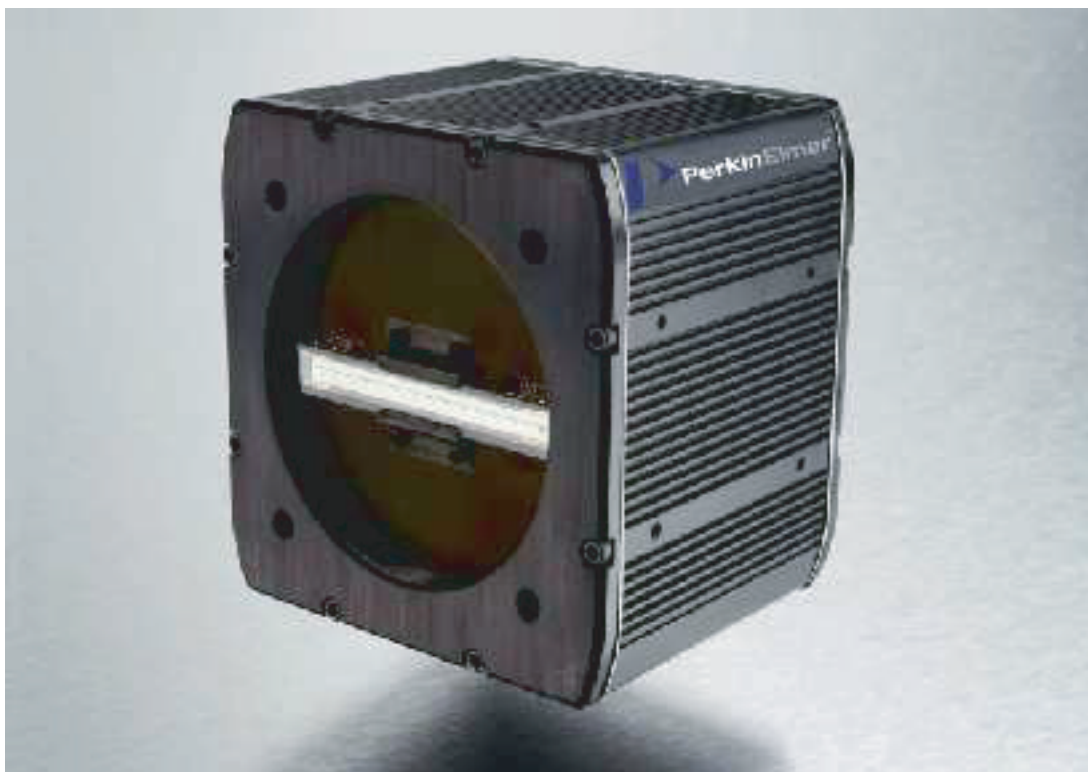


**RETICON[®]**

YYImaging

YD5000-Series Camera Instruction Manual

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1 Introduction

1.1 What's In This Manual

This manual describes the receiving, unpacking and inspection of your YD5000 series camera. Included is a operational overview that defines the camera operation and the controls provided. Guidance is provided for the installation, setup and initial operation of your YD5000 camera.

1.2 Purpose

To provide machine vision system engineers and technicians a definitive guide for integrating YD5000 series cameras into their specific machine vision application.

1.3 Product Overview

The YD5000 series cameras are designed for linear line scan image capture applications. 1024, 2048, 4096 and 6144 pixel line scan image capture is offered at 30 megapixels/second, depending on the camera model selected. Each camera uses a tri-linear color array with 10 μ m pixel pitch at a 10 μ m aperture and a 40 μ m color spacing. This provides a 54dB dynamic range over a spectral range of 400 to 800nm. All camera control functions are selected over the CameraLink™ serial port. Digital I/O is provided as differential RS-644 for all camera models.

1.4 Functional Description

The YD5000 series cameras incorporate a high performance, high resolution line scan image sensor featuring photodiode pixels. Each photodiode converts incident light into discrete charge packets that are converted to an analog voltage.

The analog voltage from each color is processed as a single channel sampled and held raster order analog video data signal. Analog processing circuitry provides adjustable gain levels allowing the accommodation of unique lighting requirements. Figure 1 is a block diagram illustrating the major camera components.

