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APPLICATION NOTE NO. 11 Chelsea — Revised February 2010

Calculating Calibration Coefficients for Chelsea PAR Light Sensor with Built-In Log Amplifier

This application note applies to the Chelsea PAR Light sensor, which has a built-in log amplifier This PAR sensor is compatible with the following Sea-Bird CTDs:

- SBE 9*plus*
- SBE 16 or 19 – This PAR sensor 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 this PAR sensor. The PAR sensor interfaces with an A/D voltage channel on the CTD.
- SBE 16*plus* V2, 16*plus*-IM V2, or 19*plus* V2 –The PAR sensor interfaces with an A/D voltage channel on the CTD.
- SBE 25 – CTD's PAR connector (standard on current production SBE 25s, optional on older versions) not used with this PAR sensor. 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:

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

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

M = $1.0 / (\log_{10} e * A1 * 1000) = 1.0 / (0.43429448 * A1 * 1000)$ (Note 2)
B = $- M * \log_{10} e * A0 = - A0 / (A1 * 1000)$ (Note 2)
calibration constant = $10^9 / 0.046 = 2.174 \times 10^{10}$
multiplier = 1.0 for output units of µEinsteins/m^2•sec (Note 3)
offset = (Note 4)

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). Select Par/Irradiance, Biospherical/Licor as the auxiliary voltage sensor; the algorithm applies to the Chelsea PAR sensor as well.
2. A0 and A1 are constants from the Chelsea calibration sheet with an equation of form:
   PAR (ln µWatts/cm^2) = A0 + (A1 * mV)
3. 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.
4. Offset: To determine the offset, enter M, B, Calibration constant, and Multiplier, and set Offset to 0.0 in the configuration (.con or .xmlcon) file. In Seasave V7, display the *calculated PAR output* with the sensor covered (dark); then enter the negative of this reading as the offset in the configuration (.con or .xmlcon) file.

Mathematical Derivation

1. Chelsea computes: PAR = $K * e^{(A0 + A1 * 1000 * V)}$ (V=sensor output in volts)

2. SEASOFT computes: PAR = [multiplier * $10^9 * 10^{(V - B) / M}$ / Calibration constant] + offset (V=sensor output in volts)

3. To determine Calibration constant, let multiplier = 1.0 and offset = 0, and set equations 1 and 2 equal to each other.

   $K * e^{(A0 + A1 * 1000 * V)} = 10^9 * 10^{(V - B) / M}$ / Calibration constant

   If $e^{(A0 + A1 * 1000 * V)} = 10^{(V - B) / M}$, then K = 10^9 / Calibration constant → Calibration constant = 10^9 / K

   where K = 0.046 for PAR units of μEinsteins/m^2·sec

4. If $e^x = 10^y$ → $\log_{10} e^x = y$ and $x \log_{10} e = y$.

   Let x = A0 + A 1 * 1000 * V and y = (V - B) / M

   Let W = $\log_{10} e$ = 0.43429448 → (A0 + A 1 * 1000 * V) W = (V - B) / M
   → W * A0 + W * A1 * 1000 * V = (V / M) – (B / M) → (W * A0) + (W * A1 * 1000 * V) = – (B / M) + (V / M)

   Equating like terms:
   (W * A1 * 1000 * V) = (V / M) → M = 1.0 / (W * A1 * 1000)
   (W * A0) = – (B / M) → B = - M * W * A0 = - A0 / (A1 * 1000)