Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 2265
CALIBRATION DATE: 14-Feb-14

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.33185264e-003
h = 6.43918821e-004
i = 2.36253120e-005
j = 2.24297344e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS

a = 3.68121185e-003
b = 6.01981499e-004
c = 1.66101790e-005
d = 2.24456324e-006
f0 = 2848.081

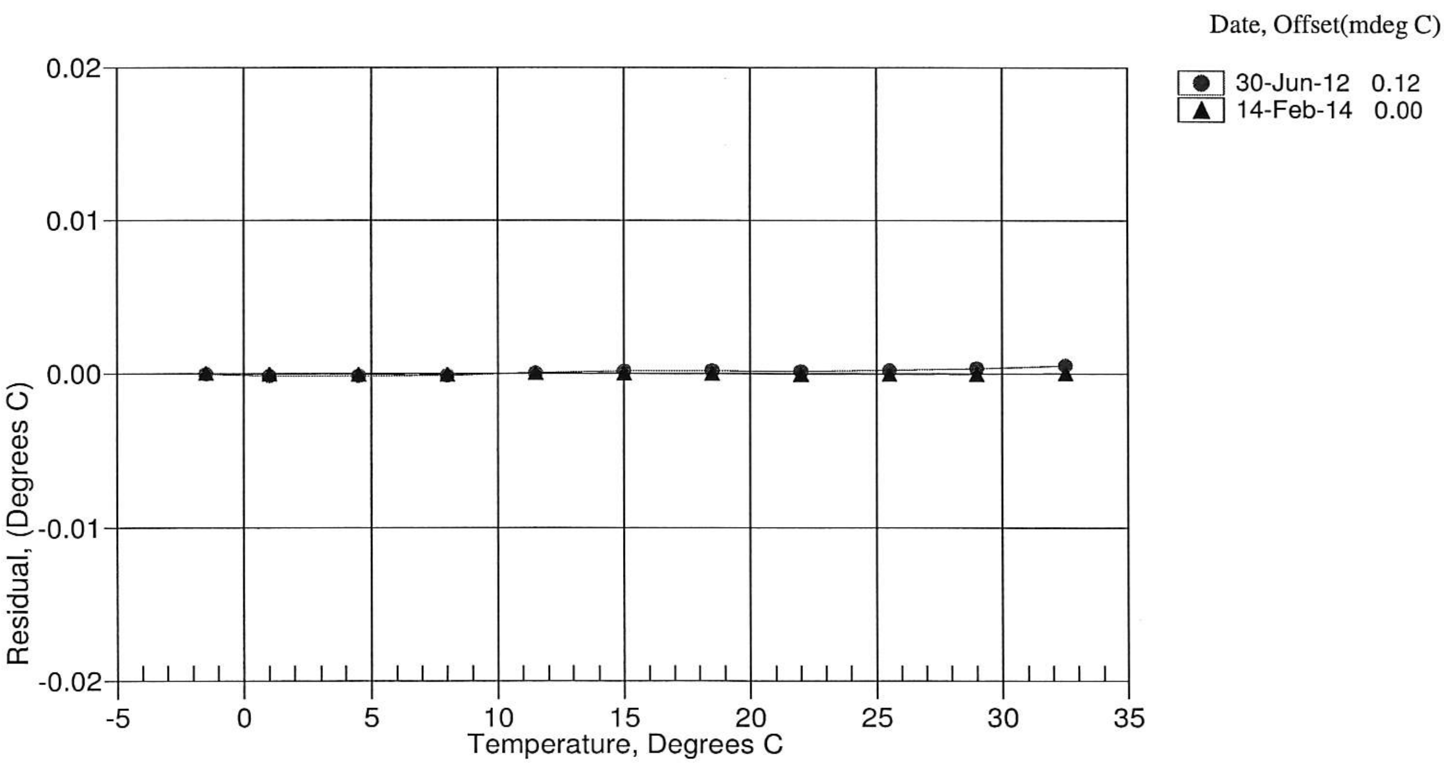
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	2848.081	-1.5000	0.00003
1.0000	3011.709	1.0000	-0.00002
4.5000	3252.097	4.5000	-0.00004
8.0000	3506.016	8.0000	-0.00004
11.5000	3773.839	11.5001	0.00006
15.0000	4055.907	15.0000	0.00005
18.5000	4352.574	18.5000	0.00002
22.0000	4664.172	22.0000	-0.00004
25.5000	4991.034	25.5000	-0.00003
29.0000	5333.464	29.0000	-0.00004
32.5000	5691.770	32.5000	0.00004

