



SEA-BIRD
SCIENTIFIC

User manual

Transmissometers

BAM | C-Star | C-Rover

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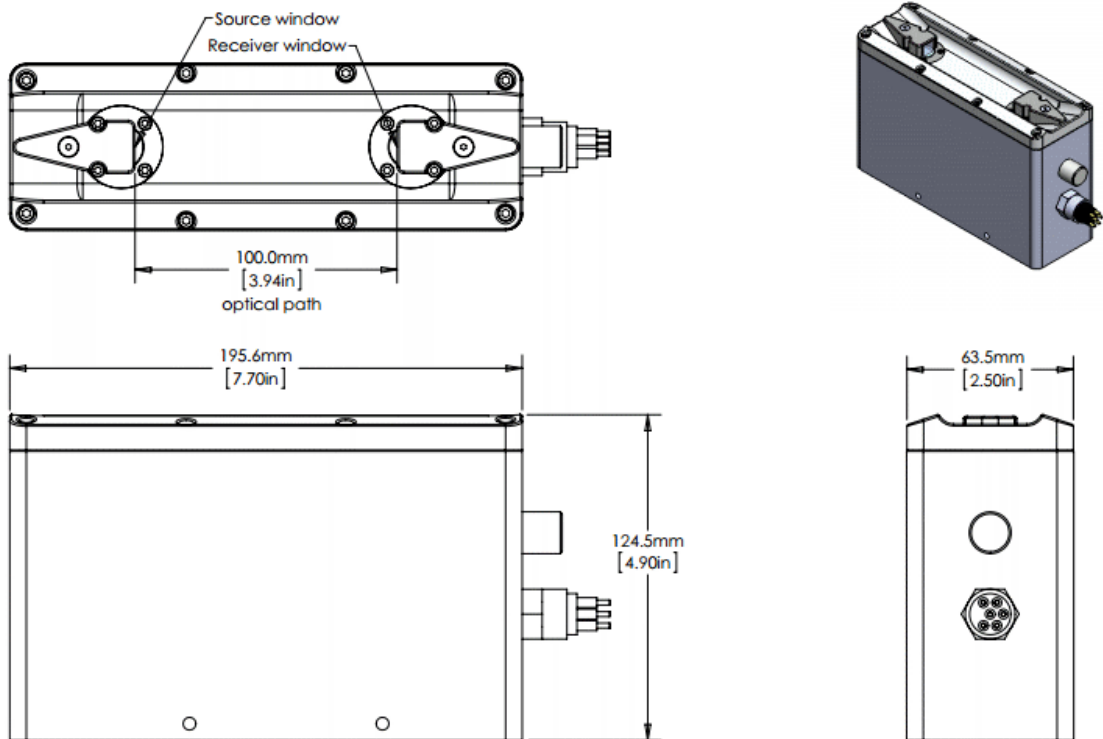
Section 1 Specifications

