

CS511

Dissolved Oxygen Sensor



Guarantee

This equipment is guaranteed against defects in materials and workmanship. We will repair or replace products which prove to be defective during the guarantee period as detailed on your invoice, provided they are returned to us prepaid. The guarantee will not apply to:

- Equipment which has been modified or altered in any way without the written permission of Campbell Scientific
- Batteries
- Any product which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific will return guaranteed equipment by surface carrier prepaid. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This guarantee and the Company's obligation thereunder is in lieu of all other guarantees, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

Please inform us before returning equipment and obtain a Repair Reference Number whether the repair is under guarantee or not. Please state the faults as clearly as possible, and if the product is out of the guarantee period it should be accompanied by a purchase order. Quotations for repairs can be given on request. It is the policy of Campbell Scientific to protect the health of its employees and provide a safe working environment, in support of this policy a "Declaration of Hazardous Material and Decontamination" form will be issued for completion.

When returning equipment, the Repair Reference Number must be clearly marked on the outside of the package. Complete the "Declaration of Hazardous Material and Decontamination" form and ensure a completed copy is returned with your goods. Please note your Repair may not be processed if you do not include a copy of this form and Campbell Scientific Ltd reserves the right to return goods at the customers' expense.

Note that goods sent air freight are subject to Customs clearance fees which Campbell Scientific will charge to customers. In many cases, these charges are greater than the cost of the repair.



Campbell Scientific Ltd,
80 Hathern Road,
Shepshed, Loughborough, LE12 9GX, UK
Tel: +44 (0) 1509 601141
Fax: +44 (0) 1509 270924
Email: support@campbellsci.co.uk
www.campbellsci.co.uk

About this manual

Please note that this manual was originally produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

Area: 1 in ² (square inch) = 645 mm ²	Mass: 1 oz. (ounce) = 28.35 g 1 lb (pound weight) = 0.454 kg
Length: 1 in. (inch) = 25.4 mm 1 ft (foot) = 304.8 mm 1 yard = 0.914 m 1 mile = 1.609 km	Pressure: 1 psi (lb/in ²) = 68.95 mb
	Volume: 1 UK pint = 568.3 ml 1 UK gallon = 4.546 litres 1 US gallon = 3.785 litres

In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users.

Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials may also not be applicable according to your locality.

Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered. Details of the alternatives will be covered in separate manuals.

Part numbers prefixed with a “#” symbol are special order parts for use with non-EU variants or for special installations. Please quote the full part number with the # when ordering.

Recycling information



At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.



Campbell Scientific Ltd, 80 Hathern Road, Shepshed, Loughborough, LE12 9GX,
UK Tel: +44 (0) 1509 601141 Fax: +44 (0) 1509 270924
Email: support@campbellsci.co.uk
www.campbellsci.co.uk

Safety

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND **TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.** FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.eu or by telephoning +44(0) 1509 828 888 (UK). You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General

- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines.**
- Maintain a distance of at least one-and-one-half times structure height, or 20 feet, or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

Table of contents

1. Introduction	1
2. Precautions	1
3. Initial inspection	1
4. QuickStart	2
5. Overview	4
6. Specifications	5
7. Installation	6
7.1 Getting sensor ready to use	7
7.2 Wiring	8
7.3 Programming	8
7.4 Calibration	9
8. Maintenance	10
Appendix A. Importing Short Cut code into CRBasic Editor	13
Appendix B. Example program	14
Appendix C. Dissolved oxygen tables	16

1. Introduction

The CS511 is a rugged, low-maintenance sensor that is manufactured by Sensorex. It consists of a self-polarizing galvanic cell that generates a millivolt signal proportional to the amount of oxygen present in the measured medium (typically water).

NOTE:

This manual provides information only for CRBasic data loggers. For retired Edlog data logger support, see an older manual at www.campbellsci.com/old-manuals. Also refer to an older manual if the CS511 was purchased before June 2008 and for information on using the retired PT4-L Agitator.

2. Precautions

- READ AND UNDERSTAND the [Safety](#) section at the back of this manual.
- The CS511 is a precision instrument. Please handle it with care.
- Because the CS511 is shipped dry, electrolyte needs to be added before using the sensor. See [Getting sensor ready to use](#) (p. 7) for more information.
- Letting the CS511 dry in the field shortens the life of the membrane and sensor.
- The sensor should be stored dry and empty. Therefore, empty the electrolyte, rinse the sensor, and remove the membrane.
- Replace the membrane and recalibrate the sensor before redeploying the CS511 after it has been stored out of water or dried up in the field.
- While cleaning, do not touch the centre electrode. See [Maintenance](#) (p. 10) for more information.

3. Initial inspection

- Upon receipt of the CS511 inspect the packaging and contents for damage. File damage claims with the shipping company.

- Immediately check package contents against the shipping documentation. Contact Campbell Scientific about any discrepancies.
- The model number and cable length are printed on a label at the connection end of the cable. Check this information against the shipping documents to ensure the expected product and cable length were received.

