

# **EX-Q Wafer Mapping Sensors**

## ***Instructions for Installation and Use***

**For use with**

- **EX-43Q**
- **EX-73Q**
- **EX-83Q**
- **EX-93Q**



**CAUTIONS:**

The semiconductor laser used in EX-Q wafer mapping sensors generates Class 1 invisible laser radiation. Laser light emanates from front face of sensor. Avoid direct viewing or staring into the laser beam. These devices meet the standards required by the Center for Devices and Radiological Health (CDRH) of the U.S. Food and Drug Administration.

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

EX-Q sensors contain no user-serviceable parts. Refer all servicing to an authorized CyberOptics Semiconductor agent.

These sensors conform to IEC 60825-1 (2001-08) (laser safety) and to the laser safety requirements of SEMI S2-0200.

**Careful installation and alignment of the sensor is required for optimal performance. Read the instructions before installation.**

These instructions are required for successful operation of the sensor. They should be transmitted to the end user in the case of OEM installation of the sensor.



*Class 1 Laser Product Label*

**Technical Support**

Providing responsive technical support for our products is a top priority for CyberOptics Semiconductor. We have a dedicated technical support group available to answer your questions Monday through Friday, 8 a.m. - 5 p.m. (PT).

Call toll-free **1-800-366-9131**, or call **503-495-2200**

E-mail **CSsupport@cyberoptics.com**

Fax **503-495-2201**

Web **www.CyberopticsSemi.com**

For non-support inquiries please call or e-mail [CSinfo@cyberoptics.com](mailto:CSinfo@cyberoptics.com).

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## **1.0 INTRODUCTION AND FEATURES**

Wafer mapping sensors are used to detect the presence or absence and slotting errors (ex. cross-slots) of semiconductor wafers in processing equipment. They are typically mounted on robot arms or other wafer handling devices.

EX-Q Wafer Mapping Sensors are general purpose wafer mapping sensors that excel at detecting even the most difficult to detect dark or coated wafers. EX-Q sensors can be used for notched or flatted wafers of any standard size. They can scan at the wafer center as well as aimed off center.

### **EX-Q sensor features include**

- Excels at detecting dark or coated wafers at factory gain setting
  - Laser transmitters and receivers fine-tuned for maximum sensitivity while still maintaining Class 1 status (CDRH)
- Reliably detects cross-slotted and ultra-thin wafers
  - Thin laser stripe (0.05mm) combined with multiple apertures and spatial filtering reduces noise, improving mapping accuracy
- Insensitive to interference from the mapping environment
  - Beam geometry and built-in ambient light filter minimize stray reflections and ambient lighting influences
- Accommodates all SEMI™ standard wafers, regardless of size or edge geometry, through Patented Dual and Wide Beam technologies
- Easy to use “off-the-shelf” direct interface requires no amplification or signal conditioning
- Available in four standoff distances
  - EX-43Q 1.5"
  - EX-73Q 2.2"
  - EX-83Q 3.0"
  - EX-93Q 4.5"
- Non-intrusive wafer mapping solution protects valuable wafers from inadvertent crashes
- No moving parts that can result in particulate contamination



## 2.0 DIMENSIONS

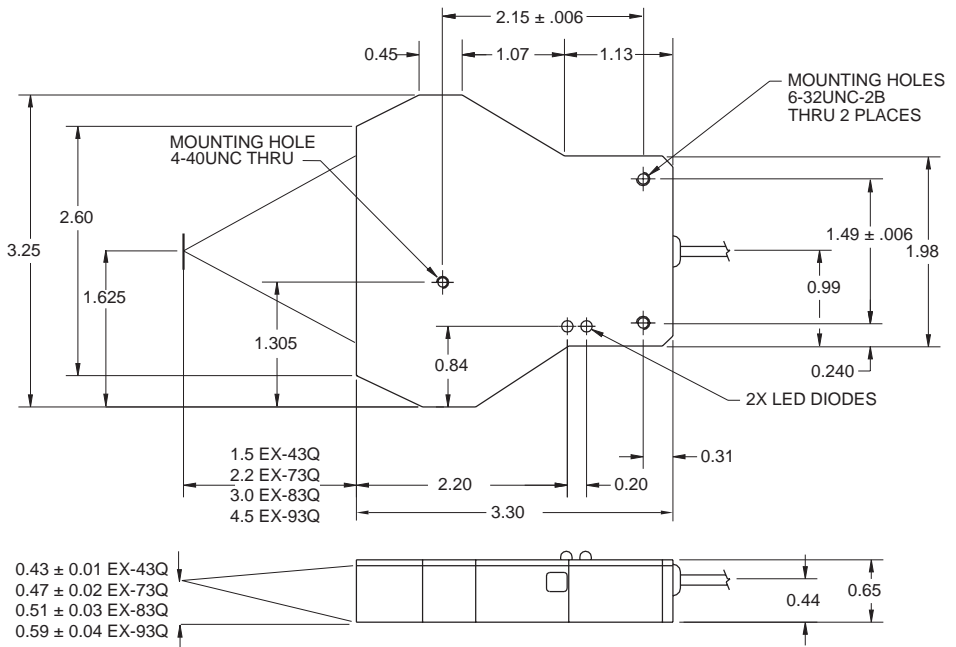


Figure 1 - EX Sensor Dimensions (inches)

### 3.0 SPECIFICATIONS

	<b>EX-43Q</b>	<b>EX-73Q</b>
Method of detection	Dual Wide Beam	
Optimum detecting distance	1.5"	2.2"
Maximum detecting range	1.4" to 1.6"	2.05" to 2.35"
Supply voltage	9 to 24 V DC	
Current consumption	130 mA typical, 200 mA max.	
Light source	2 X 850 nm diode lasers	
at exit port	2 X 0.600 mW max.	
at CDRH aperture	0.077 mW max.	
Laser class	Class 1 (CDRH)	
Detectable objects	Transparent, opaque and mirror-surfaced objects	
Laser spot size	10mm x 0.05mm	16mm x 0.06mm
Working angle range	± 16 degrees relative to the sensor front surface	± 11 degrees relative to the sensor front surface
Operation	Light-ON/Dark-ON switch, enable switch, gain setting	
Response time	400-µs max.	
Minimum pulse width	5 msec. (refer to Section 10 for options)	
Indicator	Laser power - RED led, Signal OUT - GREEN led	
Control output	MOSFET open drain, Low-True, 80mA max @24VDC.	
Connections	16", 4 conductor cable (refer to Section 10 for options)	
Temperature limits	Operating: 32 to 104°F (0 to 40°C) Storage: -20 to 130°F (-30 to 55°C)	
Materials	Lenses: glass, plastic; Case: aluminum	
Weight	4.3 oz (122g)	