1.1 Mechanical

1.1.1 Beam Attenuation Meter (BAM)

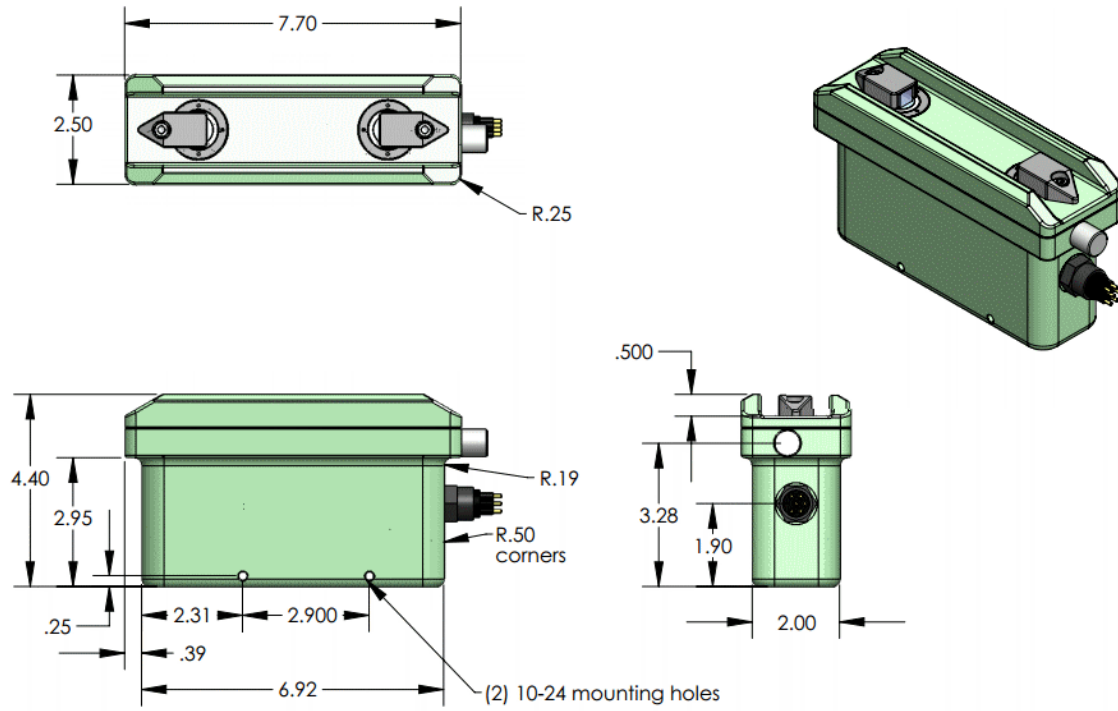
Length	19.56 cm
Height	12.45 cm
Width	6.35 cm
Weight in air, water	Std 3.28 kg, 2.06 kg; SSC 1.91 kg, .88 kg
Rated depth	Std 1000 m SSC 600 m
Temperature range, operation	-2–40 °C
Temperature range, storage	-40–70 °C
Temperature stability	0.02% FS/°C; 3.28 kg, 2.06 kg
Internal air volume	454 cc

