AML-6 RT: User Manual

Multiparameter Real Time Instrument

Revision History

Revision	Date	Description
1.1	June 06, 2020	Document Created
1.1.1	July 21, 2020	Added note to serial communication information
1.2	Feb 03, 2021	Sleep Mode, Monitor Checksum, AMLx Files
1.3	April 30, 2021	RS-485, Deep Variant
1.4	Sep 07, 2021	Storage Recommendations, Additional Commands, USB FAQ
1.5	Jan 14, 2022	Additional power setting commands

1 Introduction

The AML-6 series of instruments is a highly configurable family of multiparameter sondes designed for a wide range of data collection applications. The '6' designation refers to the number of sensors that may be simultaneously installed on the instrument endcap. Additional sensors may be connected externally, allowing up to 8 sensors in total.

There are two primary configurations of instruments in the AML-6 family: the AML-6 LGR, a self-powered instrument designed for profiling applications, and the AML-6 RT, an externally powered instrument intended for Real Time applications. While nearly identical in size and form factor, the two configurations differ in a few key features which specialize them for their respective applications.

Instruments with the LGR designation (ie. AML-6 LGR) are self-powered via a rechargeable internal battery and have a mechanical on/off switch adjacent to their shackle. These instruments are designed to internally log sensor measurements and transfer data post-deployment. These instruments are most commonly used for multiparameter profiling.

Real-Time instruments (ie. AML-6 RT), in contrast, are designed to stream data while in-situ (though they have the ability to internally record data as well). Both power and communication to these instruments is facilitated via a waterproof connector located adjacent to the shackle. These instruments rely on external power for operation and the application of this power turns the instrument on in lieu of a mechanical switch These instruments are commonly used in moored applications, buoys, underwater observatories, and ROVs.

This manual describes the operation of the Real-Time version, the AML-6 RT.

1.1 Instrument Overview

AML-6 instruments are highly customizable and so may be equipped with a wide range of user-specific sensors, functionality, and features. The instrument described here is intended to be a representative example of a typical setup and therefore may not be identical to the Reader's. The Reader is directed to any unit-specific supplementary documentation provided with their instrument for information on features and functionality not described here.

Figure 1 depicts a typical AML-6 RT arrangement.
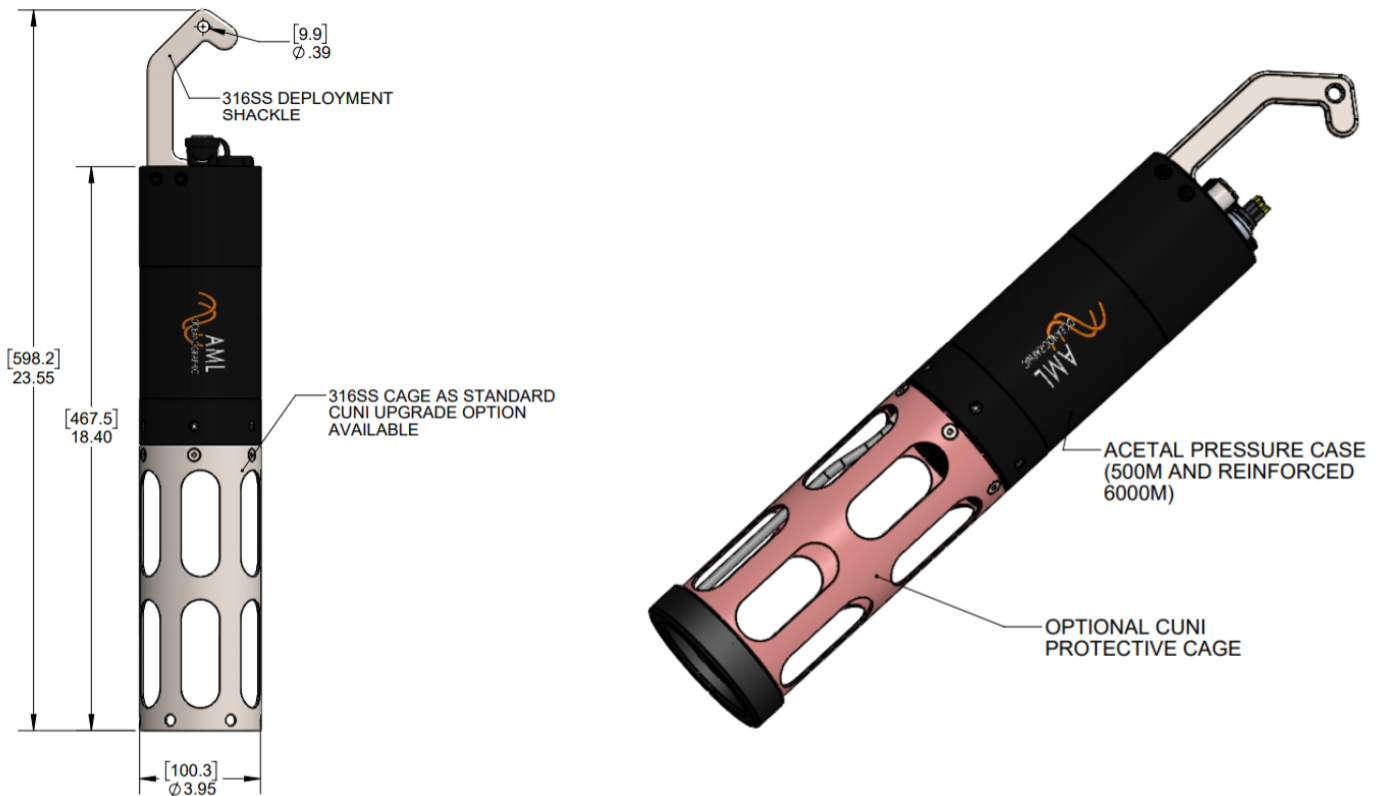
Figure 1: A typical AML-6 RT arrangement. The arrangement shown here is representative only and may differ from the Reader's instrument. Top left image depicts the recommended deployment orientation - fixed vertically with the shackle end up.

By default, AML-6 RT instruments come equipped with a shackle, a USB-C connector, a waterproof MCBH connector, and a status indicator LED. The shackle has a hole coincident with the axis of the instrument to facilitate suspension during deployment. It is also hook-shaped to provide secure handling by a user.

The instrument end opposite the shackle, houses the sensor payload which is mechanically protected by a bolted-on sensor cage. In some configurations the cage may be made from a copper alloy to prevent biofouling (optional upgrade) but the default configuration uses stainless steel.

Specifications:

Model	500m	6000m
Depth rating	500 meters / 1640 feet	6000m / 19685 feet
Material	Acetal, 316 stainless steel, titanium, polycarbonate	Acetal, 316 stainless steel, titanium, polycarbonate
Data storage	30 GB	30 GB
Software	Sailfish	Sailfish
Communication	RS-232 or RS-485 (Factory set) USB-C	RS-232 or RS-485 (Factory set) USB-C
Maximum Sample Rate	20 Hz Note: Sampling by pressure or sound velocity increment is also available.	20 Hz Note: Sampling by pressure or sound velocity increment is also available.
Power	2 Cell Internal Battery 21Wh PC or wall charging over USB (10W minimum) 8-30VDC via MCBH connector Note: External power supply should be able to support at least 10W output. Consider voltage drop when using longer cables.	2 Cell Internal Battery 21Wh PC or wall charging over USB (10W minimum) 8-30VDC via MCBH connector Note: External power supply should be able to support at least 10W output. Consider voltage drop when using longer cables.
Temperature Operation Storage	-20 to +45°C -20 to +60°C	-20 to +45°C -20 to +60°C
Dimensions Diameter Length Weight* Weight in water*	10.0 cm / 3.90 in 60.0 cm / 23.6 in 4.00 kg / 8.80 lb 2.00 kg / 4.40 lb	10.0 cm / 3.90 in 60.0 cm / 23.6 in 5.80 kg / 12.80 lb 3.80 kg / 8.40 lb

*With no installed sensors, deployment weight will vary.

