SEA·BIRD SCIENTIFIC

SATLANTIC

User's Manual
PAR Sensor - Serial

Applies to serial numbers above 1000

Titanium and Plastic Housing PAR Sensors

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Table of Contents

1 Introduction 5
1.1 Purpose of this Manual 5
1.2 Definitions, Acronyms and Abbreviations 5
1.3 Referenced Documents 6
2 Description of PAR Sensor 7
2.1 Specifications 7
3 Safety 11
3.1 Personal Safety 11
3.1.1 Flooded Instrument 11
3.1.2 Electricity 11
3.2 Equipment Safety 11
3.2.1 Instruments 11
3.2.2 Connections 11
3.2.3 Recovery 11
4 Operating the PAR Sensor 12
4.1 Serial Interface 12
4.1.1 Telemetry Formats 12
4.1.1.1 Calibration Frame Telemetry Format 13
4.1.1.2 Short ASCII Telemetry Format 14
4.1.1.3 Full ASCII Telemetry Format 15
4.1.2 Configuration 17
4.1.2.1 Command Console 17
4.1.2.1.1 help Command 17
4.1.2.1.2 set Command 18
4.1.2.1.3 get Command 18
4.1.2.1.4 dac Command 18
4.1.2.1.5 freset command 19
4.1.2.1.6 exit Command 19
4.1.2.1.7 reboot Command 19
4.1.2.1.8 upgrade Command 19
4.1.2.1.9 su Command 19
4.1.2.1.10 user Command 20
4.1.2.2 Configuration Parameters 20
4.1.2.2.1 Telemetry Baud Rate 20
4.1.2.2.2 Sample Average Size 20
4.1.2.2.3 Output Frame Type 20
4.1.2.2.4 Calibration Coefficients 20
4.1.2.2.5 Apply Immersion Coefficient 21
4.1.2.2.6 Sample Interval 21
4.1.2.2.7 Display Status Messages 21
4.1.2.2.8 Message Level 21
4.1.2.2.9 Range 21
4.1.2.2.10 Voltage Output Type 22
4.1.2.2.11 Pitch Offset 22
4.1.2.2.12 Roll Offset 22
4.1.3 Controlling the Frame Rate 22
4.1.4 Using the PAR Sensor with SatView 23
4.1.5 PAR Sensor Serial Data Analysis 25
4.1.5.1 Processing PAR Data with SatCon 25
4.1.6 Firmware Updates 30
4.2 Analog Interface 31
4.2.1 Linear Voltage Output Data Analysis 31
4.2.2 Logarithmic Voltage Output Data Analysis 31
4.2.3 In-System Calibration of the Analog Voltage Output 32

4.2.3.1 Calculation of Linear Mode Coefficients 32
4.2.3.2 Calculation of Log Mode Coefficients 32
5 Maintenance 33
5.1 Preventive Maintenance 33
6 Warranty 34
7 Contact Information 35
Location 35
Business Hours 35
Appendix A - Derivation of the calibration coefficients for a Sea-Bird Electronics data logger. 36
Appendix B - TDF templates 37
CAL Frame TDF Template 37
SHORT_ASCII Frame TDF Template 38
FULL_ASCII Frame TDF Template 39

Index of Tables

Table 1: PAR Sensor Specifications 7
Table 2: PAR Sensor Physical Specifications 8
Table 3: PAR 1000m and PAR 7000m Sensor Connector Pin Configurations 8
Table 4: PAR-AUV Sensor Pin Configuration 8
Table 5: Calibration Frame Data Format 13
Table 6: Short ASCII Frame Data Format 14
Table 7: Full ASCII Frame Data Format 15

Index of Illustrations

Figure 1 PAR Sensors 5
Figure 2 Spectral Response 7
Figure 3 Cosine Response 7
Figure 4: PAR Sensor Mechanical Configurations 9
Figure 5: PAR-1000m and PAR-AUV 10

1 Introduction

1.1 Purpose of this Manual

Photosynthetically **A**ctive **R**adiation, PAR, is the spectral range of solar radiation from 400 to 700 nm. Phytoplankton and higher plants use electromagnetic energy in the PAR region for photosynthesis. PAR is usually measured as Photosynthetic Photon Flux Density (PPFD), which 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 (μmol photons$\cdot m^{-2} \cdot s^{-1}$).

PAR is an important parameter used in energy balance models, ecosystem characterization, and productivity analyses for agronomic, oceanic, and limnological studies. In addition, measurements of PAR are routinely used in laboratory studies focusing on plant physiology and photosynthesis.

Satlantic PAR sensors measure quantum irradiance with near flat spectral response and cosine spatial response. Cosine collectors for in air and in water measurements, housings for two depth ratings, and digital and analog data output options, listed below, support integration of the PAR sensor in instrument packages for a range of deployment conditions.

Optical

ICSW	Irradiance Cosine in Water
ICSA	Irradiance Cosine in Air

Depth rating

1000m	Plastic housing
7000m	Titanium housing

Data interface

SER	RS-232 Serial ASCII
LIN	Linear Analog 0.125 – 4.0V
LOG	Logarithmic Analog 0.125 – 4.0V

Platform custom integration

AUV	Through-hull mounting in Slocum Glider

This manual describes the following PAR Sensor models.

- PAR SER ICSW 1000m
- PAR SER ICSW 7000m
- PAR SER ICSA 1000m
- PAR SER ICSA 7000m
- PAR SER ICSW AUV 1000m

Figure 1 PAR Sensors

1.2 Definitions, Acronyms and Abbreviations

AUV	Autonomous Underwater Vehicle
ICSA	Irradiance Cosine in Air
ICSW	Irradiance Cosine in Water
LIN	Linear Analog Output
LOG	Logarithmic Analog Output
PAR	Photosynthetically Active Radiation
PPFD	Photosynthetic Photon Flux Density
SER	Serial, RS-232, ASCII output

1.3 Referenced Documents

RD1. Satlantic Instrument File Standard, Satlantic LP, SAT-DN-00134, Version 6.1(G), 2011-11-18

RD2. Satlantic Log File Standard, Satlantic LP, SAT-DN-00135, Version 1.1, 2007-08-30

RD3. SatView User Guide, Satlantic LP, Version 2.9(D), 2008-10-02

RD4. SatCon Manual, Satlantic LP, Version 1.5(B), 2011-03-09

RD5. Sea-Bird Electronics Seasoft V2: Seasave V7 User's Manual 03/18/14, www.seabird.com

2 Description of PAR Sensor

2.1 Specifications

Table 1: PAR Sensor Specifications

Standard Configuration	PAR 1000m	PAR 7000m	PAR AUV 1000m
Electrical			
Input Voltage	6-28 VDC		
Input Current @ 12 V	20 mA (17 mA RS-232 not connected)		
Interface	RS-232 and Analog		RS-232
Output Voltage	0.125 - 4.000 VDC		-
Baud Rate	57600 bps (8N1) default User-configurable 9600, 19200, 38400, 57600, 115200 bps		
Auxilliary Sensors	Pitch, Roll, Internal Temperature		
Optical			
Spectrum	400 – 700 nm		
PAR Range (typical)	0 – 5000 µmol photons·m^{-2}·s^{-1}		
Spatial	cosine response		
Cosine error	<3% 0° – 60° <10% 60° – 85°		
Collector area	86.0 mm^2		
Detector	17 mm^2 silicon photodiode		

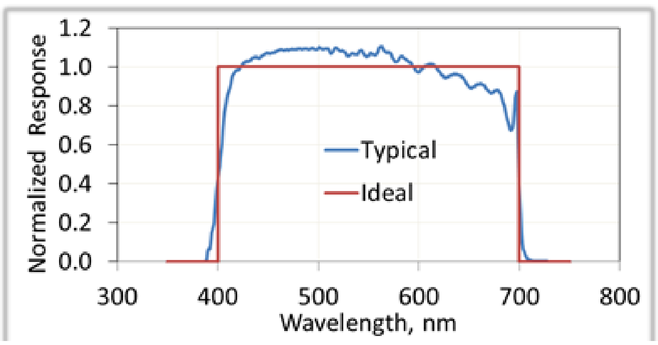


Figure 2 Spectral Response

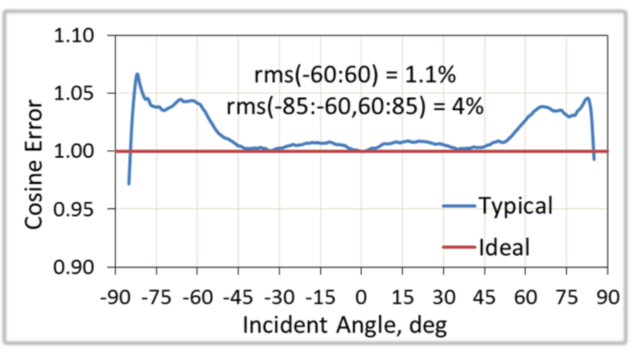


Figure 3 Cosine Response

Table 2: PAR Sensor Physical Specifications

Depth Rating	**PAR 1000m**	**PAR-AUV 1000m**	**PAR 7000m**
Construction	Plastic	Plastic	Titanium
Dimensions			
Length	11.0 mm (4.35 in) [excluding connector pins]	7.6 cm (3.00 in)	11.0 mm (4.35 in) [excluding connector pins]
Diameter	2.5 cm (0.98 in)	3.2 cm (1.25 in)	2.5 cm (0.98 in)
Weight (in air)	88 g (0.194 lb)	52 g (0.115 lb)	182 g (0.401 lb)
Weight (in water)	39 g (0.086 lb)	47 g (0.104 lb)	133 g (0.293 lb)
Operating Temperature	-4 to 40 °C		

