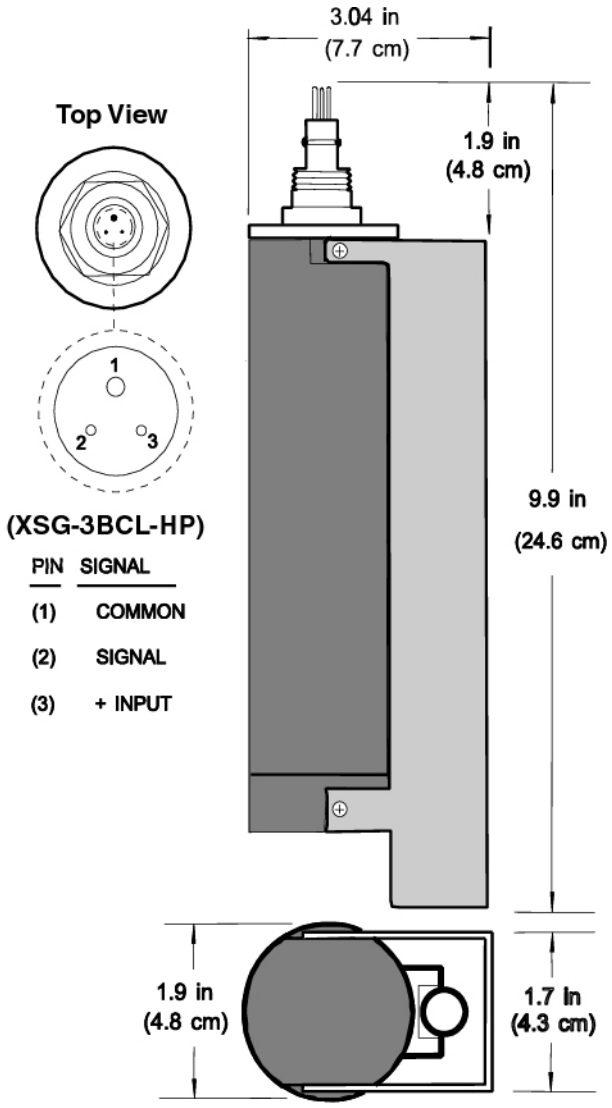
Conductivity Sensor

SBE 4

SBE 4 series conductivity sensors are modular, self contained instruments that measure conductivity from 0 to 7 S/m (Siemens/meter), thus covering the full range of lake and oceanic applications. Using an upgraded electronic technique (Version 2; S/N 2000 and higher), these new sensors have 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 - 7 S/m). The sensors offer improved temperature compensation, smaller fit residuals, and faster turn-on stabilization times. Supply voltage range has been increased to 6 - 24 volts.

The **SBE 4C** is a primary sensor for Sea-Bird's SBE 9 CTD Underwater Unit and SBE 25 Sealogger CTD. Available in 6800 m aluminum or 10500 m titanium housings, the 4C has a quick-disconnect for plumbing to the CTD pump. Supplied without the quick-disconnect fitting, the **SBE 4M** is also available with a low-corrosion 6061 aluminum 3400 m housing for long-term moored deployments.

The sensing element is a 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 together, electric fields are confined inside the cell, making the measured resistance (and instrument calibration) independent of the calibration bath size or proximity to protective cages or other objects. In particular, the internal field permits effective antifoul protection using toxic "gatekeepers" positioned at the cell ends. 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 instrument to measure conductivity down to 0 for "fresh" water work.