### 3.0 SPECIFICATIONS (continued)

	<b>EX-83Q</b>	<b>EX-93Q</b>
Method of detection	Wide Beam	
Optimum detecting distance	3.0"	4.5"
Maximum detecting range	2.8" to 3.2"	4.2" to 4.8"
Supply voltage	9 to 24 V DC	
Current consumption	130 mA typical, 200 mA max.	
Light source	1 X 850 nm diode lasers	
at exit port	1 X 0.600 mW max.	
at CDRH aperture	0.077 mW max.	
Laser class	Class 1 (CDRH)	
Detectable objects	Transparent, opaque and mirror-surfaced objects	
Laser spot size	15mm x 0.09mm	22mm x 0.14mm
Working angle range	-4 to +8 degrees relative to the sensor front surface	
Operation	Light-ON/Dark-ON switch, enable switch, gain setting	
Response time	400- $\mu$ s max.	
Minimum pulse width	5 msec. (refer to Section 10 for options)	
Indicator	Laser power - RED led, Signal OUT - GREEN led	
Control output	MOSFET open drain, Low-True, 80mA max @24VDC.	
Connections	16", 4 conductor cable (refer to Section 10 for options)	
Temperature limits	Operating: 32 to 104°F (0 to 40°C) Storage: -20 to 130°F (-30 to 55°C)	
Materials	Lenses: glass, plastic; Case: aluminum	
Weight	4.3 oz (122g)	

## **4.0 INSTALLATION**

### **4.1 UNPACKING**

**Warning:** *Any contact with the lenses could result in severely degraded optics performance.*

Check the model number of the sensor against the model number recommended for the equipment and against the model number ordered. Inspect the sensor for signs of damage. Keep sensor in its plastic bag until the sensor is ready for installation.

Report any damage to:

*CyberOptics Semiconductor  
13555 SW Millikan Way  
Beaverton, OR 97005  
503-495-2200  
800-366-9131  
503-495-2201 (fax)  
CSsupport@cyberoptics.com*

## 4.2 INSTALLATION PROCEDURE

This installation procedure is to be used to check for proper setup, wiring, alignment and operation. The following procedure is intended to demonstrate the most common setup and wiring for EX-Q sensors. Specific wafer mapping sensor implementations may vary.

- 1) Set DIP switches on the side of the sensor to the CLOSED position as shown.
  - A) Output signal polarity: Light ON
  - B) Remote Enable: OFF

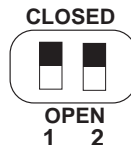


Figure 2 -  
DIP Switch Settings

**Note:** EX-Q sensors are set to optimum gain at factory. Contact technical support if adjustment is required.

- 2) The EX-Q sensor typically ships with no connector so the appropriate connector must be installed on the sensor using the following wiring instructions.
  - A) Red wire +9V to +24V
  - B) Black wire to Ground
  - C) Green wire is the output, Open drain. Connect Green wire through pull-up resistor R1 (10K, typical) to +V where +V is +5 to +24 volts DC. R1 should limit current to 80 mA max. If sensor option U is installed, R1 (10K) is installed inside the sensor and no external R1 is required.
  - D) Yellow wire is not required if Remote Selector Switch (see figure 4) is set to CLOSED. The current limiting resistor R2 needed in previous model sensors is not required. However, the sensor will work with R2 (up to 700 ohms) installed in the wiring external to the sensor.
- 3) Confirm the 16 position gain switch is set to the appropriate level. CyberOptics Semiconductor recommends using the factory setting for most applications. The factory gain settings are listed in the Table A. Please contact CyberOptics Semiconductor Technical Support if you believe gain adjustments are required.

Model #	Recommended Gain Setting
EX-43Q	6
EX-73Q	6
EX-83Q	10
EX-93Q	12

Table A: Factory (recommended) Gain Settings

Installation Procedure continued on next page.

## 4.2 INSTALLATION PROCEDURE (continued)

4) Mount the EX-Q sensor on the robot or load port door, and set up for proper offset and alignment.

A) Apply power to the sensor.

Response:

Red LED Illuminates

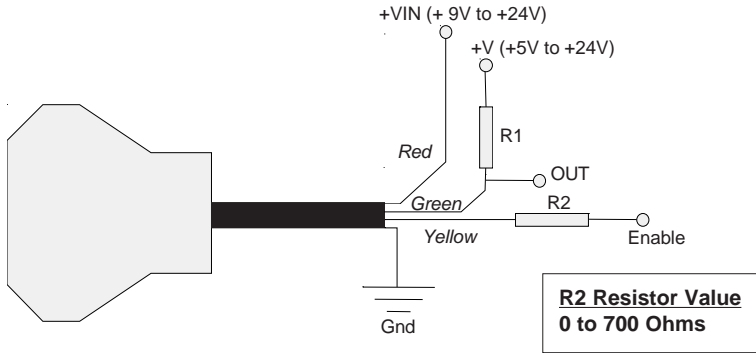


Figure 3 - Typical Connection

Wave hand in front of sensor and the Green LED will illuminate.

B) Set the sensor to the correct standoff distance for the EX-Q model (refer to

**Warning:** CyberOptics Semiconductor strongly recommends that EX-Q sensors be used only at the specified standoff distance. Sensor optics and geometry are carefully matched to the specified standoff distance so that the sensor will respond to wafers throughout (and beyond) the range of variations in wafer parameters. Outside the specified standoff distance sensor response to wafers is degraded, and the sensor will not respond correctly to the full possible range of wafer parameters.

Installation Procedure continued on next page.

## 4.2 INSTALLATION PROCEDURE (continued)

Section 3.0 for the correct standoff distance.)

- C) Set the sensor's alignment for the correct single or multiple pass scans. For single pass scans, an on-axis scan is recommended for maximum detection robustness. For mapping implementations where multiple pass scans are utilized, space the scan passes such that each scan pass falls within the recommended working angle range (refer to Section 3.0 for further details). Please contact CyberOptics Semiconductor Technical Support if you have a question regarding the optimum working angle range for your specific application.

