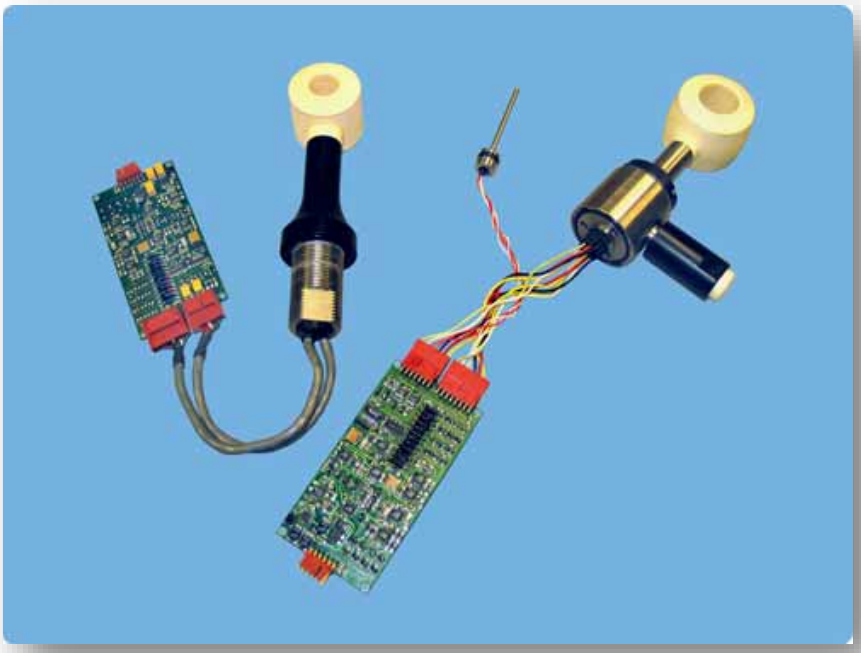
CT-EK-A

OEM CT Sensor

High Accuracy Conductivity and Temperature Sensor with Direct Analog Output

Technical Manual



8001-CTS-ANALOG (February 2019)

TELEDYNE RD INSTRUMENTS
Everywhereyoulook™

Table of Contents

List of Figures

List of Tables

Revision History

February 2019

- Corrected typo on Power Requirements, page 4
- Fixed K-Constant equation on page 12 from $K*1/(R/T2)$ to $K*1/(R/T^2)$

February 2017

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

May 2010

- Converted manual to TRDI format

February 2011

- Page 4, corrected O-ring size from 2-123 to 2-124.

November 2011

- Changed model number from CT-EKL-A to CT-EK-A

March 2012

- Updated Cleaning the CT Sensor section

June 2012

- Updated conductivity specifications accuracy to ±0.002 S/m (±0.02 mS/cm)
- Updated conductivity specifications stability to ±0.005 S/m/month (0.05mS/cm/month (typical))

CT-EK-A Technical Manual

SECTION 1: Introduction

The Teledyne RD Instruments OEM CT Sensor provides high accuracy conductivity and temperature measurements 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 a CT Sensor board and provides direct analog outputs of conductivity and temperature.

Customer Service

TRDI welcomes your feedback. Please contact TRDI customer service to offer any comments or suggestions or to request technical support. TRDI can be contacted using any of the following means:

Teledyne RD Instruments

14020 Stowe Drive
Poway, California 92064

Phone +1 (858) 842-2600

FAX +1 (858) 842-2822

Sales – rdisales@teledyne.com

Field Service – rdifs@teledyne.com

Teledyne RD Instruments Europe

2A Les Nertieres
5 Avenue Hector Pintus
06610 La Gaude, France

Phone +33(0) 492-110-930

FAX +33(0) 492-110-931

Sales – rdie@teledyne.com

Field Service – rdiefs@teledyne.com

Client Services Administration – rdicsadmin@teledyne.com
Web: http://www.teledynemarine.com/rdi

For all your customer service needs including our emergency 24/7 technical support, call
+1 (858) 842-2700

Self-Service Customer Portal

Use our online customer portal at http://www.teledynemarine.com/rdi and click on the **Support** link to download manuals, firmware updates, software, or other Teledyne RDI documentation. Log into your account and then click the **Software/Firmware** link or **Documentation** link.

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.

500-Meter Rated

The CT Sensor with a 500-meter depth rating is shown in Figure 1. 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 2.

