RETICON®

YD5000 Series Cameras

1024, 2048, 4096 and 6144 Pixel Color Cameras

Description

In the YD5000-series of digital line scan cameras, PerkinElmer Optoelectronics has combined the best features of photodiode array detection, high speed charge coupled scanning, and digital color line scanning technology to offer an uncompromising solution to the increasing demands of advanced color imaging applications.

The YD5000-series is a high-performance color camera series based on a tri-linear sensor. With output speeds up to 90 MHz (30 MHz per output, each output corresponding to either the red, green, or blue color channel), pixel resolutions of 1024, 2048 4096 or 6144, and a base configuration CameraLink™ interface, the YD5000 is capable of stable imaging in the vast majority of high-performance line scan applications.

In order to allow the user to compensate for variations in illumination found in real-world application environments, the YD5000 series feature individual color channel gain and offset. The cameras feature a geometrically precise photodiode CCD image sensor, with 10µm square photoelements. Line spacing between the color-filtered linear rows is 40 µm. State-of-the-art electronic design enables the YD5000 to deliver consistent, reliable performance, while the sturdy metal housing provide maximum protection in a variety of harsh environments and factory floor conditions.

The YD5000 series cameras can be interfaced to CameraLink-compatible frame grabber cards, allowing for a tested, plug-and-play solution. Typical high-performance color line scan applications include printing inspection, document scanning, produce and food inspection, plastics sorting, paper recycling, motion picture film imaging, and many other industrial and scientific applications requiring high speed imaging.

Features:

- Array lengths of 1024, 2048, 4096 and 6144 pixels
- 8 bit depth per output
- Tri-linear color CCD with 10µm aperture, 40µm center-to-center line spacing
- CameraLink™ output style
- 90 MHz total data rate (3 outputs x 30 MHz per output)
- Small size: 99mm x 99mm x 83mm
- Line scan rates to 21.0 kHz
- User-adjustable gain and offset for each color channel
- CDS (Correlated double sampling)
- Single power supply operation (+12 to +24VDC)
- CE mark certified

PerkinElmer™ optoelectronics

YD5000 Camera and Sensor

Table 1. Camera Features Summary

Camera	Array	Pixels (per color)	Pixel Size (µm)	# Taps	Max Output Clock/Tap	Bits/ Pixel	Max. Line Rate (kHz)	Min. Line Period (µsecs)
YD5010	Tri-linear	1024 x 1	10 x 10	3	30 MHz	8 bits	21.48	46.55
YD5020	Tri-linear	2048 x 1	10 x 10	3	30 MHz	8 bits	10.81	92.50
YD5040	Tri-linear	4096 x 1	10 x 10	3	30 MHz	8 bits	5.10	200.00
YD5060	Tri-linear	6144 x 1	10 x 10	3	30 MHz	8 bits	4.88	204.80

The Sensor

The YD5000 color cameras are based on a tri-linear color CCD line scan sensor with 1024, 2048, 4096 or 6144 active pixels. The pixel size of the sensor is 10µm by 10µm. The separation between color lines is 40µm (center-to-center). The separation distance (40µm) assures correct color reconstruction within the camera. Each of the three color lines is fabricated with a filter on the die to maximize color intensity and clarity. Peak light response occurs on the sensor at 630 nm (red), 540 nm (green) and 460 nm (blue). An IR filter is recommended to eliminate imaging of non-visible light.

Table 2. Camera/Sensor Characteristics

Characteristic	Low	Typical	High	Unit
Spectral range	400	-	800	nm
Dynamic range[1]	316:1	390:1	-	ratio
Total transfer efficiency	95	98	-	%
Saturation Exposure				
Red	-	0.32	-	lx-s
Green	-	0.37	-	lx-s
Blue	-	0.29	-	lx-s
Saturation Voltage	1.5	2.0	-	V
Image Lag	1.0	2.0	5.0	%

Note 1. Gain = 0dB (1X)

Color Reconstruction

In the YD5000, color separation and imaging is accomplished through the tri-linear image sensor. However, given the 40µm center-to-center spacing between the color lines, the image must be reconstructed to combine the colors into a usable image. This is accomplished on the YD5000 through an internal memory system (patent pending), operated by setting a delay in the camera through the serial port. By doing so, the user can synchronize the camera to its target. Delay can be set from +15 to -15 lines, allowing the camera to image in either direction; i.e., red, green, blue, or blue, green, red.

