



***PAR Sensor
Operation Manual***

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Revision History

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1 Introduction

1.1 Purpose of this Manual

Photosynthetically Active Radiation (PAR, 400-700 nm) is an important parameter used in energy balance models, ecosystem characterization, and productivity analyses for agronomic, oceanic, and climnological studies. In addition, measurements of PAR are routinely used in laboratory studies focusing on plant physiology and photosynthesis.

Phytoplankton and higher plants use electromagnetic energy in the PAR region for photosynthesis. The radiation in this range, usually measured as Photosynthetic Photon Flux Density (PPFD), has units of quanta (photons) per unit time per unit surface area. The units most commonly used are micromoles of quanta per square meter per second ($\mu\text{mol photons}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$).

1.2 Definitions, Acronyms and Abbreviations

PAR Photosynthetically Active Radiation
PPFD Photosynthetic Photon Flux Density

1.3 Referenced Documents

- RD1. Satlantic Instrument File Standard, Satlantic Inc., SAT-DN-00134, Version 6.0, 2000-05-23
- RD2. Satlantic Log File Standard, Satlantic Inc., SAT-DN-00135, Version 1.0, 2000-05-23
- RD3. SatView User Guide, Satlantic Inc., Version 2.8, 2004-12-21

2 Description of PAR Sensor

The Satlantic PAR sensor comes in four configurations. Your particular configuration must be specified at the time of purchase. The four PAR sensor configurations are:

- 1.) Deep water linear PAR sensor (PAR-LIN-d) – This PAR sensor has a linear output and stainless steel housing suitable for use at depths of up to 7000m
- 2.) Shallow water linear PAR sensor (PAR-LIN-s) – This PAR sensor has a linear output and Acetal housing suitable for use at depths of up to 600m
- 3.) Deep water logarithmic PAR sensor (PAR-LOG-d) – This PAR sensor has a logarithmic output and stainless steel housing suitable for use at depths of up to 7000m
- 4.) Shallow water logarithmic PAR sensor (PAR-LOG-s) – This PAR sensor has a logarithmic output and Acetal housing suitable for use at depths of up to 600m

2.1 Specifications

Standard Configuration	PAR-LIN-d	PAR-LIN-s	PAR-LOG-d	PAR-LOG-s
Electrical				
Input Voltage	6-30 VDC			
Input Current @ 12 V	6 mA		6 mA	
Output Voltage	0-5 VDC			
Max Output Current	30 mA @ 12 VDC		6 mA @ 12 VDC	
Physical				
Operating Temperature	-40°C - 85°C			
Dimensions				
Length	88.8 mm (3.25 in)	76.2 mm (3 in)	88.9 mm (3.25 in)	76.2 mm (3 in)
Diameter	38.1 mm (1.5 in)	30.5 mm (1.2 in)	38.1 mm (1.5 in)	30.5 mm (1.2 in)
Construction	Stainless Steel	Acetal	Stainless Steel	Acetal
Weight	618 g (1.36 lb)	102 g (0.22 lb)	618 g (1.36 lb)	102 g (0.22 lb)
Depth Rating	7000 m	600 m	7000 m	600 m
Optical				
Field of view	cosine response (spectrally corrected)			
Collector area	86.0 mm ²			
Detectors	custom 17 mm ² silicon photodiode			
Cosine response	Within 3% 0°– 60° / within 10% 60°– 85°			
Range	0 - 5500 μmol photons•m ⁻² •s ⁻¹		0-6500 μmol photons•m ⁻² •s ⁻¹	

Table 1 - Instrument Connector Pinout Description

Pin	Signal	Description
1	GND	Power Supply Return / Signal Ground
2	Analog out	Analog out signal (0 to 5 volts)
3	AGND	Analog ground (Note: Analog ground and power supply ground are internally connected)
4	Vin+	DC Power Supply (6 to 30 Volts)