Table 3: PAR 1000m and PAR 7000m Sensor Connector Pin Configurations

PAR 1000m and PAR 7000m

Pin	***ID***	***Description***
1	Vin+	DC Power Supply (6 to 28 V)
2	GND	Power Supply Return
3	N.C.	Not internally connected
4	N.C.	Not internally connected
5	TXD	RS-232 Transmit (Data from Sensor)
6	RXD	RS-232 Receive (Data to Sensor)
7	Signal	Voltage output (0.125 to 4.000 V)
8	N.C.	Not internally connected

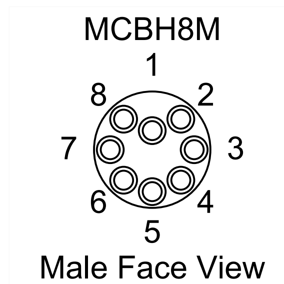
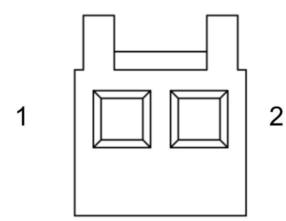


Table 4: PAR-AUV Sensor Pin Configuration

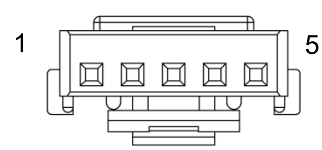
Connector : Molex 22-01-3027

Pin	***ID***	***Wire Colour***	***Description***
1	GND	Black	Power Supply Return
2	Vin+	Red	DC Power Supply (6 to 28 V)



Connector : Molex 35507-0500

Pin	***ID***	***Wire Colour***	***Description***
1	GND	Black	Power Supply Return
2	RXD	Blue	RS-232 Receive (Data to Sensor)
3	TXD	Green	RS-232 Transmit (Data from Sensor)
4	-	-	Not connected
5	-	-	Not connected



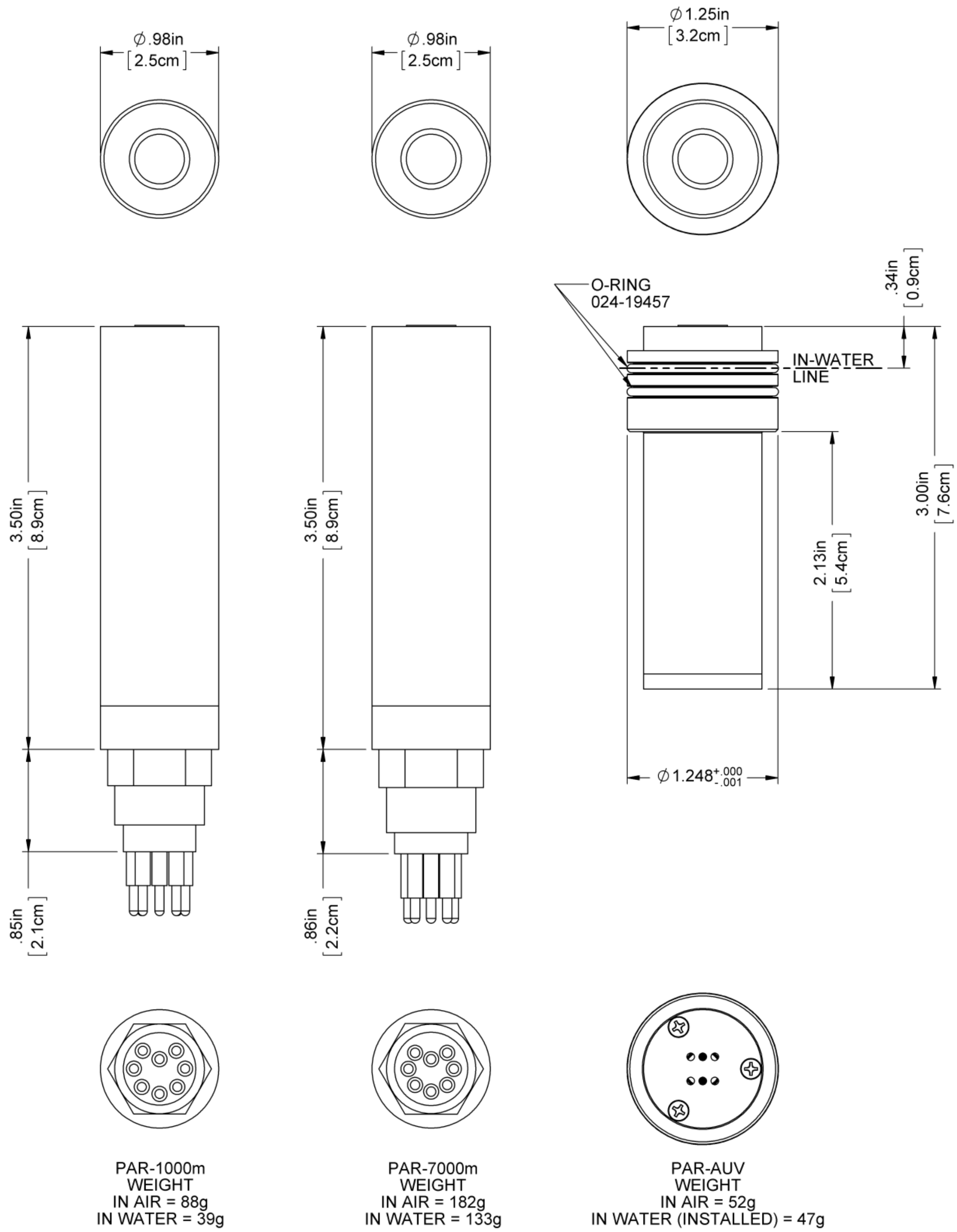


Figure 4: PAR Sensor Mechanical Configurations

Figure 5: PAR-1000m and PAR-AUV

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 safety 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. For the AUV version, slowly unscrew the three end cap retaining screws a quarter turn at a time to allow trapped water to escape. 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.

4 Operating the PAR Sensor

Satlantic's PAR 1000m and PAR 7000m sensors provide both an RS-232 serial interface and an analog (voltage) output with a 0.125-4.000 Vdc output range. The PAR-AUV 1000m sensor provides just the RS-232 serial interface.

Section 4.1 describes the RS-232 serial interface, with information on how to configure and operate the sensor as well as how to interpret the data that is generated.

Section 4.2 7)describes the analog interface and how to calculate PAR using the measured voltage data.

4.1 Serial Interface

To begin operation, connect an appropriate power/telemetry cable to the PAR sensor. Connect the cable to a suitable power supply (12 VDC nominal) and a spare RS-232 port on your computer. Using your favourite terminal emulator (Windows HyperTerminal, Tera Term, etc), configure the port for 57600 bps, with 8 data bits, no parity, 1 stop bit, and no flow control. Telemetry will begin automatically when power is applied.

During operation, the default behavior of the instrument is to continually sample its optical sensor and output telemetry on the RS-232 telemetry interface. When the instrument is used in the field, this telemetry must be collected and saved to a storage medium. To collect the data, a data acquisition application such as Satlantic's SatView software may be used, or simply capture the data with a terminal emulator. Alternatively, the instrument may be integrated with a data logger.

4.1.1 Telemetry Formats

The telemetry format for the PAR instrument, as with all Satlantic instrumentation, follows the Satlantic Data Format Standard. This standard defines how Satlantic telemetry can be generated and interpreted. For every sample taken of the instruments sensors, the instrument will compose and transmit one frame of telemetry containing all the relevant sensor information for that sample. The format of the telemetry frame varies depending on the *outfrtyp* configuration parameter (see Section 4.1.2.2.3. A calibration or Telemetry Definition File (TDF) file defines the specific format of each frame; sample TDF files are provided in Appendix B - TDF templates. These formats are described in the following sections.

4.1.1.1 Calibration Frame Telemetry Format

The "Calibration Frame" is the basic data frame that provides raw ADC (Analog-to-Digital Converter) counts for the optical sensor. It is used for factory calibration and is back-compatible with earlier versions of the PAR instrument (sn 0001 – 0999). Data is presented as variable length, comma-delimited ASCII text.

Relevant configuration parameters:

o*utfrtyp:* *cal*

Table 5: Calibration Frame Data Format

Field Name	Field Size (bytes)	Description
Instrument	6	A unique 6 character AS formatted string denoting the start of a frame of telemetry. For this frame type, the instrument string is "**SATPAR**".
Serial Number	4	An AS or AI formatted string denoting the serial number of the instrument. This field combined with the INSTRUMENT field uniquely identifies the instrument. This combination is known as the frame header or synchronization string.
Comma	1	Comma delimiter
Timer	5 - 11	The field is an AF formatted string indicating the number of seconds that have passed since the end of the initialization sequence. This field is precise to three digits after the decimal.
Comma	1	Comma delimiter
PAR counts	8	An AU formatted value representing the sampled Analog-to-Digital converter counts.
Comma	1	Comma delimiter
Checksum	1-3	The checksum is the two's complement of the least significant byte of the sum of the ASCII codes of all characters in a given frame, up to and including the comma right before the checksum. This includes commas and periods.
Terminator	2	This field indicates the end of the frame. The frame is terminated by a carriage return/line feed pair ($0D_{hex}$ and $0A_{hex}$).

Example telemetry:

```
SATPAR9999,1.216,34172960,53
```

4.1.1.2 Short ASCII Telemetry Format

For this frame type, data is presented as variable length, comma-delimited ASCII text. Rather than raw ADC counts, the PAR value is calculated from the calibration coefficients stored onboard. Additionally the sensor provides pitch and roll orientation measurements, as well as internal temperature.

