EX Wafer Mapping Sensors
Instructions for Installation and Use

For use with

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

CYBEROPTICS® SEMICONDUCTOR

CAUTIONS:

The semiconductor laser used in EX wafer mapping sensors generates Class 1 invisible laser radiation. 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.

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

Careful installation and adjustment 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 I
Laser Product

Class 1 Laser Product Label

Technical Support

A dedicated technical support group is available to answer your questions Monday through Friday, 8 a.m. - 5 p.m. (PST).

Call toll-free **1-800-366-9131, or call 503-495-2200**
E-mail **CSsupport@cyberoptics.com**
Fax **503-495-2201**

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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 Wafer Mapping Sensors are general purpose wafer mapping sensors excel at detecting even the most difficult to detect dark or coated wafers. EX 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 sensor features include

EX-43

- Excels at detecting dark or coated wafers
- Laser transmitters and receivers fine-tuned for maximum sensitivity while still maintaining Class 1 status (CDRH)
- Reliably detects cross-slotted and ultra-thin (< 0.3mm) wafers
  - Thin laser stripe (0.15mm) 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 fluorescent 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 stand-off distances
  - EX-43   1.5"
  - EX-73   2.2"
  - EX-83   3.0"
  - EX-93   4.5"
- Non-intrusive wafer mapping solution protects valuable wafers from inadvertent crashes
- No mechanically moving parts that can result in unwanted contamination

2.0 DIMENSIONS

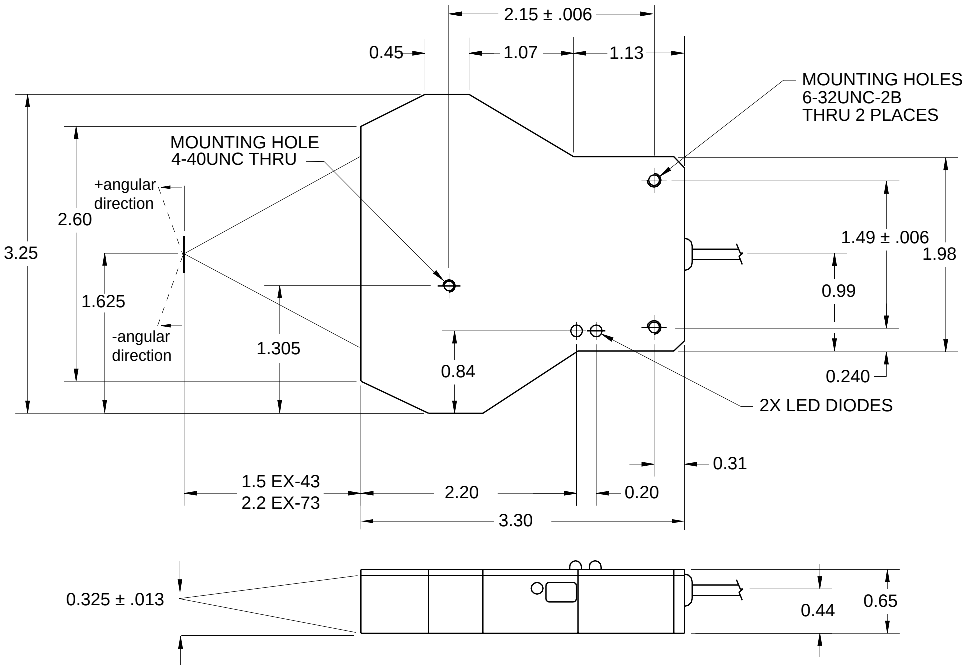

Figure 1 - EX Sensor Dimensions (inches)

Note: this drawing is accurate for EX-43 and EX-73 sensors, please contact CyberOptics Semiconductor for information regarding the EX-83 and EX-93

3.0 Specifications

	EX-43	EX-73
Method of detection	Dual Wide Beam	
Optimum detecting distance	1.5"	2.2"
Maximum detecting range	1.3" to 1.7"	1.9" to 2.5"
Supply voltage	12 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 0.450 mW max.	
at CDRH aperture	0.065 mW max.	
Laser class	Class 1 (CDRH)	
Detectable objects	Transparent, opaque and mirror-surfaced objects	
Laser spot size	10mm x 0.15mm	
Angular coverage	± 23 degrees relative to the sensor front surface	± 13 degrees relative to the sensor front surface
Sensitivity adjustments	1.) HI GAIN/LO GAIN switch, 2.) 16-position sensitivity switch	
Operation	Light-ON/Dark-ON switch	
Response time	ON delay 400-μs max., OFF delay 5ms min.	
Indicator	Laser power - RED led, Signal OUT - GREEN led	
Control output	NPN open collector, 80mA max @24VDC.	
Connections	16", 4 conductor cable	
Temperature limits	Operating: 32 to 110ºF (0 to 45ºC) Storage: -20 to 130ºF (-30 to 55ºC)	
Materials	Lens: glass, plastic; Case: aluminum	
Weight	4.3 oz (122g)	

For specifications for the EX-83 and EX-93 please contact CyberOptics Semiconductor.

