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The *Mega*Plus®
Model 4.2i Camera
User's Manual

REDLAKE MASD, INC

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List of Manual Revisions

User's Manual – Model 4.2i, Part Number 91000058-003

Revision	Date	EO No.	Notes
A	10-01-01		Reissued to reflect Redlake MASD, Inc. change and general editorial changes.

RELATED DOCUMENTS

*Mega*Plus Remote Control Panel User's Manual, Part Number 91000055-001

FCC DECLARATION OF CONFORMITY

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Subpart B of Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

This equipment has been certified to comply with the limits for a Class A computing device, pursuant to FCC rules. In order to maintain compliance with FCC regulations, shielded cables must be used with this equipment. Operation with non-approved equipment or unshielded cables is likely to result in interference to radio and TV reception. The user is cautioned that changes and modifications made to the equipment without the approval of the manufacturer could void the user's authority to operate this equipment.

PRECAUTIONS

WARNING!

LIFE SUPPORT APPLICATIONS POLICY

***Mega*Plus cameras are not authorized for and should not be used within life support systems without the specific written consent of Redlake MASD, Inc.**

NON-CRITICAL MEDICAL APPLICATIONS

***Mega*Plus cameras must be grounded to building earth ground while operating. This camera has passed IEC 601 class B standards.**

The voltage drop on the camera's power return line must be less than 0.5 Volts DC. Use a heavier gauge power cable to reduce the voltage drop below 0.5 Volts DC. For medical applications, any power supply connected to the camera must meet IEC 601 specifications.

CAUTION: A laser beam focused on the sensor, either directly or by reflection, can cause permanent damage to the sensor. Any laser powerful enough to produce localized heating at the surface of the sensor will cause damage, even if the camera power is off. A sensor damaged by laser light is NOT covered by the warranty.

OPERATING TEMPERATURE

The *Mega*Plus camera is designed to operate satisfactorily in an environment where the ambient temperature is between 0° and 35°C (32° and 95°F), with no water condensation present.

STORAGE TEMPERATURE

Do not store the equipment in an area where the temperature will drop below –25°C (-13°F) or exceed 80°C (176°F). Do not allow moisture to condense on the system.

SHIPPING

When shipping, use a carton that protects the camera from shock and moisture, similar to the carton in which the unit was originally delivered. Do not ship the equipment in a cargo area where the temperature will drop below -25°C (-13°F) or exceed 80°C (176°F). Do not allow moisture to condense on the system.

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1. INTRODUCTION

1.1 Introduction

The Redlake MASD, INC. *Mega*Plus Camera, Model 4.2i, is a high-resolution solid-state camera designed for scientific and industrial imaging applications. The system consists of a DC powered Camera Head with a 68 pin digital interface. There are no manual user controls on the camera, however the camera is operated by commands sent through a serial communication link. The Camera is configured with either an RS232 or RS422 serial communications command input.

The operation of the *Mega*Plus Camera is very similar to the operation of a 35mm film camera. In a film camera, the film is exposed by opening the shutter for a specific amount of time. The shutter then closes and the film is advanced to the next frame. In the *Mega*Plus Camera, a built-in electromechanical shutter is used the same way.

The shutter opens exposing the sensor, then closes while the image captured by the sensor is sent to a frame store device. The shutter in the *Mega*Plus Camera can be controlled internally or externally.

The Camera features a high-resolution Charge-Coupled-Device (CCD) array containing 2029 (H) x 2044 (V) light sensitive elements (pixels). These pixels are 9.0 microns square and have a center-to-center spacing of 9.0 microns (100% fill ratio).

The equal horizontal and vertical geometry simplify measurements taken with the camera. The benefit of having a 100% fill ratio is reduced aliasing, improved subpixel accuracy, and a 100% light sensitive area. The Camera has an eight or ten bit digital video output. Exposure is adjustable from 1 millisecond to 100 seconds in 1-millisecond increments using the internal exposure control. Exposure times from 1 millisecond to the longest time practical can be had by using an external exposure control signal.

The camera can be triggered asynchronously to capture high-speed events. Separate exposure and readout cycles can be achieved by using a pulsed illumination light source such as a strobe. An external strobe flash unit can be synchronized through a BNC connector on the rear panel of the camera. This dramatically improves picture quality when the object being photographed is in motion.

The *Mega*Plus Camera is ruggedly designed and can accommodate moderate amounts of shock and vibration. Gaskets protect the camera's interior components from dust, contaminants and EMI.

1.2 How to Use This Manual

WARNINGS, CAUTIONS and NOTES
As you read this manual, you will notice that some of the information is presented as a WARNING, CAUTION or NOTE. It is important that you understand the significance of these terms.

A **WARNING** is important to the safety of anyone operating the Camera and should not be disregarded under any circumstances.

A **CAUTION** is intended to alert you to an operation or condition that may cause loss of data or harm to your Camera.

A **NOTE** contains information that is important to the operation of your Camera.

Chapter 1 contains an introduction to the *Mega*Plus camera, an explanation of this manual, some general precautions, and a warranty statement.

Chapter 2 explains the function of the controls and connectors of the *Mega*Plus Camera.

Chapter 3 is intended to give the user some insight into how to choose the correct mode of operation for this *Mega*Plus camera. The correct mode of operation is defined as what will get the imaging results you are looking for.

Chapter 4 details the specifications of the *Mega*Plus camera with the intent to give you all of the information you require when using this camera.

NEW EQUIPMENT WARRANTY
REDLAKE MASD, INC. *MEGA*PLUS CAMERA

REDLAKE MASD, INC. (HEREAFTER REFERRED TO AS REDLAKE) WARRANTS THIS CAMERA, AND ACCESSORIES MANUFACTURED BY REDLAKE, TO FUNCTION PROPERLY FOR ONE YEAR FROM THE DATE OF SHIPMENT.

Redlake agrees to perform the following equipment warranty services in the United States.

1. Repair service: if shipped to us, repairs will be made at no charge.
2. Parts replacement: replacement parts installed under warranty will be provided at no charge.

THIS WARRANTY DOES NOT APPLY TO THE FOLLOWING CONDITIONS:

- Failure to operate the *Mega*Plus Camera in accordance with Redlake's written instructions, including environmental specifications listed in the User's Manual.
- Evidence of the Camera being subjected to accidental damage, misuse or abuse.
- The Camera having been repaired or tampered with by persons other than Redlake personnel, customer personnel trained by Redlake or without permission of Redlake.
- Shipping damage is not covered by this warranty. The purchaser has the responsibility to place a claim of damage in shipment with the carrier.

REDLAKE MASD, INC. MAKES NO OTHER WARRANTIES, EXPRESSED, IMPLIED, OR OF MERCHANTABILITY FOR THIS EQUIPMENT. IF THIS CAMERA DOES NOT FUNCTION PROPERLY DURING THE WARRANTY PERIOD, REDLAKE WILL REPAIR IT WITHOUT CHARGE ACCORDING TO THE TERMS STATED ABOVE. REPAIR WITHOUT CHARGE IS REDLAKE'S ONLY OBLIGATION UNDER THIS WARRANTY. REDLAKE WILL NOT BE RESPONSIBLE FOR ANY CONSEQUENTIAL OR INCIDENTAL DAMAGES RESULTING FROM THE SALE, USE OR IMPROPER FUNCTIONING OF THIS EQUIPMENT EVEN IF LOSS OR DAMAGE IS CAUSED BY THE NEGLIGENCE OR OTHER FAULT OF REDLAKE.