Relevant configuration parameters:
outfrtyp: *short_ascii*

Table 6: Short ASCII Frame Data Format

Field Name	Field Size (bytes)	Description
Instrument	6	A unique 6 character AS formatted string denoting the start of a frame of telemetry. For this frame type, the instrument string is "**SATPRS**".
Serial Number	4	An AS or AI formatted string denoting the serial number of the instrument. This field combined with the INSTRUMENT field uniquely identifies the instrument. This combination is known as the frame header or synchronization string.
Comma	1	Comma delimiter
Timer	5 - 11	The field is an AF formatted string indicating the number of seconds that have passed since the end of the initialization sequence. This field is precise to three digits after the decimal.
Comma	1	Comma delimiter
PAR	5 - 9	An AF formatted value representing the calculated PAR value. The units are µmol photons•m^{-2}•s^{-1}
Comma	1	Comma delimiter
Pitch	3 - 5	An AF formatted value representing the pitch angle of the sensor, in degrees. This value is precise to one digit after the decimal.
Comma	1	Comma delimiter
Roll	3 - 5	An AF formatted value representing the roll angle of the sensor, in degrees. This value is precise to one digit after the decimal.
Comma	1	Comma delimiter
Internal Temperature	3 - 5	An AF formatted value representing the internal temperature of the sensor, in Celsius. This value is precise to one digit after the decimal.
Comma	1	Comma delimiter
Checksum	1-3	The checksum is the two's complement of the least significant byte of the sum of the ASCII codes of all characters in a given frame, up to and including the comma right before the checksum. This includes commas and periods.
Terminator	2	This field indicates the end of the frame. The frame is terminated by a carriage return/line feed pair ($0D_{hex}$ and $0A_{hex}$).

Example telemetry:

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

4.1.1.3 Full ASCII Telemetry Format

This frame type provides the same data as the Short ASCII frame type (see Section 4.1.1.2) as well as the raw digital values and calculated voltages for the various onboard sensors. Additionally the output voltage being presented on the analog interface as well as the analog output mode is indicated. Data is presented as variable length, comma-delimited ASCII text.

Relevant configuration parameters:
outfrtyp: *full_ascii*

Table 7: Full ASCII Frame Data Format

Field Name	Field Size (bytes)	Description
Instrument	6	A unique 6 character AS formatted string denoting the start of a frame of telemetry. For this frame type, the instrument string is "**SATPRL**".
Serial Number	4	An AS or AI formatted string denoting the serial number of the instrument. This field combined with the INSTRUMENT field uniquely identifies the instrument. This combination is known as the frame header or synchronization string.
Comma	1	Comma delimiter
Timer	5 - 11	The field is an AF formatted string indicating the number of seconds that have passed since the end of the initialization sequence. This field is precise to three digits after the decimal.
Comma	1	Comma delimiter
PAR	5 - 9	An AF formatted value representing the calculated PAR value. The units are µmol photons•m^{-2}•s^{-1}
Comma	1	Comma delimiter
Pitch	3 - 5	An AF formatted value representing the pitch angle of the sensor, in degrees. This value is precise to one digit after the decimal.
Comma	1	Comma delimiter
Roll	3 - 5	An AF formatted value representing the roll angle of the sensor, in degrees. This value is precise to one digit after the decimal.
Comma	1	Comma delimiter
Internal Temperature	3 - 5	An AF formatted value representing the internal temperature of the sensor, in Celsius. This value is precise to one digit after the decimal.
Comma	1	Comma delimiter
Analog mode	3	An AS formatted string denoting the analog output operating mode. The text will be **LIN** for linear mode and **LOG** for logarithmic mode.
Comma	1	Comma delimiter
PAR counts	8	An AU formatted value representing the sampled Analog-to-Digital converter counts.
Comma	1	Comma delimiter
ADC volts	11-12	An AF formatted value representing the voltage at the input of the ADC used for PAR measurements. This value is precise to nine digits after the decimal place.
Comma	1	Comma delimiter
Voltage out	9	An AF formatted value representing the voltage output on the analog interface. This value is precise to seven digits after

		the decimal.
Comma	1	Comma delimiter
X axis	1 – 5	An AI formatted value representing the raw signed counts from the accelerometer X-axis
Comma	1	Comma delimiter
Y axis	1 – 5	An AI formatted value representing the raw signed counts from the accelerometer Y-axis
Comma	1	Comma delimiter
Z axis	1 – 5	An AI formatted value representing the raw signed counts from the accelerometer Z-axis
T counts	1 – 5	An AI formatted value representing the raw counts from the temperature sensor ADC.
Comma	1	Comma delimiter
T volts	5	An AF formatted value representing the voltage at the input of the ADC used for temperature measurements. This value is precise to three digits after the decimal.
Comma	1	Comma delimiter
Status	1-3	An AI formatted value used to indicate device status. Currently always reports as 0
Comma	1	Comma delimiter
Checksum	1-3	The checksum is the two's complement of the least significant byte of the sum of the ASCII codes of all characters in a given frame, up to and including the comma right before the checksum. This includes commas and periods.
Terminator	2	This field indicates the end of the frame. The frame is terminated by a carriage return/line feed pair ($0D_{hex}$ and $0A_{hex}$).

Example telemetry:

```
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
```

4.1.2 Configuration

The PAR sensor has been configured at Satlantic with standard configuration parameters. These parameters control aspects of the instruments operation to account for the wide variety of applications in which the PAR sensors are used. In addition to the autonomous mode described in Section 4.1, a configuration mode is also available to modify configuration parameters and test various systems of the instrument. This configuration mode is implemented by the instrument's **Command Console**.

In most cases, the command console is accessed using a terminal emulation program. For communication with the PAR instrument, you will need to make a direct connection to the serial port hosting the instrument. Connect the instrument using the RS-232 telemetry interface. For communications software, use your favourite terminal emulator (Windows® XP and earlier versions came with one called HyperTerminal®). Ensure that the serial connection to the instrument is at the telemetry baud rate. Use any ANSI or ANSI-compliant (i.e. VT-xxx) emulation. While operating in this mode, the PAR instrument uses simple character I/O with no control character interpretation. Therefore, most terminal emulators can be used.

The command console can be accessed at any point during the instruments operation by sending the *$* character to the PAR sensor.

4.1.2.1 Command Console

When the console is first invoked, you will see a prompt on your terminal emulator screen similar to the one shown below:

```
PAR Command Console.
Serial - 9999
Firmware - R2.1.3 (Variant: Default, Build: May  7 2014-14:13:07)
Clock: 83.027 seconds
Type 'help' for a list of available commands.

PAR>
```

The command prompt is `PAR>`. Using the command line is quite simple. Type a command at the prompt followed by the <Enter> key. This will execute the command, displaying the results to the screen, if any. You can easily edit commands if you make a mistake. Use the <Backspace> key to delete characters in your command before you execute them.

The command console interprets all commands as case sensitive. This means that the command "`exit`" is different from "`EXIT`". Most commands require small case letters.

4.1.2.1.1 help Command

If this is your first time using the command console, a good starting point is the "`help`" command. As you probably noticed, the command prompt header suggests this command for novice users. Executing this command will display the following text:

```
PAR>help

Command      Description

help         Print this message
set          Write settings (Type 'help --set' for a reference)
get          Read settings (Type 'help --get' for a reference)
```

```
dac         DAC in-system cal and test [--min|--max|--par]
freset      [--force | --all] Factory reset
exit        Resume operational mode
reboot      Reboot sensor
upgrade     Start bootloader (firmware update tool)
su          Switch to super user (production) mode
user        Switch to unprivileged mode
$Ok
```

All commands available to the instrument are listed on the left, with descriptions on the right. The available parameters are also indicated.

Some commands require additional command line parameters. Entering a command with an invalid or missing parameter will result in an "`Invalid command`" error message.

4.1.2.1.2 set Command

The "`set`" command modifies configuration parameters for the instrument. These parameters affect various aspects of the instruments operation and can be modified by the user to customize the instrument. Changes are saved immediately if the command is valid.

This command requires two command line parameters. The first parameter specifies the configuration parameter to modify. The second specifies the new value to assign to the parameter. A list of all available configuration parameters is shown by typing "`help --set`".

IMPORTANT! Be careful using this feature. Changes made to the PAR sensor configuration parameters affect the way the instrument operates. Before you modify any of configuration parameters, make sure you understand the consequences of the change.

For more information on these parameters and their effect on your instruments operation, see section 4.1.2.2 below.

4.1.2.1.3 get Command

The "`get`" command displays configuration parameters for the instrument. These parameters are modified by the "set" command explained above. This command requires only one command line parameter, which is the same as the first parameter of the "`set`" command. Using the "`get`" command in this way displays the current value of the configuration parameter.

For more information on these parameters and their effect on your instruments operation, see section 4.1.2.2 below.

4.1.2.1.4 dac Command

The "`dac`" command is used to test and calibrate the analog interface. The `dac` command accepts one of three parameters: `--min`, `--max`, and `--par`.

Entering `dac –min` will force the analog output voltage to its minimum allowed value, while `dac –max` will force the output voltage to its maximum allowed value. Entering `dac –par <value>` where `<value>` is a floating point value (implied units of µmol photons•m^{-2}•s^{-1}) will force the output to an appropriate voltage. The PAR sensor will respond with the current analog output mode, as well as the expected output voltage. For example:

```
PAR>dac --min
$Ok LINEAR, expected Vout=0.1250019
```

```
PAR>dac --max
$Ok LINEAR, expected Vout=4.0000610

PAR>dac --par 850
$Ok LINEAR, expected Vout=0.7869495

PAR>dac --par 850.5
$Ok LINEAR, expected Vout=0.7873870

PAR>dac --par 851
$Ok LINEAR, expected Vout=0.7877620
```

When in logarithmic mode, the output voltage for a given PAR value will be significantly different than when in linear mode. For example:

```
PAR>dac --par 850
$Ok LOG, expected Vout=3.3654263

PAR>dac --par 851
$Ok LOG, expected Vout=3.3658638
```

The maximum allowed voltage corresponds to the maximum PAR value determined by the range parameter (see Section 4.1.2.2.9). The default setting for the range is 5000 µmol photons•m^{-2}•s^{-1}. The minimum voltage corresponds to a minimum PAR value of -5 µmol photons•m^{-2}•s^{-1} when operating in linear mode and 0.1 µmol photons•m^{-2}•s^{-1} when operating in logarithmic mode. The output voltage will simply stop at the minimum or maximum allowed voltage.