Supply Voltage	6 - 24 VDC
Supply Current	18 ma at 6V; 12 ma 10 - 24 V
Signal output	1V square wave capacitively coupled
Materials	3400 m 6061-T6 aluminum 6800 m 7075-T6 aluminum 10500 m 6Al4V titanium
Weight (Al)	0.7 kg (1.6 lbs) in air 0.34 kg (.75 lbs) in water
Weight (Ti)	1.1 kg (2.4 lbs) in air 0.7 kg (1.5 lbs) in water

SPECIFICATIONS[1]

Measurement Range	0.0 to 7 Siemens/meter (S/m)
Initial Accuracy	0.0003 S/m
Stability[2]	0.0003 S/m/month
Resolution[3]	0.00004 S/m @ 24 Hz
Time Response[4]	0.060 seconds (pumped)
Settling Time	0.7 seconds to within 0.0001 S/m

[1] Typical specifications, referenced to NIST-traceable calibration.
[2] Not applicable in areas of high biofouling activity, highly contaminated waters or if procedures in Application Bulletin 2D are not followed.
[3] Achieved with Sea-Bird's SBE 9 CTD. In custom applications, resolution will depend on the frequency measuring technique used.
[4] Time to reach 63% of final value following a step change in conductivity.

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Conductivity Sensor SBE 4

APPLICATION

Because of the SBE 4's low noise characteristics, hybrid frequency measuring techniques (used in Sea-Bird's CTD instruments) may be used to obtain rapid sampling with very high temporal and spatial resolution. The SBE 4 is ideally suited for obtaining horizontal data with towed systems or vertical data with lowered systems. Because of its small size, it is especially useful for moorings, portable CTD systems, or through-the-ice work. In moored applications, anti-foulant attachments (PN 24012) may be used to protect the cell from biological growth. After a 5 month mooring at depths of 80 to 290 meters, four SBE4s with anti-foulant protection showed drifts of <0.0015 S/m over a year's interval between calibrations. The anti-foul is effective for 6 to 12 months in areas of high biological activity.

CALIBRATION

Sea-Bird calibrates the sensors over the range of approximately 3 to 6 S/m in computer controlled baths using natural seawater; a water sample at each point is compared to IAPSO seawater using a Guildline AutoSal. A least squares fitting technique (also including a zero conductivity point in air) yields calibration coefficients for use in the following equation:

$$\text{Conductivity} = \frac{g + hf^2 + if^3 + jf^4}{10\,[1 + \delta t + \varepsilon p]} \quad \text{[S/m]}$$

where f is the instrument frequency [kHz], t is temperature [°C], p is pressure [decibars], and δ represents the bulk compressibility (-9.57e-08) and ε the thermal coefficient of expansion (3.25e-06) 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.

SAMPLE CALIBRATION DATA

CALIBRATION DATA FOR SENSOR SERIAL NUMBER = 2020

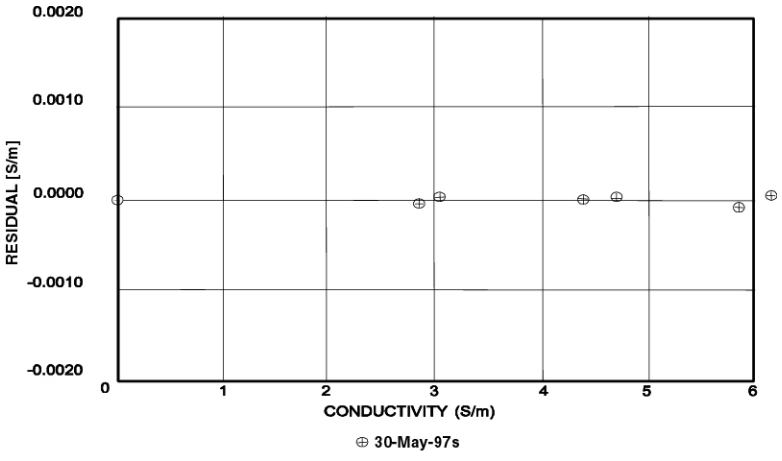
CALIBRATION DATE: 30 May 97

Practical Salinity Scale 1978: C(35,15,0) = 4.2914 [Siemens/meter]

g = -1.05697877e+01 i = -4.32023820e-03

h = 1.42707291e+00 j = 4.53455585e-04

BATH TEMP [°C68]	BATH SAL [ppt]	BATH COND [S/m]	INST FREQ [kHz]	INST COND [S/m]	RESIDUAL (INST - 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



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