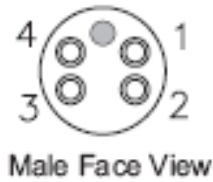


Figure 1 - Instrument Connector Pinout

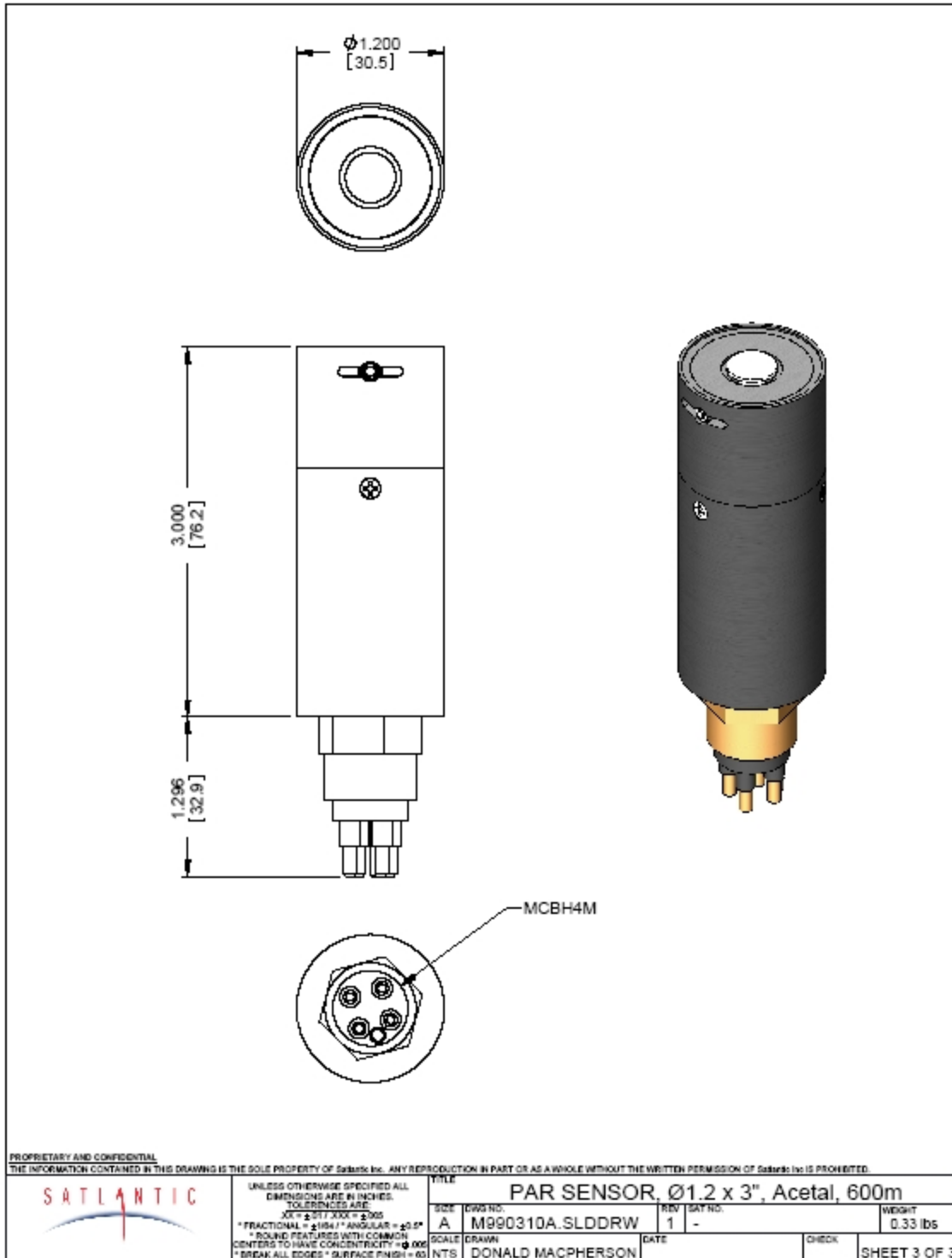


Figure 2 - Physical Dimensions of the Shallow Water PAR Sensor

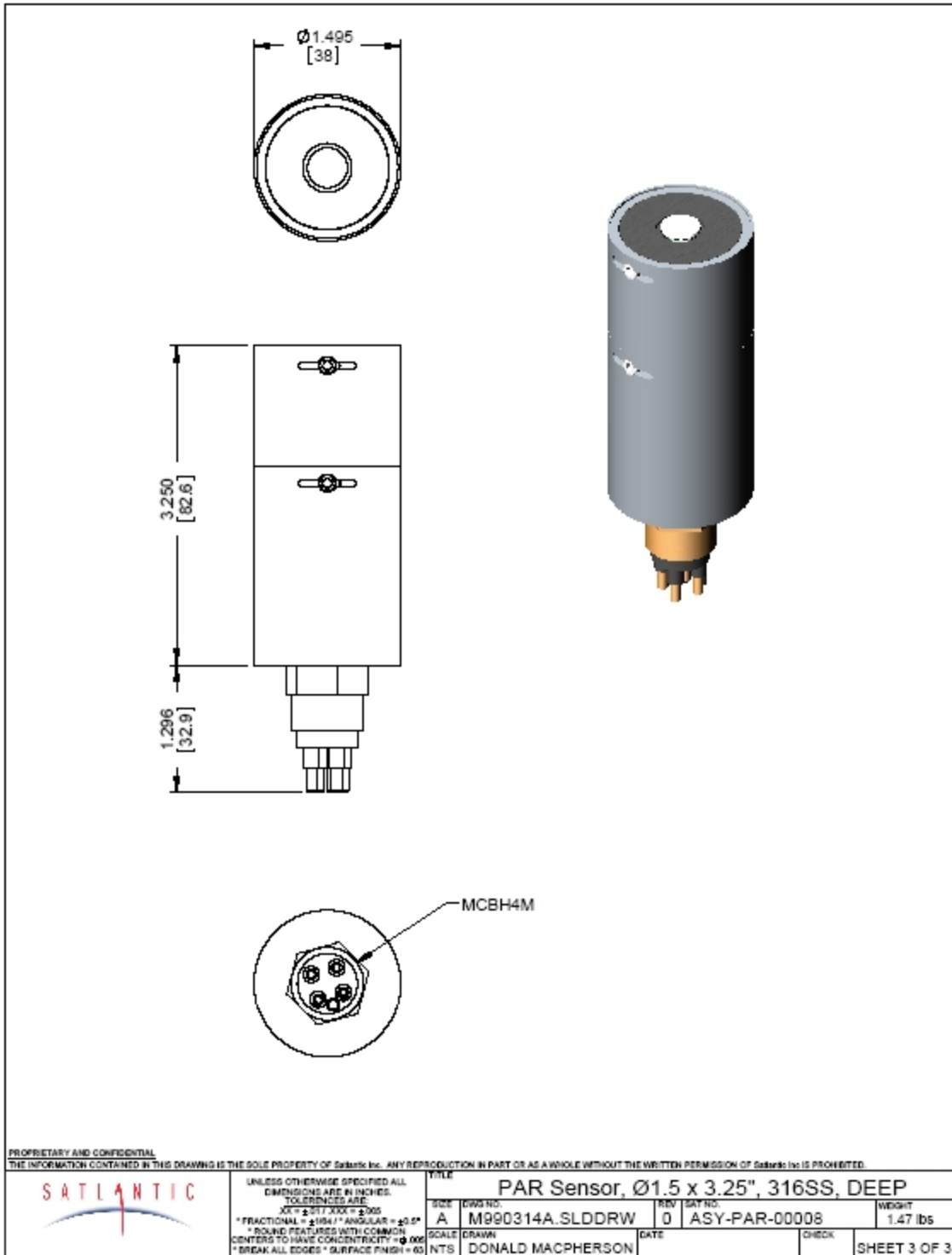


Figure 3 - Physical Dimensions of the Shallow Water PAR Sensor

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3 Safety

Satlantic equipment should be operated and maintained with extreme care only by personnel trained and knowledgeable in the use of oceanographic electronic equipment.

3.1 Personal Safety

3.1.1 Flooded Instrument

Use EXTREME CAUTION handling any instrument suspected of being flooded. If the instrument leaked at depth it might be pressurized when recovered. Indications of a flooded instrument include short circuits between connectors or an extended gap between the end cap and housing. If an instrument is suspected of being flooded, disconnect its power source, place it in a safe location and contact Satlantic for further instructions.