**Note:** CyberOptics Semiconductor has developed an Alignment Card to assist in the proper setup and calibration of the EX-Q sensor. Contact CyberOptics Semiconductor

**Warning:** Do not touch the sensor's emitter or receiver surfaces. This may result in serious impairment to the sensor's performance.

Technical Support to obtain an Alignment Card and Instructions.

- D) Using the appropriate robot set up procedure, teach the robot position(s) for wafer sensing. Note that any time a sensor is installed or reinstalled, the position(s) should be retaught to the robot.

## 4.3 MECHANICAL INSTALLATION OVERVIEW

- Refer to Section 2.0 for dimensional drawing with mounting hole alignment.
- Refer to Section 7.4 for proper alignment.
- Refer to Section 5 for setting switches.
- Check other equipment manuals to ensure correct connector wiring.

## 5.0 INDICATORS, CONTROLS, AND CONNECTIONS

### 5.1 INDICATORS

#### 5.1.1 OUT SIGNAL INDICATOR

The OUT SIGNAL indicator (green LED) is a visual representation of the output signal. In the LIGHT ON mode, the signal indicator illuminates, and the output signal is low, whenever an object is present; in the DARK ON mode, whenever it is absent.

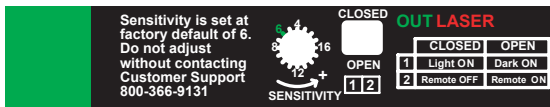


Figure 4 - Indicators & Controls  
(figure is representative of EX-43Q label)

#### 5.1.2 LASER ON INDICATOR

The LASER ON indicator (red LED) illuminates when the laser diode is emitting radiation.

### 5.2 CONTROLS

#### 5.2.1 GAIN SELECTOR SWITCH

The electrical gain has been set at the factory for optimal use. This gain level is denoted in green on the gain dial and is different for various sensor models. Refer to Table A on page 7 for these settings. CyberOptics Semiconductor does not recommend changing this setting in the field.

#### 5.2.2 DETECTION MODE SWITCH (LIGHT ON/DARK ON)

In LIGHT ON (closed position) detection mode, the OUT signal will be low when an object is present within the detecting range and reflected light pulses are detected in the receiver. In DARK ON (open position) detection mode, the output signal is low when an object is not present or the reflected pulses are not strong enough to register in the receiver. See Section 6.3 for more details on the OUT signal.

#### 5.2.3 REMOTE SELECTOR SWITCH (See Figure 5)

In REMOTE OFF (closed position) mode, the sensor is controlled by the Power line. The ENABLE line is not used. The timing is shown in figure 5. After power-on there is an initial reset period of 200 msec (maximum). Then the sensor is immediately enabled, and there is a period of 120 msec (maximum) during which the laser power is ramped up to full power. After that time, the sensor is fully functional. Note that the detection capability of the sensor is active after power-up initialization but before the lasers reach full power. A strongly reflective object in front of the sensor can cause the DETECT output to be asserted even before the lasers reach full power. It is recommended that the sensor be powered on with no object in the detector field of view.

### 5.2.3 REMOTE SELECTOR SWITCH (continued)

In REMOTE ON (open position) mode (after the power-up sequence), the sensor is switched to standby mode with the laser radiation controlled by the ENABLE input signal. This method should be used in an application requiring a shorter delay between enabling the laser and measuring the signal. When the ENABLE signal is asserted there is a period of 120 msec (maximum) during which the laser power is ramped up to full power. After that time, the sensor is fully functional. In the REMOTE ON mode, if Enable is applied at the same time as power-on, or within 200 msec of power-on, the timing is the same as the REMOTE OFF mode. Note that the detection capability of the sensor is active after ENABLE is asserted but before the lasers reach full power. A strongly reflective object in front of the sensor can cause the DETECT output to be asserted even before the lasers reach full power. It is recommended that the sensor be enabled with no object in the detector field of view.

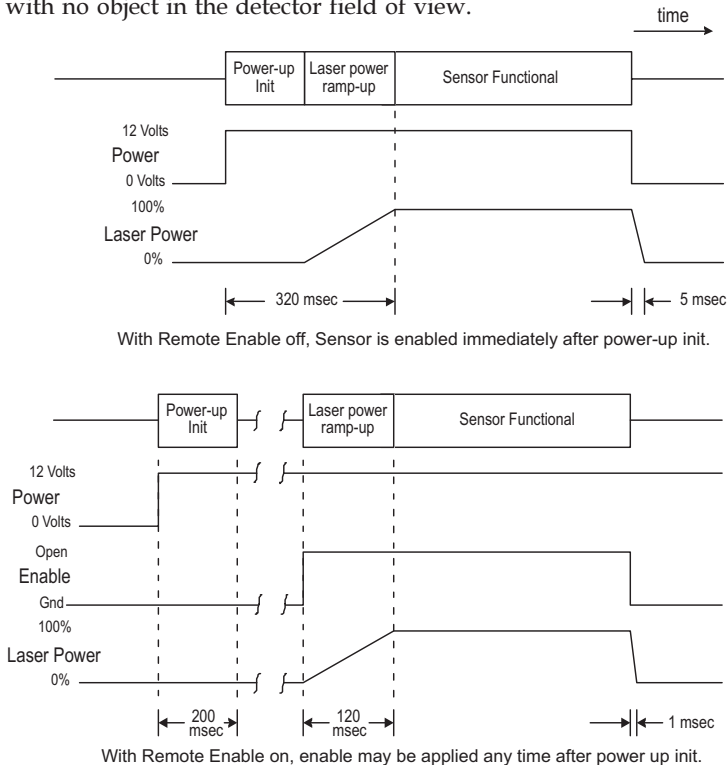


Figure 5 - Remote Timing

## 5.3 CONNECTIONS *(See Figure 6)*

### 5.3.1 +VIN (POWER INPUT) (RED WIRE)

EX-Q sensors can operate with the input voltage between +9 and +24 VDC on the red wire. The maximum current draw will be 200 mA with the lasers on and 100 mA with the lasers off.

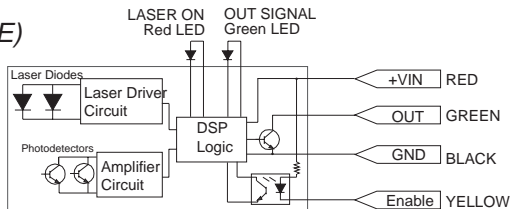


Figure 6 - Wiring Connections

Note: EX-83 and EX-93 have only 1 laser diode

### 5.3.2 GND (COMMON RETURN) (BLACK WIRE)

The black wire is the common return line for the power connections as well as for the output and enable connections. EX-Q sensor cases are connected to the GND connection to ensure that the internal circuitry is shielded from EMI. The sensor case should be insulated from any equipment that may generate large current surges in the case of ground connection.

