SEA·BIRD SCIENTIFIC

User manual

PAR

Photosynthetically Active Radiation sensor

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Section 1 Overview

Photosynthetically Active Radiation is the spectral range of solar radiation from 400–700 nm. Phytoplankton and higher plants use the electromagnetic energy in this range for photosynthesis. PAR is usually measured as Photosynthetic Photon Flux Density (PPFD), which has units of quanta per unit time per unit surface area. The most common unit is micromoles of quanta per square meter per second (µmol photons/m^2/s).

PAR is used in energy balance models, ecosystem characterization, and productivity analyses for agronomic, oceanic, and limnological studies. PAR measurements are also used in studies of plant physiology and photosynthesis.

PAR sensors measure quantum irradiance with near flat spectral response and cosine spatial response. The manufacturer makes Irradiance Cosine in Water (ICSW) models or Irradiance Cosine in Air (ICSA) models.

Data output options:

- Serial + analog output for depths of either 1000 or 7000 m
- Analog only, for 1000 or 7000 m
- AUV with serial only-output for 1000 m, for use in Slocum Gliders

1.1 Safety information

⚠ WARNING

If the user thinks that a sensor has water in the pressure housing: Disconnect the sensor from any power supply. Put on safety glasses and make sure that the sensor is pointed away from the body. Use the purge port (if the sensor is so equipped), or very SLOWLY loosen the bulkhead connector to allow the pressure to escape.

⚠ CAUTION

Do not leave the sensor in direct sun. Heat over 35 °C can cause damage to the sensor.

⚠ CAUTION

Do not use WD-40® or petroleum-based lubricants on bulkhead connectors. It will cause damage to the rubber.
Damaged connectors can cause a loss of data and additional costs for service.

Damaged connectors can cause damage to the sensor and make it unserviceable.

⚠ CAUTION

Do not use acetone or other solvents to clean any part of the sensor.

NOTICE

Protect electrical connectors: Push straight on to install and pull straight out to remove. Do not twist the connectors. This can harm the contacts and connectors.

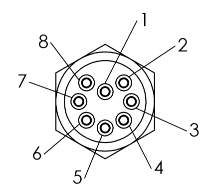
Section 2 Specifications

2.1 Mechanical

	PAR 1000 m	PAR 7000 m	PAR-AUV 1000 m
Length	8.9 cm		7.6 cm
Diameter	2.5 cm		3.2 cm
Weight in air, water	0.09 kg, 0.04 kg	0.18 kg, 0.13 kg	0.052 kg, 0.047 kg
Depth rating	1000 m	7000 m	1000 m
Temperature range	-4–40 °C		
Material	Plastic	Titanium	Plastic

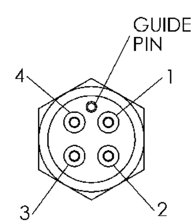
2.1.1 Serial sensor bulkhead connector

Table 1 Serial sensor connector functions

Contact	Function	Description	Connector
1	Voltage in	Voltage Direct Current, 6–28 VDC	MCBH-8-MP 
2	Ground	Ground	
3	No connect	No connect	
4	No connect	No connect	
5	RS232 TX	RS232 transmit	
6	RS232 RX	RS232 receive	
7	Voltage out	0.125–4.00 VDC	
8	No connect	No connect	

2.1.2 Analog-only sensor bulkhead connector

Table 2 Analog-only connector functions

Contact	Function	Description	Connector
1	Ground	Ground	
2	Analog in	Analog in	
3	Analog ground	Analog ground	
4	Voltage in	Voltage Direct Current, 6–28 VDC	

2.1.3 Serial-only sensor bulkhead connectors

Table 3 AUV connector functions

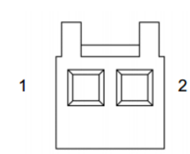
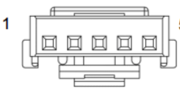
Contact	Function	Wire color	Description	Connector
1	Ground	Black	Ground	Molex 22-01-3027 
2	Voltage in	Red	Voltage Direct Current, 6–28 VDC	

Table 3 AUV connector functions (continued)

Contact	Function	Wire color	Description	Connector
1	Ground	Black	Ground	Molex 35507-0500 
2	RS232 RX	Blue	RS232 receive	
3	RS232 TX	Green	RS232 transmit	
4	—	—	No connect	
5	—	—	No connect	

2.2 Electrical

Input	6–28 VDC
Current draw, typical	17 mA
Communications	PAR Ser: RS232 and analog PAR AUV: RS232 only PAR: analog only; user-configurable to linear or logarithmic output
Output voltage	0.125–4.00 VDC
Data rate	57600 baud

2.3 Optical

Spectrum	400–700 nm
Range, typical	0–5000 µmol photons/m²/s
Spatial	Spectrally corrected cosine response
Cosine error	within 3% @ 0–60 °C • within 10% @ 60–85 ºC
Collector area	86 mm²
Detector	Custom 17 mm² silicon photodiode

2.4 Calibration values

Sensor-specific calibration values are shown on the calibration page that ships with each sensor.

