

LISST-ABS

Acoustic Backscatter Sensor

User's Manual

Version 1.7

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FOR TECHNICAL ASSISTANCE please contact your local Distributor, or Sequoia if the instrument was purchased directly from Sequoia. Please be sure to include the instrument serial number with any correspondence.

A list of local Sequoia distributors can be found at <http://www.sequiasci.com/about/contact/distributors>

For warranty terms, see <https://www.sequiasci.com/support/warranty/>

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Section 1: Quick Start

Introduction The LISST-ABS uses acoustic backscatter to measure the concentration of particles suspended in water. For an introduction to its operating principles, see Appendix C: How the LISST-ABS works. It measures suspended sediment in terms of “Uncalibrated Concentration” (or C_u). Uncalibrated Concentration is defined with reference to 75-90 micron glass microspheres. It can be converted to absolute concentration of known sediments, if necessary, using procedures similar to those used for turbidity sensors (also see Appendix B: Converting Uncalibrated Concentration to Concentration).

The LISST-ABS is shipped ready for use. It takes just three steps to start making measurements.

Step 1: Unpack box The LISST-ABS is shipped with a protective red cap over the sensing end, and a locking cap on the connector. Software and electronic documents are on a USB memory card (which resembles a credit card). Depending on the options purchased, it may also include a 2-meter USB cable, or a 5 to 50-meter-long cable with adapters for USB, RS-232, SDI-12 and analog interfaces.

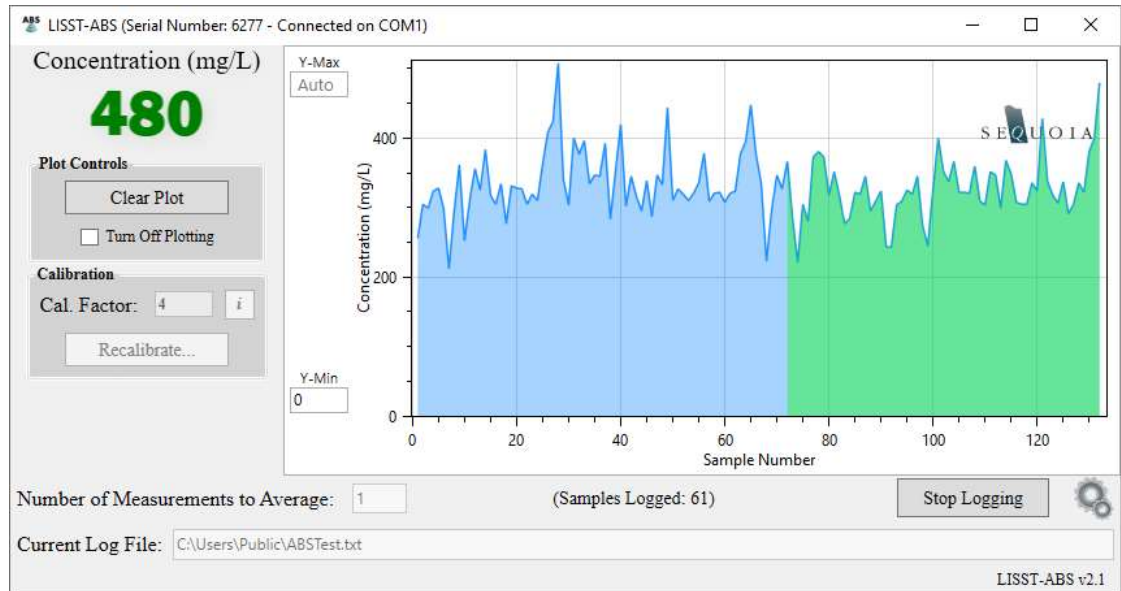
Removing the protective red cap from the LISST-ABS, you will see a light-colored disc, which is the acoustic transducer. This must be protected from impact damage, so keep it covered when not in use. But the instrument cannot make measurements when the cap is on. The underwater connector is also covered with a protective cap.

Step 2: Install Software A simple program that can be used for testing the LISST-ABS is included on the USB memory card. To install the software on your computer run the LISST-ABS_installer.exe program on the memory card. This will install the LISST-ABS software. In rare cases you may need to install Microsoft’s .NET 4.0 Framework. The memory card includes a separate installer for the .NET 4.0, if required. For more software details, see section 2.5, USB Operations via PC software, on page 16.

Step 3: Plug in USB cable and Start Program The LISST-ABS is a sensor only and must be connected to a power source. USB cables supplied by Sequoia Scientific provide power and communicate with the instrument via one connection. When you connect the appropriate cable to the LISST-ABS and to a USB port, you should see the green LED on the LISST-ABS start to blink. Every time the LISST-ABS blinks data is being sent up the cable to the USB port.

If the LISST-ABS was purchased without a cable you will need to provide power to the LISST-ABS and connect the RS232 output to the PC to use the provided software (details in section 2.3, RS232 Output Operations, on page 9).

You can now start the LISST-ABS software to see the values in real time. You can also use the software to log data. Below is a screen shot of the software while data is being logged to text file.



The Cal Factor is a calibration value that is used to convert Uncalibrated Concentration (C_u) to Concentration in mg/L. The LISST-ABS is calibrated and adjusted at the factory using 75 to 90-micron particles so that the Cal Factor for these particles will always be 1. You may use this value for a quick approximation of concentration, but the most accurate results require your own calibration, as described in Appendix B.

The LISST-ABS generates a new measurement every second. If you wish, you can reduce sample-to-sample variability by averaging. Type the desired number of measurements to average in the box below the plot. If you enter 5, for example, each point on the plot will show the average of the last 5 samples.

To save measurements to a text file press the 'Start Logging' button. You will be asked to select a location and name for the file. Data will be saved to the file until 'Stop Logging' is pressed. The log file contains a header with the Cal Factor value, time zone, and the instrument serial number. Following the header are three columns of data: date, time, and measured concentration (mg/L). The Log file is a space delimited ASCII file that can be easily imported into programs such as Excel.

Detailed instructions on various interfacing options are covered in subsequent sections of this manual: SDI-12 Operation on page 4, RS232 Output Operations on page 9, Analog Output Operations on page 14, and USB Operations via PC software on page 16.

Section 2: Instructions

2.1 Introduction

The LISST-ABS is a single-point acoustic sediment sensor, designed to provide higher quality data than optical turbidity sensors. Its key advantages over optical turbidity sensors are:

- Superior response to particles of grain size >30 microns.
- Relatively flat sensitivity to particles from 30-400 microns in sizes.
- Greater immunity to fouling.
- Wide dynamic range of concentrations from 1mg/L to 30 g/L.

The LISST-ABS internally measures Attenuation Corrected Backscatter (ACB). The ACB value is converted to an Uncalibrated Concentration (C_u) and then output. To convert the Uncalibrated Concentration to sediment concentration a simple multiplier is required. The multiplier, or Cal Factor, is dependent on the specific type and size of sediment being measured. When a user recalibrates an instrument, it is this multiplier that is updated. For more detailed understanding of the technology, please see Appendix C: How the LISST-ABS works on page 29.

