



Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, WA 98005
USA

Phone: (425) 643-9866
Fax: (425) 643-9954
E-mail: seabird@seabird.com
Web: www.seabird.com

APPLICATION NOTE NO. 11 QSP-L

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**Calculating Calibration coefficients for Biospherical Instruments PAR Light Sensor
with Built-In Log Amplifier**

This application note applies to the following Biospherical Instruments PAR light sensors, which all have a built-in log amplifier:

- QSP-200L and QCP-200L - no longer in production
- QSP-2300L, QSP-2350L, QCP-2300L, QCP-2300L-HP, and MCP-2300 - current production

These PAR sensors are compatible with the following Sea-Bird CTDs:

- SBE 9*plus*
- SBE 16 or 19 – These PAR sensors may not be compatible with 6-cell housing version of these CTDs; consult Sea-Bird.
- SBE 16*plus*, 16*plus*-IM, or 19*plus* – CTD’s optional PAR connector **not** required when using one of these PAR sensors. The PAR sensor interfaces with an A/D voltage channel on the CTD.
- SBE 16*plus* V2, 16*plus*-IM V2, 19*plus* V2, or 25*plus* –The PAR sensor interfaces with an A/D voltage channel on the CTD.
- SBE 25 – CTD’s PAR connector (optional on older versions) **not** used with these PAR sensors. The PAR sensor interfaces with an A/D voltage channel on the CTD.

Note: The CTD voltage channel for use with the PAR sensor can be single-ended or differential.

Seasoft computes PAR using the following equation:

$$\text{PAR} = [\text{multiplier} * (10^9 * 10^{(V-B)/M}) / \text{calibration constant}] + \text{offset}$$

Enter the following coefficients in the CTD configuration (.con or .xmlcon) file:

M = 1.0 and **B** = 0.0 (Notes 2 and 3)

calibration constant = $10^5 / C_w$ (Notes 2 and 4)

multiplier = 1.0 for output units of $\mu\text{Einsteins}/\text{m}^2\cdot\text{sec}$ (Note 5)

offset = $-(10^4 * C_w * 10^V)$ (Note 6)

Notes:

1. In our Seasoft V2 suite of programs, edit the CTD configuration (.con or .xmlcon) file using the Configure Inputs menu in Seasave V7 (real-time data acquisition software) or the Configure menu in SBE Data Processing (data processing software).
2. Sea-Bird provides two calibration sheets for the PAR sensor in the CTD manual:
 - Calibration sheet generated by Biospherical, which contains Biospherical’s calibration data.
 - Calibration sheet generated by Sea-Bird, which incorporates the Biospherical data and generates M, B, and calibration constant needed for entry in Sea-Bird software (saving the user from doing the math).
3. For all SBE 911*plus*, 16, 16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19, 19*plus*, 19*plus* V2, 25, and 25*plus* CTDs, M = 1.0. For SBE 9/11 systems built before 1993 that have differential input amplifiers, M = 2; consult your SBE 9 manual or contact factory for further information. B should always be set to 0.0.
4. C_w is the *wet* $\mu\text{Einsteins}/\text{cm}^2\cdot\text{sec}$ coefficient from the Biospherical calibration sheet. A typical value is 4.00×10^{-5} .
5. The multiplier can be used to calculate irradiance in units other than $\mu\text{Einsteins}/\text{m}^2 \text{ sec}$. See Application Note 11 General for multiplier values for other units.
The multiplier can also be used to *scale* the data, to compare the *shape* of data sets taken at disparate light levels. For example, a multiplier of 10 would make a $10 \mu\text{Einsteins}/\text{m}^2\cdot\text{sec}$ light level plot as $100 \mu\text{Einsteins}/\text{m}^2\cdot\text{sec}$.
6. Offset ($\mu\text{Einsteins}/\text{m}^2\cdot\text{sec}$) = $-(10^4 * C_w * 10^V)$, where V is the *dark voltage*.

For typical values ($C_w = 4.00 \times 10^{-5}$ and Dark Voltage = 0.150), offset = -0.5650. The dark voltage may be obtained from:

- Biospherical calibration certificate for your sensor, or
- CTD PAR channel with the sensor covered (dark) -- in Seasave V7, display the *voltage output* of the PAR sensor channel.

Instead of using the dark voltage to calculate the offset, you can also directly obtain the offset using the following method: Enter M, B, and Calibration constant, and set offset = 0.0 in the configuration (.con or .xmlcon) file. In Seasave V7, display the *calculated PAR output* with the sensor dark; then enter the negative of this reading as the offset in the configuration file.

Mathematical Derivation

1. Using the sensor output in volts (V), Biospherical calculates:
$$\text{light } (\mu\text{Einsteins}/\text{cm}^2\cdot\text{sec}) = C_w * (10^{\text{Light Signal Voltage}} - 10^{\text{Dark Voltage}}).$$
2. Seasoft calculates: $\text{light } (\mu\text{Einsteins}/\text{m}^2\cdot\text{sec}) = [\text{multiplier} * 10^9 * 10^{(V-B)/M}] / \text{Calibration constant} + \text{offset}$
where M, B, Calibration constant, multiplier, and offset are the Seasoft coefficients entered in the CTD configuration file.
3. To determine Calibration constant, let B = 0.0, M = 1.0, and multiplier = 1.0. Equating the Biospherical and Seasoft relationships:
$$10^4 (\text{cm}^2/\text{m}^2) * C_w * (10^{\text{Light Signal Voltage}} - 10^{\text{Dark Voltage}}) = (10^9 * 10^V) / \text{Calibration constant} + \text{offset}$$

Since $\text{offset} = - (10^4 * C_w * 10^{\text{Dark Voltage}})$, and $V = \text{Light Signal Voltage}$:
$$\text{Calibration constant} = 10^9 / (10^4 * C_w) = 10^5 / C_w$$

Example:

If Wet calibration factor = $4.00 \times 10^{-5} \mu\text{Einsteins}/\text{cm}^2\cdot\text{sec}$, then $C = 2,500,000,000$ (for entry into configuration file).

Notes:

- See Application Note 11S for integrating a Surface PAR sensor with the SBE 11*plus* Deck Unit (used with the SBE 9*plus* CTD).
- See Application Note 47 for integrating a Surface PAR sensor with the SBE 33 or 36 Deck Unit (used with the SBE 16, 16*plus*, 16*plus* V2, 19, 19*plus*, 19*plus* V2, 25, or 25*plus* CTD).

Application Note Revision History

Date	Description
	Initial release.
July 2001	Add information about offset term, and clarify units.
October 2004	<ul style="list-style-type: none">• Update with new (2003) Biospherical PAR sensor part numbers.• Expand / rewrite / reorganize.
June 2005	Provide output in microEinsteins/m ² sec, and refer to Application Note 11 General for conversion to other units.
May 2007	Incorporate Seasave V7, and eliminate discussion of Seasoft-DOS.
March 2008	<ul style="list-style-type: none">• Update to include V2 SeaCATs (16<i>plus</i> V2, 16<i>plus</i>-IM V2, 19<i>plus</i> V2).• Remove 'amps' in description of calibration coefficients and units on Biospherical's calibration sheet, because Biospherical changed their calibration sheet.
February 2010	<ul style="list-style-type: none">• Add information on QSP-2350L (same functioning as QSP-2300L, just different connector) and QCP-2300L-HP (same functioning as QCP-2300L, just higher depth range), which are on current price list• Change Seasoft-Win32 to Seasoft V2.• Add information on .xmlcon files.• Update address.
October 2012	Update to include SBE 25 <i>plus</i> .