4.1.2.1.5 freset command

The `freset` command will return ALL settings to their factory defaults, including serial number and calibration coefficients. If the `–force` parameter is included the user will not be prompted before this occurs.

Do not use this command unless requested to do so by Technical Support staff.

4.1.2.1.6 exit Command

The “`exit`” command ends the current command console session. Once the console exits, normal operation will resume.

4.1.2.1.7 reboot Command

The “`reboot`” command performs a software reset of the application firmware. Once the firmware restarts, normal operation will resume.

4.1.2.1.8 upgrade Command

The “`upgrade`” command will force the PAR sensor switch to its bootloader application, allowing the user to perform a firmware update over the serial interface using a terminal emulator. Note that the emulator must support XMODEM file transfers in order to update the firmware. See 0 for details.

4.1.2.1.9 su Command

The “`su`” command allows the user to enter Super-User mode with extended privileges in order to modify some protected parameters. A password is required.

4.1.2.1.10 user Command

The "`user`" command reverts Super-User privileges.

4.1.2.2 Configuration Parameters

This section describes, in detail, the function of each configuration parameter used by the PAR sensor. The title of each section identifies the function of the parameter, with the command line parameter keyword and any required value parameters identified immediately below. The command line parameter keyword is used with both the "`set`" and "`get`" commands.

See the descriptions of the "`set`" and "`get`" commands described in the 4.1.2.1 section above for more information.

4.1.2.2.1 Telemetry Baud Rate

Command Line Parameter: `--baudrate`
Value Parameter: `9600|19200|38400|57600|115200`
Example: `set --baudrate 19200`

The telemetry baud rate defines the speed at which data is transferred on the telemetry interface. This should not be confused with the frame (data update) rate. Baud rates are specified in units of bits per second (bps). Any data acquisition or terminal emulation software must be configured to communicate with the instrument at this baud rate.

The default baud rate is 57600 bps. A reboot is required for any change to take effect.

4.1.2.2.2 Sample Average Size

Command Line Parameter: `--navg`
Value Parameter: `1 - 50`
Example: `set --navg 10`

The sample average size specifies the number of measurements to average for the output data frame. Raw data is averaged before calculating the PAR value. In some environments, increasing this value can reduce noise and produce more consistent measurements. Note that the data frame rate is affected by sample averaging.

The default sample average size is 10.

4.1.2.2.3 Output Frame Type

Command Line Parameter: `--outfrtyp`
Value Parameter: `short_ascii|full_ascii|cal`
Example: `set --outfrtyp short_ascii`

The output frame type specifies the format of the data frame that will be transmitted over the serial interface. The various frame formats are described in Section 4.1.1.

4.1.2.2.4 Calibration Coefficients

Command Line Parameter: `--caldata`
Value Parameter: `[a0,a1,im]`
Example: `get --caldata`

The `caldata` parameter can be used to set or retrieve the calibration coefficients that are used to convert raw ADC counts to PAR; `a0` is the dark offset, `a1` the scale factor, and `im` the immersion factor. Normally the user will only retrieve calibration coefficients, as specialized equipment is required to calibrate the PAR sensor in order to generate new coefficients.

4.1.2.2.5 Apply Immersion Coefficient

Command Line Parameter: `--immersed`
Value Parameter: `true|false`
Example: `set --immersed true`

The apply immersion coefficient parameter enables (true) or disables (false) the application of the stored immersion coefficient to the PAR data in the frames that provide engineering units. The immersion coefficient should be enabled when the sensor is used in water and disabled when used in air.

4.1.2.2.6 Sample Interval

Command Line Parameter: `--smplint`
Value Parameter: `10 - 60000`
Example: `set --smplint 100`

The sample interval specifies the time in milliseconds between PAR ADC samples. Note that the data frame rate is affected by the sample interval.

The default sample interval is 100.

4.1.2.2.7 Display Status Messages

Command Line Parameter: `--msgtotlm`
Value Parameter: `true|false`
Example: `set --msgtotlm true`

The display status messages parameter enables (true) or disables (false) the transmission of system messages over the serial interface.

Message display is enabled by default.

4.1.2.2.8 Message Level

Command Line Parameter: `--msglevel`
Value Parameter: `error|warn|info|debug`
Example: `set --msglevel warn`

The message level parameter specifies the verbosity of generated status messages.

The default level is `warn` (only warning or error messages are displayed).

4.1.2.2.9 Range

Command Line Parameter: `--range`
Value Parameter: `100 - 10000`
Example: `set --range 5000`

The range parameter specifies the maximum PAR value (in µmol photon photons•m^{-2}•s^{-1}) that can be represented on the analog interface. If the range of PAR values that can be expected for a deployment is known in advance, this parameter can be used to optimize the output voltage resolution. For most users, the default range value of 5000 µmol photons•m^{-2}•s^{-1} is appropriate.

4.1.2.2.10 Voltage Output Type

Command Line Parameter: `--votype`
Value Parameter: `none|linear|log`
Example: `set --votype linear`

The voltage output type specifies the operating mode the analog interface. If the value is set to `none`, the output voltage will not change with the measured PAR signal. If the type is set to `linear`, the output voltage will increase linearly over the measurement range. If set to log, the output voltage will increase logarithmically over the measurement range. The upper limit of the measurement range is set by the `range` parameter (see Section 4.1.2.2.9). The lower limit is set at -5 μmol photons•m^{-2}•s^{-1} in `linear` mode and 0.1 μmol photons•m^{-2}•s^{-1} in `log` mode.

The default voltage output type is `linear`.

4.1.2.2.11 Pitch Offset

Command Line Parameter: `--poffset`
Value Parameter: `-5.0 - +5.0`
Example: `set --poffset -0.8`

The pitch offset specifies a value to subtract from the calculated pitch measurement in order to correct for small errors due to mounting offsets.

The default pitch offset is 0.0 degrees; however, this value may be adjusted at Satlantic during final assembly.

4.1.2.2.12 Roll Offset

Command Line Parameter: `--roffset`
Value Parameter: `-5.0 - +5.0`
Example: `set --roffset -0.8`

The roll offset specifies a value to subtract from the calculated pitch measurement in order to correct for small errors due to mounting offsets.

The default roll offset is 0.0 degrees; however, this value may be adjusted at Satlantic during final assembly.

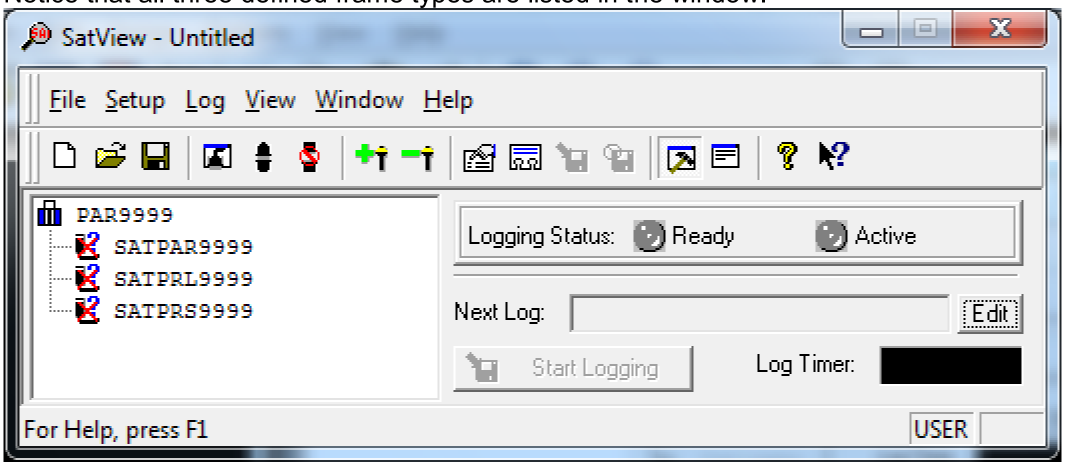
4.1.3 Controlling the Frame Rate

The PAR Sensor does not have a single setting that controls the data frame (update) rate. Instead, the frame rate is controlled primarily by the sample interval (`smplint`) and averaging (`navg`) parameters. For example, with the default `smplint` setting of 100 ms and `navg` setting of 10, the frame rate is 1 sample per second. However, if the `navg` setting is changed to 1, the frame rate will be 10 samples per second. The maximum frame rate of 100 samples per second is achieved by setting `navg` to 1 and `smplint` to 10 milliseconds.

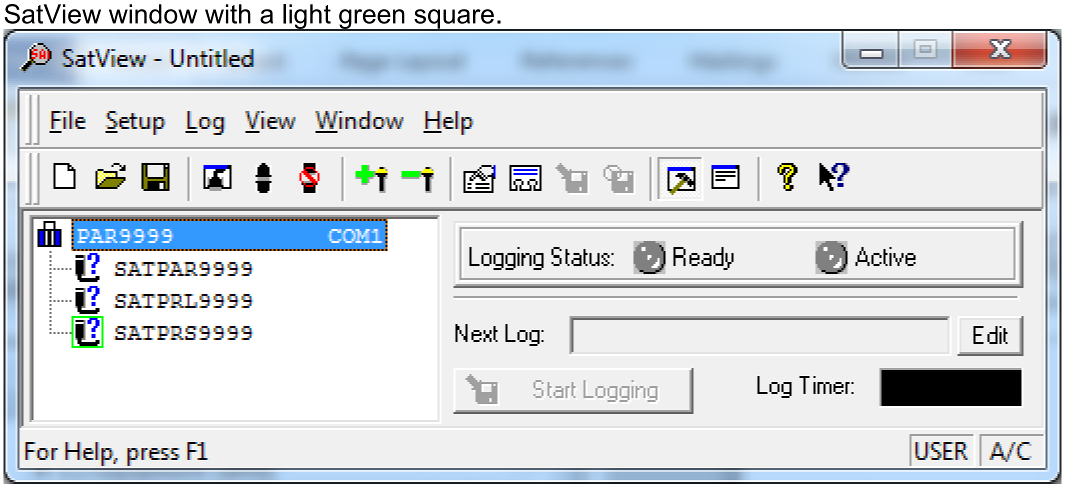
4.1.4 Using the PAR Sensor with SatView

SatView can be used to view and record PAR serial data.