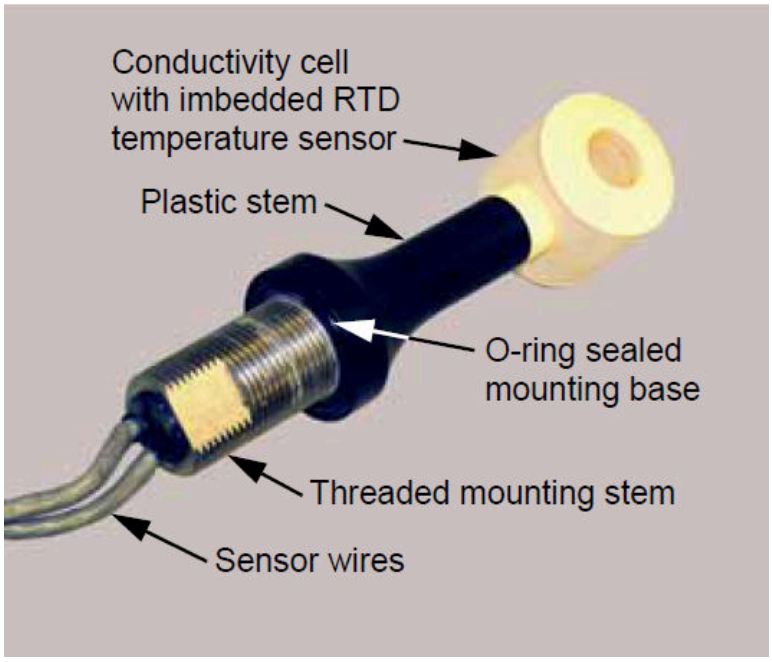


Figure 1. The 500-Meter Rated CT Sensor with Internal Temperature Sensor

7000-Meter Rated

The CT Sensor with a 7000-meter depth rating is shown in Figure 2. 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.

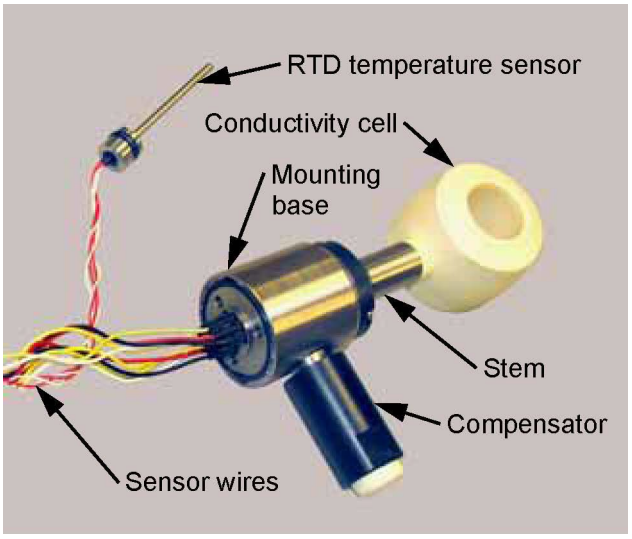


Figure 2. The 7000-Meter Rated CT Sensor with External Temperature Sensor

CT Sensor Electronics

The CT Sensor electronics is contained on a single printed circuit board, the CT Sensor board. The CT Sensor board outputs analog voltages proportional to conductivity and temperature. The user interface connects to a 6-pin interface connector on one end of the board, and the sensor connects to two connectors on the opposite end.

The output voltage ranges can be set to one of four available factory settings as follows:

- 0–2.5 VDC
- 0–4.0 VDC
- ± 2.5 VDC
- 0–5.0 VDC

Specifications

Below are the general specifications for the OEM CT Sensor and the CT Sensor board. For mechanical outline drawings of the sensor and the board, refer to SECTION 4: Mechanical Outline Drawings.

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
Control logic input:	<0.8 VDC (low), >1.5 VDC (hi)
Output voltage range:	0–2.5 VDC standard; other ranges optional
Output impedance:	500 ohms
Depth rating:	500 m (internal temperature sensor), 7000 m (external temperature sensor)
Interface connector:	6-pin Molex Series 2695
Sensor mounting:	1-14 UN Class 2B thread
O-ring:	Buna-N p/n 2-124
CT Sensor board size:	5.08 cm (2 in.) by 10.2 cm (4.0 in.)