The LISST-ABS can output the Uncalibrated Concentration using three different methods, SDI-12, RS232, and analog output. All three of these outputs are available on the underwater connector on the end of the LISST-ABS. The output used is determined by how the instrument is connected to a datalogger.

The LISST-ABS can be powered in two ways. For testing purposes, a special USB cable is available. When using this cable, power to the instrument is provided by the USB port. When connecting to a datalogger you will need to supply a voltage between 10-18VDC. The current drain at 12V is 100 ma when actively collecting data. If the supply voltage is too low the LISST-ABS will output an Uncalibrated Concentration value of -999.

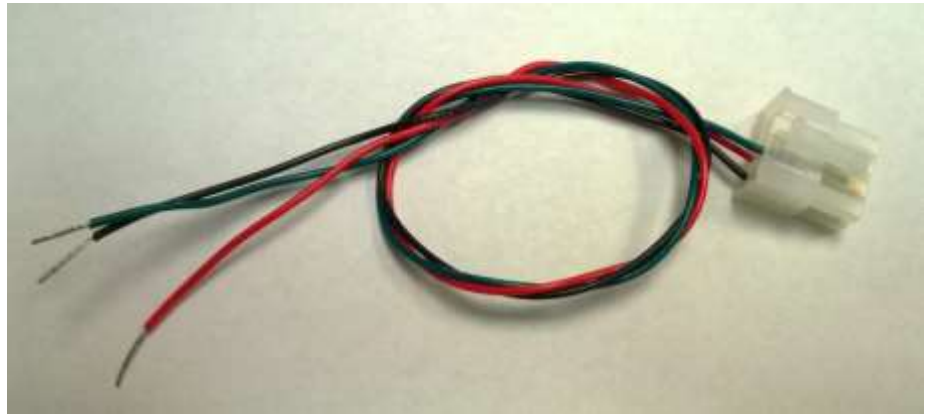
When the LISST-ABS is powered up the green LED on the endcap will start to blink at about once per second. This indicates the instrument is powered up and operating normally. When the LISST-ABS is actively sampling it will double blink (two blinks in quick succession). When idle but still powered up it will do a single blink once per second.

2.2 SDI-12 Operation

The LISST-ABS is compatible with SDI-12 protocol version 1.3.

SDI-12 Connections

SDI-12 only requires three connections: power, ground, and data. Appendix A: LISST-ABS Cable Wiring and Connector Pinouts includes detailed descriptions of the use of the individual pins of the 8-pin connector on the LISST-ABS. If you will be using a cable from Sequoia for connecting to your SDI-12 compatible datalogger, it will include adapters tailored to different connection requirements, such as the one pictured below. The mating connector makes it easy to remove the long cable without disconnecting the wires from the datalogger. You can also easily switch between the datalogger and the USB cable if needed.



The wires are labeled and color coded. Connect the Black wire to ground on your logger, the red wire to +12V, and the green wire to SDI-12 Data.

SDI-12 Address

The LISST-ABS is shipped pre-configured with an SDI-12 instrument address of 0. If you have multiple instruments (LISST-ABS or others) wired to the same SDI-12 system, you must ensure they have unique addresses.

SDI-12 Command Summary

Command Name	Command Code	Notes
Address Query	?!	Request address of single sensor on bus
Acknowledge Active	a!	Request response from sensor at address <i>a</i>
Change Address	aAb!	Change address of sensor at address <i>a</i> to <i>b</i>
Send Identification	al!	Send ID string including SI address, SDI version, Manufacturers ID, sensor model, sensor Firmware version and device serial number
Start Measurement	aM!, aMC! aM1!, aMC1! aM2!, aMC2! aM3!, aMC3! aM4!, aMC4!	Start a measurement, returns number of seconds till sample is ready to be read. Sends service request when measurement is complete. An M command returns a single 1 second average. M1, M2, M3, and M4 return a 30, 60, 120, or 300 second average. C following a command requests a CRC code in the data return (D command).
Start Concurrent Measurement	aC!, aCC! aC1!, aCC1! aC2!, aCC2! aC3!, aCC3! aC4!, aCC4!	Same as Start Measurement command except does not send service request.
Send Data	aDb!	Requests output <i>b</i> (0-9) from Sensor <i>a</i>
Continuous Measurements (Read)	aR!	Not supported
Start Verification	aV!	Not Supported

SDI-12 Command Details

Basic Command Set

?!	Address Query
Syntax:	?!
Description:	Request address of single sensor on bus. Note: sensor must be the only sensor on the bus or multiple instruments will respond simultaneously.
Example:	Command: ?! Response: 0 (responds with address of sensor, in this case 0)

a!	Acknowledge Active
Syntax:	a!
Description:	Request response from sensor at address <i>a</i> .
Example:	Command: 0! (request sensor at address 0 to confirm it is active)

	Response: 0 (responds with address of sensor)
--	---

aAb!	Change Address
Syntax:	aAb!
Description:	Change address of sensor at address <i>a</i> to <i>b</i>
Example:	Command: 0A3! (request sensor at address 0 to change to address 3) Response: 3 (responds with new address of sensor)

a!	Send Identification
Syntax:	a!
Description:	Send ID string including SI address, SDI version, Manufacturers ID, sensor model, sensor Firmware version and device serial number.
Example:	Command: 3! Response: 313SequoiaSABS001001123456 Where: 3 = Sensor address (1 character) 13 = SDI Version compatibility (2 characters) SequoiaS = Manufacturers ID (8 characters) ABS001 = Sensor Model (6 characters) 001 = Sensor Firmware (3 characters) 123456 = Sensor Serial Number (6 characters)

aM!	Start Measurement
Syntax:	aM!, aMC!, aM1!, aMC1!, aM2!, aMC2!, aM3!, aMC3!, aM4!, or aMC4!
Description:	Start a measurement, returns number of seconds till sample is ready to be read. Sends service request when measurement is complete.
Examples:	Command: 3M! (request sensor at address 3 to make as measurement) Response: 30011 (3 is the address, 001 is # of seconds, 1 is the # of values) <after 1 second> 3 (sends address to confirm measurement is ready to be read) Command: 3M1! (request sensor at address 3 to get a 30 second average) Response: 30011 (3 is the address, 031 is # of seconds, 1 is the # of values) <after 31 seconds> 3 (sends address to confirm measurement is ready to be read) Command: 3MC1! (request sensor at address 3 to get a 30 second average with CRC in returned data) Response: 30011 (3 is the address, 031 is # of seconds, 1 is the # of values) <after 31 seconds> 3 (sends address to confirm measurement is ready to be read)

aC!	Start Concurrent Measurement
Syntax:	aC!
Description:	Start a measurement, returns number of seconds till sample is ready to be read. Does not send service request when measurement is complete.
Example:	<p>Command: 3C! (request sensor at address 3 to make as measurement) Response: 30011 (3 is the address, 001 is # of seconds, 1 is the # of values) <after 1 second, measurement is ready, but no response is sent></p> <p>Command: 3C1! (request sensor at address 3 to get a 30 second average) Response: 30011 (3 is the address, 001 is # of seconds, 1 is the # of values) <after 1 second, measurement is ready, but no response is sent></p>

aDb!	Send Data
Syntax:	aDb!
Description:	Requests output <i>b</i> (0-9) from Sensor <i>a</i>
Examples:	<p>Command: 3D0! (request sensor at address 3 to send data block 0) Response: 3+1234.56 (responds with Uncalibrated Concentration, C_u)</p> <p>Note: in response to certain commands, the data returned after a D command may have a CRC value appended to it.</p> <p>Since the LISST-ABS has only one output only the aD0! command is required.</p>

aR!	Continuous Measurements
Syntax:	aR!
Description:	Not supported. The LISST-ABS is not a continuous measurement device. No data will be returned. The response to this command is below.
Example:	<p>Command: 3R! (request continuous measurement) Response: 3 (responds with address of sensor)</p>

aV!	Start Verification
Syntax:	aV!
Description:	Not supported but the sensor will respond to the command with the response shown below.
Example:	<p>Command: 0A3! (request sensor at address 0 to change to address 3) Response: 30000 (responds with current address of sensor)</p>