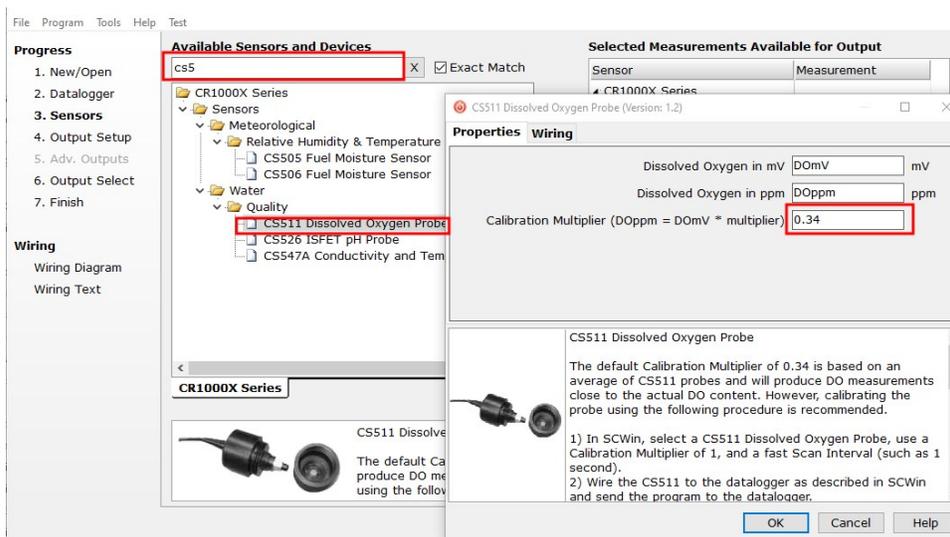
4. QuickStart

A video that describes data logger programming using *Short Cut* is available at:

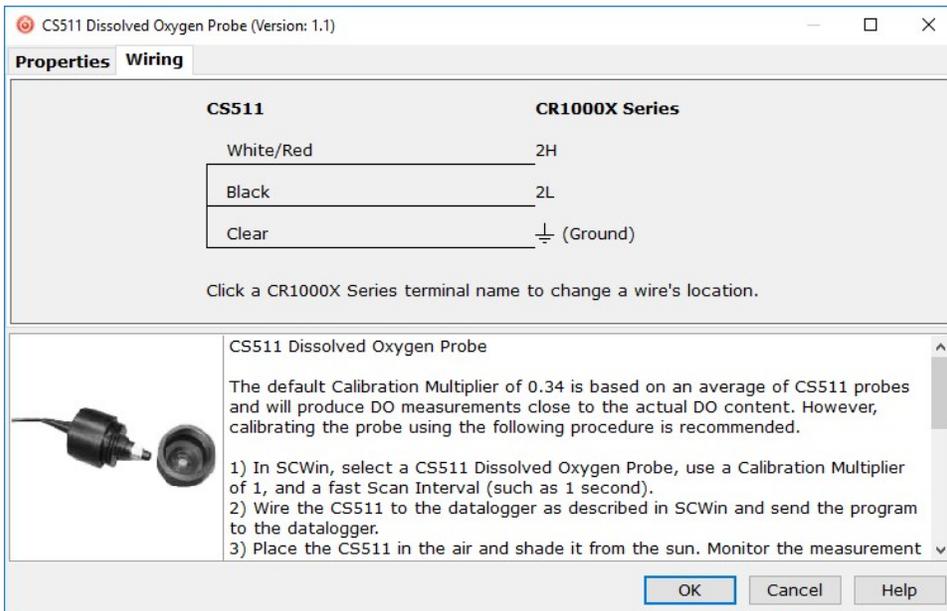
www.campbellsci.eu/videos/cr1000x-data-logger-getting-started-program-part-3.  *Short Cut* is an easy way to program your data logger to measure the sensor and assign data logger wiring terminals. *Short Cut* is available as a download on www.campbellsci.eu.  It is included in installations of *LoggerNet*, *RTDAQ*, and *PC400*.

The following procedure also shows using *Short Cut* to program the CS511.

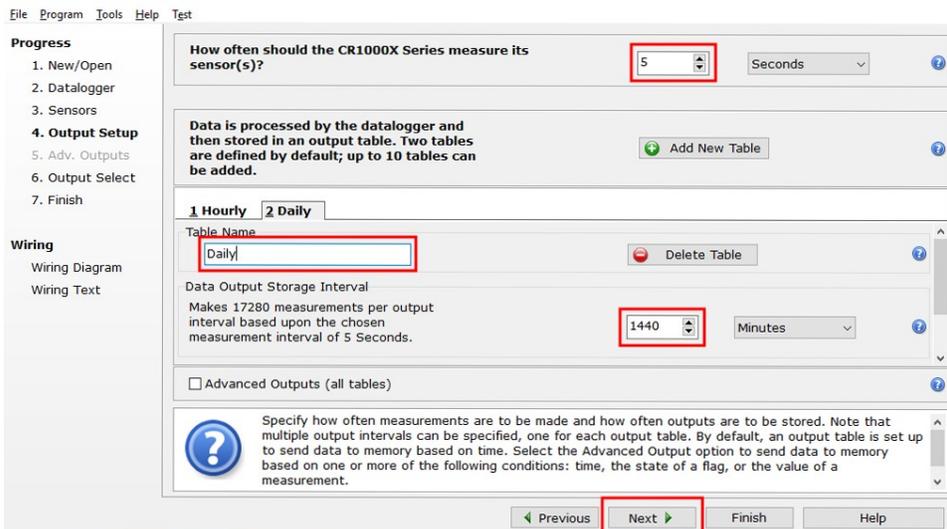
1. Open *Short Cut* and click **Create New Program**.
2. Double-click the data logger model.
3. In the **Available Sensors and Devices** box, type CS511 or locate the sensor in the **Sensors > Water > Quality** folder. Double click on the **CS511 Dissolved Oxygen Probe**. The default calibration value of 0.34 is based on an average. It is preferable to calibrate the sensor by using the procedure provided in [Calibration](#) (p. 9).