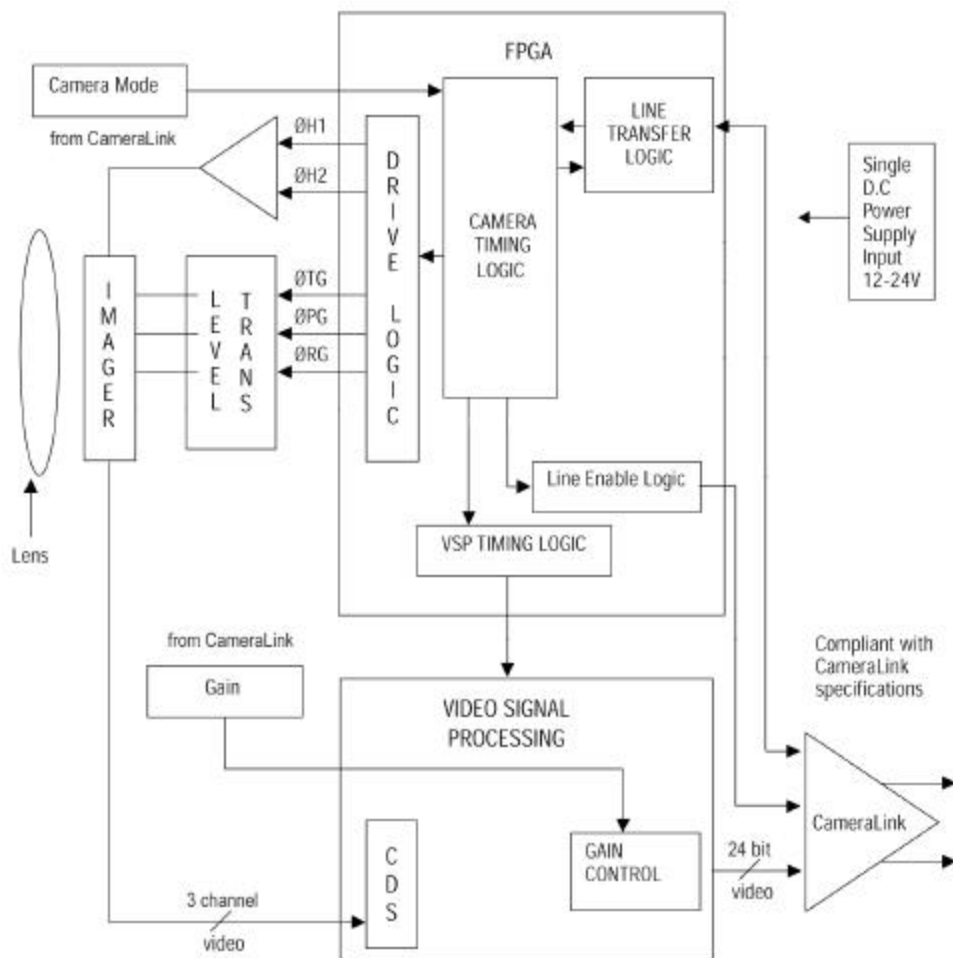


Figure 1 YD5000 Series Camera Block Diagram

2 Typical Installation

Figure 2 illustrates a typical machine vision installation showing the major system components and defines the coordinate system used throughout this manual.

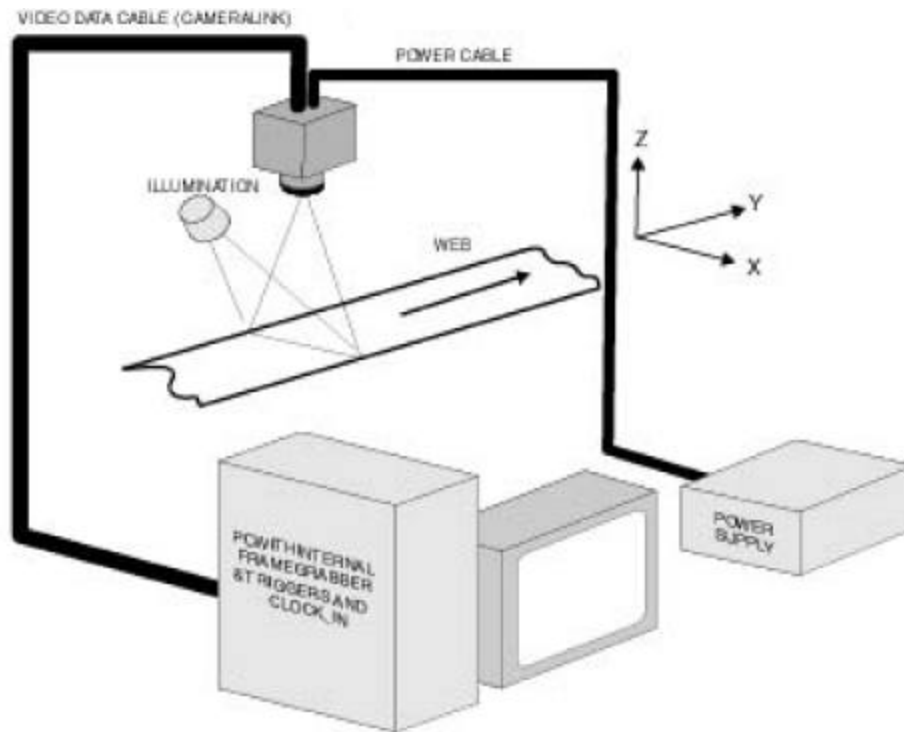


Figure 2 Typical Machine Vision Environment

3 Receiving and Inspecting Your Camera

3.1 Unpacking Your Camera

Inspect the received shipping container for any damage. If a shipping container shows visible signs of damage, it should be retained until all of the contents have been checked for completeness and absence of damage. Unpack the received shipping container and account for each item listed on the accompanying packing list. Visually inspect each item for absence of damage. In the event of damage, notify the shipper and the PerkinElmer shipping department. Retain all shipping materials for shipper inspection.

Your first YD5000 shipping container in accordance with the enclosed packing list should contain the following:

1. YD5000 camera in static resistant envelope with unbroken seal.

3.2 Customer Supplied Components

The following components, not supplied with the camera, are required for installation and operation of the camera in your particular machine vision environment.

1. Camera Lens + Extender (Available by contacting PerkinElmer)
2. Camera mounting hardware
3. PC with Frame Grabber and digital I/O
4. Power Supply
5. Interface Cable (Available by contacting PerkinElmer)
6. Web illumination source
7. Web speed and light control.

This is not a complete list of items that may be required for your specific application, but represents a minimum required to verify camera operation.

Note: The majority of the customer supplied items are peculiar to each installation and may require custom fabrication. Guidelines for fabrication are provided in Appendix A.

4 Camera Operation Overview

The camera operation is a 2 stage process that consists of exposure and data output transfer. This process operates the same regardless of mode. The only differences are the events that initiate exposure and data output transfer.

The YD5000 series cameras offer multiple exposure modes for maximum flexibility to capture image data in a variety of applications.

4.1 Camera Exposure Modes

The following exposure modes are provided:

- Master Mode
- Slave Mode

The camera modes are selected by the serial connection on the Camera Link connector. The camera communicates at 9600 Baud with 8 data bits, 1 start bit, 2 stop bits, and no parity bits.

4.1.1 Data Output

The digital video output is identical in all modes of operation. The digital video is output together with two synchronization signals: Camera Clock (CCLK), and Line Enable (LEN). The LEN signal brackets the valid digital video that is output in synchronization with the CCLK. LEN is output on the LVAL signal line and CCLK is output on the STRB signal line in accordance with the Camera Link specification.

4.1.2 Master Mode

The master mode is a stand-alone operating mode that requires only DC power for operation.

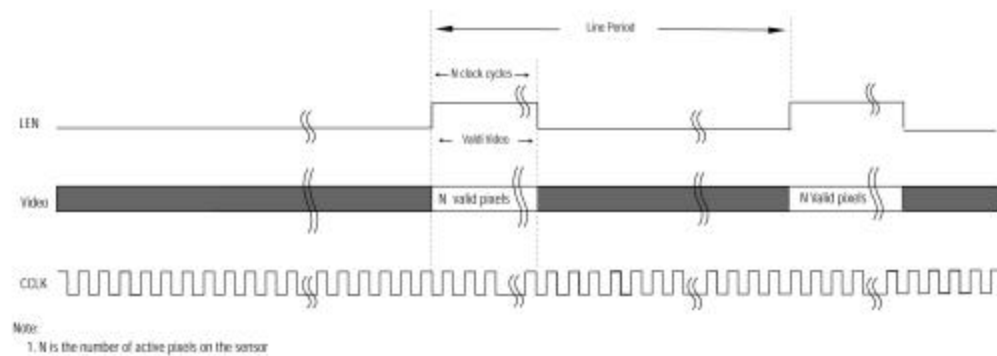


Figure 3 Master Mode Timing

The exposure time in master mode is determined by the line period that is fixed at $N+X$ clock cycles, where N is the number of pixels and X is the number of overclock pixels. See Table 1 for a listing of these line periods.