**LISST-ABS and SDI-12
Best practices**

To obtain the most accurate results it is recommended that the LISST-ABS collect a 30 second or longer average. This is because the LISST-ABS measures within a relatively small volume of water, where the number of large particles at any instant may be small. Therefore, measuring a representative sample requires averaging over a period of time to increase the effective volume of the measurement. Using the M1!, M2!, M3! Or M4! Commands will acquire an average of 30, 60, 120, or 300 seconds.

The LISST-ABS will remain powered between SDI-12 commands. If low power consumption is required it is suggested that the LISST-ABS be powered down between measurements to conserve power. The M commands can be sent one second after power up.

For advice on mounting, cleaning and maintenance, see General Use and Care on page 25.

2.3 RS232 Output Operations

The LISST-ABS supports RS232 communication in both transmit-only and two-way communication modes.

RS232 Connections

RS232 requires four wires. Power, Ground, Transmit and Receive. Appendix A includes detailed descriptions of the use of the individual pins of the 8-pin connector on the LISST-ABS. However, in most cases you will be using a cable provided by Sequoia for connecting to your RS232 compatible datalogger. To make the connections easier we have provided different cable terminations designed specifically for different connection requirements. For example, we provide a termination with only the four individual wires that are labeled and can be easily connected to the datalogger. The mating connector makes it easy to remove the long cable without disconnecting the wires from the datalogger. You can also easily switch between the datalogger and the USB cable if needed.



The wires are labeled and color coded. Connect the Black wire to Ground. Connect the Red wire to +12V. Connect the Yellow ABS Transmit wire to the datalogger receive input and the Blue ABS Receive wire to the datalogger transmit output.

The LISST-ABS uses a baud rate of 9600 with 8 data bits, one stop bit, no parity, and no flow control.

By default, the LISST-ABS will automatically start outputting the Uncalibrated Concentration values out the RS232 connection upon power up. The values are output at once per second. The values are one value per line in scientific notation. The line is terminated with a linefeed character. We call this the Automatic Mode output.

The simplest method of collecting RS232 data is to capture and store the values being returned from the LISST-ABS as it is output. As described below in the recommended sampling procedure, the instrument should be allowed to output for 30 seconds after power up before measurements are recorded.

There are also a set of commands that can be sent to the LISST-ABS to give more control of the flow of data. The available RS232 commands are described below. The commands are not case sensitive and there are multiple command codes for the same command function.

Following the command descriptions are some suggested best practices for using the LISST-ABS with RS232.

LISST-ABS RS-232 Command Summary

Command Name	Command Code	Notes
Display Status	DS Status	Display the Current Status of the instrument including instrument serial number and firm-ware version
Start Automatic Mode	GO Return Automode Exit	Returns the LISST-ABS to automatic mode where results are output to the RS232 every 1 second
Take and Transmit Sam-ple (and hold)	GS GetSample	Instrument makes a measurement, stores it in temporary memory, and outputs the re-sults to the RS-232.
Take Sample and hold it	HS HoldSample	Instrument makes a measurement and stores it in temporary memory. The results are NOT sent to the RS-232 output.
Transmit last sample	SL SendLast	Transmits the last sample collected by the issuing of a GS or HS command that was stored in temporary memory.
Help	HE Help	Displays a list of commands available with brief descriptions

See the next page for details of the RS232 commands.

LISST-ABS RS232 Command Details

Basic Command Set

DisplayStatus	Display Status
Syntax:	DS or ds or status
Description:	Display the Current Status of the instrument including instrument serial number and firmware version
Example:	Command: DS Response: Serial number: 6014 SDI-12 address: 0 Version Jul 8 2015 15:01:34 LISST-ABS>

GetSample	Take and Transmit Sample (and hold)
Syntax:	GS or gs or getsample
Description:	Instrument makes a measurement, stores it in memory, and outputs the averaged Uncalibrated Concentration value to the RS-232 output.
Example:	Command: GS 30 Response: <delay of 30 seconds> 1.23456E3 LISST-ABS> Command: GS Response: <delay of 1 second> 1.23456E3 LISST-ABS>

HoldSample	Take Sample and hold it
Syntax:	HS or hs or holdsample
Description:	Instrument makes a measurement and stores it in memory. The results are NOT sent to the RS-232 output. Only a LISST-ABS> prompt is returned.
Example:	Command: HS 30 Response: LISST-ABS> <Value in memory will be updated in 30 seconds> Command: HS Response: LISST-ABS> <Value in memory will be updated in 1 second>

SendLast	Transmit last sample
Syntax:	SL or sl or sendlast
Description:	Transmits the last sample collected by the issuing of a GetSample or HoldSample command.
Example:	Command: SendLast Response: 1.23456E3 LISST-ABS>

Return	Return to Automatic Mode
Syntax:	GO or return or exit or automode
Description:	Returns the LISST-ABS to automatic mode where results are output to the RS232 every 1 second
Example:	Command: Exit Response: <delay of 1 second> 1.23456E3 <delay of 1 second> 1.23456E3 ...

Help	Display Help
Syntax:	HE or help
Description:	Displays a list of commands available with brief descriptions
Example:	Command: help Response: **** LISST-ABS help menu **** DS or Status Display status. GS or GetSample Take a sample and return the uncalibrated concentration. HE or Help This menu. HS or HoldSample Take a sample and hold the value (nothing returned). AutoMode, Exit, Return to 1hz sampling. Press <cr> three times to or Return halt sampling. SL or ShowLast Display the previous sample taken by GS or HS. Commands are not case sensitive. LISST-ABS>

**LISST-ABS and RS232
Best practices**

For the most accurate results it is recommended that the LISST-ABS be powered up and allowed to sample in the automatic mode (green LED double blinking) for 30 seconds or more before issuing a Start Measurement command. This 30 second wait should be done every time power is applied. During these 30 seconds the LISST-ABS initializes a running average of attenuation that is used internally to compute the concentration. Shorter waits may result in noisier measurements when concentrations are above roughly 1000 mg/liter. At lower concentrations, the attenuation has no significant effect, so the 30-second wait is not necessary.

