



SEA-BIRD  
SCIENTIFIC

# User manual

## PAR

Photosynthetically Active Radiation sensor

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B





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# Section 1 Safety information

Please read this entire manual before this equipment is unpacked, set up, or operated. Pay attention to all danger, warning, and caution statements. Failure to do so could result in serious injury to the operator or damage to the equipment.

## DANGER

Indicates a potentially or imminently hazardous situation which, if not avoided, will result in death or serious injury.

## WARNING

Indicates a potentially or imminently hazardous situation which, if not avoided, could result in death or serious injury.

## CAUTION

Indicates a potentially hazardous situation that may result in minor or moderate injury.

## NOTICE

Indicates a situation which, if not avoided, may cause damage to equipment. Information that requires special emphasis.

## 1.1 Hazard information

### WARNING

This product can expose the user to chemicals with silica, crystalline (airborne particles of respirable size), which is known to the State of California to cause cancer and birth defects or other reproductive harm. For more information, go to [www.P65Warnings.ca.gov](http://www.P65Warnings.ca.gov).

### 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 and other people. In a well ventilated area, use the purge port (if the sensor is so equipped), or very SLOWLY loosen the bulkhead connector to let the pressure release.

### WARNING



Sensors that use ultraviolet light sources (< 400 nm): Do not look directly at a UV light source when it is on. It can cause damage to the eyes. Keep products that have UV light sources away from children, pets, and other living organisms. Wear polycarbonate UV-resistant safety glasses to protect the eyes when a UV light is on.

## NOTICE

The manufacturer is not responsible for any damages due to misapplication or misuse of this product including, without limitation, direct, incidental and consequential damages, and disclaims such damages to the full extent permitted under applicable law. The user is solely responsible to identify critical application risks and install appropriate mechanisms to protect process during a possible equipment malfunction.

### 1.2 Equipment labels

Read all labels and tags attached to the equipment. Personal injury or damage to the equipment could occur if not observed. A symbol on the equipment is referenced in the manual with a precautionary statement.



Electrical equipment marked with this symbol may not be disposed of in European domestic or public disposal systems. Return old or end-of-life equipment to the manufacturer at no charge to the user.



EFUP: Hazardous material exists over the threshold of GB/T 26572.2011. The number in the center of the symbol is the Environmentally Friendly Use Period as specified by SJ/T 11364-2014, China's marking for the Restriction of the Use of Hazardous Substances in Electrical and Electronic Products. This product should be recycled after its environmentally friendly use period.

## Section 2 PAR quick start guide

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### ⚠ 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 and other people. In a well ventilated area, use the purge port (if the sensor is so equipped), or very SLOWLY loosen the bulkhead connector to let the pressure release.

### ⚠ WARNING



Sensors that use ultraviolet light sources (< 400 nm): Do not look directly at a UV light source when it is on. It can cause damage to the eyes. Keep products that have UV light sources away from children, pets, and other living organisms. Wear polycarbonate UV-resistant safety glasses to protect the eyes when a UV light is on.

This quick start guide gives the steps necessary to make sure that the PAR sensor operates correctly and collects data before it is deployed.

1. Connect the test cable to the PAR and a PC.
2. Install and start the SatView software.
3. Supply power to the PAR sensor.
4. Configure the sensor. Refer to [Verify functionality](#) on page 11 for details.
5. Go to the **Log** menu, then select *Options* to set up the file name.
6. Push **Start Logging** in the main window.  
The sensor collects data.
7. Save the settings: select the **File** menu, then *Save As...* and find or make a file name and location.
8. Turn off the power supply to stop the sensor.
9. After a deployment, flush the sensor with clean fresh water and attach the dummy plug and lock collar.
10. Keep the sensor out of direct sunlight.



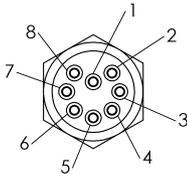
# Section 3 Specifications

## 3.1 Mechanical

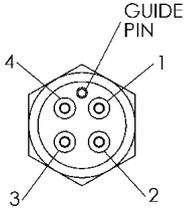
	PAR 1000 m	PAR 7000 m	PAR-AUV 1000 m
Length	8.9 cm		7.6 cm
Diameter	2.5 cm		3.2 cm
Weight in air, water	0.09 kg, 0.04 kg	0.18 kg, 0.13 kg	0.052 kg, 0.047 kg
Depth rating	1000 m	7000 m	1000 m
Temperature range	-4–40 °C		
Material	Plastic	Titanium	Plastic

