7900-2 SERIES 2048 X 2048 PROGRESSIVE SCAN CAMERA

TECHNICAL REFERENCE MANUAL

CAMERA LINK VERSION

CE
FCC

F-MOUNT
(Nikon Compatible)

46.5 MM BACK SPACE
1:1 ASPECT RATIO SENSOR
21.43 MM DIAGONAL

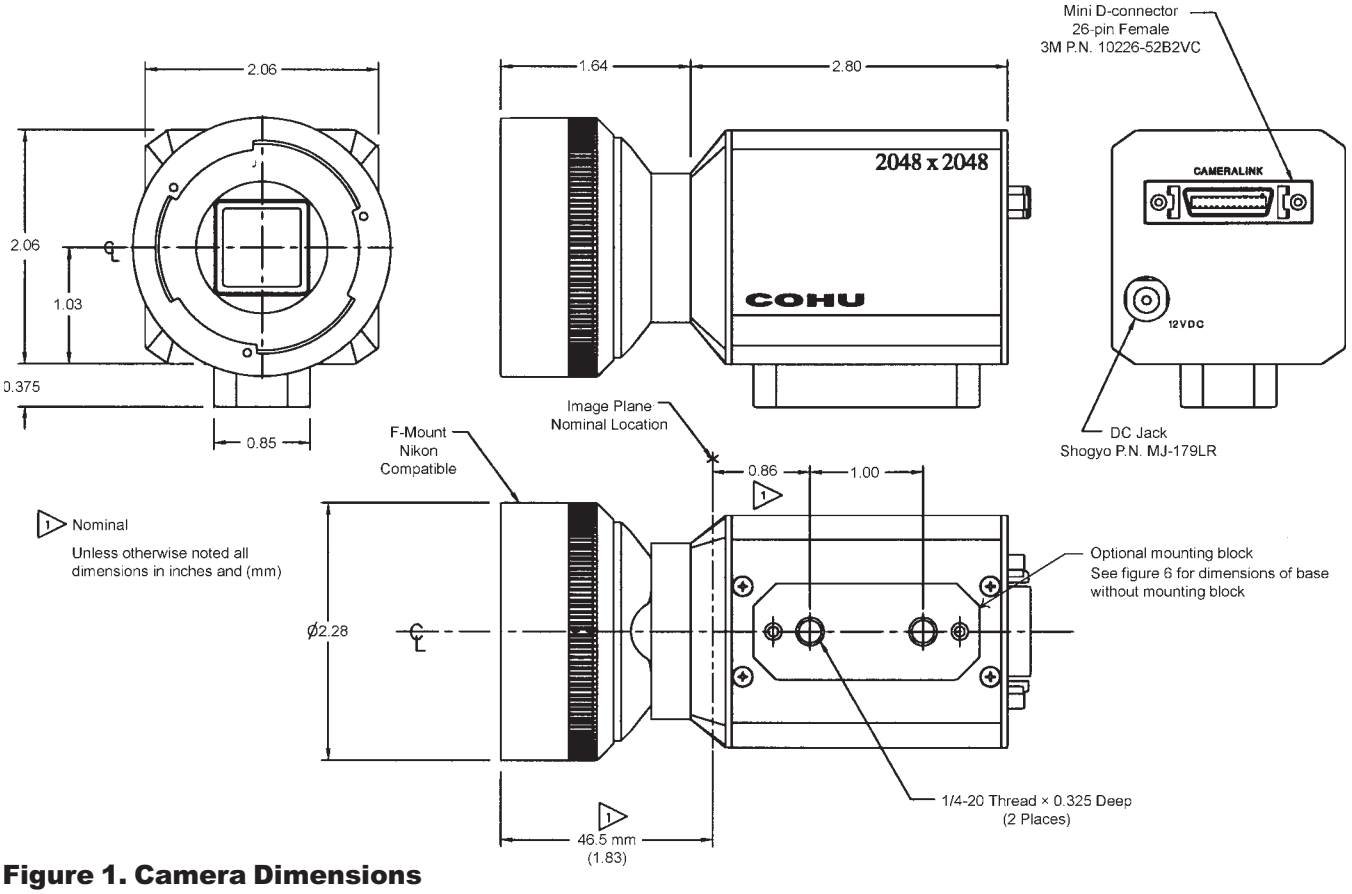


Figure 1. Camera Dimensions

Technical Manual 6X-1039

August 25, 2004

COHU
Cohu Inc., Electronics Division

Table 1. Specifications

SPECIFICATIONS	
ELECTRICAL	
Format	4/3 format (21.43 mm diagonal) monochrome interline transfer CCD with square pixels
Active Pixels	2048 × 2048 (approximately 4.19 M)
Pixel size	7.4 µm × 7.4 µm
Total Pixels	2112 x 2072 (approximately 4.24 M)
Sync	Internal crystal (40 MHz)
Frame Rate	8.6 frames per second - single channel 17.2 frames per second - dual channel (in development)
Electonic Shutter	Implicit: 1/15,000 to 1/35 sec (11 steps) Explicit: 1-2064 lines (1 line = 56.15 µs)
Integration	1 to 65,000 frames (1 frame = 116 ms - single channel)
Sensitivity	4 lux, no shuttering
Gamma	1 (fixed)
Gain	0 to 30 dB, externally controlled
S/N Ratio	58 dB black, 48 dB white
Power Input	+9 to +18 V dc
Power Consumption	1 A at +9 V dc / 800 mA at +12 V dc / 500 mA at +18 V dc. Note: Current will increase with reduced window height in partial scan operation

MECHANICAL AND ENVIRONMENTAL	
Size	See dimensional drawings (figure1 and figure 6)
Weight	14 ounce
Shock	15 g's any axis, nonoperating condition per MIL-E-5400T
Operating Temperature	-20 to 60 °C (-4 to 140 °F)
Storage Temperature	-30 to 70 °C (-22 to 158 °F)
EMI Emissions	CE class A
CAMERA INTERFACES	
Lens Mount	F-mount (Nikon compatible). Adjustable back focus locked by rotating ring
Camera Link Connector	26 pin MDR
Power Connector	+9 to +18 V dc with locking detents (Cohu 1310513-001)

1.0 GENERAL DESCRIPTION

This introduction briefly describes the overall characteristics of the Model 7900-2 Camera Link camera (figure 1) related to its installation and operation. A model number interpretation diagram appears in figure 2.

