

# OvationONS™ Laser Navigation Sensors

## Features

- Hardware resolution to 3200 cpi
  - Ability to maintain full resolution at speeds up to 50 ips
- Multiple resolution control modes, including:
  - Continuously variable resolution
  - Independent control of resolution in the x and y direction
- PC cursor speeds to 160,000 cps
- Market-leading 40 kHz positioning sampling rate
- Superior tracking performance
- Integrated single package 850 nm VCSEL and laser driver
  - No power calibration or optical alignment required
  - Fault-tolerant drive circuitry for Class 1 eye safety compliance
  - Improved ESD tolerance: 2 kV versus 200V typical for standalone laser
  - Self-aligning snap-on lens for ease of assembly
- Peripheral interface:
  - 4-wire SPI port
  - Native 16-bit x and y directional reports from the sensor
- Power:
  - Wide operating voltage range: 2.7V to 3.6V
  - Self-adjusting nap and sleep modes
  - Hibernate mode for USB suspend requirements

## Description

The OvationONS™ CYONS1001x laser navigation sensors are breakthrough solutions for wired and wireless mice, and precision motion-sensing applications. Built around Cypress Semiconductor's patented OptiCheck™ laser technology, these devices offer a variety of significant advantages.

Unlike any other laser-based sensor on the market today, the CYONS1001x sensors provide:

- the unique ability to maintain full resolution at speeds up to 50 inches per second (ips)
- low power consumption regardless of tracking speed or resolution
- an unprecedented 40 kHz positioning sampling rate



As a result, the CYONS1001x sensors deliver fast, precise, responsive tracking, without the trade offs between power and performance that characterize traditional image-correlation sensors.

Moreover, the CYONS1001x sensors are strategically designed to simplify assembly, reduce manufacturing costs, and improve yield. The sensor IC, vertical-cavity surface emitting laser (VCSEL), and laser driver are integrated in a single 8x8 QFN package with a self-aligning snap-on lens. Laser output power is calibrated before shipment to meet eye-safety standards. Consequently, there is no need for laser handling, laser power calibration, or optical alignment.

Five versions of the CYONS1001x sensor are available, each with features designed for its target application. Optimized for gaming and other specialized high-performance applications, the CYONS1001U, CYONS1001G, and CYONS1001 combine unrivalled effective cursor speeds with continuously variable resolution to 3200 counts per inch (cpi) and independent resolution control in the x and y directions. The general purpose CYONS1001L and CYONS1001T, designed for desktop mouse and trackball applications, support two self-adjusting power down modes for extended battery life.

All CYONS1001x sensors provide maximized counts per second, minimized latency to motion changes, and optimum signal quality in the detection of laser-speckle signatures over a wide range of surfaces, offering users the ultimate experience of fast, precision tracking.

**Table 1. OvationONS CYONS1001x Laser Navigation Sensors**

| Parameter                                     | CYONS1001U | CYONS1001G | CYONS1001  | CYONS1001L         | CYONS1001T   |
|---|------------|------------|------------|--------------------|--------------|
| Maximum resolution                            | 3200 cpi   | 2800 cpi   | 2400 cpi   | 1200 cpi           | 1150 cpi     |
| Maximum speed                                 | 50 ips     | 50 ips     | 45 ips     | 20 ips             | 20 ips       |
| Resolution control                            | Continuous | Continuous | Continuous | 400, 800, 1200 cpi | 50 cpi steps |
| Maximum cursor speed                          | 160,000    | 140,000    | 120,000    | 24,000             | 23,000       |
| Maximum position sampling rate                | 40 kHz     | 40 kHz     | 40 kHz     | 40 kHz             | 40 kHz       |
| Acceleration                                  | 10G        | 10G        | 10G        | 8G                 | 8G           |
| All sensors sold with the CYONSLENS1001 lens. |            |            |            |                    |              |

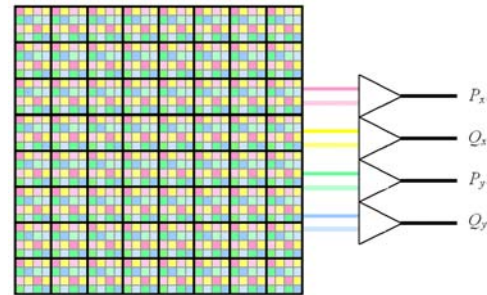
## Applications

- CYONS1001U and CYONS1001G are the ideal solutions for high speed, high performance gaming mouse applications.
- CYONS1001 is designed to enable high precision and high accuracy tracking performance. The device is ideal for industrial control, noncontact digital measurement tools, graphics design peripherals, and other high precision motion-sensing applications.
- CYONS1001L is designed for desktop and mobile mouse applications.
- CYONS1001T is an elegant solution for low power, high precision trackball applications.

## OptiCheck™ Technology

The OvationONS sensors use Cypress Semiconductor’s patented OptiCheck technology — a fundamentally different approach to laser navigation sensing. Instead of image capture and correlation, OptiCheck uses an “Optical Checkerboard” or array of light-sensitive elements connected in a patented, 2D comb detector configuration<sup>1</sup>. The outputs of the detector are amplified and combined in a unique arrangement to form four data outputs that completely describe the motion of the sensor. These four outputs are digitized and sent to a small digital signal processor to generate x and y location displacement data. Figure 1 shows the interconnection of the comb detector elements and the resulting four outputs.

Figure 1. OptiCheck Optical Checkerboard



There are three key advantages to the OptiCheck approach:

- First, power consumption does not increase with an increase in tracking speed. OptiCheck requires only four data inputs to calculate x and y displacement, compared to the hundreds of inputs typically required for image correlation. OptiCheck therefore provides a much more efficient calculation. This increase in efficiency means the signal processing blocks have a negligible impact on power consumption, resulting in a system where current draw is nearly independent of speed.
- Second, tracking speed is independent of resolution. OptiCheck’s processing requirements are independent of sensor resolution. This enables simpler and lower cost scaling for products that require both high speed and high resolution tracking performance.
- Third, the unique signal processing method employed by OptiCheck sensors enables continuously variable native resolution in the x and y directions independently. This unique capability offers application designers immense flexibility and freedom.

**Note**

1. U.S. Patent No. 7,138,620, entitled “Two-dimensional Motion Sensor”, describes aspects of this technology.

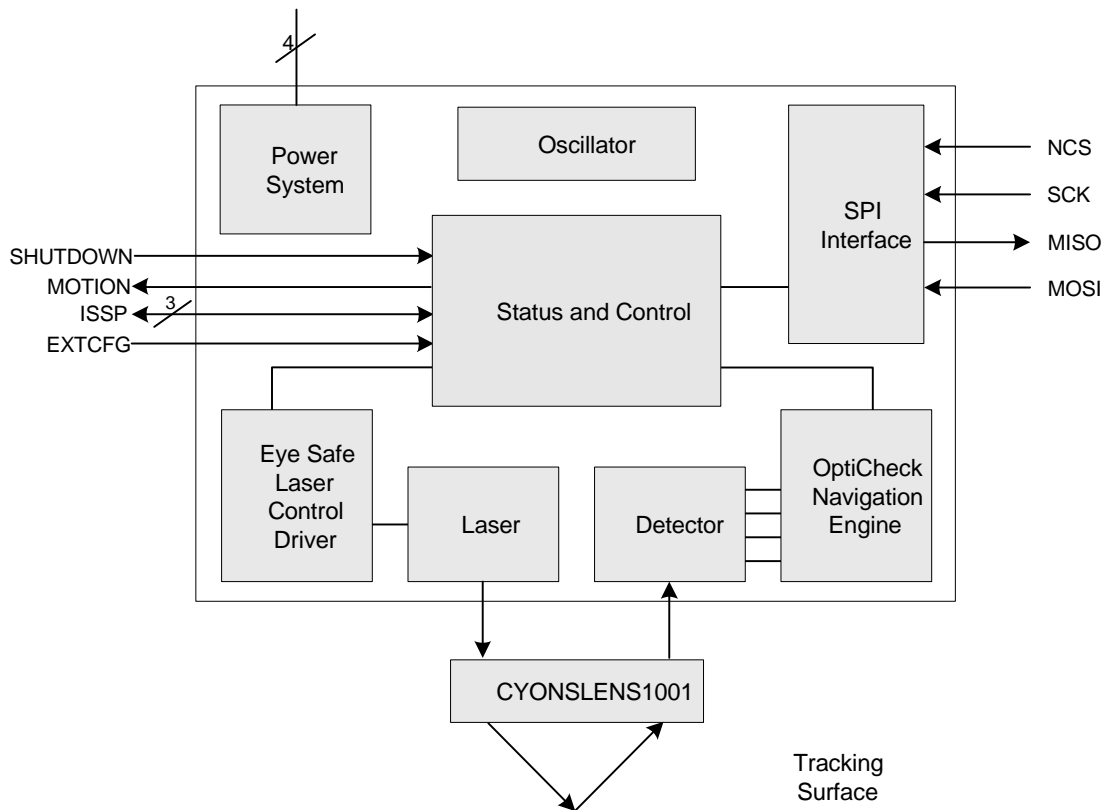
## Functional Description

The CYONS1001x sensor is a two piece solution: a sensor IC and VCSEL in an 8x8 QFN package, and a self-aligning snap-on lens. The optical system consists of a precision aperture and an optical lens. Laser speckle signals are processed by the optical system and transferred to the detector for signal processing.

