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APPLICATION NOTE NO. 11 QSP-PD **Revised February 2010**

Calculating Calibration Coefficients for Biospherical Instruments PAR Light Sensor *without* Built-In Log Amplifier

This application note applies to the following current output Biospherical Instruments PAR light sensors:
- QSP-200(PD) (no longer in production)
- QSP 2200(PD) and QCP 2200(PD) *

*** Note**: Biospherical's 2200 series includes other instruments which are not compatible with Sea-Bird CTDs. Only the 2200(PD) sensors can be integrated with Sea-Bird CTDs.

These PAR sensors are compatible with the following Sea-Bird CTDs:
- SBE 16, 16*plus*, 16*plus*-IM, 19, or 19*plus* CTD configured with an optional log amplifier and PAR sensor connector
  Note: Optional log amplifier and PAR sensor connector are **not** available on **V2** SEACATs (16*plus* V2, 16*plus*-IM V2, and 19*plus* V2)
- SBE 25 CTD configured with a log amplifier and PAR sensor connector (standard on current production SBE 25s, optional on older versions)
- SBE 9*plus*, 16, 16*plus*, 16*plus*-IM, 16*plus* V2, 16*plus*-IM V2, 19, 19*plus*, 19*plus* V2, or 25 CTD interfacing with a PN 90310 Log Amp Module. The Log Amp Module mounts on the CTD or cage, and connects to a single-ended or differential A/D voltage channel on the CTD.

The current output of these sensors is measured through a log amplifier in your CTD (or through the PN 90310 Log Amp Module) to obtain adequate resolution over the measurement range. SEASOFT computes PAR using the following equation:

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

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

M = slope of log amplifier (Note 2)
B = offset of log amplifier (Note 2)
calibration constant $C_S = 6.022 \times 10^{13} / C_W$ (Note 3)
multiplier = 1.0 for output units of µEinsteins/m^2·sec (Note 4)
offset = 0, typically (Note 5)

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 C_C needed for entry in Sea-Bird software (saving the user from doing the math).
3. For calculation of C_W and C_S, see Mathematical Derivation below.
4. 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.
5. Offset may be used to *offset* the data by a constant, if field data indicates sensor drift. To calculate the offset: Enter M, B, calibration constant, and multiplier, and set offset = 0 in the configuration (.con or .xmlcon) file. With the sensor dark (covered), display the *calculated PAR output* in Seasave V7; then enter the negative of this reading as the offset in the configuration file.

Mathematical Derivation

C_W = Biospherical wet calibration factor from Biospherical calibration sheet [(quanta/cm^2·sec) / nAmp]
Output in water from Biospherical calibration sheet (quanta/cm^2·sec) = C_W * probe output (nAmp)
Output in water (quanta/cm^2·sec) = $C_W * 10^9$ * probe output (Amp)
I = probe output (Amp)
Output in water (quanta/cm^2·sec) = $C_W * 10^9 * I$
Output in water (quanta/m^2·sec) = $C_W * 10^9 * I * 10^4 = C_W * 10^{13} * I$
Output in water (µEinsteins/ m^2·sec) = $C_W * 10^{13} * I / 6.022 \times 10^{17}$
(see Application Note 11General for conversion from quanta to µEinsteins)

SEASOFT calculates: Light (µEinsteins/ m^2·sec) = $I \times 10^9 / C_S$
where C_S = calibration constant

Equating the Biospherical and SEASOFT relationships:
$C_W * 10^{13} * I / 6.022 \times 10^{17} = I \times 10^9 / C_S$
$C_W / 6.022 \times 10^{13} = 1 / C_S$
$C_S = 6.022 \times 10^{13} / C_W$

Example:

C_W = Biospherical wet calibration factor from Biospherical calibration sheet = 4.77×10^{14} (quanta/cm^2·sec) / nAmp
Calibration constant $C_S = 6.022 \times 10^{13} / C_W = 6.022 \times 10^{13} / 4.77 \times 10^{14} = 0.126$ (for entry into .con or .xmlcon 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 an SBE 33 or SBE 36 Deck Unit (used with the SBE 16, 16*plus*, 16*plus* V2, 19, 19*plus*, 19*plus* V2, or 25 CTD).