EG&G® RETICON

LC1912
Modular Line Scan Camera

Introduction

The LC1912 modular line scan camera is a compact, high-performance, rugged, industrial camera. It is constructed to operate and survive in harsh industrial environments while delivering the performance and precision required under laboratory conditions. The LC1912 features a two-channel, time-division-multiplexed, video format that allows video data rates up to 20 MHz.

Applications for the LC1912 camera include high-speed data acquisition, dimensional gauging, noncontact measurement, process control and monitoring, optical inspection, biomedical imaging, remote sensing, and many other industrial and scientific applications.

Key Features

- Geometrically precise, solid-state, charge-coupled photodiode image sensor
- 256-, 512-, 1024-, and 2048-element array selection
- 13 µm or 26 µm pixel aperture
- High-speed pixel data rates to 20 MHz
- Line reset exposure control (electronic shutter)
- Antiblooming sensor structure
- Rugged construction for industrial environments
- Differential digital I/O signals for electrical noise immunity
- Angular-corrected, bore-sighted sensor, referenced to precision registration holes
- Scan rates over 70,000 lines per second
- Removable, through-the-lens viewer (optional)
- Calibrated photoresponse
- CE Mark Compliant

General Description

The LC1912 line scan camera is a precision, electro-optical instrument that is housed in a compact, lightweight, and extremely rugged enclosure. Internal construction utilizes an EG&G Reticon D Series, charge-coupled photodiode (CCPD) sensor and highly reliable, surface-mount components to ensure continued operation under conditions that could destroy conventional cameras.

Figure 1. LC1912 Camera

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The LC1912 camera senses light from a scene and converts it into an analog video signal. The amplitude of the video signal is a linear function of the incident illumination from the scene. Antiblooming features built into the sensor and electronic shuttering ensure superior performance over a wide range of lighting conditions. Full control is provided over integration time and video data rate allowing the user to dynamically correct for variations in illumination found in real-world environments. The LC1912 can be ordered with either a 256-, 512-, 1024-, or 2048-element array to accommodate the most stringent spatial resolution and speed requirements.

Functional Description

The LC1912 camera contains a high-performance, line scan image sensor that converts incident light on each photodiode into discrete charge packets as shown in Figure 2. After an appropriate integration period, the charge packets are transferred into two, high-speed, CCD shift registers for transport to the output of the device. Video from the sensor is processed using adjustable photoresponse and antiblooming circuits to deliver exceptional signal quality.

Video is output from the LC1912 through two, time-division-multiplexed, serial data channels. Video from odd numbered pixels is output on one channel, and video from even numbered pixels is output on the other. This "odd and even" output scheme allows the video to be processed at half the combined data rate, reducing the cost and complexity of external processing equipment and A/D conversion hardware.