Table 2: 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:	±0.005 S/m/month (0.05mS/cm/month (typical))

Table 3: 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) 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

SECTION 2: Wiring the CT Sensor

User connections to the OEM CT Sensor are made to the interface connector of the CT Sensor board which is shown in Figure 3. The interface connector is a 6-pin Molex Series 2695 connector shown by itself on the right side of the board. It requires a Molex P/N 22-01-3067 terminal housing mating connector with Molex P/N 08-65-0814 crimp terminals. The two connectors on the left side of the board are used to connect to the CT Sensor.

Wiring the Interface Connector

Wiring the interface connector requires connecting power and ground, connecting two control inputs and connecting to the signal output.

Interface Connector Connections

The interface connector wiring information is shown in Table 4 and descriptions of each of the connections are listed below.

Signal Output: Outputs one of four analog voltages in accordance with the S0 and S1 settings.

- A linear voltage proportional to conductivity.
- A linear voltage proportional to temperature.
- A zero range calibration reference voltage.
- A full scale range calibration reference voltage.

Signal Return: The signal output ground.

S0: Along with S1, determines which signal output is selected in accordance with Table 2-2 on page 2-3.

S1: Along with S0, determines which signal output is selected in accordance with Table 2-2 on page 2-3.

Power Input: DC input voltage of 6–14 VDC. The voltage should be relatively noise free. Optional 5 VDC input voltage can be specified at time of order.

Power Return: The power input ground.

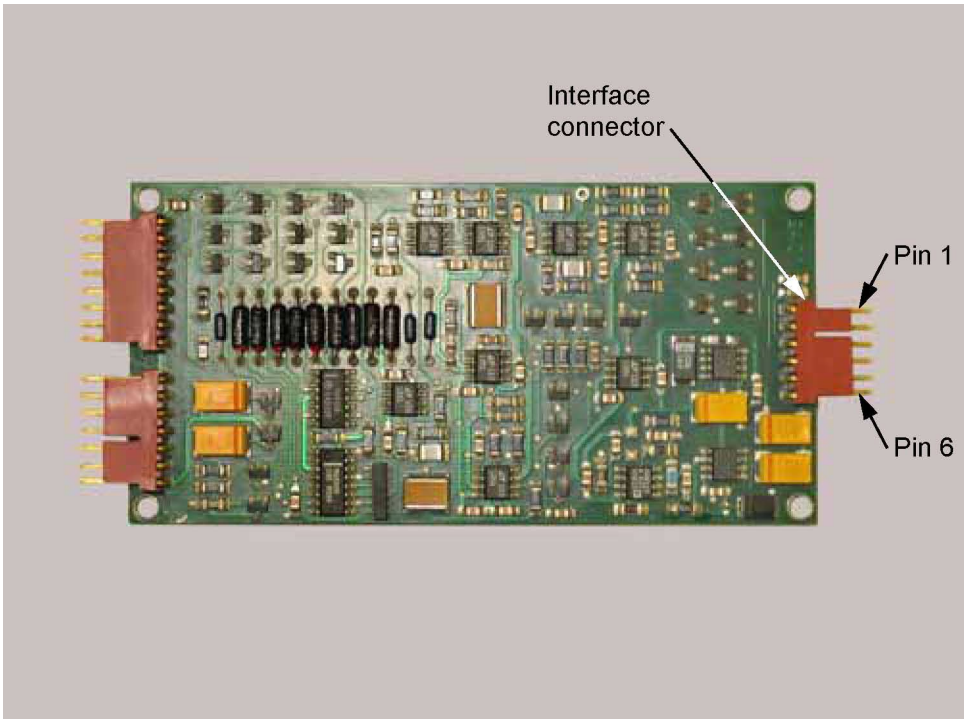


Figure 3. The CT Sensor Board

Table 4: Interface Connector Connections

PIN	LABEL	FUNCTION
1	Signal (+)	Signal Out
2	Signal (-)	Signal Ground
3	S0	Control 0
4	S1	Control 1
5	Power (+)	Power In
6	Power (-)	Power Ground

Control Input Connections

The S0 and S1 connections are TTL compatible control inputs to the CT Sensor board. They are used to select which of the four analog voltages to output on the Signal Output connection of the interface connector in accordance with Table 5.

Table 5: Control Inputs

S0	S1	SIGNAL OUTPUT
Low	Low	Conductivity
High	Low	Temperature
Low	High	Low Reference
High	High	High Reference

NOTE. To prevent powering the CT Sensor board from the S0 and S1 connections when using CMOS levels, these inputs must be held in the low (0 VDC) state when the board is not powered. To allow for S0/S1 to CT Sensor board voltage differences, install a 1.0-kohm resistor on each CMOS output. These resistors are also recommended for TTL outputs to prevent any possibility of latch conditions occurring during power-up transients.