### 3.1.1 Serial sensor bulkhead connector

Table 1 Serial sensor connector functions

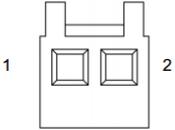
Contact	Function	Description	Connector
1	Voltage in	Voltage Direct Current, 6–28 VDC	<p>MCBH-8-MP</p> 
2	Ground	Ground	
3	No connect	No connect	
4	No connect	No connect	
5	RS232 TX	RS232 transmit	
6	RS232 RX	RS232 receive	
7	Voltage out	0.125–4.00 VDC	
8	No connect	No connect	

### 3.1.2 Analog-only sensor bulkhead connector

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

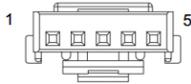
### 3.1.3 Serial-only sensor bulkhead connectors

Table 2 AUV connector functions

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

## Specifications

**Table 2 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	

## 3.2 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

## 3.3 Optical

Spectrum	400–700 nm
Range, typical	0–5000 $\mu\text{mol photons/m}^2/\text{s}$
Spatial	Spectrally corrected cosine response
Cosine error	within 3% @ 0–60 • within 10% @ 60–85
Collector area	86 mm <sup>2</sup>
Detector	Custom 17 mm <sup>2</sup> silicon photodiode

## 3.4 Calibration values

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

### 3.4.1 Serial PAR, analog mode

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  $\mu\text{mol photons/m}^2/\text{s}$ .

$\text{PAR} = I_m \times a_1(\text{counts} - a_0)$ , where:

$I_m$  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  $\mu\text{mol photons/m}^2/\text{s}$ .

$\text{PAR} = m \times \text{voltage} + b$ , 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 19 for details.

**Logarithmic output calculation**

Calculation is for the standard range of 0.1–5000  $\mu\text{mol photons/m}^2/\text{s}$ .

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

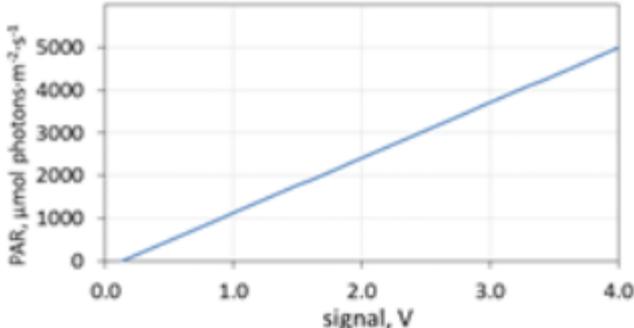
$p$  = a standard coefficient of 0.824661

$q$  = a standard coefficient of 0.949663

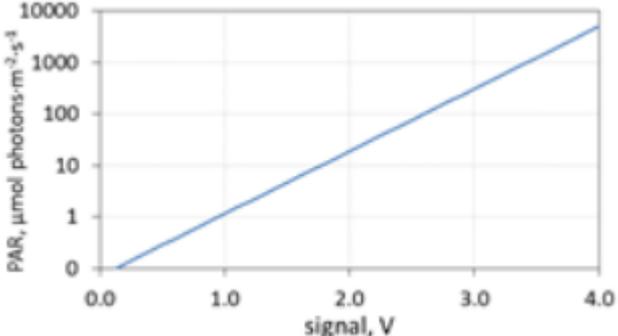
**3.4.2 Analog-only PAR**

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 3 Linear analog output**

<p><math>\text{PAR} = I_m \times a_1 \times (\text{volts} - a_0)</math>, where:  <math>I_m</math> is the immersion coefficient  <math>a_1</math> is the scale factor  <math>a_0</math> is the offset</p>	
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**Table 4 Logarithmic analog output**

<p><math>\text{PAR} = I_m \times 10^{(\text{volts} - a_0) \div a_1}</math>  <math>I_m</math> is the immersion coefficient  <math>a_1</math> is the scale factor  <math>a_0</math> is the offset</p>	
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## Section 4 Operation

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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 micro moles of quanta per square meter per second ( $\mu\text{mol photons/m}^2/\text{s}$ ).

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

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<sup>®</sup>, 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](#) on page 13 for descriptions of the terminal commands.

### 4.1 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, .cal, or .tdf file to the main window of the SatView 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". (This is auto-filled if a .sip file was moved in step 4.)
  - 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. An example of binary data converted to ASCII:

SN	INTTIME (LU)	SAMPLE (DELAY)	LU(350.87)	LU(354.14)	...	LU(793.97)	LU(797.23)	DARK_SAMP (LU)	DARK_AVE (LU)	TEMP (PCB)	FRAME (COUNTER)	TIMER	CHECK (SUM)	DATETAG	TIMETAG2
148	0.512	0.3	0.0380634	0.0421915	...	1.0622929	1.0631173	15	1304	28.5	82	178.73	0	2018-074	58:42.0
148	0.512	0.3	0.0385593	0.0415194	...	1.0591354	1.0641263	15	1303	28	83	180.16	0	2018-074	58:43.4
148	0.512	0.3	0.0393858	0.0411034	...	1.0611541	1.0623208	15	1306	28	84	181.58	0	2018-074	58:44.8

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.