2.4.1 Serial PAR

PAR sensors with serial RS232 output can also operate in an analog mode with output that is either linear or logarithmic. The analog output from these sensors does not correlate with the analog output from an analog-only PAR sensor.

Serial output

Calculation is for the standard range of 0–5000 µmol photons/m^2/s.

PAR = Im × a_1(counts - a_0), *where*:

Im is the immersion coefficient

a_1 is the scale factor

a_0 is the offset

x is counts

Analog output

Linear output calculation

Calculation is for the standard range of 0–5000 µmol photons/m^2/s.

PAR = m × voltage + b, *where*:

m = slope, with a standard coefficient of 1291.593195

b = offset, with a standard coefficient of -166.45163

Note that these values will change if the range is changed. Refer to In-system analog calibration *on page 17 for details.*

Logarithmic output calculation

Calculation is for the standard range of 0.1–5000 µmol photons/m^2/s.

PAR = $10^{(\text{voltage - q}) \div \text{p}}$ *where*:

p = a standard coefficient of 0.824661

q = a standard coefficient of 0.949663

2.4.2 Analog-only PAR

Analog PAR sensors are user-configurable to either linear or logarithmic mode. They have no serial output, and the analog output from these sensors does not correlate with the analog output from a serial PAR.

Table 4 Linear analog output

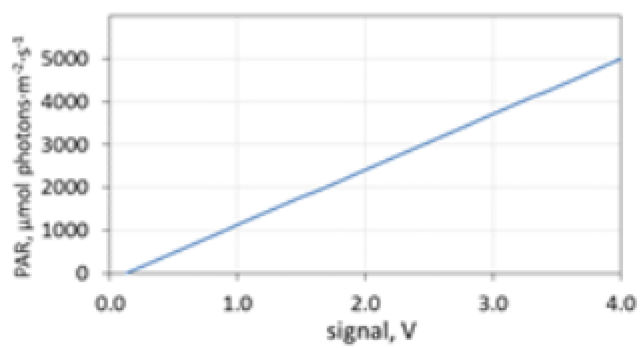
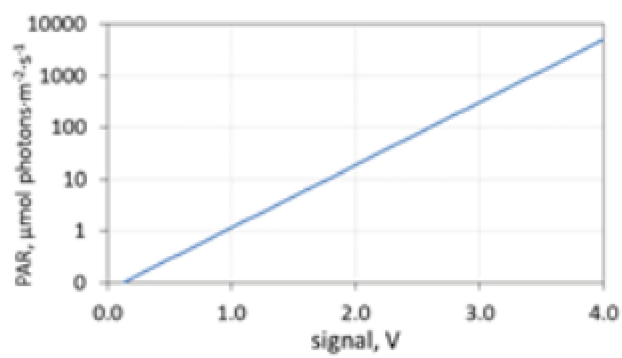
PAR = Im × a_1 × (volts - a_0), *where*: Im is the immersion coefficient a_1 is the scale factor a_0 is the offset	

Table 5 Logarithmic analog output

PAR = Im × $10^{(\text{volts} - a_0)}$ ÷ a_1 Im is the immersion coefficient a_1 is the scale factor a_0 is the offset	

Section 3 Operation

Use the SatView software to look at data and save it to the connected PC. Data is in binary format and needs to be converted with SatCon software. Use a terminal program such as Tera Term, HyperTerminal®, or Putty to see and to change any settings. It is also possible to save data on the PC through the terminal program. Data is in ASCII and does not need to be converted. Refer to Configuration commands for descriptions of the terminal commands.

3.1 Verify functionality

Make sure that the sensor operates correctly before further setup and deployment.