4.1.3 Slave Mode

The slave mode allows the synchronization of the camera operation with a user controlled exposure period. When operating in the Slave Mode, the user supplies an LT (Line Transfer) signal. The rising edge of the LT signal initiates an end to the exposure time and a start of the digital video readout. For slave mode timing, see Figure 4. See Table 1 for a listing of the minimum LT periods.

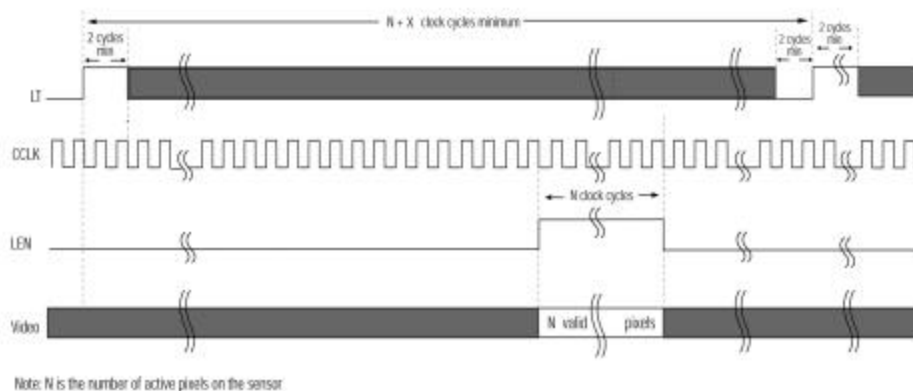


Figure 4 Slave Mode Timing

4.1.4 Line Period Limits

Table 1 Line Period Limit Definition

Model	# Pixels (N)	Clock	Max Line Scan Rate	Min. Line Scan Period
YD5010	1024	30 MHz	21,500 L/sec	46.50 μ sec
YD5020	2048	30 MHz	10,810 L/sec	92.50 μ sec
YD5040	4096	30 MHz	5,000 L/sec	200.0 μ sec
YD5060	6144	30 MHz	4,882 L/sec	204.8 μ sec

5 Installation Guidelines

The following guidelines are offered as an aid to permit the user for setting up the camera such that it can be verified for proper operation. Specific requirements are included only for items closely related to the camera operation.

5.1 Optical Interfacing

The YD5000 series cameras require properly chosen lenses and lens extenders to allow the imaging of the chosen web width onto the sensor array. Table 2 shows the array length and number of pixels on the array for each camera model.

Table 2 Camera Sensor Array Lengths

Camera Model	Active Array Length (AL)	Active Pixels
YD5010	0.403" (10.24 mm)	1024
YD5020	0.806" (20.48 mm)	2048
YD5040	1.613" (40.96 mm)	4096
YD5060	2.419" (61.44 mm)	6144

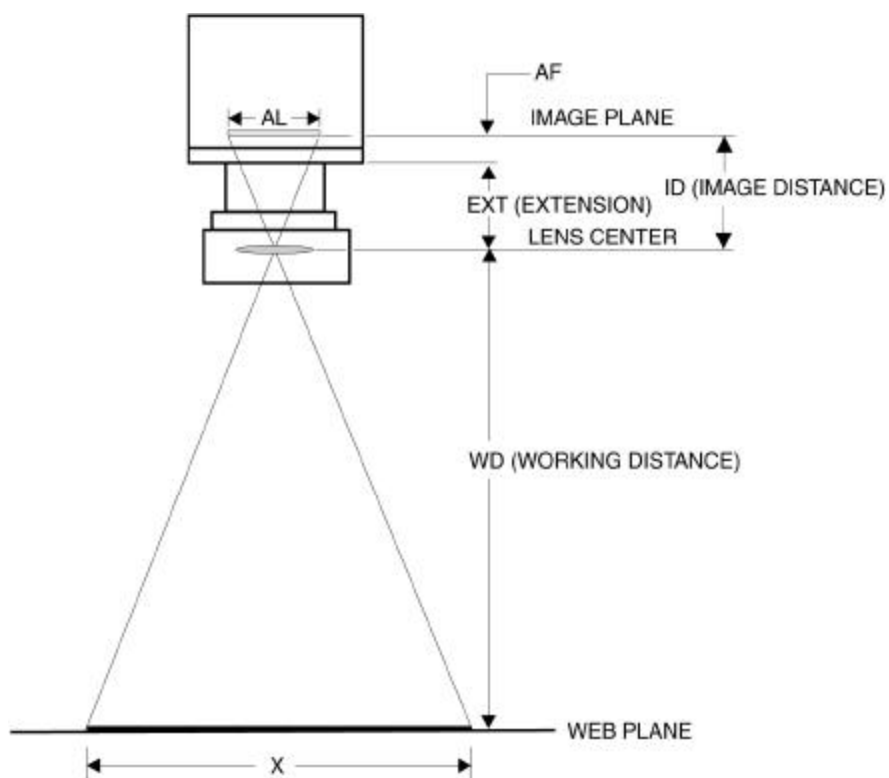


Figure 5 Imaging Geometry Definition

5.1.1 Estimating the Working Distance

The following relationships assume a thin lens relationship that is deemed sufficiently accurate to permit reasonably accurate estimates of the optical configuration. Referring to Figure 5:

$$ID = EXT + AF + f$$

$$M = \frac{AL}{X} = \frac{ID}{WD}$$

$$f = \frac{WD * M}{M + 1}$$

$$WD = \frac{f * (M + 1)}{M}$$

Where: ID = Image Distance

EXT = Length of Extender

AF = Sensor to Camera Face distance

f = focal length of lens

AL = Length of sensor array

X = Web width imaged

M = magnification

WD = working distance

Since the actual results will vary from these idealized estimates, sufficient adjustment capability is required.

Example

Assuming that an 80 mm lens has been chosen for an YD5060 camera and is installed without an extender and that it is desired to image a 36" (882 mm) web.