4.0 INSTALLATION

4.1 Unpacking

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

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4.2 QUICK START PROCEDURE

This quick start procedure is to be used to check for proper wiring and operation. This is the most common setup and wiring for EX sensors.

This is only a typical setup. If the sensor is being used as a replacement sensor on a piece of equipment, refer to the manual for that piece of original equipment and use the wiring and switch positions recommended for the sensor.

1) Set DIP switches on the side of the sensor to the following positions.
    1) Gain set to high
    2) Output signal polarity: Light ON
    3) Remote Enable: OFF

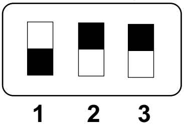

Figure 2 - DIP Switch Settings

2) Wiring Instructions
    A) Red wire +12V to +24V
    B) Black wire to Ground
    C) Green wire is the output, Open collector, NPN. Connect Green wire through pull-up resistor R1 (10K, typical) to +V. 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 OFF. 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.

4.2 QUICK START PROCEDURE (cont.)

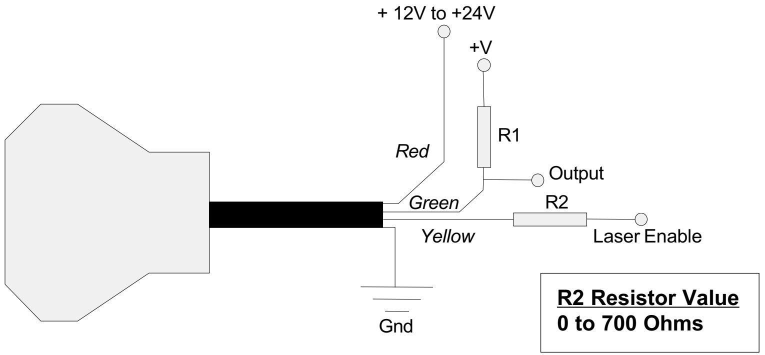

Figure 3 - Typical Connection

3) Apply power to the sensor.
   Response:
   Red LED Illuminates
   Wave hand in front of sensor and the Green LED will illuminate.

4.3 Mechanical Installation Overview

- Refer to Section 2.0 for dimensional drawing with proper mounting hole alignment.
- Refer to Section 7.3 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 whenever an object is present; in the DARK ON mode, whenever it is absent.

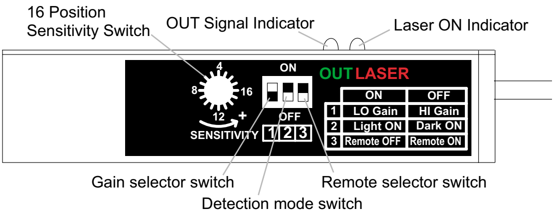

Figure 4 - Indicators & Controls

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

EX sensors have two gain (sensitivity) modes – the down position selects the HIGH GAIN range. The up position selects the LOW GAIN range. The gain ratio between HIGH and LOW is approximately 54 to 1.

5.2.2 DETECTION MODE SWITCH (LIGHT ON/ DARK ON)

In LIGHT ON (up position) detection mode, the OUT signal will be triggered when an object is present within the detecting range and reflected light pulses are detected in the receiver. In DARK ON (down position) detection mode, the output signal is triggered 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 (up position) mode, the laser starts to emit radiation approximately 150ms after applying power to the sensor and is ready to detect the presence of an object. In this mode, there is no need for controlling the LASER ENABLE input signal.

In REMOTE ON (down position) mode (after the power-up sequence), the sensor is switched to standby mode with the laser radiation controlled by the LASER ENABLE input signal. This method should be used in an application requiring a small delay (max. 30ms) between enabling the laser and measuring the signal.