1.2 Internal Battery

While an AML-6 RT instrument must use external power for operation, the instrument does contain a small rechargeable internal battery. The internal battery is used to retain the time, date, and configuration information when the instrument is not externally powered. The battery also helps to provide a graceful shutdown in the event of sudden power loss. **The internal battery is not intended to sustain operation of the instrument.** However, if the power supplied to the instrument is insufficient (for example with sufficient voltage but insufficient current), it is possible that the internal battery will supplement the external power to keep the instrument running. To avoid depleting the battery under poor external power conditions, the instrument can be configured to only boot up above a specific input voltage, and the instrument can be configured to shut down when it detects that the internal battery is supplementing the external power. See *batvnoboot* and *batinoboot* commands for more information.

The battery typically requires a charging top-up when the instrument is first received by the user. Application of power through the MCBH connector will charge the internal battery. **Note that the instrument body may get warm during charging.** This is normal and a result of the instrument's fast-charge capability. This behaviour does not occur during typical deployments.

The instrument has the ability to charge its internal battery via USB-C connector, but USB-C ports found on most computer systems do not provide enough current to achieve this. To charge the instrument through its USB-C port, connect the instrument to an appropriate USB-C-wall wart adapter (minimum 5W charger).

1.3 Connectors and Cables

AML-6 RT instruments come with two connectors:

1. **A waterproof MCBH connector.**

    a. This connector is used to provide external power and serial communications to the instrument during deployment. The instrument can be factory set to either RS-232 or RS-485 full duplex. Its typical use is for the transmission of live measurements during deployment. **Note: Internally logged data cannot be downloaded with this connector (instead, use the USB-C connector).**

RS-232 COMMUNICATIONS (default)

Micro-6 Connector

	Pin		Ground	Pin	9 Pin "D" Connector
Signal - Rx	1	White		3	
Ground	2	Black		5	
Power +	3	Red			
Signal - Tx	4	Green		2	
N/C	5	Blue	N/C		
N/C	6	Brown	N/C		
N/C		Screen	N/C		

Power +

RS-485 COMMUNICATIONS

Micro-6 Connector

	Pin		Ground	Pin	9 Pin "D" Connector
Signal - 485Z	1	White		2	
Ground	2	Black		5	
Power +	3	Red			
Signal - 485Y	4	Green		7	
Signal - 485A	5	Blue		3	
Signal - 485B	6	Brown		8	
N/C		Screen	N/C		
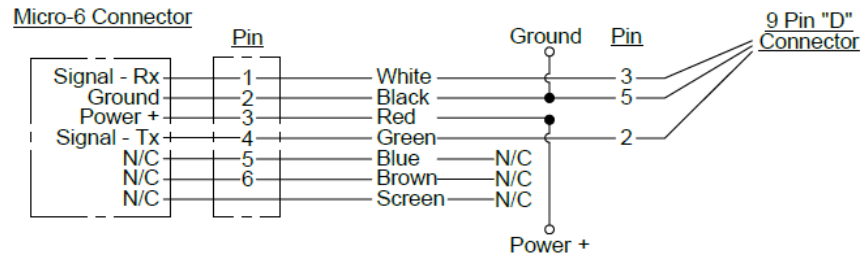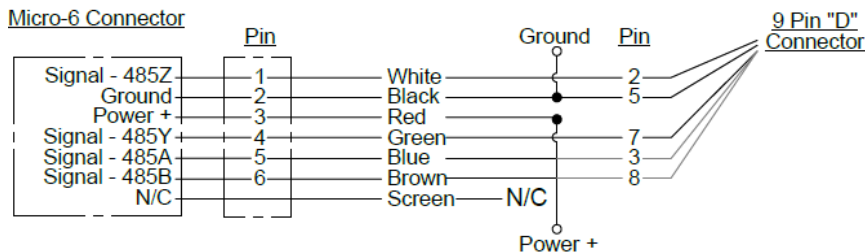
Power +

b. AML-6 RT instruments are typically sold with a length of underwater cable which has an MCBH series connector at one end, and a serial DB9 connector with flying power leads at the other end. This cable provides a means to communicate serially with the instrument and apply external power in bench top settings.

c. If a serial communication cable longer than 3 metres is used then it is necessary to add surge protection.

2. **A USB-C connector** with waterproof cover.

a. This connector provides power to the instrument (when connected to a compatible USB port) and also provides high speed communications. This connector is used for data transfer (downloading internally logged data) and configuration via AML's interface software, Sailfish. **Note: This connector is only waterproof when the protective cover is installed. It is not intended for use when deployed. Do not remove the waterproof cover when the instrument is wet.**

b. AML-6 RT instruments come with a USB-C to USB-A adapter cable to maximize PC compatibility. The instrument may also be connected to any USB-C port using a standard USB-C interconnect cable, though cable length should not exceed 1m.

1.4 Auxiliary Sensors

It is possible for AML-6 instruments to be equipped with sensors which are not installed on the instrument sensor endcap, such as Dissolved Oxygen (DO) and PAR sensors. These are referred to as auxiliary sensors and may be either fastened to the side of the instrument body or installed on adjacent moored equipment. In all cases, auxiliary sensors are connected to the instrument via a waterproof connector on the Connector Endcap, providing power and communication (note that Figure 1 does not show any auxiliary sensors).

It is typical for auxiliary sensors mounted on the side of the instrument to be protected by a stainless steel or copper alloy guard.

1.5 UV biofouling control

AML-6 instruments are frequently equipped with AML's UV biofouling control technology, which consists of a titanium housing with LEDs behind a glass window. The LEDs are oriented such that they illuminate the critical surfaces of the sensor payload. A plastic S clip secures the stem to the sensor cage. All surfaces with a direct line of sight to the LEDs will receive biofouling protection, including the externally mounted auxiliary sensors. The UV biofouling system is a factory-equipped option.

UV-equipped instruments are factory-set to emit UV-C light on a pre-programmed duty cycle immediately on instrument powerup. **Do not expose bare skin or eyes to the emitted light.**

For most applications, AML-6 RT instruments are shipped from the factory with all sensors pre-installed and configured.

1.6 Indicator LED Flash Patterns

The instrument is equipped with a multi-colour indicator LED, located adjacent to the shackle. The tables below describe the pattern and colour indications.

	Steady (solid on)	Single flash - - - - - -	Smooth transition	Rapid flash
Green	Ready Battery good	Logging Battery good	-	-
Red	Ready Battery low	Logging Battery low	-	Shutting down Battery critical level
Orange/ White/ Blue	-	-	Boot up or boot down sequence.	-
White	-	-	-	Error state

1.7 Pressure Ratings

Pressure ratings may differ between installed sensors and the instrument body, and deployments should never exceed the shallower of these ratings. For example, a 500 m instrument equipped with a 6000 dBar pressure sensor is limited to deployments of 500 m depth or less. Similarly, a 6000 m instrument equipped with a 500 dBar pressure sensor is also limited to deployments of 500 m depth or less.

The instrument pressure rating is identified on the end of the instrument, adjacent to the shackle. Typical ratings for AML-6 RT instruments are 500m and 6000m (note that both ratings use plastic housings).

2 Getting Started

This section provides an overview of basic instrument operation and functionality under a factory-default setup. Specifically, this section describes how to connect to the instrument, change settings via interface software, stream sensor measurements, and record and download data.

Details describing how to change the instrument's configuration and behaviour are described in the *Configuration* section of this document.

2.1 Serial (MCBH) vs USB-C connection - What's the difference?

Serial and USB-C connections provide equivalent capabilities - both connection types allow for instrument configuration, access to command line, ability to stream data etc. However, there are two features which are unique to the USB-C connection:

1. Firmware updates may only be done over USB-C (via Sailfish).
2. Data logged on the instrument (if configured to log data) can only be downloaded by USB-C.