## 4.2 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 13.

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,in]
--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 (uHol photons*h^-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.

### 4.2.1 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.

## Operation

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

<b>Output frame type</b>	
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 <a href="#">Short ASCII output</a> on page 23 and <a href="#">Full ASCII output</a> on page 24 for details.

<b>Calibration coefficients</b>	
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.

<b>Immersion coefficients</b>	
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.

<b>Sample interval</b>	
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

<b>Sample average size</b>	
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)

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

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

<b>Range</b>	
Command line:	--range
Value:	100–10000
Example:	set --range 5000
Description:	Specifies the maximum PAR value that shows on the analog interface ( $\mu\text{mol photon photons/m}^2/\text{s}$ .) Default: 5000

<b>Voltage output type</b>	
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 <b>Range</b> parameter. The lower limit is set at $-5 \mu\text{mol photons/m}^2/\text{s}$ in linear mode and 0.1 in log mode.

<b>Pitch offset</b>	
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.

<b>Roll offset</b>	
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.

## Operation

dac	
Command line:	dac
Value:	min   max   par
Example:	dac --par
Description:	<p>dac lets the user test and calibrate the analog output.</p> <p>min = minimum value of output voltage, typically 0.1 volts.</p> <p>max = maximum value of output voltage, typically 4 volts.</p> <p>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.</p>

**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 --smp1int
$Ok 500
PAR>get --msgtot1m
$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 5 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.

$PAR = Im \times a_1 (x - a_0)$  where:

$Im$  = immersion coefficient

$a_1$  = scale factor

$a_0$  = offset

$x$  = ADC raw counts

PAR is calculated in units of  $\mu\text{mol photons/m}^2/\text{s}^1$ .

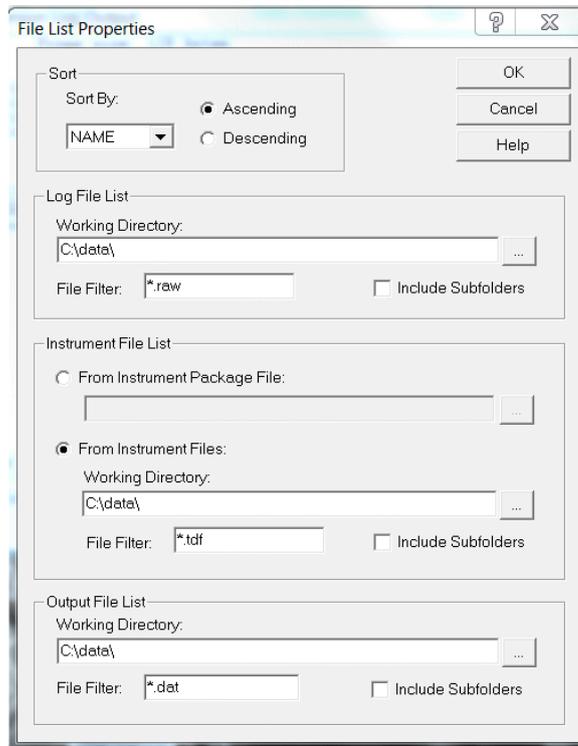
If the sensor is set up with the `--outfrtyp short_ascii` or `long_ascii`, the data is in calibrated units and it is not necessary to process it further. If, however, data is collected in the SatView software, the binary timestamps need to be converted to ASCII. The manufacturer-supplied SatCon software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

1. Install the software from the manufacturer-supplied CD or from the manufacturer's web site.
2. Start the program.

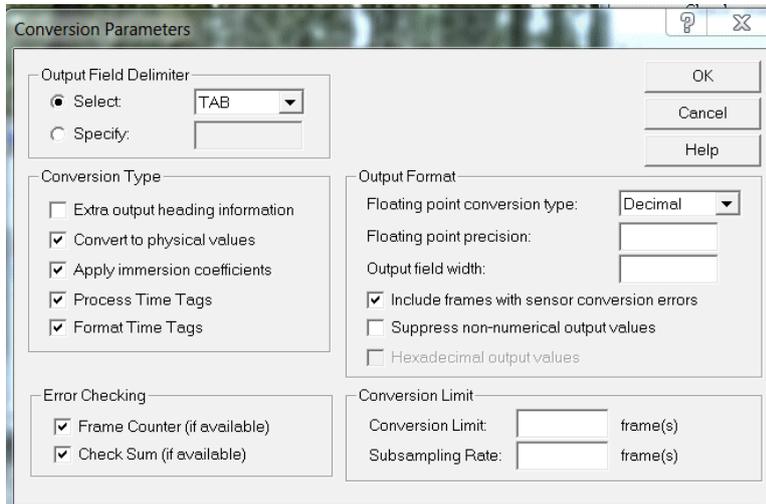
This is the main window. (No files will show the first time it is opened.)