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



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SENSOR SERIAL NUMBER: 4148
CALIBRATION DATE: 13-Feb-14

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.37339822e-003
h = 6.61391828e-004
i = 2.44785198e-005
j = 2.08486115e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS

a = 3.68121178e-003
b = 6.15743618e-004
c = 1.77138642e-005
d = 2.08654499e-006
f0 = 2962.975

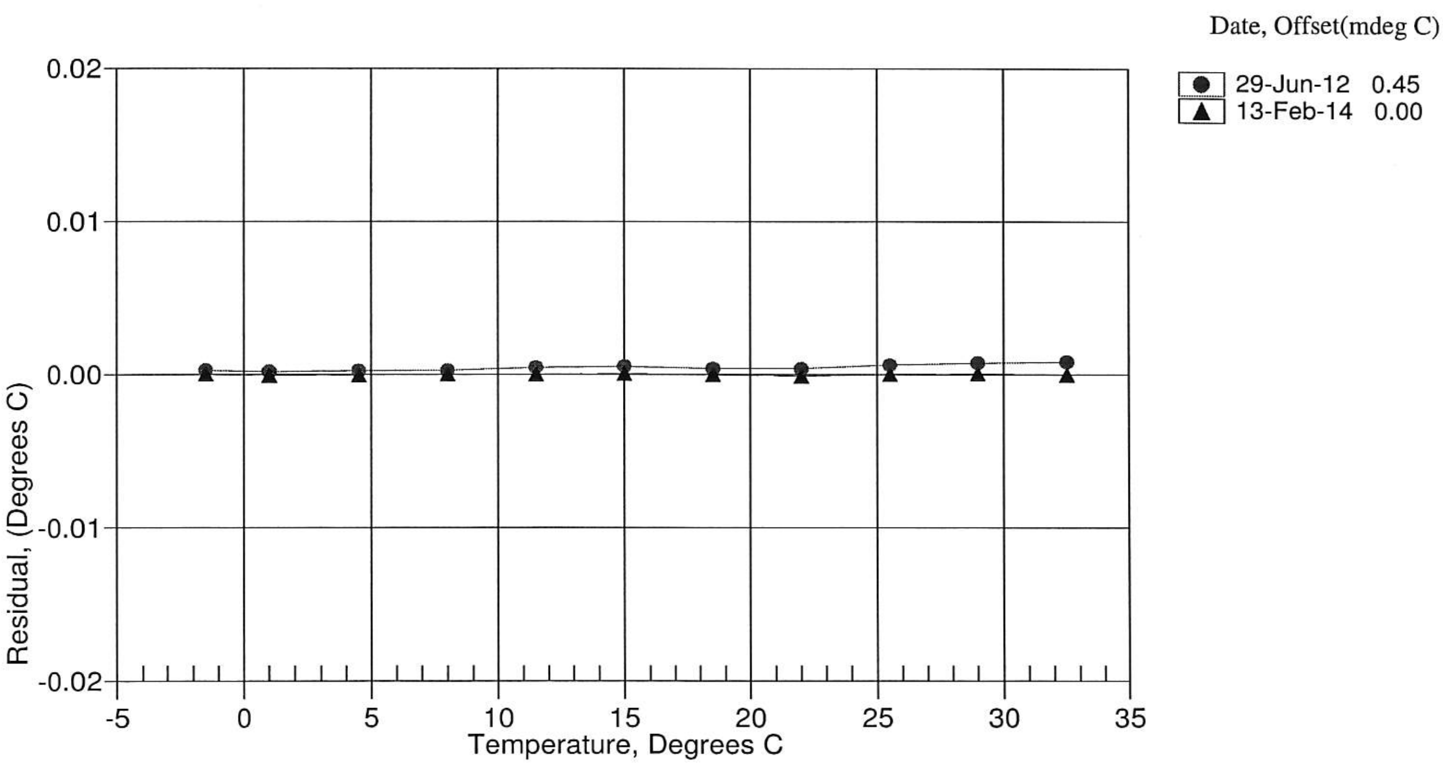
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	2962.975	-1.5000	0.00004
1.0000	3129.297	0.9999	-0.00006
4.5000	3373.309	4.5000	-0.00002
8.0000	3630.651	8.0000	0.00003
11.5000	3901.661	11.5000	0.00001
15.0000	4186.685	15.0001	0.00006
18.5000	4486.033	18.5000	-0.00001
22.0000	4800.027	21.9999	-0.00011
25.5000	5128.994	25.5000	0.00002
29.0000	5473.199	29.0001	0.00007
32.5001	5832.923	32.5001	-0.00003