1. Install the software on the PC. The software is available from the CD that ships with the sensor or from the manufacturer's web site.
2. Connect the manufacturer-supplied test cable to the bulkhead connector on the sensor and to the PC.
3. Start the software.
4. Supply power to the sensor.
5. Move ("drag") the .sip or .tdf file to the main window of the software from the supplied CD or from PC if it has been copied there.
6. In the new window that shows, enter configurations for the sensor:
   a. Enter a name for the sensor at "Instrument Package Name".
   b. Put a check in the box next to "Auto Read From:" and select the applicable COM port.
   c. Select the "Baud Rate." The default is 57600.
   d. Push **OK**.
   A green border shows around the sensor icon in the software. The sensor collects data.
7. Select (highlight) the sensor with the green border, then right-click and select *Control Panel*. The "Frames Read" value increments.
8. Double-click on any or all of the views in the "View List" area. Move each window as desired to see real-time data.
9. Right-click on the sensor name in the software window, then select *Properties*, then select OPTICS. Put a check in the box next to "Immersed (Wet)" if the sensor is in water. Push **OK**.
10. Go to the **Log** menu, then *Options*.
    a. In the "File Naming Mode" select AUTO CAST. The software automatically names data files with AA, AB, AC, etc.
    b. Select the ... at "Log Directory" to find or make a folder for saved data.
    c. Put a check in "Log Duration" and select the amount of time for the PC to save data.
    d. Push **OK**.
11. Push **Start Logging** in the main window.
    The "Ready" and "Active" status indicators are green and the "Log Time" counter increases. Note that the data is saved in binary format. Use the manufacturer's SatCon software to convert and process this data.
12. To save the settings from the session, select the **File** menu, then *Save As...* and find or make a file name and location.
    The software saves the settings from this session so it is not necessary to go through the setup steps again. The software will start when the user double-clicks the saved *xxx*.sat file.
13. Turn off the power supply to stop the sensor.

3.2 Verify or change sensor settings

Use a terminal program such as Tera Term to look at and, if necessary, change the settings in the sensor prior to a deployment. The manufacturer has set up the sensor with default values listed in Configuration commands on page 11.

1. Make sure that the sensor is connected to the PC that has the terminal program installed.
2. Start the terminal program.
3. Select "Serial" then push **OK**.
4. Select **Setup**, then *Serial Port*.
5. Change the "Baud rate" to 57600. Other settings do not need to be changed:
   - Data: 8 bit
   - Parity: none
   - Stop: 1 bit
   - Flow control: none
6. Push **OK**.
7. Supply power to the sensor.
   Data shows in the terminal window.
8. To stop the data collection, enter the **$** character. It may be necessary to enter this character several times to stop the sensor.
   The **PAR>** prompt shows. The sensor is ready to accept commands.

```
SATPRS1005,2.964,-0.001,-74.3,-15.7,21.5,127
SATPRS1005,6.964,-0.000,-74.2,-15.7,21.5,125

PAR Command Console.
Serial - 1005
Firmware - R2.2.0 (Variant: Default, Build: Oct 14 2014-14:58:05)
Clock: 10.580 seconds
Type 'help' for a list of available commands.

PAR>help
```

9. Type **help --set** to see the available settings and ranges.

```
PAR>help --set

Setting      Description                                   Valid values

--baudrate   Telemetry baudrate                            9600,19200,38400,57600,115200
--navg       Sample average size                           1-50
--outfrtyp   Telemetered frame type                        NONE, SHORT_ASCII, FULL_ASCII, BINARY, CAL
--caldata    calibration coefficients                      format: [a0,a1,im]
--immersed   apply immersion coefficient switch            true(apply)|false(do not apply)
--smplint    ADC sampling interval (milliseconds)          10 - 60000
--msgtotlm   Replicate message log in telemetry            true/false
--msglevel   Message log verbosity                         ERROR,WARN,INFO,DEBUG
--range      voltage output range (uMol photons*m^-2*s^-1) 100-10000
--votype     voltage output type                           NONE|LINEAR|LOG
--poffset    pitch offset                                  -5.0 to +5.0 degrees
--roffset    pitch offset                                  -5.0 to +5.0 degrees
$Ok
PAR>
```

10. The settings stored in the sensor by the manufacturer should not need to be changed. To see the value of a specific setting:
    For example, type **get --baudrate** at the PAR> prompt to see the baud rate value that is stored in the sensor.
11. Type **exit**.
    The terminal emulator session ends and the sensor collects data again.
12. Use the terminal program to save data to the PC.
13. To stop data collection, Select **File**, then *Disconnect*.
    The sensor stops data collection.
    Other commands:

    Contact Technical Support for use of **freset**, **upgrade**, and **su** commands. These are typically used only by the manufacturer.

The **exit** command ends the current session. The sensor collects data again.

The **reboot** command resets the terminal software. Data collection starts again when the operation is complete.

3.2.1 Configuration commands

The commands below let the user change the settings in the sensor and are used with the "get" and "set" commands.

Get	
Command line:	get
Description:	"Get" lets the user see the current value of a setting that is stored in the sensor.

Set	
Command line:	set
Description:	"Set" lets the user change the current value of a setting that is stored in the sensor.

Serial number	
Command line:	--serialno
Value:	serial number of the connected sensor.
Example:	get --serialno
Description:	The serial number of the sensor shows.

Firmware version	
Command line:	--fwversn
Example:	get --fwversn
Description:	Shows the current version of firmware installed in the sensor.