In addition to an integrated optical detector and signal processor, the CYONS1001x sensor package includes integrated laser driver circuitry and laser fault detection circuitry for IEC/EN 60825-1 Class 1 eye safety compliance. An on-chip oscillator provides system timing without the need for an external crystal.

## Logic Block Diagram

Figure 2. CYONS1001x Block Diagram



Pinouts

Figure 3. CYONS1001x Package Pinout

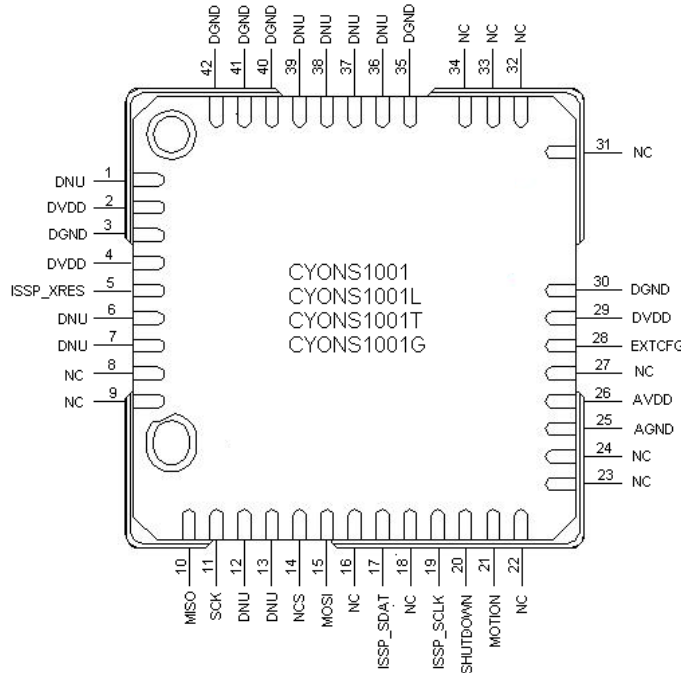


Table 2. CYONS1001x Pin Description

| Pin Number                                   | Signal Name                | Type   | Number of Pins | Function                                |
|--|----------------------------|--------|----------------|---|
| 14   | NCS                        | I      | 1              | SPI chip select                         |
| 11   | SCK                        | I      | 1              | SPI serial clock input                  |
| 10   | MISO (Master In/Slave Out) | O      | 1              | SPI output                              |
| 15   | MOSI (Master Out/Slave In) | I      | 1              | SPI input                               |
| 20   | SHUTDOWN                   | I      | 1              | Enter hibernate mode                    |
| 21   | MOTION                     | O      | 1              | Motion detect; active HIGH output       |
| 28   | EXTCFG                     | I      | 1              | External configuration for factory test |
| 26   | AVDD                       | Power  | 1              | Analog supply voltage                   |
| 2,4,29                                       | DVDD                       | Power  | 3              | Digital supply voltage                  |
| 25   | AGND                       | Ground | 1              | Analog ground                           |
| 3, 30  | DGND                       | Ground | 2              | Digital ground                          |
| 1, 6, 7, 12, 13, 36, 37, 38, 39              | DNU                        |        | 9              | Do Not Use                              |
| 8, 9, 16, 18, 22, 23, 24, 27, 31, 32, 33, 34 | NC                         |        | 12             | No connect                              |
| 35, 40, 41, 42                               | Tie to DGND                |        | 4              | Must be connected to DGND               |
| E-PAD (case bottom)                          | DGND                       | Ground | 1              | Digital ground                          |
| 19 <sup>[2]</sup>                            | ISSP_SCLK                  | IO     | 1              | ISSP serial clock                       |
| 17 <sup>[2]</sup>                            | ISSP_SDAT                  | IO     | 1              | ISSP serial data IO                     |
| 5 <sup>[2]</sup>                             | ISSP_XRES                  | IO     | 1              | ISSP reset drive                        |

Note

2. Pins 5, 17, and 19 are solely for in-system firmware upgrades.

## Technical Specifications

**Table 3. Absolute Maximum Ratings**

| Parameter               | Min  | Typ | Max            | Unit | Notes   |
|-------------------------|------|-----|----------------|------|---|
| Storage temperature     | -40  |     | 85             | °C   | Case temperature                                  |
| Operating temperature   | -15  |     | 55             | °C   | Case temperature                                  |
| Lead solder temperature |      |     | 260            | °C   | 3 cycles with 20 second dwell at peak temperature |
| Supply voltage          | -0.5 |     | 3.7            | V    |   |
| ESD                     |      |     | 2              | kV   | All pins, HBM MIL 883 method 3015                 |
| Input voltage           | -0.5 |     | $V_{DVDD}+0.5$ | V    |   |
| Latch up current        |      |     | 100            | mA   |   |

**Table 4. Operating Conditions**

| Parameter                             | Min   | Typ   | Max   | Unit   | Notes  |
|---------------------------------------|-------|-------|-------|--------|--|
| Operating temperature                 | 5     |       | 45    | °C     | Operation beyond this range may cause laser to exceed Class 1 limits |
| Power supply voltage                  | 2.7   |       | 3.6   | V      | Operation beyond this range may cause laser to exceed Class 1 limits |
| Power supply rise time                | 100   |       |       | µs     |  |
| Supply noise – AVDD (sinusoidal)      |       |       | 25    | mV p-p | 10 kHz–50 MHz  |
| Supply noise – DVDD (sinusoidal)      |       |       | 100   | mV p-p | 10 kHz–50 MHz  |
| Serial port clock frequency           | 0.5   |       | 2.0   | MHz    | Active drive, 50% duty cycle   |
| Distance from PCB to tracking surface | 12.53 | 12.78 | 13.03 | mm     | Deviation from nominal adversely impacts lift detection and tracking |
| Load capacitance                      |       |       | 100   | pF     | MOTION, MISO   |

**Table 5. DC Electrical Characteristics**

At 25°C, 3.3V unless otherwise specified

| Parameter                    | Min            | Typ  | Max  | Unit | Notes   |
|------------------------------|----------------|------|------|------|---|
| DC current in tracking mode  |                | 13.5 | 15.5 | mA   | Full speed motion                               |
| DC current in nap mode       |                | 3.0  | 4.5  | mA   | After 4 seconds of inactivity                   |
| DC current in sleep mode     |                | 375  | 550  | µA   | After 30 seconds of inactivity                  |
| DC current in hibernate mode |                | 45   | 70   | µA   | After receiving SHUTDOWN signal from controller |
| Input low voltage            |                |      | 0.8  | V    |   |
| Input high voltage           | $0.7V_{DVDD}$  |      |      | V    |   |
| Input hysteresis             |                | 100  |      | mV   |   |
| Input leakage current        |                | ±1   | ±10  | µA   | MOSI, NCS                                       |
| Output low voltage           |                |      | 0.7  | V    | MISO, MOTION                                    |
| Output high voltage          | $V_{DVDD}-0.7$ |      |      | V    |   |
| Input capacitance            |                |      | 10   | pF   | MOSI, NCS                                       |