Table 3. Camera Signal Uniformity

Characteristic	Low	Typical	High	Unit
Dark Signal Non-Uniformity (DSNU)				
Blue	-	0.34	0.85	DN
Red, Green	-	0.17	0.85	DN
Photo Response Non-Uniformity (PRNU)	-	6	18	%

YD5000 Camera Architecture

Video Signal Processing

YD5000-series sensors operate by converting incident photons of light into free electronics in the pixel area. These electrons are collected in the photodiode until the exposure period has ended. The charge packets are then moved into a high-speed serial shift register. The shift register then moves these packets, at rates up to 30 MHz, into a charge-to-voltage amplifier. The image sensor outputs a voltage waveform proportional to the amount of incident photons collected at each photosite.

The first stage of the camera electronics is a Correlated Double Sampling (CDS) circuit. CDS reduces the amount of random noise present on the voltage waveform, thus producing a higher dynamic range. Following is an adjustable Auto-Zero stage. This stage is used as an automatic black-level balancing tool between the colors. Auto-zero also corrects for sensor dark current.

YD5000 Camera Architecture (cont.)

The next step on the camera electronics is a gain stage. The gain adjustment is from 0 (or 0dB) to 127 (or 15.875dB). Each step is equal to 0.125dB of gain. Gain is adjusted over the CameraLink serial port.

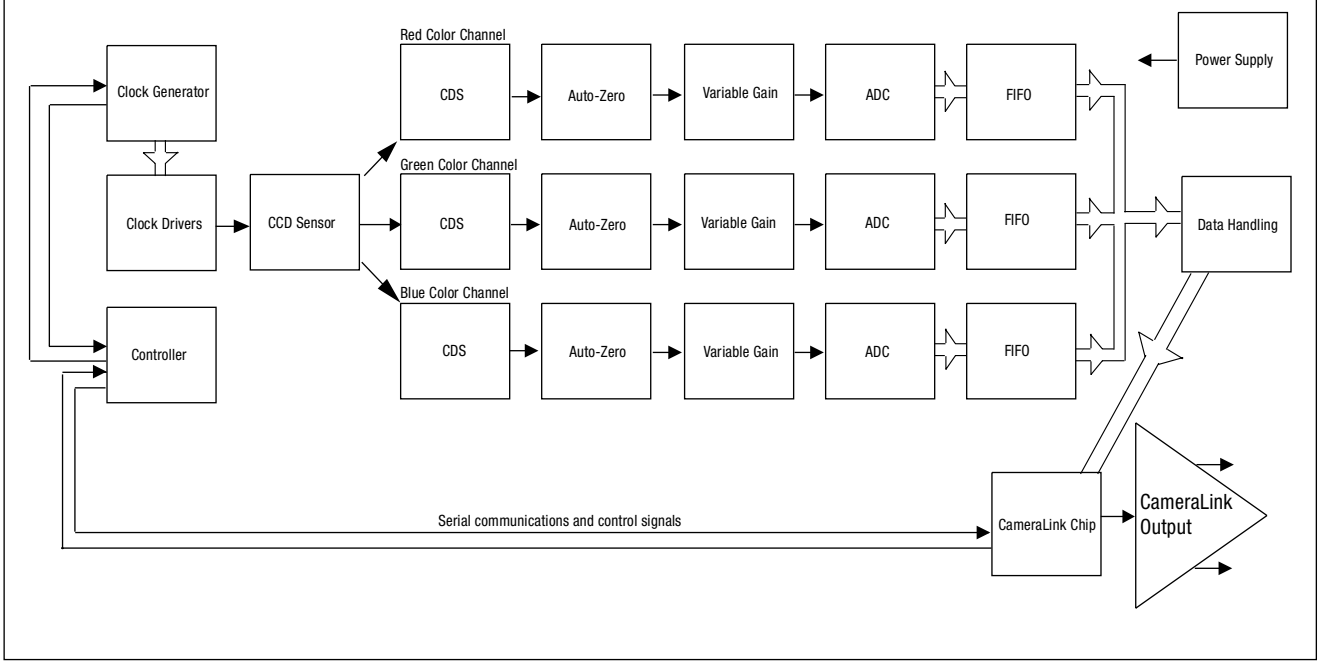
The video waveform is then digitized to 8-bits at a 10-bit Analog-to-Digital Convertor. This circuit is repeated simultaneously for all other color taps.