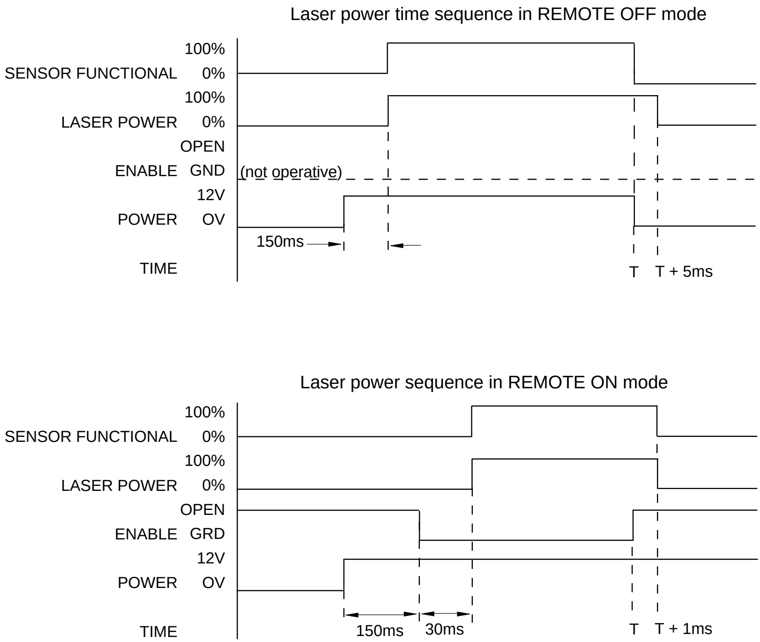

Figure 5 - Remote Timing

5.2.4 SENSITIVITY ROTARY SWITCH

The sensitivity rotary switch allows the user to adjust the gain of the sensor in small repeatable steps from the highest gain to a gain more than three decades lower. The sensitivity rotary switch (16 positions) works in combination with the gain selector switch (2 positions). The table below shows how the gain varies as the gain selector and sensitivity rotary switch positions are varied.

Rotary switch position	HIGH GAIN	LOW GAIN
	Relative gain	Relative gain
16	7100	130
15	5700	110
14	4700	86
13	4200	78
12	3000	55
11	2100 - **Note 2**	39
10	1600	30
9	1300	25
8	1000 - **Note 1**	18
7	720	13
6	580	11
5	480 - **Note 3**	8.8
4	360	6.7
3	260	4.9
2	200	3.8
1	170	3.1

Table A - Sensitivity Rotary Switch and Gain

Note 1. Factory set point – best general purpose gain setting for most wafer types

Note 2. Recommended initial gain setting for 200-mm diameter wafers with mixtures of uncoated and dark coated wafers. Also for ultra-thin wafers.

Note 3. Recommended initial gain setting for 300-mm diameter wafers with mixtures of uncoated and dark coated wafers

The EX sensor is factory set to a sensitivity switch position 8 and the gain selector switch in HIGH GAIN. This is the best general purpose gain setting for most wafer types. The EX will detect wafers that vary by more than 3 decades in reflected edge signal. To ensure optimum wafer detection, use the highest gain that still avoids false cross slots. Since 300 mm wafers are thicker and return more signal, the gain can be set slightly lower for these wafers. (Note 3) If only 200 mm wafers or ultra-thin wafers will be scanned, the gain can be set higher (Note 2). In general as the gain setting increases, the apparent width of wafers will also increase.

The settings in the above table should be the starting point in the initial setup of the wafer mapper on a robot. To further optimize performance refer to Section 7.1.

5.3 CONNECTIONS *(See Figure 6)*

5.3.1 +VIN (POWER INPUT) (RED WIRE)

EX sensors can operate with the input voltage between +12 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.

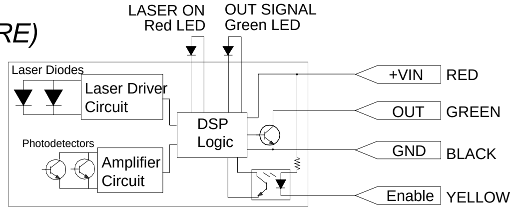

Figure 6 - Wiring Connections

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 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 or ground connection.

5.3.3 OUT (SENSOR OUTPUT) (GREEN WIRE)

The output connection is connected inside the sensor to the open collector of an NPN transistor. The collector must be connected through a pull-up resistor *(See Figure 3)* to a source of positive voltage (+12 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.

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

The laser enable circuitry is connected internally through a 10.8k ohm resistor to +VIN. If the remote selector switch is set to OFF (up position) the enable line will have no affect 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.