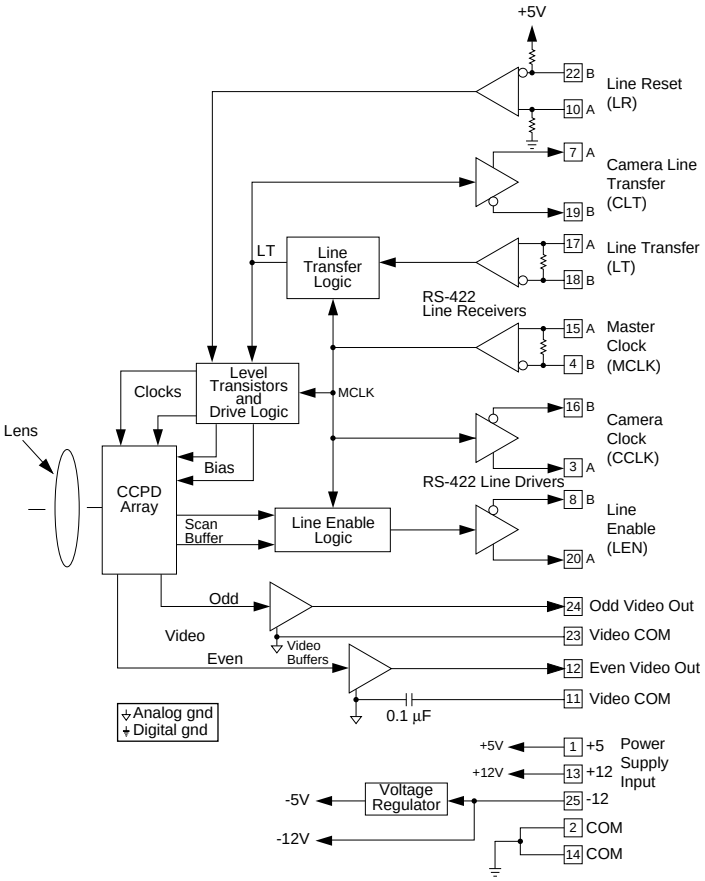
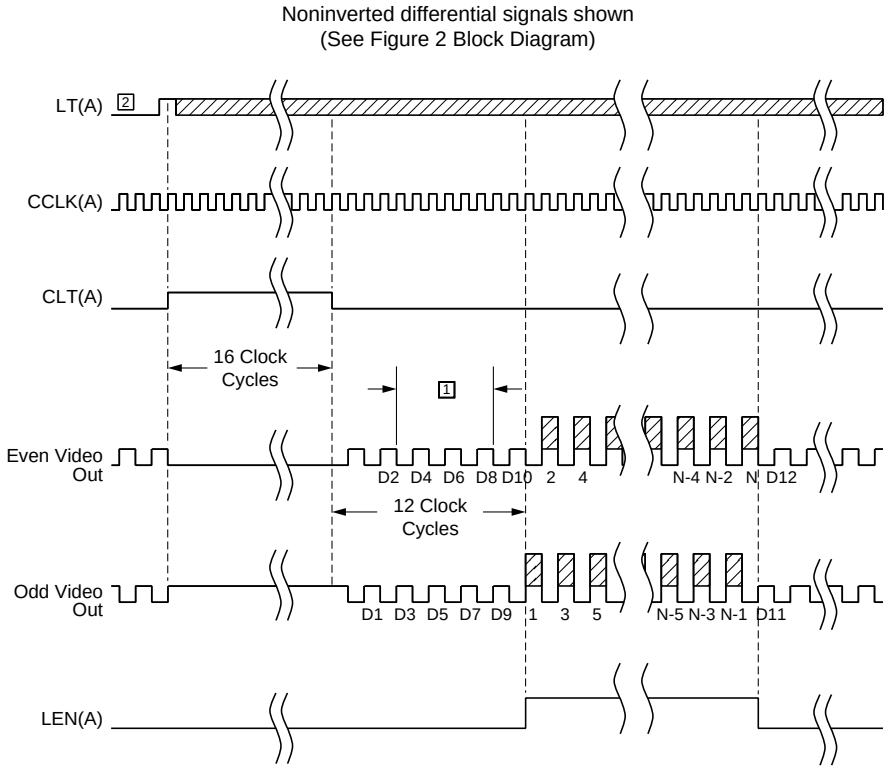


Figure 2. Camera Block Diagram



NOTES: 1 D3 through D8 may be used as the dark reference.

2 Minimum LT repetition rate is N (pixel elements) +32 clock cycles.

Figure 3. LC1912 Timing Diagram

Camera operation is controlled by three, externally generated, differential input signals. The frequency of the master clock input determines the video data rate; the period of the line transfer input defines the line scan rate, and the line reset signal, used in conjunction with the line transfer input, controls the integration period. This arrangement provides for video data rates up to 20 MHz, line rates exceeding 70,000 lines per second, and electronic exposure control.

This direct control over camera speed and pixel integration time allows the data rate to be set to a convenient readout speed for external processing hardware while allowing an integration time appropriate to capture higher speed events. The antiblooming circuitry, combined with the electronic exposure control, allows the camera to operate over a wide range of lighting conditions without blooming and with minimum smearing.