1.1 Electrical Characteristics

Cameras of the 7900-2 series provide either an 8-bit or10-bit output in Camera Link format to an external frame grabber. Operating in progressive scan mode, they use a 4/3 format monochrome sensor to provide 2048 × 2048 pixel resolution at 8.6 frames per second. Higher frame rates can be established, but with a corresponding reduction in the number of lines available for readout from the camera.

All processing is performed by the external frame grabber and computer.

Setup and control of the camera is through the rear-panel MDR connector operating via asynchronous serial communications. Offset, gain, and other functions are adjustable through this serial interface. Camera configuration is stored in non-volatile memory.

The 7900-2 Camera provides a progressive scan 2k output for machine vision and other type systems.

Partial readout allows the user to select a region of interest in four-line increments for increased frame rates.

Depending on the model, output is either 8-bit dual channel or10-bit single channel digital in Camera Link format. With 10 bit full resolution output, frame rate is 8.6. The 8-bit dual channel format will provide full resolution at approximately 17 frames per second.

Full asynchronous image capture with programmable partial scan (region of interest) provides the flexibility to utilize the camera in a variable machine vision applications. The sensor is highly sensitive in the near infrared spectrum.

Table 1 lists specifications for this 7900-2 series progressive scan camera. Figure 3 shows the quantum efficiency of the sensor. Figure 4 illustrates the transmissivity of the faceplate glass on the sensor. Note that figure 3 and figure 4 are aligned to each other for wavelength.

1.2 Mechanical Characteristics

The camera consists mainly of a main body casting and front casting assembly. Dimensions in figure 1 give Camera dimensions with the optional mounting block installed. For dimensions of the base without the optional mounting block see figure 6.

Interconnections are via two connectors located on the rear panel. One is a miniature two-pin power connector and the other is a standard 26-pin Camera Link connector.

An adjustable F-mount adapter mounts threads into the front of the casting. It is secured from turning by a locking ring. Lenses must be Nikon compatible.

An optional mounting block can be installed onto the bottom of the camera to provide two industry standard 1/4-20 mounting holes for securing at the desired mounting location. Maximum allowable depth for the mounting screw is 0.325 inch. The 1/4-20 mounting screw should not be allowed to bottom out in this hole.

If the mounting block is not used, two 4-40 screw holes are available for mounting. Mounting screws should not thread into these screw holes more than 0.21 inch.

2.0 INSTALLATION

In addition to the actual installation requirements, this section covers a number of other items including proper shipping and handling of the camera.

2.1 Unpacking and Receiving Inspection

This item was thoroughly tested and carefully packed in the factory. Upon acceptance by the carrier, they assume responsibility for its safe arrival. Should you receive this item in a damaged condition, apparent or concealed, a claim for damage must be made to the carrier.

To return the product to the factory for service, please contact the Customer Service Department for a Return Authorization Number. If a visual inspection shows damage upon receipt of this shipment, it must be noted on the freight bill or express receipt and the notation signed by the carrier's agent. Failure to do this can result in the carrier refusing to honor the claim."

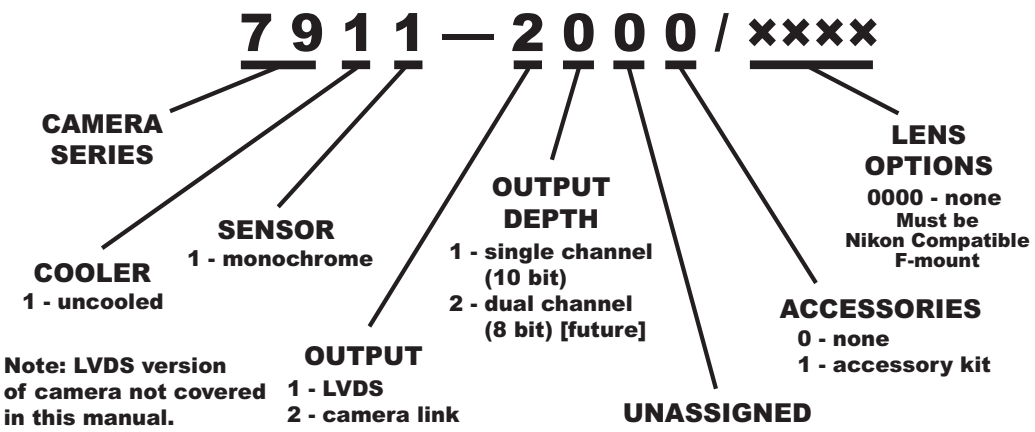


Figure 2. Model Number Interpretation Diagram

When the damage is not apparent until the unit is unpacked, a claim for concealed damage must be made. Make a mail or phone request to the carrier for inspection immediately upon discovery of the concealed damage. Keep all cartons and packing materials.

Since shipping damage is the carrier's responsibility, the carrier will furnish you with an inspection report and the necessary forms for filing the concealed-damage claim

2.2 Static Discharge Protection

Procedures in this manual do not require entry into the housing of the camera. However in the event that an open unit were available, the following precautions should be followed:

CAUTION

This Camera contains sensitive devices that can be damaged by static discharge. Use appropriate static control methods when working inside the Camera.

Components used in modern electronic equipment, especially solid state devices, are susceptible to damage from static discharge. The relative susceptibility to damage for semiconductors varies from low with TTL to high with CMOS. Most other semiconductors fall between TTL and CMOS in susceptibility to static discharge. As a minimum, therefore, observe the following practices when working inside this or any other electronic equipment:

FCC STATEMENTS

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This eqiupment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Caution: Changes or modifications to this device not expressly approved by Cohu Electronics could void the user's authority to operate the device.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

1. Use conductive sheet stock on the work bench surface.

2. Connect the sheet stock to ground through an 1 megohm or greater value resistor.

3. Use a wrist strap connected to ground through an 1 megohm or greater value resistor when working at the bench.

4. Maintain relative humidity of the room above 30 percent.This may require a room humidifier.Working on circuits with relative humidity below 30 percent requires extraordinary procedures not listed here.

5. Use antistatic bags to store and transport an exposes chassis, circuit boards, and components. Use new antistatic bags. Old, used bags loose their static protection properties.

This list serves as a reminder of the minimum acceptable practices. Be sure that all static discharge devices at the work bench are properly installed and maintained. Standard grounding mats and wrist straps purchased for use at work benches are supplied with leads having current limiting resistors for safety. Never substitute with a grounding lead not having the resistor.

