

# SBE 4

## CONDUCTIVITY TEMPERATURE SENSOR

### Overview

The SBE 4 conductivity sensor is a modular, self-contained instrument that measures conductivity from 0 to 7 S/m, covering the full range of lake and oceanic applications. The sensor has electrically isolated power circuits and optically coupled outputs to eliminate any possibility of noise and corrosion caused by ground loops. Interfacing is also simplified by the square-wave variable frequency output signal (nominally 2.5 to 7.5 kHz, corresponding to 0 to 7 S/m). The sensor offers improved temperature compensation, smaller fit residuals, and faster turn-on stabilization times.

Because of the SBE 4's low noise characteristics, hybrid frequency measuring techniques (used in Sea-Bird's CTD instruments) provide rapid sampling with very high temporal and spatial resolution. The SBE 4 is ideally suited for obtaining vertical data with lowered systems or horizontal data with towed systems. Because of its small size, it is especially useful for moorings, portable CTD systems, or through-the-ice work.

The SBE **4C** is a primary sensor for the SBE 9plus, 25, and 25plus profiling CTDs; it has a quick-disconnect fitting to simplify plumbing to the CTD pump. The SBE **4M**, intended for long-term moored deployments, is supplied without the quick-disconnect fitting.

### Features

Cylindrical flow-through borosilicate glass cell with three internal platinum electrodes. The electrode arrangement offers distinct advantages over inductive or open external field cells. Because the outer electrodes are connected, electric fields are confined inside the cell, making the measured resistance (and instrument calibration) independent of calibration bath size or proximity to protective cages or other objects. The cell resistance controls the output frequency of a Wien Bridge oscillator circuit. A unique Sea-Bird design feature introduces a fixed conductivity offset, permitting the SBE 4 to measure conductivity down to 0 for fresh water work.

Built-in acquisition circuits and frequency outputs; allows for calibration as separate modules.

Each sensor is calibrated in state-of-the-art calibration baths; a water sample at each point is compared to IAPSO seawater using a Guildline AutoSal.

Five-year limited warranty.



### Options

- SBE 4C for profiling applications to 6800 or 10,500 m, or SBE 4M for moored applications to 3400 or 10,500 m.
- Aluminum (3400 or 6800 m) or titanium (10,500 m) housing.
- XSG or wet-pluggable MCBH connector.

## Calibration Equation

A least-squares fitting technique (including a zero conductivity point in air) yields calibration coefficients for use in the following equation:

$$\text{Conductivity [S/m]} = (g + hf^2 + if^3 + jf^4) / (10 [1 + \delta t + \epsilon p])$$

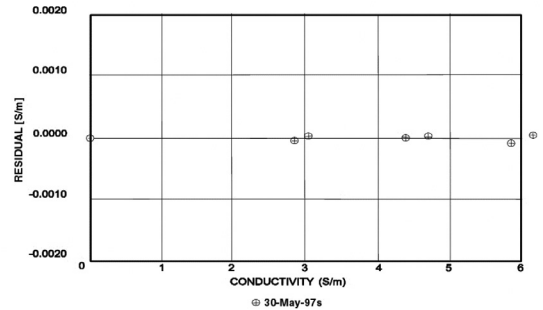
where f is SBE 4 output frequency [kHz], t is temperature [°C], p is pressure [decibars], and  $\delta$  is thermal coefficient of expansion ( $3.25 \times 10^{-6}$ ) and  $\epsilon$  is bulk compressibility ( $-9.57 \times 10^{-8}$ ) of the borosilicate cell. The resulting coefficients g, h, i, and j are listed on the calibration certificate. Residuals are typically less than 0.0002 S/m.

**Example Calibration Data** (sensor serial number 2020, 30 May 1997):

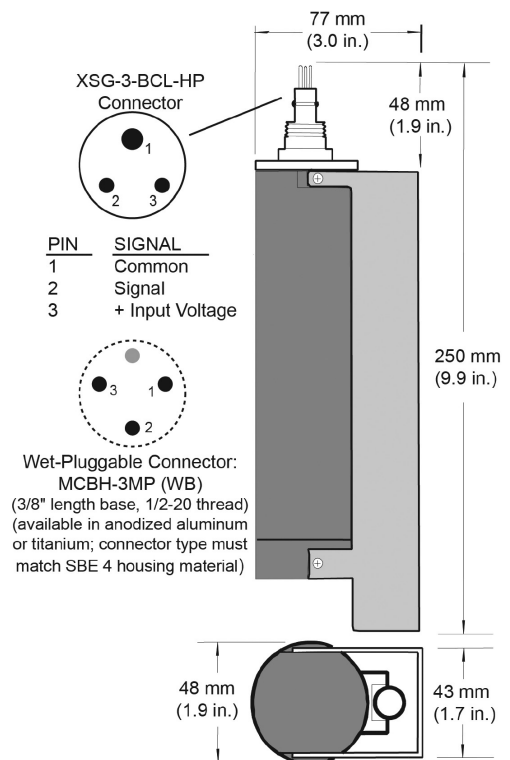
Practical Salinity Scale 1978:  $C(35,15,0) = 4.2914$  [S/m]

$$g = -1.05697877e+01 \quad h = 1.42707291e+00 \quad i = -4.32023820e-03 \quad j = 4.53455585e-04$$

Bath Temperature [°C 68]	Bath Salinity [ppt]	Bath Conductivity [S/m]	Instrument Frequency [kHz]	Instrument Conductivity [S/m]	Residual (Instrument Bath) [S/m]
0.0000	0.0000	0.00000	2.72957	0.00000	0.00000
-1.3428	35.2722	2.80855	5.22318	2.80850	-0.00005
1.0942	35.2724	3.01943	5.36370	3.01947	0.00004
15.2226	35.2731	4.34337	6.17207	4.34338	0.00001
18.6914	35.2731	4.69132	6.36724	4.69135	0.00003
29.0800	35.2708	5.77613	6.93974	5.77603	-0.00010
32.6309	35.2657	6.15878	7.13053	6.15885	0.00007



Performance	
Measurement Range	0.0 to 7.0 S/m
Initial Accuracy <sup>1</sup>	± 0.0003 S/m
Stability <sup>2</sup>	0.0003 S/m per month
Resolution <sup>3</sup>	0.00004 S/m at 24 samples/sec
Response Time <sup>4</sup>	0.060 sec (pumped)
Settling Time	< 0.7 sec to within 0.0001 S/m
Electrical	
Input Power	6 - 24 VDC; 18 mA at 6V, 12 mA at 10 - 24 V
Output Signal	1 V square wave capacitively coupled
Mechanical	
6061-T6 Aluminum housing	Depth rating: 3400 m; Weight: 0.7 kg in air, 0.3 kg in water
7075-T6 Aluminum housing	Depth rating: 6800 m; Weight: 0.7 kg in air, 0.3 kg in water
6Al-4V Titanium housing	Depth rating: 10,500 m; Weight: 1.1 kg in air, 0.7 kg in water



<sup>1</sup> Typical specifications, referenced to NIST-traceable calibration.

<sup>2</sup> Not applicable in areas of high biofouling activity or highly contaminated waters, or if Application Note 2D procedures not followed.

<sup>3</sup> Achieved with SBE 911plus CTD. In custom applications, resolution depends on frequency measuring technique.

<sup>4</sup> Time to reach 63% of final value following a step change in conductivity.