It is also recommended that bursts of 30 measurements or more be recorded and averaged to obtain the best results. Because of the small measurement volume of the LISST-ABS the measurements can vary from sample to sample as clouds of turbidity pass through the sensitive volume.

For example, if measurements every 15 minutes are desired we recommend the following procedure:

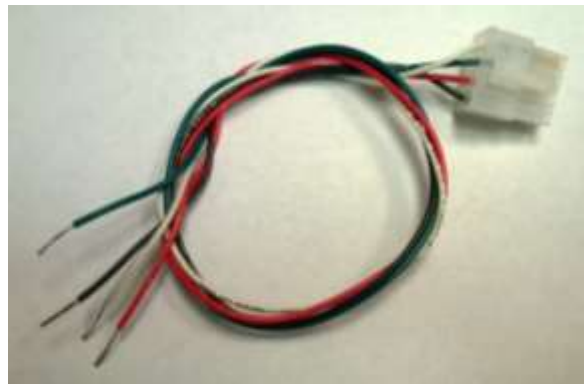
- 1) Power up the LISST-ABS 45 seconds before the beginning of the desired sample time and allow it to sample.
- 2) Option 1: Start recording the values being output by the LISST-ABS to record 60 measurements 1 second apart.
Option 2: Issue GetSample commands to record 60 individual measurements 1 second apart.
- 3) Power down the LISST-ABS and wait till the next sample time.

For general usage recommendations, see page 25.

2.4 Analog Output Operations

The LISST-ABS also provides an analog output for use with data acquisition systems that do not support RS232 or SDI-12 interfaces.

Using the Analog Output requires four wires. Power, Power Ground, Signal and Signal Ground. The two grounds can be combined, but separating them provides the best accuracy. Appendix A includes detailed descriptions of the use of the individual pins of the 8-pin connector on the LISST-ABS. However, in most cases you will be using a cable provided by Sequoia for connecting to your datalogger. To make the connections easier we have provided different cable terminations designed specifically for different connection requirements. For example, we provide a termination with only the four individual wires that are labeled and can be easily connected to the datalogger. The mating connector makes it easy to remove the long cable without disconnecting the wires from the datalogger. You can also easily switch between the datalogger and the USB cable if needed.



The wires are labeled and color coded. Connect the Black wire to Power Ground. Connect the Red wire to +12V. Connect the Green wire to Analog input and the White wire to the Signal Ground.

Analog Output Range and Interpretation

The analog output nominally ranges from 0.1 to 4.1 V. To accommodate the full dynamic range of the ABS within this range of voltages, the output is logarithmic. With an uncalibrated concentration (C_u) of 1 mg/l, the analog output is 1.0 V, and each decade of increase or decrease in the concentration changes the output by 0.5V.

To convert the analog output in volts to Uncalibrated Concentration, use the formula:

$$C_u = 10^{2*(V-1)}$$

In Microsoft Excel, you can use the formula shown below.

		=10^(2*(A4-1))			
	A	B	C	D	E
1					
2					
3	ACB in Volts	Uncalibrated Concentration			
4	0.011	0.01			
5	0.251	0.03			
6	1.110	1.66			
7	2.100	158.49			
8	3.100	15848.93			
9	4.100	1584893.19			

Analog outputs of 0.25V and lower correspond to concentrations that are too low for the ABS to measure, and should be considered invalid. These readings may result from an object in the measurement volume, or the transducer not being fully submerged.

Analog Sampling Best Practices

In order to obtain the most accurate results it is recommended that the LISST-ABS be powered up and allowed to sample in the automatic mode (green LED double blinking) for 30 seconds or more before recording the analog voltage output. This 30 second wait should be done every time power is applied. During these 30 seconds the LISST-ABS is obtaining a running average of attenuation that is used internally to compute the concentration value. Shorter waits will result in noisier measurements.

It is also recommended that bursts of 30 measurements or more be recorded and averaged to obtain the best results. Because the LISST-ABS measures concentration within a small volume, natural variability in the distribution of particles will be reflected in the ABS measurements.

For example, if measurements every 15 minutes are desired we recommend the following procedure:

- Power up the LISST-ABS 45 seconds before the beginning of the desired sample time and allow it to sample.
- Record 60 measurements of the analog voltage 1 second apart.
- Power down the LISST-ABS and wait till the next sample time.

For general usage recommendations, see page 25

2.5 USB Operations via PC software

The LISST-ABS is shipped with a simple windows application that allows for viewing and logging of data. The application also provides a feature that allows for easy calibration of the LISST-ABS.

Installation

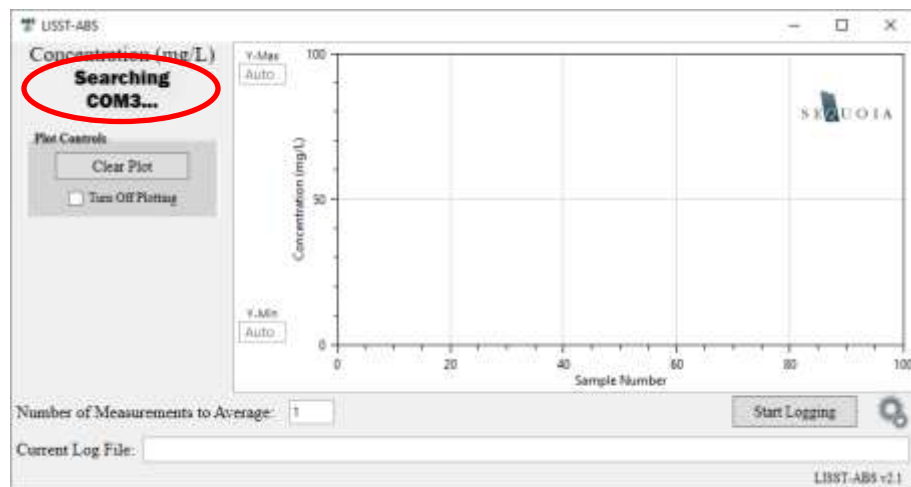
The installer and related software files are located on the USB card included with the instrument. Open the installer by double clicking on 'LISST-ABS_installer.exe.' Follow the onscreen instructions to complete the installation on your computer.

USB Drivers

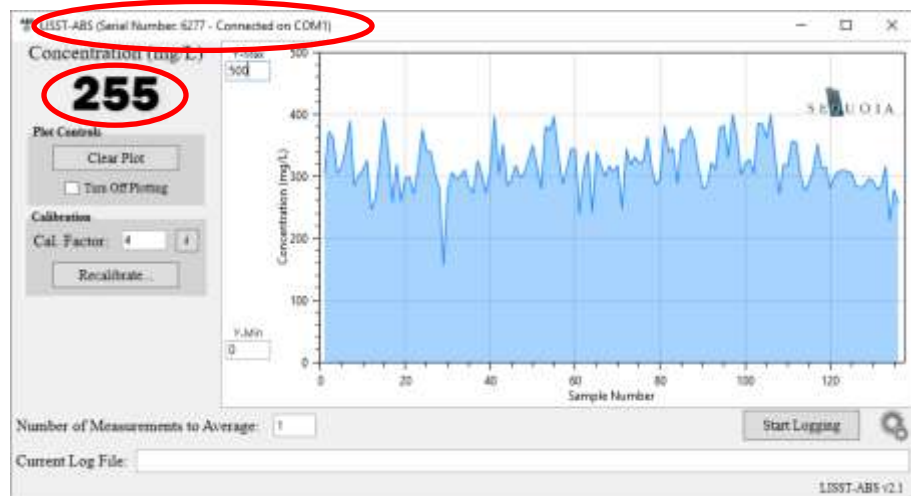
Before launching the LISST-ABS software, plug the USB cable into your computer. If the computer has an internet connection it should automatically install the correct drivers. A notification will appear on the screen if the drivers are being installed automatically. If the drivers are not installed, go back to the USB card, and run 'CDM USB Driver.exe.' Follow the on-screen instructions to install the drivers.