2.3 Equipment Supplied

The equipment supplied depends on what has been ordered. In its most basic form only the following would be supplied:

1. The camera itself with F-lens mount

The following items will also be supplied if they were ordered:

2. Accessory Kit (8473-6) See table 2.

a. Mounting block with two screws (two 1/4-20 mounting holes)

b. Power plug

3. Lens, F-mount (Nikon compatible). For 4/3 sensor (21.43 mm diagonal)

4. 115 V ac to 12 V dc, 1.5 A power supply (Cohu model 8473-3)

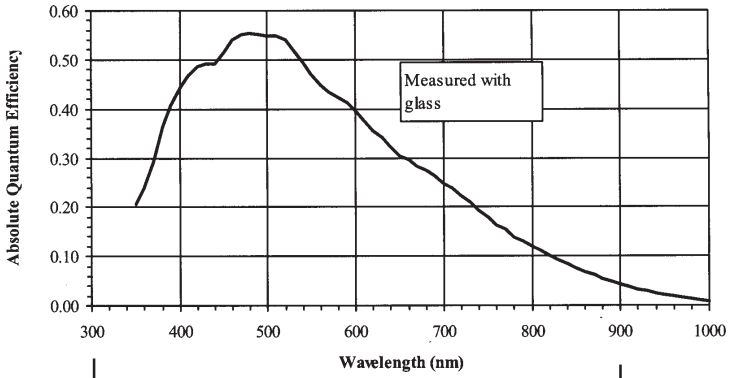


Figure 3. Quantum Efficiency

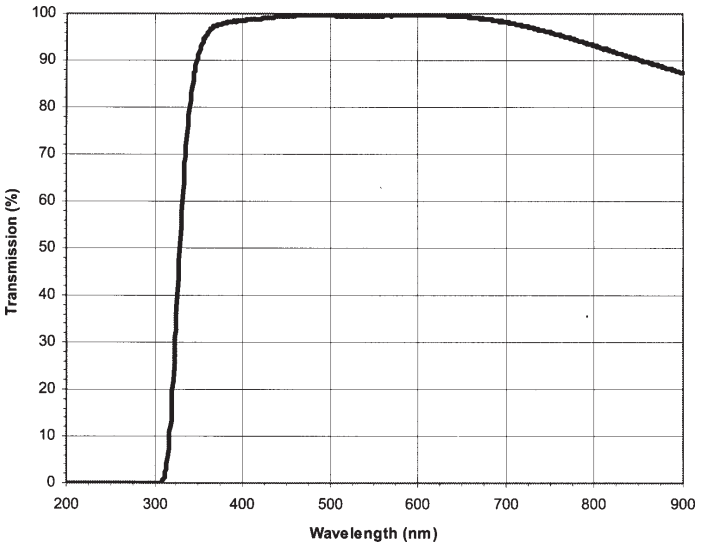


Figure 4. Glass Transmission

Note that special-order cameras and cameras modified for special purposes may be shipped with other items. The above listing are the basic items for typical applications.

2.4 Equipment Required but Not Supplied

If the following items were not ordered with the Camera these will be required to make it operational:

1. F-mount lens (Nikon compatible), for 4/3 format sensor (21.43 mm diagonal)

2. Power supply, 12 V dc, 800 mA output, minimum - with Shogyo MP-121CR or equivalent connector

3. Camera Link Cable, camera to frame grabber

These following additional items are required depending on the intended application:

Table 2. Optional Accessory Kit Items

OPTIONAL ACCESSORY KIT 8473-6	
DESCRIPTION	**PART NUMBER**
Power Plug (Shogyo p.n. MP-121CR)	1310513-001
Mounting Block (with two 4-40 x 5/16 pan head cross slotted screws)	8428-8
Note: If the optional accessory kit has been ordered with the camera these items will be contained in a separate packet included in the shipping box.	

4. Frame Grabber with drivers written for the Cohu Model 7900-2 camera

5. Command/control GUI software to interface Cohu 7900-2 camera through frame grabber card. (May be integral to frame grabber software or stand alone GUI that can be addressed to camera via frame grabber interface.

The camera, frame grabber, and interface GUI all must work closely together to ensure trouble-free operation.

Note: A number of frame grabber companies offer models of their product line that operate with the 7900 camera. Contact Cohu Applications Engineers for information about having drivers written for the frame grabber of your choice in the event it does not currently support the Cohu model 7900 camera.

2.5 Cabling Requirements

The Model 7900-2 is a Camera Link device. Standard off-the-shelf cables are available with connectors that universally mate with Camera Link cameras and frame grabbers. Table 3 lists a source for a selection of cable lengths from 1 to 10 meters. These cables are also available from a variety of other sources.

Figure 5. Type 7911-2 115 V ac to 12 V dc Power Supply (Cohu part No. 8473-3)

2.6 Power Requirements

A miniature connector on the rear panel provides for power input. The camera operates from a nominal +12 V dc, 800 mA (minimum) regulated supply. A 115 V ac to +12 V dc, 1.5 A, power supply with mating connector installed can be ordered with the camera. The power supply plug may also be ordered by itself or as a part of the optional accessory kit (table 2).

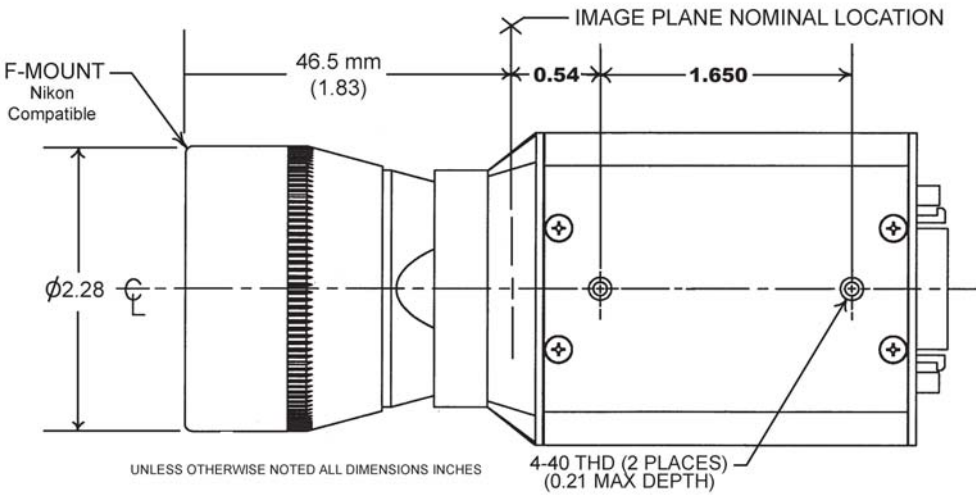
Figure 5 shows the optional power supply available for use with the Camera. Figure 7 details the power plug on the cable of this supply that mates with the Camera rear panel power input connector.