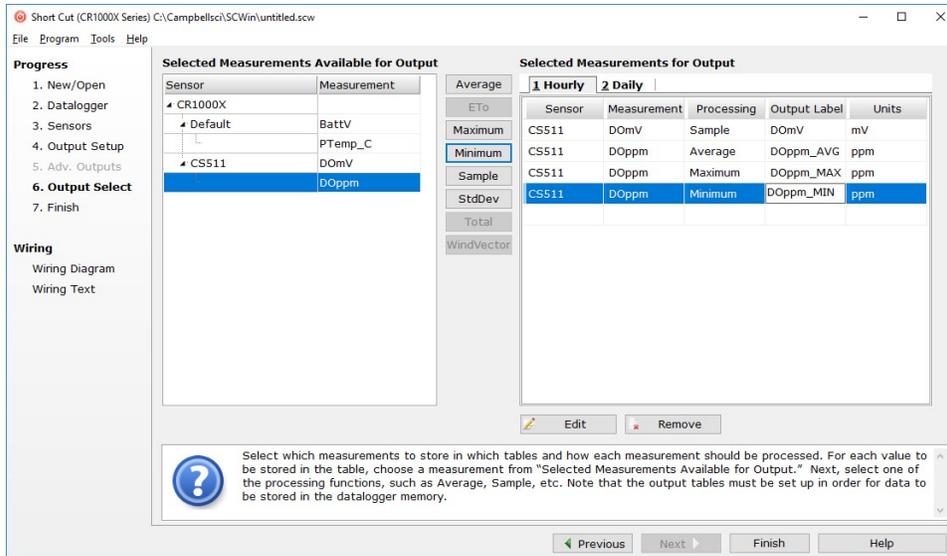
- Click on the **Wiring** tab to see how the sensor is to be wired to the data logger. Click **OK** after wiring the sensor.



- In **Output Setup**, type the scan rate, meaningful table names, and **Data Output Storage Interval**. Click **Next**.



- Select the measurement and its associated output option.



- Click **Finish** and save the program. Send the program to the data logger if the data logger is connected to the computer.
- If the sensor is connected to the data logger, check the output of the sensor in the data display in *LoggerNet*, *RTDAQ*, or *PC400* to make sure it is making reasonable measurements.

5. Overview

The CS511 is a galvanic sensor, which produces a millivolt signal proportional to the amount of oxygen present in the measured medium. Oxygen diffuses through the membrane onto the cathode, reacts chemically, and combines with the anode. An electrical current is produced by this chemical reaction which is converted from microamps to millivolts by an in-line resistor. An in-line thermistor also conditions the signal providing automatic temperature compensation. With these features, the sensor produces a linear, millivolt output proportional to the oxygen present in the medium in which it is placed.

The sensor consists of two parts, an upper part with cathode, anode, and cable, and a lower part comprising of a screw-on membrane cap. The CS511 is shipped dry, but has a membrane installed in the cap. With the membrane in place, the cap must be filled with electrolyte solution before the cap is screwed onto the top component.

The CS511 is self-polarizing and requires no external power source.

Features:

- In-line thermistor provides automatic temperature compensation
- Compatible with Campbell Scientific CRBasic data loggers: CR6, CR1000X, CR800-series, CR350-series, CR300-series, CR3000, CR1000

6. Specifications

Principle of measurement:	Membrane-covered, galvanic oxygen sensor
Output signal:	33 mV ± 9 mV (100% saturation), < 2 mV (0% saturation)
Measurement range:	0.5 to 50 ppm
Accuracy:	Better than ± 2% of reading ± 1 digit when calibration temperature equals measuring temperature ± 5 °C
Response time:	5 min. from 100% to 0% oxygen
Operating conditions	
Temperature:	0 to 50 °C (32 to 122 °F)
Pressure:	0 to 100 psig
Minimum submersion depth:	60 mm (2.5 in)
Minimum water flow:	5 cm/s (2 in/s) across membrane
Calibration:	In air or in air saturated water
Temperature compensation:	Automatic from 4 to 40 °C (40 to 104 °F)
Sensor electrolyte:	NaCl + glycerol (prevents freezing)
Materials	
Body:	Noryl
Anode:	Zinc
Cathode:	Silver
Cable jacket:	PVC
Diameter:	5.72 cm (2.25 in)
Height:	17.78 cm (7 in) from bottom of sensor to end of cable-strain relief; see Figure 6-1 (p. 6)
Shipping weight:	0.8 kg (1.75 lb) including sensor and shipping kit

