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APPLICATION NOTE NO. 11 General

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PAR Light Sensors

Sea-Bird has several application notes dealing with PAR sensors from various manufacturers; this application note provides an overview of PAR measurements and units, and is applicable to all PAR sensors.

PAR is an abbreviation for **Photosynthetically Available Radiation** (also called **Photosynthetically Active Radiation**). Solar radiation reaching Earth's surface is a mixture of ultraviolet light, visible light, and near-visible infrared radiation. All of this radiation conveys heat; the portion between approximately 400 and 700 nm wavelength can be captured and used by photo-autotrophs (organisms capable of obtaining energy directly from sunlight), and is called PAR.

Irradiance is the flux of solar radiation incident on a surface per unit time per unit area and is reported in units of energy content (Watts/m²) or photon content (quanta/m² sec or μ Einsteins/m² sec). Conversion from energy to photon content can be made with Planck's equation, provided that the light wavelength is known. The energy of a photon is related to its wavelength as follows:

$$E = hc / \lambda$$

where

h = Planck's constant (6.626×10^{-34} Joules sec)

c = speed of light (2.998×10^8 m/sec)

λ = wavelength (m)

This equation provides the energy for a single wavelength. For a broad spectrum PAR sensor, a wavelength of approximately 550 nm (550×10^{-9} m) is typically used for the conversion.

"For marine atmospheres with sun altitudes above 22 degrees, the quanta/watt ratio for the region 400 to 700 nm is 2.77×10^{18} quanta/sec/Watt to an accuracy of plus or minus a few percent." This quote and further discussion of the relationship of quanta to Watts in the water column is found in Smith and Morel (1974) Limnol. Oceanogr. 19(4):591-600.

E (at 550 nm) = hc / λ = (6.626×10^{-34} Joules sec) * (2.998×10^8 m/sec) / (550×10^{-9} m) = 3.61×10^{-19} Joules
(Note: $1 / 3.61 \times 10^{-19} = 2.77 \times 10^{18}$ quanta/sec/Watt, the value quoted in the above reference.)

Application notes for underwater PAR sensors (**11Chelsea**, **11Licor**, **11QSP-L**, and **11QSP-PD**) and surface PAR sensors (**11S** and **47**) describe how to enter coefficients from the manufacturer's calibration in the CTD configuration (.con or .xmlcon) file to provide SEASOFT output in μ Einsteins/m²·sec. To calculate irradiance in other units:

To convert to:	For Underwater PAR Sensors, set Multiplier to:	For Surface PAR Sensors, multiply calculated Conversion factor by:
μ Einsteins/m ² ·sec	1.0	
μ Einsteins/cm ² ·sec	$(1.0) / (100 \text{ cm/m})^2 = 1 \times 10^{-4}$	
Einsteins/m ² ·sec	$(1.0) / (1 \times 10^6 \mu\text{Einsteins/Einstein}) = 1 \times 10^{-6}$	
Einsteins/cm ² ·sec	$(1 \times 10^{-6}) / (100 \text{ cm/m})^2 = 1 \times 10^{-10}$	
quanta/m ² ·sec	$(1 \times 10^{-6}) * (6.022 \times 10^{23} \text{ quanta/Einstein}) = 6.022 \times 10^{17}$	
quanta/cm ² ·sec	$(6.022 \times 10^{17}) / (100 \text{ cm/m})^2 = 6.022 \times 10^{13}$	
Watts/m ²	$(6.022 \times 10^{17}) / (2.77 \times 10^{18} \text{ quanta/sec/Watt}) = 0.2174$	
Watts/cm ²	$(0.2174) / (100 \text{ cm/m})^2 = 2.174 \times 10^{-5}$	
μ Watts/m ²	$(0.2174) * (1 \times 10^6 \mu\text{Watts/Watt}) = 2.174 \times 10^5$	

Note: 1 Einstein = 1 mole (6.022×10^{23}) of photons

1 Watt = 2.77×10^{18} quanta/sec

Notes:

- 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).
- Multiplier can also be used to scale output for comparing the shape of data sets taken at disparate light levels. For example, a multiplier of 10 would make a 10 μ Einsteins/m²·sec light level plot as 100 μ Einsteins/m²·sec.

Application Note Revision History

Date	Description
-	Initial release.
May 2007	<ul style="list-style-type: none">• Incorporate Seasave V7.• Eliminate discussion of DOS software.
February 2010	<ul style="list-style-type: none">• Change Seasoft-Win32 to Seasoft V2.• Add information on .xmlcon configuration file.• Update address.
February 2011	Correct units for $h = \text{Planck's constant}$ (6.626×10^{-34} Joules/sec corrected to Joules sec)