### 5.3.3 OUT (SENSOR OUTPUT) (GREEN WIRE)

The output connection is connected inside the sensor to the open drain of a MOSFET transistor. The drain must be connected through a pull-up resistor (See Figure 3) to a source of positive voltage (+5 to +24 volts). The resistor should have a value chosen to limit the transistor current to 80 mA or less (typical value is 10K). The output can then be observed as a voltage level change at the sensor output (sensor side of the resistor). If there is no connection to voltage, there will be no noticeable change in the voltage on the OUT connection when the sensor is operating. If the internal pull-up resistor option is ordered, a 10k resistor is connected to the open collector output and no external resistor is required. This signal is low-true. In the LIGHT ON mode the signal goes low when an object is detected. In the DARK ON mode the signal goes low when an object is not detected.

### 5.3.4 ENABLE (YELLOW WIRE) (Refer to Figure 7a & b)

In the standard configuration the laser enable circuitry is connected internally through a 10.9k ohm resistor to +VIN. If the remote selector switch is set to OFF (closed position) the enable line will have no effect on operation. Up to 700Ω can be used in external resistor at R2. Refer to figure 7a. If the positive enable option is ordered refer to figure 7b for enable input signal. R2 is not required in either configuration.

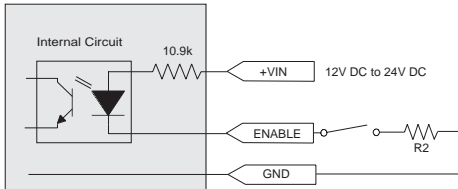


Figure 7a - Enable Input Signal, Standard

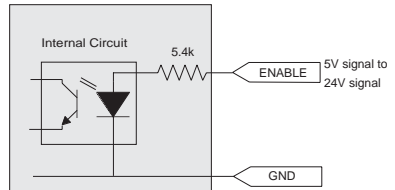


Figure 7b - Enable Input Signal  
with Positive Enable Option

## **6.0 THEORY OF OPERATION**

EX-Q sensors have three main subsystems: laser transmitter, receiver, and signal processing. The combination of the three subsystems allows for reliable and robust wafer detection in a multitude of environments and in a small package size. The circuitry is a combination of both analog and digital.

### **6.1 LASER TRANSMITTER**

There are two infrared (850 nm) laser diodes in each EX-43Q and EX-73Q sensor. There is one laser diode in the EX-83Q and EX-93Q sensor. Each diode has an integral photodetector for control of the laser output over various operating temperatures. Each laser output is set at the factory to comply with the Center for Devices and Radiological Health (CDRH) limits on Class 1 lasers. (Class 1 lasers have the lowest operating power of any CDRH class and Class 1 regulations are the least restrictive). There are no adjustments available to the user to alter the laser power.

Each laser diode operates from a closed loop driver that modulates the laser. The modulation signal is a square wave at approximately 8 KHz. The modulation allows EX-Q sensors to synchronously detect the return signal from the wafers and greatly increases the detector sensitivity.

The laser optics are identical for both lasers. The optics for the EX-43Q is designed to create a laser spot at the focal point that is approximately 10 mm wide and 0.05 mm tall. The two laser transmitters are both aimed from one side of the sensor to a common focal point in front of the sensor. The laser optics are mounted with a slight upward tilt (approximately 3 degrees). This eliminates undesired reflections from the back of wafer carriers and makes the sensor insensitive to reflections from structure on the top surface of the wafer.

### **6.2 RECEIVER**

The two receiver channels contain high sensitivity phototransistors in identical “telescope” systems that each look at the same spot illuminated by the laser transmitters. Each receiver has a relatively large ½ inch diameter collector lens and an ambient light filter to block visible light. The two receivers are on the opposite side of the sensor from the laser transmitters and only respond to light entering within a  $\pm 10$  degree angle from each telescope optical axis. The receiver and transmitter beams cross at the target distance at a relatively high angle. This minimizes sensitivity of the sensor to objects at other distances. Transmitter light that is reflected from somewhere other than at the target distance is very unlikely to be reflected back into the receiver telescopes at the required angle for collection. The optical axis of the detectors are also tilted upward approximately 3 degrees to match the axis of the lasers. This makes EX-Q sensors insensitive to stray reflections from cassettes and FOUUPS.

## 6.3 SIGNAL PROCESSOR

The signal processor subsystem in its simplified form has two inputs and one output. One input is the 8 KHz square wave signal that drives the laser diodes. The other input is the output of the receiver subsystem. The signal processor quantizes the received signal and compares this to the 8 KHz square wave, at the points where the 8 KHz square wave changes sense (goes high or goes low). A match is found if the quantized signal is in the correct state. When matches are found in two consecutive cycles of 8 KHz, and if there are no incorrect transitions of the quantized signal, the DETECT output signal is asserted. This reduces the frequency of false detection caused by noise. When DETECT is asserted, it stays asserted until there are three cycles without a correct signal match, or there are three incorrect transitions of the quantized signal. This effects a form of hysteresis; in asserting DETECT, the processor is intolerant of noise, but once DETECT is asserted, the processor is slightly more tolerant of noise. This reduces the effect of noise in the received signal to cause DETECT output chatter or spurious transitions that are sometimes called drop-outs.

Background light modulated at any other frequency is ignored. Because the processor requires matches on two consecutive cycles before asserting the DETECT output, the sensor requires at least 250 microseconds to respond to a detection event.

EX-Q sensors also feature a minimum output time response circuit. Small or moving objects detected at high speeds could generate very short output pulses. To make these short output pulses “visible” to slower equipment, the minimum output pulse width is set to 5 ms. Objects smaller than 5 ms (in terms of the time in front of the sensor) will always generate an output pulse 5ms wide (as shown on Fig. 8 Object < 5 ms). Larger objects will generate a pulse of the object width (Figure 8 Object > 5 ms). This minimum output pulse width is factory preset to 5 ms. As an option, an output pulse width of 1 ms or 10 ms is available.