Output Conversion Formula

The following calculation should be used to convert the CT Sensor output voltage to a measurement of conductivity and temperature.

Find Cs = (Cf - Co)/(Vf - Vo)

Find Cz = Cf - (Cs * Vf)

Find Cond (mmho/cm) = Cs Vc + Cz

Find Ts = (Tf - To)/(Vf - Vo)

Find Tz = Tf - (Ts * Vf)

Find Temp (°C) = Ts * Vt + Tz

Where the measured values are the following:

Vc = Voltage output for conductivity

Vt = Voltage output for temperature

Vo = Voltage output for low reference

Vf = Voltage output for high reference

And the factory calibration values are the following:

Co = Zero conductivity calibration value

Cf = Full scale conductivity calibration value

To = Low temperature calibration value

Tf = High temperature calibration value

SECTION 3: Installing and Maintaining the CT Sensor

The OEM 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 4, and for the temperature sensor in Figure 5. Mount the CT Sensor board using the four mounting holes, one on each corner of the board. For mechanical outline drawings of the sensor and the board, refer to SECTION 4: 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.

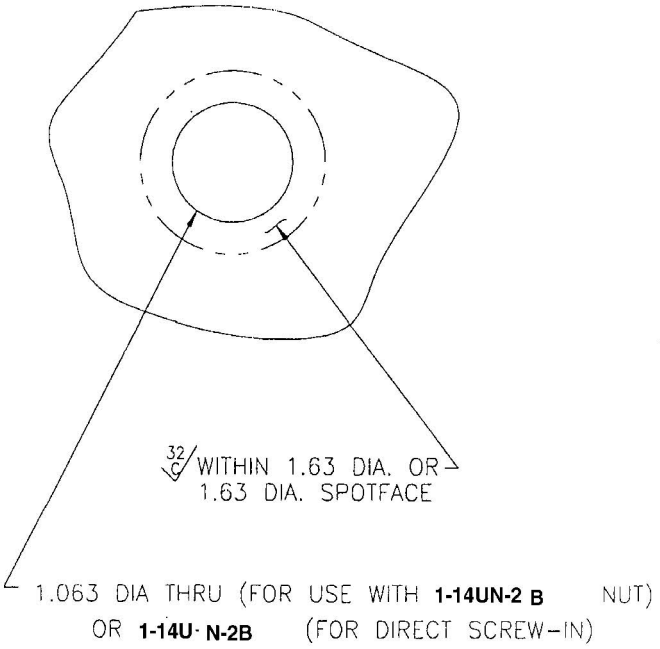


Figure 4. CT Sensor Mounting Hole Detail

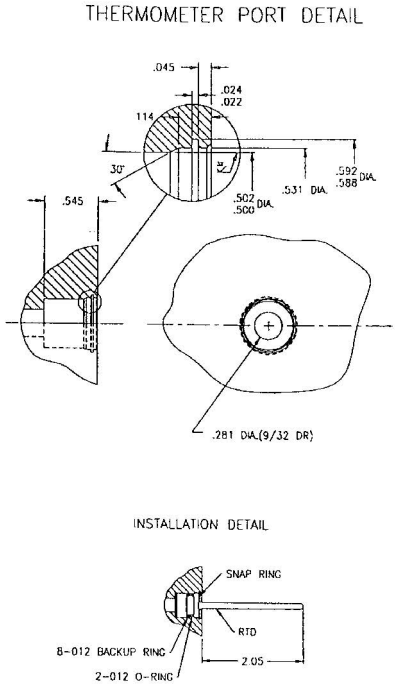


Figure 5. External Temperature Sensor Mounting Hole Detail

Calibrating the CT Sensor

The CT-Sensor can be calibrated using primary standards of temperature and conductivity. The two channels should be calibrated at or as near the end points as possible. Linearity can be checked after calibration using midpoint baths.