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2. CONTROLS AND CONNECTORS

2.1 Camera

NOTE: A lens cap is installed on each camera to keep dust from getting on the optical sensor or components when it is shipped. Remove the lens cap and install your lens in a dust free environment.

2.1.1 Mounting the Camera

The *Mega*Plus Camera Head has four threaded screw holes for mounting, two on the bottom and two on the top of the camera body. All holes accept 1/4-20 threaded screws. In most situations the camera is attached to a tripod via the mounting point on the bottom of the Camera Head. It is a good practice to mount the camera head on the tripod before attaching a lens to the camera.

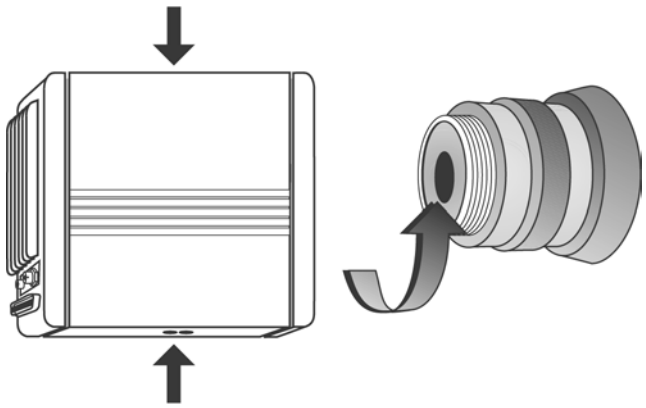


Figure 2-1. Camera Body

2.1.2 Attaching the Lens

The camera can be purchased with either a C-mount or F-mount lens adapter. If your camera is equipped with an F-mount lens adapter, insert the lens into the locking ring, then rotate the lens counterclockwise until it clicks into position. To remove the lens, hold the release button down as you rotate the lens clockwise.

If your camera is equipped with a C-mount lens adapter, screw the lens clockwise into the adapter until you are no longer able to turn the lens with light pressure.

CAUTION: Some C-mount lenses may extend into the camera more than 0.20 inches (5.08 mm), which may cause damage to internal optical components. Check the dimension of any lens you plan to use as shown in Figure 2-2.

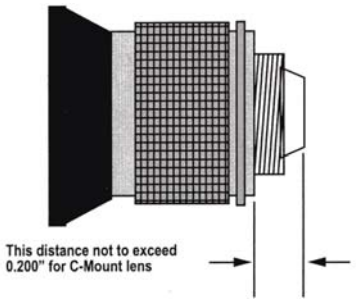
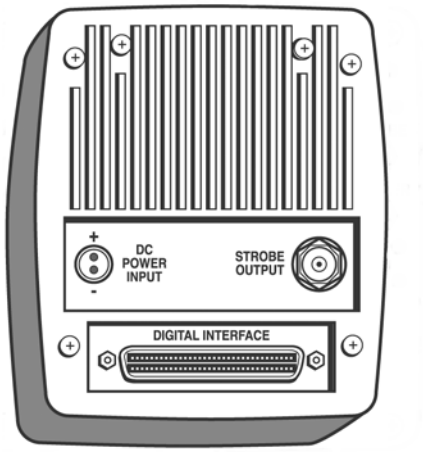


Figure 2-2. C-Mount Lens Length Limit



The mating connector for the DC power input is manufactured by LEMO as part number FGG.0B.302.CLAD42

Figure 2-3. 4.2i Rear Panel

2.2 Camera Rear Panel

2.2.1 Digital Interface

This is a 68-pin, high density, dual row, D type connector that interfaces the *Mega*Plus Camera to a frame grabber board and serial communication interface for camera control. The frame grabber board processes and displays video from the camera. A complete technical description of the connector and the signals that it carries is contained in chapter four of this manual.

2.2.2 Strobe Output

The leading edge of this output signal can be used to fire a strobe light. This output signal is TTL compatible and can drive a 50-ohm load. A strobe light with a flash duration of less than 1 millisecond is useful for capturing images of fast moving objects.

2.2.3 DC Power Input

This two-pin connector is the power input for the camera. The power supply voltage should be between 12 and 28 volts DC measured at the connector on the camera rear panel. The current draw is a maximum of 0.8 amps at the lowest input supply voltage and 0.3 amps at the highest input supply voltage.

WARNING!

Reversing the polarity of the DC voltage input or voltage levels in excess of 30 volts may permanently damage the camera

2.3 Cables

There are three different cables available to connect the *Mega*Plus Camera to your computer, as shown in Figure 2-4 below.

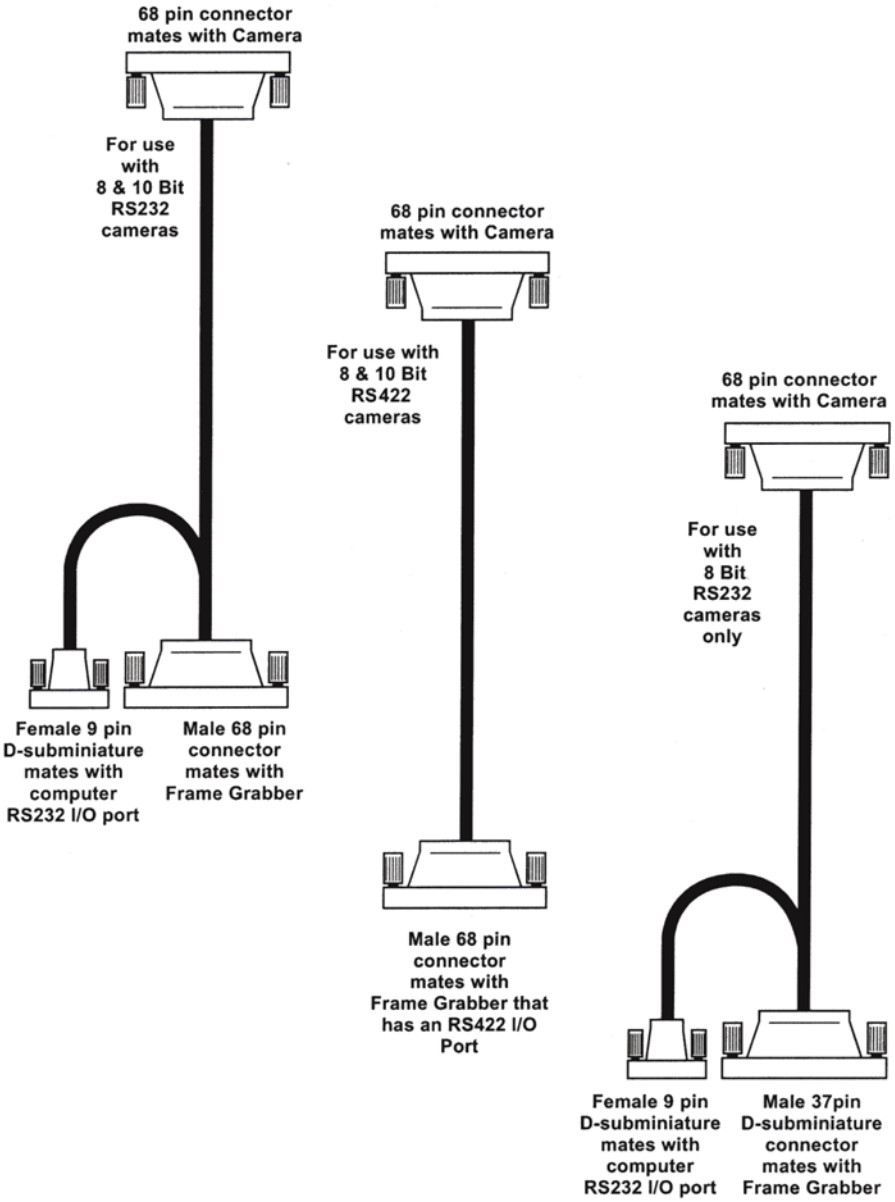


Figure 2-4. 4.2i Cable Types

2.4 Hardware Setup

Follow the instructions supplied by the frame grabber manufacturer when you are using their cables to install your camera. If using Redlake supplied cables, connect the camera as shown in Figure 2-5 below.