Std. BAM dimensions



Specifications

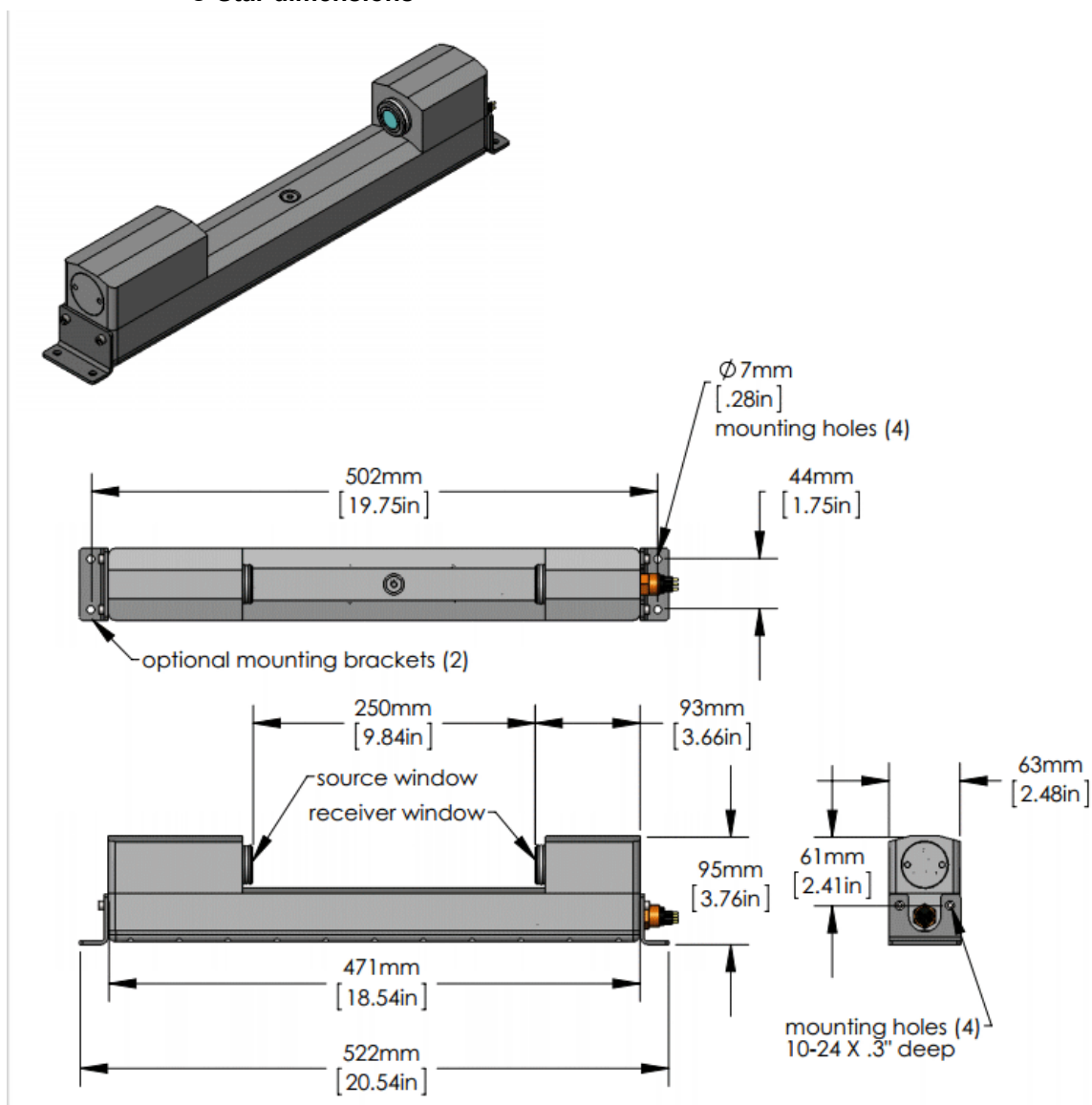
SSC BAM dimensions



1.1.2 C-Star

Dimensions	25 cm pathlength: 9.3 x 6.4 x 47 cm; 10 cm pathlength: 9.3 x 6.4 x 29.2 cm
Weight in air	25 cm pathlength: 2.2 kg; 3.6 kg (aluminum); 10 cm pathlength: 1.8 kg
Rated depth	600 m; 6000 m
Temperature range, operation	-2–40 °C
Temperature range, storage	-20–50 °C

C-Star dimensions

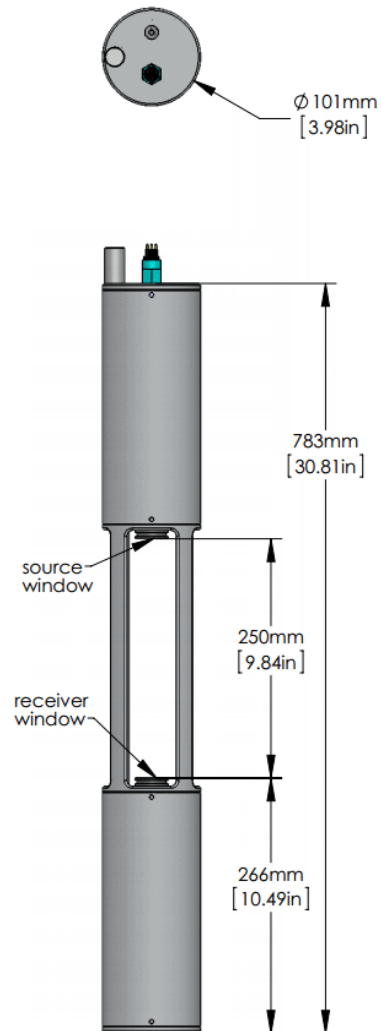


Specifications

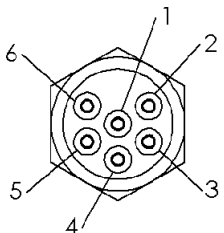
1.1.3 C-Rover

Length	78.3 cm
Diameter	10.1 cm
Weight in air, water	4.11 kg, 0.028 kg
Displacement	4546 ml
Rated depth	2000 m
Temperature range, operation	-2–40 °C
Temperature range, storage	-20–50 °C

