C-Rover Transmissometer

User’s Guide

WET Labs, Inc.
PO Box 518
Philomath, OR 97370
(541) 929-5650
www.wetlabs.com
C-Rover Warranty

This unit is guaranteed against defects in materials and workmanship for one year from the original date of purchase. Warranty is void if the factory determines the unit was subjected to abuse or neglect beyond the normal wear and tear of field deployment, or in the event the pressure housing has been opened by the customer.

To return the instrument, contact WET Labs for a Return Merchandise Authorization (RMA) and ship in the original container. WET Labs is not responsible for damage to instruments during the return shipment to the factory. WET Labs will supply all replacement parts and labor and pay for return via 3rd day air shipping in honoring this warranty.

Shipping Requirements for Warranty and Out-of-warranty Instruments

1. Please retain the original shipping material. We design the shipping container to meet stringent shipping and insurance requirements, and to keep your meter functional.

2. To avoid additional repackaging charges, use the original box (or WET Labs-approved container) with its custom-cut packing foam and anti-static bag to return the instrument.
   - If using alternative container, use at least 2 in. of foam (NOT bubble wrap or Styrofoam “peanuts”) to fully surround the instrument.
   - Minimum repacking charge for C-Rover meters: $90.00.

3. Clearly mark the RMA number on the outside of your shipping container and on all packing lists.

4. Return instruments using 3rd day air shipping or better: do not ship via ground.
1. Instrument Operation

C-Rover has an analog output of 0–5 VDC that is proportional to the amount of transmitted light received by the detector. The ratio of the output signal in a water sample to the signal in clean water (provided by our calibration sheet) is called the transmittance. A four-socket bulkhead connector (Figure 1) provides for power, ground, analog out, and analog return signals (analog return and instrument ground are connected together inside the instrument). This instrument requires a clean source of 7–15 VDC. The analog out and return signals may be connected to the data acquisition system of your choice. C-Rover is designed to connect directly to many CTD systems and is compatible with other platforms that can provide power and accept a 0–5 VDC analog signal.

![C-Rover connectors](image)

**Figure 1. C-Rover connectors**

<table>
<thead>
<tr>
<th>Socket Number</th>
<th>Socket Function</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Ground</td>
</tr>
<tr>
<td>2</td>
<td>Analog out</td>
</tr>
<tr>
<td>3</td>
<td>V +</td>
</tr>
<tr>
<td>4</td>
<td>Analog ground</td>
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The standard C-Rover delivery package includes the following:

- C-Rover instrument
- This manual
- Calibration sheet
1.1 Handling C-Rover
C-Rover must be handled carefully to maintain its precise calibration. Do not squeeze the central struts. Do not drop it or set it down roughly. Do not twist the ends. The case is designed to withstand ocean pressure, not human abuse.

**WARNING!**
Opening the pressure housing will void the warranty. Additionally, the C-Rover must be re-pressure tested prior to deployment. We cannot be responsible for leakage that occurs after the instrument has been opened by the user.

The instrument is sealed with a small vacuum. Do not remove the hex-key plug or the bulkhead connector. Doing so will necessitate returning the instrument to WET Labs for servicing.

Acids and some solvents will damage the acetal plastic pieces of the instrument. Soap and water is often sufficient for cleaning windows. If in doubt, contact WET Labs before using anything stronger.

1.2 Initial Checkout
A 9-volt battery makes a good power supply for bench testing the C-Rover. Apply 7–15 VDC to the instrument to provide power to the LED and electronics. Ensure that positive voltage is applied to socket 3, and common or ground is connected to socket 1 (the large socket in the bulkhead connector). The LED should illuminate. This light may be seen by placing a white card into the beam path. You may need to dim the room lights to see the beam spot.

Connect socket 2 (analog out) and socket 4 (analog return) to a digital multimeter. The analog output voltage should closely agree with the air value on the calibration sheet, provided the instrument’s optics are clean and dry.

1.3 Mounting and Deployment
The instrument must be mounted to a float by its upper can only (Figure 2). Clamping both ends will stress the center section, leading to optical instability and bad data. Clamping only to the lower can could allow cable motion or tension to induce stresses in the center section.
C-Rover is designed for deployment on autonomous floats. It has low power consumption, it can maintain a stable calibration over a long period of time, and it is nearly neutrally buoyant. Compared to WET Labs’ C-Star transmissometers, C-Rover is a relatively delicate instrument. It is not rugged enough for normal ship-based operations.

1.4 Data Collection

C-Rover’s output is limited to a current of 10 mA or less. Its output impedance is approximately 500 ohms, which effectively limits the drive current. Therefore, the electrical signal will degrade over a long electrical wire due to the electrical resistance of the cable. For best results, the analog signal should be fed directly into an A/D converter with a high impedance input through a short cable (1–2 meters).

1.5 Data Analysis

C-Rover’s output value increases linearly with increasing transmittance over the instrument’s measurement range. The output is proportional to the amount of light received by the detector over a given pathlength. With the instrument in water, the output (V_{sig}) should vary from a minimum value (V_{dark}) (obtained by blocking the beam) to a maximum signal obtained in clean water (V_{ref}). The ratio of the signal output to the reference output is known as transmittance and will vary from 0 to 1, or 0 to 100 percent.
Transmittance is related to $c$ by the relationship

$$Tr = e^{-cx}$$

where $x$ is the pathlength through the water volume.