Baud rate	
Command line:	--baudrate
Value:	9600 | 19200 | 38400 | 57600 | 115200
Example:	set --baudrate 57600
Description:	Rate at which the sensor operates. Default: 57600 bps.

Output frame type	
Command line:	--outfrtyp
Value:	short_ascii | full_ascii | cal
Example:	set --outfrtyp short_ascii
Description:	Specifies the format of the data frame. Refer to the sections about Short ASCII output on page 21 and Full ASCII output on page 22 for details.

Calibration coefficients	
Command line:	--caldata
Value:	a0 | a1 | im

Example:	get --caldata
Description:	Set or get the calibration coefficients used to convert raw ADC counts. a0 = dark offset. a1 = scale factor. im = immersion factor.

Immersion coefficients	
Command line:	--immersed
Value:	true | false
Example:	set --immersed true
Description:	Turns on (true) or off (false) the stored immersion coefficient in the frames that show engineering units. Turn on in water. Turn off in air.

Sample interval	
Command line:	--smplint
Value:	10–60000
Example:	set --smplint 100
Description:	Specifies the time in milliseconds between PAR ADC data collection. The data frame rate is related to this time. Default: 100 ms

Sample average size	
Command line:	--navg
Value:	1–50
Example:	set --navg 10
Description:	Specifies the number of measurements to average for output. Raw data is averaged before the PAR value is calculated. An increase in this value may reduce noise and give more consistent measurements. The data frame rate is affected by the sample average. Default: 10
Frame rate examples:	smplint=100, navg=10: 1 sample/sec smplint=100, navg=1: 10 samples/sec smplint=10, navg=1: 100 samples/sec (maximum rate)

Show status messages	
Command line:	--msgtotlm
Value:	true | false
Example:	set --msgtotlm true
Description:	Turns on (true) or off (false) the system messages over the serial interface.

Message level	
Command line:	--msglevel
Value:	error | warn | info | debug
Example:	set --msglevel warn
Description:	Specifies the verbosity of status messages. Default: warn

Range	
Command line:	--range
Value:	100–10000

Example:	set --range 5000
Description:	Specifies the maximum PAR value that shows on the analog interface (µmol photon photons/m²/s.) Default: 5000

Voltage output type	
Command line:	--votype
Value:	none | linear | log
Example:	set --votype linear
Description:	Specifies the mode for analog operation. none = output voltage will not change with a measured PAR signal. linear = output voltage will increase linearly over the measurement range. log = output voltage will increase logarithmically over the measurement range. The upper limit of the measurement range is set by the **Range** parameter. The lower limit is set at -5 µmol photons/m²/s in linear mode and 0.1 in log mode.

Pitch offset	
Command line:	--poffset
Value:	-5.0 to +5.0
Example:	set --poffset -0.8
Description:	Specifies a value to subtract from the calculated pitch measurement to correct for small errors from mounting offsets.

Roll offset	
Command line:	--roffset
Value:	-5.0 to +5.0
Example:	set --roffset -0.8
Description:	Specifies a value to subtract from the calculated roll measurement to correct for small errors from mounting offsets. Default is 0.00 degrees but may be adjusted by the manufacturer during final assembly.

dac	
Command line:	dac
Value:	min | max | par
Example:	dac --par
Description:	dac lets the user test and calibrate the analog output. min = minimum value of output voltage, typically 0.1 volts. max = maximum value of output voltage, typically 4 volts. par = output is forced to an appropriate voltage, typically the current output in volts. Note that this value will be different between linear mode and logarithmic mode.

Figure 1 PAR settings

```
PAR>get --serialno
$Ok 1003
PAR>get --baudrate
$Ok 57600
PAR>get --fwversn
$Ok 2.1.4
PAR>get --nacvg
$Ok 1
PAR>get --outfrtyp
$Ok FULL_ASCII
PAR>get --clock
$Ok 1914.715 seconds
PAR>get --caldata
$Ok a0: 34151264 a1: 0.00029213 im: 1.359
PAR>get --caldataf
$Ok a0: 34151264 a1: 2.921300e-04 im: 1.359000e+00
PAR>get --immersed
$Ok FALSE
PAR>get --smplint
$Ok 500
PAR>get --msgtotlm
$Ok TRUE
PAR>get --msglevel
$Ok WARN
PAR>get --range
$Ok 5000
PAR>get --votype
$Ok LINEAR
PAR>get --poffset
$Ok 0.0
PAR>get --roffset
$Ok 0.0
PAR>
```

Example of settings in a PAR sensor.

Section 4 Process data

The serial PAR sensor uses a linear fitting function to convert raw ADC counts to PAR. The equation below is on each sensor-specific calibration page.