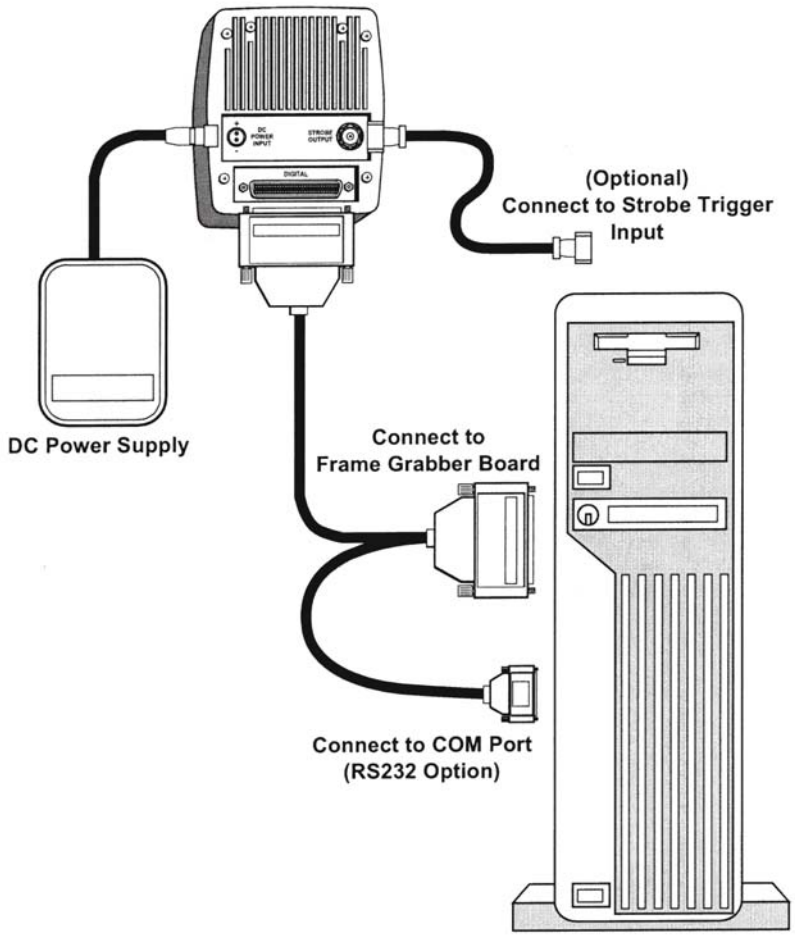


Figure 2-5. Component Connection Diagram

2.5 Routine Maintenance

There are no user serviceable parts in the camera. Should the shutter malfunction, the camera must be returned to the factory for repair.

The lens should be cleaned according to good photographic practices. This will help keep your camera producing top quality pictures.

The camera can be ordered from the factory with an infrared filter installed in the lens mount. If an infrared filter was not ordered originally, a piece of clear glass will be installed in place of the filter. The filter or its glass replacement keep the interior of the camera sealed from dust and should never be removed in other than a clean room environment. Because of the high resolution of the camera, a single speck of dust on the sensor is very noticeable.

If you need to use different filters in your application from time to time, we recommend that you order the camera with the clear glass installed. The spectral sensitivity can then be changed by exchanging filters on the end of the lens as in 35mm photography.

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3. CAMERA OPERATION

3.1 Introduction

The *Mega*Plus Camera, Model 4.2i does not have any manual controls. Camera operation is accomplished by commands sent to the camera through a serial data link from a personal computer. In this chapter we will present the various operating modes of the camera with an explanation of the function followed by the command sequence that must be transmitted by the computer. The control lines to the camera can be configured as an RS232 or an RS422 serial data link. The camera is ordered from the factory configured one way or the other. The command syntax is the same in either case.

3.2 Serial Communications Protocol

The camera uses a full duplex UART type asynchronous system, using standard nonreturn-to-zero (NRZ) format (one start bit, eight data bits, one stop bit, no parity). The baud rate is fixed at 9600. The character code is based on the ASCII standard.

The character flow control protocol is XON/XOFF. XON is assigned DC1 (control-Q) and XOFF is assigned DC3 (control-S). The receiver sends the XOFF character when it wants the sender to pause in sending data and an XON character when it wants the sender to resume.

The camera will recognize a command as three command characters, followed by a space bar character, followed by an argument that consists of one or more characters, ended by the carriage return and line feed characters. The camera responds to a valid command with a carriage return and line feed (CR-LF).

The camera will recognize a query as three command characters, followed by the question mark character, then ended by the carriage return character.

The camera responds to a query with three command characters, followed by a space bar character, followed by an argument that consists of one or more characters, then ended by carriage return character and line feed (CR-LF).

3.3 Error Messages

The camera can respond to an erroneous command or query in one of three possible ways.

MESSAGE FROM CAMERA	EXPLANATION
ERROR-SYNTAX	The camera cannot make sense of the command.
ERROR-ARGUMENT OUT OF RANGE	The command is recognized, but the argument is out of range or indecipherable.
ERROR-TRANSMISSION	The receiver detected a transmission error such as buffer overflow, parity, noise, or framing

3.4 Mode Control

The *Mega*Plus Camera operates in one of three modes, TRIGGER, CONTINUOUS, or CONTROL. The mode of operation is selected by the mode command. The mode command's fourth option, PARALLEL INTERFACE, delegates mode selection to three control lines, MC0 - MC2, input through the Digital Interface Connector

3.4.1 Trigger

Each exposure is started by a signal connected to the EXPOSE input pins of the “Digital Interface” connector on the rear panel of the camera. The exposure command sets the exposure time and, indirectly, the frame rate.

The EXPOSE input sets the start time for each frame of video. When the trigger signal lasts longer than the combined exposure and readout time, the camera will continue to take exposures until the trigger signal goes away.

The trigger mode of operation is used to capture a single picture or sequence of pictures. If the object that you are trying to capture is fast moving, a strobe light may be used to freeze the action. The short flash duration (sometimes less than 50 microseconds) of a strobe is the key to minimizing blur caused by speedy subjects. The Strobe Output on the rear panel of the camera can be used to start the strobe flash.

3.4.2 Continuous

The continuous mode of operation is useful when the operator wishes to monitor an ongoing event. The camera will repeatedly take pictures as fast as the exposure time selected allows.

The exposure command sets the exposure time and, indirectly, the frame rate. Each new exposure starts as soon as the previous image has been transferred to the camera output by the camera electronics.

3.4.3 Control

The start and exposure time of each picture is controlled directly by the user. Control is accomplished by the EXPOSE input pins in the “Digital Interface” connector on the rear panel of the camera. The exposure time is equal to the time the EXPOSE input signal is true.

3.4.4 Parallel Interface

This option provides compatibility with previous models of the *Mega*Plus Camera. This mode enables limited camera control by a frame grabber board installed in a host computer. When the mode is set to Parallel Interface, the state of the control lines MC0, MC1, and MC2 determines the operating mode of the Camera. See page 4.2 for details on control lines MC0 - MC2.