Automatic Instrument Detection

When the LISST-ABS software is launched, it will begin searching for the instrument on the ports of your computer.



Ensure the instrument is connected to the computer via the USB cable. Within a few seconds the software will find the instrument and begin displaying concentration values (default calibration factor of 1). The instrument serial number will also be displayed at the top left of the screen.



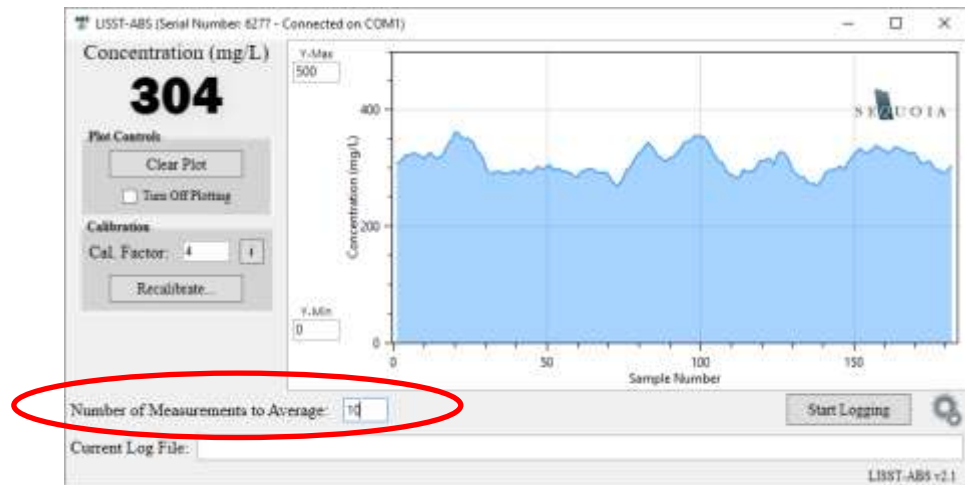
The software will automatically start plotting the concentration as function of sample number.

If the Sequoia USB cable is not available you can still use the software via any RS232 connection (or USB-RS232 adapter) to the PC. You will need to power the instrument separately (see Appendix A: LISST-ABS Cable Wiring and Connector Pinouts).

Should you have more than one ABS instrument plugged into your computer, the software will interface with the first instrument it finds while searching your computer's ports. To change to a different port, see 'Settings/Tools' on page 23. You may also open several instances of the LISST-ABS program to view data from multiple instruments.

Sampling Parameters

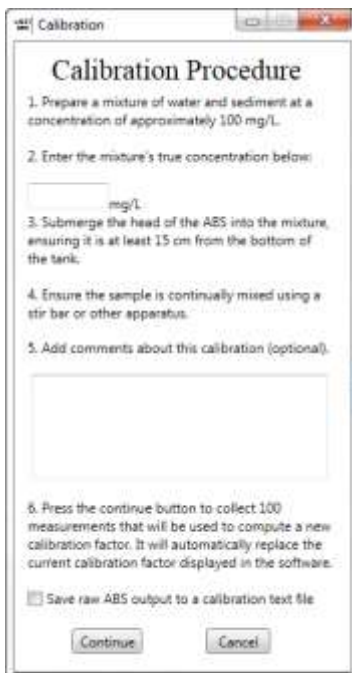
Just below the concentration plot, you can adjust the number of measurements to average per data point. This is calculated as a running average. For example, if you set the measurement average to 10, each point shown on the plot would be an average of the 10 previous measurements. If you do not want any averaging of the ABS output, set the measurement average to 1.



Calibration

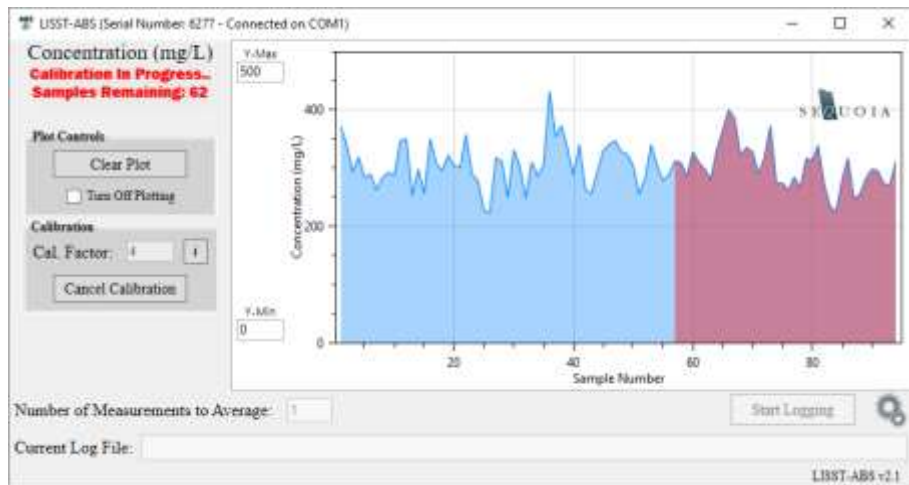
The concentration displayed in the software will be incorrect unless an accurate calibration factor, appropriate to the dominant sediment type in your measurement, is entered in the software (see page 28 for an explanation of calibration constants). If you are only interested in viewing and logging uncalibrated (relative) concentration, you can skip this section.

If you already have a calibration factor for your instrument, you can simply type it into the 'Cal. Factor' text box. The ABS output is multiplied by this value to calculate the calibrated concentration, which will then be displayed to the screen.



If you do not have a calibration factor, you will need to calibrate the instrument. This can be easily achieved by pressing the 'Recalibrate...' button. A new window will appear. It will list the steps you need to follow to calibrate the instrument (left). A check box at the bottom of the window allows you to save a calibration text file that contains the 100 uncalibrated ABS measurements that were used to calculate the new calibration factor value. You may wish to save this file for your records, but it is not required for the calibration to proceed.

After following the calibration steps, the software will begin collecting 100 measurements (If you elected to save a calibration file, you will be prompted for a location to save the file before the calibration begins).



The sample number will count down from 100. Once completed, a new calibration factor will be calculated and entered in the text box. This calibration factor is saved in the software between sessions (i.e. next time you open the software, the 'Cal. Factor' from your previous session will be filled in automatically).

