTERNAL
Data Rate (MHz)	20

Example

Use this command to reset the camera:

	Command	Value
Binary	1000 0000	-
Hex	80h	-

3.6 Adjusting Gain

Bit [6] of register 1 is the Video Gain control bit. When this bit=0 the video channel gain=1x. When this bit =1, the video channel gain=4x.

Example

Use this command to set the gain to 4x:

	Command	Value
Binary	1000 0010	*1** ****
Hex	82h	**h

Note: The register containing the Gain bit also controls other configuration data. All bits must be set appropriately.

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

3.7 Adjusting Anti-Blooming

Bit [5] of register 1 is the Anti-Blooming control bit. When this bit=0 anti-blooming is enabled. When this bit = 1, anti-blooming is disabled.

Example

Use this command to disable Anti-Blooming

	Command	Value
Binary	1000 0010	**1* ****
Hex	82h	**h

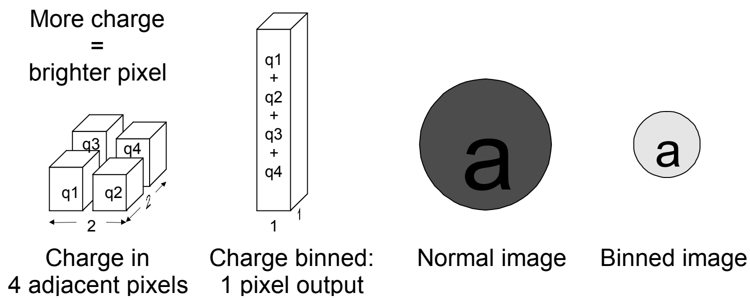
Note: The register containing the Anti-Blooming bit also contains other configuration data. All bits (*) must be set appropriately.

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

3.8 Controlling Binning

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

Example: 2x2 Binning



The 1M60 is capable of 2x2 binning. Bit [4] of register 1 is the Binning control bit. When this bit=0 the camera is in standard 1x1 mode. When this bit = 1, the camera will operate with 2x2 binning.

Example: Setting the camera to 2x2 binning mode

	Command	Value
Binary	1000 0010	**** 1***
Hex	82h	**h

Note: When the camera is in 2x2 binning mode, the **BIN** LED on the right side of the rear cover will be illuminated.

Note: The register containing the Binning bit also contains other configuration data. All bits (*) must be set appropriately.

3.9 Adjusting User Offset

User offset is adjustable from -2047 to +20478 by a 12 bit value as an MS and LS byte. The offset data is only written when the most-significant 8 bits are written to the MS Offset register. Therefore, the lower 4 bits should be written first to the LS Offset register, followed by the upper 8 bits, which will cause the offset to be applied to the pixel output.

The pixel offset data is written as a 2's compliment number. Therefore either positive or negative offsets can be added to the pixel output to enhance the image contrast.

The offset value that is programmed effects the pixel offset by a ratio of about 8 to 5. So, for that example, if an offset value of a positive 16 is entered to registers 2 and 3 the resulting pixel data will be adjusted by a positive 10.

PIXEL OFFSET EXAMPLES.

Programmed Offset Decimal/2's Complement	Register 3	Register 2	Resulting Pixel Offset
88 (058h)	X8h	05h	55 (37h)
-96 (FA0h – 2's compliment)	X0h	FAh	-60 (-FC4h)
152 (098h)	X8h	09h	95 (5Fh)
-2040 (808h)	X8h	80h	-1275 (-4FBh)

The read user offset commands allow the user to read back this information from the camera.

Reading Offset from the Camera

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

	Read LSB	Read MSB
Binary	1100 1000	1100 0100
Hex	C8h	C4h

Note: Register 3 contains other configuration data. All bits must bet set to the appropriate values.

3.10 Triggering, Integration, and Frame Rate Overview

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

- Integration time can be less than 1/frame rate, but it can never be greater.
- 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, either by toggling a bit or 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:

Max 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 14. Integration/Frame Rate Limits

Binning	Read out Time (mS)	Max Frame Rate	Data Rate (MHz)	Integration Value (ms)
1 x 1	15.46	60	20	15.8
2 x 2	8.15	110	10	8.2

The default integration time was chosen to give a frame rate of 60 fps (see section *3.12 Controlling Frame Rate*). Changing the integration time involves writing to the three integration time registers.