Generally speaking USB-C use should be reserved for clean, dry environments like labs and offices. In the field, the serial (MCBH) connector should be used exclusively as it is more physically robust and impervious to saltwater.

When using Sailfish, either connection type may be used (Sailfish supports both). When using a Serial Terminal (such as Real Term, Tera Term, etc), the serial (MCBH) connector should be used.

2.2 Deployment workflow

There are multiple means of communicating with an AML-6 RT instrument. When deployed, power and communication must be administered via the waterproof MCBH connector. In dry environments, either the USB-C connector or the serial MCBH connector may be used for communication. **Note: External power should be applied via the flying leads on the serial interconnect cable regardless of which communication method is used to prevent draining of the internal battery.**

First-time users of an AML-6 RT instrument are encouraged to familiarize themselves with operation by following the workflow described below:

1. On a dry workbench, apply external power to the instrument (8-30 VCD via the MCBH connector) and connect the instrument to a PC using the USB-C connector. Use the provided software interface to explore the instrument configuration options. Details on this process are described in the following section: *Getting Started with Sailfish via USB-C Connection*.

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2. After configuration, verify the desired functionality in an 'as-deployed' state by connecting to a serial terminal via the MCBH connector and streaming live data with the instrument submerged in a saltwater bath. This process is described in the following section: *Getting Started with Serial Communications*.

3. If the instrument is configured to internally log data, conduct a post-deployment data retrieval by removing the instrument from the saltwater bath and re-connecting it to the provided interface software via its USB-C connection. Use the software to download the logged files. **Note that the USB-C connection must be used to download logged data.**

2.3 Getting started with Sailfish (USB-C or Serial Connector)

The preferred (but not the only) method of communicating with the instrument is via AML's software interface, Sailfish; a user-friendly GUI-based platform which allows users to easily configure an instrument, observe live sensor measurements (live data streaming), and download logged data. Sailfish may be downloaded from the AML Oceanographic website (www.AMLoceanographic.com).

Sailfish provides the easiest means of adjusting the instrument's configuration and supports both USB-C and RS-232 connections. Advanced commands not accessible via the GUI exist and can be applied via command line. Refer to section *Configuring an Instrument* in this document for more details.
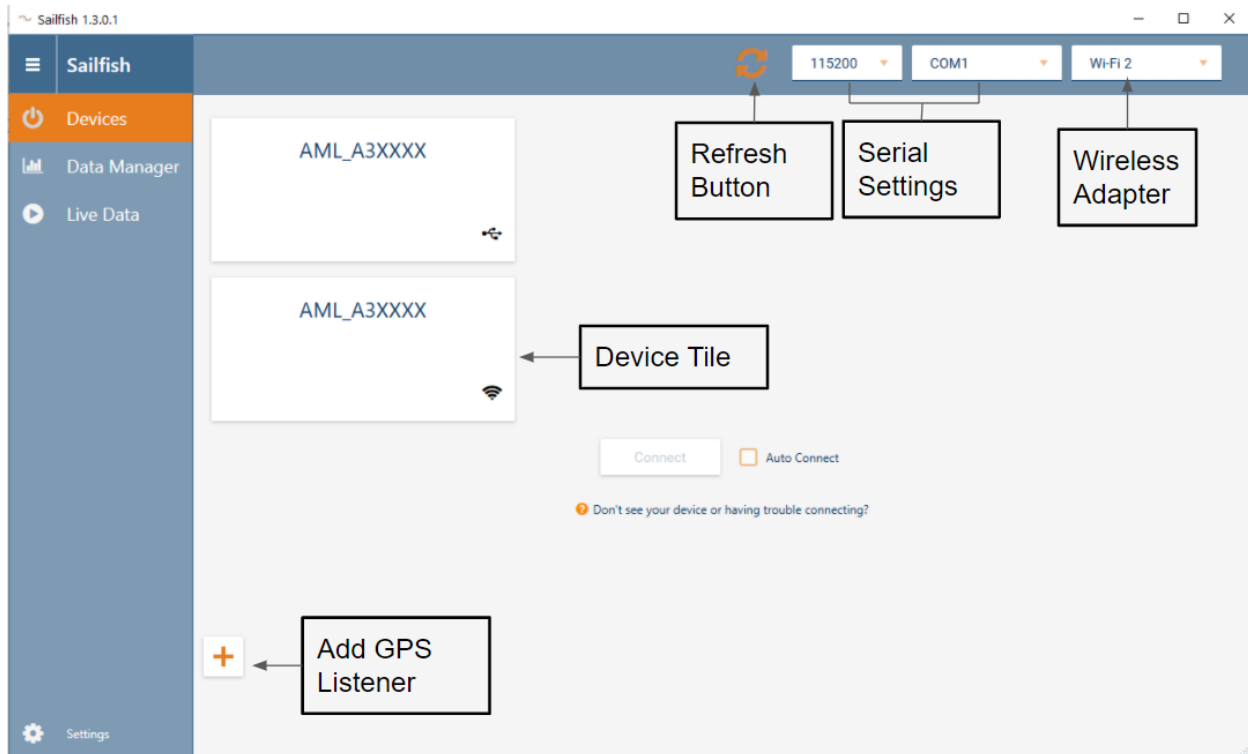
To use Sailfish to configure the AML-6 RT instrument, follow the procedure described below:

1. Download the Sailfish install file from the website (or provided USB thumb drive) and follow the on-screen installation instructions. Sailfish is compatible with Windows 7, 8, and 10.
2. Connect the serial cable and apply 8-30 VDC to the flying leads.
3. Connect the instrument to the PC via the serial connection or the included USB-C cable. The instrument will typically take about 10 seconds to boot up upon the application of external power. The boot up sequence will be displayed on the LED.
4. Start Sailfish and wait for the software to load.
5. If you open Sailfish before connecting your instrument you will need to click on the 'Refresh' button for your instrument to appear.
6. If recognition is successful, Sailfish will display an instrument tile with serial number in the *Devices* tab. Select the corresponding tile, then press 'Connect' at the bottom of the tab to establish a connection.

7. Click the gear icon on the instrument tile (top left corner of the tile) to open the *Configuration* page. Follow the on-screen instructions to configure the instrument.
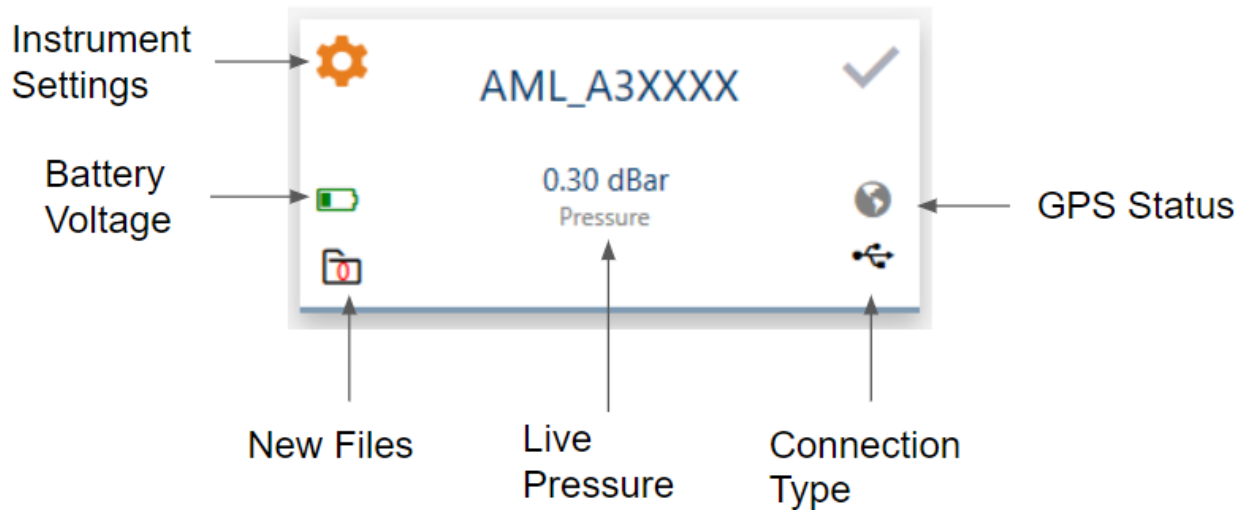
    a. Note: A common action at this step is to tare the pressure sensor if required. This is achieved by clicking the Gear Icon and selecting Tare Pressure Sensor.
8. The user is encouraged to explore the *Instrument Settings* page to familiarize themselves with typical settings.
9. A common step is to commence real-time measurement (data) streaming from the instrument. This is achieved through the *Live Data* tab in Sailfish.