2.7 Mounting Requirements

Figure 1 and figure 6 show dimensional views of the camera both with and without the optional mounting block.

The Camera can be mounted in either of two ways: directly to its base using two 4-40 screws or to a mounting block attached to the base. The mounting block provides two 1/4-20 threaded holes. With either of these methods care must be taken not to bottom out the screws in the holes.

The 4-40 threaded holes on the base of the Camera should be engaged with the screw threads to a maximum of 0.21 inch. The 1/4-20 threaded holes in the mounting block are meant to accept not more than 0.325-inch threaded engagement by the mounting bolts. If these depths are exceeded the bolts can either break off or perhaps "punched" through. An optional mounting block may be ordered by itself or as part of the optional accessory kit (table 2).



(Camera bottom shown without optional mounting block)

Figure 6. Direct Base Mount Dimensions

2.8 F-mount Adapter

The camera requires Nikon compatible F-mount lenses for use with a 4/3 format sensor having a diagonal of 21.43 mm. An F-mount adapter can be adjusted for back focus distance by loosening a locking ring. The back focus distance from lens shoulder to sensor imaging surface for a monochrome camera is 46.5 mm.

2.9 Camera Link Cable Specification

Camera Link Interface Standard defines a cable and signal specification between cameras and frame grabbers. Table 4 is a listing of the 26 connector pins grouped by functions. This table lists both camera pin functions and corresponding pins on a compatible frame grabber.

Table 5, though, shows pin functions of the camera connector in numerical order from 1 to 26.

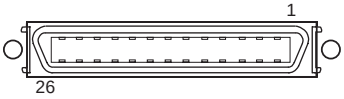
2.10 Sensor Characteristics

Figure 3 shows the sensitivity response characteristic of the sensor across the various wavelengths.

Figure 4 illustrates the faceplate glass transmissivity of the sensor. Note that this illustration is aligned with the sensor response characteristic shown above.

Figure 8 is a layout diagram of the sensor showing rows and columns of pixels. Note that this surface is divided into four different types of areas: (1) Image Pixels (2) Addressable Dark Pixels, (3) Non addressable Dark Pixels, and (4) Dummy Pixels.

Table 3. Camera Link Cables



3M Camera Link Cable (T series) *Thumbscrew type shells at each end*	
3M PART NUMBER	**LENGTH (meters)**
14T26-SZLB-100-0LC	1
14T26-SZLB-200-0LC	2
*14T26-SZLB-300-0LC	3
14T26-SZLB-450-0LC	4.5
14T26-SZLB-500-0LC	5
14T26-SZLB-700-0LC	7
14T26-SZLB-A00-0LC	10
**The 3-meter cable is available from Cohu stock as p/n 7610169-301 (3 meter).*	
3M Interconnection Solutions Division 6801 River Place Blvd Austin, TX 78726-9000 Phone: 800-225-5373	

Table 4. Camera to Frame Grabber Functions

7900 CAMERA LINK CABLE PINOUT			
COHU CAMERA SIGNAL	CAMERA CONNECTOR	FRAME GRABBER CONNECTOR	CAMERA LINK SIGNAL
DGNND	1	1	Inner Shield
DGNND	14	14	Inner Shield
TXOUT0-	2	25	X0-
TXOUT0+	15	12	X0+
TXOUT`1-	3	24	X1-
TXOUT1+	16	11	X1+
TXOUT2-	4	23	X2-
TXOUT2+	17	10	X2+
TXCLK-	5	22	Xclk-
TXCLK+	18	9	Xclk+
TXOUT3-	6	21	X3-
TXOUT3+	19	8	X3+
RX+	7	20	SerTC+
RX-	20	7	SerTC-
TX-	8	19	SerTFG-
TX+	21	6	SerTFG+
—	9	18	CC1-
—	22	5	CC1+
—	10	17	CC2-
—	23	4	CC2+
TRIG+	11	16	CC3-
TRIG-	24	3	CC3+
NC	12	15	CC4-
NC	25	2	CC4+
DGNDD	13	13	Inner Shield
DGNDD	26	26	Inner Shield

This sensor array contains a total of 2048 × 2048 active pixels that are bordered with buffer rows and column, dark rows and columns, and dummy pixels at the left and right for clocking video out of the sensor.

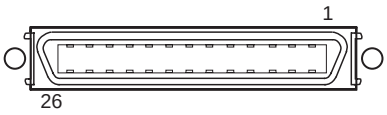
3.0 OPERATION

This camera typically operates in conjunction with a frame grabber and related Graphical User Interface (GUI).

3.1 Communications Protocol

The communications protocol for this Camera appears at the end of this manual. The typical operator will not have to work with this protocol. It is a reference document for those programming a software interface between the Camera and computer.

Table 5. Camera Link Connector Pin Functions



CAMERA LINK CONNECTOR		
PIN	NAME	DESCRIPTION
1	DGnd	digital ground
2	TxOut 0-	-digital video data
3	TxOut 1-	-digital video data
4	TxOut 2-	-digital video data, frame valid, line valid
5	TxClk-	-pixel clock
6	TxOut 3-	-digital video data
7	Rx+	+serial control receive
8	Tx-	-serial control transmit
9	-	(no connection)
10	-	(no connection)
11	Trig-	-snapshot trigger input start
12	-	(no connection)
13	DGnd	digital ground
14	DGnd	digital ground
15	TxOut 0+	+digital video data
16	TxOut 1+	+digital video data
17	TxOut 2+	+digital video data, frame valid, line valid
18	TxClk+	+pixel clock
19	TxOut3+	+digital video data
20	Rx-	-serial control receive
21	Tx+	+serial control transmit
22	-	(no connection)
23	-	(no connection)
24	Trig+	+snapshot trigger input start
25	-	(no connection)
26	DGnd	digital ground

3.2 Operation Functions

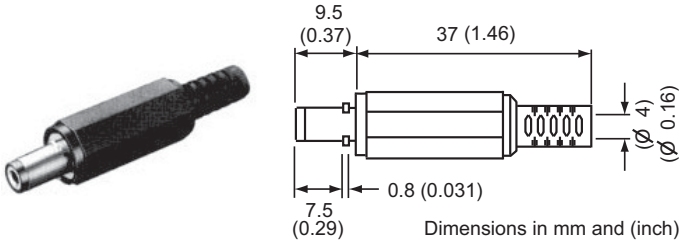
Table 6 lists various functions/ modes of the Camera available for software interface control.