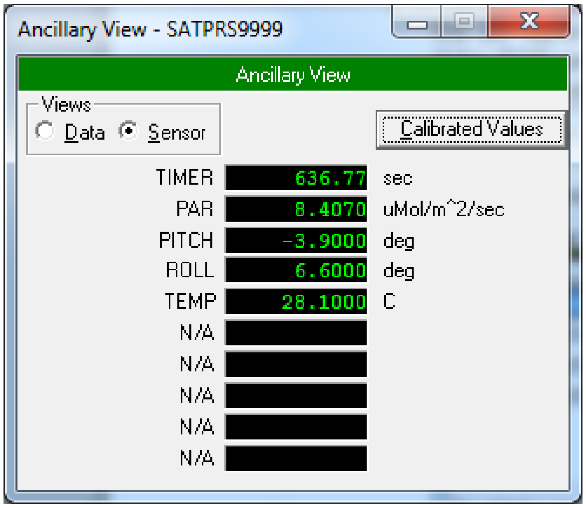
1. Install SatView on the PC and start it. Review the tutorial if desired.
2. Create a folder on your computer and save the PAR sensors .SIP (Satlantic Instrument Package) file in the folder. Here we'll use C:\PAR.
3. Connect the power/telemetry cable to the PAR sensor, PC, and power supply. Apply power.
4. Load the PAR .SIP file by dragging and dropping it in the SatView window, as shown. Notice that all three defined frame types are listed in the window.



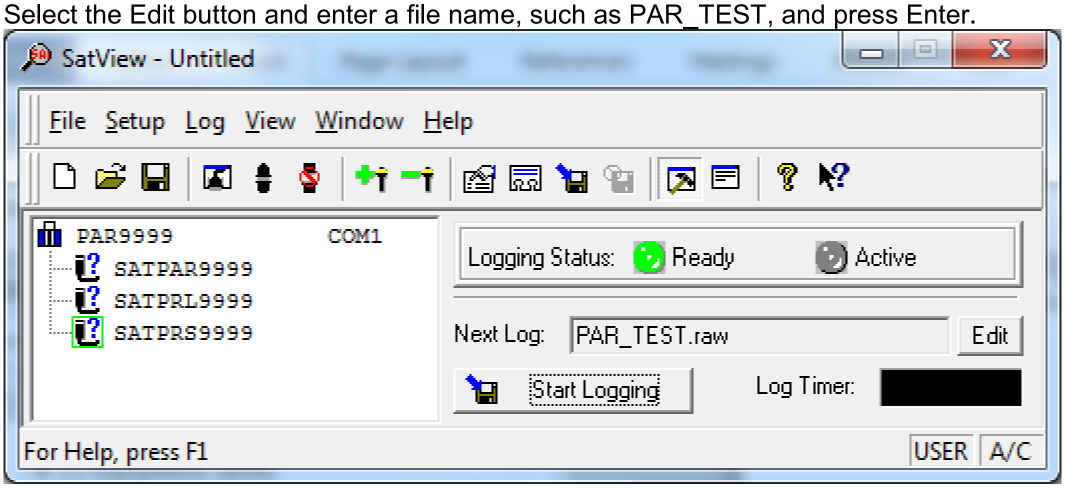
5. Configure SatView to read from the appropriate communication port by right-clicking on the SIP file in the SatView window and selecting "Read From…". Here we'll use COM1. If the PAR sensor is running, notice the active frame type will be highlighted in the SatView window with a light green square.



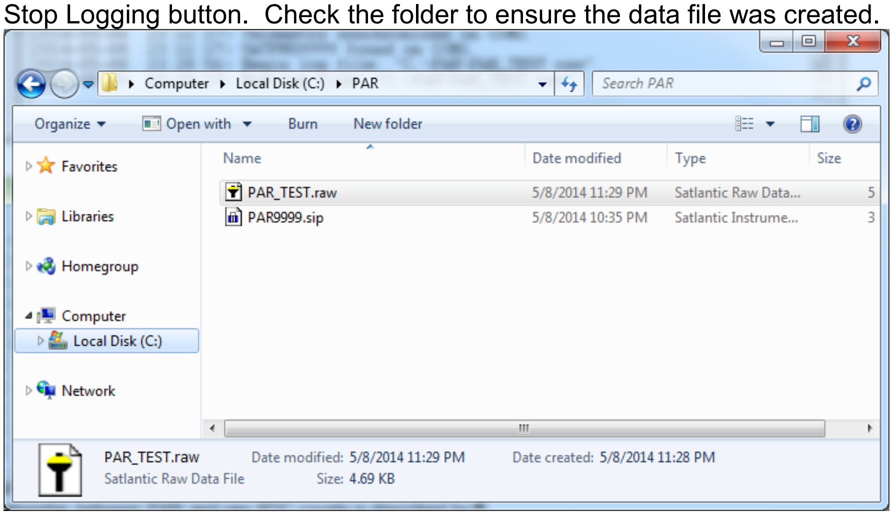
6. Double-click on the highlighted frame type (here SATPRS) in the SatView window to open the control panel, then double-click Ancillary View in the View List window to display the PAR data.



7. To log data in SatView, first select Log→Options to open the Logging Options window, then set the File Naming Mode to USER DEFINED. Change the Log Directory to the test directory you created earlier (C:\PAR). Click OK to close the dialog.
8. Select the Edit button and enter a file name, such as PAR_TEST, and press Enter.



9. Press the Start Logging button and log about 30 seconds of data, and then press the Stop Logging button. Check the folder to ensure the data file was created.



10. Remove power from the sensor and close SatView.

Refer to Section 4.1.5.1 for an explanation of processing the logged data with SatCon.

4.1.5 PAR Sensor Serial Data Analysis

The PAR Sensor uses a linear fitting function to convert between raw ADC counts and PAR. The relationship between PAR and raw ADC counts is described by:

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

where *Im* is the immersion coefficient, a_1 is the scaling factor, a_0 is the offset, and x is the ADC raw counts reported by the PAR sensor. This information can be found on your calibration sheet, and can also be retrieved from the PAR sensor with the `get —caldata` command (see Section 4.1.2.2.4). This equation calculates PAR in units of μmol photons•m^{-2}•s^{-1}.

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

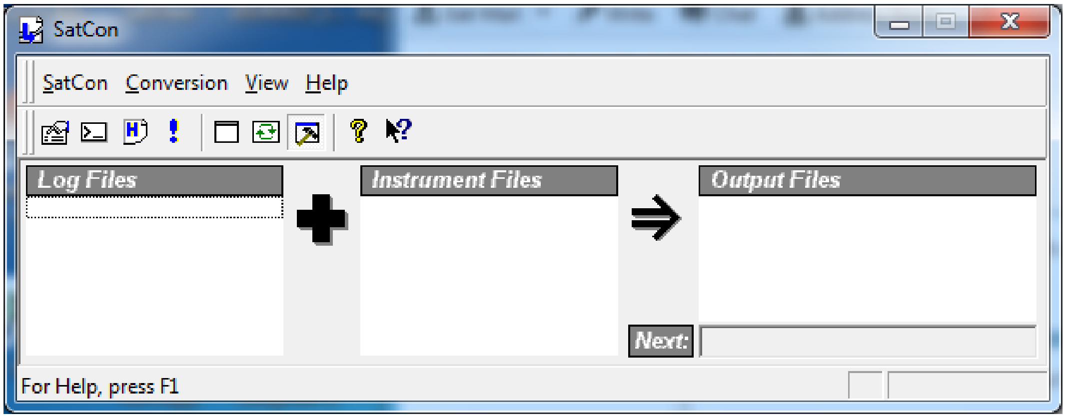
If using the SHORT_ASCII or FULL_ASCII frames, the sensor reports PAR in calibrated units and no additional processing is required. However if you have logged the data with SatView you may wish to process the data with SatCon so that the SatView-applied binary timestamps are converted to a friendlier ASCII format. If using the CAL frame and logging data with SatView, SatCon will apply the coefficients stored in the calibration files to generate the PAR value.