**Table 6. AC Electrical Characteristics**

At 25°C, 3.3V unless otherwise specified

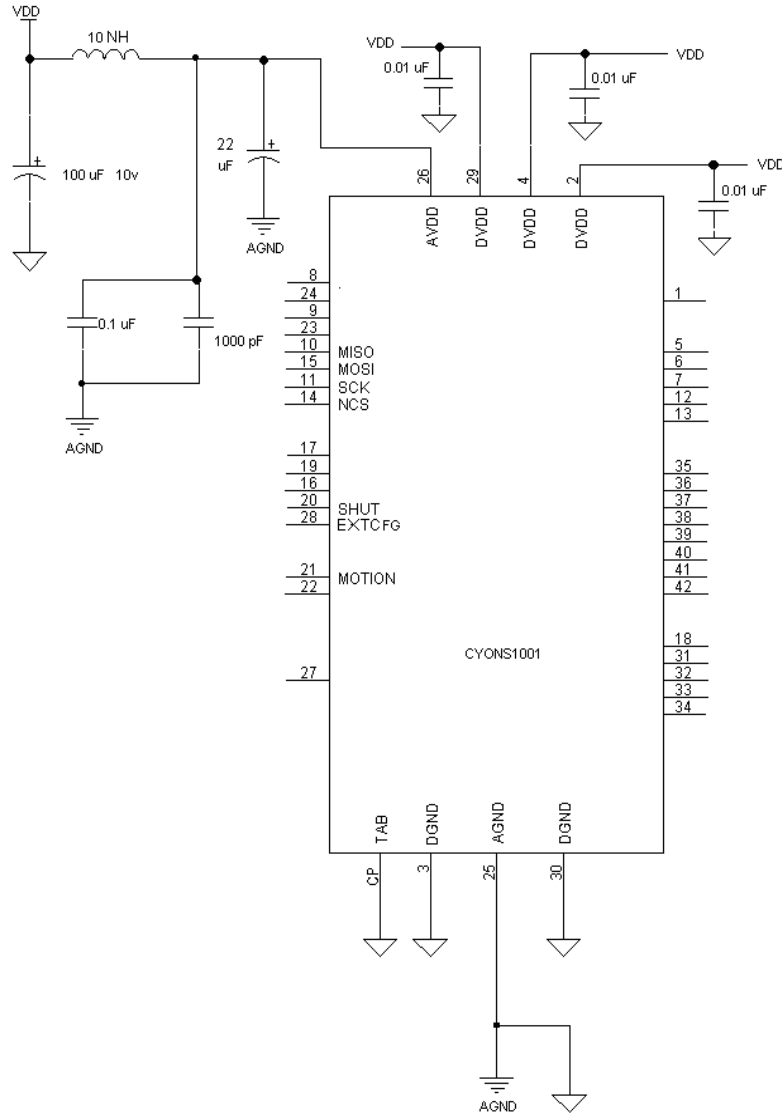
| Parameter  | Min       | Typ | Max | Unit     | Notes   |
|--|-----------|-----|-----|----------|---|
| Reset delay  |           |     | 100 | ms       |   |
| Hibernate  |           |     | 10  | ms       | From SHUTDOWN high to low current                                       |
| Wake from hibernate  |           |     | 20  | ms       | From SHUTDOWN low to normal operation                                   |
| MISO rise time   |           | 150 | 300 | ns       | 100 pF load   |
| MISO fall time   |           | 150 | 300 | ns       | 100 pF load   |
| MISO delay after SCK   |           |     | 120 | ns       |   |
| MISO hold time   | 0.5       |     |     | μs       |   |
| MOSI hold time   | 200       |     |     | ns       |   |
| MOSI setup time  | 120       |     |     | ns       |   |
| Delay between SPI commands   |           |     |     |          |   |
| after write command<br>$t_{CMD\_1}$                                  | 30        |     |     | μs       | Falling edge of SCK to rising edge of SCK for next command              |
| after read/burst read command<br>$t_{CMD\_2}$                        | 300       |     |     | μs       | Falling edge of SCK to rising edge of SCK for next command              |
| Delay within SPI commands  |           |     |     |          |   |
| after command byte<br>$t_{SPI\_DELAY\_1}$                            | 400       |     |     | μs       | All commands  |
| between data bytes<br>$t_{SPI\_DELAY\_2}$                            | 20        |     |     | μs       | Burst read command  |
| from addr to data byte<br>$t_{SPI\_DELAY\_3}$<br>$t_{SPI\_DELAY\_4}$ | 20<br>100 |     |     | μs<br>μs | End of addr byte to start of data byte<br>Write command<br>Read command |
| NCS setup time - $t_{NCS\_SU}$                                       | 120       |     |     | ns       | All commands  |
| NCS hold time - $t_{NCS\_HOLD}$                                      | 500       |     |     | ns       | All commands  |
| NCS to MISO high Z   |           |     | 20  | μs       | 5 pF load, Thevenin load  |
| MOTION rise time   |           | 150 | 300 | ns       | 100 pF load   |
| MOTION fall time   |           | 150 | 300 | ns       | 100 pF load   |

## Power and Ground Interface

The CYONS1001x sensors are powered by a single 2.7–3.6V power supply. Two external components are required to isolate the analog and digital sections of the sensor and ensure proper analog power supply ramp time: a 22  $\mu\text{F}$  capacitor and a 10 nH inductor. Place decoupling capacitors at all power pins as close to the pin as possible.

Figure 4 shows the recommended power and ground circuitry. Note that to meet laser safety requirements, the power supply voltage supplied to the sensor circuit must meet the operating conditions requirements specified in this document. Additionally, increasing the laser output power by any other means (hardware, firmware, or otherwise) can result in a violation of the Class 1 safety limit.

Figure 4. Recommended Power and Ground Circuitry



## Power Management

The CYONS1001x sensors are equipped with power management features designed to meet the needs of their target applications. The CYONS1001L and CYONS1001T sensors, which target general purpose tracking applications such as wireless mice, offer two power saving sleep modes that extend battery life, and an ultra low power hibernate mode that is used to meet USB suspend requirements. The CYONS1001, CYONS1001G, and CYONS1001U sensors are optimized for high performance applications that require fast response at all times; therefore, these devices only support hibernate mode.

The operational modes supported by the CYONS1001x sensors are summarized in [Table 7](#). The current consumption of each mode is listed in [Table 5](#) on page 5.

**Table 7. Summary of CYONS1001x Operational Modes**

| Mode      | CYONS1001, 1001G, 1001U | CYONS 1001L, 1001T |
|-----------|-------------------------|--------------------|
| Tracking  | Yes                     | Yes                |
| Nap       | No                      | Yes                |
| Sleep     | No                      | Yes                |
| Hibernate | Yes                     | Yes                |

### Tracking Mode

In tracking mode, the sensor is in motion and tracking x/y changes. Tracking mode consumes the most power, with fast motion drawing slightly more current than slow motion. After approximately 4 seconds of inactivity, the sensor automatically switches to nap mode.

### Nap Mode

In nap mode, the sensor can detect gross motion. If motion is detected, the sensor switches to tracking mode within 20 ms. If motion is not detected for 30 seconds after entering nap mode, the sensor automatically switches to sleep mode.

### Sleep Mode

In sleep mode, the sensor can also detect gross motion. If motion is detected, the sensor enters tracking mode within 250 ms. If motion is not detected, the sensor remains in sleep mode indefinitely.

### Hibernate Mode

The controller can place the sensor in hibernate mode by asserting the SHUTDOWN pin. In this state, the sensor cannot detect motion, and can only be activated by resetting the SHUTDOWN pin to LOW. Startup time from hibernate mode to full tracking capability is 20 ms max.

### Passive Power Management

The CYONS1001L and CYONS1001T sensors are ideal for passive power management. Unlike other laser sensors, these devices control their own low power modes, freeing the application designer from concerns about power minimization. No additional firmware is required to take advantage of their self-adjusting power-saving nap and sleep modes.

### Active Power Management

For applications requiring further power reduction, mouse firmware can use the SHUTDOWN and MOTION pins to implement active power management. This means the controller actively switches the sensor between tracking and hibernate modes to reap the benefit of low current draw during hibernate mode.

A typical requirement for a mouse is that mouse movement must be able to wake the system from a low power operating state. Though the sensor is unable to detect motion in hibernate state, firmware can be designed to periodically check for motion by temporarily bringing the sensor out of hibernation. A recommended approach to active power management is as follows:

1. Choose a motion-check period, such as once per second. Longer periods save more power, but also result in longer delays in detecting motion.
2. Assert the SHUTDOWN pin to put the sensor in hibernate mode.
3. At the start of each motion-check period, deassert the SHUTDOWN line, then wait until the sensor sets the MOTION line high (20 ms or less).
4. Send two read tracking data commands to the sensor, ensuring sufficient delay between the commands. The sensor reports zeroes in response to the first command to avoid sending spurious data. The second report has valid x-y data.
5. If the data is two counts or more for either x or y, the sensor has been moved and the controller must initiate its wakeup sequence. If the data is 1 count or less for both x and y, the sensor has not been moved and the controller can reassert SHUTDOWN until the next motion-check period.



## Resolution Control Capabilities

The CYONS1001x sensors support a variety of resolution control modes that offer users both precision tracking and flexibility. The resolution control capabilities of each sensor are summarized in [Table 8](#). The various resolution control modes are described in the following sections.

### Standard Resolution Control

In standard control mode, resolution is adjusted in increments of 200 or 400 cpi, depending on the sensor.

### X/Y Resolution Control

In x/y resolution control mode, the x-direction and y-direction resolution are independent: they need not be set to the same value. Resolution in either direction is adjusted in increments of 50 cpi.

### Fine Resolution Control

Fine control mode enables continuously variable resolution in increments of less than 1 cpi.

### Setting Sensor Resolution

Sensor resolution is controlled by the change resolution command described on page 11.

- Standard resolution control requires a single change resolution command to change the resolution in both the x and y direction.
- X/Y resolution control requires a separate change resolution command for each direction.
- Fine resolution control requires two change resolution commands to specify the resolution. In both commands, the two most significant bits select the resolution control mode. In the first command, bits 5-0 provide the first half of the resolution code. In the second command, bits 5-0 provide the second half of the resolution code.

**Table 8. Resolution Control Capabilities of CYONS1001x Sensors**

| Sensor      | Minimum Resolution | Maximum Resolution | Standard Resolution Control | X/Y Resolution Control | Fine Resolution Control |
|-------------|--------------------|--------------------|-----------------------------|------------------------|-------------------------|
| CYONS1001L  | 400 cpi            | 1200 cpi           | 400 cpi steps               | –                      | –                       |
| CYONS1001T  | 50 cpi             | 1150 cpi           | –                           | 50 cpi steps           | –                       |
| CYONS1001   | 400 cpi            | 2400 cpi           | 200 cpi steps               | 50 cpi steps           | <1 cpi steps            |
| CYONS 1001G | 400 cpi            | 2800 cpi           | 200 cpi steps               | 50 cpi steps           | <1 cpi steps            |
| CYONS 1001U | 400 cpi            | 3200 cpi           | 200 cpi steps               | 50 cpi steps           | <1 cpi steps            |

## SPI Interface

### SPI Interface Configuration

The main interface to the CYONS1001x sensor is a 4-pin SPI interface. The sensor is an SPI slave, and the external controller is the master. If the sensor is the only slave device, the controller can hold the NCS pin low at all times.

The sensor SPI bus is configured as follows:

- Bit order is MSB first
- The SPI bus clock input (SCK) must be between 500 kHz and 2 MHz
- CPOL = 0, the clock idle state is low
- CPHA = 0, data is registered as input on the leading edge of SCK and output on the trailing edge of the SCK

The sensor can process SPI commands when the MOTION pin is asserted by the sensor. The sensor cannot process SPI commands in nap, sleep, or hibernate mode.

### SPI Interface Commands

Table 9 shows the format of the commands the external controller can issue to the sensor. Except for the change resolution and read resolution commands, the commands are identical for all for all CYONS1001x sensors.

