# CT-EK-D

High Accuracy Conductivity and Temperature Sensor with Direct Digital Output

## Technical Manual


8001-CTS-DIG, Rev. 7 (February 2017)



TELEDYNE RD INSTRUMENTS
Everywhereyoulook™

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# Revision History

February 2017

- Updated cleaning procedure
- Added a recommended maintenance list to the maintenance chapter.
- Updated TRDI website address to http://www.teledynemarine.com/rdi

November 2011

- Changed model number to CT-EK-D

March 2012

- Updated Cleaning the CT Sensor section
- Changed “The water salinity in PSU-78 units” to “The seawater salinity in accordance to PSS78 (Practical Salinity Scale 1978)”.

# CT-EK-D Technical Manual

# Introduction

The Teledyne RD Instruments CT-EK-D CT Sensor provides high accuracy conductivity, temperature, salinity, and sound velocity measurements. The CT Sensor is available in a package that is designed for original equipment manufacturer (OEM) applications, where the sensor is to be integrated into a housing or other type of sensor platform of another manufacturer's design. The sensor includes an CT Sensor board with TRDI's patented Excell circuit technology and can be ordered with an RS-232, RS-485 or CMOS serial interface for direct digital output of all the measurements.

# Customer Service

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The technology used in the CT-EK-D CT sensor is currently under patent protection, both in the United States of America and internationally. TRDI will aggressively utilize its full rights under patent law to protect its interest in these technologies.

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# CT Sensor Types

The CT Sensor includes a ceramic type inductive conductivity cell and a high stability platinum resistance temperature device (RTD) temperature sensor. The conductivity cell is highly stable and accurate while being resistant to the effects of bio-fouling. In addition, the large inside diameter of the cell eliminates the need for a pump. There are two basic types of CT Sensors, a 500-meter depth rated sensor and a 7000-meter depth rated sensor. The 500-meter configuration is available with an internal or an external temperature sensor; the 7000--meter, with an external temperature sensor only. The 500-meter configuration with an internal temperature sensor is also available as a completely assembled instrument that includes a housing with the CT Sensor board and an external bulkhead connector for power and data. This configuration is shown in Figure 1.


**Figure 1. The 500-Meter Rated CT Sensor with Internal Temperature Sensor as a Completely Assembled Instrument**

# 500-Meter Rated

The CT Sensor with a 500-meter depth rating is shown in Figure 2. This configuration also includes an internal temperature sensor. The CT Sensor comprises a Delrin plastic stem with an O-ring seal at its mounting base and a 1-inch stainless steel threaded mounting stem. The RTD temperature sensor is embedded inside the ceramic conductivity cell near its surface. Wires connect to the CT Sensor through the mounting stem. The external temperature sensor configuration includes the same RTD temperature sensor used for the 7000-meter CT Sensor and is shown in Figure 3.

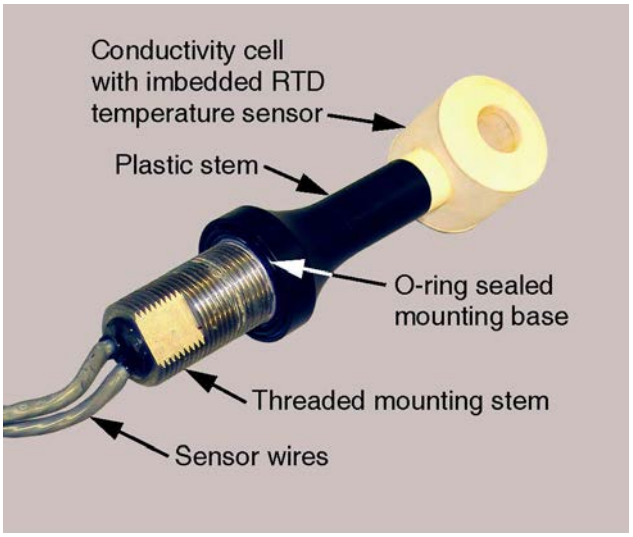



**Figure 2. The 500-Meter Rated CT Sensor with Internal Temperature Sensor**

# 7000-Meter Rated

The CT Sensor with a 7000-meter depth rating is shown in Figure 3. The CT Sensor comprises a titanium stem and mounting base and includes an external temperature sensor. The base includes an O-ring seal and three tapped holes for mounting. The assembly is oil filled, and a pressure compensation bladder is mounted on the side of the base. The compensator creates a zero difference pressure between the inside of the conductivity cell and ambient regardless of depth. The external temperature sensor is encased in a titanium sheath with an O-ring gland seal. Wires connect to the sensor through the mounting base.

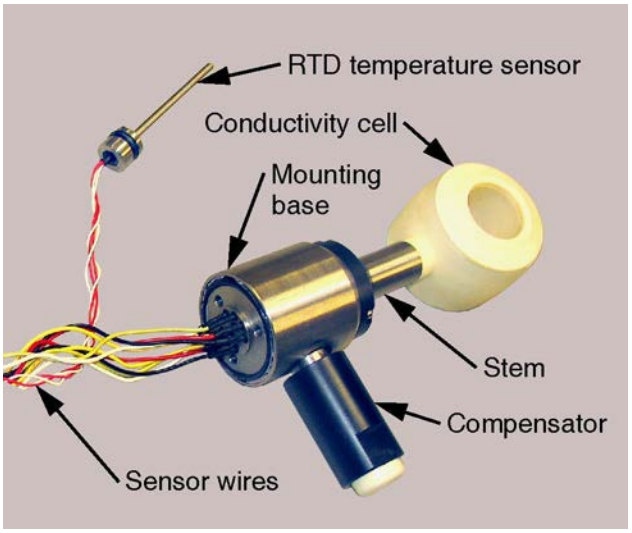



**Figure 3. The 7000-Meter Rated CT Sensor with External Temperature Sensor**

# CT Sensor Electronics

The CT Sensor electronics are contained on a single printed circuit board, the CT-EK-D CT Sensor board. The board outputs conductivity, temperature, salinity, and sound velocity data on one of the three available serial interfaces. The user interface connects to an 8-pin interface connector on one end of the board, and the sensor connects to two connectors on the opposite end.

# Specifications

Below are the general specifications for the CT-EK-D CT Sensor and the CT Sensor board. For mechanical outline drawings of the sensor and the board, refer to CT Sensor Commands.

**NOTE.** These specifications are subject to change without notice.

**Table 1: General Specifications**

| | |
|---|---|
| **Power requirements:** | 6–14 VDC, 50 mw @ 6 VDC; optional 5 VDC can be specified at time of order |
| **Warmup time:** | 100 ms from power up |
| **Mode select setting time:** | 100 ms from power up |
| **Resolution:** | 18 bits |
| **Sample rate:** | 1.8 Hz |
| **Communication interface:** | RS-232, RS-485 or CMOS; specified at time of order |
| **Data format:** | 8 data bits, 1 stop bit |
| **Output format:** | Scaled or floating point |
| **Baud rate:** | 300, 1200, 9600, and 19,200 |
| **Channels:** | 4 plus user programmable pressure |
| **Depth rating:** | 500 m (internal temperature sensor); 7000 m (external temperature sensor) |
| **Interface connector:** | 8-pin Molex Series 7478 |
| **Sensor mounting:** | 1-14 UN Class 2B thread **O-ring:** Buna-N p/n 2-123 |
| **CT Sensor board size:** | 3.81 cm (1.5 in.) by 17.78 cm (7.0 in.) |

**Table 2: Assembled Instrument Specifications**

| | |
|---|---|
| **Overall size:** | 45.9 cm (18.11 in.) long (including dummy plug)<br>by 5.2 cm (2.05 in.) diameter |
| **Housing material:** | Delrin |
| **Bulkhead connector:** | 5-pin female Subconn Micro series |
| **Weight in air:** | 0.65 kg (1.44 lb) |
| **Weight in water:** | Neutral |

**Table 3: Conductivity Specifications**

| | |
|---|---|
| **Sensor type:** | Inductive cell |
| **Range:** | 0–7.0 S/m (0–70.0 mS/cm) |
| **Accuracy:** | ±0.002 S/m (±0.02 mS/cm) |
| **Stability:** | ±0.0005 S/m/month<br>(±0.005 mS/cm/month) |
| **Response:** | 20.0 cm @ 1 m/sec |

**Table 4: Temperature Specifications**

| | |
|---|---|
| **Sensor type:** | Platinum resistance |
| **Range:** | -2–35°C |
| **Accuracy:** | ±0.05°C |
| **Stability:** | ±0.005°C/month |
| **Response:** | 20 s (internal temperature sensor)<br>1 s (external temperature sensor) |
| **Sensor type:** | Aged thermistor |
| **Range:** | -2–32°C standard, -5–45°C optional |
| **Accuracy:** | ±0.002°C |
| **Stability:** | ±0.0005°C/month |
| **Resolution:** | 0.0001°C |
| **Response:** | 100 msec |

# Wiring the CT Sensor

Connections to the CT-EK-D CT Sensor are made to the interface connector of the CT Sensor board, which is shown in Figure 4. The interface connector is an 8-pin Molex Series 7478 connector shown by itself on the right side of the board. It requires a Molex P/N 22-01-3087 terminal housing mating connector with Molex P/N 08-56-0110 crimp terminals. The two connectors on the left side of the board are used to connect to the CT Sensor. The CT Sensor is configured with an RS-232, RS-485 or CMOS serial interface as designated on the serial tag.

## Wiring the Interface Connector

The interface connector is used to input power and output data on one of the serial interfaces. Wiring the interface connector requires connecting power, ground and the data output. The interface connector wiring information is shown in Table 5.