The 8-bit digital data is then fed into a 384K FIFO buffer memory. This is done to insure adequate color recombination within the camera. The user may select the amount of delay using the CameraLink serial port. Following the memory buffer is the CameraLink output drivers. The data is then presented to the user in 'base configuration' CameraLink style, contained on one connectors. One signal is presented in parallel with the data: LVAL, which envelopes the valid pixel data.

Table 4. Camera Specifications

Characteristic	Min	Typ	Max	Unit
Active pixels (per color)				
YD5010	-	1024	-	pixels
YD5020	-	2048	-	pixels
YD5040	-	4096	-	pixels
YD5060	-	6144	-	pixels
Pixel size	-	10 x10	-	µm
Center-to-center color spacing	-	40	-	µm
Spectral response	400	-	800	nm
peak response				
Red	-	630	-	nm
Green	-	540	-	nm
Blue	-	460	-	nm
Antiblooming controls?	-	Yes	-	-
Output resolution per pixel	-	8	-	bits
Output type	-	CameraLink	-	-
Noise (1X Gain)	50	52	-	dB
CE approval?	-	Yes	-	-
Lens Mount				
YD5010	-	C-mount	-	-
YD5020	-	F-mount	-	-
YD5040, YD5060	-	M72 x 0.75"	-	-
Operating temperature	0	-	50	°Celsius
Storage temperature	-20	-	50	°Celsius
Input voltage	12	-	24	VDC
Input power	-	7.5	-	Watts

Figure 1: YD5000 Camera Block Diagram



Control Software and Camera Configuration

Setting of the selectable parameters in the microcontroller is done through the CameraLink serial port. Control commands are listed in Table 3. Note that commands are case sensitive.

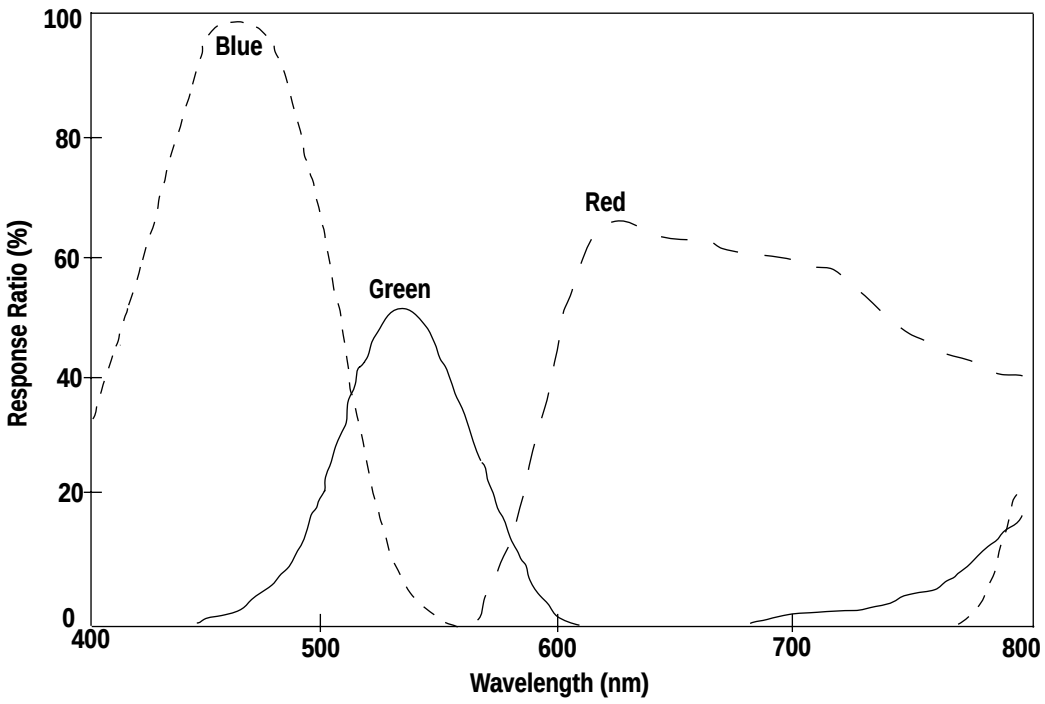
COM port settings are as follows: 9600 baud rate, 8 data bits, 1 start bit, 2 stop bits, and no parity. Users should match these exactly to eliminate any potential communications problems.