If the instrument cannot be safely stored away, the following steps may be taken to release the pressure to render the instrument safe. **PROCEED AT YOUR OWN RISK.** To depressurize the PAR Sensor, slowly unscrew the instrument bulkhead just enough to break the seal with the end cap, allowing trapped water to escape around the connector threads. Attempt to drain the instrument completely. Depressurized and drained, the PAR Sensor is safe for normal storage.

3.1.2 Electricity

Use care when handling, connecting and operating power supplies and batteries. A shorted power supply or battery can output high current, harming the operator and damaging equipment.

While trouble-shooting with a multi-meter, take care not to short the probes. Shorts can damage equipment, create safety hazards, and blow internal fuses.

3.2 Equipment Safety

3.2.1 Instruments

Do not leave instruments in direct sunlight when not in use. Direct sunlight can easily increase the internal temperature of the instrument beyond its rating.

Employ measures to protect instruments and cables from being fouled or overrun by the vessel.

3.2.2 Connections

Handle electrical terminations carefully. They are not designed to withstand strain. Disconnect the cables from the components by pulling on the connector heads and not the cables or molded splices. Twisting or wiggling the connector while pulling will damage the connector pins.

3.2.3 Recovery

Do not haul instruments in by their electrical cables, unless they are reinforced with mechanical strength members for the purpose. Hauling on electrical cables can cause damage to the instrument port connectors, cables, and splices.

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4 Operating the PAR Sensor

Satlantic's linear PAR sensor and Logarithmic PAR sensor are both analog output sensors with a 0-5Vdc range. Sections 4.1 and 4.2 below describe the calibration coefficients and how to compute PAR based on a measured analog voltage

4.1 Linear PAR Sensor Data Analysis

The linear output PAR Sensor uses a linear fitting function to convert between output voltage and PAR. The relationship between PAR and voltage is described by:

$$PAR = Im \bullet a_1 (x - a_0)$$

where Im is the immersion coefficient, a_1 is the scaling factor, a_0 is the voltage offset, and x is the voltage. This information can be found on your calibration sheet. This equation calculates PAR in units of $\mu\text{mol photons}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$.

For more information on this fitting function please refer to the Satlantic Instrument File Standard document (RD1).

4.2 Logarithmic PAR Sensor Data Analysis

The PAR Sensor with a logarithmic output uses a logarithmic fitting function to convert between output voltage and PAR. The relationship between PAR and voltage is described by:

$$PAR = Im * 10^{\frac{x-a_0}{a_1}}$$

where a_1 is the scaling factor, a_0 is the voltage offset (typically '0'), and x is the voltage. This information can be found on your calibration sheet. This equation calculates PAR in units of $\mu\text{mol photons}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$.

The calibration sheet also shows the calibration coefficients for integrating the Logarithmic PAR sensor into a Sea-Bird Electronics data logger. See Appendix A - Derivation of the calibration coefficients for a Sea-Bird Electronics data logger.

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5 Maintenance

5.1 Preventive Maintenance

The PAR Sensor requires virtually no maintenance. Protecting it from impacts, rinsing it with fresh water after each use, and properly storing it with the dummy connector in place will prolong the life of the PAR Sensor. External power sources should always be removed during storage.

The electrical connector and cable are the most vulnerable components of the PAR-Sensor. Subconn provides the following guidance for handling connectors:

- Lubricate connector sparingly with silicone grease, such as Dow Corning Molykote 44. (Satlantic recommends Dow Corning DC-4 electrical insulating compound, a lubricant designed for electrical connectors, and DC-111 valve lubricant and sealant.)
- Do not use petroleum based lubricants.
- Any accumulation of sand or mud in the female contact should be removed with fresh water to prevent splaying of the contact and damage to the o-ring seals.
- Do not over tighten bulkhead nuts.
- When disconnecting, pull straight, not at an angle or by moving side to side.
- Do not disconnect by pulling on the cable.
- Avoid sharp bends at cable entry.
- Ensure there are no angular loads on connectors.

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6 Warranty

Warranty Period

All Satlantic equipment is covered under a one-year parts and labor warranty from date of purchase.