4.1.5.1 Processing PAR Data with SatCon

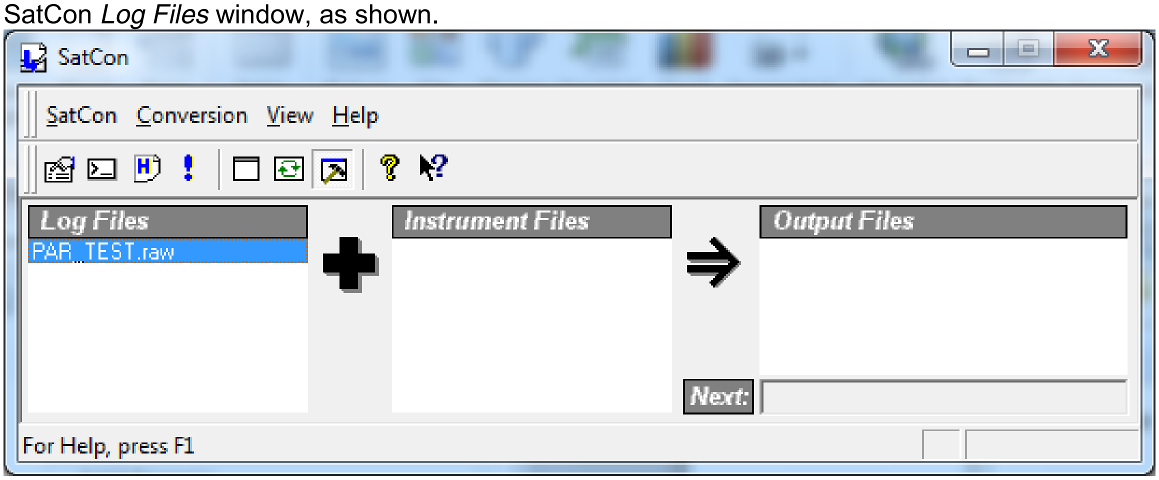
Satlantic's SatCon software is a Windows application for converting raw data log files into human readable, delimited ASCII text files. The raw data log files generally contain data that is formatted into frames or records. Each frame in a log file will contain one sample from each sensor within the instrument. The raw telemetry of most instruments made by Satlantic falls into a fixed format that conforms to Satlantic's data format standard (RD2). This program allows data analysts to extract the samples in a form suitable for use with applications such as spreadsheets or Matlab. The analyst can optionally retrieve calibrated or raw digital data in ASCII form. The data format information required for the conversion is obtained from a Calibration file (.cal) or Telemetry Definition File (.tdf). Generally calibration files are used to describe binary data while tdf files are used with variable length ASCII data or non-Satlantic instruments, but this is not always true. As long as the proper formats are used within the file, it does not matter which file extension is used. These files define the format of the data and contain the coefficients for converting raw digital samples into calibrated physical units, if required. SatCon will work for any instrument or data source that conforms to Satlantic's data format standard. Generally Satlantic provides all tdf and calibration files for a system in a compressed (zip format) Satlantic Instrument Package (.sip) file that can be used with SatCon.

To assist users in getting started, a simple walkthrough for SatCon is provided below using the standard application window. For details on using the command line interface for SatCon, please refer to the users manual (RD4) or online help.

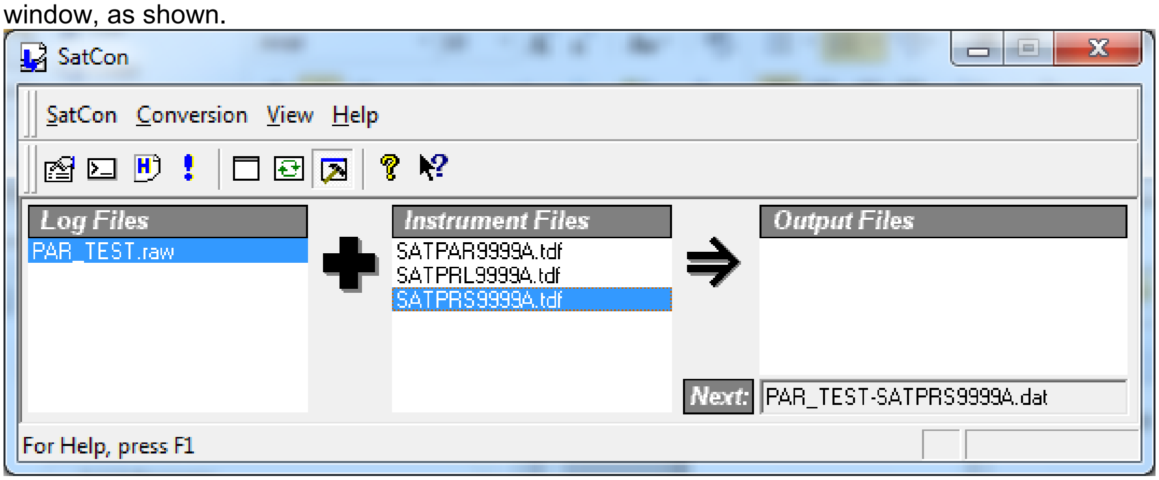
1. Install SatCon version 1.5.5 (or later) by clicking on the self-installing executable provided on CD. The installation wizard will step you through the installation process. Refer to the Readme file for release information.
2. Start the program if it is not already running. You should see the following screen:



3. It is always a good idea to display the conversion log window. It provides useful runtime information, and is invaluable when troubleshooting problems. Select **View** → **Conversion Log**. A separate Conversion Log Output window will open – arrange the windows as desired.
4. SatCon supports drag-n-drop operation. Select the desired .RAW file and drag it into the SatCon *Log Files* window, as shown.

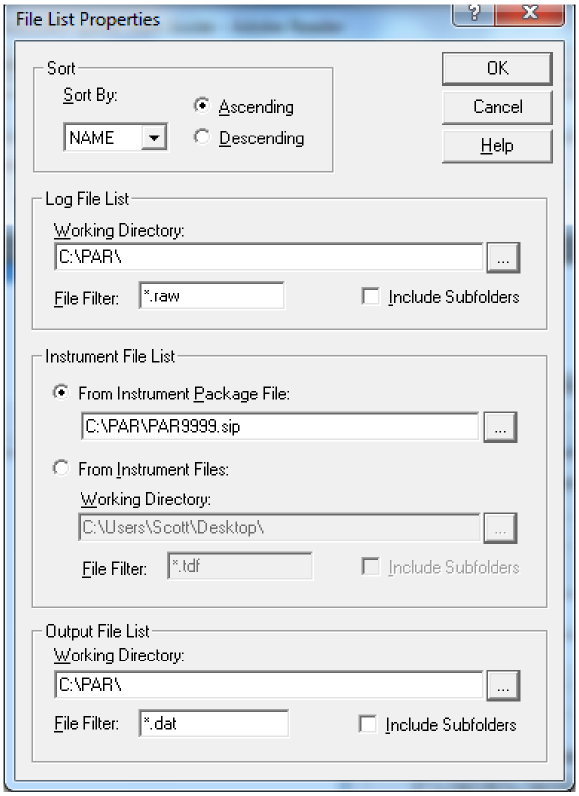


5. Similarly, load the calibration files by dragging the sip file into SatCon's *Instrument Files* window, as shown.

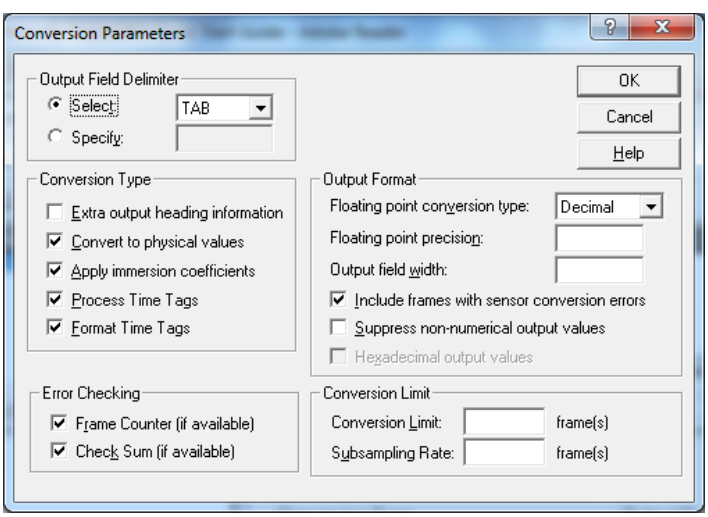


The SIP file contains the three tdf files describing the supported frame types.

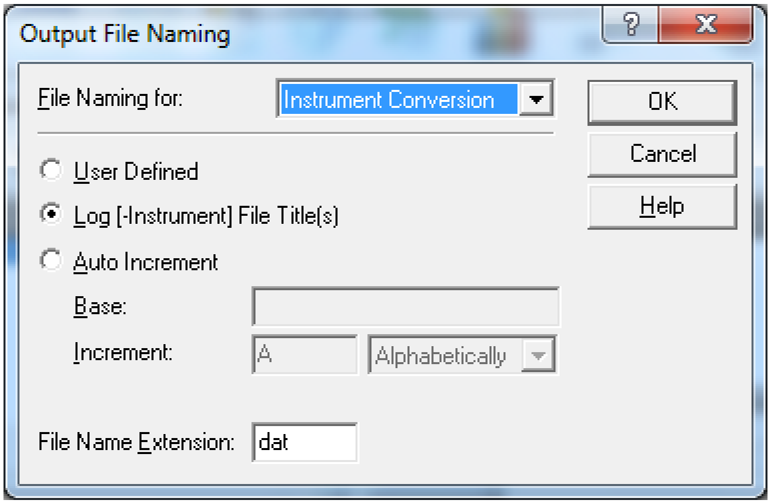
6. Next, we want to instruct SatCon as to where to place the converted files. Select **View → Properties**. A *File List* Properties dialog box will appear. Notice that the Log File List and Instrument File List paths are correct from our drag-n-drop operations above. At the bottom of the window is the Output File List path – let's set this to our test directory C:\PAR\, as shown. Click OK to close the dialog.



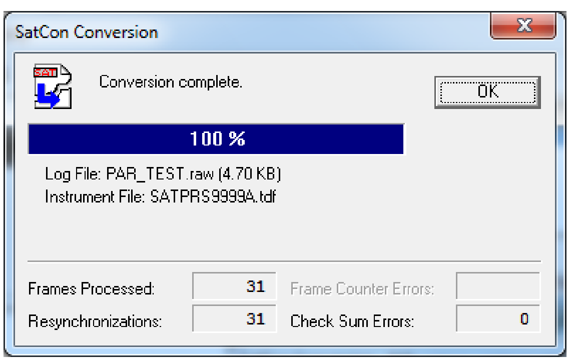
7. Next we will configure the data conversion parameters. Select **Conversion → Parameters** to open the *Conversion Parameters* dialog.
8. Configure the *Conversion Parameters* dialog as shown below, and then click OK to close the dialog.