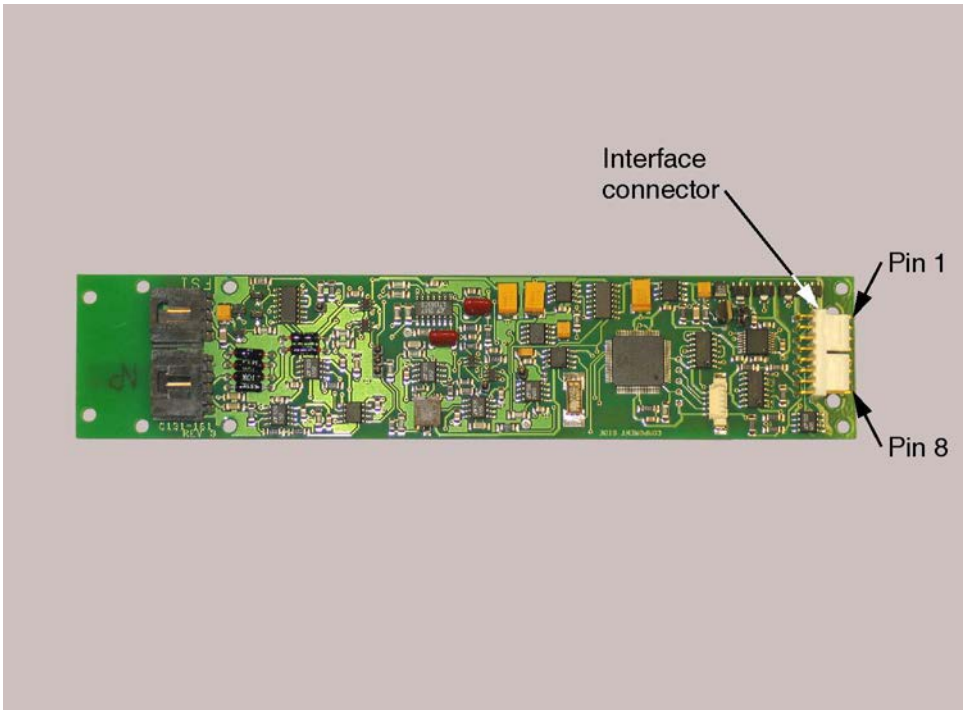



**Figure 4. The CT-EK-D CT Sensor Board**

**Table 5: Interface Connector Connections**

| PIN | LABEL | FUNCTION |
|---|---|---|
| 1 | Gnd | Signal and Power Ground |
| 2 | RS-232 RXD | RS-232 Received Data |
| 3 | Power (+) | Power In |
| 4 | RS-232 TXD | RS-232 Transmitted Data |
| 5 | A | RS-485A |
| 6 | B | RS-485B |
| 7 | CMOS RXD | CMOS Received Data |
| 8 | CMOS TXD | CMOS Transmitted Data |

# Wiring the Bulkhead Connector

A bulkhead connector is included on the bottom end cap of the assembled instrument configuration of the CT Sensor. It is used to input power and output data on one of the serial interfaces. The bulkhead connector is a Subconn MCBH5F, and the mating connector is a Subconn MCIL5M connector pigtail, which is supplied. Figure 5 shows the pin orientation for the bulkhead connector. The connector wiring information for the connector pigtail is shown in Table 6 for the RS-232, RS-485 and CMOS serial interfaces. Wiring the bulkhead connector requires connecting power, ground and the data output.

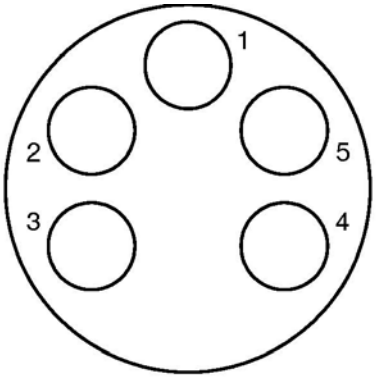



**Figure 5. Bulkhead Connector—Face View Female**

**Table 6: Bulkhead Connector Mating Connector Connections**

| PIN | COLOR | RS-232 | RS-485 | CMOS |
|---|---|---|---|---|
| 1 | Black | Gnd | Gnd | Gnd |
| 2 | White | RS-232 RXD | A | CMOS RXD |
| 3 | Red | Power (+) | Power (+) | Power (+) |
| 4 | Green | RS-232 TXD | B | CMOS TXD |
| 5 | Orange | Not Used | Not Used | Not Used |

# Installing and Maintaining the CT Sensor

The CT-EK-D CT Sensor is designed to be installed into a housing or other type of sensor platform of another manufacturer's design. The sensor requires little maintenance other than cleaning. However, if required, the sensor can be recalibrated. This section provides information on how to mount the sensor and board, how to recalibrate the sensor if necessary, and how to clean the sensor.

## Mounting the CT Sensor and Board

The CT Sensor should be mounted into a 1.063-inch clearance hole and secured with the supplied nut. The sensor can also be mounted in a tapped 15/16-inch hole. Mounting hole details are provided for the CT Sensor in Figure 6, and for the external temperature sensor in Figure 7. Mount the CT Sensor board using four of the available mounting holes, one on each corner of the board. For mechanical outline drawings of the sensor and the board, refer to Mechanical Outline Drawings.

**WARNING.** Do not torque the conductivity cell when tightening the CT Sensor. Doing so may damage the bond between the ceramic cell and the stem. Such damage is not covered under the warranty.

The sensor should have a free radius around the conductivity cell of 10 cm minimum. Objects within this radius must be electrically stable, either a complete dielectric or a conductor, and their position must be fixed in relation to the sensor. In addition, if objects are within 10 cm of the sensor, it will require recalibration to correct the conductivity output.

### Securing the Wires

The CT Sensor wires should be secured into position and kept away from electronics that contain large amplitude 2.0-kHz signals.

## Applying Anti-Foulant

The CT Sensor can be coated with any hard finish anti-foulant coating. Excessive build up of anti-foulant coatings in the center section of the sensor may reduce sensitivity and result in lowered conductivity values. In this case the sensor should be recalibrated.

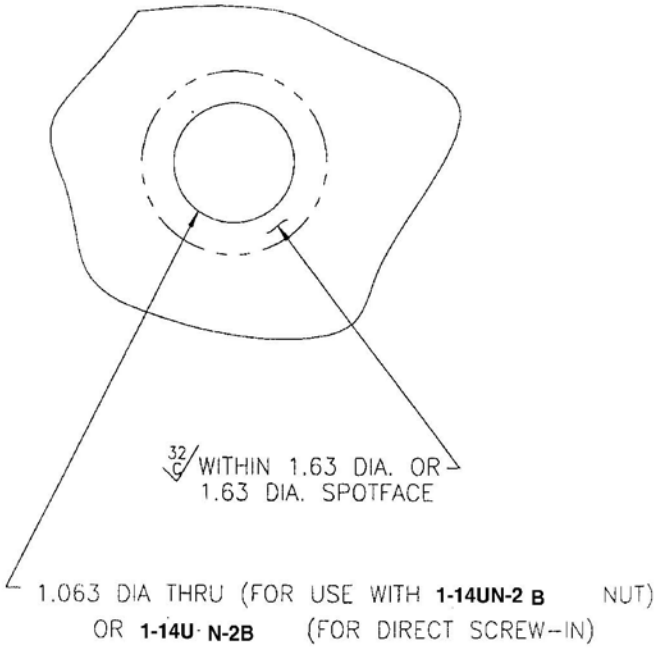



**Figure 6. CT Sensor Mounting Hole Detail**

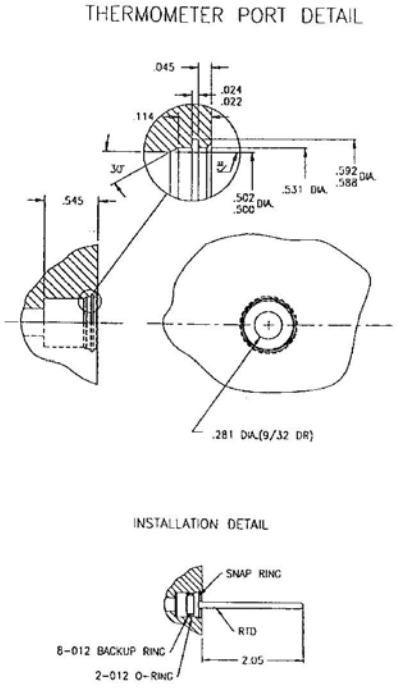



**Figure 7. External Temperature Sensor Mounting Hole Detail**

# Calibrating the CT Sensor

The CT-Sensor can be calibrated using primary standards of temperature and conductivity.

The following equipment is required for calibrating the CT Sensor:

- Standard platinum resistance thermometer recently calibrated at the Triple Point of Water and the Gallium Point.
- Neil Brown Instruments ATB-1250 or equivalent temperature bridge with a CSA-1250 or equivalent conductivity adapter.
- *Well* stirred temperature controlled bath with a minimum 5-gallon capacity, a short term stability in excess of +/- 0.001°C, and a range of operation of 0.5°C to 29°C.
- A computer with an RS-232 or RS-485 serial interface and running a terminal program, such as ProComm Plus. The data format is 8 data bits and 1 stop bit. The computer must be wired to the interface connector of the CT Sensor board. For wiring information, refer to Wiring the CT Sensor.
- 8–14 VDC power supply, and the test cable provided with the CT Sensor.

## Calibrating Conductivity

The conductivity sensor can be calibrated using high quality primary standards and established calibration techniques. TRDI provides a calibration service if you do not have access to a primary standard calibration facility. TRDI recommends that the sensor be returned to the factory for recalibration if possible.

To calibrate conductivity:

1. Reset calibration coefficients A1, B1, C1, and D1 as follows:

   A1 = 0

   B1 = 1

   C1 = 0

   D1 = 0

2. Use the ***R command to set the sensor into Run mode.

3. Collect data at a minimum of five conductivity points for both the CT Sensor and the ATB-1250 with the CSA-1250 adapter. The recommended conductivities are 20, 30, 40, 50, and 60 mmho/cm (± 3.0 mmho/cm).

4. Using a polynomial regression, determine the relationship of the CT Sensor data to the ATB-1250 data after correcting the measurements for the thermal expansion of the CT Sensor conductivity cell. (Refer to Correcting for the Thermal Expansion of the CT Sensor Conductivity Cell for instructions on how to make the correction.)

   The equation has the following form:

$$Cstd = A1 + B1 \times Cocm + C1 \times Cocm^2 + D1 \times Cocm^3$$

**NOTE.** A variety of curve fitting programs are commercially available. Contact TRDI if you need assistance in locating an appropriate one.

5. Use the ***O command to set the sensor into Open mode, and then enter the values for A1, B1, C1 and D1.

6. Verify calibration at a minimum of three different standard temperature/conductivity points, again correcting for the thermal expansion of the CT Sensor conductivity cell.