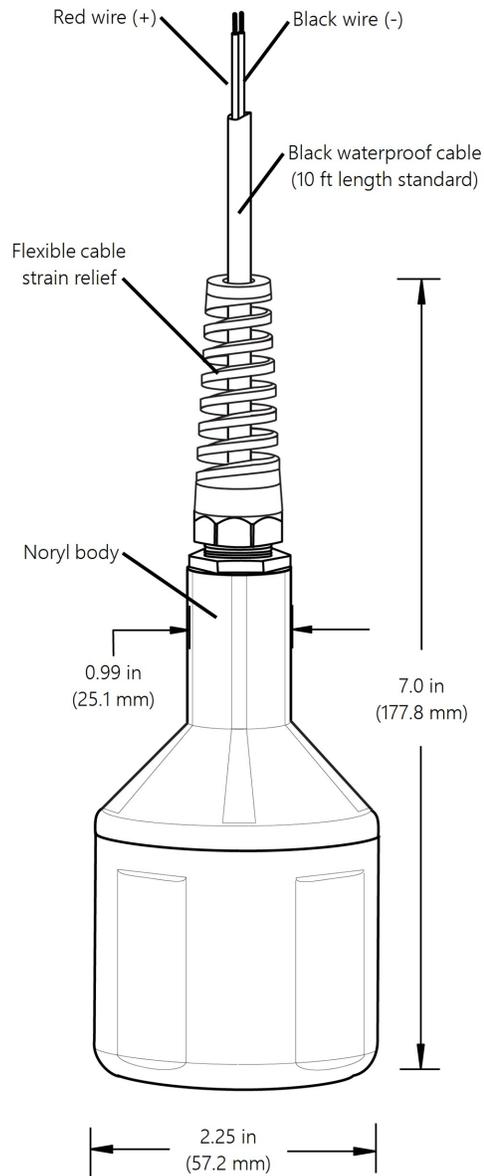


Figure 6-1. CS511 dimensions

7. Installation

If you are programming your data logger with *Short Cut*, skip [Wiring](#) (p. 8) and [Programming](#) (p. 8). *Short Cut* does this work for you. See [QuickStart](#) (p. 2) for a *Short Cut* tutorial.

7.1 Getting sensor ready to use

1. Unscrew the lower body from the upper body.

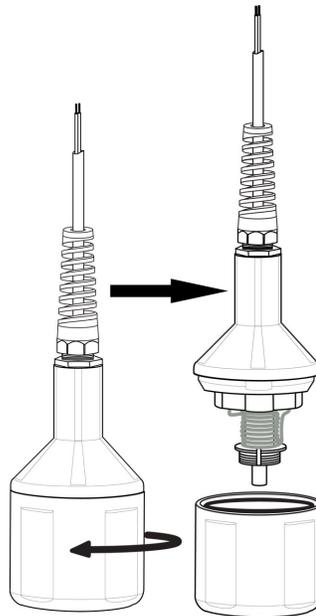


Figure 7-1. Separate the lower body from the upper body

2. Inspect the membrane for wrinkles. Replace membrane if wrinkled. See [Maintenance](#) (p.10).
3. Pour clean water into the lower body and look for leakage around the membrane. Dispose of the water, and if there is leakage, replace membrane. See [Maintenance](#) (p.10).

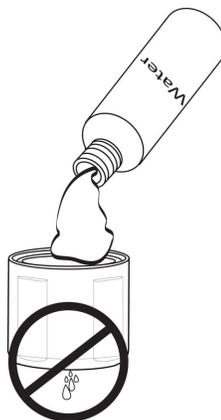


Figure 7-2. Check for leakage

4. Pour fresh electrolyte in the bottom cap and fill to the top of the cap.
5. Keep the sensor upright with the cable pointed upwards (not sideways). Screw the bottom cap onto the upper body until hand tight.

7.2 Wiring

Data logger connection is provided in following table. The CS511 can use one differential terminal or one single-ended terminal. Differential wiring is better at rejecting electrical noise and ground loop error.

Table 7-1: Wire colour, function, and data logger connections			
Wire colour	Wire function	Differential data logger connection	Single-ended data logger connection
White	Signal high	U configured for differential input ¹ , DIFF H (differential high, analogue-voltage input)	U configured for single-ended input ¹ , SE (single-ended, analogue-voltage input)
Black	Signal reference	U configured for differential input ¹ , DIFF L (differential low, analogue-voltage input)	⏏ (analogue ground)
Clear	Shield	⏏ (analogue ground)	⏏ (analogue ground)

¹U terminals are automatically configured by the measurement instruction.

7.3 Programming

Short Cut is the best source for up-to-date programming code for Campbell Scientific data loggers. If your data acquisition requirements are simple, you can probably create and maintain a data logger program exclusively with *Short Cut*. If your data acquisition needs are more complex, the files that *Short Cut* creates are a great source for programming code to start a new program or add to an existing custom program.

NOTE:

Short Cut cannot edit programs after they are imported and edited in *CRBasic Editor*.

A *Short Cut* tutorial is available in [QuickStart](#) (p. 2). If you wish to import *Short Cut* code into *CRBasic Editor* to create or add to a customized program, follow the procedure in [Importing Short Cut code into CRBasic Editor](#) (p. 13). This document provides programming basics for *CRBasic* data loggers. A complete program is provided in [Example program](#) (p. 14).

The [VoltDiff\(\)](#) or [VoltSE\(\)](#) can be used to measure the CS511. Choose a voltage range of 100 mV or higher. Refer to the following section for information on determining the multiplier.

7.4 Calibration

The multiplier is used to calibrate the CS511 sensor. Do the following to calculate the multiplier:

1. Program the data logger by using a multiplier of one; see [QuickStart](#) (p. 2) or [Programming](#) (p. 8).
2. Connect the CS511 to the data logger.
3. If the CS511 has been deployed in the field, gently wipe the membrane with a soft cloth.
4. Place the CS511 in air away from direct sunlight with the membrane facing upward.
5. Place a drop of clean water on the membrane.
6. Wait for readings to stabilize. This may take 15 minutes or more.
7. Determine the air temperature and barometric pressure.
8. Using a calibration chart such as that provided in [Dissolved oxygen tables](#) (p. 16), determine the oxygen concentration of the air.
9. Use the following equation to calculate the multiplier:

$$M = P/R$$

where: M = Multiplier

P = Concentration in PPM of the air (from the calibration chart)

R = The signal output of the sensor when using a multiplier of one

10. Change the multiplier in the data logger program from one to the calculated number; see [QuickStart](#) (p. 2) or [Programming](#) (p. 8).