To disconnect the instrument simply unplug the USB-C or serial cable, or click the Disconnect button.

2.4 Getting started with a Serial Terminal

While a Sailfish provides a user-friendly means of interacting with the instrument in a benchtop environment, communication with a deployed instrument must be conducted via serial connection through the MCBH connector. This connection type provides a command-line means of configuring the instrument and streaming live measurements.

The command prompt also allows the use of advanced commands not available in Sailfish.

To connect to the instrument and establish serial communication:

1. Insert one end of the wet-mateable cable into the MCBH connector of the instrument. Connect the DB9 into the computer's serial port (or use a USB-RS232 adapter).
2. Apply 8-30V to the flying leads of the wet-mateable connector cable. The instrument will commence it's boot sequence. Typical boot time is approximately 10 seconds.
3. If the internal battery is low, the instrument may begin to charge. This may result in the instrument body warming up. Note that the internal battery will not support stand-alone operation of the instrument. Use external power when deploying the instrument.

4. Use a Serial Terminal to open the appropriate COM port and establish communication with the instrument. **The default baud is 115200** (8 data bits, no parity, 1 stop bit)**.** Sending a carriage return (enter key) will land the instrument at prompt.

2.4.1 Basic Command Line Functionality

The commands described in this section are intended to provide an overview of basic functionality in order to familiarize the user. There are many commands available, however, and the reader is directed to the *Appendix* or *Configuration* section of this document for further details.

A list of commands is available by issuing the command

>*HELP*

View information about installed sensors, parameters, and units

To see information about the installed sensors, issue the command:

>*DISPLAY SENSORS*

[SensorMetaData]
Columns=Port,Model,SerialNumber,Firmware,Parameter,Units,CalibrationDate,CalibrationTime,Accuracy,RangeMin,RangeMax

[SensorData]
1,CT.Xchange,450801,,Cond,mS/cm,2020-03-28,11:47:47,0.002,0,56
1,CT.Xchange,450801,,TempCT,C,2020-03-27,23:31:03,0.001,-5,45
2,P.X2,306207,1.00.1,Pressure,dbar,2020-04-28,11:28:06,0.007,0,48
3,Turbidity,600342,1.01.0,Turbidity,NTU,2020-05-05,12:12:12,0.000,0,0
4,SV.X2,206261,2.00.0,SV,m/s,2000-01-01,16:27:25,0.010,1375,1625
5,Idronaut pH,750105,1.00,pH,pH,2019-10-18,13:51:04,0.087,0,0
6,SVT.X2,220281,2.00.1,SV,m/s,2000-01-01,00:00:00,0.020,1375,1625
6,SVT.X2,220281,2.00.1,TempSVT,C,2000-01-01,00:00:00,0.003,-2,35

[MeasurementMetadata]
Columns=Date,Time,Cond,TempCT,Pressure,Turbidity,SV,pH,SV,TempSVT,UV,Depth
Units=yyyy-mm-dd,hh:mm:ss.ss,mS/cm,C,dbar,NTU,m/s,pH,m/s,C,Status,m

The *Sensor Meta Data* section provides information on how to interpret the results of the *Sensor Data* table immediately following. For reference, *Port* refers to the sensor port that a sensor is installed into on the instrument endcap (6 total ports in total on an AML-6 RT endcap, 3 total ports on an AML-3 RT endcap). Auxiliary sensor(s) (such as DO and PAR) will be listed as being installed on Port 7 or 8 on an AML-6 RT, and port 4 on AML-3 RT.

In this example there are 6 sensors installed on the AML-6 RT instrument. Port 1 (as labeled on the endcap) has a combined Conductivity and Temperature sensor installed, so it is depicted as two sensors - one with a *Cond* parameter, and one with a *TempCT* parameter. Likewise, Port 6 has a combined sound velocity and temperature sensor installed.

The *Measurement Meta Data* section provides information on how to interpret the columns of measurements when the instrument is streaming data.

Streaming live data (MONITORING)

Live data streaming is referred to as monitoring. To commence monitoring, issue the command

>MONITOR

```
2038-01-19,03:14:07.00,51.281,20.867,0.23,-1.19,1526.593,6.31,1526.677,10.000,0,0.23
2038-01-19,03:14:07.00,51.280,20.867,0.23,-1.17,1526.595,6.31,1526.677,10.000,0,0.23
2038-01-19,03:14:07.00,51.280,20.868,0.23,-1.13,1526.595,6.31,1526.677,10.000,0,0.23
2038-01-19,03:14:07.00,51.282,20.866,0.23,-1.14,1526.594,6.31,1526.677,10.000,0,0.23
2038-01-19,03:14:07.00,51.279,20.866,0.23,-1.13,1526.595,6.32,1526.677,10.000,0,0.23
2038-01-19,03:14:07.00,51.279,20.868,0.23,-1.14,1526.594,6.31,1526.677,10.000,0,0.23
2038-01-19,03:14:07.00,51.280,20.868,0.23,-1.16,1526.595,6.32,1526.677,10.000,0,0.23
2038-01-19,03:14:07.00,51.278,20.867,0.23,-1.12,1526.594,6.31,1526.676,10.000,0,0.23
2038-01-19,03:14:07.00,51.281,20.867,0.23,-1.06,1526.594,6.31,1526.676,10.000,0,0.23
...
```

The monitor command invokes the streaming of sensor measurements and derived parameters if configured to do so. The instrument will continue to stream data indefinitely until manually halted by command. **Monitoring is halted by sending a carriage return (pressing enter).** The instrument can be configured to cease monitoring only on transmission of specific key sequence, referred to as ROBUST MONITOR MODE. Refer to the *Configuration* section of this document for details.

The *Measurement Metadata* table contextualizes the provided data columns with respective parameters and units. In this case, column 3 (first measurement 51.281) is for parameter *Cond* (conductivity) in units of mS/cm.

Monitor behaviour and output format is configurable. Refer to the *Configuration* section of this document for more details.

Application note on monitor formats

While columns of data are easy to read by humans, in instances where the streaming data will be interpreted by machines (ie. other logging devices, software, telemetry modules, etc), users are strongly encouraged to utilize AML's extensible format, referred to as AMLx. Refer to Appendix B for more information.

Internally Logging Data

Data logging is distinct from monitoring; the two operations may happen independently from each other. An instrument may log data without monitoring, monitor without logging, or do both simultaneously. In all cases, data logging is indicated by symmetric on/off flashing by the indicator LED.

Data logging can commence in multiple ways:

1. By default, the instrument is configured to immediately begin logging data when it **detects water immersion.** Immersion detection is triggered when measurements from an installed conductivity or sound velocity sensor exceeds a lower threshold (typically close to 0). For example, the default behaviour is for a powered instrument to begin logging data immediately upon immersion in water regardless of command line state (monitoring or not). The indicator light will flash green.

2. Alternatively, logging can be controlled manually by entering the command

    >*SET LOGMODE MANUAL*

    And sending the command

    >*LOGON*

    Logging invoked in this method may be ceased by sending the command

    >*LOGOFF*

    In this instance, logging will commence independent of in-water status.

3. Logging can be linked to monitor mode - ie, logging occurs whenever monitor mode is engaged. To link logging to monitor, issue the command

    >*SET MONITOR LOG YES*

    The instrument will commence logging whenever a monitor command is issued.

