

## SBE 3F CTD Temperature Sensor

Intended primarily for use on the SBE 25 and 25plus CTD system, the SBE 3F can also be used as a component in custom oceanographic systems or for high-accuracy industrial and environmental temperature monitoring applications.

The superior performance of the SBE 3F results from its optimized electronic design, superior calibration, and quality testing program. The SBE 3F has a time response of approximately 0.07 sec and an initial accuracy of 0.001 °C, and is typically stable to 0.002 °C/year.

### Features

- Glass-coated thermistor bead, pressure-protected in 0.8 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 °C.
- Built-in acquisition circuits and frequency outputs; allows for calibration as separate modules.
- Individually calibrated in Sea-Bird's computer-controlled, super-low-gradient calibration baths.
- Overall system accuracy limited only by the accuracy of the CTD's master clock. A typically small clock error of 1 ppm affords a temperature error of less than 50 µ°C.
- 6800 m aluminum or 10,500 m titanium housing.
- Five-year limited warranty.



### Calibration

SBE 3F sensors are calibrated to ITS-90 temperature using Sea-Bird's computer-controlled calibration baths. 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 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 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):

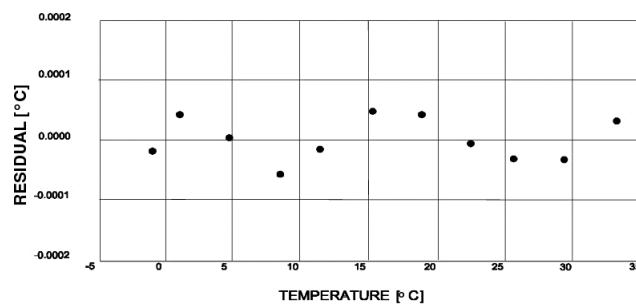
$$T = 1 / [g + h \ln(f_0/f) + i \ln^2(f_0/f) + j \ln^3(f_0/f)] - 273.15$$

where T is temperature [°C],  $\ln$  is natural log function, and f is SBE 3F 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 2234, 01 Jun 1996):

g = 4.31635693e-03    h = 6.41530157e-04    i = 2.27237634e-05    j = 2.17153096e-06     $f_0 = 1000.000$

Bath Temperature [°C]	Instrument Frequency [Hz]	Instrument Temperature [°C]	Residual (Instrument - Bath) [°C]
-1.4283	2787.505	-1.4283	-0.00002
1.0814	2948.210	1.0814	0.00004
4.5728	3182.770	4.5728	0.00000
8.1715	3438.281	8.1715	-0.00006
11.6037	3695.317	11.6037	-0.00001
15.1611	3975.833	15.1611	0.00005
18.6649	4266.480	18.6649	0.00004
22.1634	4571.240	22.1634	-0.00001
25.7228	4896.542	25.7228	-0.00003
29.1375	5223.350	29.1375	-0.00003
32.6712	5577.028	32.6712	0.00003



## Options

- Aluminum (6800 m) or titanium (10,500 m) housing.
- XSG or wet-pluggable MCBH connector.

## Performance

Measurement Range	-5 to +35 °C
Initial Accuracy <sup>1</sup>	± 0.001 °C
Stability	0.002 °C per year typical
Response Time <sup>2</sup>	0.065 sec ± 0.010 sec (1.0 m/s water velocity) 0.070 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

<sup>1</sup> NIST-traceable calibration applying over entire oceanographic range.

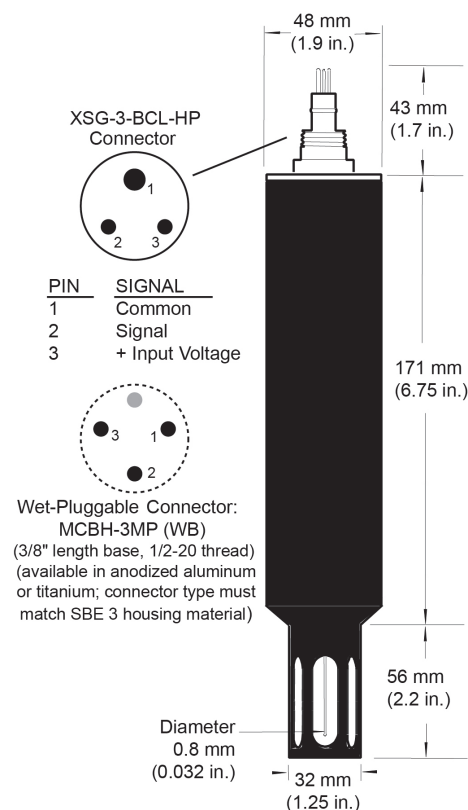
<sup>2</sup> Time to reach 63% of final value following step change in temperature.

## Electrical

Input Power	11-16 VDC, 25 mA
Output Signal	± 0.5 V square wave

## Mechanical

7075 Aluminum housing	Depth rating: 6800 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



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