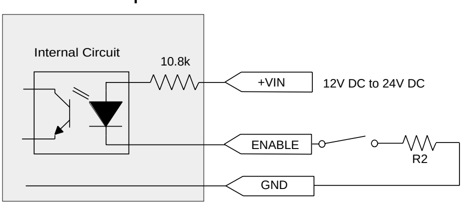

Figure 7a - Enable Input Signal, Standard

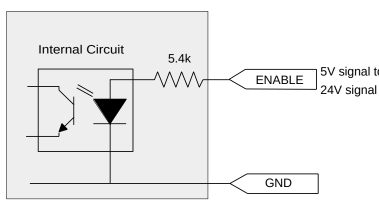

Figure 7b - Enable Input Singnal with Positive Enable Option

6.0 THEORY OF OPERATION

EX 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 (850nm) laser diodes in each EX-43 and EX-73 sensor. There is one laser diode in the EX-83 and EX-93 sensor. Each diode has an integral photodetector for control of the laser output over various operating temperatures. Each laser diode operates from a closed loop driver that modulates the laser at about 8KHz square wave with a 50% duty cycle. The modulation allows EX sensors to synchronously detect the return signal from the wafers and greatly increases the detector sensitivity and signal to noise ratio. 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.

The laser optics are identical for both lasers. The optics for the EX-43 and EX-73 are designed to create a laser spot at the focal point that is 10mm wide and 0.15 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 diodes used in EX sensors undergo rigorous life-testing at CyberOptics Semiconductor during the time of manufacture and should exceed the lifetime of any robot or tool with which the EX sensor is integrated.

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 from the phototransistor. The two receivers are on the opposite side of the sensor from the laser transmitters and only respond to light entering within a ± 15 degree angle from each telescope optical axis. The receiver and transmitter beams cross at a relatively high angle only at the target distance. Transmitter light that is reflected from somewhere other than a wafer at the target distance is very unlikely to be reflected back into the receiver telescopes at the required angle for collection. This makes EX sensors very insensitive to stray reflections from cassettes and FOUPS.

6.3 SIGNAL PROCESSOR

The signal processor subsystem in its simplified form has two inputs and one primary output. One input is the 8KHz square wave signal that drives the laser diodes. The other input is the output of the receiver subsystem. The signal processor looks at these two inputs and tries to find three sequential rising and falling pulse edges that match in the two inputs. When the processor finds three matching pulse edges it judges that a true wafer edge has been sensed and drives the output signal high. As long as transitions continue without interruption the signal will be active. When one pulse transition is missed the processor turns the output off and starts the detection process over. This algorithm discriminates against glint, dust, accidental exposure to another laser, and background radiation. All background light modulated at any other frequency, and at almost any intensity level, is ignored. Because the processor senses three sequential transitions before driving the output signal high, the sensor requires 400 microseconds to respond to a detection "event".

EX 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 5ms. Objects smaller than 5ms (in terms of the time in front of the sensor) will always generate an output pulse 5ms wide (as shown on Fig. 8 Object < 5ms). Larger objects will generate a pulse of the object width (Figure 8 Object > 5ms). This minimum output pulse width is factory preset to 5ms. As an option, an output pulse width of 1ms or 10ms is available.

To ensure maximum performance and stability of the sensor over the whole sensitivity range, EX sensors have indirectly proportional hysteresis. Using this unique technique, the sensor features almost zero hysteresis when operating in the highest sensitivity setting. However, hysteresis increases as sensitivity decreases.

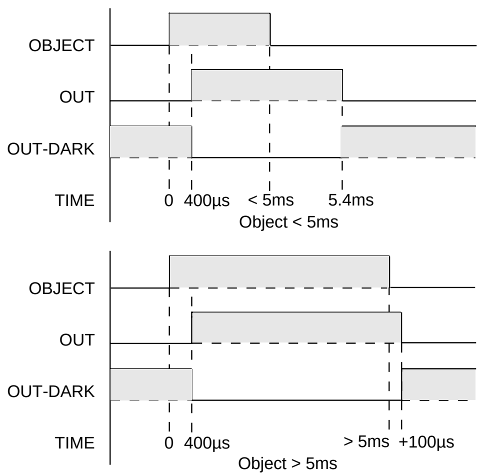

Figure 8 - Output Timing

7.0 GUIDELINES FOR SETUP AND USE

EX sensors are the most sensitive, easiest to use, robust wafer detection sensors ever developed by CyberOptics Semiconductor. The guidelines below will ensure best performance.

7.1 SENSITIVITY

For optimum detection, the EX sensor should be operated at the highest gain that avoids false cross slot signals. Refer to section 5.2.4 for guidance in the initial setting. With the most reflective wafers, if the initial setting produces false cross slot results , the gain should be decreased until the false signals cease and then the gain should be decreased by another two switch positions to ensure that there is sufficient head room to avoid false signals in the future.