While the output format of monitor mode is configurable, log file format is fixed; however, data between the two is generally identical. For example, sensor measurement and derived parameters that are visible in a monitor sentence will also be included in the log file. Logging and monitoring will also use identical sample rates.

The instrument will create a new log file every time logging commences.

3 Configuration

Commands can be sent to the instrument via command prompt, or with Sailfish when connected over serial or USB. Sailfish provides a user-friendly method of configuring basic instrument settings, but command line-based configuration provides access to a wider range of configuration.

3.1 Configure with Sailfish

To configure with Sailfish, please reference the Getting Started with Sailfish section.

3.2 Configure with a terminal

Advanced commands can be sent to the instrument via command prompt when connected via serial connection. The commands described in this section are not an exhaustive list. Refer to Appendix A for more details.

3.2.1 Baud Rate

Changing the instrument's baud rate will disconnect the terminal from the instrument and will require the terminal baud rate to be modified accordingly.

Command	Description
set baud <baudrate>	Set the serial baud rate for the instrument. All standard baud rates between 9600 and 115200 are accepted. Default is 115200. Note: This command takes immediate effect. Users must change the BAUD rate of their terminal program.

3.2.2 Sampling Settings

Burst Mode and Single Mode Sampling

The instrument can be configured in two different sampling modes: Single and Burst. In Single Mode, the instrument will log/output single samples at a configured interval. Burst Mode, in contrast, provides groups of samples at configured intervals. For example, an instrument in burst mode may be configured to output (and/or log) 6 samples at a rate of 2 samples/sec on 30 seconds intervals.
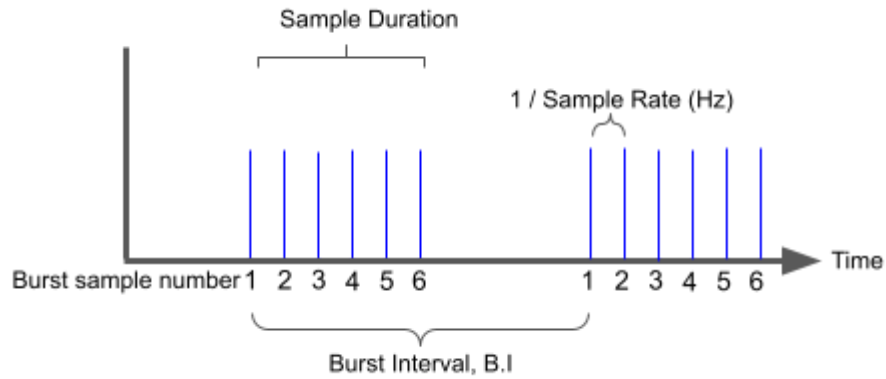
Figure 2: Burst mode functionality. Blue bars indicate instrument samples.

Sampling mode is common to both logging and monitoring. If sampling mode is set to Burst, then both logging and monitor activities will operate in Burst mode.

Burst mode behaviour is configured by prescribing the Number of Burst Samples, Burst Interval, and Sample Rate, as depicted in Figure 2. The Sample Rate (frequency with which sensor measurements are obtained) is common between Burst Mode and Single Mode.

Example:

To configure an instrument to output and log 6 samples at a rate of 2 samples/sec on 30 second intervals, use the following command sequence:

>*SET SAMPLE 2/S*   *-set the sample rate to 2 samples per second.* ***Note that sample rate must be set prior to enabling burst mode.***

>*SET SCAN MODE BURST*   *-Set the global instrument scan mode to Burst. Logging and monitoring will now be in bursts.*

Scan mode: Burst
Sample rate: 2 /sec
Burst interval: 30 secs
Burst samples: 10
Burst monitor: Samples

>*SET BURST SAMPLES 6*   *-Prescribe 6 samples for each burst.*

>*SET BURST INTERVAL 30*   *-Commence the burst every 30 seconds.*

>*MONITOR*   *-Commence streaming measurements*

>2020-05-29,17:56:50.32,-5.10,0.000
2020-05-29,17:56:50.82,-5.15,0.000
2020-05-29,17:56:51.32,-5.30,0.000
2020-05-29,17:56:51.82,-5.36,0.000
2020-05-29,17:56:52.32,-5.39,0.000

2020-05-29,17:56:52.82,-5.55,0.000

For the configuration of a Burst Mode to be valid, the Sample Duration of a given burst must be less than or equal to the burst interval, B.I. This is described in the following equation.

Equation 1: *Sample Duration $\leq$ B.I*, where $Sample\ Duration\ = \frac{n}{S.R}$

S.R = sample rate (Hz), n=number of samples

Burst Averaging

The instrument may also be configured to report a single value representing the average of the samples within a burst (ref: *SET BURST MONITOR [SAMPLES | AVERAGE]* command). For example, an instrument in burst mode may be configured to obtain 6 samples at a rate of 2 samples per second on 30 seconds intervals. If burst-averaging is on, the instrument will output a single value for each parameter at 30 second intervals, where each value is the average of the 6 samples obtained during the burst.

Burst-averaging applies only to data output during monitoring. The instrument will log all underlying samples in each burst, regardless of averaging status.

Command	Description
set sample <rate> [/second | /minute, /hour | seconds | minutes | hours | max]	Set the rate at which the instrument logs and monitors data from the sensors. Maximum sample rate is 20 Hz.
set scan mode [burst | single]	Switch between single and burst mode. When the instrument is in burst mode it will sample in bursts at a set interval. Note that the Sample Duration must be less than or equal to the Burst Interval (Equation 1)
set burst interval <interval>	Set the burst interval in seconds. Minimum: 5 Maximum: 14400
set burst samples <samples>	Set the number of samples taken per burst. Samples will be taken at the set sample rate. Minimum: 2 Maximum: 1200

set burst monitor [samples	average]	Set whether the monitor output will display all the burst samples or an average of the samples. Note: averaging applies only to monitor data. Log files will record individual samples.
display burst	Display the current burst mode settings.

Sleep Mode

The instrument can be configured to enter a low power state in between taking samples. The instrument will only enter sleep mode if the sleep and sampling settings are configured so that the sample period is longer than the minimum sleep time. By default the minimum time the instrument is allowed to sleep is 40 seconds plus a 5 second delay after taking the sample. Sleep mode is also compatible with Burst Mode.

Equation 2: *Min Sleep Time + Sleep Delay ≤ Sample Period*

Equation 3: *Min Sleep Time + Sleep Delay ≤ Burst Interval - Sample Duration*

Example 1:

Minimum Sleep Time = 40 s (default)

Sleep Delay = 5 s (default)

 >*SET SCAN SLEEP Y*   *-enable sleep mode*

 >*SET SAMPLE 2 MIN*   *-set sample period greater than 45 seconds*

 45 < 120   *-Equation 2 is satisfied and instrument will sleep between taking samples*

Example 2:

 >*SET SCAN MODE BURST*   *-enable burst mode*

 >*SET BURST INTERVAL 60*   *-set burst interval to 60 seconds*

 >*SET BURST SAMPLES 30*   *-set the number of burst samples to 30*

>*SET SAMPLE 5/S*   -set sample rate fast enough so that burst interval - sample duration is greater than minimum sleep time

45 < 60 - 30 / 5   *-Equation 3 is satisfied and instrument will sleep between bursts*

= 45 < 54

Command	Description
set scan sleep [y | n]	Enable/disable sleep mode.
set minsleeptime <seconds>	Set the minimum number of seconds the instrument is allowed to sleep. **It is not recommended to change this.** Default: 40 seconds Min: 20 seconds
set scan sleepdelay <seconds>	Set the number of seconds the instrument will wait to sleep after taking a sample. Default: 5 seconds

3.2.3 Monitor Modes

Behaviour of monitor functionality is configurable.