Restrictions

Warranty does not apply to products that are deemed by Satlantic to be damaged by misuse, abuse, accident or modifications by the customer. The warranty is considered void if any optical or mechanical housing is opened. In addition, the warranty is void if the warranty seal is removed, broken or otherwise damaged.

Provisions

During the one year from date of purchase warranty period, Satlantic will replace or repair, as deemed necessary, components that are defective, except as noted above, without charge to the customer. This warranty does not include shipping charges to and from Satlantic.

Returns

To return products to Satlantic, whether under warranty or not, contact the Satlantic Customer Support Department and request a Returned Material Authorization (RMA) number and provide shipping details. All claims under warranty must be made promptly after occurrence of circumstances giving rise thereto and must be received by Satlantic within the applicable warranty period. Such claims should state clearly the product serial number, date of purchase (and proof thereof) and a full description of the circumstances giving rise to the claim. All replacement parts and/or products covered under the warranty period become the property of Satlantic Inc.

Liability

IF SATLANTIC EQUIPMENT SHOULD BE DEFECTIVE OR FAIL TO BE IN GOOD WORKING ORDER THE CUSTOMER'S SOLE REMEDY SHALL BE REPAIR OR REPLACEMENT AS STATED ABOVE. IN NO EVENT WILL SATLANTIC INC. BE LIABLE FOR ANY DAMAGES, INCLUDING LOSS OF PROFITS, LOSS OF SAVINGS OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING FROM THE USE OR INABILITY TO USE THE EQUIPMENT OR COMPONENTS THEREOF.

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7 Contact Information

If you have any problems, questions, suggestions or comments about the equipment or manuals, please contact us.

Location

Satlantic Inc.
 Richmond Terminal, Pier 9
 3481 North Marginal Road
 Halifax, Nova Scotia
 B3K 5X8 Canada

Tel: (902) 492-4780
 Fax: (902) 492-4781

Email: support@satlantic.com
 Web: <http://www.satlantic.com>

Business Hours

Satlantic is normally open for business between the hours of 9 AM and 5 PM Atlantic Time. Atlantic Time is one hour ahead of Eastern Time. Daylight saving time is in effect from 2:00 a.m. on the second Sunday in March through 2:00 a.m. on the first Sunday in November. Atlantic Standard Time (AST) is UTC-4. Atlantic Daylight Saving Time (ADT) is UTC-3.

Satlantic is not open for business during the following holidays:

New Year's Day	1 January
Good Friday	Friday before Easter Sunday (Easter Sunday is the first Sunday after the full moon on or following March 21st, or one week later if the full moon falls on Sunday)
Victoria Day	First Monday before 25 May
Canada Day	1 July
Halifax Natal Day	First Monday in August
Labour Day	First Monday in September
Thanksgiving Day	Second Monday in October
Remembrance Day	11 November
Christmas Day	25 December
Boxing Day	26 December

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Appendix A - Derivation of the calibration coefficients for a Sea-Bird Electronics data logger.

The following is a derivation for taking Satlantic's Logarithmic calibration coefficients and using them in a Sea-Bird Electronics data logger. Please see Sea-Bird Electronics application note: APPLICATION NOTE NO. 11 QSP-L for more information.

Satlantic's equation for calculating PAR is:

$$PAR = Im * 10^{\frac{x-a_0}{a_1}} \quad .1$$

where a_1 is the scaling factor, a_0 is the voltage offset (typically '0'), and x is the voltage. Sea-Bird Electronics Sea Soft program uses the following equation to calculate PAR:

$$PAR = \frac{multiplier * 10^9 * 10^{\frac{V-B}{M}}}{Calibration_const.} + offset \quad .2$$

where $multiplier = 1$ (from their technical note), $B = 0$ (From their technical note). For the Satlantic Logarithmic sensor the offset is also set to zero. This makes equation 2 equivalent to:

$$PAR = \frac{10^9 * 10^{\frac{V}{M}}}{Calibration_const.} \quad .3$$

To make equation 3 equivalent to equation 1 (Satlantic's equation) then:

$$M = a_1$$

$$Calibration_const = \frac{10^9 * 10^{\frac{a_0}{a_1}}}{Im}$$

and from equation 2:

$$multiplier = 1$$

$$B = 0$$

$$offset = 0$$