TYPE IN:	RESPONSE	EXPLANATION
MDE xx	CR-LF	Sets the mode as determined by the argument TR, CS, DC, PI.
MDE?		Queries the current mode setting.
	MDE xx	Means the mode is set as indicated.

Sample commands with arguments:

MDE TR Sets the mode to TRIGGER.
MDE CS Sets the mode to CONTINUOUS.
MDE CD Sets the mode to CONTROLLED.
MDE PI Delegates mode control to Control Lines MC0 – MC2.

3.5 Shutter

The *Mega*Plus Camera may be operated with the shutter on or off. When the shutter is off, the shutter blades can be locked open or closed. The shutter is controlled by the SHE command in the CONTINUOUS, CONTROL and TRIGGER modes of operation. When the camera is set to LINE operation, the shutter is controlled by the command line MC2.

When the shutter is on, the exposure time is set by the exposure command for both the CONTINUOUS and TRIGGER modes of operation. When the camera is operated in the CONTROL mode, the exposure lasts for as long as the EXPOSE input to the camera is “true”.

In general, the shutter should be turned off with the blades open if you are working in a darkened area with a light source that is flashed. The camera is always gathering light even as an image is being read from the sensor. If there is light on the subject between exposures, the shutter should be used to prevent image smear. If you need to acquire a dark current frame, turn the shutter off with the blades closed and transfer a frame.

TYPE IN:	RESPONSE	EXPLANATION
SHE xx	CR-LF	Enables or disables the shutter as determined by the argument ON, FO, or FC.
SHE?		Queries the current shutter setting.
	SHE xx	Means the shutter is enabled or disabled as indicated.

Sample commands with arguments:

SHE ON Enables the Shutter.
SHE FO Disables the Shutter and locks it in the open position.
SHE FC Disables the Shutter and locks it in the closed position.

3.6 Exposure

This command sets the exposure time of the camera in increments of one millisecond. The exposure times can be any value between one millisecond and one hundred seconds. This exposure time setting affects the CONTINUOUS and TRIGGER modes only. The camera produces the most uniform picture when the exposure time is between 50 and 200 milliseconds. The maximum frame rate is directly related to exposure time. The maximum frame rate with the exposure set for 50 milliseconds is 1.8 frames per second. For an exposure time of 500 milliseconds, the fastest frame rate becomes 1.0 frame per second.

Frame Rate = 1/(485 milliseconds + exposure time + shutter transition time)

When your application involves low light levels and a subject that is not moving, exposure times of more than one second may be necessary. As you push the exposure time beyond one second, you may notice that image quality deteriorates. This is caused by sensor dark current accumulating over time. The CONTROL mode allows you to extend the exposure time beyond 100 seconds, but you should understand that picture quality degrades with the longer exposure times.

TYPE IN:	RESPONSE	EXPLANATION
EXExxxxxx	CR-LF	Sets the exposure in one millisecond increments using the argument with a range from 1 to 100000.
EXE?		Queries the current Exposure setting.
	EXExxxxxx	Means the exposure is set as indicated.

Sample commands with arguments:

EXE 1 Sets the Exposure to one millisecond.
EXE 100000 Sets the Exposure to one hundred thousand milliseconds (100 seconds).

3.7 Trigger

This command enables and sets the polarity of the EXPOSE input on the Digital Interface Connector on the rear panel of the camera.

TYPE IN:	RESPONSE	EXPLANATION
TRM x	CR-LF	Sets the EXPOSE input signal in the Digital Connector to positive (TRM P) or negative (TRM N) logic. Either command enables the expose input port pins if they were disabled.
TRE x	CR-LF	TRE 0 forces an exposure. TRE 1 resets the exposure to transfer/idle. Either command disables the EXPOSE input. Use the TRM command to turn the EXPOSE input back on.
TRM?		Queries the current EXPOSE polarity.
	TRM P	Means EXPOSE signal is set to positive logic
	TRM N	Means EXPOSE signal is set to negative logic.
	TRM O	Means EXPOSE input port has been disabled. This can only occur if TRE 0 or 1 has been executed.
TRE?		Queries the current state of the TRIGGER command.
	TRE 0	Means an exposure is taking place.
	TRE 1	Means the camera is in the Transfer Frame and then Idle state.

Sample commands with arguments:

COMMAND	EXPOSE (+) INPUT	ACTION
TRM P	HIGH	Expose.
TRM P	LOW	Transfer frame and then idle.
TRM N	HIGH	Transfer frame and then idle
TRM N	LOW	Expose.

NOTE: Trigger must be set to positive, TRM P, if you are using a frame grabber designed for the *Mega*Plus 4.2i camera.

3.8 Gain

The gain of the camera is variable in 2dB steps between 0dB and 24dB. The normal gain position is 6dB. 0dB halves the gain, 12dB multiplies the gain by 2, 18dB multiplies the gain by 4 and 24dB multiplies the gain by 8. A change in gain of 6dB is the same as changing the lens aperture by one f-stop.

As you increase the gain of the camera the noise in the picture will increase. By adjusting the camera gain, the operator can optimize the signal to noise ratio and the sensitivity of the camera for the application.

TYPE IN:	RESPONSE	EXPLANATION
GAE xx	CR-LF	Sets the gain control in 2dB increments. The range of values is 0 to 24. Only even numbers are valid
GAE?		Queries the current gain setting.
	GAE xx	Indicates that the gain is set to the value given in dB.

Sample commands with arguments:

GAE 0 Sets the camera gain to 0dB.
GAE 4 Sets the camera gain to 4dB.
GAE 24 Sets the camera gain to 24dB.

3.9 Black Level

The black level control functions much like the brightness control on a television set. To get reasonable results under most circumstances, use the BKF or fixed black level. The fixed video black level is set at the factory so that the output video is just above the black clipping level with the lens capped. The black level can be varied over a range of plus or minus 50 percent of peak white video. This adjustment range lets the user compensate for poor lighting.

TYPE IN:	RESPONSE	EXPLANATION
BKF	CR-LF	Sets the black level to an internal fixed value of approximately 50 counts above zero for 10 bits or 12 for 8 bits.
BKE xxxx	CR-LF	Sets the black level as determined by the argument with a range from –2048 to +2047.
BKE?		Queries the current black level setting.
	BKF	Means the black level is at the factory preset level.
	BKE xxxx	Means black level externally set to the value indicated.

COMMAND	APPROX. OUTPUT OFFSET	
	8-Bits	10-Bits
BKE -2048	-128 counts	-512 counts
BKE 0	0 counts	0 counts
BKE 2047	+127 counts	+511 counts

NOTE: The video will be clipped to 0 counts until it overcomes a negative offset. The video will be offset towards white by a positive offset.

3.10 Strobe Polarity

The STROBE OUTPUT on the rear panel of the camera provides a trigger signal for the user's stroboscopic light source. The polarity of the strobe signal is set by this command. Use the leading edge of the strobe signal as the trigger point, because the trailing edge may vary. The Strobe output is capable of driving a 50-ohm load.

TYPE IN:	RESPONSE	EXPLANATION
STP x	CR-LF	Sets the polarity of the strobe trigger pulse to positive (STP P) or to negative (STP N).
STP?		Queries the strobe trigger output polarity.
	STP P	Means the strobe output is a high going pulse.
	STP N	Means the strobe output is a low going pulse.

Sample commands with arguments:

STP P Makes the strobe output a high going pulse.
STP N Makes the strobe output a low going pulse.