All serial command parameters are in compliance with the official CameraLink specification, available on-line or by contacting PerkinElmer. Most frame grabbers integrate serial communication abilities into their CameraLink boards; contact PerkinElmer for recommendations and frame grabber compatibility lists.

Table 5. Serial Commands (case sensitive)

Command	Description
BO [value 0...127]<enter>	Set blue offset
BG [value 0...127]<enter>	Set blue gain
b<enter>	Get blue gain and offset
RO [value 0...127]<enter>	Set red offset
RG [value 0...127}<enter>	Set red gain
r<enter>	Get red gain and offset
GO [value 0...127]<enter>	Set green offset
GG [value 0...127}<enter>	Set green gain
g<enter>	Get green gain and offset
s<enter>	Get serial number
D [value+/-0...15]<enter>	Set delay
d<enter>	Get delay
?<enter>	Help
M1<enter>	Set Master mode
M2<enter>	Set Slave mode

Figure 2. Spectral Sensitivity Curve (without IR filter)



Note: Gain=0

Camera Exposure Modes

Exposure Modes

The camera has the ability to operate in two modes of exposure. Exposure is the time where the camera is collecting data from the target image. These modes are as follows.

Master Exposure Mode

The camera offers a free-running mode called Master Mode. In this mode, the camera continuously exposes and reads out data from the target image. This mode is set by the CameraLink serial port. In Master Mode, the camera will run at it's maximum line rate. The camera will then ignore any external timing signal it receives during operation.

Slave Exposure Modes

Slave mode requires the user to supply the trigger signal externally. This mode offers the greatest flexibility. By triggering the camera externally, users can instruct the camera to image only when needed, as well as synchronize the camera to their systems. The camera is triggered through CC1 on the CameraLink connector.

Data Readout Modes

The camera reads out data in a sequential color order. Red pixels 1...N are read out in order over the red output tap, blue pixels 1...N over the blue, and green pixels 1...N over the green.

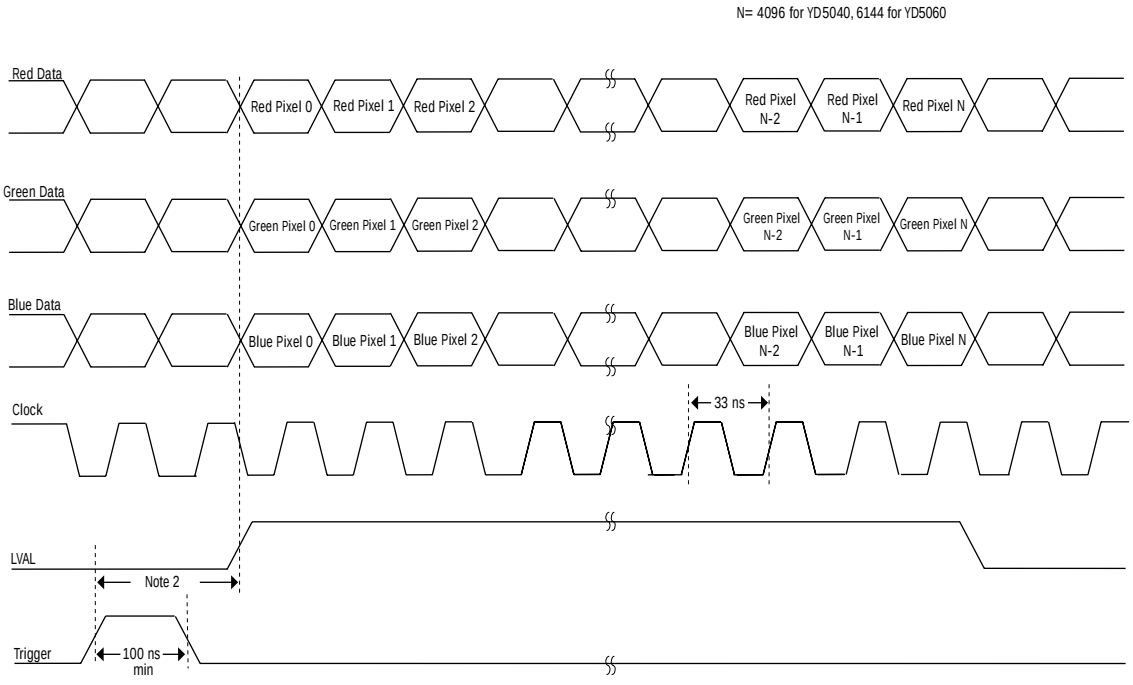
Data reordering for color alignment is performed inside the camera, and is user adjustable as described earlier.