C-Rover dimensions



1.1.4 Standard bulkhead connector

Contact	Function	MCBH-6-MP connector
1	Ground	
2	RS232 RX	
3	Reserved	
4	Voltage in	
5	RS232 TX	
6	Reserved	

1.2 Electrical

Input	7–15 VDC
Current draw	35 mA
Linearity	99%
Long-term stability	0.02% FS/hour, 6 hours
Short-term noise	0.027% FS Std dev over 1 minute

1.3 Communication

1.3.1 BAM

Sample rate	to 8 Hz
RS232 output rate	19200 baud
Data resolution	14 bit
Output maximum	13500 ±100 counts

1.3.2 C-Star and C-Rover

Sample rate	1 Hz (default) to 8 Hz
RS232 output rate	19200 baud (default); Range 2400–115200
Data resolution	14 bit
Digital output maximum	~16380 counts
Analog output maximum	5 V (C-Star only)

1.4 Optical

Wavelengths	470 nm, 532 nm, 650 nm
Optical pathlength	25 cm C-Star, C-Rover; 10 cm BAM, (C-Star optional)
Acceptance angle	~1°
Bandwidth (FWHM)	~20 nm
Precision	0.003 m ⁻¹ @ 1 Hz
Linearity	99%

Section 2 Operation

2.1 Verify sensor operation

⚠ CAUTION

Do not supply more than 15 VDC to the sensor. More than 15 VDC will cause damage.

The manufacturer makes three types of transmissometers:

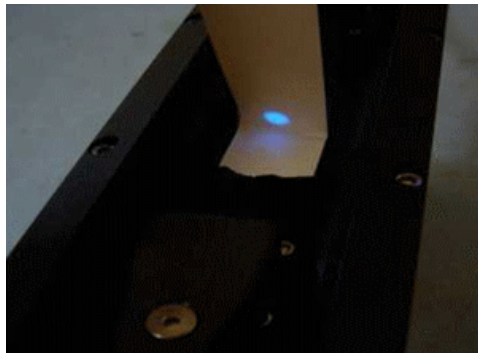
- Beam Attenuation Meter (BAM), designed for Autonomous Underwater Vehicles (AUVs) where size and drag are important.
- C-Star, designed for general purposes. It is available with a 6000 m rated depth. There is also a 10 cm pathlength sensor.
- C-Rover, designed for profiling floats. It is rated to 2000 m.

Each sensor has one of three wavelengths:

- Red (650 nm), best for particle dynamics, e.g. mass concentration studies.
- Green (530 nm), best for estimates of in-situ visibility.
- Blue (470 nm), best for estimates of blue light penetration.

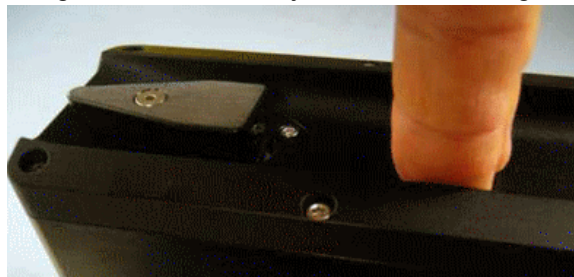
Make sure that the sensor collects data and operates correctly before deployment.

1. Start a terminal communication program such as HyperTerminal® or Tera Term. Select:
 - a. Bits per second: 19200
 - b. Data bits: 8
 - c. Parity: none
 - d. Stop bits: 1
 - e. Flow control: none.
2. Make sure that the sensor is connected to a PC and power supply.
3. Turn on the power supply if necessary.
4. Put a piece of paper in the light path.



A circle of light shows.

5. Put a finger or other solid object in front of the light source.



6. Look at the data from the signal and the corrected signal. They are at or near 0.

2.2 Transmissometer operational criteria

Data is output from the sensor as shown below.

