

SBE 3S

OCEANOGRAPHIC TEMPERATURE SENSOR

Overview

Intended primarily for use on moored and fixed-site temperature measuring systems, the SBE 3S can also be used as a component in custom systems or for high-accuracy industrial and environmental temperature monitoring applications. The low noise characteristics of the SBE 3S allow the use of hybrid frequency measuring techniques to obtain rapid sampling with very high resolution; $40 \mu\text{C}$ resolution can be readily obtained at a 6 Hz sampling rate.

The superior performance of the SBE 3S results from its optimized electronic design, superior calibration, and quality testing program. The SBE 3S has a time response of approximately 0.6 sec and an initial accuracy of $0.001 \text{ }^\circ\text{C}$, and is typically stable to $0.002 \text{ }^\circ\text{C}/\text{year}$.

Features

Glass-coated thermistor bead, pressure-protected in 2.1 mm diameter thin-walled stainless steel tube. Exponentially related to temperature, the thermistor resistance is the controlling element in an optimized Wien Bridge oscillator circuit. Resulting sensor frequency is inversely proportional to the square root of the thermistor resistance and ranges from approximately 2 to 6 kHz, corresponding to -5 to $+35 \text{ }^\circ\text{C}$.

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

Individually calibrated in Sea-Bird's state-of-the-art calibration baths.

Overall system accuracy limited only by the accuracy of the logger's master clock. A typically small clock error of 1 ppm affords a temperature error of less than $50 \mu\text{C}$.

3400 m aluminum or 10,500 m titanium housing.

Five-year limited warranty.

Options

- Aluminum (3400 m) or titanium (10,500 m) housing.
- XSG or wet-pluggable MCBH connector



Calibration

SBE 3S sensors are calibrated to ITS-90 temperature using Sea-Bird's calibration baths. Extremely well insulated, the baths provide a uniform toroidal circulation, yielding an overall transfer accuracy against an SPRT within $0.0002 \text{ }^\circ\text{C}$. Repeatability at each of twelve individually mapped sensor positions is better than $0.0001 \text{ }^\circ\text{C}$.

Sea-Bird's metrology lab underpins the temperature calibration baths. Following consultation with the U.S. National Institute of Standards and Technology, the lab was configured to achieve temperature precision of $50 \mu\text{K}$ and accuracy of $0.0005 \text{ }^\circ\text{C}$.

To obtain this performance, premium primary references, including four Jarrett water triple-point cells (with maintenance bath) and an Isotech gallium melt cell, are operated in conjunction with two YSI 8163 standards-grade platinum resistance thermometers and an ASL F18 Automatic Temperature Bridge.

Calibration Equation

The calibration yields four coefficients (g, h, i, j) that are used in the following equation (Bennett):

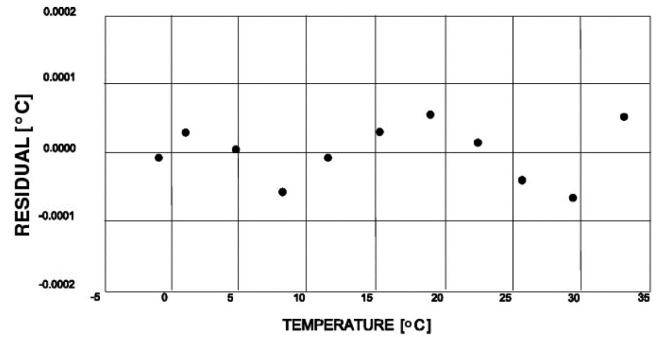
$$T = 1 / [g + \ln(f_0/f) + i \ln^2(f_0/f) + j \ln^3(f_0/f)] - 273.15$$

where T is temperature [°C], ln is natural log function, and f is SBE 3S output frequency [Hz]. Note that f_0 , an arbitrary scaling term used for purposes of computational efficiency, was historically chosen as the lowest sensor frequency generated during calibration. For calibration results expressed in terms of ITS-90 temperatures, f_0 is set to 1000. Calibration fit residuals are typically less than 0.0001 °C.

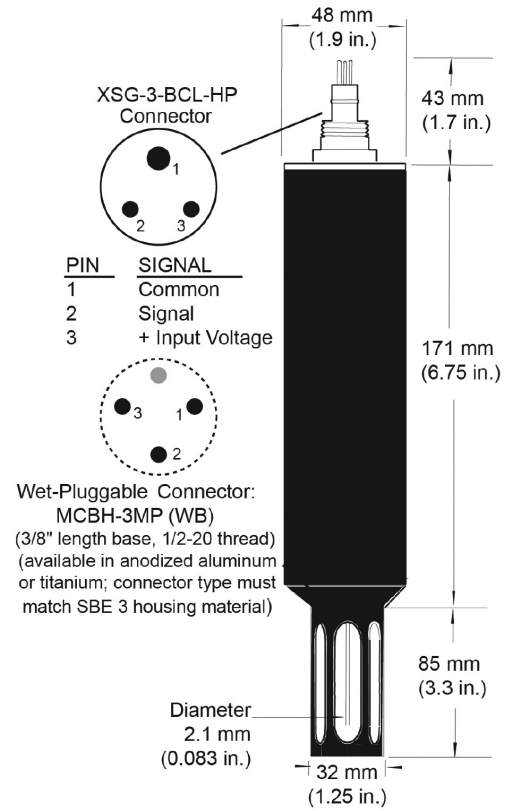
Example Calibration Data (sensor serial number 2213, 30 May 1996):

$$g = 4.28793855e-03 \quad h = 6.25807786e-04 \quad i = 2.19368239e-05 \quad j = 1.84262924e-06 \quad f_0 = 1000.000$$

Bath Temperature [°C]	Instrument Frequency [Hz]	Instrument Temperature [°C]	Residual (Instrument Bath) [°C]
-1.4262	2727.631	-1.4262	-0.00001
1.0833	2888.869	1.0834	0.00003
4.5745	3124.656	4.5745	0.00000
8.1730	3382.083	8.1730	-0.00006
11.6052	3641.635	11.6052	-0.00001
15.1623	3925.500	15.1623	0.00003
18.6658	4220.277	18.6659	0.00006
22.1644	4530.069	22.1644	0.00001
25.7234	4861.419	25.7234	-0.00004
29.1380	5195.062	29.1380	-0.00007
32.6711	5556.867	32.6711	0.00005



Performance	
Measurement Range	-5 to +35 °C
Initial Accuracy ¹	± 0.001 °C
Stability	0.002 °C per year typical
Response Time ²	0.580 sec ± 0.010 sec (1.0 m/s water velocity) 0.690 sec ± 0.010 sec (0.5 m/s water velocity)
Self-heating Error	< 0.0001 °C in still water
Settling Time	< 0.5 sec to within 0.001 °C
Electrical	
Input Power	11-16 VDC, 25 mA
Output Signal	± 0.5 V square wave
Mechanical	
6061 Aluminum housing	Depth rating: 3400 m; Weight: 0.6 kg in air, 0.3 kg in water
6Al-4V Titanium housing	Depth rating: 10,500 m; Weight: 0.9 kg in air, 0.6 kg in water



¹ NIST-traceable calibration applying over entire oceanographic range.
² Time to reach 63% of final value following step change in temperature.