Instead of step 10, the following expression can be used that allows a new multiplier to be added to the program without rewriting, compiling, and downloading the program to the data logger.

$$DO_{ppm} = DO_{mult} * DO_{mV}$$

With this method, the multiplier value is typed into the expression through the Public Table by using the numeric display in *LoggerNet*, *PC400*, or data logger keyboard display.

8. Maintenance

Campbell Scientific offers maintenance kits that contain membranes, membrane O-rings, washers, and a bottle of electrolyte. A spare parts kit is also available that contains two membrane locks, two tensioning washers, two body O-rings, and one membrane replacement tool. Refer to www.campbellsci.eu/order/cs511-l  for more information.

The CS511 uses a strong, easy-to-clean, and easy-to-change membrane in a screw-on membrane cap. The sensor can be fully overhauled in five minutes.

Cleaning sensor and replacing membrane procedure:

1. Unscrew the lower body from the upper body. See [Figure 7-1](#) (p. 7).
2. Safely dispose of the electrolyte.

CAUTION:

Make sure the O-ring does not fall out of the cap.

3. Using the membrane tool, unscrew the membrane lock that is in the lower body; see [Figure 8-1](#) (p. 10).
4. Remove and dispose of the membrane and its O-ring.

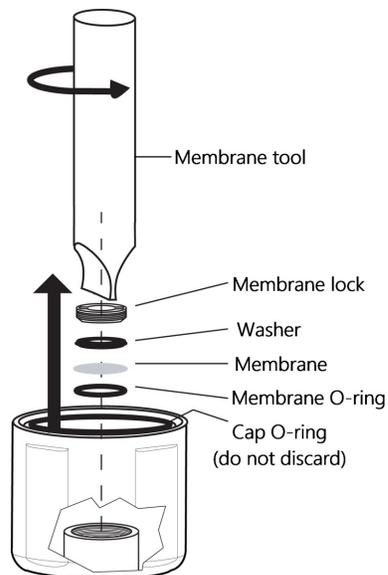


Figure 8-1. Remove membrane and membrane O-ring

5. To clean, immerse the top part of the sensor in distilled white vinegar (3% acetic acid) for about 30 minutes. If vinegar is unavailable, use a soft toothbrush, automatic dishwasher detergent, and clean water to clean the cathode, anode, and plastic without touching the centre electrode; see [Figure 8-2](#) (p. 11). Rinse all components thoroughly with clean water after cleaning.

CAUTION:

Avoid touching or scratching the centre electrode while cleaning.

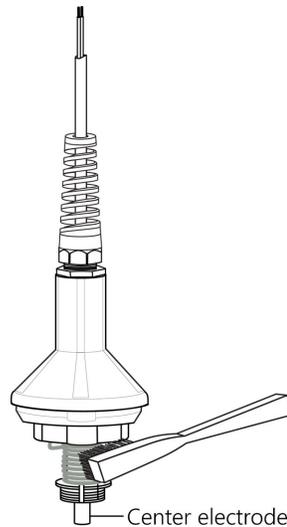


Figure 8-2. Using toothbrush to clean sensor

6. Replace the membrane and its O-ring. See [Figure 8-3](#) (p. 12)
 - a. Place the new O-ring at the bottom of the membrane cavity.
 - b. Remove the paper backing from a new membrane.
 - c. Place the new membrane on top of the O-ring.
 - d. Place the washer on top of the membrane.
 - e. Using the membrane tool, install the membrane lock on top of the washer.

CAUTION:

Make sure the cap is upright (not sideways) when securing the membrane lock to the washer.

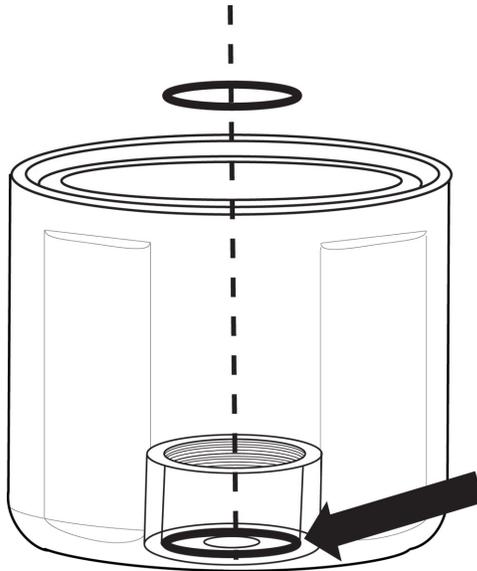


Figure 8-3. Proper O-ring placement

7. Inspect the membrane for wrinkles. Replace membrane if wrinkled.
8. Pour clean water into the lower body and look for leakage around the membrane. Dispose of the water, and if there is leakage, replace membrane. See [Figure 7-2](#) (p. 7).
9. Pour fresh electrolyte in the bottom cap and fill to the top of the cap.
10. Keep the sensor upright with the cable pointed upwards (not sideways). Screw the bottom cap onto the upper body until hand tight.