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



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SENSOR SERIAL NUMBER: 2446
CALIBRATION DATE: 13-Feb-14

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

```
g =  4.37247477e-003
h =  6.48296136e-004
i =  2.37876805e-005
j =  2.19965081e-006
f0 = 1000.0
```

IPTS-68 COEFFICIENTS

```
a =  3.68121256e-003
b =  6.03875938e-004
c =  1.65129435e-005
d =  2.20123017e-006
f0 = 3024.116
```

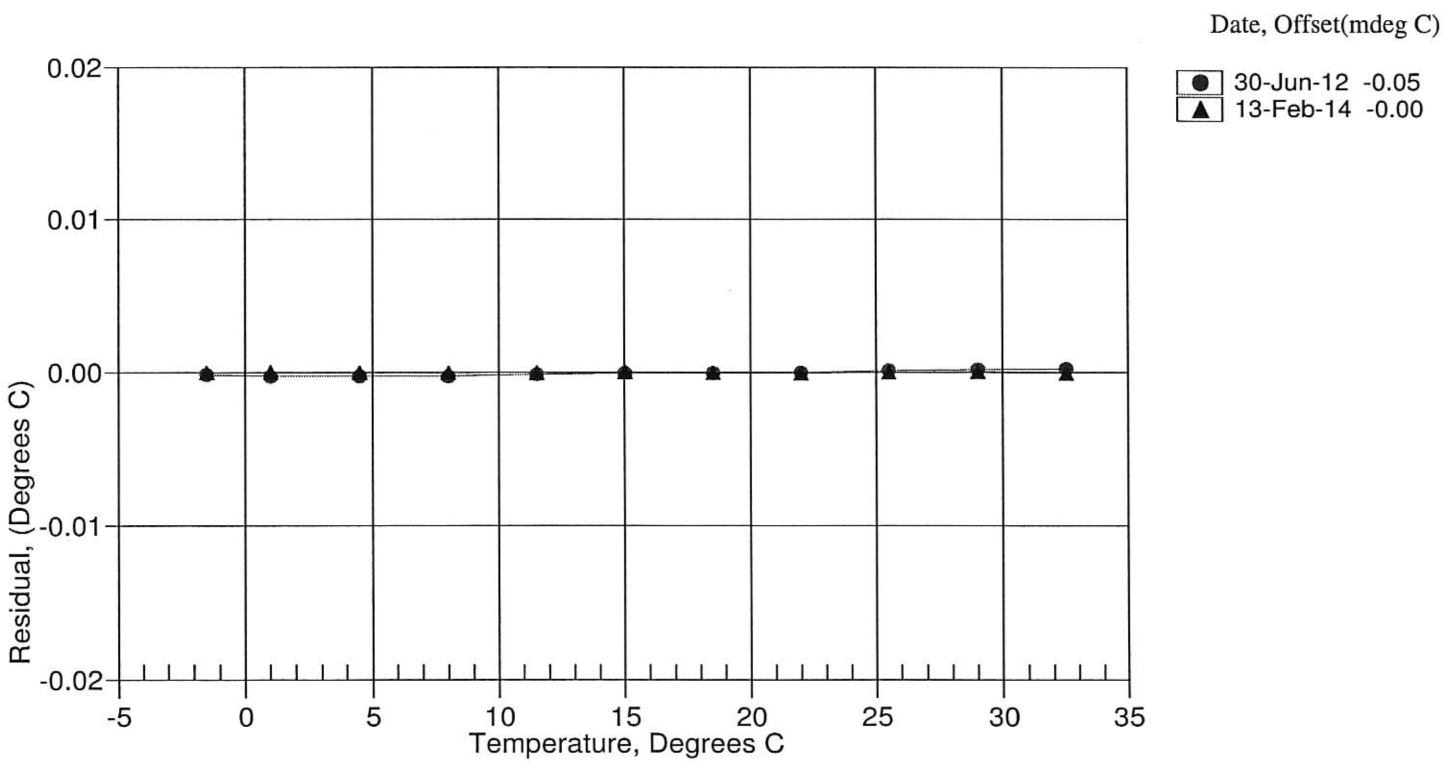
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	3024.116	-1.5000	-0.00002
1.0000	3197.301	1.0000	0.00002
4.5000	3451.655	4.5000	0.00001
8.0000	3720.247	8.0000	-0.00001
11.5000	4003.458	11.5000	-0.00002
15.0000	4301.665	15.0000	0.00004
18.5000	4615.212	18.5000	-0.00002
22.0000	4944.458	21.9999	-0.00005
25.5000	5289.747	25.5000	0.00002
29.0000	5651.390	29.0001	0.00007
32.5001	6029.691	32.5001	-0.00004