Table 7 gives a brief description of the operating modes that can be implemented. Refer to the frame grabber GUI documentation for operation details.

REAR PANEL POWER CONNECTOR

Rear Panel Connector	FUNCTION	MATING PLUG
4	not use	-
2	+12 V dc return (ground)	Outer Ring
3	+12 V dc, 800 mA (minimum)	Inner Ring

Use 800 mA (minimum)



MATING POWER CABLE PLUG

Figure 7. Power Connectors

4.0 PREPARATION FOR SHIPMENT AND STORAGE

For storage periods exceeding about one month, seal the unit in a vapor-proof bag containing a fresh desiccant pack.

Maintain the camera storage environment within a range of -30 to 70 °C (-22 to 158 °F).

For shipment, package with enough foam padding or other packing material to prevent damage that can occur during shipping. The original shipping carton is a good container if it has not been damaged or subjected to excessive moisture. For shipping to the factory by Common Carrier, use the following address:

Cohu Electronics
3912 Calle Fortunada
San Diego, CA 92123-1827

Please contact the Customer Service Department for a Return Authorization (RA) number before sending any shipments to the factory:

cst@cohu.com
or
858-277-6700 extension 261

Prominently display the RA number on the outside of the shipping container(s) and on paperwork contained inside. Give a brief description of why the equipment is being returned and list the symptoms of any problems being experienced with the equipment.

-end text-

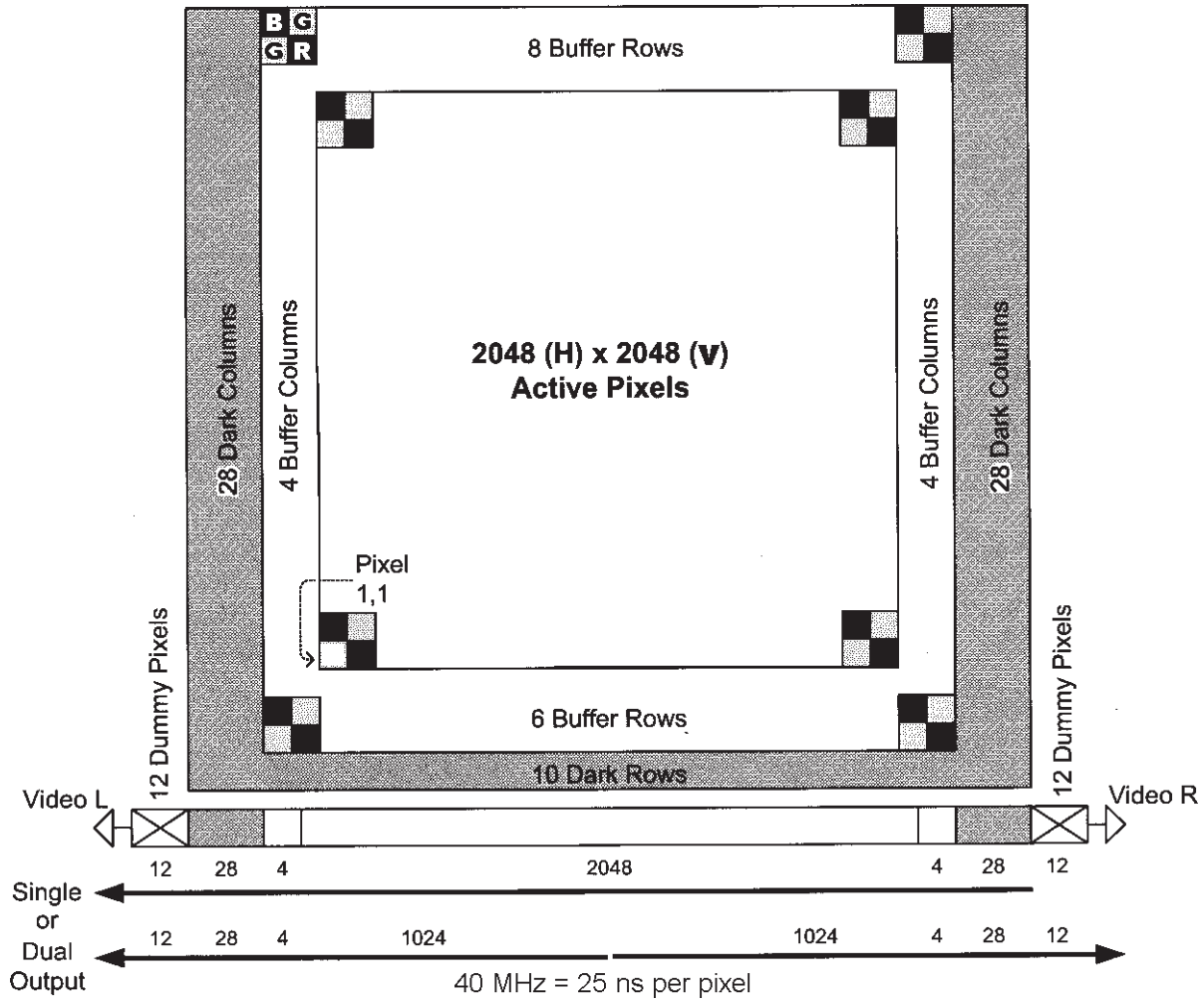


Figure 8. Sensor Architecture

Table 6. Serial Control Modes

SERIAL CONTROL FEATURES	
SERIAL CONTROL	LVDS via Camera Link: 9600 baud rate, 8 data bits, 1 start bit, 1 stop bit, no parity, and no handshaking
SERIAL INPUT COMMANDS (see protocol at back of manual)	
SETUP COMMANDS	Go to Factory Default Settings
	Set Capture Mode Operational Mode: Continuous / Snapshot
	Set Exposure Mode, Multiple Lines Implicit (11 steps) Multiple Lines Explicit, Multiple Frames, External (Asynch Snapshot Capture Mode Only)
	Set Offset Level (Black Level)
	Set Gain Level
	Set Partial Readout (starting and stopping lines)
OPERATIONAL MODES	Continuous, Full Resolution, High Speed Shutter (Implicit or Explicit)
	Continuous, Full Resolution, Low Speed Exposure (Multiple Frames)
	Continuous, Partial Scan, High Speed Shutter (Implicit or Explicit)
	Continuous, Partial Scan, Low Speed Exposure, Multiple Frames)
	Snapshot, Full Resolution, Internal Exposure (High Speed Shutter or Multiple Frames)
	Snapshot, Full Resolution, External Exposure (Trigger Pulse Width)
	Snapshot, Partial Scan, Internal Exposure
	Snapshot, Partial Scan, External Exposure