Interfacing with the Cameras

Gain Control

Gain can be adjusted from 0dB to 15.875dB using the CameraLink serial port. Gain is primarily used for 'white balancing' the camera output. Gain can also be used to improve signal quality in cases where low illumination or low dynamic range hampers output quality. Users should note that clipping above 255 DN may occur. Gain may be required where low line periods, exposure periods, or lighting intensity prevent adequate signal integration.

Figure 3: Timing Diagram



Note 1: Timing is shown at input/output of CameraLink driver/receiver.
Note 2: 26.9 µs for YD5060, 61.0 on YD5040

Interfacing with the Cameras (cont.)

Line Period

Line periods of the YD5000 series color line scan cameras can be as low as 46.5 µsec. Line rates can reach as high as 21.48 kHz.

Cables and Hardware Interface

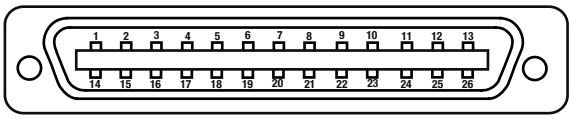
The YD5000 series cameras employ a CameraLink output style. The standard 3M CameraLink cable should be used for the CameraLink connection. Reference Figure 4 for an illustration of the CameraLink connector and recommended cable, and Table 7 for a pinout of the CameraLink connector. All connections and pinouts are compliant with CameraLink specifications.

Power is provided to the camera through a Hirose HR10A power connector. See Table 6 for the power connector pinout, and Figure 5 for a illustration of the power connector.

Table 8. YD5000 Physical Specifications

Characteristics	Value
Length, width, height	3.3"L x 3.9"W x 3.9"H (8.25 x 9.9 x 9.9 cm)
Weight	1lb, 15 oz
Connect points	Side: 4x4-40 threaded holes each side for 1/4"- 20 tripod plate (optional) Front: 4x4-40 threaded holes with precision hole and slot
Lens mount	C-mount (YD5010) F-mount (YD5020) M72 x 0.75mm (YD5040, YD5060)
Sensor alignment	0.005" to align holes; 0.3^0 rotation
Power	+12 to +24 VDC
Total input power	7.5 watts

Figure 4. Connector Diagram



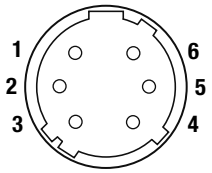
3M Connector MDR26 Position Plug

Recommended Cable: 3M 14x26S2LB-xxx-OLC

Table 7. Camera Link Connector Pinout

Pin	Signal	Pin	Signal
1	Inner Shield	14	Inner Shield
2	X0-	15	X0+
3	X1-	16	X1+
4	X2-	17	X2+
5	Xclk-	18	Xclk+
6	X3-	19	X3+
7	SerTC+	20	SerTC-
8	SerTFG-	21	SerTFG+
9	CC1-	22	CC1+
10	CC2+	23	CC2-
11	CC3-	24	CC3+
12	CC4+	25	CC4-
13	Inner Shield	26	Inner Shield

