

Oceanographic Temperature Sensor

SBE 3S


DESCRIPTION



The **SBE 3S** is an enhanced version of Sea-Bird's proven SBE 3 (slow response) temperature sensor. The superior performance of the SBE 3S results from its optimized electronic design combined with an extraordinarily precise calibration procedure and quality testing program. The SBE 3S has a time response of approximately 0.6 second, an initial accuracy of 0.001 °C, and is typically stable to 0.002 °C per year.

Every SBE 3S is calibrated in Sea-Bird's computer-controlled calibration baths. These super-low-gradient baths produce temperature calibrations with resolution and accuracy previously unavailable commercially.

These sensors can be successfully calibrated as separate modules because they have built-in acquisition circuits and frequency outputs. When used with a data logging system, overall system accuracy is equal to the sensor accuracy degraded only by the uncertainty in the logger's master clock. A typically small clock error of 1 ppm affords a temperature error of less than 50 µ°C.

APPLICATION

Intended primarily for use on moored and fixed-site temperature measuring systems, the SBE 3S can 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; a resolution of 40 µ°C can be readily obtained at a 6 Hz sampling rate.

Depth ratings to 3400, 6800, and 10500 meters are offered to suit different application requirements.

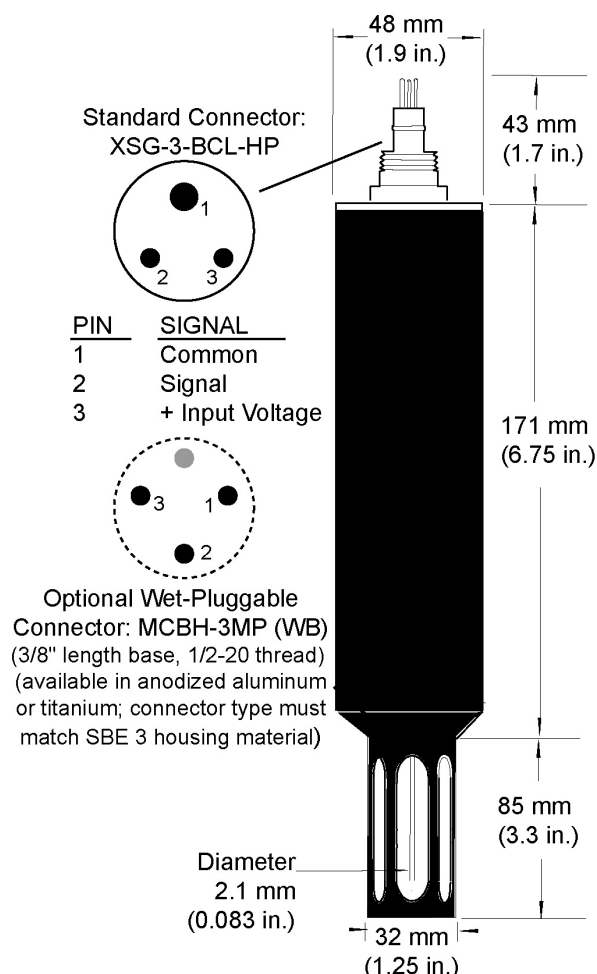
SPECIFICATIONS

Range	-5.0 to +35 °C
Initial Accuracy ¹	± 0.001 °C
Stability	0.002 °C per year typical
Response Time ² [sec.]	0.580 ± 0.010 (1.0 m/s water velocity) 0.690 ± 0.010 (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
Power Required	11 - 16 VDC, 25 ma
Signal Output	± 0.5V square wave

Housing	Depth Rating	Weight
6061 aluminum	3400 meters	0.63 kg (1.4 lbs) in air; 0.28 kg (0.6 lbs) in water
7075 aluminum	6800 meters	0.63 kg (1.4 lbs) in air; 0.28 kg (0.6 lbs) in water
6Al-4V titanium	10500 meters	0.90 kg (2.0 lbs) in air; 0.55 kg (1.2 lbs) in water

¹ NIST-traceable calibration applying over the entire oceanographic range.

² Time to reach 63% of final value following a step change in temperature.



OPERATION

The sensing element is a glass-coated thermistor bead, pressure-protected inside a 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. The resulting sensor frequency is inversely proportional to the square root of the thermistor resistance and ranges from approximately 2 to 6 kHz, corresponding to temperature from -5 to +35 °C.

CALIBRATION

SBE 3S sensors are calibrated to ITS-90 temperature using Sea-Bird's computer-controlled calibration bath. Extremely well insulated, the baths provide a uniform toroidal circulation yielding an overall transfer accuracy against an SPRT within 0.0002 °C. Repeatability at each of twelve individually mapped sensor positions is better than 0.0001 °C. Sea-Bird's metrology laboratory underpins the temperature calibration baths. Following consultation with the U.S. National Institute of Standards and Technology, the met lab was configured to achieve temperature precision of 50 µK and accuracy of 0.0005 °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):

$$T = \frac{1}{g + h \ln(f_0/f) + i \ln^2(f_0/f) + j \ln^3(f_0/f)} - 273.15, \quad [^{\circ}\text{C}]$$

where T is temperature [°C], $\ln$ is the natural log function, and f is the SBE 3S output frequency in 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 all calibration results expressed in terms of ITS-90 temperatures, the f_0 term is set to 1000. Calibration fit residuals are typically less than 0.0001°C.

ACTUAL CALIBRATION DATA for Sensor Serial Number 2213

CALIBRATION DATE: 30 May 96

g = 4.28793855e-03 h = 6.25807786e-04
i = 2.19368239e-05 j = 1.84262924e-06
f₀ = 1000.000

BATH TEMP [°C]	INST FREQ [Hz]	INST TEMP [°C]	RESIDUAL (INST - 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