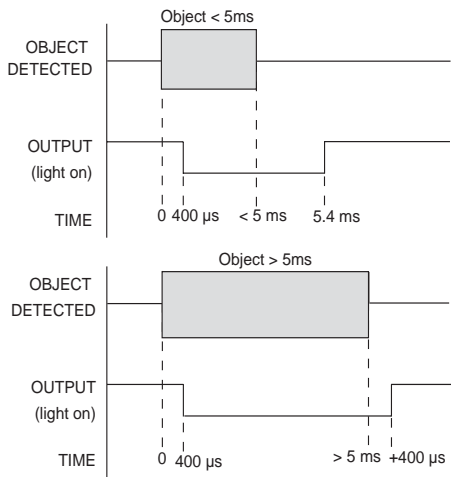


Figure 8 - Output Timing

## 7.0 GUIDELINES FOR SETUP AND USE

The guidelines below will ensure optimum wafer mapping sensor performance.

### 7.1 WAFER MAPPING OVERVIEW

Wafers may be present in wafer carrier slots (see Figure 9). Each slot may have a status, present, absent or cross-slot. A cross-slotted wafer is supported by two different wafer carrier slots.

A sensor is moved relative to a wafer carrier during wafer mapping. Each scan starts with the sensor before the first wafer slot and ends with the sensor beyond the last slot (see dotted line in Figure 9). Scans may be upward or downward, but should always be in the same direction to minimize mechanical backlash, sensor latency and sensor hysteresis effects. The sensor indicates with the DETECT signal when a wafer is detected. The DETECT signal has only two possible states. Software receives data indicating the relative position of the sensor and the wafer carrier slot. A wafer map is a list of the states of wafer carrier slots. Slots are numbered starting from the bottom of a carrier, starting with the number 1. The carrier illustrated in Figure 9 has a map of: (from the bottom) Present, Absent, Present, Present, Cross, Cross, Present, Present, Absent, Present, Present, Absent.

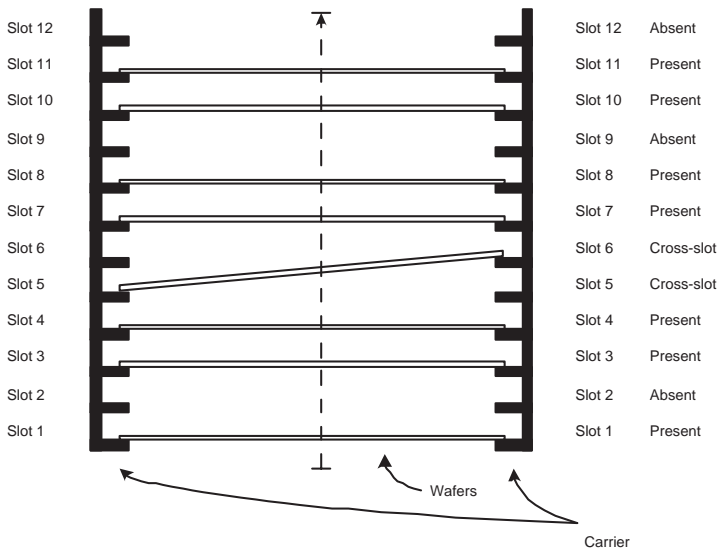


Figure 9 - Wafer Placement in Wafer Carrier

## 7.2 SENSITIVITY

The EX-Q sensor sensitivity is set at the factory for the optimum detection of wafers of all sizes, thicknesses and coating types. In rare cases, sensitivity adjustment may be necessary. Contact CyberOptics Semiconductor Technical Support before adjusting EX-Q gain settings.

## 7.3 AMBIENT LIGHT

EX-Q sensors include an ambient light filter that blocks visible and some infrared light from the phototransistor. The ambient light filters are composed of RG-9 filter glass. RG-9 is a high-pass filter that blocks light below 720 nm. They will filter out the effects of fluorescent and other lighting found in most fabs. Please note if you are upgrading to the EX-Q sensor from a previous model of CyberOptics Semiconductor or HAMA wafer mapping sensor which had an optional ambient light filter installed, the ambient light filter is now standard on the EX-Q.

## 7.4 ALIGNMENT

EX-Q wafer mapping sensors require proper alignment with respect to target wafers in order to assure optimum performance. Each sensor model has a recommended working angle range which the sensor must stay within during operation. This is defined to be the angle of the sensor face with respect to the tangent line on the wafer edge. This is equivalent to the angle between the axis of the sensor, and a line drawn to the wafer center from the point where the axis intersects the wafer edge. When the sensor is directly facing the wafer, the working angle is zero. (Refer to Figure 10).

A wide working angle range is useful for two reasons. The first is to allow two scans to be done at different points on the wafer edge. This is often done for redundancy and to give the ability to detect wafer tilt as an indicator of a misplaced wafer.

The second need for a wide working angle range is for use with flatted wafers. The wafer scanning strategy must take into account the fact that the flat may be at any orientation, so that even with the worst case flat position, the wafer edge is still within the recommended working angle of the sensor. For the EX-73Q, -83Q and -93Q distance models two scans are needed to guarantee that in at least one scan the flat will be within the recommended working angle.

The sensor optics are tilted upward 3 degrees with respect to the plane of the sensor. This is to avoid reflections from structure that may be present on the top surface of wafers, and to avoid reflections from the back of FOUPs, in the case of 300 mm wafers. To maintain this advantage, the sensor should be oriented within  $\pm 0.5$  degrees of the same plane as the target wafer. This means that the wafer and the sensor need to be parallel to within  $\pm 0.5$  degrees. Note that this upward tilt results in a slight offset in vertical location of the sense point as compared to earlier revision EX-Q sensors. (Refer to Section 2.0.)

## 7.4 ALIGNMENT (continued)

In the case that the sensor is mounted on a wafer handling robot, the sensor working angle should not be confused with the robot arm angle, or the “theta motion” of the robot arm. While it is possible to convert from robot theta motion to sensor working angle, the conversion depends on working distance, wafer diameter, and robot arm extension. The exact calculation is presented in the following paragraphs.

In addition the tables on pages 20 and 21 present typical setups from which approximations can be derived.

For each mapping setup the working angle of the sensor should be calculated to make sure that the sensor is being used in the proper range to achieve the recommended sensing performance.

As shown in figure 10, the following values are defined.

$\phi$  = Working angle: Angle between sensor axis and line between wafer center and focal point.

$\theta$  = Robot arm angle: The angle at the robot axis between the line to the sensor and the line to the wafer center. When  $\theta = 0$  the sensor is pointed directly at the center of the wafer.