NOTE:

Excess electrolyte will leak out at the joint between the sensor cap and upper body.

Appendix A. Importing *Short Cut* code into *CRBasic Editor*

Short Cut creates a .DEF file that contains wiring information and a program file that can be imported into the *CRBasic Editor*. By default, these files reside in the C:\campbellsci\SCWin folder.

Import *Short Cut* program file and wiring information into *CRBasic Editor*:

1. Create the *Short Cut* program. After saving the *Short Cut* program, click the **Advanced** tab then the **CRBasic Editor** button. A program file with a generic name will open in CRBasic. Provide a meaningful name and save the CRBasic program. This program can now be edited for additional refinement.

NOTE:

Once the file is edited with *CRBasic Editor*, *Short Cut* can no longer be used to edit the program it created.

2. To add the *Short Cut* wiring information into the new CRBasic program, open the .DEF file located in the C:\campbellsci\SCWin folder, and copy the wiring information, which is at the beginning of the .DEF file.
3. Go into the CRBasic program and paste the wiring information into it.
4. In the CRBasic program, highlight the wiring information, right-click, and select **Comment Block**. This adds an apostrophe (') to the beginning of each of the highlighted lines, which instructs the data logger compiler to ignore those lines when compiling. The **Comment Block** feature is demonstrated at about 5:10 in the [CRBasic | Features](#) video .

Appendix B. Example program

This CR1000X program measures the sensor using the `VoltDiff()` instruction. Other CRBasic data loggers are programmed similarly. The following table shows the wiring for the example.

CR1000X connection	Sensor wire colour
1H	White
1L	Black
⏏	Clear

CRBasic Example 1: CR1000X program that measures the CS511 using the VoltDiff() instruction

```
'CR1000X

'Declare Variables and Units
Public Batt_Volt
Public D0mV
Public D0ppm
Public D0Mult

Units Batt_Volt=Volts
Units D0mV=mV
Units D0ppm=ppm

'Define Data Tables
DataTable(Hourly,True,-1)
  DataInterval(0,60,Min,10)
  Sample(1,D0mV,FP2) Sample(1,D0ppm,FP2)
  Sample(1,Batt_Volt,FP2)
EndTable

DataTable(Daily,True,-1)
  DataInterval(0,1440,Min,10)
  Minimum(1,Batt_Volt,FP2,False,False)
EndTable

'Main Program
BeginProg
  Scan(5,Sec,1,0)
```

CRBasic Example 1: CR1000X program that measures the CS511 using the VoltDiff() instruction

```
'Default Data Logger Battery Voltage measurement Batt_Volt:  
Battery(Batt_Volt)  
  
'CS511 Dissolved Oxygen Sensor measurements D0mV and D0ppm:  
VoltDiff(D0mV,1,mV200,1,True,0,60,1,0)  
D0ppm = D0Mult * D0mV  
  
'Call Data Tables and Store Data  
CallTable(Hourly)  
CallTable(Daily)  
NextScan  
EndProg
```

Appendix C. Dissolved oxygen tables

Table C-1 (p. 16) is a dissolved oxygen table for fresh water applications and Table C-2 (p. 18) is a dissolved oxygen table for salt water applications.

Table C-1: Dissolved oxygen solubility (mg/L) as a function of temperature and elevation for moist air													
Temp. (°C)	Elevation above sea level												
	0 m (0 ft)	152 m (500 ft)	305 m (1000 ft)	457 m (1500 ft)	610 m (2000 ft)	762 m (2500 ft)	914 m (3000 ft)	1067 m (3500 ft)	1219 m (4000 ft)	1372 m (4500 ft)	1524 m (5000 ft)	1676 m (5500 ft)	1829 m (6000 ft)
0	14.6	14.34	14.09	13.84	13.6	13.36	13.12	12.89	12.67	12.44	12.22	12.01	11.8
1	14.2	13.95	13.7	13.46	13.22	12.99	12.76	12.54	12.32	12.1	11.89	11.68	11.47
2	13.81	13.57	13.33	13.1	12.87	12.64	12.42	12.20	11.98	11.77	11.56	11.36	11.16
3	13.45	13.21	12.98	12.75	12.52	12.3	12.09	11.87	11.66	11.46	11.26	11.06	10.86
4	13.09	12.86	12.64	12.41	12.2	11.98	11.77	11.56	11.36	11.16	10.96	10.77	10.58
5	12.76	12.53	12.31	12.09	11.88	11.67	11.47	11.26	11.07	10.87	10.68	10.49	10.31
6	12.44	12.22	12	11.79	11.58	11.38	11.18	10.98	10.79	10.6	10.41	10.23	10.05
7	12.13	11.91	11.7	11.5	11.29	11.1	10.9	10.71	10.52	10.33	10.15	9.97	9.8
8	11.83	11.62	11.42	11.22	11.02	10.83	10.63	10.45	10.26	10.08	9.91	9.73	9.56
9	11.55	11.34	11.15	10.95	10.76	10.57	10.38	10.2	10.02	9.84	9.67	9.5	9.33
10	11.28	11.08	10.88	10.69	10.5	10.32	10.14	9.96	9.78	8.61	9.44	9.27	9.11
11	11.02	10.82	10.63	10.44	10.26	10.08	9.9	9.73	9.56	9.39	9.22	9.06	8.9
12	10.77	10.58	10.39	10.21	10.03	9.85	9.68	9.51	9.34	9.17	9.01	8.85	8.7
13	10.53	10.34	10.16	9.98	9.8	9.63	9.46	9.29	9.13	8.97	8.81	8.66	8.5
14	10.29	10.11	9.93	9.76	9.59	9.42	9.25	9.09	8.93	8.77	8.62	8.47	8.32
15	10.07	9.89	9.72	9.55	9.38	9.22	9.05	8.89	8.74	8.58	8.43	8.28	8.14
16	9.86	9.68	9.51	9.35	9.18	9.02	8.86	8.7	8.55	8.4	8.25	8.11	7.96