Column	Value	Example output
1	Model-Serial Number	xxx-0000 11829 13838 13695 0.003 527
2	Reference	xxx-0000 11829 13838 13695 0.003 527
3	Signal	xxx-0000 11829 13838 13695 0.003 527
4	Corrected signal	xxx-0000 11829 13838 13695 0.003 527
5	Calculated beam c, m ⁻¹	xxx-0000 11829 13838 13695 0.003 527
6	Thermistor	xxx-0000 11829 13838 13695 0.003 527

1. Look at a clear light path to make sure that the corrected signal is within 100 counts of the Corrected Signal Counts (CSC_{air}) value on the sensor's calibration page or the previous user-monitored value.
 - a. The sensor operates correctly and the optical windows are clean.
 - b. Record the output of the sensor and keep the information to compare to the next check.
2. If the corrected signal is more than 100 but less than 500 counts more than the CSC_{air} :
 - a. Clean the optical windows. Refer to [Clean the optics](#) on page 13 for details.
 - b. Clean the optical windows again if necessary, until the signal is either less than 100 counts different from CSC_{air} or stable between user-collected values.
 - c. Record the output of the sensor and keep the information to compare to the next check.
3. If the output of the sensor is more than 500 corrected counts greater than CSC_{air} :
 - a. Clean the optical windows. Refer to [Clean the optics](#) on page 13 for details.
 - b. Clean the optical windows again if necessary, until the signal is either less than 100 counts different from CSC_{air} or stable between user-monitored values.
 - c. Record the output of the sensor and keep the information to compare to the next check.
4. If the output of the sensor is still more than 500 counts greater than CSC_{air} , contact the manufacturer.

2.3 Transmissometer hardware setup

Attach sensor to frame

- Make sure to electrically isolate the sensor from any metal.
- Sensors that are depth-rated to 2,000 or 6,000 m have a zinc anode installed near the bulkhead connector to protect the sensor from normal corrosion.
- BAM: use the 1/2-20 threaded holes to attach the sensor to any frame.
- C-Star, C-Rover: the manufacturer recommends non-nylon cable ties or monofilament line to attach the sensor to a lowering frame or metal cage.
- C-Star, C-Rover: if the sensor is attached to a frame with hose clamps, Use a sheet of rubber or dielectric tape to prevent metal-to-metal contact. Use corrosion-resistant 316 stainless steel or titanium clamps.
- C-Star, C-Rover: make sure to attach hose clamps around the upper and lower housings on the sensor. Tighten one clamp approximately a quarter-turn, and tighten the other. Move between the two clamps to tighten each equally.

- C-Star, C-Rover: do not attach the hose clamps too tightly or the optical path of the sensor may twist, and the data collected may be incorrect.
- C-Star: operate the sensor with or without a pump. The manufacturer recommends the SBE-5T pump, which has an adjustable motor, so flow rates can accurately be controlled to 20–30 ml/sec to flush the flow tube. Attach the optional flow tube if the sensor is operated with a pump.

2.4 Deployment procedures

After the sensor is attached to the cage or frame on which it will be deployed, verify that it operates correctly with the power source to be used during the deployment.

- Do the steps in [Transmissometer operational criteria](#) on page 10 to verify the sensor operates correctly.

If the sensor will not be deployed within a short period of time:

- Do the steps in [Transmissometer operational criteria](#) on page 10 to verify the sensor operates correctly just before deployment.
1. Before deployment, put a drop of diluted detergent on the sensor optics to help keep the optics clean when the sensor is on the water's surface. Refer to [Clean the optics](#) on page 13 for details.
 2. Deploy the sensor.
 3. When the sensor is removed from the water, flush all of the surfaces with clean water to remove salt water and loose material.
 4. Dry the windows with clean air.
 5. Do the steps from the [Maintenance](#) on page 13 section of this document to clean the sensor.
 6. Verify that the output of the sensor meets the criteria in the [Transmissometer operational criteria](#) on page 10 section of this manual.

Section 3 Maintenance

The Corrected Signal Counts in air (CSC_{air}) is supplied on the calibration page. The manufacturer recommends that the user use the CSC_{air} value to:

- monitor the basic operation of the sensor
- determine when to clean the sensor
- determine when the sensor is clean.