Command	Description
set monitor robust [y | n]	Enable/disable robust monitor mode. When enabled, monitoring is halted via 3 carriage returns. When disabled, a single carriage return will halt monitoring.
set monitor auto <seconds>	Monitoring will begin automatically after an interval of inactivity. Setting to "0" disables auto monitor. Min value: 5 This command applies only to monitoring via serial connection

set monitor startup [y | n]	Enable/disable monitoring on startup. When enabled the instrument will start monitoring when powered on. This command applies only to monitoring via serial connection
set monitor log [y | n]	Enable/disable monitor log mode. When enabled, the instrument will log data when monitoring. Halting monitoring will halt logging. Note: If LOG MODE is set to AUTO the instrument will commencing logging when in water regardless of monitor status.
set monitor delimiter [comma | tab | space | colon]	Set the delimiter of the monitor output.
set monitor checksum [y | n]	Enable/disable a 8 bit XOR checksum in the monitor output. The checkum is appended to each scan preceded by a "*". Ex. >mon 1450.132,14.543*2B 1451.122,15.133*29 Note that checksum does not appear in log files.
display monitor	Display the current monitor settings.

Additional monitor commands are described in 5.2 Monitor commands.

3.2.4 Derived Parameters

Command	Description

set scan <parameter>	Add a parameter to be included in the log file and monitor output. Optional Parameters: date time bat (battery) dep (calculated depth) sal (calculated salinity) den (calculated density) sound (calculated sound velocity) Note: a parameter will only be provided if it is ALSO enabled. Refer 'SET DERIVE' command, below.
set scan no<parameter>	Remove a parameter from being included in the log file and monitor output.
set derive <parameter> [y | n]	Enable/disable a parameter to be calculated if the required sensors are installed. Derived Parameters: depth (from pressure) salc (salinity from conductivity) salsv (salinity from sound velocity) density (requires salinity) sv (sound velocity, requires salinity) Note: a parameter will only be output if it is ALSO included in monitor scans. Refer 'SET SCAN' command, above.

3.2.5 UV Antifouling

The following commands pertain only to an instrument with a UV antifouling system installed.

Command	Description
set uv time <ontime> <offtime>	Set the duty cycle of the UV lantern in seconds. Note: Setting UV time to 0 0 will disable light emission.

3.2.6 Data Logging

Data logging can be configured to start automatically when the instrument detects that it is in water. The instrument will determine that it is in water if measurements from a sound velocity or a conductivity sensor exceed a threshold (typically close to 0). Alternatively, data logging may be configured to start and stop only via manual command.

Command	Description
*set logmode [auto	manual]*	By default logmode will be set to "auto" and will automatically start logging when the water immersion is detected.
logon	Start logging when log mode is set to manual.
logoff	Stop logging when log mode is set to manual.
*set filetype [columns	amlx	all]*	Set the file type that data will be logged to. The columns format has file extension ".aml" while the amlx format has extension ".amlx". If ALL is selected, two files will be created, one in each format. See Appendix B for more details on these two formats.

3.2.7 Help

The AML-6 RT has a built-in help menu containing a complete list of all user commands.

Command	Description
display options	Display a list of all configurable settings and their current values.
help	Display a menu of all user commands.

---

4 Contact AML

Service

To request an RMA or technical support:

Email: service@AMLoceanographic.com

Phone: 1-250-656-0771

Phone: 1-800-663-8721 (NA)

http://www.AMLoceanographic.com

Sales

For all general sales inquiries:

Email: sales@AMLoceanographic.com

Phone: 1-250-656-0771

Phone: 1-800-663-8721 (NA)

http://www.AMLoceanographic.com

5 Appendix A - Full command list

All of the commonly utilized settings are accessible via GUI using Sailfish. However, Sailfish does not provide GUI access to the entire command set; advanced functionality beyond common settings exists. This advanced functionality is described here.

These commands are applied to the instrument via command line. This is achieved by using the *Advanced Commands* section of the bottom of the *Instrument Settings* page in Sailfish.

5.1 Sampling commands

Command	Description
set sample <rate> [/second | /minute, /hour | seconds | minutes | hours | max]	Set the rate at which the instrument logs and monitors data from the sensors. Maximum sample rate is 20 Hz.
set scan mode [burst | single]	Switch between single and burst mode. When the instrument is in burst mode it will sample in bursts at a set interval. Note that the burst duration must be less than or equal to the burst interval.
set burst interval <interval>	Set the burst interval in seconds. Minimum: 5 Maximum: 14400
set burst samples <samples>	Set the number of samples taken per burst. Samples will be taken at the set sample rate. Minimum: 2 Maximum: 1200
set burst monitor [samples | average]	Set whether the monitor output will display all the burst samples or an average of the samples. Note: averaging applies only to monitor data. Log files will record individual samples.
display burst	Display the current burst mode settings.

set trigger [time | sound | pressure]	Set the sampling trigger to sample by time, sound velocity increment or pressure increment. Sampling by sound or pressure increment is not supported in burst mode.
set sound inc <value>	Set sound velocity increment.
set pressure inc <value>	Set pressure increment.
set <detection parameter> threshold <value>	Set the threshold for water detection to begin automatic logging. Valid detection parameters are "conduct", "sound", and "pressure". By default pressure is set to 99999.99 and it is not recommended to detect water by pressure unless there are no sound velocity or conductivity sensors installed. Note: This is a secure command.

5.2 Monitor Configurations and commands

Command	Description
monitor	Start streaming data on the user terminal. Hit <enter> to exit monitor, hit <enter> three times to exit monitor when in robust mode.
mmonitor	Start streaming data in AMLx format.
scan	Print a single line of the latest sensor data.
mscan	Print a single line of the latest sensor data in AMLx format.
set monitor robust [y | n]	Enable/disable robust monitor mode. When enabled, monitoring is halted via 3 carriage returns. When disabled, a single carriage return will halt monitoring.

set monitor auto <seconds>	Monitoring will begin automatically after an interval of inactivity. Setting to "0" disables auto monitor. Min value: 5 This command applies only to monitoring via serial connection
set monitor startup [y | n]	Enable/disable monitoring on startup. When enabled the instrument will start monitoring when powered on. This command applies only to monitoring via serial connection
set monitor log [y | n]	Enable/disable monitor log mode. When enabled, the instrument will log data when monitoring. Stopping monitor will halt logging. Note: If LOG MODE is set to AUTO the instrument will commence logging when in water regardless of monitor status.
set monitor delimiter [comma | tab | space | colon]	Set the delimiter of the monitor output.
set monitor checksum [y | n]	Enable/disable a 8 bit XOR checksum in the monitor output. The checkum is appended to each scan preceded by a "*". Ex. >mon 1450.132,14.543*2B 1451.122,15.133*29
set monitor format [columns | amlx]	Set the monitor output format. See Appendix B for a description of the columns and AMLx formats. Note that checksum does not appear in log files.
display monitor	Print the current monitor settings.

5.3 Log File Format/Monitor Output

Command	Description

set scan <parameter>	Add a parameter to be included in the log file and monitor output. Optional Parameters: date time bat (Battery) dep (Calculated Depth) sal (Calculated Salinity) den (Calculated Density) sound (Calculated Sound Velocity) Note: Calculated parameters will output -99.9999 if outside of the valid range of the calculation formula.
set scan no<parameter>	Remove a parameter from being included in the log file and monitor output.
*set derive <parameter> [y	n]*	Enable/disable a parameter to be calculated if the required sensors are installed. Derived Parameters: depth (from pressure) salc (salinity from conductivity) salsv (salinity from sound velocity) density (requires salinity) sv (sound velocity, requires salinity) Note: a parameter will only be output if it is ALSO included in monitor scans. Refer 'SET SCAN' command, above.

5.4 UV Antifouling

Note that these commands apply only in the instance of a UV system installed on the instrument.

Command	Description
display uv	Print the current UV settings.
set uv time <ontime> <offtime>	Set the duty cycle of the UV lantern in seconds. Note: Setting UV time to 0 0 will disable light emission.