$\gamma$  = Wafer angle: Angle at wafer center between line to focal point and line to robot center

$\psi$  = Carrier-robot angle: Angle of carrier axis with respect to line between wafer center and robot axis.

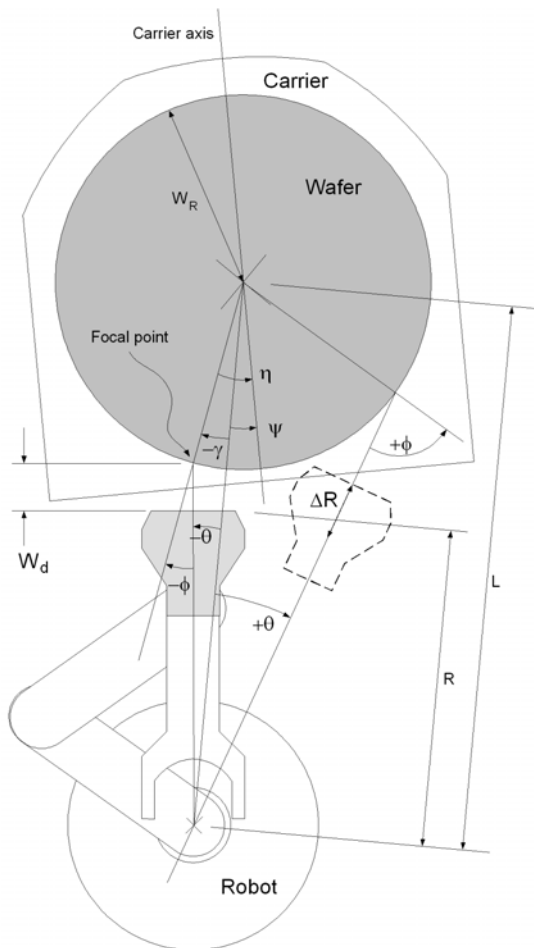


Figure 10 - Wafer Mapping Sensor Geometry (top view)

## 7.4 ALIGNMENT (continued)

$\eta$  = Carrier-sensor angle: angle of the carrier axis with respect to line between wafer center and focal point. Carrier-sensor angle is the sum of wafer angle and carrier-robot angle. Carrier-sensor angle is negative of wafer angle when robot axis is on FOUP axis.

$W_D$  = Working distance: This is the distance along the sensor axis from the wafer edge to the center of the front of the sensor.

$R$  = Distance from sensor face to robot axis for  $\theta = 0$ . This is the distance from the center front face of the sensor to the robot arm's center of rotation.

$W_R$  = Wafer radius. This is  $\frac{1}{2}$  the diameter of the wafer (i.e. 150 mm for a 300 mm wafer).

$L$  = distance from robot center (rotation axis) to wafer center.

$\Delta R$  = radial offset of robot for given angle  $\theta$  needed to maintain  $W_D$

Often when the sensor is mounted on a robot the sensor must be positioned using robot rotational and radial coordinates, corresponding to "robot arm angle" and  $R$ . The following equations are useful for finding  $\theta$  and  $R$  or  $\Delta R$ .

We first define the following constant,  $Q$ .

$$Q \equiv \frac{W_R}{L} \equiv \frac{W_R}{W_R + W_D + R}$$

To calculate the working angle  $\phi$ , first calculate  $\gamma$  for a given robot angle  $\theta$ .

$$\gamma = \sin^{-1} \left( \frac{\sin \theta}{Q} \left[ \cos \theta - \sqrt{Q^2 - \sin^2 \theta} \right] \right)$$

The working angle  $\phi$  is then calculated from  $\gamma$  and  $\theta$ .

$$\phi = \theta + \gamma$$

When the robot angle  $\theta$  is changed it is necessary to also change the robot arm extension,  $R$ , to maintain the sensor working distance  $W_D$ . This is calculated as  $\Delta R$ .

$$\Delta R = \left( \frac{W_R \sin \gamma}{\sin \theta} \right) - (R + W_D)$$

## 7.4 ALIGNMENT (continued)

Below are a set of tables showing the calculated working angles for a sensor at typical set-up values. They can be used to get a rough estimate of the relationship for the various set-up parameters.

<b>EX-43Q Example</b>			
Working distance (WD)=		38.1 mm	
Robot axis distance (R) =		250 mm	
Wafer Diameter =		300 mm	
Robot $\theta$ (deg)	Wafer $\gamma$ (deg)	Working Angle $\phi$ (deg)	$\Delta R$ (mm)
0	0.0	0.0	0.000
0.5	1.0	1.5	0.032
1	1.9	2.9	0.128
1.5	2.9	4.4	0.289
2	3.9	5.9	0.514
2.5	4.8	7.3	0.805
3	5.8	8.8	1.162
3.5	6.8	10.3	1.586
4	7.8	11.8	2.079
4.5	8.7	13.2	2.641
5	9.7	14.7	3.274

<b>EX-73Q Example</b>			
Working distance (WD)=		55.9 mm	
Robot axis distance (R) =		250 mm	
Wafer Diameter =		300 mm	
Robot $\theta$ (deg)	Wafer $\gamma$ (deg)	Working Angle $\phi$ (deg)	$\Delta R$ (mm)
0	0.0	0.0	0.000
0.25	0.5	0.8	0.009
0.5	1.0	1.5	0.035
0.75	1.5	2.3	0.080
1	2.0	3.0	0.142
1.25	2.6	3.8	0.222
1.5	3.1	4.6	0.319
1.75	3.6	5.3	0.435
2	4.1	6.1	0.568
2.25	4.6	6.9	0.720
2.5	5.1	7.6	0.890

## 7.4 ALIGNMENT (continued)

<b>EX-83Q Example</b>			
Working distance (WD)=		76.2 mm	
Robot axis distance (R) =		250 mm	
Wafer Diameter =		300 mm	
Robot $\theta$ (deg)	Wafer $\gamma$ (deg)	Working Angle $\phi$ (deg)	$\Delta R$ (mm)
0	0.0	0.0	0.000
0.15	0.3	0.5	0.004
0.3	0.7	1.0	0.014
0.45	1.0	1.4	0.032
0.6	1.3	1.9	0.057
0.75	1.6	2.4	0.089
0.9	2.0	2.9	0.128
1.05	2.3	3.3	0.174
1.2	2.6	3.8	0.227
1.35	2.9	4.3	0.288
1.4	3.0	4.4	0.310

