

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 9plus
- SBE 16 or 19 – This PAR sensor may not be compatible with 6-cell housing version of these CTDs; consult Sea-Bird.
- SBE 16plus, 16plus-IM, or 19plus – 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 16plus V2, 16plus-IM V2, 19plus V2, or 25plus – The PAR sensor interfaces with an A/D voltage channel on the CTD.
- SBE 25 – CTD's PAR connector (optional on some 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:

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

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

$$M = 1.0 / (\log_{10} e * A1 * 1000) = 1.0 / (0.43429448 * A1 * 1000) \quad (\text{Note 2})$$

$$B = -M * \log_{10} e * A0 = -A0 / (A1 * 1000) \quad (\text{Note 2})$$

$$\text{calibration constant} = 10^9 / 0.046 = 2.174 \times 10^{10}$$

conversion units = appears in data file header; does not modify calculated values, which are controlled by Multiplier entry

$$\text{multiplier} = 1.0 \text{ for output units of } \mu\text{Einsteins/m}^2 \cdot \text{sec} \quad (\text{Note 3})$$

$$\text{offset} = \quad (\text{Note 4})$$

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). 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:

$$\text{PAR} (\ln \mu\text{Watts/cm}^2) = A0 + (A1 * \text{mV})$$
3. The multiplier can be used to calculate irradiance in units other than $\mu\text{Einsteins/m}^2 \cdot \text{sec}$. 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 $\mu\text{Einsteins/m}^2 \cdot \text{sec}$ light level plot as 100 $\mu\text{Einsteins/m}^2 \cdot \text{sec}$.
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.

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

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

where $K = 0.046$ for PAR units of $\mu\text{Einsteins}/\text{m}^2 \cdot \text{sec}$

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

$$\text{Let } x = A0 + A1 * 1000 * V \quad \text{and} \quad y = (V - B) / M$$

$$\text{Let } W = \log_{10} e = 0.43429448 \rightarrow (A0 + A1 * 1000 * V) W = (V - B) / M$$

$$\rightarrow W * A0 + W * A1 * 1000 * V = (V / M) - (B / M) \rightarrow (W * A0) + (W * A1 * 1000 * V) = - (B / M) + (V / M)$$

Equating like terms:

$$(W * A1 * 1000 * V) = (V / M) \rightarrow M = 1.0 / (W * A1 * 1000)$$

$$(W * A0) = - (B / M) \rightarrow B = - M * W * A0 = - A0 / (A1 * 1000)$$