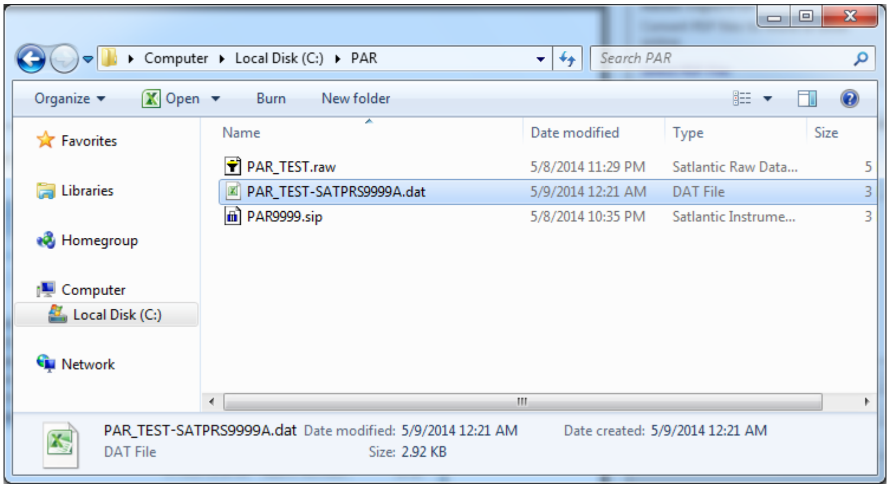
9. Next, set the output file naming convention. Select **Conversion** → **File Naming**, then configure the dialog as shown; this will automatically name the converted file based on the log file and instrument file. Click OK to close the dialog when you are finished.



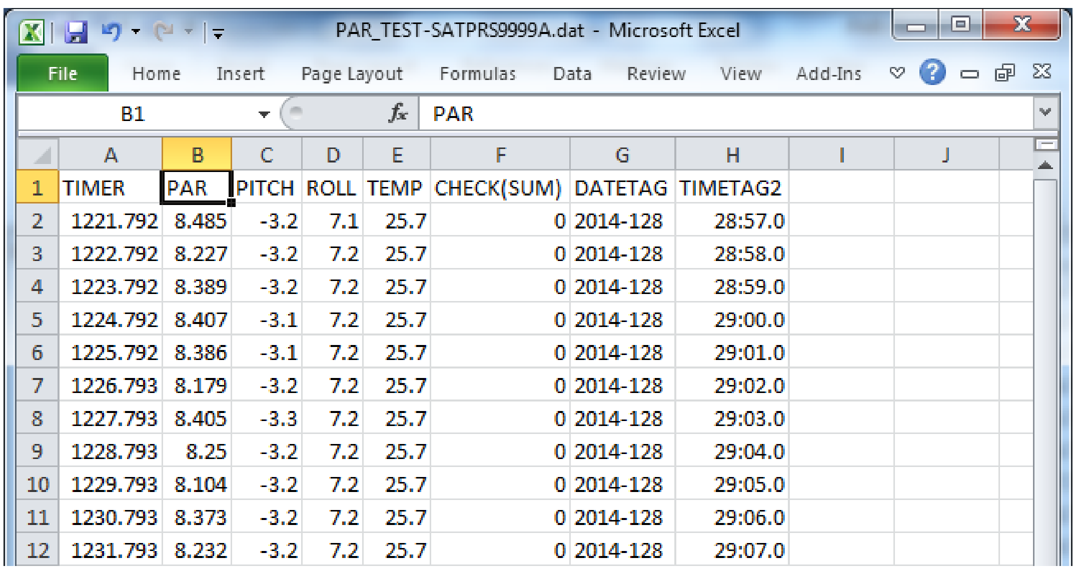
10. In the main SatCon window, select the RAW file and as well as the tdf file to be used, in this case SATPRS. Notice the output file name is automatically created in the *Next:* box.
11. Press the blue exclamation point (**!**) or select **Conversion** → **Convert** to begin the data conversion. Click OK if SatCon gives warnings about not finding valid frame counter sensors – this is because you have indicated in the Conversion Parameters dialog to perform frame counter and checksum error checking, but no frame counters are available for this instrument.
12. As the data file is converted, you will see a conversion progress dialog, as shown below. Click OK when the conversion completes. Notice that the Conversion Log Output window has been updated – read through it if you are curious.



13. The converted file can be found in the output directory with a .dat extension, as shown.



14. The .dat files contain tab-delimited ASCII data that can be opened directly in Microsoft Excel, Open Office Calc, or other spreadsheet programs, as shown.



4.1.6 Firmware Updates

Satlantic may occasionally provide firmware updates for the PAR sensor. The firmware update will be a file named *PAR_V2_vX.Y.Z.sfw*, where *X.Y.Z* is the firmware version. The firmware upgrade is initiated via the `upgrade` command - see section 4.1.2.1.8 for details.

After the upgrade command is issued, the PAR sensor's bootloader program executes. You should see something similar to the following:

```
PAR Serial Bootloader
Version 1.0.0   Build: Apr 30 2014 12:46:10

PARBLDR>
```

Press ? to see a help listing:

```
PARBLDR> ?
Available Commands:
A - Run Application Program on startup
B - Run Bootloader on startup
C - Return program CRC
K - Return Bootloader key
R - Return Bootloader revision
S - Start program immediately
V - Validate program
W - Write Program
X - Use CRC on packets
Y - Use Checksum on packets
Z - Get packet validation
? - Display help

$Ok

PARBLDR>
```

Firmware upgrades are performed using the XMODEM protocol. The PAR bootloader uses 128-byte packets and supports both CRC and checksum error checking.

A typical upgrade procedure is as follows:

1) Press X to instruct the bootloader to use CRC validation on packets.
2) Press W to initiate the transfer.
3) Immediately browse to the folder containing the *sfw* file and transfer the file using XMODEM. Ensure the option to use CRC checking, if present, is enabled; some emulators autodetect the validation type. Note the bootloader will time out after about 10 seconds - if the transfer doesn't begin after a few seconds, cancel it and repeat step 2.
4) When the transfer completes, validate the upload by pressing V.
5) If the program validates, press A to instruct the PAR sensor to execute the application by default, otherwise it will return to the bootloader on the next power cycle.
6) Press S to start the program immediately, or power cycle the PAR sensor.
7) When the new firmware starts, enter the command console by pressing the $ key. Check the banner to ensure that the new firmware version (the X.Y.Z portion of the sfw file name) is reported.

4.2 Analog Interface

The PAR analog interface is provided by a precision 16-bit voltage-output DAC (Digital-to-Analog Converter). The user can configure the output to operate in either linear or logarithmic mode with a standard range of 0 to 5000 μmol photons•m^{-2}•s^{-1} or 0.1 – 5000 μmol photons•m^{-2}•s^{-1} respectively.

Sections 4.2.1 and 4.2.2 below describe the calibration coefficients and how to compute PAR based on the measured output voltage. The analog coefficients are not stored on the PAR sensor.

4.2.1 Linear Voltage Output Data Analysis

When in linear output mode, the PAR sensor uses a linear fitting function to convert between output voltage and PAR. The relationship between PAR and voltage is described by the simple linear equation

$$PAR = m * signal + b$$

where *PAR* is the calculated PAR value in units of μmol photons•m^{-2}•s^{-1}, *signal* is the measured analog voltage in Volts, *m* is the slope, and *b* is the offset.

With the default 5000 μmol photons•m^{-2}•s^{-1} range setting, the standard coefficients used with linear mode are:

m	1291.593195
b	-166.451613

If you change the range or wish to calibrate the voltage output in your measurement system, you must recalculate the *m* and *b* coefficients. Please refer to section 4.2.3 for details.

4.2.2 Logarithmic Voltage Output Data Analysis

When in logarithmic output mode, the PAR sensor uses a logarithmic fitting function to convert between output voltage and PAR. The relationship between PAR and voltage is described by

$$PAR = 10^{\frac{signal - q}{p}}$$

where *PAR* is the calculated PAR value in units of μmol photons•m^{-2}•s^{-1}, *signal* is the measured analog voltage in Volts, *m* is the scaling factor, and *b* is the offset.

With the default 5000 μmol photons•m^{-2}•s^{-1} range setting, the standard coefficients used with logarithmic mode are:

p	0.824661
q	0.949663

If you change the range or wish to calibrate the voltage output in your measurement system, you must recalculate the *p* and *b* coefficients. Please refer to section 4.2.3 for details.

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

4.2.3 In-System Calibration of the Analog Voltage Output

The coefficients provided in Sections 4.2.1 and 4.2.2 are based on the nominal minimum and maximum voltage output from the PAR sensor over the default PAR measurement range. For greater measurement accuracy in-system calibration coefficients can be generated. In order to perform an in-system calibration, a Y-cable is required that connects the PAR sensor to both the data acquisition device and a computer. Please contact Satlantic for assistance in creating or purchasing such a cable. The procedure to perform the in-system calibration is as follows:

1) Connect the Y-cable to the PAR sensor, your computer, a power supply and the data logger voltage input
2) Power the PAR sensor and access the `PAR>` command prompt by pressing the $ character.
3) Retrieve the current range setting with the `get --range` command; the default is 5000. If you wish to change this value, use `set --range <value>`. Record the range value.
4) Retrieve the current output mode setting with the `get --votype` command. Change to the appropriate mode if required with either `set --votype` linear or `set --votype` log.
5) At the `PAR>` prompt, enter `dac --min`. Record this value as Vmin; it should be close to 0.125 V.
6) At the `PAR>` prompt, enter `dac --max`. Record this value as Vmax; it should be close to 4.000 V.
7) Calculate the coefficients for the output voltage mode as described below in sections 4.2.3.1 or 4.2.3.2.
8) Test the coefficients with your system using the `dac --par <value>` command, where <value> is the simulated PAR measurement value. Apply the coefficients to the reported voltage and see if the calculation agrees.