The commands are described in the following sections. Timing diagrams for the commands are shown on page 13.

#### Read Tracking Data Command

The read tracking data command reads four bytes of x/y axis location information in a single long transaction. To reduce the

overhead of this frequent command, no address byte is required, only a command byte.

Tracking data is reported as relative movement since the last tracking data read. The tracking data is reported in two's complement format. Each time tracking data is read, the internal accumulators for both the x-axis and the y-axis are reset to zero.

#### Soft Reset Command

The soft reset command forces the sensor into a soft reset. The reset takes the same amount of time as a power on reset of the sensor chip, so the external controller must wait approximately 100 ms before the sensor can respond to further commands.

#### Test Write Command

The test write command writes a data byte to sensor memory, where it is read back by the test read command. These commands enable the developer to test the SPI interface between the sensor and external controller.

#### Test Read Command

The test read command reads the test write data byte from sensor memory. If a test write command has not been issued before the test read command, the value returned is undefined.

#### Read Firmware ID Command

The read firmware ID command enables the controller to read a sensor firmware ID byte, allowing the system to maintain version control of firmware updates. The command is implemented as a read to the firmware ID address of the sensor. The byte returned by the sensor is a unique identifier of the firmware. Other than that, it is not structured.

**Table 9. SPI Command Formats**

| SPI Command        | Request from Master |              |             | Response from Slave   | t <sub>SPI DELAY_1</sub> (min) | t <sub>SPI DELAY_2</sub> (min) |
|--------------------|---------------------|--------------|-------------|---|--------------------------------|--------------------------------|
|                    | Command byte        | Address byte | Data byte   |   |                                |                                |
| Read tracking data | 0x80                | None         | None        | <x_cnt_high_byte><br><x_cnt_low_byte><br><y_cnt_high_byte><br><y_cnt_low_byte>                                    | 400 μs                         | 20 μs                          |
| Soft reset         | 0x02                | 0xE0         | 0x01        | No response   | 400 μs                         | 20 μs                          |
| Change resolution  | 0x02                | 0x1A         | <data_byte> | No response   | 400 μs                         | 20 μs                          |
| Read resolution    | 0x82                | 0x1A         | None        | <data_byte>   | 400 μs                         | 100 μs                         |
| Test write         | 0x02                | 0x1C         | 0xXX        | No response   | 400 μs                         | 20 μs                          |
| Test read          | 0x82                | 0x1C         | None        | <data_byte>   | 400 μs                         | 100 μs                         |
| Read firmware ID   | 0x82                | 0xFF         | None        | <data_byte>   | 400 μs                         | 100 μs                         |
| Read product ID    | 0x82                | 0xFE         | None        | 0x0F:CYONS1001<br>0x0A:CYONS1001L<br>0x05:CYONS1001T<br>0x0B:CYONS1001G<br>0x0C:CYONS1001U<br>All others reserved | 400 μs                         | 100 μs                         |
| Read signal level  | 0x82                | 0x5B         | None        | <data_byte>   | 400 μs                         | 100 μs                         |

### Read Product ID Command

The read product ID command enables the controller to read a sensor product ID byte. The command is implemented as a read to the product ID address of the sensor. The byte returned by the sensor is a unique identifier of the product ID. Other than that, it is not structured.

### Read Signal Level Command

The read signal level command enables the controller to read an indicator of the strength of the optical signal received by the sensor. The signal level returned by the sensor is not calibrated; yet, it can provide a useful measurement of signal level during system development.

### Change Resolution Command

The change resolution command enables the external controller to select the resolution of the tracking data reported by the sensor. The command consists of command byte, address byte, and data byte. The command and address bytes are the same for all CYONS1001x sensors; however, because the CYONS1001x have different resolution control capabilities, the interpretation of the data byte varies by sensor.

Table 10 through Table 14 describe the configuration of the change resolution data byte for each CYONS1001x sensor. For a description of the resolution control modes, see “Resolution Control Capabilities” on page 9.

### Read Resolution Command

The read resolution command reads the current resolution setting of the sensor. The sensor responds with a data byte that matches the data byte in the last valid change resolution command. The interpretation of the data byte in the sensor’s response to the read resolution command depends on the sensor and the resolution control mode the sensor is using. Table 10 through Table 13 describe the data bytes for each sensor.

Because the response from the sensor includes only a single data byte and some resolution settings are specified by two data bytes, the controller must use a write-read, write-read sequence to access the two bytes required to specify resolution in x/y resolution control mode or fine control mode.

if a read resolution command is sent before a change resolution command, the sensors respond with their default setting.

**Table 10. CYONS1001L Change Resolution Data Byte**

| Bit | Function  |
|-----|---|
| 7-6 | 00 = Standard resolution mode   |
| 5-0 | Sets resolution from 400 to 1200 cpi<br>000001 = 1 = 400 cpi<br>000010 = 2 = 800 cpi<br>000011 = 3 = 1200 cpi |

**Table 11. CYONS1001T Change Resolution Data Byte**

| Bit | Function   |
|-----|--|
| 7-6 | Selects x or y direction <sup>[3]</sup><br>01 = Change y direction resolution<br>10 = Change x direction resolution                                      |
| 5-0 | Sets resolution in either the x or y direction from 50 to 1150 cpi<br>000001 = 1 = 50 cpi<br>000010 = 2 = 100 cpi<br>...etc...<br>010111 = 23 = 1150 cpi |

**Table 12. CYONS1001 Change Resolution Data Byte**

| Bit | Function  |
|-----|---|
| 7-6 | Selects resolution control mode:<br>00 = Standard resolution control<br>01 = Change y direction resolution<br>10 = Change x direction resolution<br>11 = Fine resolution control  |
| 5-0 | In standard resolution mode:<br>Sets resolution from 400 to 2400 cpi.<br>000010 = 2= 400 cpi<br>000011 = 3= 600 cpi<br>...etc....<br>001100 = 12 = 2400 cpi<br><br>In x/y resolution mode: <sup>[4]</sup><br>Sets resolution in either the x or y direction from 400 to 2400 cpi.<br>001000 = 8 = 400 cpi<br>001001 = 9 = 450 cpi<br>...etc....<br>110000 = 48 = 2400 cpi<br><br>In fine control mode: <sup>[5]</sup><br>Sets resolution from 400 to 2400 cpi in steps of 0.78125 dpi.<br>001000 000000 = 512 = 400 cpi<br>001000 000001 = 513 = 401 cpi<br>...etc....<br>110000 000000 = 3072 = 2400 cpi |

**Notes**

- The CYONS1001T only supports the x/y resolution control mode. A single change resolution command changes the resolution in either the x direction or y direction. Two commands are required to change the resolution in both directions.
- In x/y resolution control mode, a single change resolution command changes the resolution in either the x direction or y direction. Two commands are required to change the resolution in both directions.
- Fine resolution control mode requires two change resolution commands. In both commands, the first two bits select the resolution control mode. In the first command, bits 5-0 provide the first half of the resolution code. In the second command, bits 5-0 provide the second half of the resolution code.

Table 13. CYONS1001G Change Resolution Data Byte

| Bit | Function  |
|-----|---|
| 7-6 | Selects resolution control mode:<br>00 = Standard resolution control<br>01 = Change y-direction resolution<br>10 = Change x-direction resolution<br>11 = Fine resolution control  |
| 5-0 | In standard resolution mode:<br>Selects resolution from 400 to 2800 cpi.<br><br>000010 = 2= 400 cpi<br>000011 = 3= 600 cpi<br>...etc....<br>001110 = 14 = 2800 cpi<br><br>In x/y resolution mode: <sup>[4]</sup><br>Sets resolution in either the x or y direction from 400 to 2800 cpi.<br><br>001000 = 8 = 400 cpi<br>001001 = 9 = 450 cpi<br>...etc....<br>111000 = 56= 2800 cpi<br><br>In fine control mode: <sup>[5]</sup><br>Sets resolution from 400 to 2800 cpi in steps of 0.78125 dpi.<br><br>001000 000000 = 512 = 400 cpi<br>001000 000001 = 513 = 401 cpi<br>...etc....<br>111000 000000 = 3584 = 2800 cpi |

Table 14. CYONS1001U Change Resolution Data Byte

| Bit | Function  |
|-----|---|
| 7-6 | Selects resolution control mode:<br>00 = Standard resolution control<br>01 = Change y-direction resolution<br>10 = Change x-direction resolution<br>11 = Fine resolution control  |
| 5-0 | In standard resolution mode:<br>Selects resolution from 400 to 3200 cpi.<br><br>000010 = 2= 400 cpi<br>000011 = 3= 600 cpi<br>...etc....<br>010000 = 16 = 3200 cpi<br><br>In x/y resolution mode: <sup>[4]</sup><br>Sets resolution in either the x or y direction from 400 to 3150 cpi.<br><br>001000 = 8 = 400 cpi<br>001001 = 9 = 450 cpi<br>...etc....<br>111111 = 63= 3150 cpi<br><br>In fine control mode: <sup>[5]</sup><br>Sets resolution from 400 to 3199 cpi in steps of 0.78125 dpi.<br><br>001000 000000 = 512 = 400 cpi<br>001000 000001 = 513 = 401 cpi<br>...etc....<br>111111 111111 = 4095 = 3199 cpi |

## SPI Interface Timing

Figure 5. Read Tracking Data Command Timing (Burst Read)