NOTE: The STROBE OUTPUT must be set to positive, STP P, if you are using a strobe designed for use with the *Mega*Plus 4.2i camera.

3.11 Defect Correction

Occasionally, sensors are not perfect and have some areas that react differently to light. These problem pixels are usually seen as a column that is different in intensity than the immediately adjacent area. It is possible to characterize a sensor identifying the defective columns and then program their locations into the camera at the factory. When defect correction is turned on, the camera replaces the defective areas with information derived from nearby pixels making the defects less noticeable.

TYPE IN:	RESPONSE	EXPLANATION
DEF xx	CR-LF	Enables (DEF ON) or Disables (DEF OF) Defect Correction.
DEF?		Queries the state of Defect Correction.
	DEF ON	Means the Defect Correction is enabled.
	DEF OF	Means the Defect Correction is disabled.

Sample commands with arguments:

DEF ON Turns on Defect Correction.
DEF OF Turns off Defect Correction.

3.12 Reset

TYPE IN:	RESPONSE	EXPLANATION
RST	CR-LF	Resets the camera to the settings as last saved. Removing and then restoring power also performs a reset.

3.13 Save

TYPE IN:	RESPONSE	EXPLANATION
SAV	CR-LF	Saves the current camera settings to EEPROM; these settings will be recalled by a RESET or by turning the camera power on.

NOTE: The EEPROM used by the SAVE command has a finite life of roughly 10,000 erase and program cycles. We recommend that the SAVE command be used occasionally to store your most generally applicable setup and not as a daily routine.

3.14 Status Query

The Status Query command enables the user to get all of the camera operating parameter information with a single command.

TYPE IN:	RESPONSE	EXPLANATION
STS?		Gives complete camera status with one query. The following parameters are transmitted with a carriage return after each parameter:
	DEF xx	Shows Defect Concealment status.
	GAE xxx	Shows Gain setting.
	BKE xxxx	Shows Black Level setting.
	MDE xx	Shows the operating Mode.
	SHE xx	Shows the Shutter status
	EXE xx	Shows the Exposure time.
	TRM x	Shows the Trigger logic polarity.
	TRE x	Shows the Exposure state.
	STP x	Shows the polarity of the Strobe Pulse.
	SCP x	Shows the communications protocol.

A typical reply to STS? would be as follows:

DEF ON
GAE 6
BKE 610
MDE CD
SHE ON
EXE 100
TRM P
TRE 1
STP N
SCP 232

3.15 Identification Query

TYPE IN:	RESPONSE	EXPLANATION
IDN?	*Mega*Plus Model 4.2i, Vx.xx	Queries the camera model number and software version.

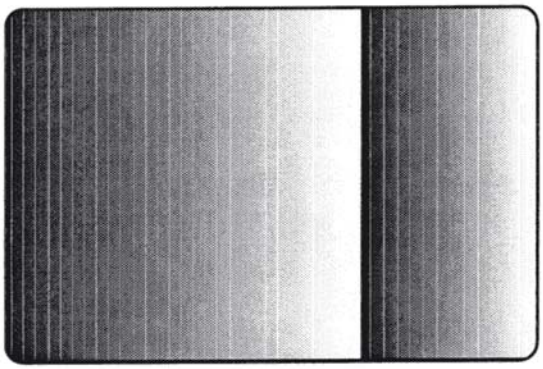

Figure 3-1. Wedge Display

3.16 Display Wedge

The wedge command displays linearly increasing gray scales in each quadrant of the image as shown in Figure 3-1. This function is useful for aligning the camera image to a frame grabber. The display wedge defaults to OFF when the power to the camera is turned off.

TYPE IN:	RESPONSE	EXPLANATION
WDG ON	CR-LF	Means the wedge is being displayed.
WDG OF	CR-LF	Means the camera is imaging.
WDG?		Queries the state of the wedge display.

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4. INTERFACE SPECIFICATIONS

4.1 Introduction

Chapter four gives you the information needed to interface the *Mega*Plus Camera, Model 4.2i to a frame grabber device. The relationship between the video outputs and the synchronization outputs of the camera are presented in the following order:

- DIGITAL INTERFACE CONNECTOR
- MODE CONTROL
- EXPOSURE TIMING
- FRAME TIMING
- LINE TIMING
- PIXEL TIMING

The *Mega*Plus Camera, Model 4.2i is a high-resolution black and white still camera presenting an eight bit (or optional 10 bit) digital video output. Each frame has 2,029 columns and 2,044 rows of pixels (picture elements) containing valid video data.

4.2 Digital Video Connector

All the signals referred to in this section are present at the Digital Interface connector on the rear panel of the camera. Table 1 lists each signal and its pin number. The connector for this port is a 68 pin, high density, dual row, D type connector. This connector is the same as that used for the "SCSI-2 B cable" interface. The connector has .050 inch (12.7mm) pin spacing and a D-type shell that is 2.5 inches (63.5mm) long. We have taken precautions to prevent damage to the CCU should a SCSI device accidentally be connected to this port.

4.3 Digital Video Outputs

The digital video output of the camera has ten bits labeled MSB through MSB-9. These signals are output as differential pairs with signal levels conforming to the RS422 specification. The noninverting part of the differential pair is present on output (+), while the inverting part of the differential pair is present on output (-).

MSB is the Most Significant Bit and MSB-7 is the least significant bit in this camera configuration. All frame grabbers designed to work with this and future *Mega*Plus Cameras should be MSB justified. MSB will always be the most significant bit in all eight or ten bit camera configurations.

4.4 Timing Outputs

There are three timing outputs presented on the Digital Interface connector. They are FRAME ENABLE (FRME ENA), LINE ENABLE (LINE ENA) and PIXEL DATA STROBE (PIX DATA STRB). These signals are output as differential pairs with signal levels conforming to the RS422 specification. The noninverting part of the differential pair is present on output (+), while the inverting part of the differential pair is present on output (-). A signal is true when the (+) line is more positive than the (-) line.

4.5 Control Inputs

The control input EXPOSE is provided as a means of externally controlling the exposure of the camera. This input is designed to accept RS-422 differential or, for backwards compatibility, single ended TTL. To drive this input differentially, connect both the (+) and (-) inputs to an RS-422 driver. When the (+) input is more positive than the (-) input the camera is exposing. When the (+) input is more negative than the (-) input the camera performs a frame transfer and then idles.

To drive the EXPOSE input with a single ended TTL signal source, connect one input to a TTL driver and leave the other input floating. If the (+) input (pin 30) is driven, then a TTL high will start an exposure or if the (-) input (pin 64) is driven, then a TTL low will start an exposure.

4.6 Mode Control Lines

The operating mode of the camera is set by the MDE command. Issuing an MDE PI command will delegate mode control to the MC0-MC2 mode control lines. MC0, MC1, and MC2 provide backward compatibility with earlier *Mega*Plus Camera control signals. Each of these inputs is designed to accept TTL level signals referenced to ground at the connector. MC0 and MC1 set the operating mode and MC2 enables the shutter. The truth table for the control lines is as follows:

Table 4-1. Mode Control Lines

MC2 (Pin 33) TTL Input	MC1 (Pin 32) TTL Input	MC0 (Pin 31) TTL Input	Shutter Operation	Operating Mode
Low (0 volts)	Low (0 volts)	Low (0 volts)	Enabled	Controlled
Low (0 volts)	Low (0 volts)	High (+5 volts)	Enabled	Triggered
Low (0 volts)	High (+5 volts)	Low (0 volts)	Enabled	Continuous
Low (0 volts)	High (+5 volts)	High (+5 volts)	Enabled	Continuous
High (+5 volts)	Low (0 volts)	Low (0 volts)	Off, blades open	Controlled
High (+5 volts)	Low (0 volts)	High (+5 volts)	Off, blades open	Triggered
High (+5 volts)	High (+5 volts)	Low (0 volts)	Off, blades open	Continuous
High (+5 volts)	High (+5 volts)	High (+5 volts)	Off, blades open	Continuous

NOTE: Redlake, MASD, Inc. does not recommend using MC0 through MC2 for mode control in new designs for *Mega*Plus cameras. The serial data port, with its complete command set, provides a more useful control interface.