If very dark wafers are not detected with the initial settings, the gain should be increased until these wafers are detected and then the gain should be increased by two switch positions to ensure head room.

Abnormal reflections from the backs of FOUPS or cassettes may cause false cross slot detections, decreasing the gain as previously described is recommended if the reflection cannot be avoided in some other manner.

7.2 AMBIENT LIGHT

EX sensors include an ambient light filter that blocks visible and some infrared light from the phototransistor. This eliminates any effects from normal fluorescent lights.

7.3 ALIGNMENT

To operate properly, EX sensors must be aligned to the wafers. The plane of the wafer and the plane of the sensor should be parallel to within ± 2 degrees. Misalignment larger than this will probably lead to the wafer handling system indicating wafer thickness larger than normal.

7.4 DISTANCE

The distance from the wafer to the sensor should be set for us at the "optimum detecting distance", as outlined in Section 3.0. EX sensors will perform sufficiently within their specified detecting range, however, the sensors performance are optimized for use at their specified optimum stand-off distance. **EX sensors may appear to operate outside of these detecting ranges, however, performance is severely degraded.**

7.5 OFFSET AND MULTIPLE SCANS

EX sensors can operate pointed either to the wafer center (on-axis), or off-axis. Most previously developed robot algorithms will work with the EX.

The EX-43 sensor will detect all standard semi flatted and notched wafers when scanning on-axis. However, two scans separated by 1/2 to 1 inch (each scan 1/4 to 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 be set up to require seeing the wafer on only one of the two scans. Angular coverage information may be found on page 4.

The EX-73, EX-83 and EX-93 sensors can detect flatted wafers if multiple scans are used. Contact CyberOptics Semiconductor for the angular coverage specifications to calculate the number and positions of scans required.

7.6 ALGORITHMS

The algorithms used in mapping have a great effect on the robustness of the detection. This is particularly true in the case of cross-slot detection. A number of items should be checked.

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 event.
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 a second.
3) Make sure that the robot is actually following the proper path. That is, ensure the distance, offset, and alignment are correct when the robot is running.

8.0 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 enable control.	Check the Remote Selector switch to make sure it is in the proper position for your application.
Object OUT light (Green Led) is constantly on or constantly off.	Gain switch or sensitivity switch not adjusted correctly.	Check Gain switch and adjust sensitivity switch (refer to Section 5.2.4).
Sensor is not responding to the object correctly.	Incorrect detecting mode.	Check the Detection Mode switch to make sure you are in the mode you want to be. Refer to Section 5.2.2 for more details.
False "cross-slot" events or abnormally thick wafer measurements.	Gain too high.	Decrease sensitivity switch. Refer to Section 7.1.
Sensor does not detect some wafers.	Sensitivity is set too low.	Refer to Section 7.1.
	Robot may be moving too fast past dark wafers with sharp edges.	Try slower robot speed.

Table B - Troubleshooting

9.0 CLEANING & MAINTENANCE

If EX 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 dust and dirt.

- Keep the sensor in its plastic bag until the sensor is ready for installation
- Inspect the lens surfaces before installation. If dust is apparent, blow off the dust with compressed gas
- If dirt appears on the lenses that cannot be removed by compressed gas, carefully wipe the lens surface with a clean lens tissue. Do not use liquid on the lens tissue

10.0 EX Sensor Options

Option	Description	Part # Nomenclature
Laser Enable	**Default** - Uses the yellow wire of the interface to turn the lasers ON with a 30-ms delay. Using this option allows the sensor to remain in standby mode when not scanning, thus reducing power consumption. The laser enable circuitry is connected internally through a 10k resistor to +VIN. Pulling this line to ground activates the sensor.	
Positive	Allows the laser enable circuitry to be activated by pulling the enable line to +VIN instead of ground.	P
Flush-mount LED	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 or LED damage is concerned.	M
Pull-up Resistor	The output signal is connected inside the sensor to the open collector of an NPN transistor. The collector must be connected through a pull-up resistor to a source of positive voltage (+12 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
Special Connector	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 is a place holder. Each customer ordering a custom connector will have there own letter designated in the part number. Standard sensor is shipped with the cable unterminated, 16" long.	-Cxx (xx in inches)
Minimum Output Pulse	Sets the minimum output pulse width in order to accommodate slower interfaces so that the interface camera will always see the pulse. The minimum output pulse width can be set to 1ms or 10ms. The default is 5ms, which is appropriate for most applications.	-01 -10

Table C - EX Sensor Options

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