The following calculations result in the working distance estimate:

$$ID = 5.8 \text{ mm} + 80 \text{ mm} = 85.5 \text{ mm}$$

$$M = \frac{AL}{X} = \frac{61.4 \text{ mm}}{882 \text{ mm}} = 0.070$$

The estimated working distance then is:

$$WD = \frac{ID}{M} = \frac{85.5 \text{ mm}}{.070} = 1227.4 \text{ mm (48.3")}$$

5.2 Lens Attachment

The YD5000 series cameras provide threaded mounting holes on the front face of the cameras to allow the attachment of custom lens adapters. The lens mount varies depending on the camera model. The YD5010 uses a C-Mount; the YD5202 uses a F-Mount; and the YD5040 and YD5060 both use a M72 x 0.75mm mount. PerkinElmer can provide such optical components as lenses, lens adapters, extension tubes, and focusing systems. Figures 6 and 7 show the location of mounting holes and registration holes for the attachment of custom lens adapters. See Appendix B for a more detailed faceplate drawing.

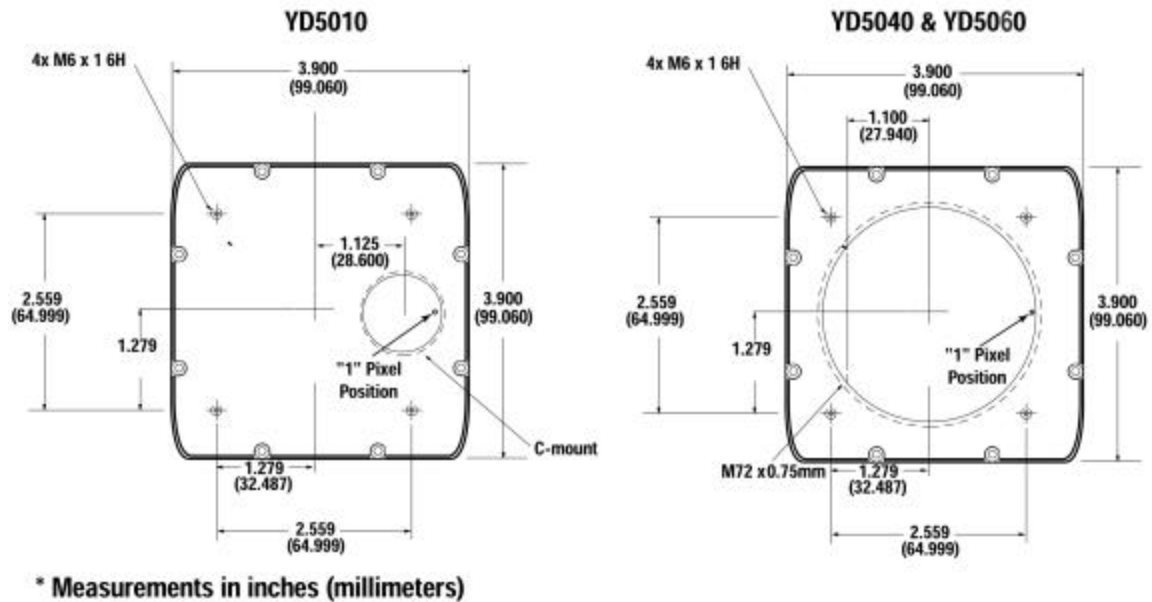


Figure 6 YD5000 Camera Lens Attachment Definition

5.3 Mounting the Camera

Camera mounting distance from the object to be imaged is determined by the required object width X , the camera array size, and the selected lens and extension. See section 1 for some general guidelines for physically locating your camera for your application. Mounting the camera may require the supplied mounting plate or customer supplied adapter. Figure 7 shows the location of the mounting holes for attaching the camera to the mounting surface and specifies the mounting hole thread. The same mounting provisions are provided on each of the camera 4 sides.

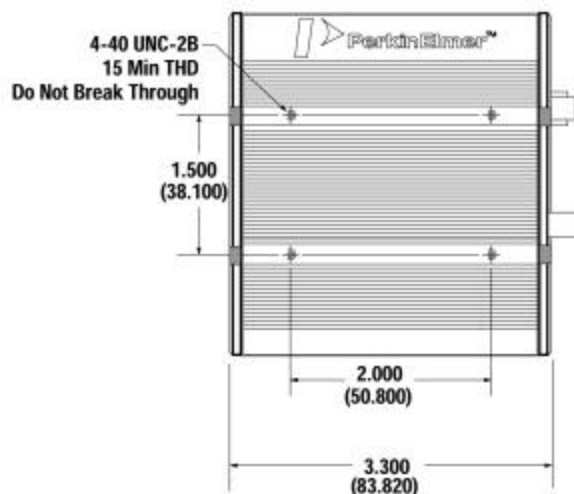


Figure 7 YD5000 Series Camera Mounting Hole Location

5.4 Connecting Power



Warning: It is the buyers responsibility to comply with all applicable code requirements.

5.4.1 Power Supply Requirements

The power supply must provide at the camera:

+12 to +24 VDC

7.5 W total input power

5.4.2 Power Supply Connector

The YD5000 camera receives its power from a 6-pin Hirose HR-10A circular connector. The power connector is common to both models.



Connector: Hirose HR10A
Mating Part: Hirose HR10A-7P-6S

Table 3 Power Connector Pin Assignment

Signal	Pin	Description
12-24VDC	1	Input Voltage
12-24VDC	2	Input Voltage
N/C	3	No Connection
N/C	4	No Connection
COMMON	5	Input Voltage Return
COMMON	6	Input Voltage Return

5.5 Interface Cabling

The cabling is in accordance with the CameraLink specification. Commercial-off-the-shelf cables are available for this camera. Contact PerkinElmer for cabling options.