Calibrating Conductivity

The conductivity sensor can be calibrated at any reference temperature. To calibrate conductivity collect data at zero conductivity (C1) and a standard value of conductivity (C2) near full scale (greater than 55 mmho/cm). Using a 5½-digit digital voltmeter, measure the zero and full scale range calibration voltages and the conductivity output voltage at both zero and full scale conductivity. Solve for the values of the reference voltages as a value of conductivity as follows:

SD1 = zero conductivity

Z1 = zero range calibration reference voltage

S1 = full scale range calibration reference voltage

C1 = conductivity

SD2 = standard conductivity

Z2 = zero range calibration reference voltage

S2 = full scale range calibration reference voltage

C2 = conductivity

A = (S1 - C1)/(Z1 - C1)

B = (S2 - C2)/(Z2 - C2)

Co = [(SD1*A) - (SD2*B) + SD2 - SD1]/(A-B)

Mc = (Co - SD1)/(Z1 - C1)

Bc = SD1 - (Mc * C1)

Cf = (Mc*S1) + Bc

Co = Zero conductivity calibration value

Cf = Full scale conductivity calibration value

K-Constant

A "K" constant is provided which allows the calibration of the sensor to be checked after installation. To check the result, wind a piece of wire T turns through the conductivity cell core and connect a high quality resistor, R. Find conductivity using the provided constants and equations and compare to K= provided on data sheet where:

Conductivity measured = $K*1/(R/T^2)$

For the 500-meter rated CT Sensor: T = 6, R = 1350 ohms

For the 7000-meter rated CT Sensor: T = 7, R = 1000 ohms

Calibrating Temperature

The temperature sensor can be calibrated at two stable reference temperatures. To calibrate temperature collect data at less than 1°C (T1) and a standard value of temperature (T2) near full scale (greater than 28°C). Using a 5½-digit digital voltmeter, measure the zero and full scale range calibration voltages and the temperature output voltage at both zero and full scale temperature. Solve for the values of the reference voltages as a value of temperature as follows.

T1 = low temperature

Z1 = zero range calibration reference voltage

S1 = full scale range calibration reference voltage

C1 = temperature

T2 = standard temperature

Z2 = zero range calibration reference voltage

S2 = full scale range calibration reference voltage

C2 = temperature

A = (S1 - C1)/(Z1 - C1)

B = (S2 - C2)/(Z2 - C2)

To = [(T1*A) - (T2*B) + T2 - T1]/(a - B)

Mt = (To - T1)/(Z1 - C1)

Bt = T1 - (Mt*C1)

Tf = (Mt*S1) + Bt

To = Low temperature calibration value

Tf = High temperature calibration value

Recommended Maintenance

To ensure your CT-EK 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 6. 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.

SECTION 4: Mechanical Outline Drawings

This section includes mechanical outline drawings which should be useful when installing an OEM 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.

500-Meter Rated CT Sensor with Internal Temperature Sensor Mechanical Outline—Long Stem:	Figure 6
500-Meter Rated CT Sensor with External Temperature Sensor Mechanical Outline—Long Stem:	Figure 7
500-Meter Rated CT Sensor with Internal Temperature Sensor Mechanical Outline—Short Stem:	Figure 8
500-Meter Rated CT Sensor with External Temperature Sensor Mechanical Outline—Short Stem:	Figure 9
7000-Meter Rated CT Sensor with External Temperature Sensor Mechanical Outline:	Figure 10
CT Sensor Board Mechanical Outline:	Figure 11