Electrical Configuration

Camera operation requires ±12V DC and +5V DC power, a single-phase clock, and a line transfer pulse. All digital input and output signals are differential line pairs conforming to EIA RS-422 specifications. The video channels are 75 ohm, single-ended outputs. An eight-foot shielded cable assembly (P/N CA1902BFN-011) is available to support power and signal transmission. Custom lengths of this cable are also available from EG&G Reticon in one-hundred-foot multiples — with or without connectors — for operation at remote locations or in electrically noisy environments.

LC1912 series camera electronics is contained on three circuit cards within the camera housing. The circuits on these cards process external control signals, generate bias and drive signals for scanning of the photodiode array, buffer the analog video outputs, and process the digital output signals. All electrical connections to and from the camera are routed through a single, 25-pin, D-subminiature connector on the rear panel.

Operation

The camera block diagram, see Figure 2, illustrates functional signal flow and rear-panel connector pin assignments for LC1912. Input signal requirements and timing characteristics are shown in Figure 3.

The camera video output is produced by scanning pixels at a rate determined by the external master clock input signal. This pixel readout rate may be any value from 20 kHz to 20 MHz and consists of two, time-division-multiplexed streams of analog video data having an amplitude that is linearly proportional to light intensity and integration time.

The odd and even video outputs can be recombined into a contiguous pixel data stream or processed independently. In either case, a dynamic range of greater than 2000:1 (saturated peak video/p-p noise, excluding clock coupling) is available for applications that demand high gray scale resolution. The “full-line dynamic range” (saturated peak video/p-p dark pattern) is typically better than 48 dB, which provides superior performance in binary or thresholding applications.

The line scan time is determined by the time interval between external line transfer pulses. A long integration time is desirable for high sensitivity, while a short line scan time is desirable to obtain a sharp image of rapidly moving objects. The line scan time may be any value between (N+32) x 50 nanoseconds and 40 milliseconds, where N is the number of array elements. Integration times longer than 40 milliseconds can introduce higher levels of dark signal that reduce the dynamic range of the sensor. Longer integration times are possible if the camera is cooled to reduce dark current. The specific characteristics of an application, such as light level and rate of object motion, will determine the optimum setting of line scan time.

Sensitivity and Spectral Response

The LC1912 contains a high-quality, silicon photodiode line array that is responsive to wavelengths of light from below 350 nanometers (UV) to 1100 nanometers (near IR) as shown in Figure 4. Relatively significant photoresponse is maintained

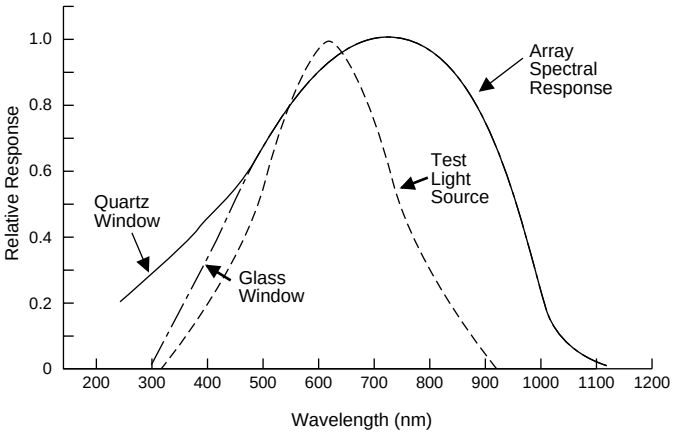


Figure 4. Relative spectral response as a function of wavelength. Dotted line shows the spectral distribution of light source used for sensitivity measurements. Measured using full array illumination and averaged relative output at test spectral frequencies.

even in the blue end of the spectrum because there is no interfering layer of polysilicon covering the photodiode as is typical of competitive sensors. Additionally, standard LC1912 cameras employ sensors with quartz windows that are more transparent to UV light than are glass windows. The response of the array to illumination is a function of sensor geometry and integration time. The LC1912 camera is available with standard (13 μm) and low-light (26 μm) aperture sensors. For more information about EG&G Reticon's D Series linear photodiode sensors, ask for data sheet 055-0223.