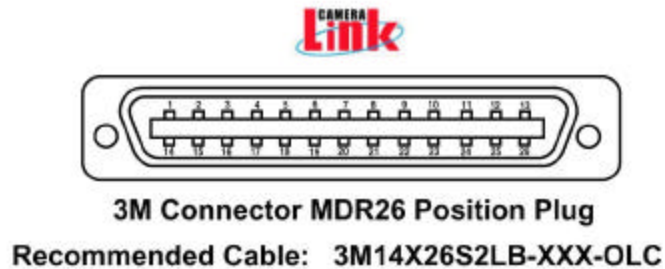


Table 4 Connector Pin Assignment

Signal	Pin	Description
SHIELD	1	Inner Shield
X0-	2	Camera Link Data
X1-	3	Camera Link Data
X2-	4	Camera Link Data
Xclk-	5	Camera Link Clock
X3-	6	Camera Link Data
SerTC+	7	Camera Link Serial TC
SerTFG-	8	Camera Link Serial TFG
CC1-	9	Line Transfer -
CC2+	10	Line Reset +
CC3-	11	Not Used
CC4+	12	Not Used
SHIELD	13	Inner Shield
SHIELD	14	Inner Shield
X0+	15	Camera Link Data
X1+	16	Camera Link Data
X2+	17	Camera Link Data
Xclk+	18	Camera Link Clock
X3+	19	Camera Link Data
SerTC-	20	Camera Link Serial TC
SerTFG+	21	Camera Link Serial TFG
CC1+	22	Line Transfer +
CC2-	23	Line Reset -
CC3+	24	Not Used
CC4-	25	Not Used
SHIELD	26	Inner Shield

Note: Always observe proper EMI shielding configuration if fabricating your own cable.

5.6 Frame Grabber Interface Guidelines

The YD5000 series cameras have been designed for use with several brands of frame grabber. It is the users responsibility to select a frame grabber that is specific to the application being served and support the CameraLink interface signals. When choosing a frame grabber, the following points must be observed:

1. Camera model (for number of pixels in sensor array).
2. Camera exposure mode. Slave modes require external input signals. See section 4.
3. The frame grabber must be able to accept differential digital video, Camera Link base configuration

Refer to the compatibility chart on the PerkinElmer website for a list of recommended frame grabber vendors.

5.7 Cleaning the Sensor

Should the sensor become dirty the user can clean the face taking care to use **Isopropyl Alcohol** only.



Caution: Do not allow any of the cleaning solution to contact any internal components, sensor pins or connector pins.



Caution: Do not remove the cover over the sensor, or the faceplate. There are no user serviceable parts inside.

6 Camera Setup

This section provides a generalized procedure for installing, configuring and activating your camera. Since every application is different, only suggested steps for a logical sequence to get the camera running are listed. It is assumed that you have familiarized yourself with the camera exposure and data output modes as described in section 4.

6.1 Preparing for the Installation

It is assumed that you have defined and implemented a machine vision environment for your application similar to that shown in Figure 2.

It is assumed that you have:

- Chosen a camera model and a lens.
- Chosen a camera operating mode and a data output mode.
- Selected a frame grabber.
- Implemented an appropriate controllable target illumination source.
- Implemented a target speed control system.
- Designed and implemented a Camera Link interface specific to your application. See section 4.
- Determined the required cable lengths.

6.2 Installing the Camera

The following is a suggested sequence of steps to physically install the camera:

1. Contact PerkinElmer for recommendations on the frame grabber interface and for the required lens adapter. Attach the lens adapter to the camera and install the lens. For camera front face attachment points see Appendix C.
2. Estimate the camera working distance as described in section 5.1.
3. Fabricate the necessary mounting adapters to be used for installing the camera. Refer to Figure 7 and Appendix B for mounting hole location and thread definition.
4. Physically install the camera using the mounting adapters.
5. Make sure that the camera power supply and the control computer frame grabber power is off.
6. Install the camera interface cable between the camera and the applicable system connectors.
7. Power up the system computer and verify that the frame grabber is operational.

6.2.1 Tripod Mounting

The YD5000 series cameras can be supplied with an optional ¼-20 UNC tripod mounting block that can be placed on any one of the 4 sides of the camera housing.

6.3 Activating the Camera

Place the test target within the cameras' projected field of view and turn on the illumination source.

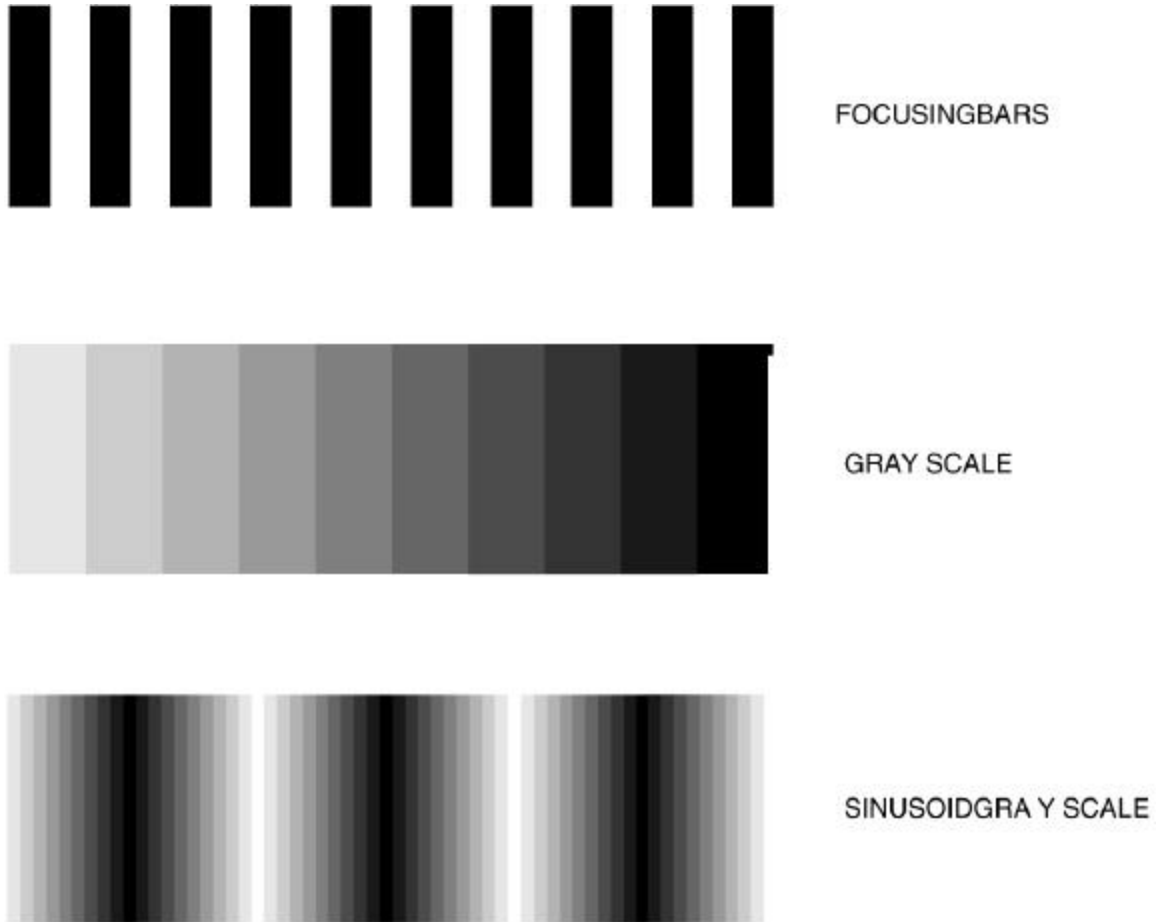


Figure 8 Test Target

Orient the test target such that the black and white Focusing Bars are directly below the camera and are aligned with the sensor array X direction as shown in Figure 9.