<b>EX-93Q Example</b>			
Working distance (WD)=		114.3 mm	
Robot axis distance (R) =		250 mm	
Wafer Diameter =		300 mm	
Robot $\theta$ (deg)	Wafer $\gamma$ (deg)	Working Angle $\phi$ (deg)	$\Delta R$ (mm)
0	0.0	0.0	0.000
0.15	0.4	0.5	0.004
0.3	0.7	1.0	0.017
0.45	1.1	1.5	0.039
0.6	1.5	2.1	0.069
0.75	1.8	2.6	0.107
0.9	2.2	3.1	0.154
1.05	2.6	3.6	0.210
1.2	2.9	4.1	0.274
1.35	3.3	4.6	0.347
1.5	3.6	5.1	0.429

## 7.5 DISTANCE

The distance from the wafer to the sensor should be set for use at the optimum detecting distance, as outlined in Section 3.0. EX-Q sensors will perform sufficiently within their specified maximum detecting range, however, the sensor performance is optimized for use at the specified optimum standoff distance.

CyberOptics Semiconductor strongly recommends that the EX-Q sensors be used only within the specified range of standoff distances. Sensor optics and geometry are carefully matched to the specified standoff distance so that the sensor will respond to wafers throughout (and beyond) the range of variations in wafer parameters. Outside the specified standoff distance sensor response to wafers is degraded, and the sensor will not respond correctly to the full possible range of wafer parameters. At other standoff distances the sensor will not respond correctly to all wafers even though it responds correctly to a test wafer.

## 7.6 OFFSET AND MULTIPLE SCANS

EX-Q sensors can operate pointed either to the wafer center (on-axis), or off-axis. The EX-43Q sensor will detect all standard SEMI™ flatted and notched wafers when scanning on-axis.

However, two scans separated by  $\frac{1}{2}$  to 1 inch (each scan  $\frac{1}{4}$  to  $\frac{1}{2}$  inch to each side of on-axis) are recommended for robust detection and to allow for misalignment in setup. When two scans are used, the scanning algorithm should allow for, and correctly detect, a wafer that is seen on only one of the two scans. Working angle information may be found on page 17.

The EX-73Q, EX-83Q and EX-93Q sensors can detect flatted wafers if multiple scans are used. For further information on offsets and multiple scans contact CyberOptics Semiconductor Technical Support at 800-366-9131 for the working angle specifications to calculate the number and positions of scans required.

## 7.7 ALGORITHMS

The EX-Q wafer mapping sensor is a component in a complete wafer mapping system and the algorithms used for wafer mapping have a great effect on the robustness of wafer detection. This is particularly true in detecting cross-slotted or ultra-thin wafers and wafers with a wide dynamic range of wafer coatings. When writing wafer mapping algorithms or adjusting wafer mapping algorithm parameters a number of items should be considered to assure optimal wafer maps.

- 1) Ensure the sensor is properly aligned and calibrated to the wafers in the Z-axis. Algorithms will often compare the measured wafer position to a predetermined position range and use that comparison to predict a cross-slot error.
- 2) Check the robot speed and calculate whether the minimum on-time of the sensor will affect the measured positions of the wafers. This is usually only a factor with robots or loaders traveling at speeds in excess of 5 inches per second.
- 3) Make sure that the robot is following the proper path. Ensure the distance, offset, and alignment are correct when the robot is running.
- 4) Verify that the configurable algorithm parameters are set for an optimum map. For example, if during initial test scans correctly positioned wafers are detected as false cross-slots, then the error threshold parameter should be checked to verify that enough space is designated for the positioning of a normal wafer.
- 5) Verify that the algorithm has dropout filtering implemented. For more information on dropout filtering refer to the CyberOptics Semiconductor's "Dropout Filter Technote."

The design of algorithms that are intended to detect cross slotted wafers must consider the geometry of wafer slots and scan position. With two or more scans, wafer slope can be determined and used as part of cross slot detection. With a single scan, only the detected position can be used, and scanning near the side of the carrier may not provide sufficient positional differentiation for reliable cross slot detection. In such cases scanning should be done within about the center 1/3 of the carrier width.

## 8.0 CLEANING & MAINTENANCE

If EX-Q sensors are kept in a clean environment no maintenance is required. Because of the precise laser beam control in EX sensors, performance can be degraded by human contact to the lens, or by dust and debris. Keep sensor in its plastic bag until the sensor is ready for installation.

### **Warning:**

- *Any contact with the lenses could result in severely degraded optics performance.*
- *Do not attempt to clean laser lens.*
- *If you have any questions please contact CyberOptics Semiconductor Technical Support.*

## 9.0 TROUBLESHOOTING

Symptom	Possible Cause	Possible Solution
Laser ON light (RED Led) does not turn on.	The power to sensor is not connected.	Check the power source and connections on the power lines.
	Sensor is in remote ON mode without remote enable control.	Check the Remote Selector switch to make sure it is in the proper position for your application.
	Component failure.	If the above troubleshooting steps do not lead to resolution of the problem, contact CyberOptics Semiconductor Technical Support for further assistance and possible RMA.
Object OUT light (Green Led) is constantly on or constantly off.	The Detection Mode Switch (Light On/Dark On) is in the incorrect position.	Switch the Detection Mode Switch to the correct position. Refer to Section 5.2.1 for more details.
False "cross-slot" events or abnormally thick wafer measurements.	Robot may be moving too fast.	Try slower robot speed.
	Robot may be improperly taught.	Reteach robot for proper Z, Radius and Theta position.
	Software algorithm on the robot or load port may be creating the cross slot.	Map the first wafer position (bottom wafer) according to SEMI.
	The error threshold value in the mapping algorithm is set too small.	Increase the threshold (the area which represents a normally positioned wafer within a FOUF or cassette.)
	Interrupts or Dropouts may be occurring.	Verify that Dropout filtering is present in software. Refer to the technote "Dropouts and Algorithm Filters" for further details.
	Ultra-thin wafer may be sagging so front edge of wafer is lower than expected.	Set up software to accommodate sagging wafers.
	Gain is set too high.	Verify the gain setting is correct. Contact tech support with questions.