Figure 5. Power Connector Diagram

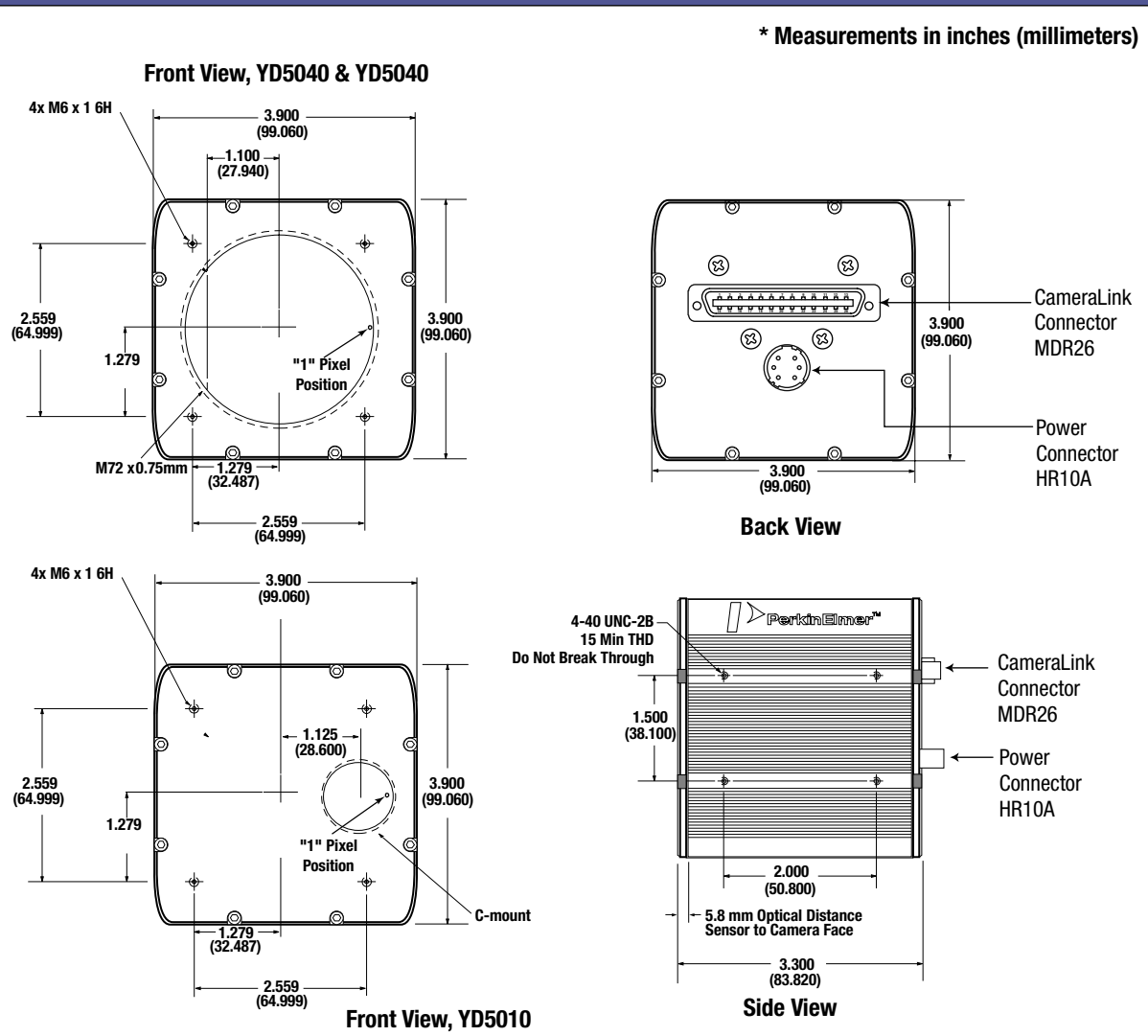


Connector: Hirose HR10A
Mating Part: Hirose HR10A-7P-6S

Table 6. Power Connector Pinout

Pin	Signal
1	12-24VDC
2	12-24VDC
3	Do not connect
4	Do not connect
5	Ground
6	Ground