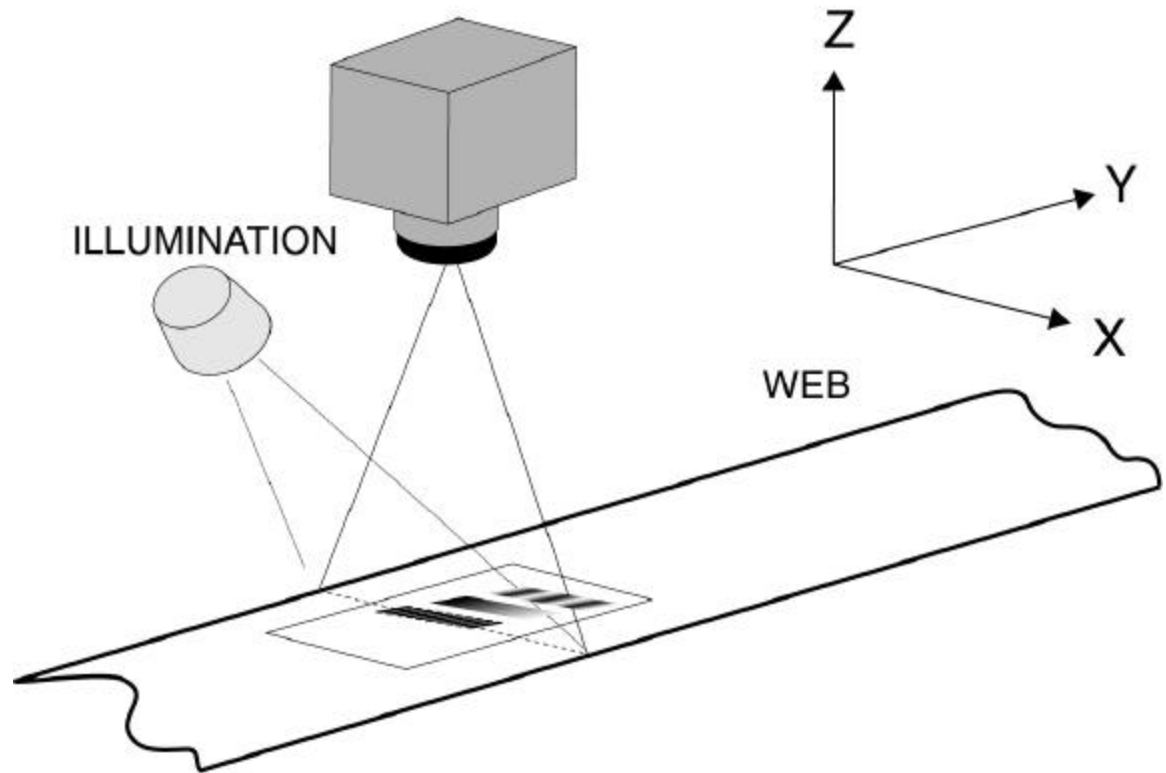


Figure 9 Test Target Placement

6.4 Camera Control

Camera control includes camera operating mode, video offset and video gain. Each of these parameters is controlled over the CameraLink serial connection.

6.4.1 Camera Operating Mode Selection

The camera operating mode is set over the CameraLink serial communications connection.

Table 5 Operating Mode Selection

Camera Mode	Serial Command
Master	M1
Slave	M2

6.4.2 Video Gain

The video gain is set over the CameraLink serial communications connection. The video gain may be adjusted while the camera is operating and does not require camera power cycling for gain changes to take effect.

The serial command to set the gain is "XG *n*". Here *X* corresponds to the color that is being changed (R, G, or B); *n* is an integer between 0 and 127. This corresponds to a gain adjustment range of 0dB to 15.875dB in steps of 0.125dB.

The video gain adjustment is useful in white balancing the image. This white balance can be performed in real time.

Table 6 Video Gain Selection

Value	Camera Gain Value (dB)
0	0.0
1	0.125
2	0.250
...	...
125	15.625
126	15.750
127	15.875

6.4.3 Video Offset

The video offset is set over the CameraLink serial communications connection. The video offset may be adjusted while the camera is operating and does not require camera power cycling for offset changes to take effect.

The serial command to set the offset is "XO *n*". Here *X* corresponds to the color that is being changed (R, G, or B); *n* is an integer between 0 and 127. This corresponds to an offset adjustment range of 0DN to 63.5DN in steps of 0.5DN.

The video offset is useful in white balancing the image. This white balance can be performed in real time.

Table 7 Video Offset Selection

Value	Camera Offset Value (DN)
0	0.0
1	0.5
2	1.0
...	...
125	62.5
126	63.0
127	63.5

6.4.4 Video Delay

The video delay is set over the CameraLink serial communications connection. The video delay may be adjusted while the camera is operating and does not require camera power cycling for delay changes to take effect.

The serial command to set the offset is "D *n*". Here *n* is an integer between -15 and 15. This corresponds to a delay adjustment range of -15 lines to +15 lines in steps of 1 line.

The video delay feature is used in reconstructing the color data. Adjusting this value sets the number of lines between the three colors, which synchronizes the target motion to the 40µm color separation on the camera.

6.4.5 Camera Power Up

1. Turn on the camera power.
2. Select Master Mode.

6.4.6 Focusing the Camera

1. Adjust the external light source for an acceptable image intensity without blooming.
2. Adjust the Z position of the camera to achieve the sharpest transition from black to white.