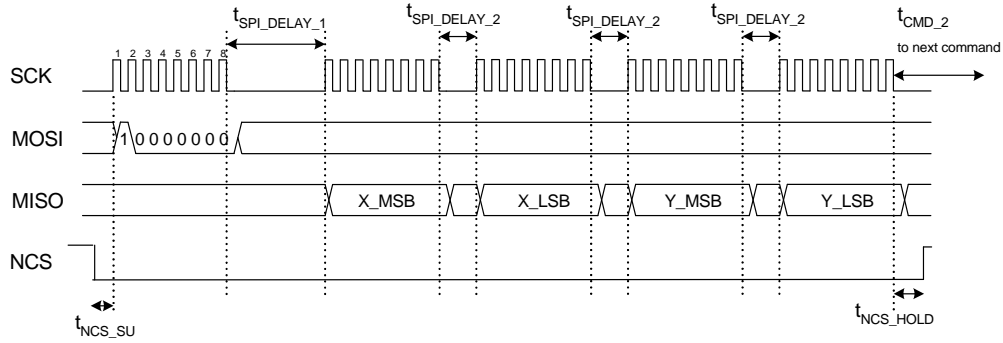


Figure 6. Timing for SPI Write Operations

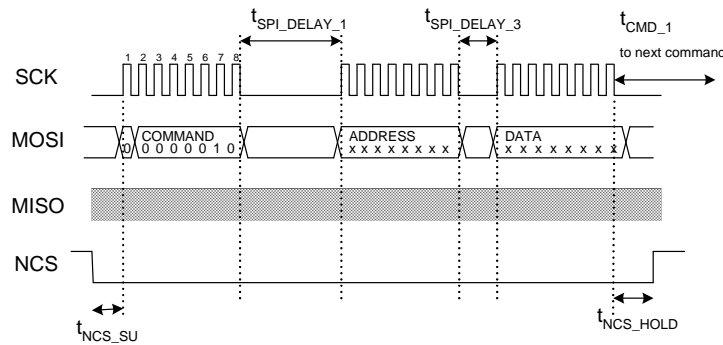
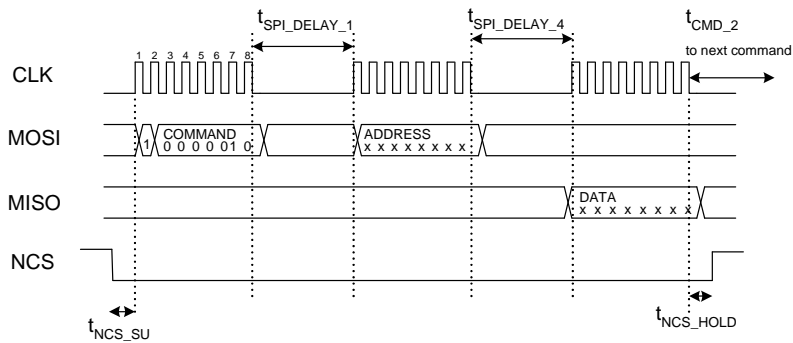


Figure 7. Timing for SPI Read Operations



## SHUTDOWN, MOTION, and EXTCFG Pins

### SHUTDOWN Pin

The SHUTDOWN pin enables hibernate mode — an ultra low power state in which the sensor cannot detect motion. When the SHUTDOWN pin is asserted, the sensor quickly powers down and remains powered down until the pin is deasserted. When the SHUTDOWN pin is deasserted, the sensor returns to the default power up state after an internal wakeup sequence. Startup time from deassertion of the pin to full tracking capability is 20 ms max.

The SHUTDOWN pin is asserted at any time except during the initial power on sequence or the wakeup sequence from a previous SHUTDOWN state.

Table 15. SHUTDOWN Pin

| SHUTDOWN pin | Sensor Operating Mode        |
|--------------|------------------------------|
| High         | Hibernate mode               |
| Low          | Tracking, nap, or sleep mode |

### MOTION Pin

The MOTION output reports the present operating mode of the sensor. When the MOTION pin is asserted, the sensor can process SPI commands. When the MOTION pin is deasserted, the sensor is in nap, sleep, or hibernate mode and cannot process SPI commands.

Table 16. MOTION Pin

| MOTION pin | Sensor Operating Mode         |
|------------|-------------------------------|
| High       | Tracking mode                 |
| Low        | Nap, sleep, or hibernate mode |

In addition, the MOTION pin serves as a startup indicator. The pin is asserted when the initial power on sequence or the wakeup sequence from SHUTDOWN state is complete. If the mouse is in motion during startup, the MOTION pin stays high; if the mouse is not moving, the MOTION pin goes low after 4 seconds.

For the CYONS1001, CYONS1001G, and CYONS1001U only, the MOTION pin can also be used as an indicator of the sensor's readiness to report x/y data. For these models, the sensor pulls MOTION low when it is processing the Read x/y command, and set MOTION high again when it is ready to report data. Using this feature, designers can use the rising edge of the MOTION line as a signal to poll the sensor. This allows the mouse to poll the sensor at the highest possible rate.

### EXTCFG Pin

The EXTCFG pin enables a factory test mode that manufacturers can use to verify laser output power for safety compliance purposes. The pin is held low by an internal 4K - 8K ohm pull down resistor, but is driven high to enable factory test mode.

To enable factory test mode, drive the EXTCFG pin high at power up. When the power on sequence is complete, the sensor asserts the MOTION pin, indicating the device is ready to accept configuration data from the external controller over the SPI bus. The test command sequence is described in "[Laser Output Power Test Procedure](#)" on page 15.

To re-enable the normal mode of operation after testing, set the EXTCFG pin low or no-connect at power up.

Table 17. EXTCFG Pin

| EXTCFG pin | Sensor Operating Mode     |
|------------|---------------------------|
| High       | Enables factory test mode |
| Low or NC  | Normal operating mode     |

## Laser Safety Considerations

CYONS1001x laser navigation sensors and the CYONSLENS1001 lens are designed and tested to enable manufacturers to achieve eye safety certification with minimal effort. This section provides guidelines for complying with the Class 1 emission requirements of IEC/EN 60825-1.

### Laser Output Power

The CYONS1001x sensor package contains an integrated VCSEL and drive circuitry. Before shipping, Cypress adjusts the laser output power to eye-safe levels, taking into account specified variations in supply voltage, temperature, lens transmission, and VCSEL polarization, and factors such as VCSEL aging and test equipment accuracy. The output remains within eye-safe limits under reasonably foreseeable single-faults, as required by the IEC standard.

From the perspective of a manufacturer, laser emission remains within the Class 1 limit, as defined in IEC 60825-1, Edition 1.2, 2001-08, provided the following requirements are met.

- The supply voltage applied to the sensor must be in the range of 2.7 to 3.6V.
- The operating temperature must be between 5 and 45 °C.
- A CYONSLENS1001 must be properly installed over the sensor.

In addition, the following requirements must be met to prevent access to radiation levels that exceed the Class 1 limit:

- The laser output power must not be increased by any means, including firmware, hardware, or mechanical modifications to the sensor or lens.
- The sensor housing must be designed in such a way that the CYONSLENS1001 cannot be opened without the use of a tool.
- If the mouse is equipped with batteries, the housing must be designed to prevent access to laser energy when the battery cover is removed.

It is the responsibility of the manufacturer to ensure these conditions are always met and to demonstrate end-product compliance to the appropriate regulatory standards.

### Laser Output Power Test Procedure

To verify the factory calibration, maximum output power is measured using the following procedure:

1. With power to the sensor off, drive the EXTCFG pin high, or temporarily tie the pin to DVDD.
2. Apply power and wait for the sensor to assert the MOTION pin. This indicates that the sensor is ready to accept configuration data from the external controller over the SPI bus.
3. Assert the SPI slave-select line and send the following configuration bytes to sensor through the SPI interface. A minimum delay of 50  $\mu$ s must be added between bytes.  

```
<0x03> <0x01> <0x00> <0x18> <0xFF> <0x02>  
<0x04> <0x00> <0xA7> <0x00> <0xFF> <0x00>
```

The sensor locks the laser to the programmed power limit with continuous wave (CW) output. The sensor provides tracking data if queried, but the tracking performance is poor due to the test mode. After testing, the sensor must be power cycled with the EXTCFG pin low or not connected to ensure optimal tracking.

### Registration Assistance

Cypress can provide assistance to customers who wish to obtain registration. Supporting documentation, including a verification test procedure to demonstrate end-product compliance with IEC and CDRH requirements is available. For further information, contact a Cypress representative.

## Firmware Update Capability

In some cases, manufacturers may wish to use Cypress's MiniProg programmer to implement factory firmware updates. Firmware updates must be obtained only from a Cypress authorized representative.

The MiniProg uses a 5-pin in-system serial programming (ISSP) protocol. By connecting the sensor's ISSP pins to the MiniProg, firmware is updated using Cypress PSoC® Programmer software.