PAR = Im × a_1 (x - a_0) *where:*

Im = immersion coefficient

a_1 = scale factor

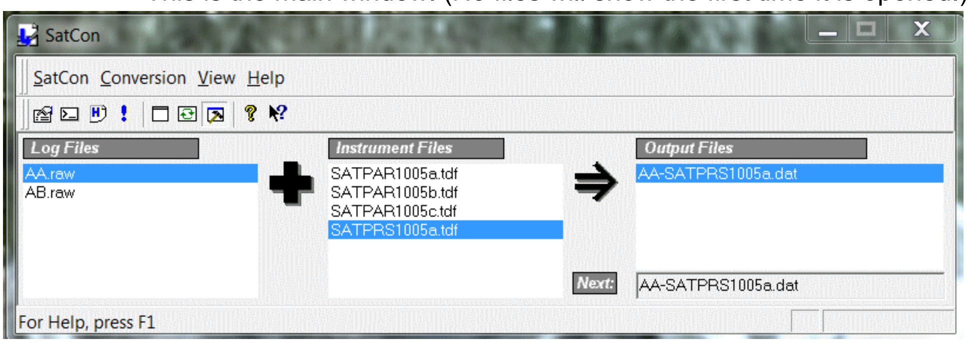
a_0 = offset

x = ADC raw counts

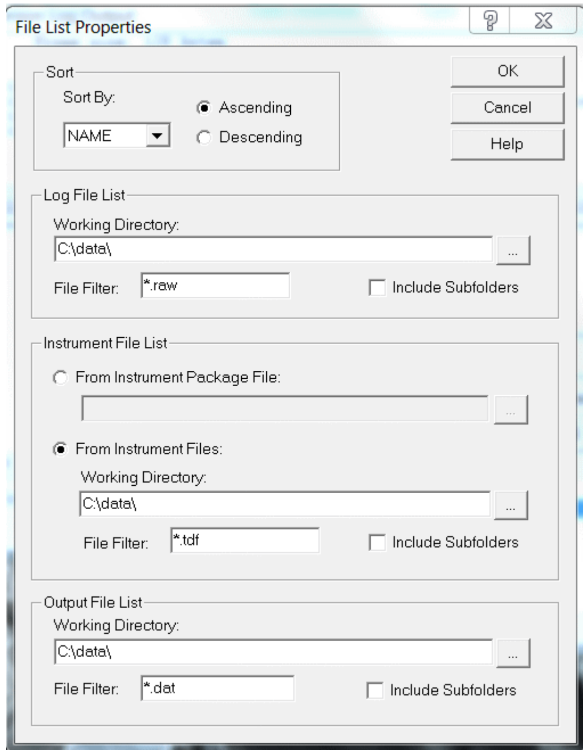
PAR is calculated in units of µmol photons/m^{2}/s^{1}.

If the sensor is set up with the --outfrtyp short_ascii or long_ascii, the data is in calibrated units and it is not necessary to process it further. If, however, data is collected in the SatView software, the binary timestamps need to be converted to ASCII. The manufacturer-supplied SatCon software will do this.

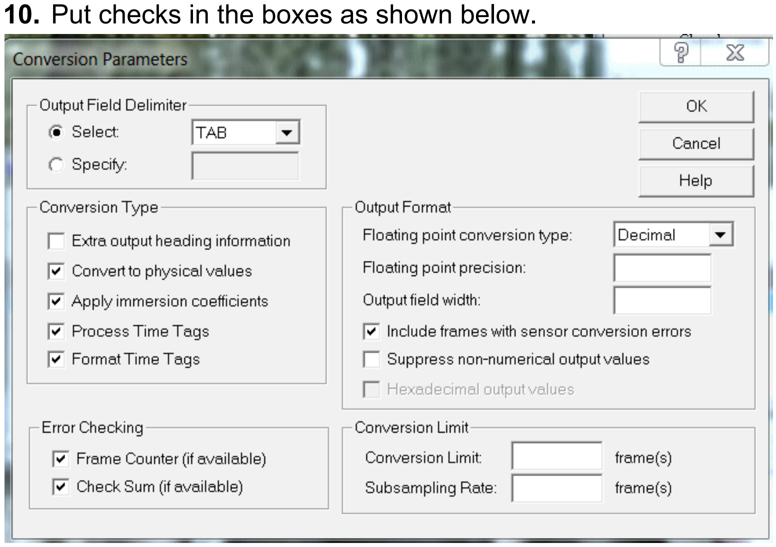
1. Install the software from the manufacturer-supplied CD or from the manufacturer's web site.
2. Start the program.
   This is the main window. (No files will show the first time it is opened.)