Typical applications for these devices normally utilize visible light; therefore, sensitivity and photoresponse uniformity are specified using a light source with the spectral distribution shown by the dotted line in Figure 4. This spectral distribution is produced by filtering a 2870°K Tungsten source with a 1 mm thick, heat absorbing, Fish Schurman, HA-11 filter.

Construction

The rugged LC1912 camera is constructed to survive and operate reliably under punishing shock and vibration conditions. Independent laboratory tests demonstrate that the camera withstands shock up to 300 g (peak) and random vibration in excess of 30 g (RMS).

All electronic components are mounted on three circuit cards within a sturdy aluminum case. The image sensor is mounted on an aluminum plate that efficiently transfers heat to the camera case. The sensor connects to the front card through slots in the plate. The camera interface connector is mounted on the rear card and protrudes through the rear panel. All circuit cards are interconnected with flexible ribbon cable.

The camera is provided with a standard 1/4-20 UNC tripod mounting block that is attachable to any of the four sides of the camera case, see Figure 5. The hole pattern used to attach the tripod mounting block can also be used to rigidly mount the camera assembly. An optional right-angle bracket and a circular mounting plate are also available for increased mounting flexibility. These mounting devices are equipped with registration pins that mate with corresponding precision registration holes on the camera face.

The sensor is precisely aligned to the registration holes, allowing the camera to be easily removed and remounted, as may be necessary for lens cleaning or equipment servicing, without the need for complicated optical realignment. Sensor position is precisely aligned at the factory (X, Y, and rotation) to the registration holes.

Optical Interface

All LC1912 cameras, except for the 2048-element sensor version, are supplied with adapters for "C" mount lenses. The 2048-element camera is supplied with an adapter for mounting Nikon "F" lenses and accessories. The product manual provides precise dimensional information for optical and mechanical interface as well as comprehensive thread information.

An optional through-the-lens viewer (Model CX9411) is available for use with the LC1912 camera to greatly simplify installation and alignment. With the appropriate lens adapter, "U" or "F" mount optics and accessories can be used with the viewer. An *Optical Calculation Worksheet* is available from EG&G Reticon to assist in selection of lenses, adapters, and extension tubes.