Note: Performing this action only ensures that the test target is imaged in focus on the sensor array within the limitations of the customer supplied lens.

6.4.7 Verifying Camera Gain Control

1. Reposition the test target in the Y direction such that the gray shade strip is displayed in place of the black and white bars.
2. Adjust the external light source such that the white portion of the strip is displayed without blooming and note the number of gray shade steps that are visible.
3. Decrease the external light source intensity such that some of the darker gray shade steps are no longer discernable.
4. Increase the video gain of the camera and verify that the gray scale steps reappear.
5. Return the video gain to the default setting.

6.5 Verifying Slave Mode Operation

Note: In order to verify the Slave Mode you must have made provisions for the required external signals in the frame grabber interface as described in section 4.

1. Make sure that the camera is powered down.
2. Power up the camera.
3. Select the Slave Mode.
4. Set the line rate of the LT (Line Transfer) signal to a value less than that specified in Table 1.
5. Make sure that the gray shade strip is displayed. Adjust the external light source and camera gain as required to obtain a barely visible display.
6. Increase the video gain of the camera and verify that the gray scale steps reappear.
7. Power down the camera and configure it for your specific application.

7 Target Speed Determination

7.1 Target Speed and Exposure Relationships

The following definitions apply:

- Image Resolution** The number of pixels in the camera sensor array.
- Spatial Resolution** The sensor array pixel dimensions mapped onto the web dimension X. (See Table 2.)
- Feature Resolution** The smallest feature to be imaged by the camera.

The target speed derives from the chosen feature size D and is limited by the minimum Line Period values defined in Table 1. The chosen feature size must equal at least 2 times the effective Y spatial resolution to satisfy the Nyquist criterion such that at least 2 effective contiguous y samples are provided for unambiguous detection of the feature of size D.

The effective y resolution is defined by the static spatial resolution plus an effective y dimension elongation that is determined by the target velocity and time of exposure. The choice of D must satisfy the following:

$$y_{eff} = \frac{D}{2} > \frac{X}{\#of\ pixels}$$

Once D has been chosen then the target velocity is determined by:

$$V_{web} = \frac{y_{eff}}{Min.Line\ Period}$$

The following is a derivation of the relationships that define the effective Y spatial resolution y_{eff} in terms of target velocity V_{web} and exposure time t_{exp} .

The static spatial resolution is:

$$x_{static} = y_{static} = \frac{X}{\#of\ pixels}$$

The effective spatial resolution y_{eff} due to target velocity V_{web} along the y axis is given by:

$$y_{eff} = y_{static} + V_{web} * t_{exp} = \frac{X}{\#of\ pixels} + V_{web} * t_{exp}$$

from which the exposure t_{exp} may be calculated given a target velocity V_{web} as follows:

$$t_{exp} = \frac{y_{eff} * \#of\ pixels - X}{\#of\ pixels * V_{web}}$$

7.2 Sample Imaging Setup

The following example assumes that you have determined the following:

- Target width X
- Image resolution # of pixels (By choice of camera)
- Required feature resolution. i.e. the smallest feature dimension “D” to be detected.

Example: To image a feature .020” dia. on an 18” web using a YD5040 Camera.

Satisfying the Nyquist criterion, the effective y sample size $y_{eff}=0.01$ ”.

Since the maximum line rate corresponding to the minimum line period from Table 1 is 200.0msec , the web velocity to assure contiguous y samples must be such that the web moves 0.010” during the line period.

$$V_{web} = \frac{0.010''}{200.0 * 10^{-6} \text{ sec}} = 50.0'' / \text{sec} = \frac{50.0'' / \text{sec}}{12'' / \text{ft}} * 60 \text{sec} / \text{min} = 250.0 \text{ ft} / \text{min}$$

The required exposure t_{exp} is then computed as follows:

$$t_{exp} = \frac{y_{eff} * \# \text{ of pixels} - X}{\# \text{ of pixels} * V_{web}} = \frac{.010 * 4096 - 18}{4096 * 50.0} = 112 * 10^{-6} \text{ sec}$$

Note 1. The calculated exposure time guarantees the effective spatial resolution of 0.010” at the maximum line period. Reliable imaging will require adjustment of the web light source and/or camera gain.

8 Troubleshooting

8.1 Troubleshooting Check List

No Video

1. Verify that the power to the camera is on.
2. Verify that the frame grabber is operating properly.
3. Verify that the interface cable is securely attached to the camera.
4. Verify the interface cable continuity on each pin.
5. Make sure that the required control signals for the camera mode selected are present.

Intermittent Video

1. Verify that all interface cable connections are securely attached.

Blurry Video

1. Make sure that the camera has been properly focused as described in section 6.3.
2. Make sure that the lens is clean.
3. Make sure that there is adequate illumination.

Operating Mode Does Not Change

1. Power down and restart the camera for mode changes to take effect.

8.2 RMA (Return Material Authorization)

Products returned for repair, warranty or non-warranty, must be assigned by a PerkinElmer technical support representative a RMA (Return Material Authorization) number. The customer is to provide a description of the problem and include a model number and serial number with the item to be returned.

8.3 Contacting Customer Support

United States	PerkinElmer Optoelectronics 2175 Mission College Blvd. Santa Clara, CA 95054 Toll Free 800-775-OPTO (6786) Phone: +1-408-565-0830 Fax: +1-408-565-0703
Germany	PerkinElmer Optoelectronics GmbH Wenzel- Jaksch-Str. 31 D-65199 Wiesbaden Germany Phone: +49-611-492-570 Fax: +49-611-492-165
Japan	PerkinElmer Optoelectronics NEopt. 18F, Parale Mitsui Building 8 Higashida-Cho, Kawasaki-Ku Kawasaki-Shi, Kanagawa-Ken 210-0005 Japan Phone: +81-44-200-9170 Fax: +81-44-200-9160 www.neopt.co.jp
Singapore	47 Ayer Rajah Crescent #06-12 Singapore 139947 Phone: +65-770-4925 Fax: +65-777-1008

APPENDIX A Interface Guidelines

A.1 RS-644 Digital Interface

The YD5000 series digital signals (CameraLink models) are received and transmitted using balanced, differential circuits that comply with the data transmission standards set forth in the EIA RS-644 specification.

All of the differential digital I/O signals on the MDR connectors are labeled (+) or (-) to indicate polarity. The following definitions apply to each pair of associated signal lines:

ON: When signal line (+) is more positive than (-).