3.11 Controlling Integration (Shutter Time)

The 1M60 allows you to control integration (also known as exposure time or shutter 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 15. Integration/Trigger Modes

Mode	Register 1 Bit [7] INTEGRATE	Register 1 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

* Indicates bit state not considered

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):

The camera speed is controlled by selecting the integration time value in the Integration Time register. The camera will run at maximum speed for the programmed integration time.

Example: Set integration time to 4ms (1/250 s)

1.0 Using the command 82h, set bit [7] of the data byte to 0 (Integration Mode = Internal), bit [3] of the data byte to 0 (Trigger Mode = Internal), and bits [2:0] to 101.

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

	Write Integration LS Byte	
	Command	Value
Binary	1000 0010	0*** 0101
Hex	82h	*5h

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 2 us 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.*

Because this signal is internally OR'ed with the Serial Trigger input, care must be taken to ensure the serial bit [7] of register 3 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 [7] of serial register 3 triggers the camera to acquire one frame of data. Integration begins within 2 us 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*.

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 Connector

When in External Integration/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 2 us after the rising edge and stops 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 (850 us)*.   This means in this mode TRIGGER IN necessarily controls both integration and frame rate.

When the camera is in External Integrate Mode the red LED will light on the back panel to indicate the camera is expecting a signal on the rear panel SMA connector.

Because this signal is internally OR'ed with the Serial Trigger input, care must be taken to ensure the serial bit [7] of register 3 is equal to a logic 0 while in SMA Trigger mode.

External Integration/Serial Connector

When in External Integration/Serial mode, a TTL rising edge on serial bit [7] of register 3 triggers the camera to acquire one frame of data. Integration begins within 2 us after the rising edge and stops 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 (850 us)*. This means in this mode TRIGGER IN necessarily controls both integration and frame rate.

When the camera is in External Integrate Mode the red LED will light on the back panel to indicate the camera is expecting a signal on the rear panel SMA connector.

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.

3.12 Controlling Frame Rate

The 1M60 allows you to control frame rate in three ways.

- **Free Running (Programmed Frame Rate):** (default) The camera free runs with the internally programmed frame rate time and 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 3.10 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 3.10 Controlling Integration Mode*)

Free Running (Programmed Fame Rate)

To specify programmed frame rate, you must set bit [7] of register 1 = 0 (Integrate Mode = Internal), and bit [3] of register 1 = 0 (Trigger Mode = Internal). Next, write the frame rate bit value to the Frame Rate register.

Example: Set the Frame Rate to 30 fps

1.0 Reference section 3.10 Triggering, Integration, and Frame Rate Overview to ensure the desired frame rate can be supported for the selected binning and integration modes.

2.0 Using the command 82h, set bit [7] of the data byte to 0 (Integration Mode = Internal), bit [3] of the data byte to 0 (Trigger Mode = Internal), and bits [2:0] of shutter control to 000.

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

3.0 Use command 88h to set bits [6:4] of control register 3 to the integration time value 001.

Value = 30 fps

	Write Frame Rate LS Byte		Write Frame Rate Center Byte	
	Command	Value	Command	Value
Binary	1000 0010	0*** 0000	1000 1000	*001 ****
Hex	82h	*0h	88h	**h

External Trigger/SMA Connector

Refer to section 3.11 Controlling Integration Mode.