Table 7. Operation Controls/Modes

OPERATING CONTROLS		
ITEM	**FEATURE**	**DESCRIPTION**
1	GAIN & OFFSET CONTROL	Gain Control: 0 to 30 dB. Setting Values from 0 to 320 via serial command
		Offset Control: Video black level adjust: 0 to 1023 via serial command
		Note: Black level (offset) will decrease as gain is increased. It may be necessary to adjust offset with gain to keep black level above zero. At gain of greater than 150 at maximum offset (1024) black level will begin to drop below zero.
2	EXPOSURE CONTROL	High Speed Implicit Shutter: 0.066 ms to 28.82 ms in 11 steps. (see table 2 on page 17 in the Protocol section of this manual)
		Multiple Lines Explicit Shutter: Exposure time adjustable by number of line intervals (56.15 µs) from 1 line to 2064 lines
		Multiple Frames: Exposure time adjustable by number of frame intervals (116 ms full resolution) from 1 to 65,000 frames
		Note: Multiple Lines exposure of 2064 = Multiple Frame exposure of 1
		External shutter: Exposure time determined by Pulse Width of an externally applied trigger pulse (Async Snapshot mode only)
3	PARTIAL READOUT	Available in the Vertical Frame
		Starting and ending line are selectable (Must be multiples of 4: 0, 4, 8, 12...) ....Full Readout: starting at line 0, ending at line 2048 ....Normal Readout Top: starting at line 0, ending line any multiple of 4 > 400 ....Normal Readout Center: starting line any multiple of 4, ending line any multiple of 4 > start + 400 ...Normal Readout Bottom: starting line any multiple of 4 < 1648. Ending line = 2048
		Minimum window height of 400 lines (Stop - Start) [Limitation of current design. Subject to future change]
4	SERIAL CONTROL	Access through camera link serial interface
		...LVDS asynchronous serial communications between camera and frame grabber (computer)
		...Controls all configuration and operation functions (including reset to factory settings)
		...9600 baud rate
		...1 start bit, 1 stop bit, no parity, no handshaking
		...See camera protocol included at the back of this manual
5	OUTPUTS	Access through camera link MDR connector
		...Video data: 10 bit resolution Single Channel / [8-bit Dual Channel - future capability]
		...Sync Output: Horizontal (line valid) drive, vertical (frame valid) drive
		...Clock Output: Pixel clock (40 MHz, 25 ns)
Continued		

Table 7. Operation Controls/Modes (continued)

OPERATING MODES		
ITEM	**MODE**	**DESCRIPTION**
6	DEFAULT SETTINGS	Default settings are those in which the camera is shipped. There is also a default mode command that when executed will set the camera mode to the default mode listed. (See protocol at the back of this manual)
		...Camera default mode is continuous, full resolution, implicit multiple line setting - 10 (512 line intervals). Gain and offset registers set to the factory settings.
7	Continuous	Free running at 8.6 frames per second (T_f = 116 ms)
	Full Resolution	Exposure time in accordance with Implicit settings
	Exposure Implicit Lines	See table 2 (Protocol)
8	Continuous	Free running
	Full Resolution	Explicit Exposure Setting less than or = 2064 at 8.6 fps (T_f = 116 ms)
	Exposure: Multiple Frame	$T_{exp} = L \times 0.0562$ [L = line intervals selected]
9	Continuous	Free Running
	Full Resolution	$F_{rate} = 1/T_f$ [T_f = F x 116 ms = frame interval] [F is number of frame intervals selected]
	Exposure: Multiple Frame	$T_{exp} = T_f$
10	Continuous	Free Running
	Partial Readout	$F_{rate} = 1/T_f$ [$T_f = H_L$ x 0.0562 + (2064 - H_L) x 0.003 ms = Frame Interval] where H_L = window height (stop line - start line)
	Exposure: Implicit Line	T_{exp} = Exposure Setting - (2064 - H_L) × 0.011 ms When $T_f = T_{exp}$, Exposure time reaches minimum value. Further reduction of window size no longer reduces exposure time
11	Continuous	Free Running
	Partial Readout	$F_{rate} = 1/T_f$ $T_f = H_L \times 0.0562 + (2064 - H_L) \times 0.003$ ms = Frame Interval H_L = Window Height (Stop - Start)
	Exposure: Explicit Line	Texp = (L x 0.0562) - (2064 - H_L) x 0.011 ms [see * 1 below] L = Exposure setting in line intervals ** 1: For a given exposure setting, exposure time reduction with reduction in window height reaches minimum value when $T_f = T_{exp}$. Further reduction of window size will no longer reduce exposure time.* ** 2: Window height (stop - start) must be larger than exposure setting (H_L > L)*
12	Continuous	Free Running
	Partial Readout	$F_{RATE} = 1/T_f$ $T_f = T_{exp} = [H_L \times 0.0562 + (2064 - H_L) \times 0.003] \times F$ where F = number of frames selected
	Exposure: Multiple Frame	$T_{exp} = T_f$
13	Async Snapshot	Trigger Output (see note 1 at end of table)
	Full Resolution	F_{RATE} = Trigger Rate (see note 2 at end of table)
	Exposure: Internal	Exposure time determined by camera settings; Implicit Lines Explicit Lines, Multiple Frame (see note 3 at end of table) T_{exp} = (see item 2 in table on previous page) T_{READ} = 116 ms

Continued

Table 7. Operation Controls/Modes (continued)