The manufacturer recommends the maintenance supplies below to clean the sensor:

- 0.2 or 0.4 μm filtered distilled and deionized water.
- One 500 ml bottle of dilute unscented detergent.
- One 500 ml bottle for clean water.
- Lint-free laboratory tissues or lens papers.
- Lint-free swabs.
- A source of compressed clean air. The manufacturer recommends dry nitrogen.
- A notebook in which to record maintenance dates and CSC_{air} values.

3.1 Clean the sensor

Clean the sensor after each deployment.

1. Flush the sensor with clean fresh water.
2. Use soapy water to cut grease or oil on the sensor.
3. Make sure that saltwater does not dry on the optical windows of the sensor. Salt crystals are difficult to clean at a later date.
4. Flush the sensor with filtered, distilled water.
5. Clean the optics. Refer to [Clean the optics](#) on page 13 for details.

3.2 Clean the optics

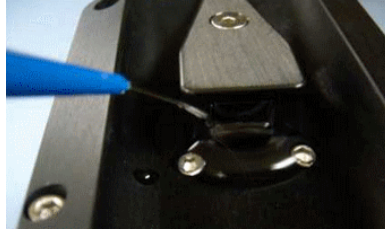
Record and save the data that is collected by the sensor at regular intervals to monitor the performance of the sensor and to see if the optical windows need to be cleaned.

- It is not necessary to clean the windows if the data from the sensor is within 100 counts of the clean air value on the sensor-specific calibration page or the user-collected value.
- Clean the windows if the data from the sensor is more than 100 counts different from the clean air value on the sensor-specific calibration page or the user-collected value.

Do the steps below to clean the optical windows. Clean the optics until the data:

- is within 100 counts of the data output value on the manufacturer-supplied calibration page,
 - is within 100 counts of the user-collected data output values, or
 - is stable, between 100 and 500 counts of the calibration page or user-collected values.
1. Remove the protective cap(s) to clean the optical windows of the sensor.
 2. Mix two drops of dilute unscented detergent with 0.2 or 0.4 μm filtered distilled water in a 500 ml bottle.
 3. Put some soap solution on the optical window.

Figure 1 Apply detergent solution on window



4. Use a lint-free tissue (e.g. Kimwipe or similar) or a swab to rub the optical window to remove particles and oil.

Figure 2 Rub window with lint-free tissue



5. Flush the detergent off of the windows with filtered distilled water.
6. Use compressed air to remove any particles that remain and to dry the optical window.

Figure 3 Dry window with compressed air



7. Wet, rub, flush, and dry each optical window two or three times to get a stable clean air value.

3.3 Bulkhead connector maintenance

⚠ CAUTION

Do not use WD-40® or petroleum-based lubricants on bulkhead connectors. It will cause damage to the rubber.






Damaged connectors can cause a loss of data and additional costs for service.

Damaged connectors can cause damage to the sensor and make it unserviceable.

Examine, clean, and lubricate bulkhead connectors at regular intervals. Connectors that are not lubricated increase the damage to the rubber that seals the connector contacts. The incorrect lubricant will cause the bulkhead connector to fail.

1. Apply isopropyl alcohol (IPA) as a spray or with a nylon brush or lint-free swab or wipes to clean the contacts.
2. Flush with additional IPA.
3. Shake the socket ends and wipe the pins of the connectors to remove the IPA.

4. Blow air into the sockets and on the pins to make sure they are dry.
5. Use a flashlight and a magnifying glass to look for:

Cracks, scratches, or other damage on the rubber pins or in the sockets.		
Any corrosion.		
Separation of the rubber from the pins.		
Swelled or bulging rubber pins.		

6. Apply a small quantity of 3M™ Spray Silicone Lubricant (3M ID# 62-4678-4930-3) to the pin end of the connector. Make sure to let it dry.
7. Connect the connectors.
8. Use a lint-free wipe to clean any unwanted lubricant from the sides of the connectors.