The most convenient way to connect the sensor pins to the MiniProg is to install a 5-pin male header on the board, routing

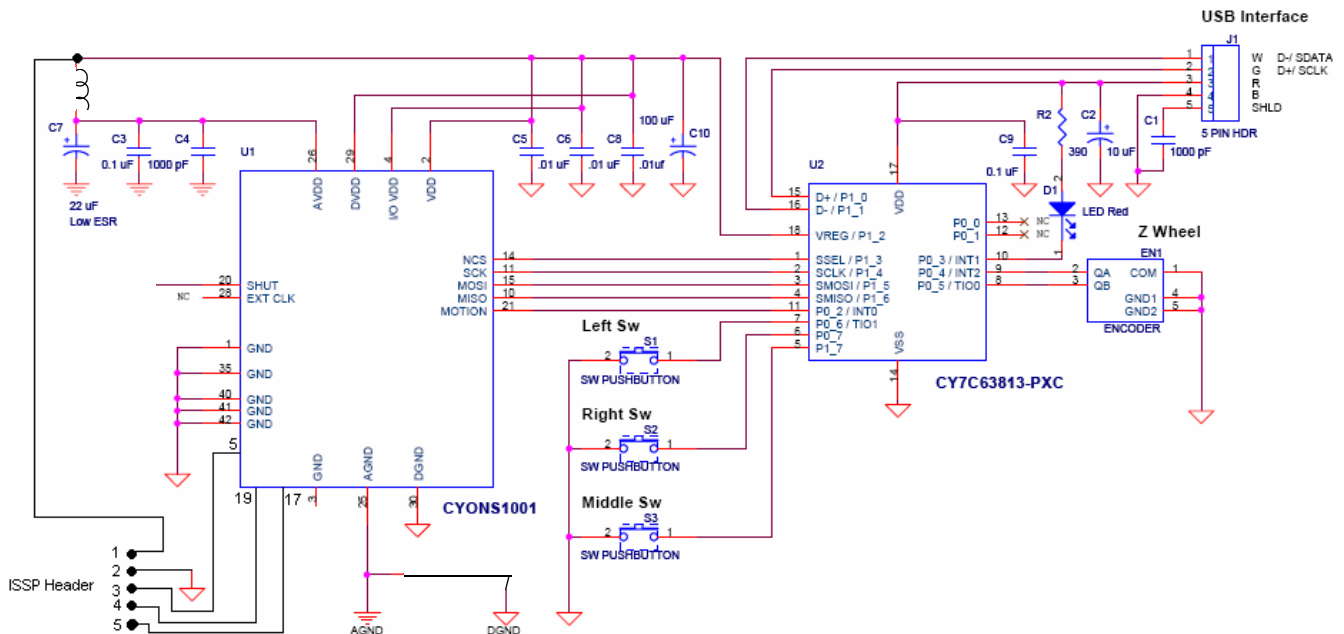
the 5 pins to the sensor pins as shown in Table 18 and the schematic diagram in Figure 8. A suggested header is part number 22-23-2051 from Molex, Inc. To eliminate the expense of a 5-pin header, test pads may be included on the board, so that the ISSP connections are made with probes.

MiniProg programmers and PSoC Programmer software are available for purchase and download at [www.cypress.com](http://www.cypress.com).

Table 18. ISSP Pin Connections

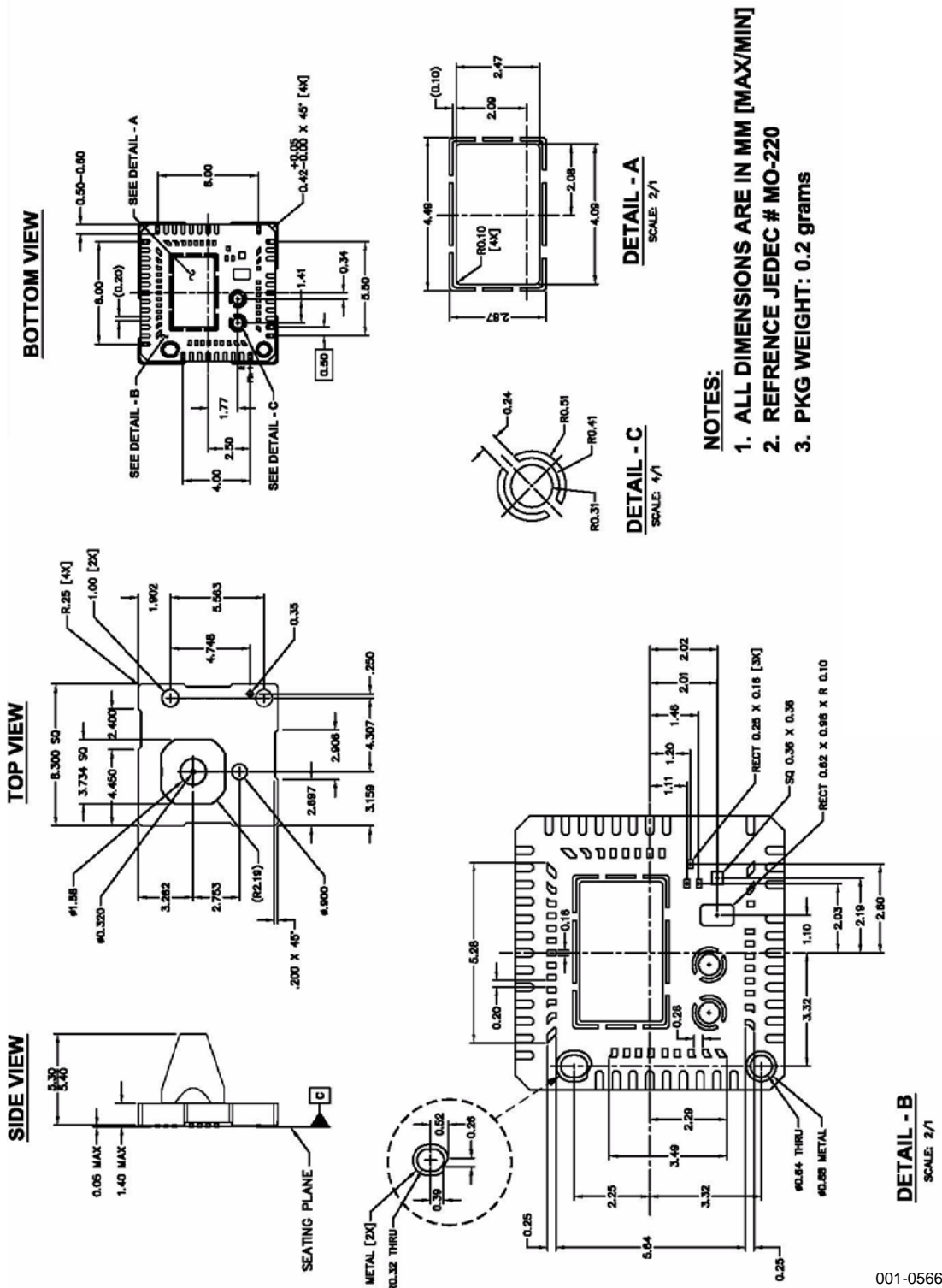
| ISSP Pin Number | CYONS1001x Pin Number | Connector Pin Name | Function                       |
|-----------------|-----------------------|--------------------|--------------------------------|
| 1               | 29                    | DVDD               | Power supply positive voltage  |
| 2               | 30                    | GND                | Power supply ground connection |
| 3               | 5                     | XRES               | Reset drive                    |
| 4               | 19                    | P1 [1]             | SCLK – serial clock            |
| 5               | 17                    | P1 [0]             | SDATA – serial data IO         |

Figure 8. Connection between ISSP Header and Typical Sensor Application





Package Diagram



001-05662 \*C

## Mechanical Design Considerations

This section provides the mechanical information required to incorporate the CYONS1001x sensor and CYONSLENS1001 lens into a mouse design.

### Housing Design Safety Considerations

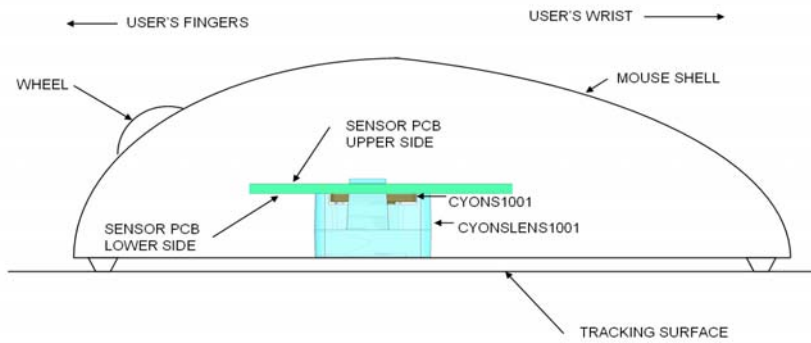
The housing must be designed to ensure compliance with Class 1 laser safety standards. To prevent exposure to radiation levels that exceed Class 1 limits, the mouse must be designed such that it cannot be disassembled without the use of a tool. In

addition, if the mouse is battery powered, the housing must be designed to prevent access to laser energy from when changing batteries.

### Orientation of PCB in a Mouse Application

Figure 9 shows the orientation of the sensor PCB in a standard mouse application. The sensor is mounted on a small PCB. Typically, the PCB is oriented sensor side down in the device housing.

Figure 9. Sensor PCB Orientation

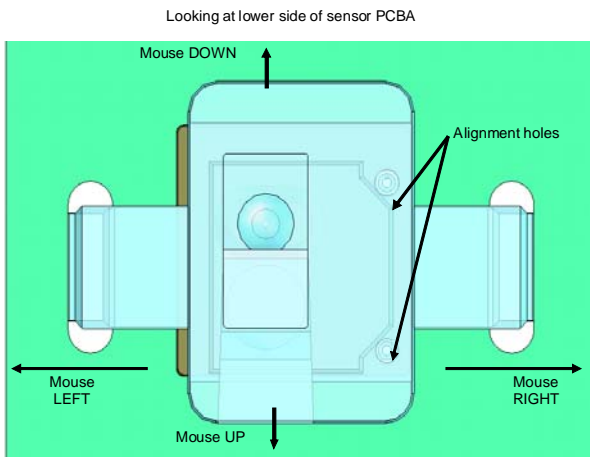


### Orientation of Sensor on PCB

Figure 10 shows the correct assignment of “mouse UP,” “mouse DOWN,” “mouse LEFT,” and “mouse RIGHT” motion. The UP and DOWN directions are reversed because the sensor side of the PCB faces down.