Table 4-2. Digital Interface Connector Pinout (On Rear of Camera)

PIN	SIGNAL NAME	PIN	SIGNAL NAME	SOURCE
1	GROUND	35	GROUND	Camera
2	MSB (+)	36	MSB (-)	Camera
3	MSB-1 (+)	37	MSB-1 (-)	Camera
4	MSB-2 (+)	38	MSB-2 (-)	Camera
5	MSB-3 (+)	39	MSB-3 (-)	Camera
6	MSB-4 (+)	40	MSB-4 (-)	Camera
7	MSB-5 (+)	41	MSB-5 (-)	Camera
8	MSB-6 (+)	42	MSB-6 (-)	Camera
9	MSB-7 (+)	43	MSB-7 (-)	Camera
10	MSB-8 (+)	44	MSB-8 (-)	Camera
11	MSB-9 (+)	45	MSB-9 (-)	Camera
12	GROUND	46	GROUND	Camera
13	Not Used	47	Not Used	
14	Not Used	48	Not Used	
15	Not Used	49	Not Used	
16	Not Used	50	Not Used	
17	Not Used	51	Not Used	
18	Not Used	52	Not Used	
19	Not Used	53	Not Used	
20	Not Used	54	Not Used	
21	Not Used	55	Not Used	
22	SER CNTRL OUT (+)	56	SER CNTRL OUT (-)	Camera
23	SER CNTRL IN (+)	57	SER CNTRL IN (-)	User
24	Not Used	58	Not Used	
25	FRME ENA (+)	59	FRME ENA (-)	Camera
26	LINE ENA (+)	60	LINE ENA (-)	Camera
27	Not Used	61	Not Used	
28	Not Used	62	Not Used	
29	PIX DATA STRB (+)	63	PIX DATA STRB (-)	Camera
30	EXPOSE (+)	64	EXPOSE (-)	User
31	MC0	65	Not Used	User
32	MC1	66	Not Used	User
33	MC2	67	Not Used	User
34	GROUND	68	GROUND	Camera

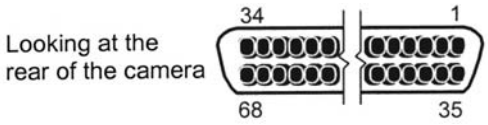


Figure 4-1. Digital Interface Connector

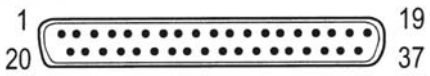
(For use with 8 or 10 bit, RS422 Cameras)

(Refer to Table 4-2 for Pinout)

Figure 4-2. 68-Pin Digital Interface Cable

Table 4-3. 37-Pin Frame Grabber Cable Pinout

PIN	SIGNAL NAME	PIN	SIGNAL NAME	SOURCE
1	PIX DATA STRB (+)	20	PIX DATA STRB (-)	Camera
2	LINE ENA (+)	21	LINE ENA (-)	Camera
3	FRME ENA (+)	22	FRME ENA (-)	Camera
4	GROUND	23	GROUND	Camera
5	Not Used	24	Not Used	
6	Not Used	25	Not Used	
7	Not Used	26	Not Used	
8	MSB (+)	27	MSB (-)	Camera
9	MSB-1 (+)	28	MSB-1 (-)	Camera
10	MSB-2 (+)	29	MSB-2 (-)	Camera
11	MSB-3 (+)	30	MSB-3 (-)	Camera
12	MSB-4 (+)	31	MSB-4 (-)	Camera
13	MSB-5 (+)	32	MSB-5 (-)	Camera
14	MSB-6 (+)	33	MSB-6 (-)	Camera
15	MSB-7 (+)	34	MSB-7 (-)	Camera
16	GROUND	35	GROUND	Camera
17	EXPOSE	36	Not Used	User
18	MC0	37	MC1	User
19	MC2			User

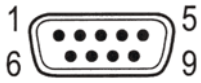


(37-Pin female D subminiature connector as viewed at the end of the cable)

Figure 4-3. 37-Pin Connector

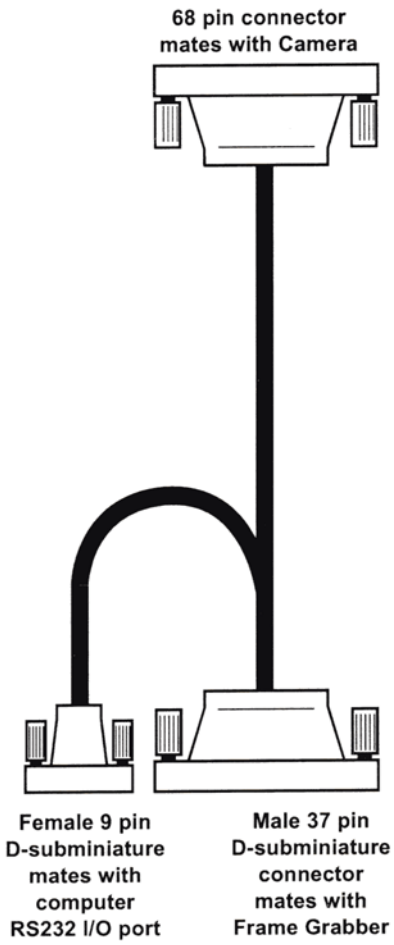
Table 4-4. 9-Pin PC COM Port Cable Pinout

PIN	SIGNAL NAME	PIN	SIGNAL NAME
1	Open	6	Open
2	Camera (TX) from Camera	7	Connected to Pin 8
3	Camera (RX) from User	8	Connected to Pin 7
4	Open	9	Open
5	Camera Ground		



(9-Pin female D subminiature connector as viewed at the end of the cable)

Figure 4-4. 9-Pin Connector



(Refer to Tables 4-3 and 4-4 for Pinouts)

Figure 4-5. 9-Pin PC COM Port/37-Pin Frame Grabber Cable

Table 4-5. 68-Pin Frame Grabber Interface Cable Pinout

PIN	SIGNAL NAME	PIN	SIGNAL NAME	SOURCE
1	GROUND	35	GROUND	Camera
2	MSB (+)	36	MSB (-)	Camera
3	MSB-1 (+)	37	MSB-1 (-)	Camera
4	MSB-2 (+)	38	MSB-2 (-)	Camera
5	MSB-3 (+)	39	MSB-3 (-)	Camera
6	MSB-4 (+)	40	MSB-4 (-)	Camera
7	MSB-5 (+)	41	MSB-5 (-)	Camera
8	MSB-6 (+)	42	MSB-6 (-)	Camera
9	MSB-7 (+)	43	MSB-7 (-)	Camera
10	MSB-8 (+)	44	MSB-8 (-)	Camera
11	MSB-9 (+)	45	MSB-9 (-)	Camera
12	GROUND	46	GROUND	Camera
13	Not Used	47	Not Used	
14	Not Used	48	Not Used	
15	Not Used	49	Not Used	
16	Not Used	50	Not Used	
17	Not Used	51	Not Used	
18	Not Used	52	Not Used	
19	Not Used	53	Not Used	
20	Not Used	54	Not Used	
21	Not Used	55	Not Used	
22	Not Used	56	SER CNTRL OUT (-)	Do Not Use
23	Not Used	57	SER CNTRL IN (-)	Do Not Use
24	Not Used	58	Not Used	
25	FRME ENA (+)	59	FRME ENA (-)	Camera
26	LINE ENA (+)	60	LINE ENA (-)	Camera
27	Not Used	61	Not Used	
28	Not Used	62	Not Used	
29	PIX DATA STRB (+)	63	PIX DATA STRB (-)	Camera
30	EXPOSE (+)	64	EXPOSE (-)	User
31	MC0	65	Not Used	User
32	MC1	66	Not Used	User
33	MC2	67	Not Used	User
34	GROUND	68	GROUND	Camera