External Trigger/Serial Connector

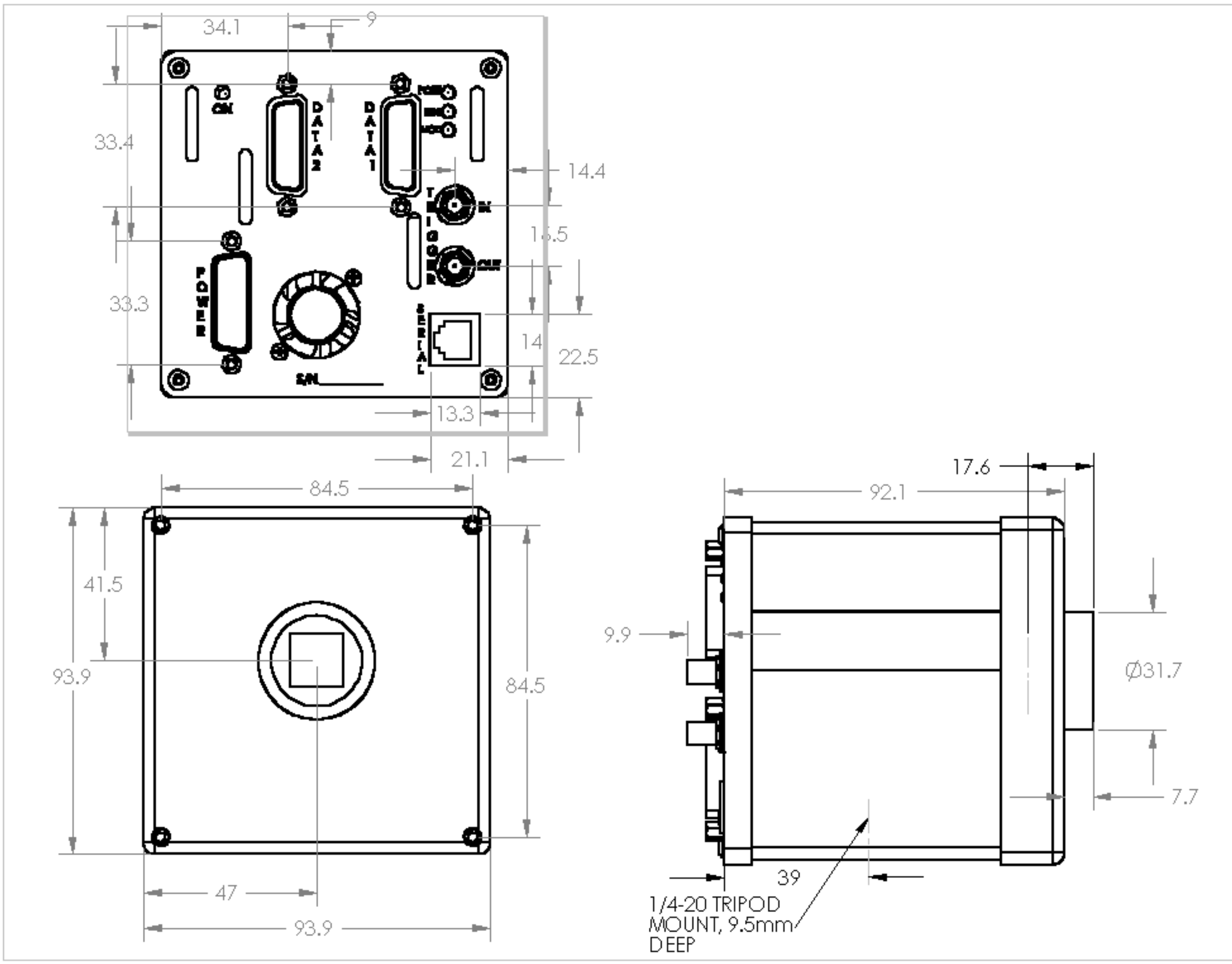
Refer to section 3.11 Controlling Integration Mode.

CHAPTER 4

4.0 Optical and Mechanical Considerations

4.1 Mechanical Interface

Figure 7. Camera Dimensions



4.2 Mechanical Tolerances

Table 16. Mechanical Tolerances

Additional Dimensions	
Center of sensor with respect to lens mount	< 0.002"
Planarity of lens flange to sensor	< 0.004"
Rotation of sensor	< 0.2°Y

4.3 Mounting the Camera

The 1M60 can be mounted via the3/8" deep, 1/4"-20 threaded tripod mount located on the bottom of the camera.

CHAPTER 5.0

5.0 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.