Note that this diagram does not apply to the CYONS1001T sensor, which is typically mounted beneath a trackball. To maintain correct x/y orientation, the y report of the CYONS1001T is inverted (opposite sign) with respect to the other sensors.

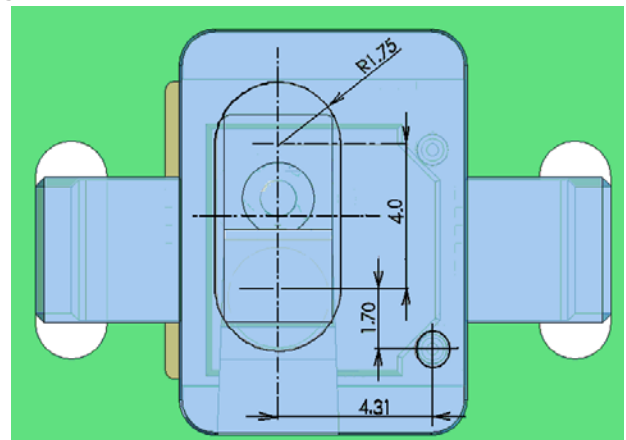
Figure 10. Orientation of Sensor on PCB



### Sensor Illumination Aperture

The illumination aperture must be properly sized to ensure light is not blocked as it enters or exits the sensor assembly. The minimum dimensions of the aperture are shown in Figure 11. Dimensions are in mm, referenced to the center of the lens alignment pin.

Figure 11. Illumination Aperture



## PCB Requirements

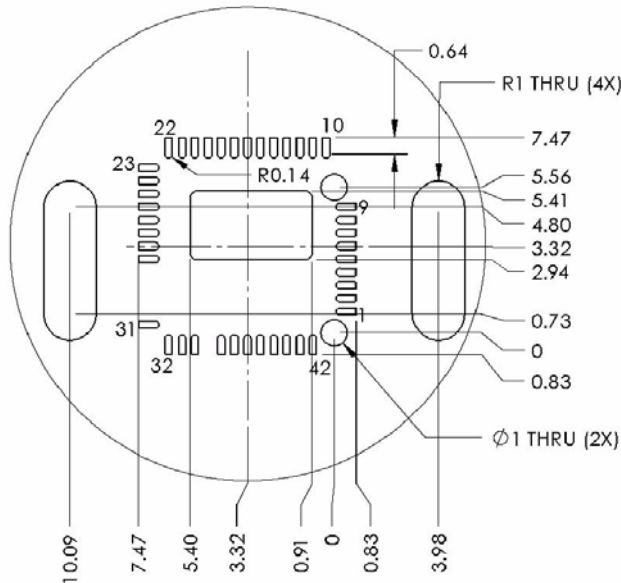
Figure 12 shows the mechanical requirements for the PCB. The board requires:

- Two clearance holes 1.00 mm in diameter for the lens alignment pins.
- Two slots for the clip legs of the lens. The radii of these slots are also 1.00 mm, giving the slot a width of 2.00 mm.

The holes and the slots must be clear of other components on both sides of the PCB.

Land pad architecture and spacing are consistent with JEDEC MO-220 (52-lead QFN). The L-shaped feature inside the array of lands must be soldered to the tab on the bottom of the sensor package and connected to the DGND signal of the PCBA. Also, the entire area within the sensor land pads must be kept free of exposed copper.

Figure 12. PCB Mechanical Features

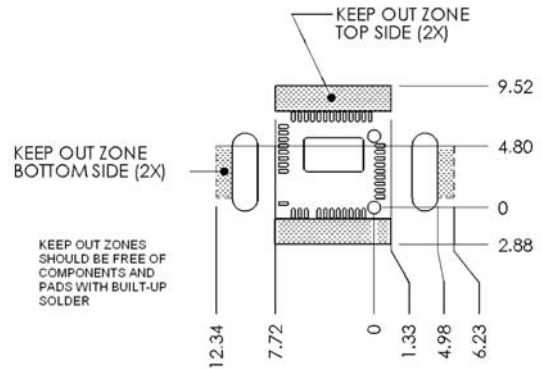


### PCB Keepout Zones

Figure 13 shows the PCB keepout zones. The keepouts on the sensor side of the board prevent interference with the CYONSLENS1001 lens after it is mounted on the sensor. The keepouts on the opposite side of the board prevent interference

with the lens clips. The keepouts must be free of both components and solder build-up.

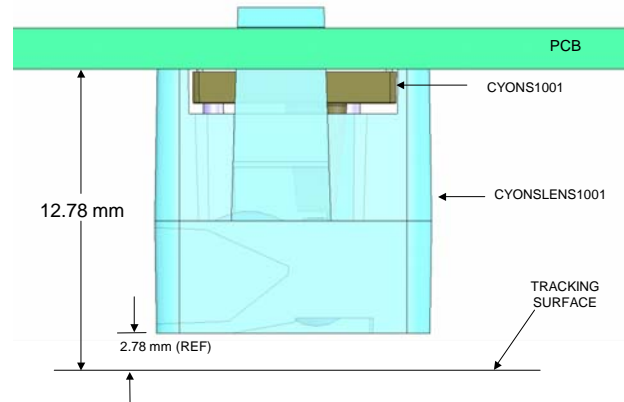
Figure 13. PCB Keepout Zones



### PCB Mounting Height

The distance between the tracking surface and the sensor must be controlled. For optimal performance, the lower edge of the PCB must be positioned  $12.78 \pm 0.25$  mm from the tracking surface, as shown in Figure 14. At this distance, the lower plane of the lens is typically 2.78 mm above the tracking surface. Deviations from the specified PCB-to-tracking surface distance degrade tracking performance and lift detection.

Figure 14. PCB Mounting Height



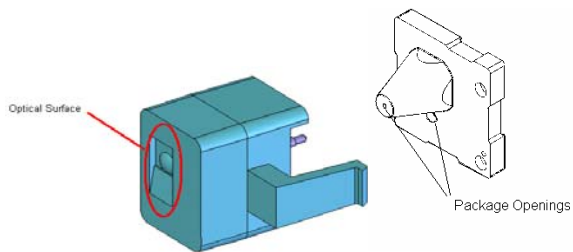
## Recommended Assembly Instructions

### Handling Guidelines

To maximize yield and performance, follow the handling guidelines listed below.

- Do not touch the optical surfaces of the CYONSLENS1001. Hold lenses only by their outer edges.
- Do not allow debris or dust to enter the optical aperture on the top of the package. Do not remove the protective tape over the package openings until immediately before the lens is attached.
- Do not wash the sensor PCBA after the laser sensor has been installed. The protective tape prevents moisture and dust from entering the sensor; however, it is not designed to withstand pressurized washing fluids.

Figure 15. Handling Guidelines



### Manufacturing Process

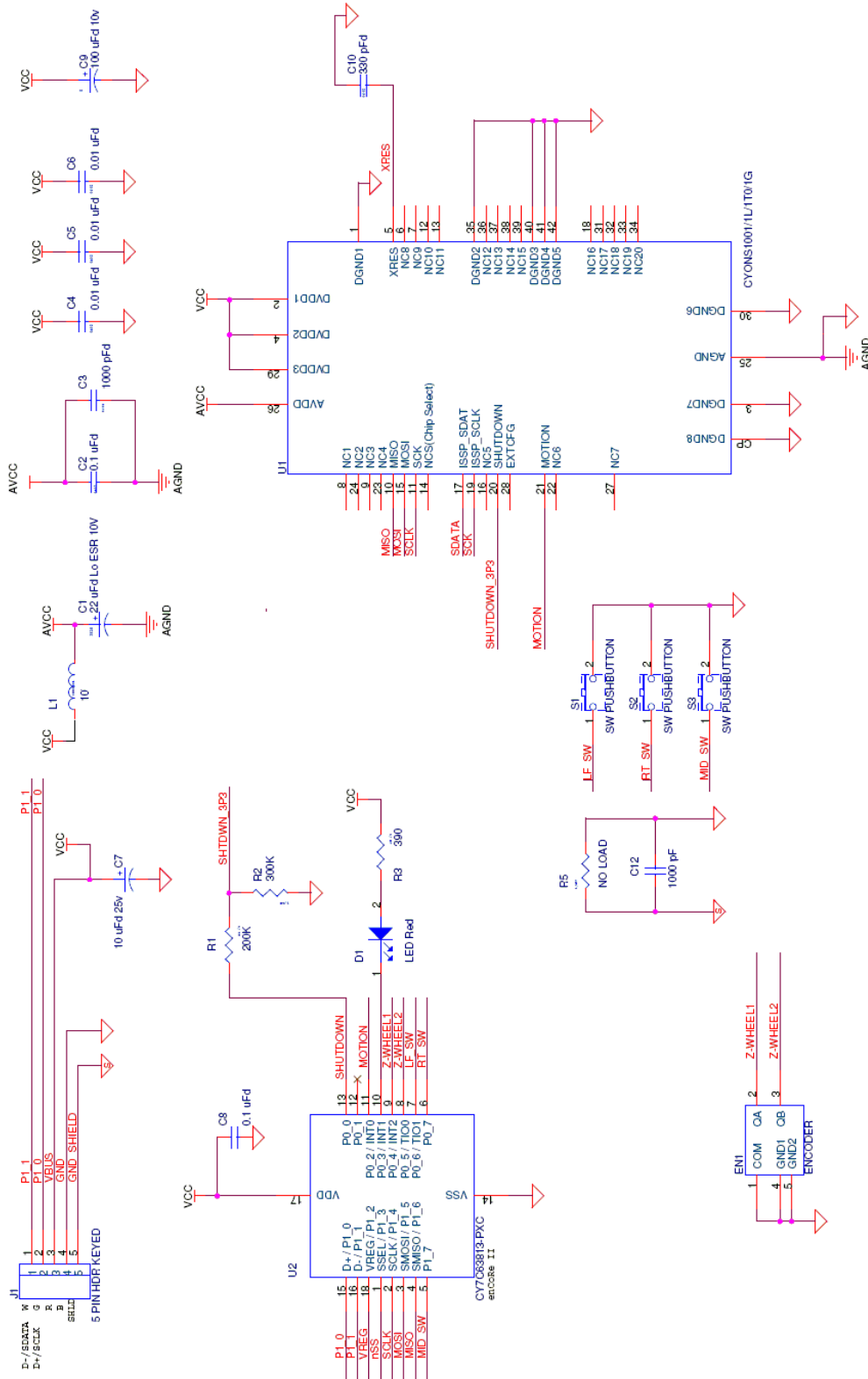
The CYONS1001x laser navigation sensors are designed to simplify the production process. Specifically,