Section 4 Reference

4.1 Common terminal program commands

Command	Parameters	Description
!!!!	none	Stops the data collected by the sensor. Lets the user to enter setup values. If the sensor is in a low-power mode, turn the power supply off for one minute, then turn the power on and push the "!" key 5 or more times.
\$save	1–255	The number of measurements that make up each row of collected data.
\$mnu	—	Prints the menu of setup values to the PC screen.
\$pkt	0–65535	Sets the number of rows of data that are collected between the specified time intervals.
\$rls	none	Gets the settings from the flash memory.
\$run	—	Uses the current setup values to operate.
\$sto	—	Saves the desired setup values to the flash memory.

4.2 Calibration

The relation of the signal output to the calibration output is transmittance and will vary from 0 to 1, or 0 to 100%. The relation of transmittance to the beam attenuation coefficient (c) is $Tr = e^{-cx}$.

where:

- Tr = transmittance
- e = natural logarithmic base, ~ 2.71828
- c = beam attenuation coefficient
- x = sensor pathlength

The manufacturer calibrates each sensor and records these values on the sensor-specific calibration page. The calibrated transmittance of the sensor is calculated below.

$$Tr = (CSC_{sig} - CSC_{dark}) \div (CSC_{cal} - CSC_{dark})$$

- CSC_{sig} = the value of the output in air.
- CSC_{dark} = the value of the output with the beam blocked.
- CSC_{cal} = the value of the output in the clean water used for calibration.

The beam attenuation coefficient is calculated below.

$$c = -1/x \times \ln(Tr)$$

$$= -1/x \times \ln [(CSC_{sig} - CSC_{dark}) \div (CSC_{cal} - CSC_{dark})]$$

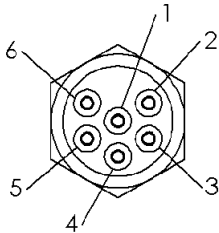
4.2.1 Verify analog data output

1. Connect the optional test cable to the sensor. Refer to the section on the [test cable](#) for details about test cables.
2. Use a regulated power supply to supply 12 VDC to the sensor or connect a 9V battery to the connectors on the test cable.
The sensor comes on.
3. Use the probes on a digital multimeter (DMM) to touch the RCA connector on the auxiliary leg(s) of the test cable.
4. Put the red (signal) probe in the RCA connector and the black (ground) on the outside.
The DMM shows approximately 5 VDC.
5. Put a solid object near the light source of the sensor.
The DMM shows approximately 0 VDC.

4.3 Bulkhead connectors

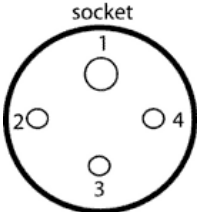
4.3.1 C-Star only: MCBH-6-MP bulkhead connector

Previous sensor models also used the bulkhead connector below for analog-only output.

Contact	Function	MCBH-6-MP
1	Ground	
2	Reserved	
3	Reserved	
4	Voltage in	
5	Reserved	
6	Analog out	

4.3.2 C-Star only: VSG-4 bulkhead connector

The oldest sensor models used the bulkhead connector shown below.

Analog		Connector diagram	Digital	
Contact	Function		Contact	Function
1	Ground		1	Ground
2	Analog out		2	Analog out
3	V+		3	V+
4	Analog return	4	RS232 TX	

4.4 Digital data output types

Data type	Description
AI	ASCII integer number
AF	ASCII floating point number
AS	ASCII string, text

Field	Length (bytes)	Data type	Description
Sensor	4	AS	Characters at the start of a row of data
Delimiter	1	AS	Hyphen delimiter
SN	4	AI	Serial number
Delimiter	1	AS	Tab delimiter
Ref raw	5	AI	Reference raw count value
Delimiter	1	AS	Tab delimiter
Sig raw	5	AI	Signal raw count value
Delimiter	1	AS	Tab delimiter
Corr Sig Raw	5	AI	Correct signal raw count value, CSC_{sig}
Delimiter	1	AS	Tab delimiter
c	6	AF	Calculated beam attenuation coefficient in m^{-1}
Delimiter	1	AS	Tab delimiter

Field	Length (bytes)	Data type	Description
Therm	3	AI	Internal thermistor raw count value
Terminator	1	AS	Line feed pair (0A _{hex}), end of row.