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



SeaBird Frequency Counter
III-28-2014
A. Bradley

1. Overview
The SeaBird dual frequency counter is an RS-232 interfaced intended to measure and report the frequencies of two SeaBird temperature sensors. It must be powered by the same voltage the Seabird sensors run on, nominally 12V.

2. Computer Interface
This is true RS-232 at 9600 baud, 8-N-1 protocol wired in a half duplex mode. This means it echos all characters sent to it as well as coughing up its own replies when asked politely.

3. Commands
Normally, the computer should send

"#SB-"

whereupon the counter will reply with

" 123456 654321[cr][lf]:[etx]"

So what you'll see on the SDO will be the whole transaction

"#SB- 123456 654321[cr][lf]:[etx]"

A help file is built in for historical reasons and is accessed by the command "#SBH" which should reply

```
#SBHelp SB, Fri, Mar 28, 2014, 08:26
- data
format T1T1T1 T2T2T2
T1T1T1=512*Fxtal/Fseabird (Fxtal=4.91548 MHz)
:•
```

(The above is captured from the device itself and includes the appropriate cr's and lf's. The "•" represents the terminating etx to signify that it's done sending.)

4. Data
The two six digit data fields are derived from the two frequencies from the two sensors. They are in decimal format and indicate the scaled inverse of the SeaBird frequencies. The algorithm computes the ratio of the internal crystal clock cycles to scaled SeaBird cycles SINCE THE LAST TIME THE DEVICE WAS QUERIED. This means the first measurements are always bonkers, but each of a sequence will be correct. The interval between queries doesn't matter, but if they are too fast, the accuracy will be less. If too slow, the internal counters overflow. Full 6 digit accuracy requires counting for about a second. Ten samples/second will reduce to 5 digit accuracy. A sample of 10 seconds doesn't overflow, but doesn't gain any more precision. For small temperature fluctuations, the data is essentially averaged over your sampling period.

The formula for the SeaBird frequency is

Fseabird=512*Fxtal/T1T1T1

where

T1T1T1 (or T2T2T2) is the 6 digit field in the reply

and
Fxtal=4.91548 MHz, the processor crystal frequency