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

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

Cleaning the Sensor Window

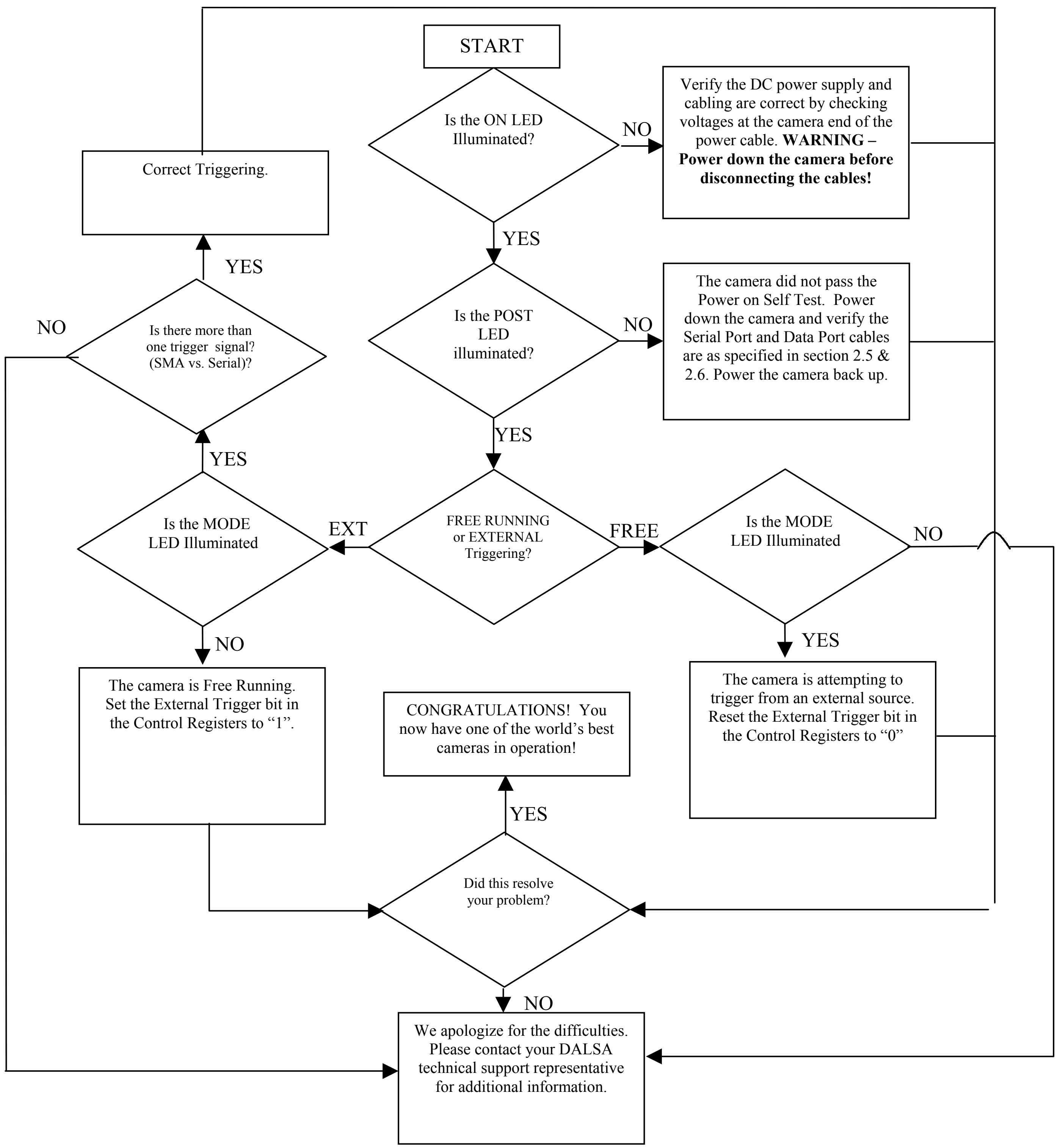
1. Use clean, dry, compressed air to blow off loose particles. This step alone is usually sufficient to clean the sensor window.
2. If further cleaning is required, use a lens wiper moistened with alcohol.
3. We recommend using lint free, ESD safe cloth wipers that do not contain particles that can scratch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

CHAPTER 6.0

6.0 Troubleshooting



CHAPTER 7

7.0 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 Customer Service 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

8.0 Index