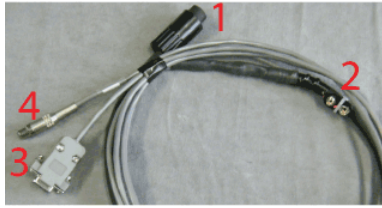
4.5 Protective diode

The C-Rover has a protective diode to prevent damage to the power supply of the sensor up to 30 volts in case power is supplied to the incorrect polarity.

Section 5 Optional equipment

5.1 Test cable

Use the optional test cable to set up and test the sensor before deployment.



1 six-contact connector	3 db-9 serial port connector
2 9-volt battery connector	4 RCA connector

1. Connect the six-contact connector to the sensor.
2. Connect the 9-volt connector to a 9-volt battery. As an alternative, it can be connected to a 12-volt regulated power supply.
3. Connect the db-9 connector to the host PC. Use a USB-to-RS232 adapter cable if necessary to see digital output.
4. Use the probes on a digital multimeter to see analog output. The inside of the RCA is power and the outside is ground.

5.2 Flow tube

The C-Star sensor has an optional flow tube for special uses. Refer to the steps below to remove, clean, and install the flow tube.

1. Loosen the 9/64" stainless steel cap screws in the flow sleeves.
It is not necessary to remove the screws.
2. Push the flow sleeves toward the middle of the flow tube.
3. Lift the flow tube from the sensor.
4. Remove the O-rings from the flow tube.
5. Wash the flow tube with a mild detergent.
6. Flush the flow tube with clean water.
7. Let the flow tube dry completely.
Use dry nitrogen to blow dry the flow tube.
8. Make sure the size 122 O-rings on the flow tube and on the optical windows are not damaged.
Replace them if necessary.
9. Make sure the sensor's optical windows are clean and dry. Refer to the section [Clean the optics](#) on page 13 for details.
Use dry nitrogen under very low pressure on the windows immediately before the flow tube is installed again.
10. Install the flow tube on the sensor.
 - a. Line up the stainless steel cap screws on the flow sleeves with the grooves in the flow tubes.
 - b. Push the flow sleeves onto each end of the flow tube.
 - c. Set the flow tube against the optical windows of the sensor.
 - d. Push the flow sleeves out on each end of the flow tube until the outside ring on the sleeve is against the optical window.
 - e. Tighten the cap screws in the flow sleeves.

Section 6 General information

Revised editions of this user manual are on the manufacturer's website.

6.1 Warranty

This sensor is warranted against defects in materials and workmanship for one year from the date of purchase. The warranty is void if the manufacturer finds the sensor was abused or neglected beyond the normal wear and tear of deployment.

6.2 Service and support

The manufacturer recommends that sensors be sent back to the manufacturer annually to be cleaned, calibrated, and for standard maintenance.

Refer to the website for FAQs and technical notes, or contact the manufacturer for support at support@seabird.com.

Do the steps below to send a sensor back to the manufacturer.

1. Complete the online Return Merchandise Authorization (RMA) form or contact the manufacturer.
Note: The manufacturer is not responsible for damage to the sensor during return shipment.
2. Remove all batteries from the sensor.
3. Remove all anti-fouling treatments and devices.
Note: The manufacturer will not accept sensors that have been treated with anti-fouling compounds for service or repair. This includes AF 24173 devices, tri-butyl tin, marine anti-fouling paint, ablative coatings, etc.
4. Use the sensor's original ruggedized shipping case to send the sensor back to the manufacturer.
5. Write the RMA number on the outside of the shipping case and on the packing list.
6. Use 3rd-day air to ship the sensor back to the manufacturer. Do not use ground shipping.
7. The manufacturer will supply all replacement parts and labor and pay to send the sensor back to the user via 3rd-day air shipping.

6.3 Waste electrical and electronic equipment



Electrical equipment that is marked with this symbol may not be disposed of in European public disposal systems. In conformity with EU Directive 2002/96/EC, European electrical equipment users must return old or end-of-life equipment to the manufacturer for disposal at no charge to the user. To recycle, please contact the manufacturer for instructions on how to return end-of-life equipment, manufacturer-supplied electrical accessories, and auxiliary items for proper disposal.

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