## 9.0 TROUBLESHOOTING (continued)

Symptom	Possible Cause	Possible Solution
False "cross-slot" events or abnormally thick wafer measurements. (continued)	Software parameters may be conflicting.	Obtain dump of "raw" sensor data and contact CyberOptics Semiconductor Technical Support for further assistance.
	Contaminated lens.	Contact CyberOptics Semiconductor Technical Support.
Sensor does not detect some wafers.	The standoff distance, or working angle, are outside the range specified for the sensor.	Check for the correct standoff distance and working angle. Refer to Section 3.0.
	Robot may be improperly taught.	Reteach robot for proper Z, Radius and Theta position.
	Software may not be properly configured.	Correct software setups.
	Wafers have non-standard characteristics that cause them to have low reflectivity	Contact CyberOptics Semiconductor Technical Support for proper gain adjustment.
Not detecting real "cross-slot" events.	Software thresholds are not properly set.	Correctly set software thresholds
	Robot not properly taught.	Reteach robot for proper Z, Radius, and Theta position.
Occasional or sporadic occurrence of unknown mapping errors, obvious erratic sensor behavior.	Intermittent disconnect in the wiring to the sensor.	Check, repair wiring or connectors.
	Faulty ground wire causing sensor and robot case to act as signal return.	Repair ground wire or connector.

## 10.0 EX-Q SENSOR OPTIONS

Option	Description	Part # Nomenclature
<b>Laser Enable</b>	The laser enable circuitry is connected internally through a 10k resistor to +VIN. Pulling this line to ground activates the sensor.	
<b>Positive</b>	Allows the laser enable circuitry to be activated by pulling the enable line to +VIN instead of ground.	P
<b>Flush-mount LED</b>	Replaces the standard LEDs that protrude from the case with low-profile LEDs that are flush with the case surface. This option is used in situations where space is constrained or LED damage is concerned.	M
<b>Pull-up Resistor</b>	The output signal is connected inside the sensor to the open drain of a MOSFET transistor. The drain must be connected through a pull-up resistor to a source of positive voltage (+5 to +24 volts). If the internal pull-up resistor option is ordered, an internal 10k resistor is connected to the collector output and no external resistor is required.	U
<b>Special Connector</b>	A connector that is added to increase ease of installation at the user's facility. Customer specifies the connector part number and desired pin-out of the connector and length of cable. Note: the C in the part number nomenclature indicates a connector is installed. Each customer ordering a custom connector will have their own two digit connector designation. Standard sensor is shipped with the cable unterminated, 16" long.	-Cxx
<b>Minimum Output Pulse</b>	Sets the minimum output pulse width in order to accommodate slower interfaces so that the interface circuit will always detect the pulse. The minimum output pulse width can be set to 1 ms or 10 ms. The default is 5 ms, which is appropriate for most applications.	-01 -10

Note: Ambient Light Filter (A) and Internal Resistor (I) are not available as option for EX-Q wafer mapping sensors, they are incorporated in the standard product.

## 11.0 COMPLIANCE DOCUMENTATION

# Declaration of Conformity

**Manufacture:** CyberOptics Semiconductor Inc.  
10220 SW Nimbus  
Suite K5  
Portland, Oregon  
97223 USA

**Declares the Product:** Wafer Sensor Products

**Product Model(s):** EX-43-XX  
EX-73-XX  
EX-83-XX  
EX-93-XX


Where XX corresponds to any and all suffix designations indicating product options.

**Complies With:** Laser Safety Classification 1

**Compliance Standards:** EN-60825-1

Safety of laser products,  
Equipment classification requirements

By



George Fabel  
President / CEO

On Nov. 13, 2002

# 11.0 COMPLIANCE DOCUMENTATION (continued)

## SEMI™ Standards

### RELATED INFORMATION 9

#### LASER CHECKLIST

NOTE: This related information is not an official part of SEMI S2 and was derived from practical application by task force members. This related information was approved for publication by vote of the responsible committee on October 21, 1999.

Laser Manufacturer:	CyberOptics Semiconductor
Model #:	EX-43, EX-73, EX-83, EX-93
Serial #:	
Laser Hazard Classification: (During Operation)	
1. Classification Number (e.g. 1, 2, 3a, 3b, 4):	Class 1 (all models)
2. Classification Standard(s) (e.g. FDA/CDRH, IEC, JIS, etc.):	FDA/CDRH (EX-43, EX-73 Accession #0120569-00: EX-83, EX-93 Accession #0120569-01)

NOTE R9-1: If any laser contained in the equipment is Class 2, 3a, 3b or 4 laser system or product, the vendor should make available upon request a hazard evaluation to include the following information for each laser in the equipment (where applicable):

#### Laser Parameters

1. Laser medium type (HcNe, Nd:YAG, CO <sub>2</sub> , Argon, Excimer, GaAs, etc.):	AlGaAs
NOTE: For Excimer lasers, specify gases:	
2. Wavelength(s) in nanometers (nm):	850nm
3. Continuous Wave	
A. Peak Power in Watts (W):	0.0012W (max)
B. Available Power in Watts (W):	0.0012W (max)
C. Irradiance in Watts/square centimeter (W/cm <sup>2</sup> ):	Not directly applicable
4. Pulse Characteristics	
A. Duration of Pulse in Seconds (s):	63 microseconds
B. Energy per Pulses in Joules (J):	0.075 microJoules (max)
C. Frequency of Pulses (Pulse Repetition Frequency) in Hertz (Hz):	8kHz
D. Average Power in Watts (W):	0.00060W (max)
E. Radiant Exposure in Joules/square centimeter (J/cm <sup>2</sup> ):	Not applicable
F. Q-Switch controlled pulses:	No
5. Beam Parameters	
A. Emerging beam diameter in millimeters (mm):	6 x 4.5mm
B. Expanded beam diameter in millimeters (mm):	Not applicable - beam expands continuously
C. Beam divergence in milliradians (mr):	EX-43 105mr (horiz) x 118 (vert) EX-73 178mr (horiz) x 80mr (vert) EX-83 118mr (horiz) x 59mr (vert) EX-93 140mr(horiz) x 39mr (vert)
D. Collecting optics type:	None
E. Focal length in millimeters (mm):	EX-43 - 38.1mm, EX-73 - 55.9mm, EX-83 - 76.2mm, EX-93 - 114.3mm



CyberOptics Semiconductor  
13555 SW Millikan Way  
Beaverton, OR 97005  
Phone: 800-366-9131 503-495-2200  
Fax: 503-495-2201  
E-mail: [CSsupport@cyberoptics.com](mailto:CSsupport@cyberoptics.com)  
Web: <http://www.CyberopticsSemi.com>