Table C-1: Dissolved oxygen solubility (mg/L) as a function of temperature and elevation for moist air

Temp. (°C)	Elevation above sea level												
	0 m (0 ft)	152 m (500 ft)	305 m (1000 ft)	457 m (1500 ft)	610 m (2000 ft)	762 m (2500 ft)	914 m (3000 ft)	1067 m (3500 ft)	1219 m (4000 ft)	1372 m (4500 ft)	1524 m (5000 ft)	1676 m (5500 ft)	1829 m (6000 ft)
17	9.65	9.48	9.31	9.15	8.99	8.83	8.68	8.52	8.37	8.22	8.08	7.94	7.8
18	9.45	9.29	9.12	8.96	8.8	8.65	8.5	8.35	8.2	8.06	7.91	7.77	7.64
19	9.26	9.1	8.94	8.78	8.63	8.47	8.32	8.18	8.03	7.89	7.75	7.62	7.48
20	9.08	8.92	8.76	8.61	8.45	8.3	8.16	8.01	7.87	7.73	7.6	7.46	7.33
21	8.9	8.74	8.59	8.44	8.29	8.14	8	7.86	7.72	7.58	7.45	7.32	7.19
22	8.73	8.57	8.42	8.27	8.13	7.98	7.84	7.71	7.57	7.44	7.31	7.18	7.05
23	8.56	8.41	8.26	8.12	7.97	7.83	7.69	7.56	7.43	7.29	7.17	7.04	6.92
24	8.4	8.25	8.11	7.96	7.82	7.69	7.55	7.42	7.29	7.16	7.03	6.91	6.79
25	8.24	8.1	7.96	7.82	7.68	7.54	7.41	7.28	7.15	7.03	6.9	6.78	6.66
26	8.09	7.95	7.81	7.67	7.54	7.41	7.28	7.15	7.02	6.9	6.78	6.65	6.54
27	7.95	7.81	7.67	7.54	7.4	7.27	7.14	7.02	6.9	6.77	6.65	6.54	6.42
28	7.81	7.67	7.53	7.4	7.27	7.14	7.02	6.89	6.77	6.65	6.54	6.42	6.31
29	7.67	7.54	7.4	7.27	7.14	7.02	6.9	6.77	6.65	6.54	6.42	6.31	6.2
30	7.54	7.41	7.28	7.15	7.02	6.9	6.78	6.66	6.54	6.42	6.31	6.2	6.09
31	7.41	7.28	7.15	7.03	6.9	6.78	6.66	6.54	6.43	6.32	6.2	6.09	5.99
32	7.29	7.16	7.03	6.91	6.79	6.66	6.54	6.43	6.32	6.21	6.1	5.99	5.89
33	7.17	7.04	6.92	6.79	6.67	6.56	6.43	6.33	6.22	6.11	6	5.89	5.79
34	7.05	6.92	6.8	6.68	6.56	6.45	6.34	6.22	6.11	6.01	5.9	5.8	5.69
35	6.93	6.81	6.69	6.57	6.46	6.34	6.23	6.12	6.02	5.91	5.81	5.7	5.6
36	6.82	6.7	6.59	6.47	6.36	6.24	6.13	6.03	5.92	5.82	5.71	5.61	5.51
37	6.72	6.6	6.48	6.37	6.26	6.15	6.04	5.93	5.83	5.72	6.62	5.52	5.43
38	6.61	6.49	6.38	6.27	6.16	6.05	5.94	5.84	5.74	5.63	5.53	5.44	5.34
39	6.51	6.39	6.28	6.17	6.06	5.96	5.85	5.75	5.65	5.55	5.45	5.35	5.26
40	6.41	6.3	6.19	6.08	5.97	5.86	5.76	5.66	5.56	5.46	5.37	5.27	5.18

Table C-2: Dissolved oxygen solubility (mg/L) as a function of temperature and salinity for moist air