3. Optional: Select **View**, then *Conversion Log* to see a separate window that gives information about conversion tasks that may help if troubleshooting is necessary.
4. Find the appropriate .raw file and move ("drag") it to the "Log Files" area on the left of the **+** sign.
5. Move the .TDF file from the CD or PC into the "Instrument Files" area.
6. Go to **View**, then *Properties*. A new "File List Properties" window shows.
   It includes information about the location of the .raw file and the .sip file.
7. Go to the bottom of the window at the "Output File List" and select the location on the PC to store the converted .raw data.



8. Push **OK**.
9. Go to **View**, then *Conversion Parameters*.
10. Put checks in the boxes as shown below.



11. Push **OK**.
12. Select **Conversion**, then *File Naming*.
13. Select "Instrument Conversion" in the "File Naming for:" area.
14. Select "Log [-Instrument] File Title(s)."
    The software automatically names the converted file to the data file.
15. Push **OK**.
16. In the main window select the .raw file and the .tdf fil to convert
17. Push the blue exclamation point or select **Conversion**, then *Convert*.
    The conversion starts.
18. If the software shows a warning about valid frame counter sensors, Push **OK** to continue.

This error message shows because frame counters are not available with the PAR sensor.

19. When the conversion is complete, a SatCon Conversion window shows with information about the number of data frames processed and the file name.
20. Push **OK** to close this window.
21. Find the converted file in the selected output file directory. It has a .dat file extension.
22. Open the file in spreadsheet software such as Microsoft Excel® or Open Office.

	A	B	C	D	E	F	G	H
1	TIMER	PAR	PITCH	ROLL	TEMP	CHECK(SU	DATETAG	TIMETAG2
2	462.98	0.009	50.9	-38.9	25.5	0	2017-360	31:51.6
3	466.981	1.059	23.2	-59.7	25.5	0	2017-360	31:55.6
4	470.981	6.268	8	8.9	25.5	0	2017-360	31:59.6
5	474.981	5.902	1.5	19.1	25.5	0	2017-360	32:03.6
6	478.981	4.39	-18.9	-1.7	25.5	0	2017-360	32:07.6
7	482.981	6.251	-0.9	15.9	25.5	0	2017-360	32:11.6
8	486.981	1.484	-37.2	-31.5	25.5	0	2017-360	32:15.6
9	490.981	2.277	26	-4.7	25.5	0	2017-360	32:19.6
10	494.982	5.027	14.2	2.9	25.5	0	2017-360	32:23.6
11	498.982	0.01	-4.2	77.5	25.5	0	2017-360	32:27.6
12	502.982	0.01	34.3	55.2	25.7	0	2017-360	32:31.6

4.1 Analog output

In serial PAR sensors with the option of analog output, a 16-bit Digital-to-Analog Converter (DAC) gives output from the sensor in volts. The PAR sensor can operate in either a linear or logarithmic mode. In linear mode, the standard range is 0–5000 µmol photons/m^{2}s. In logarithmic mode, the standard range is 0.1–5000 µmol photons/m^{2}s. Note that the standard coefficients given below will change if the range is changed. Refer to In-system analog calibration on page 17 for details.

The equations below are used to convert the output in volts to PAR. The command is **set --votype linear** or **set --votype logarithmic**. Note that the calibration coefficients are not stored in the sensor.

Linear output calculation

The standard range of 0–5000 µmol photons/m^2/s:

PAR = m × voltage + b, *where*

m = slope, with a standard coefficient of 1291.593195

b = offset, with a standard coefficient of -166.45163

Logarithmic output calculation

The standard range of 0.1–5000 µmol photons/m^2/s:

PAR = $10^{(\text{voltage} - q) \div p}$ *where*

p = a standard coefficient of 0.824661

q = a standard coefficient of 0.949663

4.2 In-system analog calibration

The manufacturer-supplied coefficients are for the nominal minimum and maximum output voltage. The user can calculate other coefficients that give greater accuracy for a specific deployment. To do an in-system calibration to re-calculate the coefficients, a Y-cable is necessary to connect the PAR sensor to both a PC and a data acquisition device. Use the output from the data acquisition device to measure V_{min} and V_{max}.

1. Connect the Y-cable to the sensor, the PC, a power supply and the data acquisition device's voltage input.
2. Start a terminal program and type **$** to get to the **PAR>** prompt.
3. Type **get --range**. (default is 5000).
4. To change the range value, type **set --range** [**value**]
5. To get the current output mode setting, type **get --votype**.
6. To change the mode, type either **set --votype linear** or type **set --votype log**.
7. Type **dac --min**. Record this value as V_{min}. It should be close to 0.125V.
   Type **dac --max**. Record this value as V_{max}. It should be close to 4.000V
8. Calculate the coefficients for linear mode:
   - $m = (range – [-5]) \div (V_{max} - V_{min})$
   - $b = range - m \times V_{max}$
9. Calculate the coefficients for logarithmic mode:
   - $p = (V_{max} - V_{min}) \div (\log_{10}[range] - \log_{10}[0.1])$
   - $q = V_{min} - p \times \log_{10}(0.1)$
10. Test the new coefficients. Type **dac --par** [**value**], where the [value] is the simulated PAR value.
11. Apply the coefficients to the output voltage. The voltage output should be close to the calculated values.