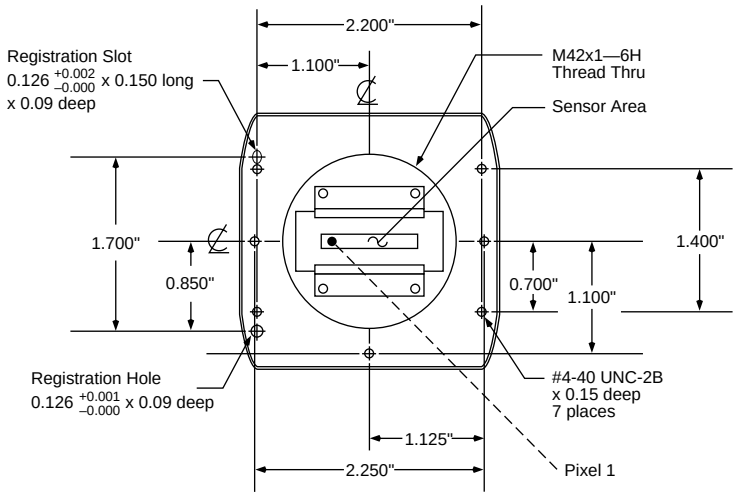
Specifications

Sensor Characteristics	
Pixel spacing	13 μm (center-to-center)
Aperture width	13 μm or 26 μm
Spectral response	300 to 1100 nm
Window	Quartz
Alignment:	
X – Y Placement	±0.005" (on camera centerline, referenced to registration holes)
Rotation	104 μm, max (13 μm aperture) 208 μm, max (26 μm aperture) (vertical displacement of first to last pixel)
Operational Features	
Dynamic range [1]	>2000:1, typ
Video data rate	20 kHz to 20 MHz
I/O signals	Differential digital (RS-422)
Video level	0.7V ± 20% (when terminated into 75Ω, pulled down to -5V)
Video output impedance	75Ω
Weight	10 ounces; 285 g
Dimensions (without mounting block)	2.5" (H) x 2.5" (W) x 1.85" (D); 6.35 cm (H) x 6.35 cm (W) x 4.7 cm (D)
Control Signals	
Master clock (MCLK)	Controls pixel data rate
Line transfer (LT)	Initiates scan readout
Camera clock (CCLK)	MCLK synchronized to video
Line Enable (LEN)	Indicates presence of valid video
Line Reset (LR) [2]	Reset all photodiodes to zero integration level
Camera line transfer (CLT)	Timing reference to establish video synchronization

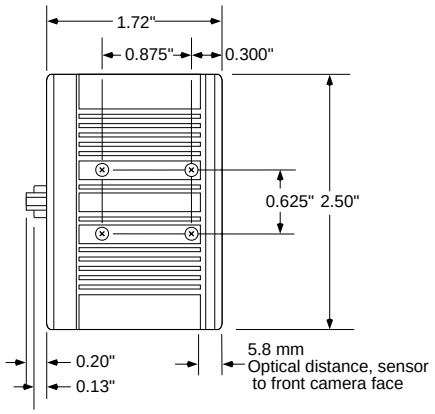
Power Requirements	
+12V DC	330 mA, max
–12V DC	56 mA, max
+5V DC	372 mA, max
Input power [3]	6.5 W at 2048 array, 20 MHz MCLK, max
Performance	
Full line signal-to-noise ratio [2,4,5]	>48 dB
Light response nonuniformity [5,6,7]	±6%, max
Photoresponse [8]	2.3 V/μJ/cm^2 (13 μm aperture) 4.6 V/μJ/cm^2 (13 μm aperture)
Saturation exposure [8]	0.30 μJ/cm^2 (13 μm aperture) 0.15 μJ/cm^2 (26 μm aperture)
Maximum exposure (integration) time [9]	40 ms at 25°C
Shock	300 g, peak (6-axis without lens)
Random vibration	30 g, RMS (3-axis without lens)
Temperature	
Operating	0 to 55°C
Storage	–40 to 80°C

Notes:

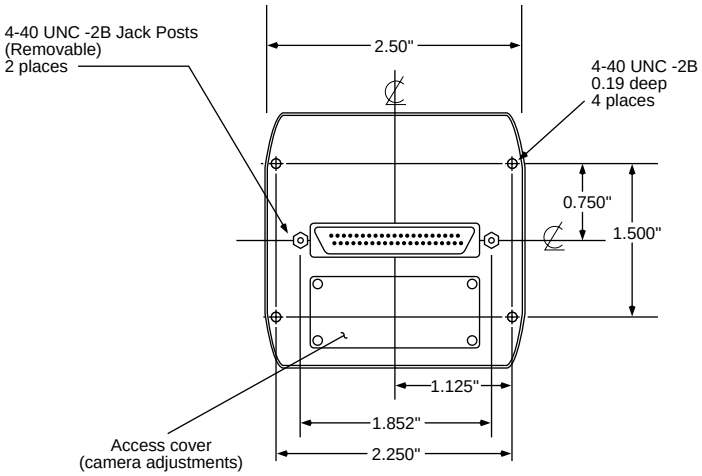
1. Dynamic Range = V_{Sat}/p-p noise (excluding clock coupling) at 25°C.
2. Use of line reset causes an increase in the fixed-pattern noise.
3. Power consumption increases as clock rate increases.
4. Full line S/N ratio = V_{Sat}/p-p fixed-pattern noise.
5. Measured at 25°C with a 1 ms integration time and a pixel data rate of 200 kHz.
6. Measured using a 2870°K tungsten lamp and a 1 mm thick, Fish Schurman HA-11 filter.
7. Measured with uniform illumination at approximately 50% of saturation (first and last pixels ignored).
8. Measured using a 637 nm LED light source with a 1 ms integration time.
9. This exposure time will cause a dark leakage current of 8% or less.