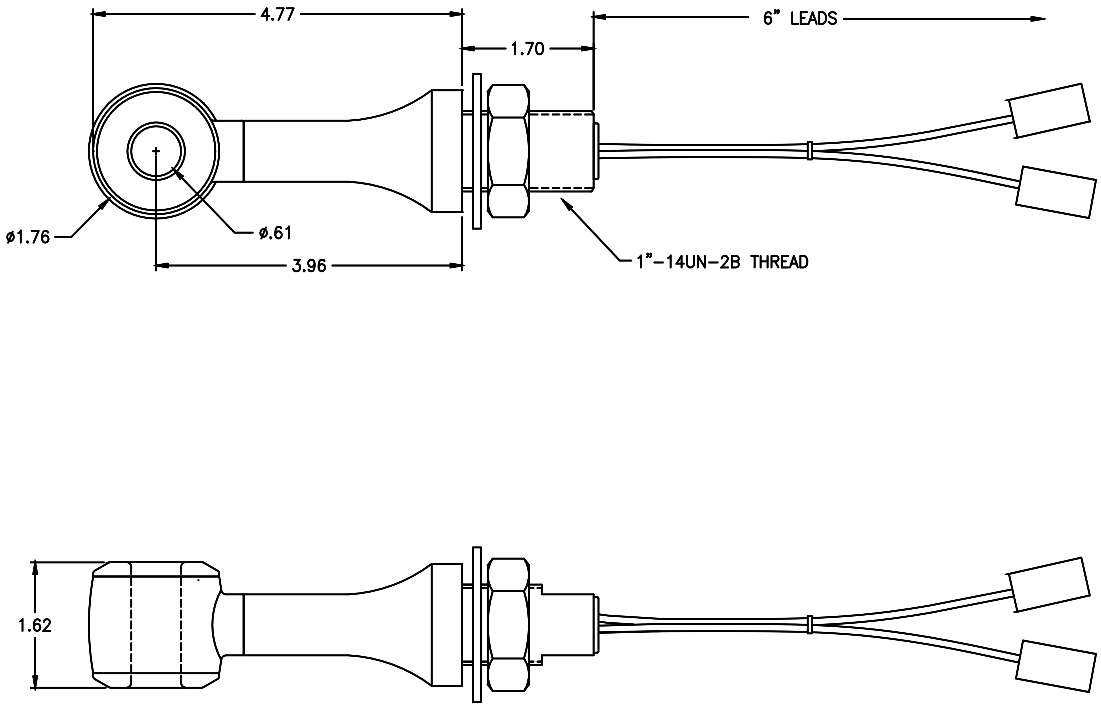


Figure 6. 500-Meter Rated CT Sensor with Internal Temperature Sensor Mechanical Outline—Long Stem

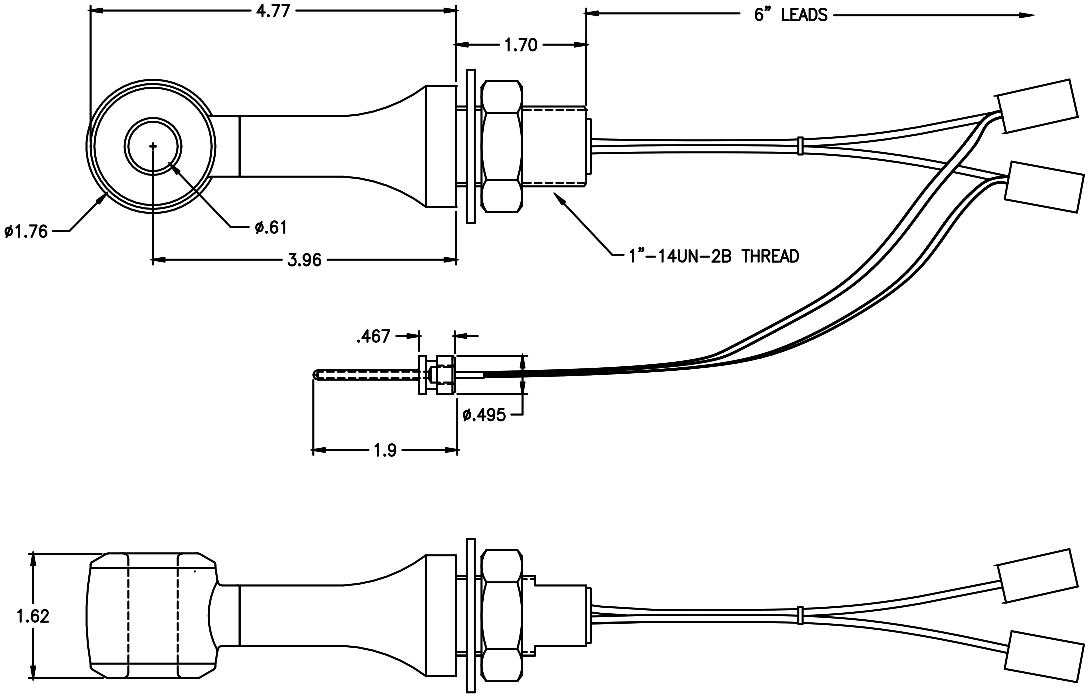


Figure 7. 500-Meter Rated CT Sensor with External Temperature Sensor Mechanical Outline—Long Stem