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

## 5.1 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  $\mu\text{mol photons/m}^2\text{s}$ . In logarithmic mode, the standard range is 0.1–5000  $\mu\text{mol photons/m}^2\text{s}$ . Note that the standard coefficients given below will change if the range is changed. Refer to [In-system analog calibration](#) on page 19 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  $\mu\text{mol photons/m}^2\text{s}$ :

$$\text{PAR} = m \times \text{voltage} + b, \text{ where}$$

$m$  = 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  $\mu\text{mol photons/m}^2\text{s}$ :

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

$p$  = a standard coefficient of 0.824661

$q$  = a standard coefficient of 0.949663

## 5.2 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:
  - $m = (\text{range} - [-5]) \div (V_{\max} - V_{\min})$
  - $b = \text{range} - m \times V_{\max}$
9. Calculate the coefficients for logarithmic mode:
  - $p = (V_{\max} - V_{\min}) \div (\log_{10}[\text{range}] - \log_{10}[0.1])$
  - $q = V_{\min} - p \times \log_{10}(0.1)$
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 6 Maintenance

<b>⚠ WARNING</b>	
	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 and other people. In a well ventilated area, use the purge port (if the sensor is so equipped), or very SLOWLY loosen the bulkhead connector to let the pressure release.

The manufacturer recommends that the user returns the sensor for calibration at regular intervals. The measurement accuracy of the sensor may decrease if the sensor is stored unused for long periods of time.

## 6.1 General maintenance

<b>⚠ WARNING</b>	
 	Sensors that use ultraviolet light sources (< 400 nm): Do not look directly at a UV light source when it is on. It can cause damage to the eyes. Keep products that have UV light sources away from children, pets, and other living organisms. Wear polycarbonate UV-resistant safety glasses to protect the eyes when a UV light is on.

<b>NOTICE</b>	
Do not use abrasive cleaner on the optical face of the sensor. It will cause scratches on the optical epoxy and glass.	

<b>NOTICE</b>	
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.

## 6.2 Clean bulkhead connectors

<b>NOTICE</b>	
Do not use WD-40® or petroleum-based lubricant 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. Use silicone-based lubricants only.	

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 failure of the bulkhead connector.

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.

## Maintenance

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:

Any corrosion.		
Cracks, scratches, or other damage on the rubber pins or in the sockets.		
Separation of the rubber from the pins.		
Swelled or bulging rubber pins.		

6. Use a silicone-based lubricant on each of the contacts of the bulkhead connector. The manufacturer recommends any of the products listed below.
  - 3M™ Spray Silicone Lubricant (3M ID# 62-4678-4930-3). Make sure to let it dry.
  - Dow Corning Molykote® III Compound (DC III)
  - Dow Corning High Vacuum Grease® (DC 976 V)
  - Dow Corning 4 Electrical Insulating Compound® (DC 4)
  - Dow Corning Molykote 44 High Temperature Grease® (DC 44)

Use a finger to put a small quantity of 100% silicone grease or spray in the sockets or on the pins. Use the mating plug or cable to help distribute the lubricant. Do not use too much lubricant, as that will prevent a good seal.

7. Connect the connectors.
8. Use a lint-free wipe to clean any unwanted lubricant from the sides of the connectors.

# Section 7 Reference

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## 7.1 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 $\mu\text{mol}/\text{m}^2/\text{s}$
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

## 7.2 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 $\mu\text{mol}/\text{m}^2/\text{s}$
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,-101
1,38,1759,0.773,0,230
```

## 7.3 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 8 General information

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

## 8.1 Warranty

Refer to the manufacturer's website for warranty information ([seabird.com/warranty](http://seabird.com/warranty)).

## 8.2 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](mailto: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, if so equipped.
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-butyltin, 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.

## 8.3 China RoHS disclosure table

Name of Part	Hazardous substance or element in product					
	Pb	Hg	Cd	Cr(VI)	PBB	PBDE
PCBs	X	O	O	O	O	O
This table is compiled to the SJ/T 11364 standard.						
O: This hazardous substance is below the specified limits as described in GB/T 26572. X: This hazardous substance is above the specified limits as described in GB/T 26572.						





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