- The sensors are rated at 2kV ESD, so standard ESD practices are acceptable.
- The laser is integrated into the sensor package, so there is no need for laser handling, lead forming, or installation.
- The laser is precalibrated, so there is no need to adjust laser output power

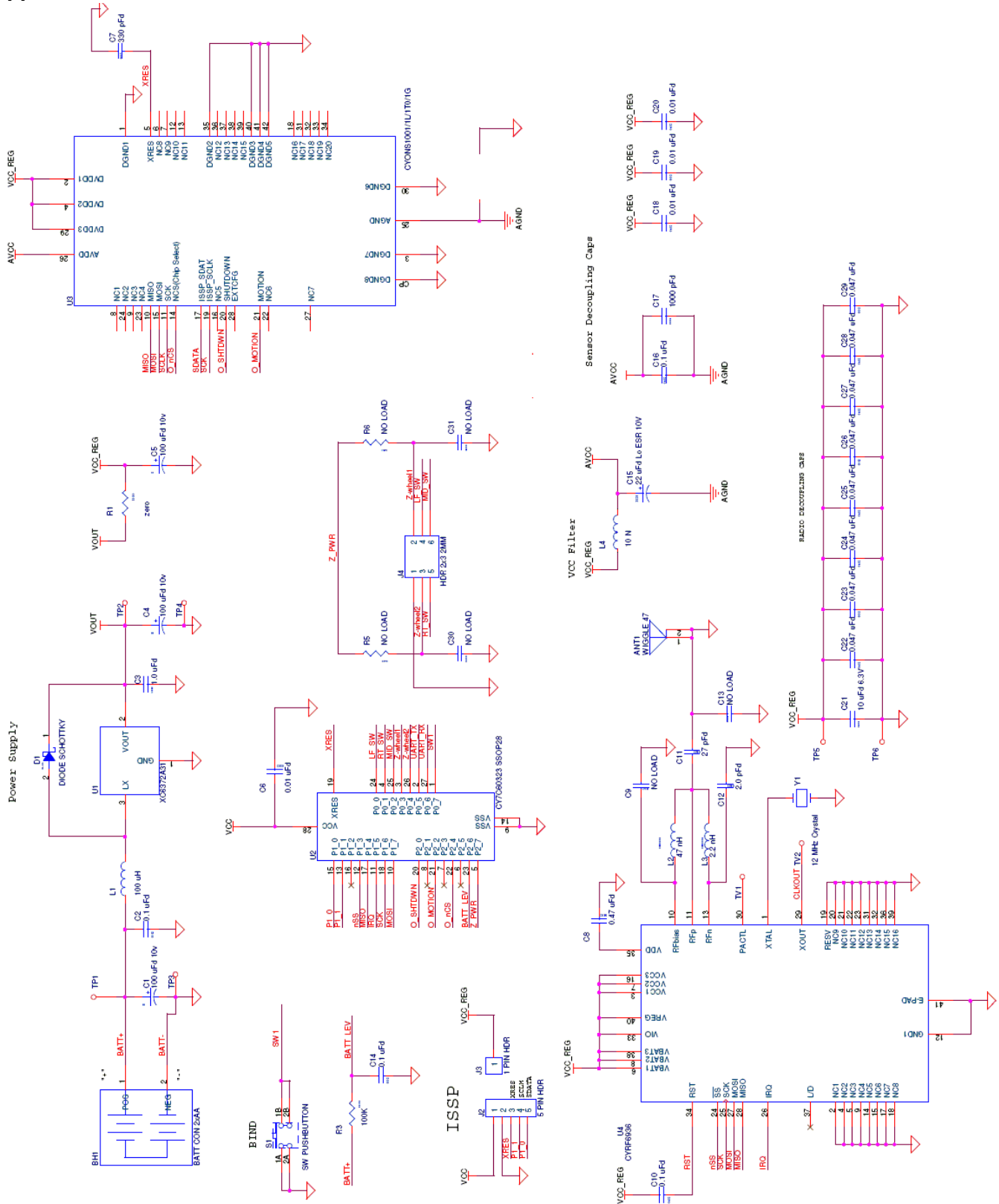
While different designs may require different manufacturing procedures, a recommended manufacturing process for a mouse is:

1. Collect sensor PCBA components (no need for select-at-test components).
2. Place laser sensor and passive components on sensor PCBA using a no-wash solder paste.
3. Solder components to PCBA.
4. Snap a CYONSLENS1001 lens over the laser sensor.
5. Install the laser sensor PCBA into the system housing.
6. Test and ship.

Appendix 1: Wired Mouse Reference Schematic



Appendix 2: Wireless Mouse Reference Schematic



**Ordering Information**

| Part Number      | Package      | Package Type                               | Operating Range |
|------------------|--------------|--|-----------------|
| CYONS1001U-LBXC  | 42-lead PQFN | PQFN (plastic quad flat) leadless, Pb free | 5–45 °C         |
| CYONS1001G-LBXC  | 42-lead PQFN | PQFN (plastic quad flat) leadless, Pb free | 5–45 °C         |
| CYONS1001-LBXC   | 42-lead PQFN | PQFN (plastic quad flat) leadless, Pb free | 5–45 °C         |
| CYONS1001L-LBXC  | 42-lead PQFN | PQFN (plastic quad flat) leadless, Pb free | 5–45 °C         |
| CYONS1001T0-LBXC | 42-lead PQFN | PQFN (plastic quad flat) leadless, Pb free | 5–45 °C         |

| Part Number     | Package | Operating Range |
|-----------------|---------|-----------------|
| CYONSLENS1001-C | Lens    | 5–45 °C         |

**Document History Page**

| Document Title: CYONS1001x OvationONS™ Laser Navigation Sensor |         |            |                 |   |
|--|---------|------------|-----------------|---|
| Document Number: 001-06398                                     |         |            |                 |   |
| REV.   | ECN NO. | Issue Date | Orig. of Change | Description of Change   |
| **   | 419897  | See ECN    | XSJ             | New data sheet  |
| *A   | 429039  | See ECN    | XSJ             | Updated pinout & parameter tables, power supply diagram, and packaging diagrams   |
| *B   | 435541  | See ECN    | XSJ             | Updated the ordering information, features, and functional descriptions; Changed nSS (chip select) to NCS; Cleaned up block diagram   |
| *C   | 464397  | See ECN    | XSJ             | Added Eye Safety (Class 1) notation; Updated product & technology names; Added PCB LAND pads to Mechanical section  |
| *D   | 486184  | See ECN    | XSJ             | Updated the operating conditions table, DC electrical table, AC electrical table, pin description table, power supply connections, block and package diagrams; Added lens part number   |
| *E   | 906420  | 04/03/2007 | XSJ             | Updated DC Electrical characteristics table.  |
| *F   | 1160423 | 06/18/07   | XSJ, FJZ, SOZ   | Combined data sheet and User Guide into one document (data sheet document). Added sections on OptiCheck, resolution control modes, firmware updates, additional SPI commands, etc. Updated description, feature list, block diagram, technical specifications and wired and wireless mouse schematics.  |
| *G   | 1202224 | See ECN    | FJZ/AESA        | Updated feature list. Updated tables 1, 2, 3, 4, 5, 6, 9, 10, 12, 13, 16, and 17. Updated figures 4, 5, 6, 7, 8, 9, and 12. Updated SPI timing, removed transient current supply spec. Updated Appendix 1, added Appendix 2. Corrected miscellaneous punctuation, grammar, and typographical errors. Updated text to make consistent with Tables and Figures. |
| *H   | 1338563 | See ECN    | XSJ, FJZ        | Updated pin description table 2. Changed "CYONS1001LENS" reference to "CYONSLENS1001". Added Package Diagram and Package Specification Number.  |
| *I   | 1684564 | See ECN    | XSJ, FJZ        | Added CYONS1001U part number/description  |
| *J   | 2035787 | See ECN    | FJZ/AESA        | Changed mechanical drawings, added minor corrections  |

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