OPERATING MODES		
ITEM	**MODE**	**DESCRIPTION**
14	Async Snapshot	Triggered Output (see note 1 at end of table)
	Full Resolution	F_{RATE} = Triggered Rate (see note 2 at end of table)
	Exposure: External	Exposure Time set by pulse width of External Trigger (Exposure begins at leading (falling) edge of trigger pulse.) (Exposure ends at trailing (rising) edge of trigger pulse) $T_{exp} = T_{PW}$ T_{READ} = 116 ms
15	Asynch Snapshot	Triggered Output (see note 1 at end of table)
	Partial Resolution	F_{RATE} = Triggered Rate (see note 2 at end of table)
	Exposure: Internal	Exposure time determined by internal camera exposure setting and partial readout window size. T_{exp} = (see items 10, 11, and 12 of this table. Also see note 3 at end of table) $T_{READ} = H_L \times 0.0562 + (2064 - H_L) \times 0.003$ ms
16	Asynch Snapshot	Triggered output (see note 1 at end of table)
	Partial Readout	F_{RATE} = Trigger Rate (see note 2 at end of table)
	Exposure: External	Exposure time determined by pulse width of trigger $T_{exp} = T_{PW}$ $T_{READ} = H_L \times 0.0562 + (2064 - H_L) \times 0.003$ ms
Notes		
Note 1	*Trigger may be accomplished by providing an external trigger pulse to camera via camera link CC3 control line (see table 4) or by giving camera serial commands to start/stop trigger. See protocol at back of manual. Trigger is initiated by leading (falling) of edge trigger pulse. Minimum pulse width is 500 nanoseconds.*	
Note 2	*Maximum trigger frequency is determined by exposure time (T_{exp}) and frame readout time (T_{READ})* *$F_{TRIG\ MAX} = 1/(T_{EXP} + T_{READ})$* *Trigger applied during active readout time are ignored*	
Note 3	***— Asynchronous Snapshot Mode using Internal Implicit Line Exposure —*** ***Explicit Line Exposure mode is not working correctly. Exposure time is 48.3 ms longer than setting. This issue as well as exposure time reduction wiith partial scan window size reduction are still under examination.*** ***All continuous modes and asynch snapshot with external or internal multiple frame exposures modes work fine.***	
End table 7		

MODEL 7900 CAMERA CONTROL PROTOCOL Ver. 1.1

8/19/04

1.1 General

This document defines the serial communication protocol used to control the camera.

The communication is full duplex, asynchronous, 8 data bits. 1 start bit, 1 stop bit and no parity. Baud rate is fixed at 9600. The Camera Link interface implements the transmit and receive physical connections.

Command messages may be generated by the host computer to modify the operation of the camera. The camera acts upon the command but does not send a response. The host computer may also generate status request messages. The camera will determine present conditions and return the appropriate values in a response message

1.2 Message Format

Command and status request messages are sent using the format:
The body of a message is built using the 7 bit ASCII character set.

Numeric values are passed as ASCII characters. A three digit decimal value will require three characters. If multiple data values are passed, they will be separated by a delimiter ',' with no white spaces. One or more leading '0' characters are permitted.

Only the camera address and checksum value may have the MSB set (high).

TABLE 1: RS- 232 COMMAND AND STATUS MESSAGE FORMAT (host to camera)

BYTE	DATA	DESCRIPTION
0	STX	Start of Text (0x02)
1	ID	Camera address (0x01 to 0xFF) (Note: 0xFF is universal)
2	'c'	Message type (camera)
3	Command Type	Command Type (In ASCII, see following sections)
4 to 4+n	Command Data	Command Data (In ASCII, see following sections)
5+n	CS	Checksum (0x80 to 0x8F)
6+n	ETX	End of message (0x03)

1.3 Checksum Calculation

By default, the camera will ignore the incoming checksum character, BUT it does require a dummy checksum character (Any value 80-8F hex).

In a response to a status request, the camera will generate a full valid checksum character according to the following:

The checksum calculation is best described by code fragments with an example:

Protocol (continued)

```
unsigned char RXbuffer [RX_MAX];     // buffer holds all received characters, positions 0 to n+6
unsigned char RXindex;               // pointer to position of a character within message
```

It is assumed that the serial receive buffer was cleared before message is sent. The receive interrupt routine stores characters in the buffer and increments the pointer. When an end of message is detected, the following data is returned:

Message	STX	ID	'c'	'C'	'0'	CS	ETX	
RXbuffer[ ]	0x02	0x01	0x63	0x43	0x30	0x81	0x03	0x00
RXindex	0	1	2	3	4	5	6	7 (final value)

The checksum calculations then proceeds:

```
unsigned char RXloop;                // scan position for checksum calculation
unsigned char RXchecksum;            // build the checksum value for received message

RXchecksum = RXbuffer [1];           // initialize checksum with value at position 1 (camera address)
RXloop = 2;                          // begin buffer scan at position 2 (always 'c')
while ((RXbuffer [RXloop] & 0x80) == 0)  // scan message from positions 2 thru 5+n (received checksum)
  RXchecksum ^= RXbuffer [RXloop++]; // checksum xor calculation in progress
RXchecksum &= 0x0F;                  // throw away upper four bits
RXchecksum |= 0x80;                  // set most significant bit
if (RXchecksum != RXbuffer [RXloop] {  // compare calculated checksum to received checksum
```

1.4 Control Commands (upper case)

The various camera control commands are listed below.
"FIELD" indicates an absolute data position.
"VALUE" indicates a relative data position and may use leading 0's; multiple data positions are separated from each other by a delimiter ",".

Note: When received, commands are stored in buffer in camera. To execute the commands requires an execution command "T0" (See 'T' Trigger)

Command Type	Command Data
'B' user analog	Set user analog offset (black level) and gain (white level) Value 0 = '0', offset command (channel 1) Value 0 = '1', gain command (channel 1) Value 0 = '2', offset command (channel 2) Value 0 = '3', gain command (channel 2) ',' delimiter Value 1 = offset (0 to 1023) or gain (0 to 320) value EXAMPLE 1: 'B0,512' sets user offset (channel 1) to 512 EXAMPLE 2: 'B1,160' sets user gain (channel 1) to 160
'C' Capture Mode:	Sets capture mode Value 0 = '0', continuous Value 0 = '1', snap-shot (asynchronous) EXAMPLE 1: 'C1' sets camera to asynchronous snap-shot mode

Protocol (continued)

'D' Default: Sets the Camera to the default mode:
camera ID = 1: camera address = 1
capture mode = 0: continuous
implicit shutter = 10: 513 lines of exposure
frame = 0,0: all lines active
offset = default: value from offset default register
gain = default: value from gain default register

EXAMPLE 1: 'D' sets all camera parameters to factory default values

'E' Exposure Time Set exposure controls
Value 0 = '0', external control (hardware or software) (**Note 1)**
Value 0 = '1', multiple frames (explicit values 1 to 65000) **(Note 2)**
Value 0 = '2', multiple lines (implicit values 0 to 10)
Value 0 = '3', multiple lines (explicit values 0 to 2064)
',' delimiter
Value 1 = number of frames or lines of exposure

NOTE 1: external control valid for asynchronous snap-shot mode only;
NOTE 2: frame time is determined by the number of active readout lines (M) and number of dumped lines (N) for partial scan operation
$T = 0.0562^* [M + (N/16)]$