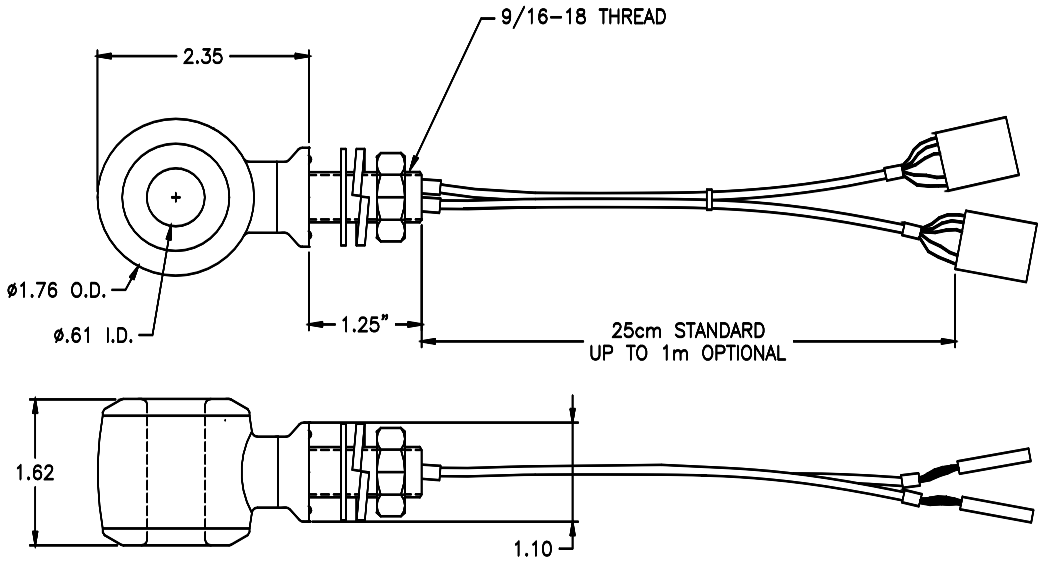


Figure 8. 500-Meter Rated CT Sensor with Internal Temperature Sensor Mechanical Outline—Short Stem

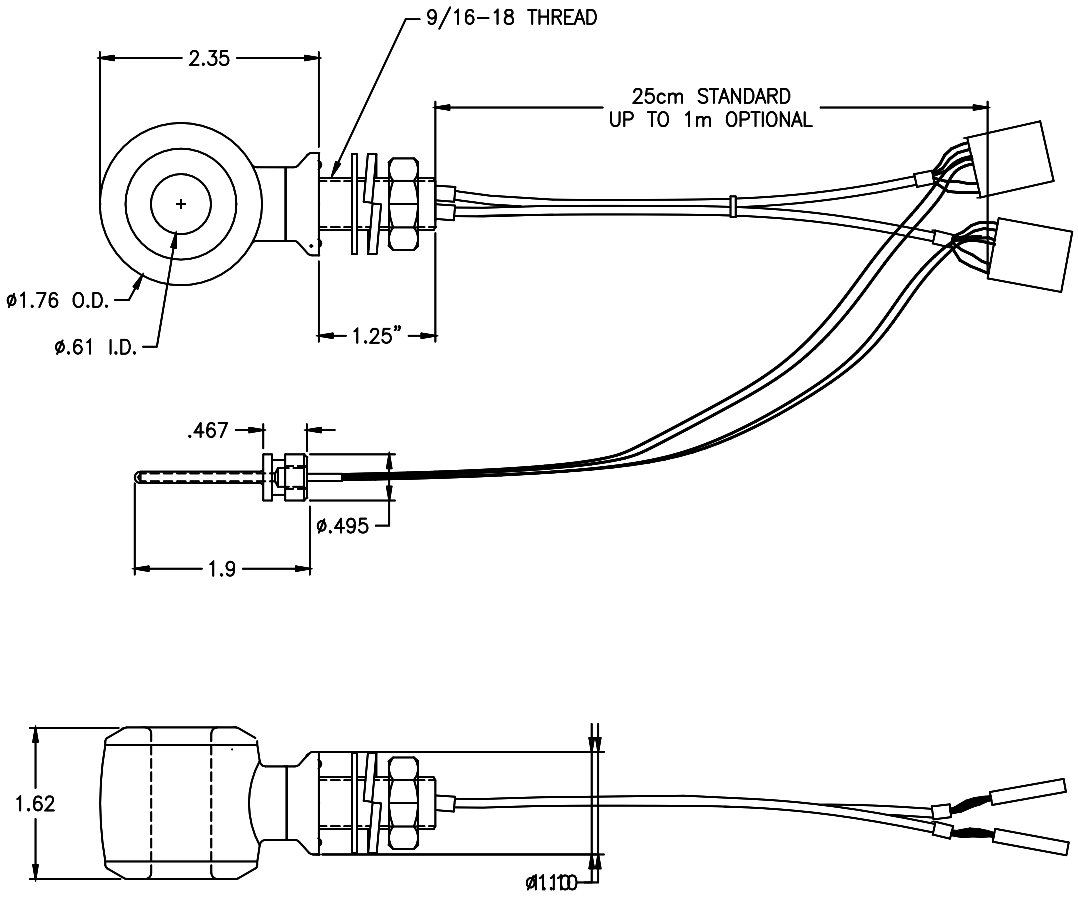


Figure 9. 500-Meter Rated CT Sensor with External Temperature Sensor Mechanical Outline—Short Stem

