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, QCP-2350L-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:

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

Make the following entries/selections in the CTD configuration (.con or .xmlcon) file:

M = 1.0 and **B** = 0.0 (Notes 2 and 3)
calibration constant = 10^5 / Cw (Notes 2 and 4)
conversion units = appears in data file header; does not modify calculated values, which are controlled by multiplier entry
multiplier = 1.0 for output units of µEinsteins/m^2·sec (Note 5)
offset = - (10^4 * Cw * 10^V) (Note 6)

Notes:

1. 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. Cw is the *wet* µEinsteins/cm^2·sec coefficient from the Biospherical calibration sheet. A typical value is on the order of
   9.0 x 10^{-6}; values have varied over the years.
5. The multiplier can be used to calculate irradiance in units other than µEinsteins/m^2 sec. See Application Note 11General 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 µEinsteins/m^2·sec light level plot as 100 µEinsteins/m^2·sec.

6. Offset (µEinsteins/m^2·sec) = - (10^4 * Cw * 10^{V}), where V is the *dark voltage*.

   The dark voltage may be obtained from:
   - Biospherical calibration certificate for your sensor (*Average Dark* volts on calibration sheet), or
   - CTD PAR channel with the sensor covered (dark) -- in Seasave V7, display the *voltage output* of the PAR sensor channel.

   Example:
   If Cw = 9.0 x 10^{-6} and Dark Voltage = 0.0021, offset = - (10^4 * 9.0 x 10^{-6} * $10^{0.0021}$) = -0.0904.

   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:
   light (µEinsteins/**cm**^{2}·sec) = Cw * ($10^{\text{Light Signal Voltage}}$ - $10^{\text{Dark Voltage}}$).

2. Seasoft calculates: light (µEinsteins/**m**^{2}·sec) = multiplier * [10^9 * $10^{(V - B) / M}$ / Calibration constant + 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 (**cm**^{2}/ **m**^{2}) * Cw * ($10^{\text{Light Signal Voltage}}$ - $10^{\text{Dark Voltage}}$) = (10^9 * 10^{V}) / Calibration constant + offset

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

   Example:
   If Wet calibration factor = 9.0 x 10^{-6} µEinsteins/cm^2·sec, then C = 1.1111 x 10^{10} (for entry into configuration file).

Notes:
- See Application Note 11S for integrating a Biospherical Surface PAR sensor with the SBE 11*plus* Deck Unit (used with the SBE 9*plus* CTD).

- See Application Note 47 for integrating a Biospherical 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).