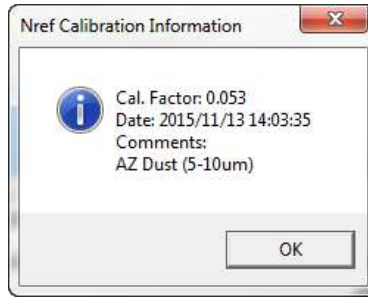
If you elected to save the uncalibrated ABS values, a text file will be saved at the location you specified before starting the calibration. It will contain a header with calibration information, followed by the 100 uncalibrated ABS measurements used to calculate the new calibration factor.

```

cal.txt - Notepad
File Edit Format View Help
Calibration Factor = 0.053
Calibration Concentration (mg/L) = 100
Calibration Date = 2015/11/13 14:03:35
Calibration Comments = AZ Dust (5-10um)
Time = UTC-08:00:00
SN = 6019
2014
2013|
1988
2082
2047
2238
2133

```

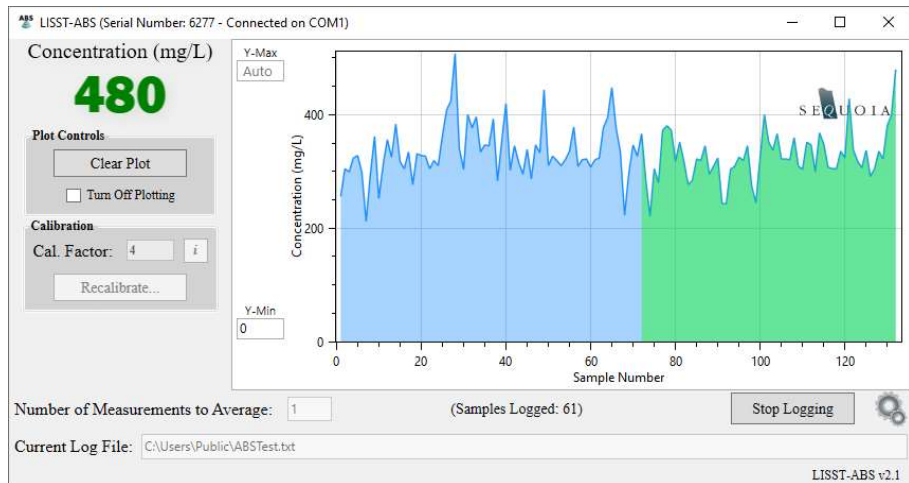
Should you need to remind yourself where a calibration factor came from, you can click the info button located next to the calibration factor textbox.



Logging

Logging is initiated by pressing the 'Start Logging' button. A browser will open that allows you to specify a location and name for the log file. Once that is complete, the location of the log file will be displayed at the bottom of the screen (note: the location displayed at the bottom of the screen can also be edited directly, which is convenient for incrementing file names).

After selecting a file, data logging begins immediately. The number of logged measurements is shown just below the concentration plot.



The log file header contains calibration information, the computer's current time zone, and the instrument serial number. The header is followed by three columns of data: date, time, and concentration (mg/L).

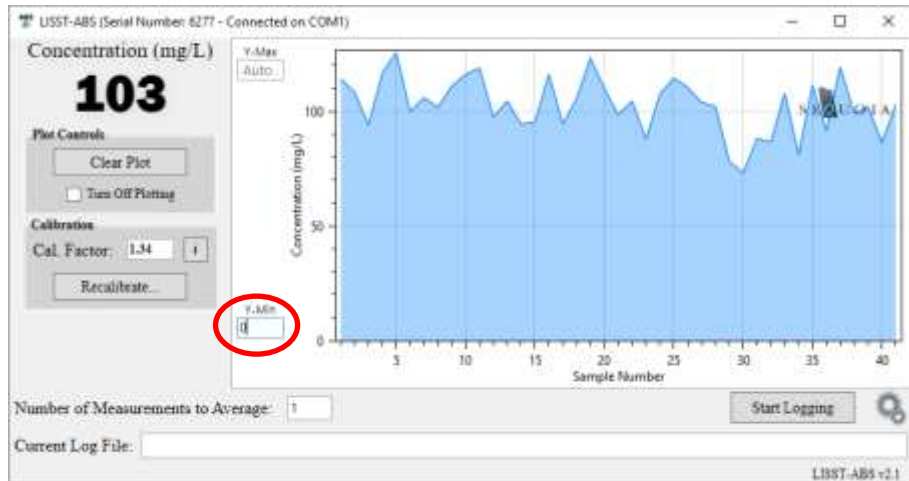
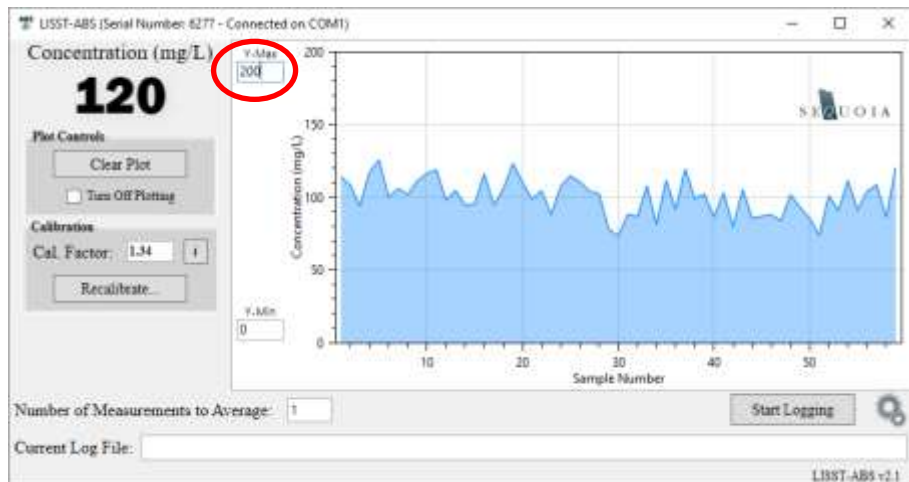
```
test.txt - Notepad
File Edit Format View Help
Calibration Factor = 0.053
Calibration Date = 2015/11/13 14:03:35
Calibration Comments = AZ Dust (5-10um)
Time = UTC-08:00:00
SN = 6019
2015/11/13 14:30:15 45.32
2015/11/13 14:30:20 45.32
2015/11/13 14:30:25 45.32
2015/11/13 14:30:30 45.32
2015/11/13 14:30:35 45.32
2015/11/13 14:30:40 45.32
2015/11/13 14:30:45 45.32
2015/11/13 14:30:50 45.32
```

Data Plotting

The LISST-ABS software automatically plots concentration as a function of sample number.

Data shown in the plot is color coded to indicate what operation the software is performing. If the concentration is simply being displayed with no logging or calibration being performed, data are plotted in blue. If concentration is actively being logged to a text file, data are plotted in green. If the instrument is currently being calibrated, data are plotted in red.