OFF: When signal line (-) is more positive than (+)

This differential interface is necessary to assure proper camera operation and optimum high speed data transmission in electrically “noisy” environments often encountered in industrial applications. RS-644 differential line drivers and receivers are available from various manufacturers. An example of a suitable drivers is National Semiconductor DS90LV047 and an example of a suitable receiver is National Semiconductor DS90LV048.

Figure 11 shows typical RS-644 input and output circuit configurations. It is also recommended to be used on the Camera Link serial communications signals SerTFG and SerTC. The following requirements apply:

1. All of the differential signal output pairs must be terminated at the receiving end with a 100-120 Ω resistor line to line.
2. The cable used for each differential signal should be twisted and shielded.
3. The shields should not be used for camera power ground return.

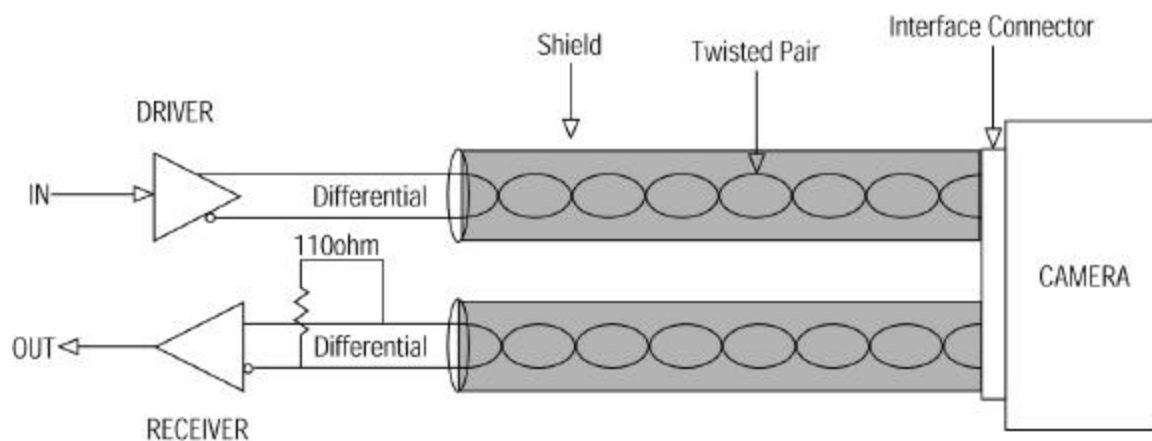
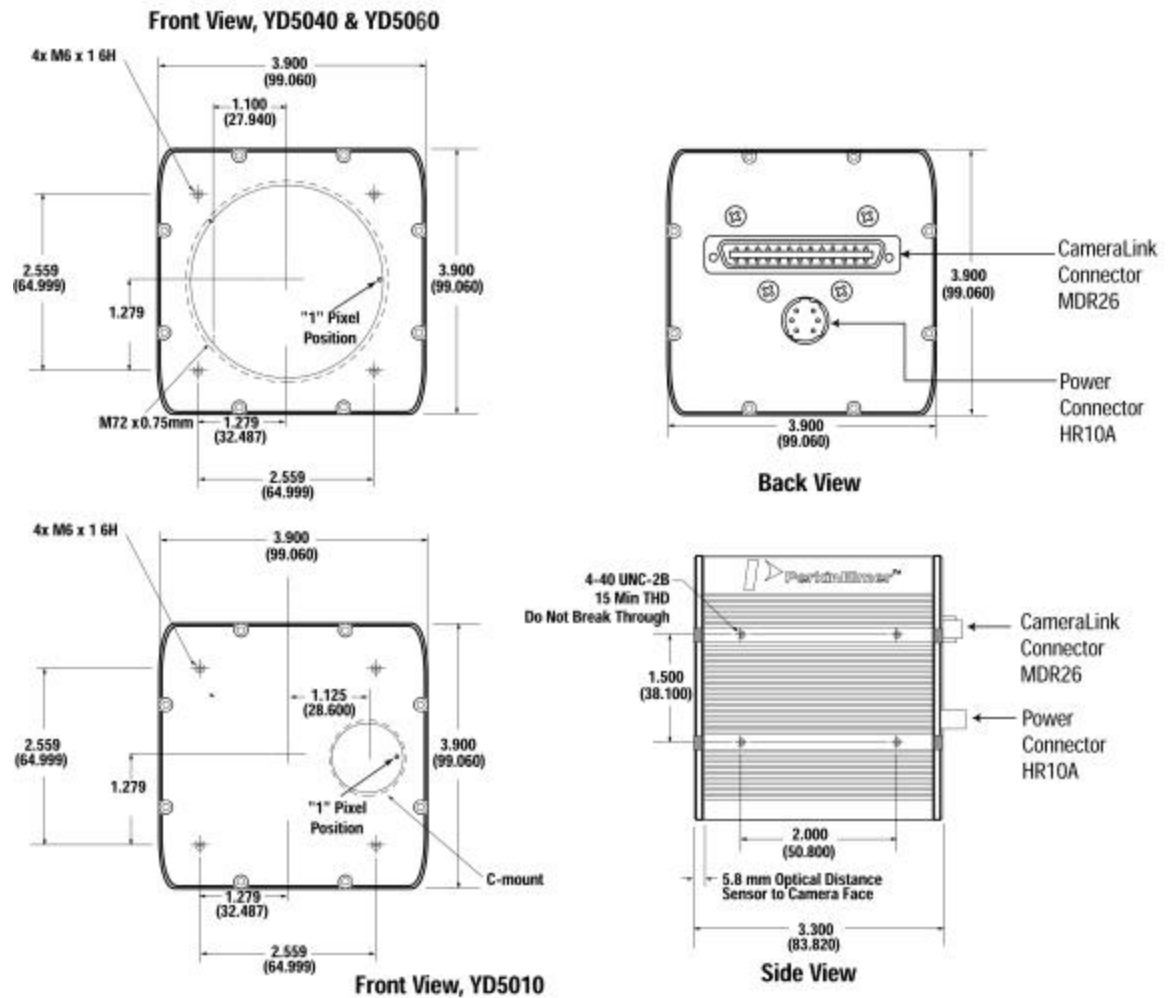


Figure 10 RS-644 Digital I/O Circuit

APPENDIX B Detailed Mechanical Drawing

* Measurements in inches (millimeters)



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