Section 5 Maintenance

5.1 Clean the sensor

⚠ CAUTION

Do not use abrasive cleaner on the optical face of the sensor. It will cause scratches on the optical epoxy and glass.

⚠ CAUTION

Do not use acetone or other solvents to clean any part of the sensor.

1. After each cast or exposure to natural water, flush the sensor with clean fresh water.
2. Use soapy water to clean any grease or oil on the optical face of the sensor. It is made of plastic and can be damaged if an abrasive cleaner is used.
3. Dry the sensor with a clean soft cloth.
4. Install the dummy plug and lock collar to protect the bulkhead connector.
5. Install the protective cap on the optical face.

5.2 Maintain bulkhead connector

⚠ CAUTION

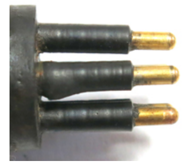
Do not use WD-40® or petroleum-based lubricants on bulkhead connectors. It will cause damage to the rubber.
Damaged connectors can cause a loss of data and additional costs for service.

Damaged connectors can cause damage to the sensor and make it unserviceable.

Examine, clean, and lubricate bulkhead connectors at regular intervals. Connectors that are not lubricated increase the damage to the rubber that seals the connector contacts. The incorrect lubricant will cause the bulkhead connector to fail.

1. Apply isopropyl alcohol (IPA) as a spray or with a nylon brush or lint-free swab or wipes to clean the contacts.
2. Flush with additional IPA.
3. Shake the socket ends and wipe the pins of the connectors to remove the IPA.
4. Blow air into the sockets and on the pins to make sure they are dry.
5. Use a flashlight and a magnifying glass to look for:

Cracks, scratches, or other damage on the rubber pins or in the sockets.		
Any corrosion.		

Separation of the rubber from the pins.	
Swelled or bulging rubber pins.	

6. Apply a small quantity of 3M™ Spray Silicone Lubricant (3M ID# 62-4678-4930-3) to the pin end of the connector. Make sure to let it dry.
7. Connect the connectors.
8. Use a lint-free wipe to clean any unwanted lubricant from the sides of the connectors.

Section 6 Reference

6.1 Short ASCII output

Output from sensors with serial functionality is calculated from the calibration coefficients stored in the sensor. Data is variable-length comma-delimited ASCII text. This is the "short" data frame.

Relevant configuration parameter: **outfrtyp --short_ascii**

Field name	Field size, bytes	Description
Instrument	6	AS-formatted string that is the start of a frame.
Serial number	4 1–10 permitted	AS- or AI-formatted string. the Instrument and Serial number are the frame header.
Comma	1	Delimiter
Timer	5–11	AF-formatted value that shows how many seconds have passed since the end of the start sequence. Accurate to three decimal places.
Comma	1	Delimiter
PAR	5–9	AF-formatted value that shows the calculated PAR in µmol/m²/s
Comma	1	Delimiter
Pitch	3–5	AF-formatted value that shows the pitch angle of the sensor in degrees. Accurate to one decimal place.
Comma	1	Delimiter
Roll	3–5	AF-formatted value that shows the roll angle of the sensor in degrees. Accurate to one decimal place.
Comma	1	Delimiter
Internal temperature	3–5	AF-formatted value that shows the internal temperature of the sensor in degrees C. Accurate to one decimal place.
Comma	1	Delimiter
Checksum	1–3	A value that verifies the validity of the data frame.
Terminator	2	This field is the end of the frame, <CR-LF>

Output example:

SATPRS9999,75.782,20.502,1.5,-0.9,24.2,183

6.2 Full ASCII output

Raw digital values and calculated voltages are shown as variable-length comma-delimited ASCII text for sensors with serial functionality. This is the "full" data frame.