(N/C = Not Connected)

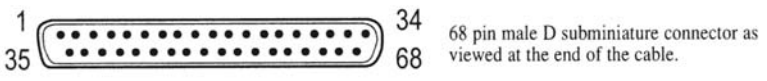
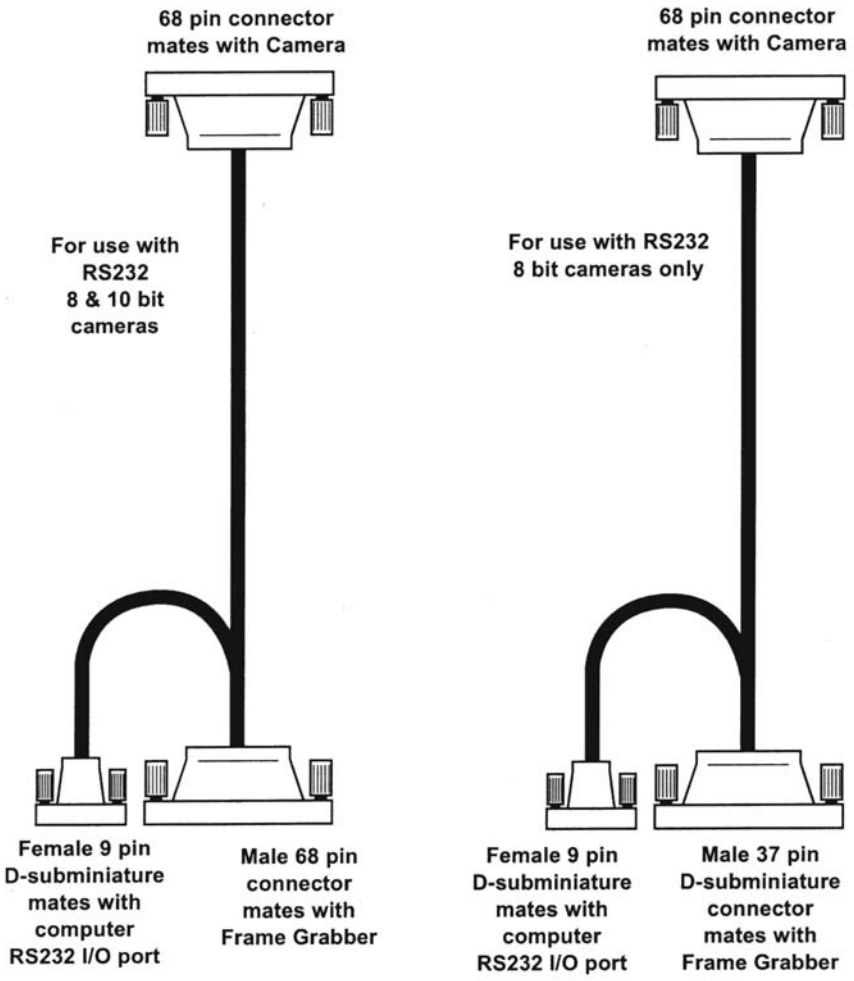


Figure 4-6. 68-Pin Frame Grabber Connector



(Refer to Table- for Pinout)

Figure 4-7. 9-Pin PC COM Port/68-Pin (and 37-Pin) Frame Grabber Cable

4.7 Sensor Specifications

Table 4-6. Sensor Specifications

ITEM	DESCRIPTION
Imaging Device	Solid-state charge-coupled device (CCD); front illuminated full-frame architecture
Total Pixel Clock Count	4,849,664 (2,368H x 2,048V)
Light-Sensitive Pixels	4,147,276 (2,029H x 2,044V)
Elements Transferred Per Line	2,368 pixel clock pulses in each line transfer (2,029 for active video + 339 for sync and blanking)
Lines Transferred Per Frame	2,048 (Four dark lines at the bottom)
Pixel Size	9.0 x 9.0 microns (square format)
Center-to-Center Pixel Spacing	9.0 microns, vertical and horizontal (unity fill-ratio)
Active Area	18.5mm(H) x 18.5mm(V) photosensitive area (100% fill factor)

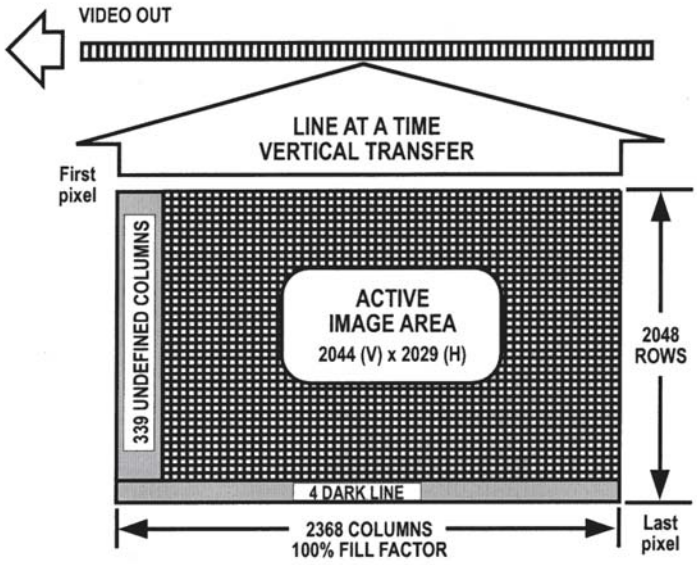


Figure 4-8. Sensor Organization

4.8 Frame Rate Data

4.8.1 Frame Rates

The frame rate of the camera is the number of images that can be taken per unit of time. The camera must transfer a full frame before it is able to make a new exposure and transfer the new frame. The rate depends on both the frame transfer time and the exposure time.

4.8.2 Frame Transfer Time

The frame transfer time is a constant. It is the number of pixels in a frame divided by the rate they are clocked out.

$$\frac{\text{2,048 lines x 2,368 clock intervals per line}}{\text{10 MHz}} = \text{Transfer Time}$$

= 4,849,664 pixels @ 10 MHz
= 485 milliseconds

4.8.3 Frame Repetition Rate

The frame repetition rate depends on both the frame transfer time and the exposure time.

$$\frac{1}{\text{(Exposure time + frame transfer time + shutter transit time)}} = \text{Frame Rate}$$

For exposures that are much shorter than the frame transfer time and when the shutter is off, the frame transfer time dominates the above equation and the frame rate approaches the maximum:

1/(485) milliseconds = 2.1 frames per second

For an exposure time of 50 milliseconds, the frame rate becomes:

1/(485 + 50 + 15) milliseconds = 1.8 frames per second

For an exposure time of 500 milliseconds, the frame rate becomes”

1/(485 + 500 + 15) milliseconds = 1.0 frames per second

It is important to remember that each line has 2,029 active pixels and that there are 2,044 lines of valid video data in each frame. The last four lines are not light sensitive.