7. Use the ***E to save the new calibration constants to flash memory.

## Calibrating Temperature

The temperature sensor can be calibrated using high quality primary standards and established calibration techniques. TRDI provides a calibration service if you do not have access to a primary standard calibration facility. TRDI recommends that the sensor be returned to the factory for recalibration if possible.

To calibrate temperature:

1. Reset calibration coefficients A2, B2, C2, and D2 as follows:

   A2 = 0

   B2 = 1

   C2 = 0

   D2 = 0

2. Use the ***R command to set the sensor into Run mode.

3. Collect data at a minimum of five temperature points for both the CT Sensor and the ATB-1250. The recommended temperatures are 0.5, 7.5, 15, 22.5, and 30°C (± 1.0°C).

4. Using a polynomial regression, determine the relationship of the CT Sensor data to the ATB-1250 data.

   The equation has the following form:

$$Tstd = A2 + B2 \times Totm + C2 \times Totm^2 + D2 \times Totm^3$$

**NOTE.** A variety of curve fitting programs are commercially available. Contact TRDI if you need assistance in locating an appropriate one.

5. Use the ***O command to set the sensor into Open mode, and then enter the values for A2, B2, C2 and D2.

6. Verify calibration at a minimum of three different standard temperature points.

7. Use the ***E to save the new calibration constants to flash memory.

# Correcting for the Thermal Expansion of the CT Sensor Conductivity Cell

Both temperature and pressure effects are common to all types of physical volume sensors such as the CT Sensor conductivity cell. Therefore, to obtain the maximum accuracy from them, they must be corrected for the effects of temperature and pressure. Pressure and temperature corrections for the CT Sensor conductivity cell are from the Fofonoff, Hayes, and Millard documents on CTD Calibration, WHOI, 1974.

The equation has the following form:

$$Gc = G (1 + a (T - T0) + b (P - P0))$$

Where:

Gc = conductivity corrected

G = conductivity reading

a = thermal coefficient of expansion for alumina (-6.5E-6)

T = temperature reading

T0 = reference temperature

b = compressibility factor (cm/cm/dBar) for alumina (-1.5 E-8)

P = pressure reading

P0 = reference pressure

**NOTE.** T0 and P0 are the temperature and pressure at which conductivity was calibrated and are shown on the conductivity calibration certificate that is included with the CT Sensor.

This equation is valid for the CT Sensor conductivity cell when used with the constants listed above. The equation corrects for changes in diameter and length of the cell measurement volume as a function of the bulk compressibility of alumina. As the conductivity cell is pressure compensated and therefore has equal pressure from the inside to the outside, the change in internal diameter is only dependent upon the bulk modulus (1/compressibility) of alumina. For temperature the cell changes physical size due to the thermal expansion of the cell material.

# Recommended Maintenance

To ensure your CT-EK-D continues to provide you with accurate data, you should inspect and clean the instrument after each use. This section provides some inspection and cleaning recommendations and instructions on how to replace the battery pack.

**Table 7. Recommended Maintenance**

| **User Maintenance** | |
|---|---|
| **Item** | **TRDI Recommended Period** |
| Housings | Inspect for damage and replace as required. |
| Hardware (bolts, nuts, washers, etc.) | Manufacturer recommends replacement after every deployment or every at least each year. Damaged hardware should never be used. |
| O-rings | Manufacturer recommends replacement every time the instrument is removed/installed. Damaged O-rings should never be used. |
| Connector | Inspect for damage and replace as required. Damaged connectors should never be used. |
| Conductivity Sensor | Manufacturer recommends verification of reasonable performance before each deployment; i.e. a reference comparison. |
| Temperature | Manufacturer recommends verification of reasonable performance before each deployment; i.e. a reference comparison. |
| **Calibration*** | |
| **Item** | **TRDI Recommended Period** |
| Conductivity Sensor | Manufacturer recommends return every 1 to 2 years for Factory calibration. |
| Temperature Sensor | Manufacturer recommends return every 1 to 2 years for Factory calibration. |
| *The measurement error band of the CTD will widen over time due to component aging. This effect happens regardless of whether or not the instrument is being operated. Due to the stringent accuracy specifications, the effects of drift rapidly become a significant portion of the overall instrument error budget. For example, the error band for the conductivity measurement will reach twice its initial value three months after calibration. Periodic recalibration of the instrument is recommended to return to the original error band. | |
| **Factory Maintenance** | |
| **Item** | **TRDI Recommended Period** |
| Housing | 3 to 5 years maximum: return to manufacturer for inspection, shorter periods may be required depending on marine growth. |
| O-rings | 3 to 5 years maximum: return to manufacturer for replacement. |
| Connector | 3 to 5 years maximum: return to manufacturer for replacement. |

# Cleaning the CT Sensor

To remove foreign matter and biofouling:

1. Remove soft-bodied marine growth or foreign matter with soapy water. Waterless hand cleaners remove most petroleum-based fouling. If there is heavy fouling or marine growth, TRDI recommends soaking the affected areas in a 50:50 bath of fresh water and apple cider vinegar for one to two hours to break down the shell-like parts. Use a wooden dowel to carefully break up larger pieces of the shells. Scrubbing with a medium stiffness brush usually removes the remaining soft-bodied parts.

Do NOT use power scrubbers, abrasive cleansers, scouring pads, high-pressure marine cleaning systems or brushes stiffer than hand cleaning brushes as this can scratch surfaces and damage softer parts like urethanes and sealants used in the construction of the system.

Do NOT use excessive force when breaking up larger pieces of shells or you risk damaging the sensitive components on the external or inside of the system.

2. Rinse with fresh water to remove soap or apple cider vinegar residue.

3. Repeat steps 1 – 3, as required to remove heavy marine growth.

Do NOT soak for longer than two hours at any time and always rinse with fresh water between soakings. Soaking for longer than two hours at a time can break down the urethane and other sealants used in the construction of the system.

4. Dry the system with low-pressure compressed air or soft lint-free towels.

Do NOT use high pressure or you may damage softer surfaces.

Always dry the system before placing it in the storage case to avoid fungus or mold growth.

After cleaning the instrument, check it carefully for signs of damage.

# CT Sensor Commands

All CT-EK-D CT Sensor commands are entered by typing them directly from the keyboard of a computer. The computer must include an RS-232 or RS-485 serial interface and be running a terminal program, such as ProComm Plus. The data format is 8 data bits and 1 stop bit. The computer must be wired to the interface connector of the CT Sensor board. For wiring information, refer to Wiring the CT Sensor.

The CT Sensor commands are listed in Table 8.

## CT Sensor Operating Modes

The CT Sensor always runs in one of three operating modes. Each command applies specifically to one or more of these modes. The sensor can be placed into any operating mode by entering the appropriate command. The CT Sensor operating modes are the following:

**Run mode** is the normal operating mode in which data are acquired and stored. The sensor normally powers up in Run mode. However, if the calibration constants are incorrect or missing, the sensor will power up in Open mode.

**Open mode** is used to update calibration and other operational parameters.

**Calibration mode** provides certain functions that are used when the sensor is calibrated.

## Command Properties

All the CT Sensor commands exhibit the following common properties:

- A command is executed only after a carriage return (<CR>) or a line feed (<LF>) character is received.
- Additional characters received after a <CR> or <LF> character are ignored until the command is executed.
- Unless specified otherwise, a command can be entered in either upper or lower case letters.
- All displays are followed by a <CR> and a <LF> character at the end of each line.
- A command is invalid if it is not recognized for the specific operating mode or if it is entered incorrectly or incompletely.
- If an entered command is invalid, the message “BAD COMMAND, TYPE ?+Enter” is displayed. Typing “?,” and then pressing Enter, lists some common commands and their descriptions. Also refer to Error Messages for the error messages and their definitions.

## Selecting the Parameters to Output

Selecting the parameters for the CT Sensor to output is performed using the commands listed below, where for each command ON specifies that the channel is enabled and the parameter be included, and OFF specifies that the channel is not enabled and the parameter not be included. The sensor must be in the Open mode.

**TEMP=ON/OFF:** Measured temperature in ITS-90 degrees Celsius.

**COND=ON/OFF:** Measured conductivity in mmho/cm.

**SALT=ON/OFF:** The seawater salinity in accordance to PSS78 (Practical Salinity Scale 1978).

**SNDV=ON/OFF:** Calculated sound velocity in m/sec.

**PRES=ON/OFF:** User entered pressure in dBars. Use the PI= command to enter the pressure.

**NOTE.** The pressure value entered using the PI= command is used in the calculation of salinity and Sound velocity.

The order of the parameters in the output is temperature, conductivity, salinity, sound velocity, and pressure. To display the on or off status of each parameter, use the RDM command.

To display one scan of data send the <CR> or <LF> character with the sensor in any mode. To display continuous scans of data, use the SC command with the sensor in either Run or Calibration mode. To stop continuous display of data, use the S command.

**NOTE.** To display data at the sampling rate of the CT Sensor when using the SC command, first set averaging to zero using the AVG= command. The sensor must be in Open mode to use this command.