Relevant configuration parameter: **outfrtyp --full_ascii**

Field name	Field size, bytes	Description
Instrument	6	AS-formatted string that is the start of a frame.
Serial number	4 1–10 permitted	AS- or AI-formatted string. the Instrument and Serial number are the frame header.
Comma	1	Delimiter
Timer	5–11	AF-formatted value that shows how many seconds have passed since the end of the start sequence. Accurate to three decimal places.
Comma	1	Delimiter
PAR	5–9	AF-formatted value that shows the calculated PAR in µmol/m²/s
Comma	1	Delimiter
Pitch	3–5	AF-formatted value that shows the pitch angle of the sensor in degrees. Accurate to one decimal place.
Comma	1	Delimiter
Roll	3–5	AF-formatted value that shows the roll angle of the sensor in degrees. Accurate to one decimal place.
Comma	1	Delimiter
Internal temperature	3–5	AF-formatted value that shows the internal temperature of the sensor in degrees C. Accurate to one decimal place.
Comma	1	Delimiter
Analog mode	3	AF-formatted value that shows the analog output mode of operation. LIN = linear mode; LOG = logarithmic mode.
Comma	1	Delimiter
PAR counts	8	AU-formatted value that shows the Analog-to-Digital Converter counts.
Comma	1	Delimiter
ADC volts	11–12	AF-formatted value that shows the voltage at the input of the ADC used for PAR measurements. Accurate to nine decimal places.
Comma	1	Delimiter
Voltage out	9	AF-formatted value that shows the voltage output on the analog interface. Accurate to seven decimal places.
Comma	1	Delimiter
X axis	1–5	AI-formatted value that shows the raw signed counts from the accelerometer X-axis.
Comma	1	Delimiter
Y axis	1–5	AI-formatted value that shows the raw signed counts from the accelerometer Y axis.
Comma	1	Delimiter
Z axis	1–5	AI-formatted value that shows the raw signed counts from the accelerometer Z axis.
Comma	1	Delimiter
T counts	1–5	AI-formatted value that shows the raw counts from the temperature sensor ADC.
Comma	1	Delimiter

T volts	5	AF-formatted value that shows the voltage at the input of the ADC used for temperature measurements. Accurate to three decimal places.
Comma	1	Delimiter
Status	1–3	AI-formatted valued that shows the status of the sensor. Shows as 0.
Comma	1	Delimiter
Checksum	1–3	A value that verifies the validity of the data frame.
Terminator	2	This field is the end of the frame, <CR-LF>

Output example:

SATPRL9999,1.468,22.784,2.2,0.7,27.3,LIN,
34174366,0.092377499,0.1465022,-13,-1011,38,1759,0.773,0,230

6.3 Update firmware

The manufacturer posts firmware upgrades to its website from time to time. The file is named *PAR_V2_vX.Y.Z.sfw*, where X.Y.Z is the firmware version. Use a terminal program that supports XMODEM to do an update.

1. Make sure that the sensor is connected to the PC and a power supply and a terminal program is started.
2. At the **PAR>** prompt, type **upgrade**.
   The prompt changes to **PARBLDR>**.
3. Optional: type **?** to see the Help list.
4. Type **X**. The bootloader uses CRC validation.
5. Type **W**.
   The upgrade starts.
6. To verify the upload, type **V**.
7. Type **A**. The sensor executes the firmware
8. Type **S** or turn the power to the sensor off, then on.
9. Type **$**. Look at the banner to make sure the new firmware starts.

Section 7 General information

Revised editions of this user manual are on the manufacturer's website.

7.1 Warranty

This sensor is warranted against defects in materials and workmanship for one year from the date of purchase. The warranty is void if the manufacturer finds the sensor was abused or neglected beyond the normal wear and tear of deployment. The manufacturer will replace or repair, as deemed necessary, any defective components. This warranty does not include shipping charges to and from the manufacturer's facility.

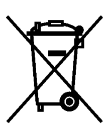
7.2 Service and support

The manufacturer recommends that sensors be sent back to the manufacturer annually to be cleaned, calibrated, and for standard maintenance.
Refer to the website for FAQs and technical notes, or contact the manufacturer for support at support@seabird.com.

Do the steps below to send a sensor back to the manufacturer.

1. Complete the online Return Merchandise Authorization (RMA) form or contact the manufacturer.
   Note: *The manufacturer is not responsible for damage to the sensor during return shipment.*
2. Remove all batteries from the sensor.
3. Remove all anti-fouling treatments and devices.
   Note: *The manufacturer will not accept sensors that have been treated with anti-fouling compounds for service or repair. This includes AF 24173 devices, tri-butyl tin, marine anti-fouling paint, ablative coatings, etc.*
4. Use the sensor's original ruggedized shipping case to send the sensor back to the manufacturer.
5. Write the RMA number on the outside of the shipping case and on the packing list.
6. Use 3rd-day air to ship the sensor back to the manufacturer. Do not use ground shipping.
7. The manufacturer will supply all replacement parts and labor and pay to send the sensor back to the user via 3rd-day air shipping.

7.3 Waste electrical and electronic equipment



Electrical equipment that is marked with this symbol may not be disposed of in European public disposal systems. In conformity with EU Directive 2002/96/EC, European electrical equipment users must return old or end-of-life equipment to the manufacturer for disposal at no charge to the user. To recycle, please contact the manufacturer for instructions on how to return end-of-life equipment, manufacturer-supplied electrical accessories, and auxiliary items for proper disposal.

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