4.9 Timing Waveforms

4.9.1 Exposure Timing

The start and stop of exposure time are synchronized with the falling edge of LINE ENA (+). The exposure time interval, whether generated internally or externally, is sampled at the falling edge of LINE ENA (+). Any start or stop exposure command occurring less than 250 nanoseconds before the falling edge of LINE ENA (+) may go undetected. This means that the camera will not respond to the start or stop command until another line has been processed.

All exposure events are quantized in steps of one line time or 236.8 µsec. This normally has no effect on exposure because one or two line times (0.2 to 0.4 ms) is a small percentage of the total 10 to 500 millisecond exposure time.

NOTE: The EXPOSE input pulse must be wide enough to be seen by at least one horizontal SYNC, which occurs once every 236.8 µsec. A pulse width of less than 236.8 µsec may be missed.

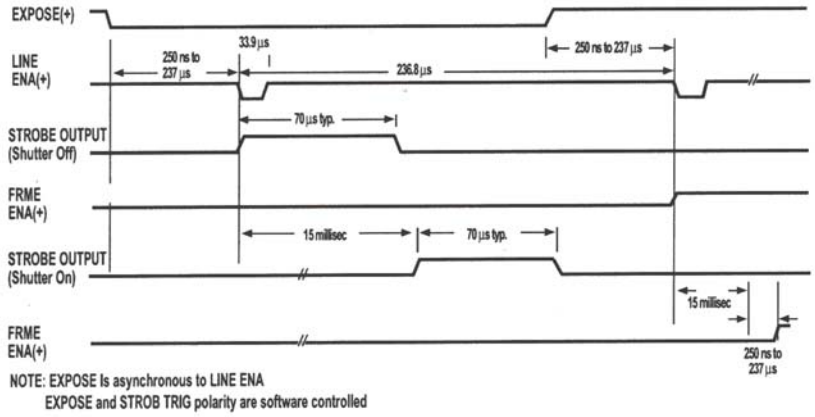


Figure 4-9. Exposure Timing Waveform

4.9.2 Frame Timing

The FRAME ENABLE signal is low while the array is exposed. The duration of this low state is variable and includes the user defined exposure time.

A complete frame of video data is transferred to the camera outputs while FRAME ENA (+) is high. The camera takes 485 milliseconds to transfer a complete image from the sensor array to the output. FRAME ENA (+) will be low while the camera is idle and while the camera is exposing.

The first pixel that is output in the frame transfer sequence is the pixel that belongs in the upper left-hand corner of the video display. Each row of video data is output from left to right and the rows are presented from top to bottom. The last pixel of the frame is placed in the lower right hand corner of the video display.

The video is transferred by shifting each row up one row. The top row is shifted into a register that performs the parallel to serial conversion as it outputs the video data. The LINE ENA (+) signal is held high for the time that it takes to output one row of video. The LINE ENA (+) signal has a period of 236.8µsec and runs continuously even if there is no video to be output.

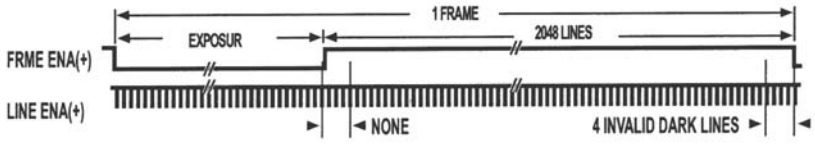


Figure 4-10. Frame Timing (Continuous Mode) Waveform

4.9.3 Line Enable

This is the Horizontal Sync for the camera. This signal runs continuously to allow external equipment to "phase lock" with the camera if desired. It is not affected by the camera mode or by any state the camera may be in (idle, exposing, or transferring).

When LINE ENA (+) is low, all lines in the sensor are shifted upward in parallel one line. The top line is shifted into the horizontal output shift register.

When LINE ENA (+) is high, the information in that horizontal shift register is clocked serially to the camera's output circuits.

Image data is valid only when both FRAME ENABLE and LINE ENABLE are high, the rest of the time the data are meaningless.

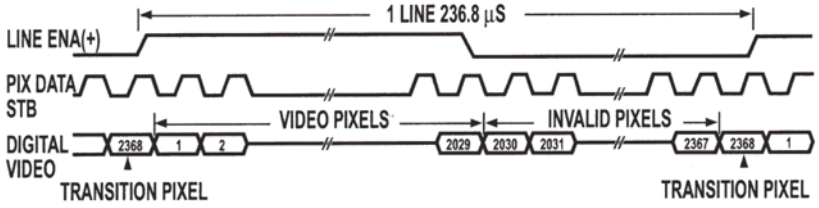


Figure 4-11. Line Timing Waveform

4.9.4 Pixel Timing

PIXEL DATA STROBE is a 10 MHz square wave that runs continuously. This clock drives the circuitry that identifies pixels, counts lines, and synchronizes the internal states of the camera. Valid digital data should be sampled at the rising edge of PIX DAT STRB (+).

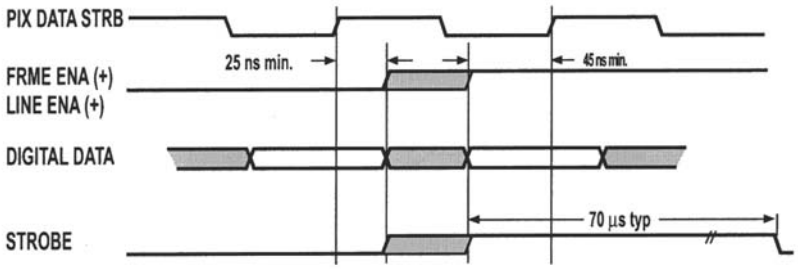


Figure 4-12. Pixel Clock Timing

4.10 Specifications

4.10.1 Video Performance

Black Level:	Clamped to black reference at the start of each frame.
Gamma:	Unity.
Scanning:	Non-Interlaced progressive scan
Synchronization:	Internal.
Dynamic Range:	Greater than 65dB at the input of the A/D Converter.
Pixel Clock Rate:	10 MHz.
Frame Rate:	2.1 frames per second @ strobe illumination 1.8 frames per second @ 50 millisecond exposure time 1.0 frames per second @ 500 millisecond exposure time

NOTE: Frame Rate = 1/(485 milliseconds + exposure time + 15 millisecond shutter transition time).

4.10.2 Camera Mechanical

Housing:	All aluminum gasket sealed case.
Dimensions:	
F-mount:	4.45”H x 3.90”W x 5.84”L (113.0 x 99.1 x 148.3mm)
C-Mount:	4.45”H x 3.90”W x 4.68”L (113.0 x 99.1 x 118.8mm)
Lens:	C-Mount or F-Mount.
Weight:	Approximately 3 pounds (1.26 Kg).
Mount:	Four ¼ - 20 threaded holes (2 on top/2 on bottom).
Vibration:	3G, sinusoidal from 5 to 150 Hz.
Shock:	20G (nonoperating).

4.10.3 Temperature

Operating:	0 to 35°C (32 to 95°F), non-condensing (Image quality will degrade with increasing temperature)
Storage:	-25 to +80°C (-13 to 176°F), non-condensing.

4.10.4 Humidity

Operating:	<80% @ 35°C (95°F).
Storage:	<40% @ 80°C (176°F).