**Table 8: CT Sensor Commands**

| COMMAND | Operating Mode | | | FUNCTION |
|---|---|---|---|---|
| | R | O | C | |
| ? | – | ● | – | Lists all commands |
| ***C | – | ● | – | Go to Calibration mode |
| ***E | – | ● | – | Write to flash memory |
| ***O | ● | – | • | Go to Open mode |
| ***R | – | ● | – | Go to Run mode |
| C | ● | ● | ● | Displays the current mode |
| CDATE | – | ● | – | Displays the calibration date |
| ADR | – | ● | – | Displays or sets the sensor address |
| AVG= | – | ● | – | Set averaging |
| CAOP | – | ● | – | Clears the address operation |

| COMMAND | Operating Mode | | | FUNCTION |
|---|---|---|---|---|
| | R | O | C | |
| <CR> or <LF> | ● | ● | ● | Display current data |
| CCKO | – | ● | – | Disable checksum output |
| CCOP | – | ● | – | Disables continuous on power up |
| CPAD | – | ● | – | Displays or sets the delay between characters |
| LPAD | – | ● | – | Displays or sets delay between lines |
| TEMP=ON/OFF | – | ● | – | Set temperature channel output on or off |
| COND=ON/OFF | – | ● | – | Set conductivity channel output on or off |
| SALT=ON/OFF | – | ● | – | Set salinity channel output on or off |
| SNDV=ON/OFF | – | ● | – | Set sound velocity channel output on or off |
| PRES=ON/OFF | – | ● | – | Set pressure channel output on or off |
| PI= | – | ● | – | Set pressure |
| MODE | ● | ● | ● | Displays the current mode |
| RAOP | – | ● | – | Displays the address operation setting |
| RCAL | – | ● | – | Displays all the calibration constants |
| RCKO | – | ● | – | Displays the checksum setting |
| RCOP | – | ● | – | Displays the continuous on power up setting |
| RDM | – | ● | – | Displays the channel names |
| ROP | – | ● | – | Displays the current operational settings |
| RSOT | – | ● | – | Displays the scaled output setting |
| SSOT | – | ● | – | Enables scaled output mode |
| CSOT | – | ● | – | Disables scaled output mode |
| SAOP | – | ● | – | Sets the address operation |
| SB | – | ● | – | Sets the baud rate |
| SC | ● | – | • | Sets continuous output |

| COMMAND | Operating Mode | | | FUNCTION |
|---|---|---|---|---|
| | R | O | C | |
| S | ● | – | • | Stops continuous output (upper case) |
| SCKO | – | ● | – | Enables checksum operation |
| SCOP | – | ● | – | Enables continuous on power up |
| S/N | – | ● | – | Displays the serial number |
| VER | – | ● | – | Displays the firmware version number |
| WHO | ● | ● | ● | Displays the sensor name |

# ?

## Lists all commands

### Usage

? <CR> or <LF>

### Operating Modes

Open

### Description

The ? command displays a Help menu that lists many of the available commands.

### Returns

Help menu. The menu contents depend on the current operating mode of the sensor.

# ***C

## Go to Calibration mode

### Usage

***C <CR> or <LF>

### Operating Modes

Open

### Description

The ***C command sets the sensor into Calibration mode. In Calibration mode reference data and raw data can be displayed.

### Returns

<CR><LF>

Entering a <CR> or <LF> character a second time and every time thereafter displays a scan of data followed by a <CR><LF>.

### See Also

S, SC

# ***E

## Write to flash memory

### Usage

***E <CR> or <LF>

### Operating Modes

Open

### Description

The ***E command causes all calibration constants and operational settings to be saved to flash memory.

**CAUTION.** The ***E command overwrites the current calibration constants and operational settings in flash memory. Before using the ***E command, use the RCAL command to verify that the calibration constants are correct.

### Returns

<CR><LF>

### See Also

RCAL

# ***O

## Go to Open mode

### Usage

***O <CR> or <LF>

### Operating Modes

Run, Calibration

### Description

The ***O command sets the sensor into Open mode. In Open mode data are not acquired and operational settings and calibration constants can be displayed and edited.

### Returns

<CR><LF>

Entering a <CR> or <LF> character a second time and every time thereafter displays the following:

Open Mode

# ***R

## Go to Run mode

### Usage

***R <CR> or <LF>

### Operating Modes

Open

### Description

The ***R command sets the sensor into Run mode. In Run mode the sensor acquires and records data.

### Returns

<CR><LF>

Entering a <CR> or <LF> character a second time and every time thereafter displays a scan of data followed by a <CR><LF>.

### See Also

S, SC

# C

## Displays the current mode

### Usage

C <CR> or <LF>

### Operating Modes

Run, Open, Calibration

### Description

The C command displays the current operating mode of the sensor.

### Returns

If the sensor is in Run mode:

RUN MODE

If the sensor is in Open mode:

OPEN MODE

If the sensor is in Calibration mode:

CAL MODE

### Example

Enter C <CR><LF>

The sensor displays the current sensor operating mode:

CAL MODE

# CDATE

## Displays the calibration date

### Usage

CDATE <CR> or <LF>

### Operating Modes

Open

### Description

The CDATE command displays the calibration date of the sensor.

**NOTE.** The calibration date cannot be changed.

### Returns

See examples below.

### Examples

Enter CDATE <CR> or <LF> The sensor displays the current date:

CDATE=12AUG05 <CR><LF>

# ADR

## Displays or sets the sensor address

### Usage

ADR <CR> or <LF>

and

ADR=nn <CR> or <LF>

### Operating Modes

Open

### Description

The ADR command displays or sets the address of the sensor.

**NOTE.** The ADR command must be followed by the ***E command to save the setting.

The nn format is 00 to 99.

### Returns

See Examples below.

### Examples

Enter ADR <CR> or <LF>

The sensor displays the address of the sensor:

ADR=05 <CR> or <LF>

Enter ADR=67 <CR> or <LF>

The sensor sets its address to 67 and outputs a <CR><LF>.

### See Also

SAOP, CAOP, RAOP, ROP, ***E

# AVG=

## Set averaging

### Usage

AVG=nnn <CR> or <LF>

### Operating Modes

Open

### Description

The AVG= command sets the number of scans over which to average the conductivity and temperature data. One line of averaged data is output after the average interval is complete. The scan rate of the sensor is approximately 1.8 Hz.

**NOTE.** The number of scans entered to average over is held in volatile memory until the ***E command is issued, at which time it is saved to flash memory.

The nnn format is 000 to 255 scans.

### Returns

No return.

### Examples

Enter AVG=255 <CR> or <LF> An average of 255 scans is entered.

Enter AVG=0 <CR> or <LF> No averaging is performed.

### See Also

SAOP, CAOP, RAOP, ADR, ROP, ***E

# CAOP

## Clears the address operation

### Usage

CAOP <CR> or <LF>

### Operating Modes

Open

### Description

The CAOP command disables address operation. The sensor will revert to sending data upon return to Run mode with the entry of the SC command, or with a <CR> or <LF> character, without the issuance of a # character and the sensor's address.

**NOTE.** The CAOP command must be followed by the ***E command to save the setting.

### Returns

Address op cleared

### Examples

Enter CAOP <CR> or <LF>

### See Also

SAOP, RAOP, ADR, ADR=, ROP, ***E

# <CR> or <LF>

## Display current data

### Usage

<CR> or <LF>

### Operating Modes

Run, Open, Calibration

### Description

Sending a <CR> or <LF> character requests the sensor to send data. Data from the sensor are displayed as decimal numbers. The current operating mode determines the number of values sent and what each value represents.

### Returns

In Run mode the return will be the data for up to five parameters for Channels 1 through 5. Only the data for the channels that have been enabled will be displayed.

In Open mode a <CR> or <LF> will always return the message "Open Mode."

### Examples

Enter <CR> or <LF>

The sensor displays a scan of data for Channels 1, 2, and 3 if the channels have been enabled:

35.2341, 7.4563, 2347.4678 <CR><LF>

### See Also

SC, SCOP, CCOP, RCOP, S, TEMP=ON/OFF, COND=ON/OFF, SALT=ON/OFF, SNDV=ON/OFF, AND PRES=ON/OFF

# CCKO

## Disable checksum output

### Usage

CCKO <CR> or <LF>

### Operating Modes

Open

### Description

The CCKO command disables the output of the checksum result with the data.

**NOTE.** The CCKO command must be followed by the ***E command to save the setting.

With the checksum output disabled, a checksum is not saved with the data or displayed when displaying data.

### Returns

checksum output cleared

### See Also

***E

# CCOP

## Disables continuous on power up

### Usage

CCOP <CR> or <LF>

### Operating Modes

Open

### Description

The CCOP command disables continuous output of data immediately after power up.

**NOTE.** The CCOP command must be followed by the ***E command to save the setting.

### Returns

Continuous cleared

### See Also

***E

# CPAD

## Displays or sets the delay between characters

### Usage

CPAD <CR> or <LF> CPAD=nnn <CR> or <LF>

### Operating Modes

Open

### Description

The CPAD displays or sets the delay between the characters in the data output.

**NOTE.** The CPAD command must be followed by the ***E command to save the setting.

The nnn format is 001 to 100.

### Returns

See Examples below.

### Examples

Enter CPAD <CR> or <LF> The sensor displays the delay:

CPAD=2 Enter CPAD=1 <CR> or <LF> A delay of 1 is entered.

### See Also

***E

# LPAD

## Displays or sets delay between lines

### Usage

LPAD <CR> or <LF> LPAD=nnn <CR> or <LF>

### Operating Modes

Open

### Description

The LPAD displays or sets the delay after a <CR><LF> in the data output.

**NOTE.** The LPAD command must be followed by the ***E command to save the setting.

The nnn format is 001 to 500.

### Returns

See Examples below.

### Examples

Enter LPAD <CR> or <LF> The sensor displays the delay:

LPAD=2 Enter LPAD=1 <CR> or <LF> A delay of 1 is entered.

### See Also

***E

# TEMP=ON/OFF

## Set temperature channel output on or off

### Usage

TEMP=ON <CR> or <LF> and TEMP=OFF <CR> or <LF>

### Operating Modes

Open

### Description

The TEMP=ON command enables, and the TEMP=OFF command disables the temperature data output.

**NOTE.** The TEMP=ON and TEMP=OFF commands must be followed by the ***E command to save the setting.

### Returns

No return.

### See Also

RDM, ***E, ***R

# COND=ON/OFF

## Set conductivity channel output on or off

### Usage

COND=ON <CR> or <LF> and COND=OFF <CR> or <LF>

### Operating Modes

Open

### Description

The COND=ON command enables, and the COND=OFF command disables the conductivity data output.

**NOTE.** The COND=ON and COND=OFF commands must be followed by the ***E command to save the setting.

### Returns

No return.

### See Also

RDM, ***E, ***R

# SALT=ON/OFF

## Set salinity channel output on or off

### Usage

SALT=ON <CR> or <LF> and SALT=OFF <CR> or <LF>

### Operating Modes

Open

### Description

The SALT=ON command enables, and the SALT=OFF command disables the salinity data output.

**NOTE.** The SALT=ON and SALT=OFF commands must be followed by the ***E command to save the setting.

### Returns

No return.

### See Also

RDM, ***E, ***R

# SNDV=ON/OFF

## Set sound velocity channel output on or off

### Usage

SNDV=ON <CR> or <LF> and SNDV=OFF <CR> or <LF>

### Operating Modes

Open

### Description

The SNDV=ON command enables, and the SNDV=OFF command disables the sound velocity data output.