4.2.3.1 Calculation of Linear Mode Coefficients

For linear mode, use the following equations to calculate the coefficients.

$$m = \frac{range - (-5)}{Vmax - Vmin}$$

$$b = range - m \times Vmax$$

4.2.3.2 Calculation of Log Mode Coefficients

For log mode, use the following equations to calculate the coefficients.

$$p = \frac{Vmax - Vmin}{\log_{10} range - \log_{10} 0.1}$$

$$q = Vmin - p \times \log_{10} 0.1$$

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.

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 LP.

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 LP 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.

7 Contact Information

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

Location

Satlantic LP
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
Heritage Day	Third Monday in February
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

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 Seasave software documentation for more information on PAR calibration coefficients.

From Section 4.2.2 Logarithmic Voltage Output Data Analysis, Satlantic's equation for calculating PAR from the output voltage in logarithmic mode is:

Equation 1:
$$PAR = 10^{\frac{signal - q}{p}}$$

where *p* is the scaling factor, *q* is the voltage offset, and *signal* is the analog voltage in Volts. Sea-Bird Electronics Sea Soft program uses the following equation to calculate PAR:

Equation 2:
$$PAR = \frac{multiplier \times 10^9 \times 10^{\frac{V-B}{M}}}{Calibration\_const.} + offset$$

When using µEinsteins/(m^2*sec), which is equivalent to µmol photons•m^{-2}•s^{-1}, the *multiplier* may be set to 1:

Equation 3:
$$PAR = \frac{10^9 \times 10^{\frac{V-B}{M}}}{Calibration\_const.} + offset$$

For the Satlantic PAR sensor with logarithmic output, the offset is also effectively 0. Therefore:

Equation 4:
$$PAR = \frac{10^9 \times 10^{\frac{V-B}{M}}}{Calibration\_const.}$$

To make equations 1 and 4 equivalent then:

$Calibration\_const = 10^9$
$B = q$
$M = p$

If using the default PAR range setting, the values for *p* and *q* are given in Section 4.2.2. Use the procedure outlined in Section 4.2.3.2 to calculate the new *p* and *q* values if you have changed the range setting or performed an in-system voltage calibration.

Appendix B - TDF templates

The following sections provide template examples of the tdf files used to describe the various PAR sensor frame types. These tdfs are used by SatView and SatCon.

CAL Frame TDF Template

```
##########################################################################################
# Telemetry Definition File:
#
# Type: Satlantic PAR Sensor <insert sn here>
# Description: Digital (RS-232) PAR Sensor - CAL frame type
# Project: <insert project # here>
# Date: <insert date>
# User: <employee name>
#
# Notes:
#       The PAR sensor outputs comma-delimited ASCII data.
#
#       This tdf file should be named SATPARxxxx[Rev].tdf, e.g. SATPAR9999A.tdf.
#       The [Rev] field is the alphabetical revision of the file, and should be
#       updated when calibration coefficients are changed.
#
# Creation Date: May 8, 2014
# Author: Scott Feener
#
# Template History:
#   2014-05-08, SF: Template created
#
#
# File History:
#   Revision:   Date:       User:       Notes:
#   A           2014-mm-dd
#
#
###########################################################################################

#
# Instrument specific header and SN
#
VLF_INSTRUMENT SATPAR9999 '' 10 AS 0 NONE

# Time since startup
FIELD NONE ',' 1 AS 0 DELIMITER
TIMER NONE 'sec' V AF 0 COUNT

#
# PAR channel#
# A0 A1 Im
# PARValue = A1 * ( COUNTS - A0 ) * Immersion
FIELD NONE ',' 1 AS 0 DELIMITER
PAR NONE 'uMol/m^2/sec' V AU 1 OPTIC2
34121900 3.195677e-004 1.3589


# ASCII check sum
FIELD NONE ',' 1 AS 0 DELIMITER
CHECK SUM '' V AI 0 COUNT

TERMINATOR NONE '\x0D\x0A' 2 AS 0 DELIMITER
```

SHORT_ASCII Frame TDF Template

```
##########################################################################################
# Telemetry Definition File:
#
# Type: Satlantic PAR Sensor <insert sn here>
# Description: Digital (RS-232) PAR Sensor - SHORT_ASCII frame type
# Project: <insert project # here>
# Date: <insert date>
# User: <employee name>
#
# Notes:
#       The PAR sensor outputs comma-delimited ASCII data.
#
#       This tdf file should be named SATPARxxxx[Rev].tdf, e.g. SATPAR9999A.tdf.
#       The [Rev] field is the alphabetical revision of the file, and should be
#       updated when calibration coefficients are changed.
#
# Creation Date: May 8, 2014
# Author: Scott Feener
#
# Template History:
#   2014-05-08, SF: Template created
#
#
# File History:
#   Revision:   Date:       User:       Notes:
#   A           2014-mm-dd
#
###########################################################################################

#
# Instrument specific header and SN
#
VLF_INSTRUMENT SATPRS9999 '' 10 AS 0 NONE

# Time since startup
FIELD NONE ',' 1 AS 0 DELIMITER
TIMER NONE 'sec' V AF 0 COUNT

#
# PAR channel #
# Calculated PAR value
#
FIELD NONE ',' 1 AS 0 DELIMITER
PAR NONE 'uMol/m^2/sec' V AF 0 COUNT

#
# Pitch data
#
FIELD NONE ',' 1 AS 0 DELIMITER
PITCH NONE 'deg' V AF 0 COUNT

#
# Roll data
#
FIELD NONE ',' 1 AS 0 DELIMITER
ROLL NONE 'deg' V AF 0 COUNT

# Temperature
FIELD NONE ',' 1 AS 0 DELIMITER
TEMP NONE 'C' V AF 0 COUNT

# ASCII check sum
FIELD NONE ',' 1 AS 0 DELIMITER
CHECK SUM '' V AI 0 COUNT

TERMINATOR NONE '\x0D\x0A' 2 AS 0 DELIMITER
```

FULL_ASCII Frame TDF Template

```
################################################################################
# Telemetry Definition File:
#
# Type: Satlantic PAR Sensor <insert sn here>
# Description: Digital (RS-232) PAR Sensor - FULL_ASCII frame type
# Project: <insert project # here>
# Date: <insert date>
# User: <employee name>
#
# Notes:
#       The PAR sensor outputs comma-delimited ASCII data.
#
#       This tdf file should be named SATPARxxxx[Rev].tdf, e.g. SATPAR9999A.tdf.
#       The [Rev] field is the alphabetical revision of the file, and should be
#       updated when calibration coefficients are changed.
#
# Creation Date: May 8, 2014
# Author: Scott Feener
#
# Template History:
#   2014-05-08, SF: Template created
#
#
# File History:
#   Revision:   Date:       User:       Notes:
#   A           2014-mm-dd
#
#
################################################################################

#
# Instrument specific header and SN
#
VLF_INSTRUMENT SATPRL9999 '' 10 AS 0 NONE

# Time since startup
FIELD NONE ',' 1 AS 0 DELIMITER
TIMER NONE 'sec' V AF 0 COUNT

#
# PAR channel #
# Calculated PAR value
#
FIELD NONE ',' 1 AS 0 DELIMITER
PAR NONE 'uMol/m^2/sec' V AF 0 COUNT

#
# Pitch data
#
FIELD NONE ',' 1 AS 0 DELIMITER
PITCH NONE 'deg' V AF 0 COUNT

#
# Roll data
#
FIELD NONE ',' 1 AS 0 DELIMITER
ROLL NONE 'deg' V AF 0 COUNT

# Temperature
FIELD NONE ',' 1 AS 0 DELIMITER
TEMP NONE 'C' V AF 0 COUNT

# Analog Output Voltage Mode
FIELD NONE ',' 1 AS 0 DELIMITER
VOTYPE NONE '' V AS 0 COUNT
```

```
# Raw PAR ADC counts
FIELD NONE ',' 1 AS 0 DELIMITER
PARRAW NONE 'counts' V AU 0 COUNT

# Raw PAR ADC voltage input
FIELD NONE ',' 1 AS 0 DELIMITER
PARV NONE 'V' V AF 0 COUNT

# Analog interface voltage output
FIELD NONE ',' 1 AS 0 DELIMITER
VOUT NONE 'V' V AF 0 COUNT

# Raw accelerometer X-axis counts
FIELD NONE ',' 1 AS 0 DELIMITER
XAXIS NONE 'counts' V AI 0 COUNT

# Raw accelerometer Y-axis counts
FIELD NONE ',' 1 AS 0 DELIMITER
YAXIS NONE 'counts' V AI 0 COUNT

# Raw accelerometer Z-axis counts
FIELD NONE ',' 1 AS 0 DELIMITER
ZAXIS NONE 'counts' V AI 0 COUNT

# Temperature raw counts
FIELD NONE ',' 1 AS 0 DELIMITER
TRAW NONE 'counts' V AI 0 COUNT

# Temperature ADC input voltage
FIELD NONE ',' 1 AS 0 DELIMITER
TV NONE 'V' V AF 0 COUNT

# STATUS
FIELD NONE ',' 1 AS 0 DELIMITER
STATUS NONE '' V AI 0 COUNT

# ASCII check sum
FIELD NONE ',' 1 AS 0 DELIMITER
CHECK SUM '' V AI 0 COUNT

TERMINATOR NONE '\x0D\x0A' 2 AS 0 DELIMITER
```