Figure 6. Camera Body Physical Layout Drawing



Optical Interfacing

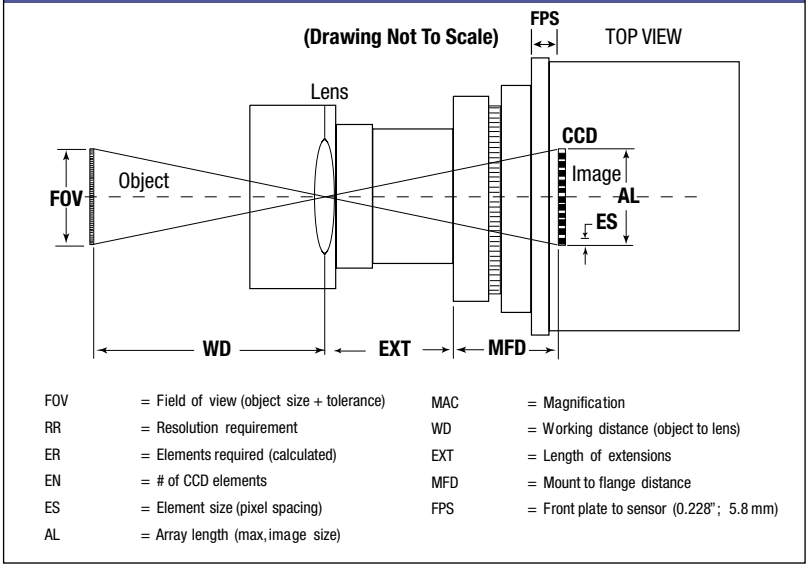
The YD5000 series have standard lens adapters. These provide adequate coverage for the 1024, 2048, 4096 and 6144 pixel resolutions (see Table 9 for array sizes). Lenses, lens adapters and extension tubes are avaliable by contacting PerkinElmer.

Additionally, PerkinElmer can provide recommendations on standard lensing applications. By working closely with leading lens manufacturers and suppliers, we assure our customers of the correct solution for their application with the best commercially-available off-the-shelf lenses possible.

The sensor is mounted in the camera within 0.005" of alignment points on the camera body, and 0.3 degrees of rotation.

Contact your PerkinElmer Optoelectronics factory representative if you require assistance on your optical interfacing.

Figure 7. Optical Interface



FOV	= Field of view (object size + tolerance)	MAC	= Magnification
RR	= Resolution requirement	WD	= Working distance (object to lens)
ER	= Elements required (calculated)	EXT	= Length of extensions
EN	= # of CCD elements	MFD	= Mount to flange distance
ES	= Element size (pixel spacing)	FPS	= Front plate to sensor (0.228"; 5.8 mm)
AL	= Array length (max, image size)		

Ordering Information

While the information provided in this data sheet is intended to describe the form, fit and function for this product, PerkinElmer reserves the right to make changes without notice.

Table 9. Ordering Information

Part Number	Active Array Length	Additional Requirements
YD5010NRS-011	0.403", 10.24 mm	Power supply, cable; CameraLink cable
YD5020NRS-011	0.806", 20.48 mm	
YD5040NRS-011	1.601", 40.96 mm	
YD5060NRS-011	1.969", 61.44 mm	

For more information e-mail us at opto@perkinelmer.com or visit our web site at www.perkinelmer.com/opto. All values are nominal; specifications subject to change without notice.

The YD5000 series contains no user-serviceable parts. Opening or modification of the cameras, which is not limited to but includes removing sensor guards, removal or modification of any housing, replacement of existing screws, removal of sensor, will invalidate the warranty. Please contact PerkinElmer for further information.

Table 10. Sales Offices

	North America
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
	Europe
Germany	PerkinElmer Optoelectronics GmbH Wenzel-Jaksch-Str. 31 D-65199 Wiesbaden, Germany Phone: +49-611-492-570 Fax: +49-611-492-165
	Asia
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

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