**NOTE.** The SNDV=ON and SNDV=OFF commands must be followed by the ***E command to save the setting.

### Returns

No return.

### See Also

RDM, ***E, ***R

# PRES=ON/OFF

## Set pressure channel output on or off

### Usage

PRES=ON <CR> or <LF> and PRES=OFF <CR> or <LF>

### Operating Modes

Open

### Description

The PRES=ON command enables, and the PRES=OFF command disables the pressure data output.

**NOTE.** The PRES=ON and PRES=OFF commands must be followed by the ***E command to save the setting.

### Returns

No return.

### See Also

RDM, ***E, ***R

# PI=

## Set pressure

### Usage

PI= xxxx.xx <CR> or <LF>

### Operating Modes

Open

### Description

The PI= command sets the pressure in dbars. The pressure value is used in the calculation of salinity and sound velocity.

**NOTE.** The PI= command must be followed by the ***E command to save the setting.

### Returns

No return.

### See Also

RDM, ***E, ***R

# MODE

## Displays the current mode

### Usage

MODE <CR> or <LF>

### Operating Modes

Run, Open, Calibration

### Description

The MODE command displays the current operating mode of the sensor.

### Returns

If the sensor is in Run mode:

RUN MODE

If the sensor is in Open mode:

OPEN MODE

If the sensor is in Calibration mode:

CAL MODE

### Example

Enter MODE <CR><LF>

The sensor displays the current sensor operating mode:

CAL MODE

# RAOP

## Displays the address operation setting

### Usage

RAOP <CR> or <LF>

### Operating Modes

Open

### Description

The RAOP command displays the address operation setting.

**NOTE.** If the sensor is presently in the address operation, its address preceded by the # character must be transmitted to disable address operation.

### Returns

If address operation is not set:

Address op cleared

If the address operation is set:

Address op set, Adr = 00

### See Also

SAOP, RAOP, ADR, ADR=, ROP

# RCAL

## Displays all the calibration constants

### Usage

RCAL <CR> or <LF>

### Operating Modes

Open

### Description

The RCAL command displays all the sensor calibration constants.

**NOTE.** The ***E command must be entered to save any changed calibration constants. In addition, the sensor serial number and the version number of the firmware cannot be changed.

### Returns

See Examples below.

### Examples

Enter RCAL <CR> or <LF>

The sensor displays the calibration constants:

```
RCAL
S/N=1539D
Ver=1.3
CDATE=07OCT04
A1=-2.083330E-02
B1=1.074020E-04
A2=3.621000E-01
B2=6.115088E-05
C2=2.035936E-12
```

### See Also

***E

# RCKO

## Displays the checksum setting

### Usage

RCKO <CR> or <LF>

### Operating Modes

Open

### Description

The RCKO command displays the checksum setting.

### Returns

If the checksum is not set:

Checksum output cleared

If the checksum is set:

Checksum output set

# RCOP

## Displays the continuous on power up setting

### Usage

RCOP <CR> or <LF>

### Operating Modes

Open

### Description

The RCOP command displays the continuous on power up setting.

### Returns

If the continuous output is not set:

Continuous cleared

If the continuous output is set:

Continuous set

### See Also

SCOP, CCOP

# RDM

## Displays the channel names

### Usage

RDM <CR> or <LF>

### Operating Modes

Open

### Description

The RDM command displays the on or off status of each of the five channels. When on, a channel is outputting data; when off, it is not outputting data. The primary channels are Channels 1 and 2.

The five channels are the following:

| | |
|---|---|
| **Channel 1:** | Temperature |
| **Channel 2:** | Conductivity |
| **Channel 3:** | Salinity |
| **Channel 4:** | Sound velocity |
| **Channel 5:** | Pressure |

### Returns

See Examples below.

### Examples

Enter RDM <CR> or <LF>

The sensor displays the five channels and the on or off status of each:

```
TEMP=on, COND=on, SALT=on, SNDV=off, PRES=off
```

# ROP

## Displays the current operational settings

### Usage

ROP <CR> or <LF>

### Operating Modes

Open

### Description

The ROP command displays all the current operational settings for the sensor.

**NOTE.** The ***E command must be entered to save any changed operational settings.

### Returns

See Examples below.

### Examples

Enter ROP <CR> or <LF>

The operational settings are displayed:

```
TAU=1
address op cleared
checksum output cleared
```

### See Also

RCOP, RSOT, RAOP, ***E

# RSOT

## Displays the scaled output setting

### Usage

RSOT <CR> or <LF>

### Operating Modes

Open

### Description

The RSOT command displays the scaled output setting.

### Returns

If the scaled output is not set:

scaled output cleared

If the scaled output is set:

scaled output set

### See Also

SSOT, CSOT, ROP

# SSOT

## Enables scaled output mode

### Usage

SSOT <CR> or <LF>

### Operating Modes

Open

### Description

The SSOT command enables the scaled output of the data over a range of 0 to 65535 counts.

**NOTE.** The SSOT command must be followed by the ***E command to save the setting.

### Returns

scaled output set

### See Also

RSOT, CSOT, ROP, ***E

# CSOT

## Disables scaled output mode

### Usage

CSOT <CR> or <LF>

### Operating Modes

Open

### Description

The CSOT command disables the scaled output of the data. The sensor will revert to sending data in engineering units upon return to Run mode after entry of this command.

**NOTE.** The CSOT command must be followed by the ***E command to save the setting.

### Returns

scaled output cleared

### See Also

RSOT, SSOT, ROP, ***E

# SAOP

## Sets the address operation

### Usage

SAOP <CR> <LF>

**Warning.** Before using the SAOP command, determine the address of the sensor using the ADR command and confirm the current baud rate.

### Operating Modes

Open

### Description

The SAOP command enables address operation which allows multiple sensors to be connected on a common RS-485 serial interface. When in address operation the sensor will respond *only* when it receives a # character followed first by a "D" or a "d" character and second by the sensor's address. When the sensor receives its address, it will respond with one scan of the current data in accordance with the operating mode it is in. However, if the "D" character is used, this sensor, and *only* this sensor, will *also* respond to all future commands until a different sensor is addressed in the same manner. Therefore use the "D" character if you want to send commands to the addressed sensor and the "d" character if you just want to display one scan of data without sending commands.

**NOTE.** The SAOP command must be followed by the ***E command to save the setting.

**NOTE.** When sending the sensor's address, do not follow the address with a <CR> or <LF>. If the sensor is in Run mode, it will respond with one scan of data within 200 µsec after receipt of the address. The sensor will not transmit the next value until it has completed the next measurement cycle in approximately one second.

**Warning:** Do not send the CAOP command as described below unless you want to permanently cease communications with the addressed sensor. Once you have sent the CAOP command and have disabled address operation, you will no longer be able to send commands to the sensor or receive data from it if it is on a common RS-485 serial interface with other sensors.

To disable address operation, send the # character followed first by the "D" character and second by the sensor's address. Next, enter Open mode using the ***O command, and then send the CAOP command.

### Returns

No return.

### Examples

Enter #D01.

The entry is followed by a display of the current data:

#D01 +26.3345, +34.0000, 2345.4454<CR><LF>

Enter #D01.

The entry is followed by a display of the current data and this sensor, and only this sensor, will respond to all future commands until a different sensor is addressed inthe same manner:

#D01+26.3345, +34.0000, 2345.4454<CR><LF>

## See Also

CAOP, RAOP, ADR, ADR=, ROP, ***E

# SB

## Sets the baud rate

### Usage

SBnn <CR> or <LF>

### Operating Modes

Open

### Description

The SB command sets and displays the baud rate of the sensor.

**NOTE.** The SB command must be followed by the ***E command to save the setting.

**WARNING.** If you change the baud rate of the sensor, you will not be able to communicate with the sensor until you set the baud rate of your computer to the same.

When setting the baud rate, use the nn format as follows:

| | |
|---|---|
| **19:** | Sets the baud rate to 19200 |
| **96:** | Sets the baud rate to 9600 |
| **12:** | Sets the baud rate to 1200 |
| **30:** | Sets the baud rate to 300 |
| **38:** | Sets the baud rate to 38,400 |
| **57:** | Sets the baud rate to 57,600 |

### Returns

See Examples below.

### Examples

Enter SB19 <CR> or <LF>

The sensor sets and displays the baud rate setting:

Unit now communicates at 19200 baud

### See Also

***E

# SC

## Sets continuous output

### Usage

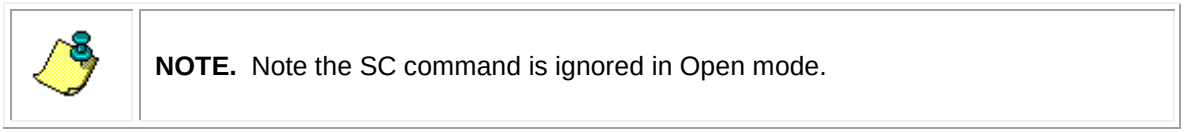
SC <CR> or <LF>

### Operating Modes

Run, Calibration

### Description

The SC command sets the sensor to output data continuously and as soon as its available. The sample rate is approximately 0.85 Hz.



**NOTE.** Note the SC command is ignored in Open mode.

Use the S command to stop the continuous output of data. This command must be entered in upper case and need not be followed by a <CR> or <LF> character.

### Returns

Data are displayed one scan at a time.

### See Also

S

# S

## Stops continuous output

### Usage

S

### Operating Modes

Run, Calibration

### Description

The S command stops the continuous output of data. No <CR> or <LF> character is required.

**NOTE.** The S command must be entered as an upper case character.

### Returns

None.

### See Also

SC

# SCKO

## Enables checksum operation

### Usage

SCKO <CR> or <LF>

### Operating Modes

Open

### Description

The SCKO command enables the output of the checksum result with the data.

**NOTE.** The SCKO command must be followed by the ***E command to save the setting.

With the checksum output enabled, a checksum in hexadecimal format, is saved with each scan of data. The checksum is shown in the rightmost column of each row of data when displaying the data.

### Returns

See Examples below.

### Examples

Enter SCKO <CR><CF>

checksum output set

The checksum is added to the data:

35.2341, 7.4563, 2347.4678, 5D <CR><LF>

### See Also

***E, CCKO, RCKO

# SCOP

## Enables continuous on power up

### Usage

SCOP <CR> or <LF>

### Operating Modes

Open

### Description

The SCOP command enables continuous output of data immediately after power up.