5.5 Data Logging

Command	Description
display status	Print the current logging status, including in-water status, number of samples recorded, log duration, and sample rate.
*set logmode [auto	manual]*	By default logmode will be set to "auto" and will automatically start logging when the water immersion is detected.
logon	Start logging when log mode is set to manual.
logoff	Stop logging when log mode is set to manual.
*set filetype [columns	amlx	all]*	Set the file type that data will be logged to. The columns format has file extension ".aml" while the amlx format has extension ".amlx". If ALL is selected, two files will be created, one in each format. See Appendix B for more details on these two formats.
dir	Display files present in the log directory.

5.6 Help

Command	Description
display options	Displays a full list of all configurable settings and their current values.
help	Displays a menu of all commands.

5.7 Communication commands

Command	Description
set baud <baud rate>	Set the serial baud rate for the instrument. All standard baud rates between 9600 and 115200 are accepted. Default is 115200. Note: This command takes immediate effect. Users must change the BAUD rate of their terminal program.

5.8 Sensor commands

Command	Description
display sensors	Print information about all connected sensors.
rawtalk <port>	Start a rawtalk session with a connected sensor. Send *<1s pause>+++<1s pause>* to exit the rawtalk session.

5.9 System commands

Command	Description
set fulltime <yyyy-mm-dd> <hh:mm:ss>	Set the system date and time.
reset factory	Restore the device's factory settings.
reset user	Restore the device's user settings.
display memory	Print the SD card's total and used memory in bytes.
display version	Print the version header, including the model name, firmware version, serial number, and total space of the installed SD card.
display volt	Print the current battery voltage.
secure on	Enables the user to send "secure" commands. Secure mode is not persistent through multiple telnet sessions or a power cycle.

5.10 GPS commands

Command	Description
*set gnss mgadbd [y	n]*	Enable/disable GPS database dump to enable GPS warm start. If enabled, the GPS module will store almanac data that will improve lock times after a recent fix has been lost. Enabling this feature generally improves GPS lock times. Note: This is a secure command.
*set gnss offline [y	n]*	Enable/disable GPS offline assist. Requires connecting to Sailfish with an active internet connection at least once every 5 days. Offline data will help improve lock times on power up.

	Note: This is a secure command.

5.11 Power commands

Command	Description
poweroff	Turn the instrument off indefinitely, until the power dial switch is toggled or external power cycled.
hibernate <minutes>	Turn the instrument off for a set amount of minutes.
set wakeonpower [y/n]	Once enabled, the instrument will stay on until a Power Off command is issued or poweroff timeout has occurred. Note: This is a secure command.
set powerofftimeout <minutes>	Set the instrument's idle timeout in minutes. If there is no user interaction and the instrument is idling, i.e. not streaming data or logging, the instrument will power down after the set timeout. Setting the timeout to 0 disables this feature.
set batwarning <voltage>	Set the threshold for the low battery warning to be triggered. If triggered the indicator led will turn red to notify users to charge the instrument. Note: This is a secure command.
set batshutdn <voltage>	Set the threshold for the low battery shutdown to be triggered. If the instrument's battery voltage drops below this threshold the instrument will shut down. It is not recommended to set this lower than 6.2 V. Note: This is a secure command.
set batvnoboot [volts]	Sets the voltage threshold allowing the instrument to boot up, between 5 and 7.8 volts. To disable, set the volts parameter to zero. Note: This is a secure command.
set batinoboot [mAmpere]	Sets the threshold to automatically shut the instrument down when the internal battery is powering the instrument, between 1 and 1000 mA. To disable, set the mAmpere parameter to zero.

	Note: This is a secure command.

6 Appendix B - Output Formats

AML-6 series instruments support two monitoring formats: a column-based format whereby all transmitted data is organized into vertical columns, and a proprietary self-describing format referred to as AMLx.

The commands to adjust monitor formats are described in 5.2 Monitor commands.

6.1 Column-Based Format

The factory default of an AML-6 instrument is column-based formatting, typically using a comma delimiter (the delimiter is configurable). This format is preferred for applications where human readability of the raw data is required as it is easy to quickly parse and interpret the scrolling columns of measurements.

The disadvantage of this format is that the user must have knowledge of the meta-data to correctly interpret the readings. The relevant meta-data is obtained by issue the following command:

>DIS SENSORS

[MeasurementMetadata]
Columns=Date,Time,Cond,TempCT,Pressure,SV,Depth
Units=yyyy-mm-dd,hh:mm:ss.ss,mS/cm,C,dbar,m/s,m

>MONITOR

>2020-05-27,18:59:26.03,5.122,24.044,10.09,1459.111,10.07
...

It is assumed the sensor meta-data is uniformly applicable to every line. that the number of columns, order of columns, and units of each measurement never change. This assumption makes the format extremely inflexible. **Users are strongly discouraged from creating drivers that rely on this output format.**

6.2 AMLx Format

The AMLx format is a proprietary self-describing string that does not rely on assumed static meta-data for interpretation. Each sentence contains sufficient information to contextualize the measurement data provided.

The general format of AMLx is:

---

msg**<MsgNumber>**{mux[meta=time,**<UnixEpochTime>**,s][data=uv,**<status>**],port**<PortNumber>**[data=**<ParameterName>**,**<Value>**,**<ParameterUnits>**][rawi=**<RawParameterName>**,**<Raw Value>**,**<RawUnits>**]}}

Sample output in this format is shown below.

>MONITOR

>msg138{mux[meta=time,1590605500.55,s],port1[data=Cond,0.000000,mS/cm][rawi=ADC,563,none][data=TempCT,23.881313,C][rawi=ADC,428710,none],port2[data=Pressure,0.071390,dbar][rawi=ADC,844470,2sComp],port3[data=SV,0.000000,m/s][rawf=NSV,0.000000,samples],derive[data=Depth,0.070998,m]}

In this format every measurement has, at minimum, an explicit unit, parameter, and port association. A driver written to interpret this format is able to understand output from every X2Change generation instrument regardless of specific sensor or derived parameter configuration. **Users are strongly encouraged to use drivers that rely on this output format.**

Parameter names:

Parameter name	Description
SV	Sound velocity
TempSVT	Temperature from an SVT.X2 sensor
Cond	Conductivity
TempCT	Temperature from a CT.X2 sensor.
Pressure	Pressure
Turbidity	Turbidity
Dissolved Oxygen	Dissolved Oxygen
DOM	CDOM/FDOM
Chloro-blue	Chlorophyll, blue excitation
Chloro-red	Chlorophyll, red excitation
pH	pH
Fluorescein	Fluorescein dye
Oil-crude	Crude oil
Oil-fine	Fine oil

Brighteners	Optical brighteners
Phycocyanin	Phycocyanin (freshwater cyanobacteria)
Phycoerythrin	Phycoerythrin (marine cyanobacteria)
PTSA	PTSA
Rhodamine	Rhodamine
Tryptophan	Tryptophan

7 Appendix C - Calculated Parameters

The AML-6 instrument has the ability to calculate certain parameters depending on your sensor configuration. Below is a table outlining the parameters that can be calculated.

Parameter	Required Sensors	Equation	Range
Salinity	C, T, P	Practical Salinity Scale 1978	0 - 90 PSU[1]
Salinity (from SV)	SV, T, P	AML	0 - 90 PSU
Density	C,T, P	TEOS10	0 - 2000 kg/m^3
Density (from SV)	SV,T, P	TEOS10	0 - 2000 kg/m^3
Sound Velocity*	C,T, P	Chen & Millero	0 - 3000 m/s
Depth	P	UNESCO	-20 - 12000 m

C - conductivity, T- temperature, SV - sound velocity, P- pressure

1 - Instrument will report 0-90 PSU, however PSS-78 equation is valid only from 2-50 PSU.

*Calculated salinity must be enabled for the calculated Sound Velocity to operate correctly

8 Appendix D - Equipping an Instrument

AML-6 instruments are shipped from the factory with sensors installed and configured. Users are generally not required to remove or install sensors in the course of normal operation. However, there are instances where a user may install or uninstall a sensor such as modifying a sensor payload, returning individual sensors to the factory for calibration, or sending a sensor in for service. AML series instruments and sensors are designed to be user-swappable for maximum flexibility.