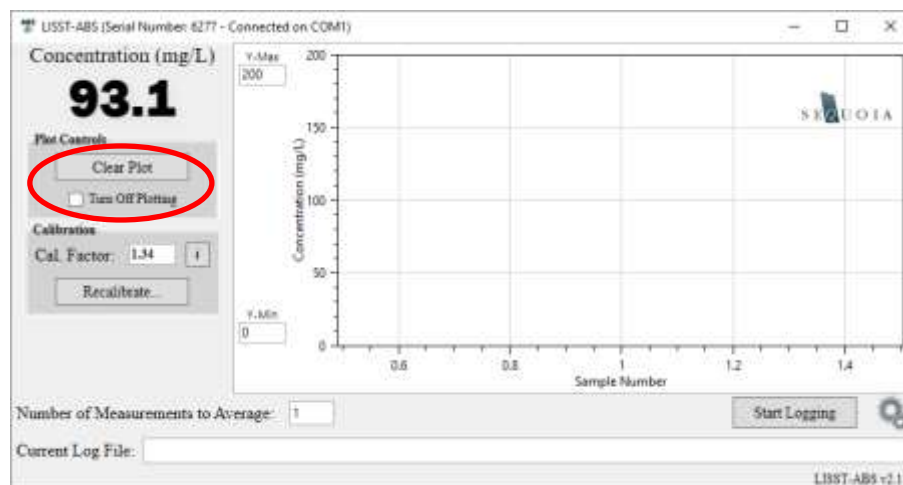
Scaling of the y-axis is handled automatically by default. However, if you wish to lock the y-axis limits at a specific value, enter a number in the text box below 'Y-Min' or 'Y-Max'. You can switch back to auto scaling by deleting the values in the text boxes.



The data currently in the plot can be cleared by pressing the 'Clear Plot' button. This will only clear the display and will have no effect on data logging or calibration. If the software is left to run for a long period of time, the plot will show a maximum of 900

data points (15 minutes of data). After 900 points, the x-axis will scroll, showing only the most recent 900 points.

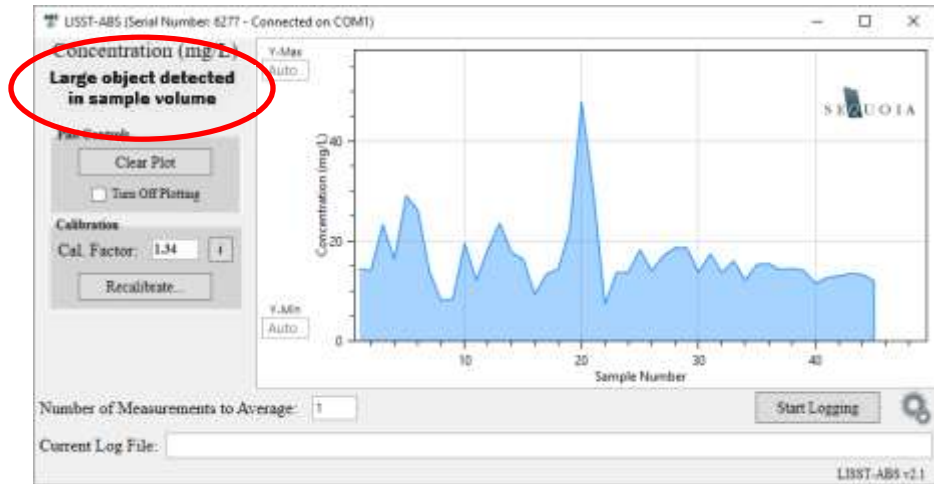
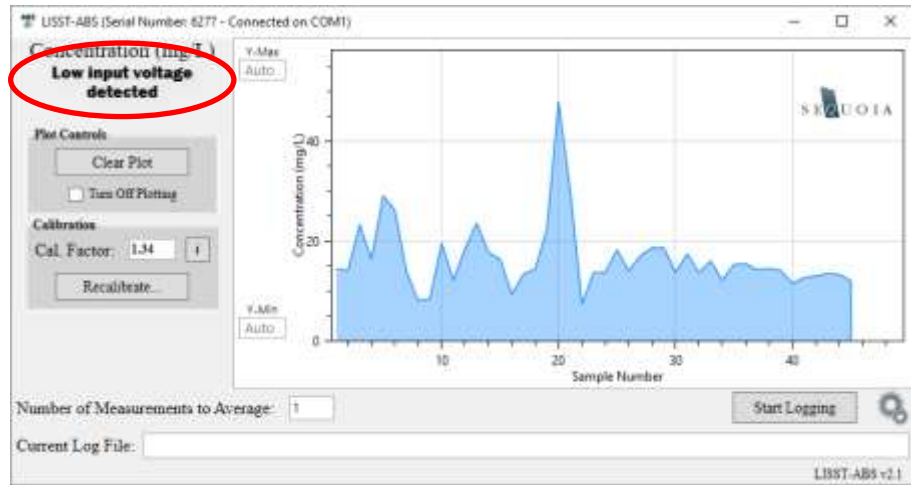
Plotting of data can be disabled by checking the 'Turn Off Plotting' checkbox. This is recommended if you will be leaving the ABS unattended to log data for long periods of time. In these cases, there is no need to tie up computer resources generating a plot that will not be viewed. To resume plotting data, simply uncheck the box.



Errors/Disconnection

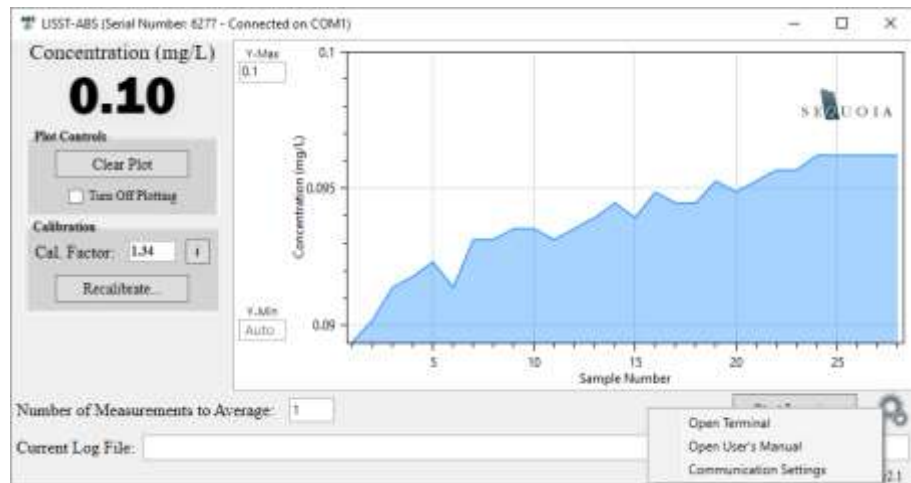
Should there be a power interruption or momentary disconnection, the LISST-ABS software will automatically reconnect when the power or connection is reestablished. If the disconnection occurs while logging data, the logging will pause and resume automatically when the instrument is reconnected.

Should one of the two error codes be produced by the ABS, a brief description of the problem will be shown. A value of -999 means low power supply voltage and the instrument cannot operate. A value of -888 indicates the backscatter from the second range cell is stronger than the first, which is abnormal, most likely indicating an object is obstructing the measurement.