**NOTE.** The SCOP command must be followed by the ***E command to save the setting.

### Returns

Continuous set

### See Also

***E

# S/N

## Displays the serial number

### Usage

S/N <CR> or <LF>

### Operating Modes

Open

### Description

The S/N command displays the serial number of the sensor.

### Returns

See Examples below.

### Examples

Enter S/N <CR> or <LF> The sensor displays the sensor serial number:

S/N=1539

### See Also

VER

# VER

## Displays the firmware version number

### Usage

VER <CR> or <LF>

### Operating Modes

Open

### Description

The VER command displays the version number of the firmware in the sensor.

### Returns

See Examples below.

### Examples

Enter VER <CR> or <LF> The sensor displays the version number of the sensor firmware:

1.5

### See Also

S/N

# WHO

## Displays the sensor name

### Usage

WHO <CR> or <LF>

### Operating Modes

Run, Open, Calibration

### Description

The WHO command displays the name of the connected sensor.

### Returns

See Examples below.

### Examples

Enter WHO <CF> or <LF> The sensor displays the sensor name:

ECT

# Error Messages

For any invalid command, the CT Sensor will respond with the message "BAD COMMAND, TYPE ?+Enter" or an error message depicting the nature of the error. A command is invalid if it is not recognized, it is incomplete, or parts are incorrect.

The error messages and their definitions are the following:

**BAD COMMAND:**

An unrecognized command. Re-enter the command after checking the validity of command in the current operational mode of the sensor. Most commands are functional only when the sensor is in Open mode.

**ERROR, NOT OPEN:**

The command requires the sensor to be in Open mode. Use the ***O command to set the sensor in Open mode, and then re-enter the initial command.

**ERROR, NOT RUNNING:**

The SC command was used while the sensor was in Open mode. Use the ***R command to place the sensor in Run mode. Re-enter the SC command.

**ERROR, CAL TERMS MISSING:**

Upon entering the ***R command to place the sensor in Run mode from either the Calibration or Open mode, a complete set of calibration constants was not available to compute conductivity. Use the ***O command to enter Open mode, and then check the status of the constants using the RCAL command. The constants A0n, A50n A100n, and Bn *must* be non-zero.

**ERROR, ADDRESSING ACTIVE:**

While in Open mode, an attempt has been made to enter address mode operations using the SAOP command while continuous on power up has been enabled using the SCOP command. Disable continuous on power up using the CCOP command, and then re-enter the SAOP command. Remember that all changed operational settings must be saved to flash memory using the ***E command to ensure the sensor will power up in the correct operational modes. All operational settings not saved using the ***E command will revert to the previous settings upon the next power up of the sensor.

**ERROR, CONTINUOUS ON POWER-UP ACTIVE:**

While in Open mode, an attempt has been made to enable continuous on power up using the SCOP command while the address operations has been enabled using the SAOP command. Disable address operations using the CAOP command, and then re-enter the SCOP command. Remember that all changed operational settings must be saved to flash memory using the ***E command to ensure the sensor will power up in the correct operational modes. All operational settings not saved using the ***E command will revert to the previous settings upon the next power up of the sensor.

**EEPROM WRITE ERROR:**

A flash memory write error was detected when the ***E command was used. Cycle the power and continue. If the error message persists, go to Open mode, re-enter the calibration constants, and then use the ***E command to save them to flash memory. If the sensor continues to display this error, consult TRDI for repair.

**EEPROM READ ERROR, CHECK EEPROM DATA:**

A flash memory write error was detected when the ***E command was used The error was detected during the read operation after the write operation at the end of the command. Cycle the power and review the calibration constants. If there are errors in the data, go to Open mode, re-enter the calibration constants, and then use the ***E command to save them to flash memory. If the sensor continues to display this error, consult TRDI for repair.

**ERROR, MUST BE ON or OFF:**

For the channel ON/OFF commands, the status of the channel can be changed by adding either "=ON" or "=OFF." This message is returned for invalid entry.

# Mechanical Outline Drawings

This section includes mechanical outline drawings which should be useful when installing a CT-EK-D CT Sensor and a CT Sensor board, or when designing a housing or mounting platform for them. The list below includes a drawing for each sensor configuration plus a drawing that shows the mechanical outline of the board. Corresponding page numbers are also listed.