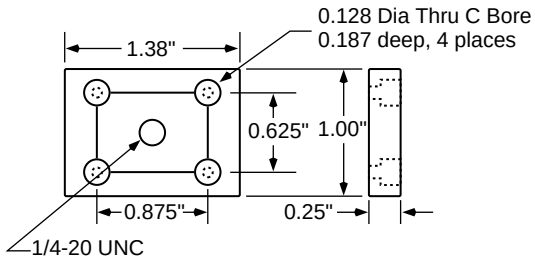
Front View



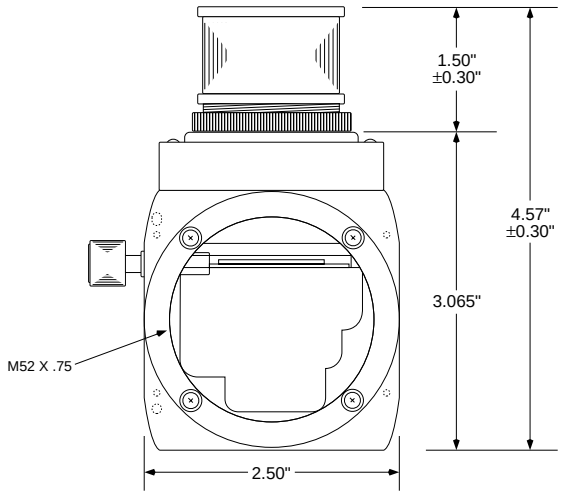
Side View



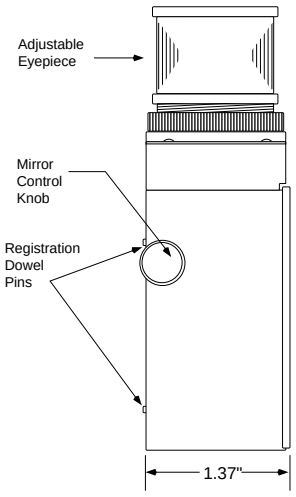
Back View



Standard Tripod Block Mounting Accessory



Front View



Side View

Thru-the-Lens Viewer (Optional)

Figure 5. Mechanical Dimensions

Lenses and Optical Accessories

EG&G Reticon offers an extensive line of optical accessories for the LC1912 camera. These products range from lenses to extension tubes. All EG&G Reticon's modular cameras have identical optical and mechanical configurations to allow easy interchange of lenses and accessories. Virtually any field of view or magnification requirement is achievable using available lenses and optical accessories.

Mounting and Other Accessories

EG&G Reticon offers high quality mounting accessories for the LC1912 camera to facilitate optimum camera positioning. These include a heavy-duty right angle precision mounting plate and a camera head assembly tripod mounting block. One tripod mounting block is supplied with the camera.

Support Electronics

Other optional support products are available from EG&G Reticon to maximize flexibility and facilitate easy use. These products include a controller/power supply (RS1910) and cables (CA Series).

Application Support

EG&G Reticon maintains a staff of highly skilled applications engineers to provide technical assistance and in-depth applications information. A library of technical articles and application notes is also available to assist our customers in the use of EG&G Reticon's machine vision products. Some examples of these are the following:

- *Depth of Field Characteristics using Reticon's Image Sensing Arrays and Cameras* (Application Note #127)
- *Optical Calculation Worksheet* (Application Note #126)
- *Design Considerations for a Solid-State Image Sensing System* (A-6)
- *Modular Solid-State Machine Vision Camera* (C-21)
- *Practical Illumination Concept and Technique for Machine Vision Applications* (C-22)

Ordering Information

Part Number	# of Elements	Standard Mount	Aperture Width
LC1912DAN-011	256	C	13 µm
LC1912FAN-011	512	C	13 µm
LC1912HAN-011	1024	C	13 µm
LC1912KAN-011	2048	F	13 µm
LC1912DKN-011	256	C	26 µm
LC1912FKN-011	512	C	26 µm
LC1912HKN-011	1024	C	26 µm
LC1912KKN-011	2048	F	26 µm

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