The C-Rover transmittance can be expressed as

$$Tr = \frac{V_{sig} - V_{dark}}{V_{ref} - V_{dark}}$$

where:

- $V_{sig}$ is the measured output signal
- $V_{dark}$ is the dark voltage offset for the instrument (factory supplied). $V_{dark}$ is obtained by blocking the C-Rover’s receiver and obtaining a “dark” reading of output voltage. This is an instrument offset that needs to be subtracted.
- $V_{ref}$ is the factory supplied clean water offset.

To obtain the beam attenuation coefficient we then solve for

$$c = -\frac{1}{x} \ln (Tr)$$

$$= -\frac{1}{x} \ln \left(\frac{V_{sig} - V_{dark}}{V_{ref} - V_{dark}}\right)$$
2. Specifications

**Mechanical**
Size: 2.48 x 31.6 in. (6.3 x 80.1 cm)
Weight in air: 4.2 lbs (1.9 kg)
Weight in water: < 0.2 lbs (90 g)
Rated depth: 2000 m
Operating range: 0–30 deg C

**Electrical**
Response time: 0.167 sec
Power input: 7–15 VDC
Data output: 0–5 V
Current draw: 400 mW (typical)
Temperature error: < 0.02 percent F.S./deg C
Linearity error: < 0.1 percent F.S.

**Optical**
Sensitivity: 1.25 mV
Pathlength: 25 cm
Wavelength: 660 nm
Acceptance angle: 1.46 deg

*Specifications are subject to change without notice.*
3. Testing and Calibration

Prior to shipment, each C-Rover is tested and calibrated to ensure that it meets the instrument’s specifications. To measure the C-Rover output voltages for tuning and calibration, the transmissometer is connected to a 12-bit A/D converter. The A/D outputs the voltages in a standard RS-232 serial text format that is collected with a terminal program.

3.1 Testing

When the instrument is completely assembled, it goes through the tests below to ensure performance.

Pressure
To ensure the integrity of the housing and seals, each C-Rover is subjected to a wet hyperbaric test. The testing chamber applies a water pressure of at least 3234 psi. This is equivalent to the full rated depth (2000 m) plus 10 percent.

Mechanical Stability
The C-Rover is subjected to a mechanical stability test. This involves subjecting the unit to mild vibration and shock. The air, water, and dark voltages must remain the same before and after the mechanical stability test.

Temperature Stability
To verify temperature stability, the C-Rover is immersed in water with a beginning temperature of approximately 30 deg C, to an ending temperature of 1 deg C. A voltage sample is collected every 30 seconds, with a 0.5 second smoothing.

Electronic Stability
This value is computed by collecting a sample once per minute for twelve hours, or more. The smoothing time for this one sample is 0.5 seconds. After the data is collected, the minimum and maximum values are determined, and the difference between these two is divided by the number of hours the test has run. The result is the stability value listed on the calibration sheet.

Noise
Noise is computed from a standard deviation over 60 samples. These samples are collected at one-second intervals for one minute. The smoothing (averaging) time for these samples is 0.5 seconds. A standard deviation is then performed on the 60 samples, and the result is the published noise on the calibration form. The calculated noise must be below 1.25 mV.

Final Water Blank Test
Clean, de-ionized, pure water is introduced into the sample volume. The output voltage should be between 4.5–4.7 V.
Voltage and Current Range Verification
To verify that the C-Rover operates over the entire specified input voltage range (7–15 V), a voltage-sweep test is performed. The C-Rover is operated over the entire voltage range, and the current and operation is observed. The total power consumption (voltage times current) must remain below 450 mW over the entire voltage range.

Linearity
Spot full scale linearity tests are performed to confirm the instrument’s linearity. This linearity test consists of using a multiple point suspended particle dilution series to characterize the response of the instrument to varying levels of turbidity. The linear regression “R squared” value must be better than 0.9900.

3.2 Calibration
Each C-Rover is subjected to a temperature bath, a clean water reading and a blocked path reading to provide the calibration values required to obtain good data in the field.

The clean water calibration is done using water from WET Labs calibration facility. It goes through several stages of de-ionization, UV screening and ultra-filtering to remove particles, bacteria and ions. This water is used to obtain the reference value of the instrument that is provided on the calibration sheet.

The offset value is obtained by blocking the beam with the instrument clean and dry. This value is recorded and provided on the calibration sheet.

An air reading is also obtained with the instrument clean and dry. This value is used as a reference when cleaning the optics and as an aid in tracking instrument drift.
## Revision History

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Revision Description</th>
<th>Originator</th>
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<tbody>
<tr>
<td>A</td>
<td>12/1/03</td>
<td>New document (DCR 351)</td>
<td>A. Derr</td>
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<tr>
<td>B</td>
<td>1/13/06</td>
<td>Clarify warranty statement (DCR 481)</td>
<td>A. Gellatly, S. Proctor</td>
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<tr>
<td>C</td>
<td>3/27/07</td>
<td>Correct acceptance angle to 1.46 degrees (ECN 254, DCR 514)</td>
<td>R. Zaneveld</td>
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