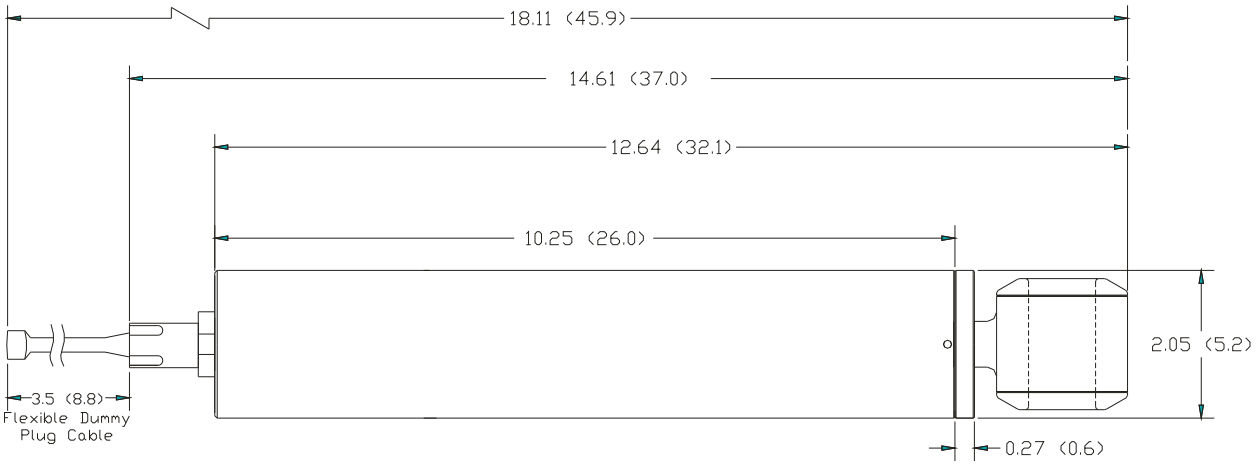



**Figure 8. 500-meter Rated CT Sensor with Housing Mechanical Outline**

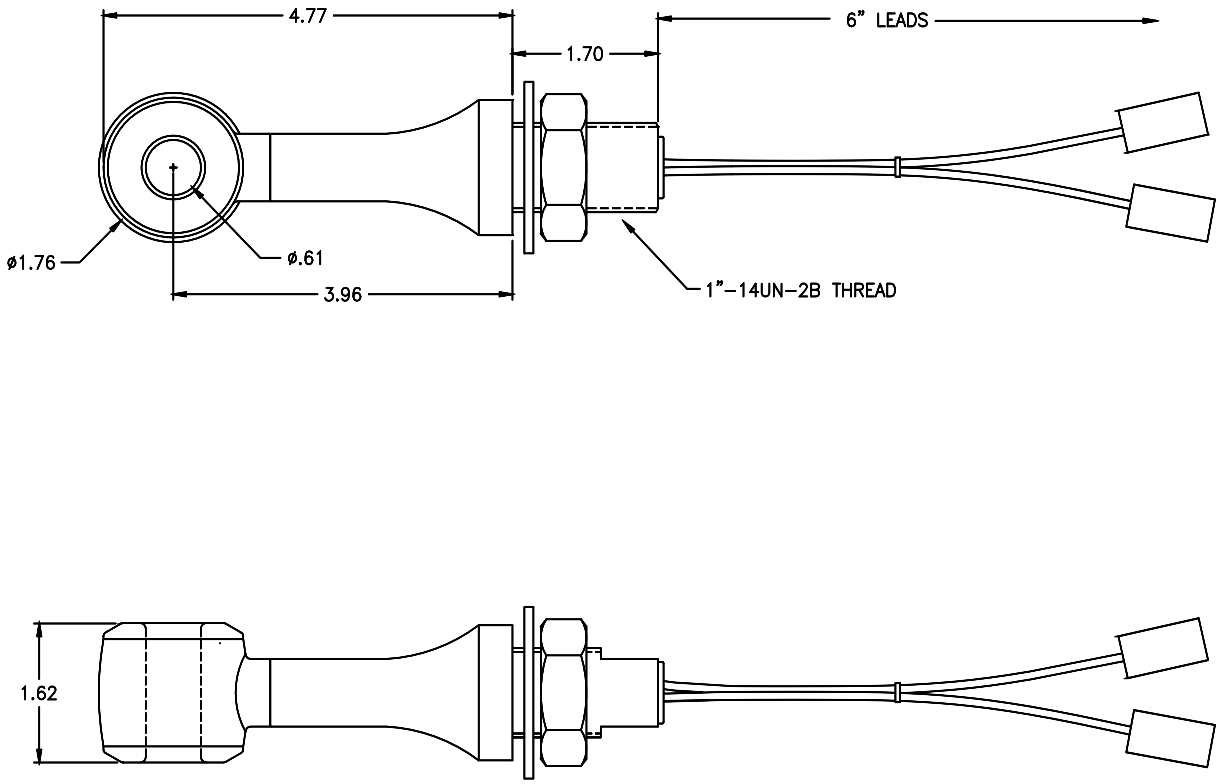



**Figure 9. 500-Meter Rated CT Sensor with Internal Temperature Sensor Mechanical Outline—Long Stem**

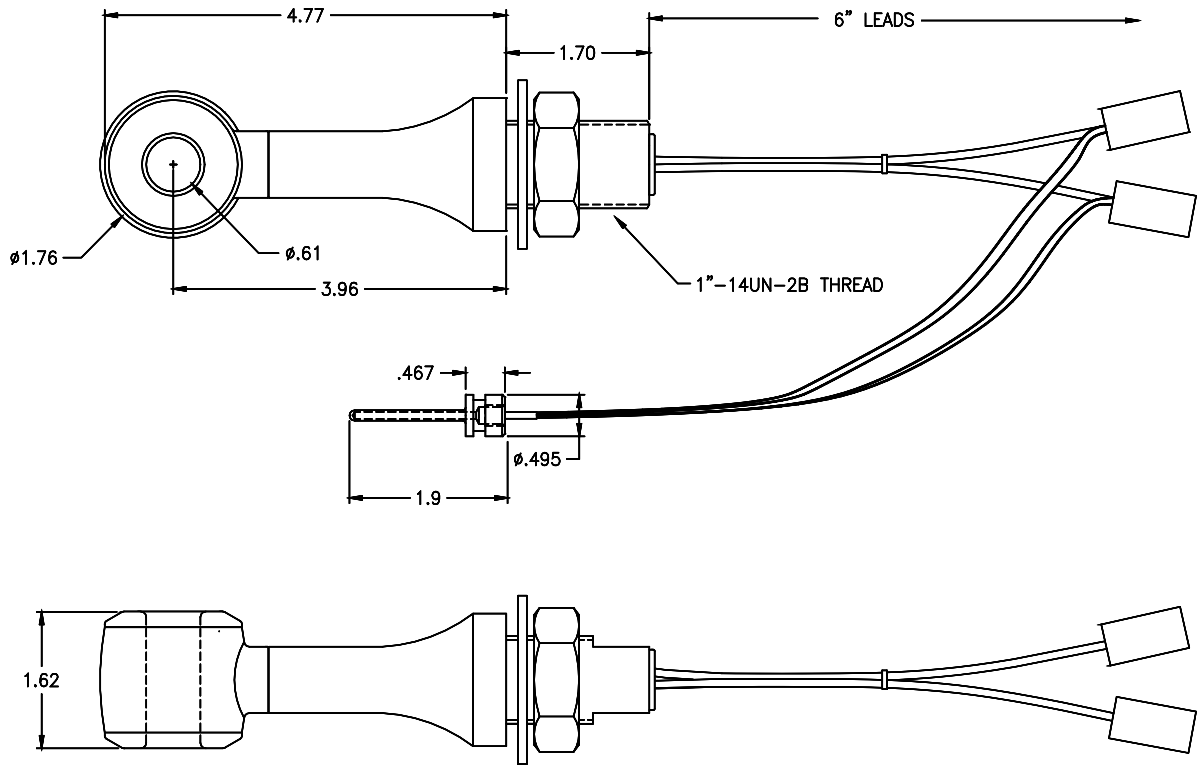



**Figure 10. 500-Meter Rated CT Sensor with External Temperature Sensor Mechanical Outline—Long Stem**

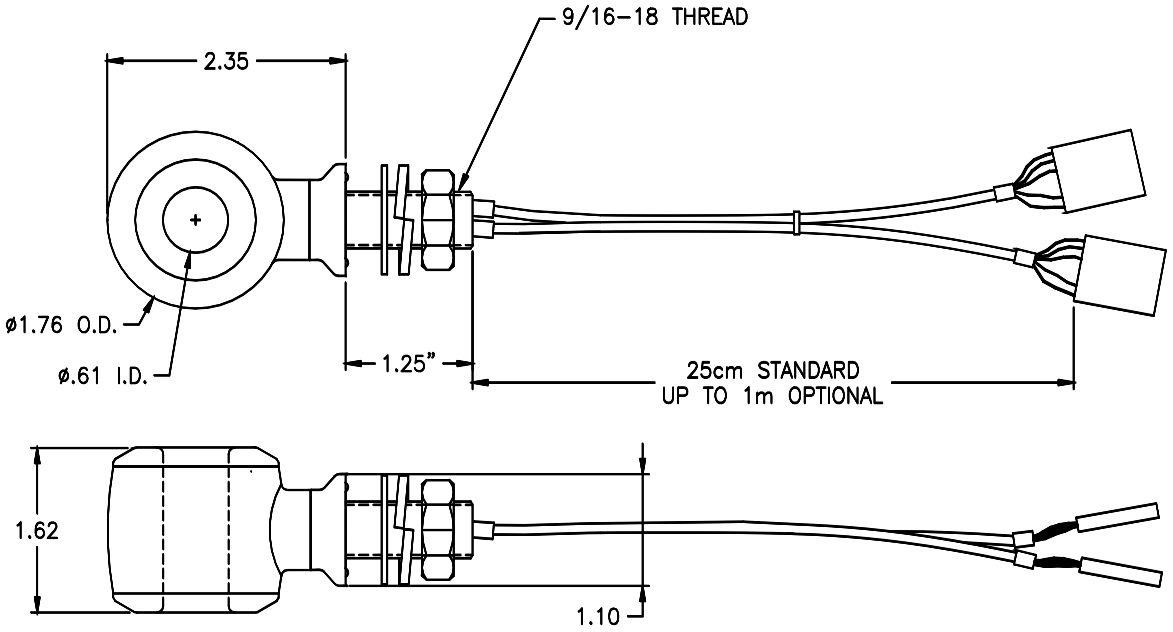



**Figure 11. 500-Meter Rated CT Sensor with Internal Temperature Sensor Mechanical Outline—Short Stem**

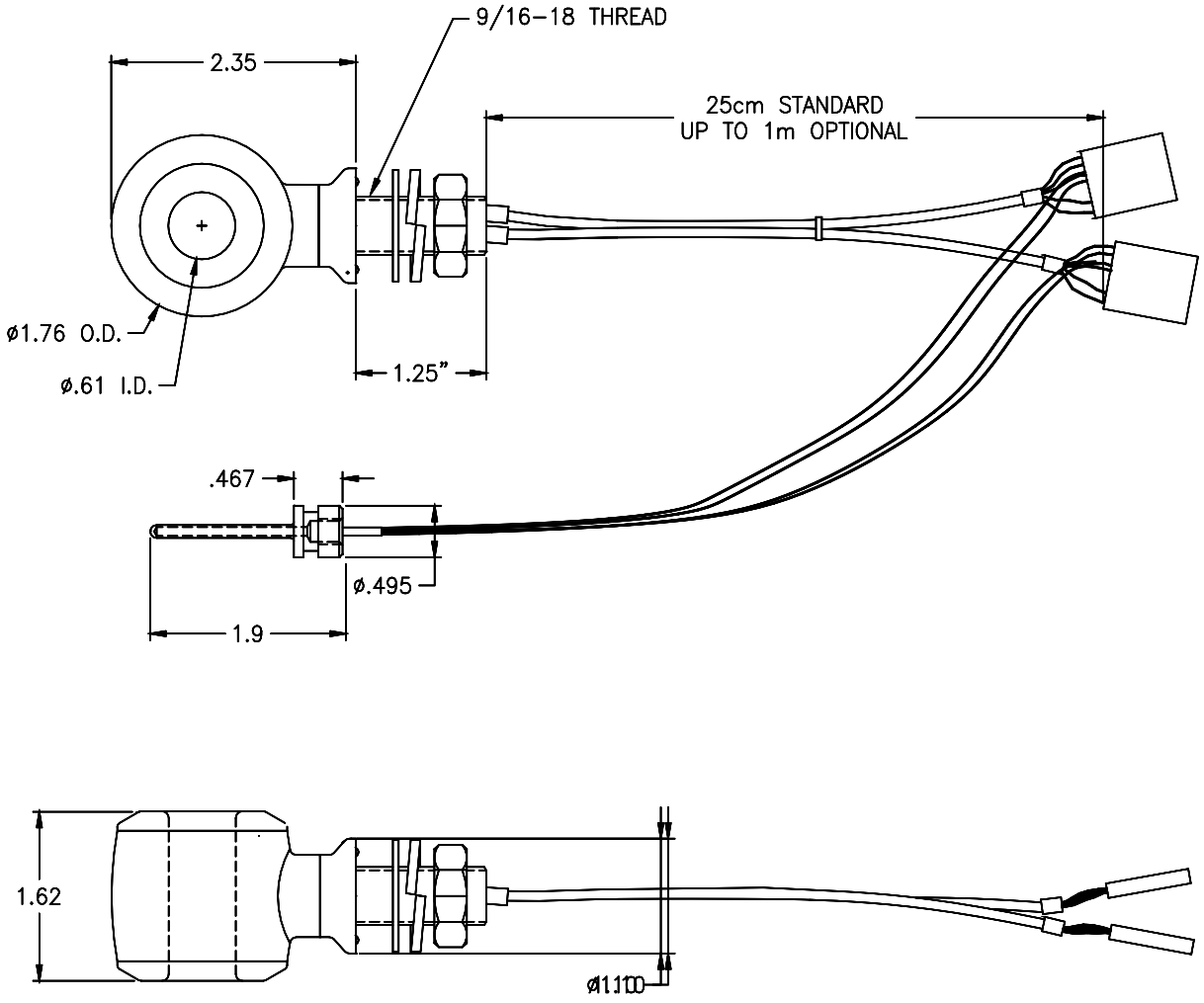



**Figure 12. 500-Meter Rated CT Sensor with External Temperature Sensor Mechanical Outline—Short Stem**

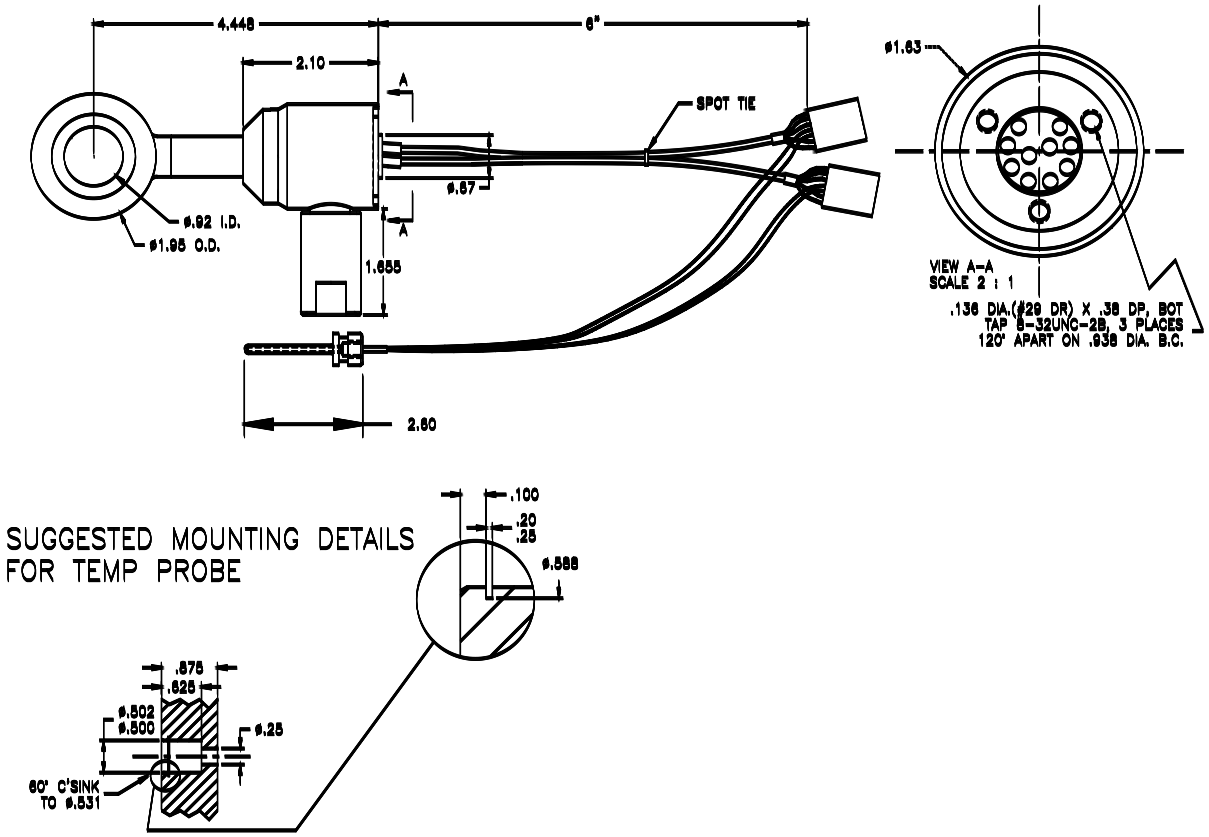



**Figure 13. 7000-Meter Rated CT Sensor with External Temperature Sensor Mechanical Outline**

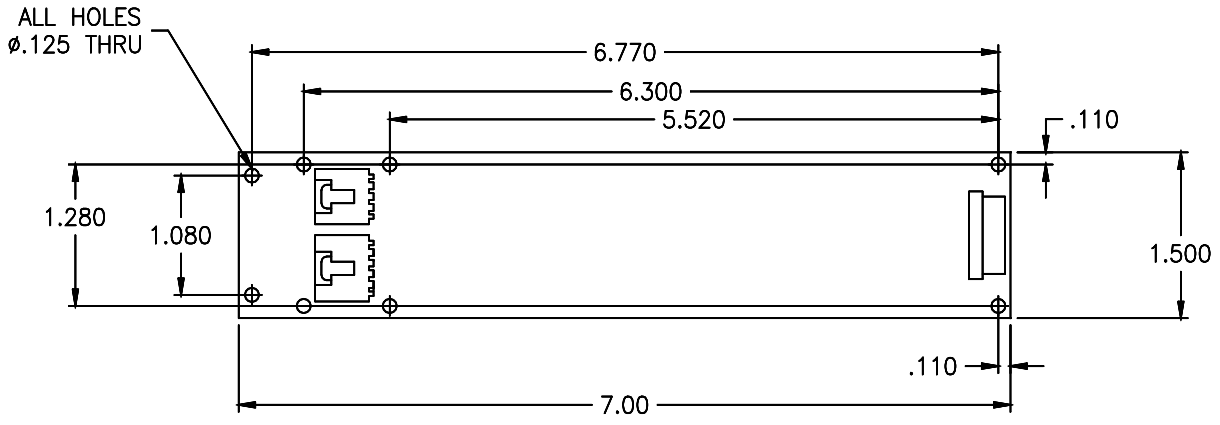



**Figure 14. CT-EK-D CT Sensor Board Mechanical Outline**

# APPENDIX A: Warranty, Liability and RMA Return Procedure

## Teledyne RD Instruments Limited Warranty

Teledyne RD Instruments (TRDI) guarantees its products to be free from defects in materials and workmanship for a period of one year from the date of shipment. In the event a product malfunctions during this period, TRDI's obligation is limited to the repair or replacement, at TRDI's option, of any product returned to the TRDI factory. Products found defective should be returned to the factory freight prepaid and carefully packed, as the customer will be responsible for any damage during shipment.

Repairs or replacements, parts, labor, and return shipment under this warranty will be at no cost to the customer. This warranty is void if, in TRDI's opinion, the product has been damaged by accident or mishandled, altered, or repaired by the customer, where such treatment has affected its performance or reliability. In the event of such mishandling, all costs for repair and return freight will be charged to the customer. All products supplied by TRDI that are designed for use under hydrostatic loading have been certified by actual pressure testing prior to shipment. Any damage that occurs as a direct result of flooding is NOT covered by this warranty.

If a product is returned for warranty repair and no defect is found, the customer will be charged a diagnostic fee plus all shipping costs. Incidental or consequential damages or costs incurred as a result of a product's malfunction are not the responsibility of TRDI.

Equipment not manufactured by TRDI is supported only to the extent of the original equipment manufacturers (OEM) original warranties. All OEM sensors that utilize electrodes (oxygen cartridges, pH, ORP, etc.) are warranted at the time of shipment, and shall perform upon initial installation within stated specifications. If the product proves to be defective within the OEM's warranty, TRDI will replace the product or defective part with a similar model, product or part, but only to the extent that the OEM warrants.

All returned products must be accompanied by a Returned Material Authorization (RMA) number issued by TRDI. Shipments without an RMA number will not be accepted.

## Liability

TRDI shall not be liable for incidental or consequential damages, injuries, or losses as a result of the installation, testing, operation, or servicing of TRDI products.

# Returning CTDs to TRDI for Service

When shipping the system to TRDI from either inside or outside the United States, the following instructions will help ensure the CTD arrives with the minimum possible delay. Any deviation from these instructions increases the potential for delay.

- All shipments must be accompanied by two copies of your commercial invoice showing value of material and any reason for return.
- Whenever possible, please send copies of the original export shipping documents with the consignment.
- If the equipment is property of TRDI, please insure for full value.
- If the value is in excess of $1,000.000, the following shippers oath must be sent with the invoices. (This can be typed on the invoice or on a separate letterhead).

  "I,_____, declare that the articles herein specified are, the growth, produce, or manufacture of the United States; that they were exported from the United States; from the Port of _____, on or about _____; that they are returned without having been advanced in value or improved in condition by any process of manufacture or any other means, that no drawback, bounty, or allowance has been paid or admitted thereof.