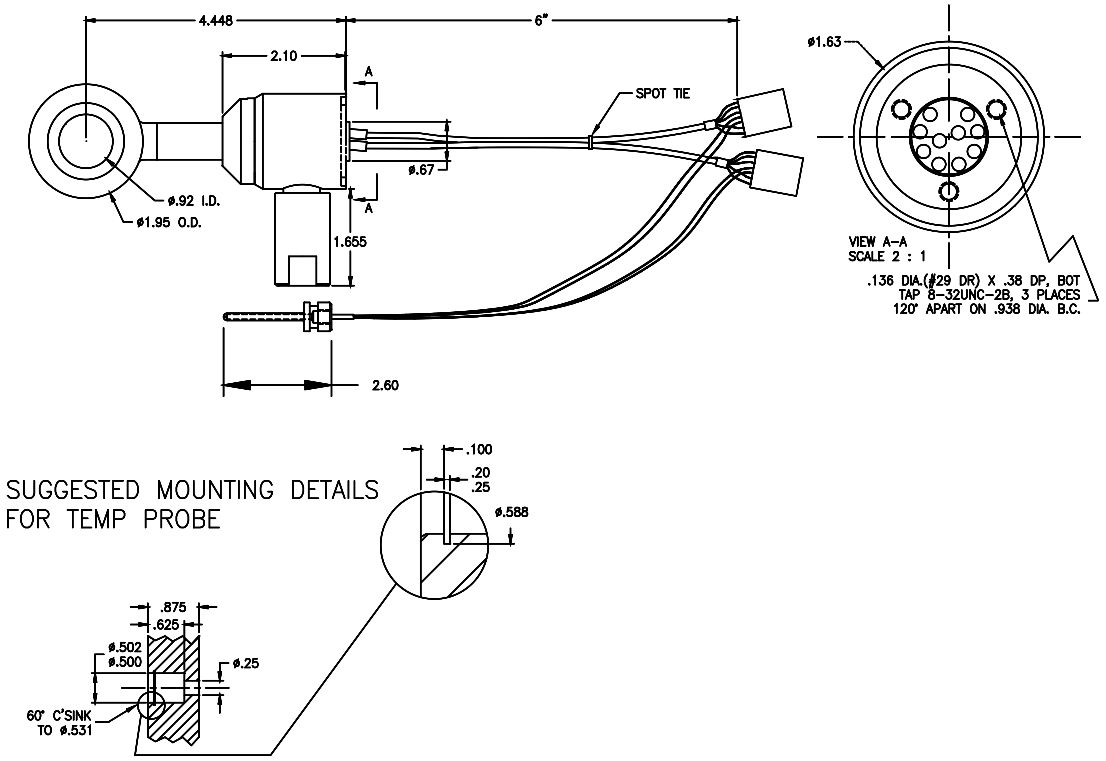


Figure 10. 7000-Meter Rated CT Sensor with External Temperature Sensor Mechanical Outline

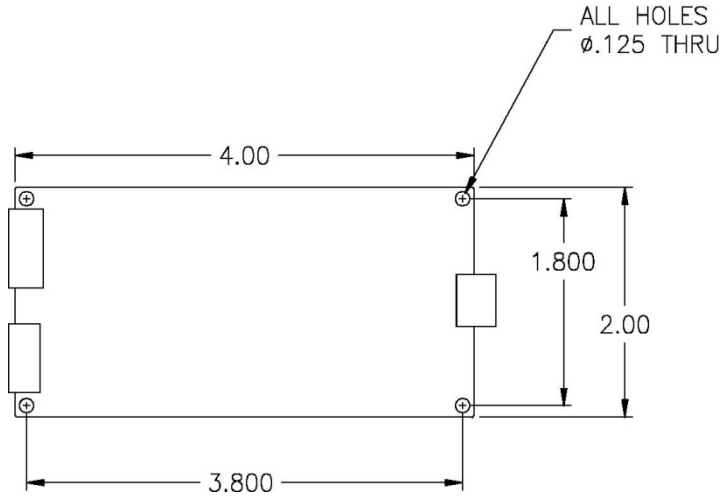


Figure 11. CT Sensor Board Mechanical Outline

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 manufacturer's (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

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