8.1 X2Change™ Sensors

X2Change™ sensors are installed on the AML-6 sensor end cap. There are 6 sensor ports available and 1 port for an optional UV Antifouling system. Sensors are installed or removed by hand with no special tools required. Most combinations of X2Change™ sensors are permitted (See notes on installing sensors).
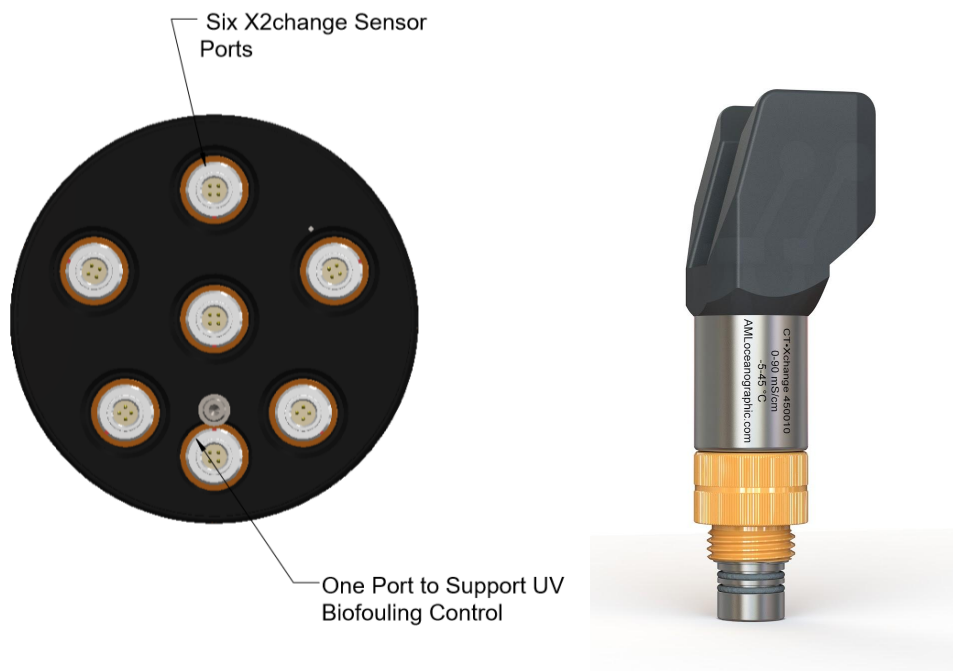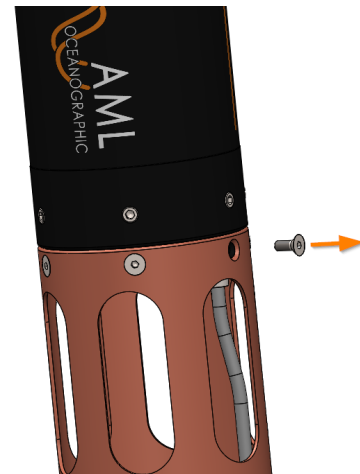

8.1.1 Removing Sensors

1. If a UV antifouling system is installed, the retaining clip must be removed prior to removing the sensor cage.

---
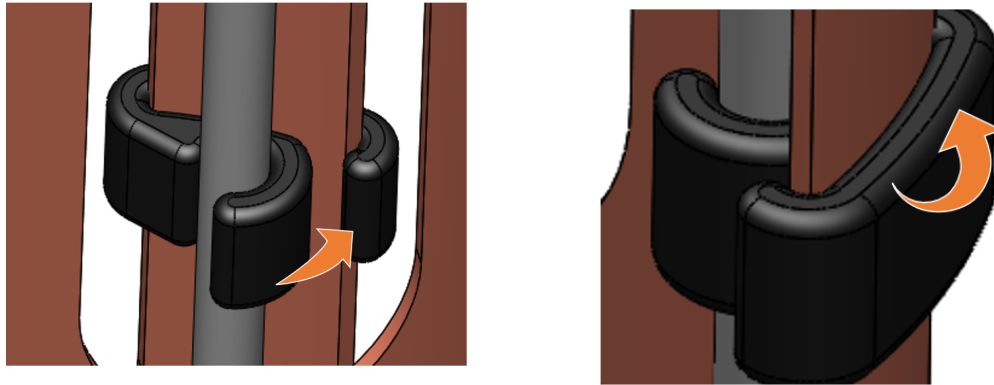
2. Configuring the sensors on the end cap is easiest when the sensor cage is removed. Use 1/8" hex tool to remove the screws when attaching or detaching the sensor cage.

3. Rotate the orange locking sleeve of the sensor you wish to remove counter-clockwise until you can gently pull the X2Change™ sensor from the sensor port.

8.1.2 Installing Sensors

1. Before installing X2Change™ sensors, ensure that the instrument socket is clean and dry.

2. Check the X2Change™ sensor's o-rings for cleanliness and replace if damaged. Apply o-ring grease to the new o-ring before replacing it.

3. Align the sensor with the sensor port so that the lock and key of the lemo connectors are aligned.

4. Place the sensor into the port.

5. Push the sensor until it drops down into the port enough to allow the orange locking sleeve threads to engage the port threads.

6. Screw down the orange locking sleeve until it stops. The bottom of the sleeve should be within 1 mm of the instrument end cap.

Notes:

- X2Change™ sensors are identified by their orange locking sleeve matching AML-6's orange sensor port.

- Older AML Xchange™ sensors with blue locking sleeves are not compatible with the AML-6 line of instruments.

- CT X2Change™ should be installed in AML-6 port 1 due to the mechanical fit between the sensor and the cage. All other X2Change™ sensors can be installed in any of the 6 sensor ports.

- A sensor riser may be required when installing a CT X2Change™ if other tall X2Change™ sensors are installed nearby.

8.2 Seals and Plugs

Before deployment, ensure that every empty X2Change™ sensor port is sealed with the X2Change™ Blanking Plug, the USB-C port is capped, and each MCBH is plugged with its dummy plug or cable. Contact AML Support to replace lost plugs or ca

9 Appendix E - Long Term Storage Recommendations

AML recommends fully charging the internal battery of the instrument before storage, as well as re-charging the instrument fully every 6 months. Failure to maintain battery charge can damage the instrument.

10 Appendix F - USB FAQ

Question	Answer
Can I charge my instrument using my computer's USB port?	Yes, but note that some USB ports on computers cannot deliver the power that is required by the instrument for charging (10 Watts). We highly recommend using the included AC-DC Wall Adapter for charging your instrument.
I cannot communicate to the instrument via USB, what should I be checking?	1. Apply power via the MCBH to activate the instrument 2. Use a powered USB hub that supports USB 3.1 connectivity. Contact AML for approved USB hubs that are tested with our instruments.
Can I use a different USB-C cable for charging/communicating to the instrument?	AML highly recommends using the factory-supplied USB cable. In cases where you have to use a different one, you may do so but AML cannot guarantee that it meets the required specification in order to work seamlessly with our instrument.

11 Appendix G - Warranty Statement

AML Warranty Policy: New Product (Instrumentation)

AML warrants the instrument and sensor for a period of TWO YEARS (24 months) from the date of delivery. AML will repair or replace, at its option and at no charge, components which prove to be defective. The warranty applies only to the original purchaser of the instruments and only to instruments and sensors manufactured by AML Oceanographic. The warranty of third party sensors will apply as per the specific vendor's warranty policy. The warranty does not apply if the instrument has been damaged, by accident or misuse, and is void if repairs or modifications are made by other than authorized personnel.

This warranty is the only warranty for new products given by AML. No warranties implied by law, including but not limited to the implied warranties of merchantability and fitness for a particular purpose shall apply. In no event will AML be liable for any direct, indirect, consequential or incidental damages resulting from any defects or failure of performance of any instrument supplied by AML.