  Signed _____"

## Domestic Shipments

### ***Step 1 - Get a Return Material Authorization***

Send an e-mail to TRDI's Sales Administration (rdicsadmin@teledyne.com) or call Customer Service and request a Return Material Authorization (RMA) number. When requesting a RMA number, please give us the following information.

- What is being shipped (include the serial number)
- When you plan to send the shipment
- What issue(s) need to be corrected
- Name of the Field Service Engineer that knows about the issue
- When you need the instrument returned

TRDI's Customer Service will then respond with the RMA number for the shipment. Please include this number on all packages and correspondence.

### ***Step 2 – Provide a MSDS as necessary***

Please provide a Material Safety Data Sheet (MSDS) if the system/transducer is painted with antifouling paint.

### *Step 3 - Ship via air freight, prepaid*

*Urgent Shipments* should be shipped direct to TRDI via overnight or priority air services. Do not send urgent airfreight as part of a consolidated shipment. If you ship consolidated, it will cost less, but may lose up to three days in transit time.

*Non-urgent shipments* may be shipped as part of a consolidated cargo shipment to save money. In addition, some truck lines may offer equivalent delivery service at a lower cost, depending on the distance to San Diego.

Mark the Package(s)

**To: Teledyne RD Instruments, Inc. (RMA Number)**
**14020 Stowe Drive**
**Poway, California 92064**

**Airport of Destination = San Diego**
**Notify Paxton, Shreve, and Hayes**
**Phone: +1 (619) 232-8941**
**Fax: +1 (619) 232-8976**

### *Step 4 - Urgent shipments*

Send the following information by fax or telephone to TRDI.

**Attention: Customer Service Administration**
**Fax: +1 (858) 842-2822**
**Phone: +1 (858) 842-2600**

- Detailed descriptions of what you are shipping (number of packages, sizes, weights, and contents).
- The name of the freight carrier
- Master Air bill number
- Carrier route and flight numbers for all flights the package will take

# International Shipments

### *Step 1 - Get a Return Material Authorization*

Send an e-mail to TRDI's Sales Administration (rdiefs@teledyne.com) or call Customer Service and request a Return Material Authorization (RMA) number. When requesting a RMA number, please give us the following information.

- What is being shipped (include the serial number)
- When you plan to send the shipment
- What issue(s) need to be corrected
- Name of the Field Service Engineer that knows about the issue
- When you need the instrument returned

TRDI's Customer Service will then respond with the RMA number for the shipment. Please include this number on all packages and correspondence.

### *Step 2 – Provide a MSDS as necessary*

Please provide a Material Safety Data Sheet (MSDS) if the system/transducer is painted with antifouling paint.

***Step 3 - Ship Via Air Freight, Prepaid***

*Urgent Shipments* should be shipped direct to TRDI via overnight or priority air services. Do not send urgent airfreight as part of a consolidated shipment. If you ship consolidated, it will cost less, but may lose up to three days in transit time.

*Non-urgent shipments* may be shipped as part of a consolidated cargo shipment to save money.

Mark the package(s) as follows:

**To: Teledyne RD Instruments, Inc. (RMA Number)**
**2A Les Nertieres**
**5 Avenue Hector Pintus**
**06610 La Gaude, France**

***Step 4 - Include Proper Customs Documentation***

The Customs statement must be completed. It should be accurate and truthfully contain the following information.

- Contents of the shipment
- Value
- Purpose of shipment (example: “American made goods returned for repair”)
- Any discrepancy or inaccuracy in the Customs statement could cause the shipment to be delayed in Customs.

***Step 4 - Send the Following Information by Fax or Telephone to TRDI***

**Attention: Sales Administration**
**Phone: +33(0) 492-110-930**
**Fax: +33(0) 492-110-931**

- Detailed descriptions of what you are shipping (number of packages, sizes, weights, and contents).
- The name of the freight carrier
- Master Air bill number
- Carrier route and flight numbers for all flights the package will take