EXAMPLE 1: 'E0' sets camera to external exposure control
EXAMPLE 2: 'E1,5' sets exposure time at 5 frames
EXAMPLE 3: 'E2,10' sets exposure time at 513lines (implicit)
EXAMPLE 4: 'E3.512' sets exposure time at 512 lines (explicit)

TABLE 2: IMPLICIT EXPOSURE TIMES

Implicit	H-lines	msec
0	1	0.066
1	2	0.123
2	3	0.179
3	5	0.291
4	9	0.516
5	17	0.965
6	33	1.86
7	65	3.66
8	129	7.25
9	257	14.44
10	513	28.82

'F' Frame Set partial readout start and stop positions **(Note 1)**
Value 0 = '0', start normal readout **(Note 2)**
Value 0 = '1', stop normal readout **(Note 2)**
',' delimiter
Value 1 = start or stop normal at line 0 to 2064 **(Note 2)**

NOTE 1: First line of active window = Start Line #. Last line of active window = Stop line -2. Actual active window height for Partial Scan Mode is = Stop - Start-2.
Minimum window height (Stop- Start) = 400 lines.

NOTE 2: Start and Stop Line #s must be multiples of 4 (0,4,8,12,…,2064) Stop Line # Must be at least 400 lines higher than Start Line #.

Protocol (continued)

EXAMPLE 1: 'F0,256' sets start of normal readout at line 256
'F1,768' sets end of normal readout at line 768
this combination reads data from center of image

EXAMPLE 2: 'F0,256' sets start of normal readout at line 256
'F1,2064' sets end of normal readout at line 2056
this combination reads data from bottom of image

EXAMPLE 3: 'F0,0' sets start of normal readout at line 0
'F1,2064' sets end of normal readout at line 2056
this combination reads entire image

'T' Trigger trigger beginning or end of snap-shot exposure
Field 0 = '0': configuration complete, execute changes
Field 0 = '1': software trigger
',' delimiter
Field 1 = '0': end of snap-shot exposure time
Field 1 = '1': start of snap-shot exposure time

NOTE 1: T1,0 and T1,1 not valid for continuous mode
NOTE 2: T1,0 valid only when external exposure enabled

EXAMPLE 1: 'T0' changes to user parameters become active
EXAMPLE 2: 'T1,1' begins exposure time
captures a snap-shot with pre-defined exposure time
EXAMPLE 3: 'T1,1' begins exposure time
'T1,0' ends exposure time
captures an image with external exposure time

1.5 Status Requests (lower case)

The camera will respond with status data as Values.

Command Type	Status Data	
'b' analog status	user offset and gain values	see table

Data	Description
STX	Start of text
ID	Camera address
'c'	Camera command
'b'	user Offset and Gain
Value 0	calibration Offset channel 2(refer to "B" command for values)
','	delimiter
Value 1	calibration Gain channel 2(refer to "B" command for values)
','	delimiter
Value 2	calibration Offset channel 1(refer to "B" command for values)
','	delimiter
Value 3	calibration Gain channel 1(refer to "B" command for values)
CS	Checksum
ETX	End of message

Protocol (continued)

'c' capture status present capture mode and exposure settings

Data	Description
STX	Start of text
ID	Camera address
'c'	Camera command
'c'	capture status request
Value 0	capture mode status (refer to "C" command value 0 mode)
','	delimiter
Value 1	exposure mode status (refer to "E" command value 0 for mode)
','	delimiter
Value 2	exposure setting status (refer to "E" command value 1 for setting)
CS	Checksum
ETX	End of message

'f' frame status present frame positions

Data	Description
STX	Start of text
ID	Camera address
'c'	Camera command
'f'	frame status request
Value 0	start normal readout position
','	delimiter
Value 1	stop normal readout position
CS	Checksum
ETX	End of message

Note 1: A setting of 2064 will read back a status of 0. i.e. setting Frame to full resolution with F0,0 and F1,2064 will result in a status readback of f0,0

'r' read Date/Revision Latest Date & revision of firmware

Data	Description
STX	Start of text
ID	Camera address
'c'	Camera command
'r'	Firmware date/revision #
month	month of year
'/'	slash
day	day of the month
'/'	slash
year	year - 00
'v'	version
revision	major revision number
'.'	period
revision	minor revision number
CS	Checksum
ETX	End of message

Protocol (continued)

SPECIAL USE FOR SYSTEM INSTALLATIONS

'N' Camera ID Set camera ID address
Value 0= camera ID 1-255
Note: 255 reserved for all cameras

Notes:

1) The camera will be shipped with a set of default parameters. However, all parameters are stored in non-volatile memory and once changed will always power up to the last state.

End Protocol

COHU ELECTRONICS WARRANTY

Cohu, Inc., Electronics Division warrants equipment manufactured to be free from defects of material and workmanship. Any part or parts will be repaired or replaced when proven by Cohu examination to have been defective within two years from date of shipment to the original purchaser for standard CCD cameras and one year from date of shipment to the original purchaser for intensified CCD cameras and all other Cohu manufactured products.

Pressurized Housings: Pressurized camera products include a lifetime pressurization warranty. Cohu will re-pressurize at no charge returned environmental cameras not exhibiting evidence of physical damage due to misuse. All warranty repairs will be performed at the factory or as otherwise authorized by Cohu in writing. Purchaser shall prepay transportation charges to Cohu.

Extended IR Cameras: Cameras utilizing extended infrared (extended IR) sensors found to exceed acceptable white blemish specifications within one month of delivery shall be repaired without charge.

This warranty does not extend to Cohu equipment subjected to misuse, accident, neglect, improper application, or repaired or altered by other than Cohu or those authorized by Cohu in writing. Cameras utilizing extended IR sensors are not warranted for use in areas of elevated levels of cosmic radiation. Television image pickup tubes, image intensifiers, lenses, and products manufactured by companies other than Cohu are warranted by the original manufacturer.

This warranty is in lieu of all other warranties, express, implied, or statutory, including warranties of fitness for a particular purpose and merchantability, and set forth buyers sole remedy in connection with such warranties. Cohu, in no event, whether as a result of breach of contract or warranty, tort (including negligence) or otherwise, shall be liable for any penalties regardless of reason; collateral, consequential, incidental, or exemplary damages, including without limitation, any loss of profit or revenues, loss of use of any equipment or goods, or removal or re-installation of equipment without prior written approval.

A Return Authorization (RA) Number must be obtained from Cohu prior to returning any item for warranty repair or replacement.

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