Temp. (° C)	SALINITY- in parts per thousand (ppt)								
	0	5	10	15	20	25	30	35	40
0	14.6	14.11	13.64	13.18	12.74	12.31	11.9	11.5	11.11
1	14.2	13.73	13.27	12.83	12.4	11.98	11.58	11.2	10.83
2	13.81	13.36	12.91	12.49	12.07	11.67	11.29	10.91	10.55
3	13.45	13	12.58	12.16	11.76	11.38	11	10.64	10.29
4	13.09	12.67	12.25	11.85	11.47	11.09	10.73	10.38	10.04
5	12.76	12.34	11.94	11.56	11.18	10.82	10.47	10.13	9.8
6	12.44	12.04	11.65	11.27	10.91	10.56	10.22	9.89	9.57
7	12.13	11.74	11.37	11	10.65	10.31	9.98	9.66	9.35
8	11.83	11.46	11.09	10.74	10.4	10.07	9.75	9.44	9.14
9	11.55	11.19	10.83	10.49	10.16	9.84	9.53	9.23	8.94
10	11.28	10.92	10.58	10.25	9.93	9.62	9.32	9.03	8.75
11	11.02	10.67	10.34	10.02	9.71	9.41	9.12	8.83	8.56
12	10.77	10.43	10.11	9.8	9.5	9.21	8.92	8.55	8.3
13	10.53	10.2	9.89	9.59	9.3	9.01	8.74	8.47	8.21
14	10.29	9.98	9.68	9.38	9.1	8.82	8.55	8.3	8.04
15	10.07	9.77	9.47	9.19	8.91	8.64	8.38	8.13	7.88
16	9.86	9.56	9.28	9	8.73	8.47	8.21	7.97	7.73
17	9.65	9.36	9.09	8.82	8.55	8.3	8.05	7.81	7.58
18	9.45	9.17	8.9	8.64	8.39	8.14	7.9	7.66	7.44
19	9.26	8.99	8.73	8.47	8.22	7.98	7.75	7.52	7.3
20	9.08	8.81	8.56	8.31	8.07	7.83	7.6	7.38	7.17
21	8.9	8.64	8.39	8.15	7.91	7.69	7.46	7.25	7.04
22	8.73	8.48	8.23	8	7.77	7.54	7.33	7.12	6.91

Table C-2: Dissolved oxygen solubility (mg/L) as a function of temperature and salinity for moist air

Temp. (° C)	SALINITY- in parts per thousand (ppt)								
	0	5	10	15	20	25	30	35	40
23	8.56	8.32	8.08	7.85	7.63	7.41	7.2	6.99	6.79
24	8.4	8.16	7.93	7.71	7.49	7.28	7.07	6.87	6.68
25	8.24	8.01	7.79	7.57	7.36	7.15	6.95	6.75	6.56
26	8.09	7.87	7.65	7.44	7.23	7.03	6.83	6.64	6.46
27	7.95	7.73	7.51	7.31	7.1	6.91	6.72	6.53	6.35
28	7.81	7.59	7.38	7.18	6.98	6.79	6.61	6.42	6.25
29	7.67	7.46	7.26	7.06	6.87	6.68	6.5	6.32	6.15
30	7.54	7.33	7.14	6.94	6.75	6.57	6.39	6.22	6.05
31	7.41	7.21	7.02	6.83	6.65	6.47	6.29	6.12	5.96
32	7.29	7.09	6.9	6.72	6.54	6.36	6.19	6.03	5.87
33	7.17	6.98	6.79	6.61	6.44	6.26	6.1	5.94	5.78
34	7.05	6.86	6.68	6.51	6.33	6.17	6.01	5.85	5.69
35	6.93	6.75	6.58	6.4	6.24	6.07	5.92	5.76	5.61
36	6.82	6.65	6.47	6.31	6.14	5.98	5.83	5.68	5.53
37	6.72	6.54	6.37	6.21	6.05	5.89	5.74	5.59	5.45
38	6.61	6.44	6.28	6.12	5.96	5.81	5.66	5.51	5.37
39	6.51	6.34	6.18	6.03	5.87	5.72	5.58	5.44	5.3
40	6.41	6.25	6.09	5.94	5.79	5.64	5.5	5.36	5.22



Global Sales & Support Network

A worldwide network to help meet your needs



Campbell Scientific Regional Offices

Australia

Location: Garbutt, QLD Australia
Phone: 61.7.4401.7700
Email: info@campbellsci.com.au
Website: www.campbellsci.com.au

Brazil

Location: São Paulo, SP Brazil
Phone: 11.3732.3399
Email: vendas@campbellsci.com.br
Website: www.campbellsci.com.br

Canada

Location: Edmonton, AB Canada
Phone: 780.454.2505
Email: dataloggers@campbellsci.ca
Website: www.campbellsci.ca

China

Location: Beijing, P. R. China
Phone: 86.10.6561.0080
Email: info@campbellsci.com.cn
Website: www.campbellsci.com.cn

Costa Rica

Location: San Pedro, Costa Rica
Phone: 506.2280.1564
Email: info@campbellsci.com
Website: www.campbellsci.com

France

Location: Vincennes, France
Phone: 0033.0.1.56.45.15.20
Email: info@campbellsci.fr
Website: www.campbellsci.fr

Germany

Location: Bremen, Germany
Phone: 49.0.421.460974.0
Email: info@campbellsci.de
Website: www.campbellsci.de

India

Location: New Delhi, DL India
Phone: 91.11.46500481.482
Email: info@campbellsci.in
Website: www.campbellsci.in

South Africa

Location: Stellenbosch, South Africa
Phone: 27.21.8809960
Email: sales@campbellsci.co.za
Website: www.campbellsci.co.za

Spain

Location: Barcelona, Spain
Phone: 34.93.2323938
Email: info@campbellsci.es
Website: www.campbellsci.es

Thailand

Location: Bangkok, Thailand
Phone: 66.2.719.3399
Email: info@campbellsci.asia
Website: www.campbellsci.asia

UK

Location: Shepshed, Loughborough, UK
Phone: 44.0.1509.601141
Email: sales@campbellsci.co.uk
Website: www.campbellsci.co.uk

USA

Location: Logan, UT USA
Phone: 435.227.9120
Email: info@campbellsci.com
Website: www.campbellsci.com