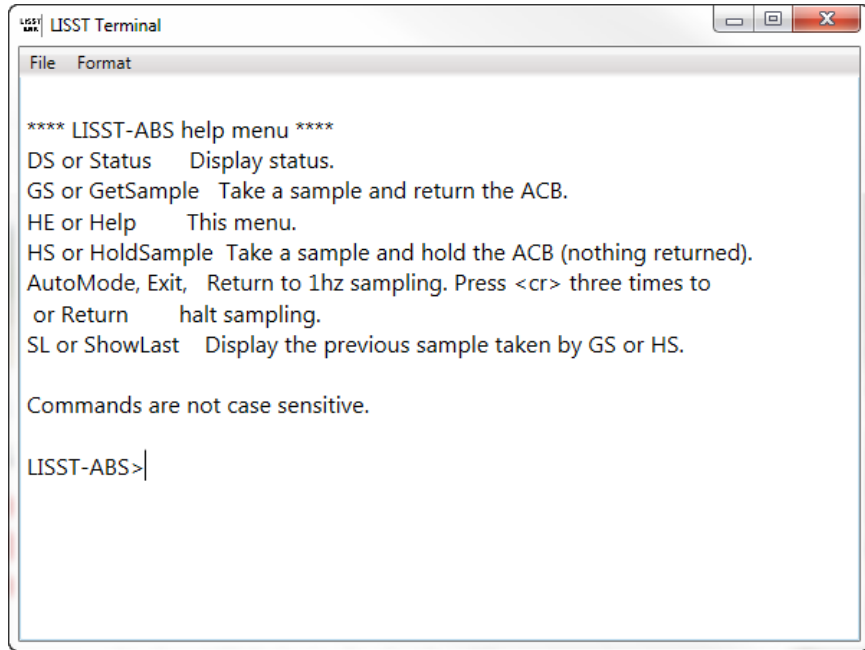


Settings/Tools

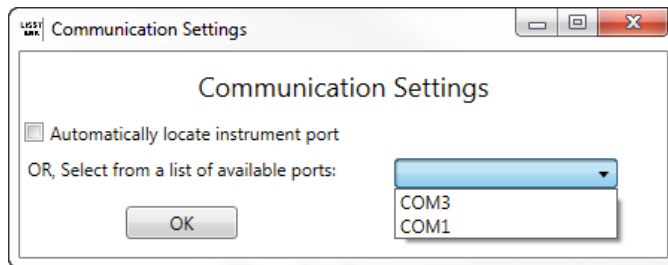
Program settings and tools are accessed by clicking the gear icon in the lower right corner. This provides access to a terminal window, the users manual, and communication settings.



The terminal window allows you to communicate directly with the instrument. This can be useful for retrieving information about your sensor or exploring the instruments serial communication features. Text from this window can be saved to file by selecting 'Save Buffer' from the 'File' menu. Text from the terminal window can be logged continuously to a text file by selecting 'Log Buffer' from the 'File' menu.



Communication Settings allows you to disable the automatic port searching feature. If you know what port your LISST-ABS is connected to, you can specify the port in this window. This can be useful if you are on a computer with many ports, or have multiple LISST-ABS's connected to one computer.



2.6 General Use and Care

The mounting and orientation of the LISST-ABS is similar to that of optical backscatter and turbidity sensor. The suggestions below may help when determining how to mount or orientate the LISST-ABS

The LISST-ABS measures backscatter from two cells at approximately 5 and 10 cm from the sensor head. The two locations are used to measure, and correct for, attenuation of the ultrasonic signal. The space for 15 cm directly in front of the sensor must be free of any objects, with no obstructions to water flow.

Mounting Orientation

To protect the ultrasonic transducer against impact, it is acceptable to recess the sensor inside a pipe, perpendicular to the water flow, with the transducer end no more than 5 cm from the end. Preferably, such a pipe would be perforated to reduce its obstruction of water flow around the transducer.

For reduced drag, mount the LISST-ABS horizontally facing into a flow. In this orientation, it may be placed very close to a boundary (e.g. a river bed), limited only by considerations of bed scour.

The instrument may also be mounted vertically. To avoid interference from bottom reflection, the sensor head must be at least 15 cm above the hard bottom. Also, avoid vertical orientation in water where there may be a strong vertical gradient of particle concentration. Calibration of the LISST-ABS assumes that the concentration is uniform within its sampling volume.

Biofouling reduction

The sensor housing is made of plastic. Do not apply excessive force while mounting. The diameter of the main body is just under 2 inches (5.1 cm). There are many different types of clamps available for this diameter.

Biofouling can be a problem for any sensor deployed in the water. Although the LISST-ABS is more tolerant to biofouling than optical sensors, anti-fouling measures may be required in some environments.

It is possible to apply anti-fouling paint directly to the transducer face, but that will affect the sensitivity, typically reducing it modestly. To maintain accuracy, you would need to measure a new calibration coefficient as described in Appendix B: Converting Uncalibrated Concentration to Concentration

Cleaning

Do not use abrasives, or harsh solvents, such as acetone, that attack plastics. Be especially careful to avoid abrasion of the light-colored transducer disk on the face.

Appendix A: LISST-ABS Cable Wiring and Connector Pinouts

Connector type

Serial numbers 6235 and higher: SubConn MCBH8M; mate: MCIL8F.
 Serial numbers 6234 and lower: Impulse MCBH8-M-P, mate: MCIL8-F-S.

SubConn vs. Impulse

While the SubConn and Impulse connectors are nearly identical and have identical pin numbering, they are not guaranteed to be interchangeable. To identify them, note male SubConn connectors have brass bodies (see photo below), while Impulse are stainless steel. The manufacturer name is also embossed in the rubber body of each connector.

Pin assignments

1. Common*
2. Supply voltage, 10 to 18 V
3. Common*
4. RS232 transmit (from ABS)
5. RS232 receive (to ABS)
6. SDI-12 input/output
7. Analog output
8. Reserved**

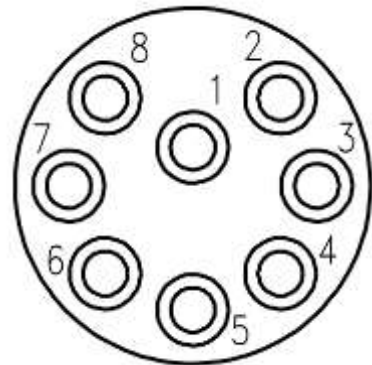
* The Common pins are interchangeable and connected to each other inside the ABS.

** In serial numbers 6245 and lower, pin 8 was a third Common. Connecting it to Common is safe, but will have no effect.

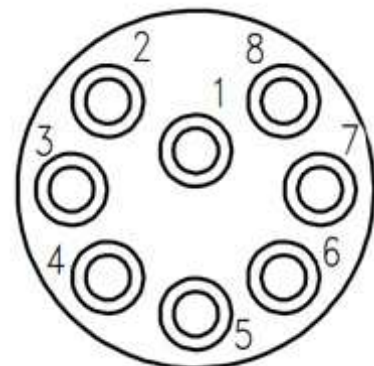
Bulkhead Connector numbering



Photo shows brass-bodied SubConn connector



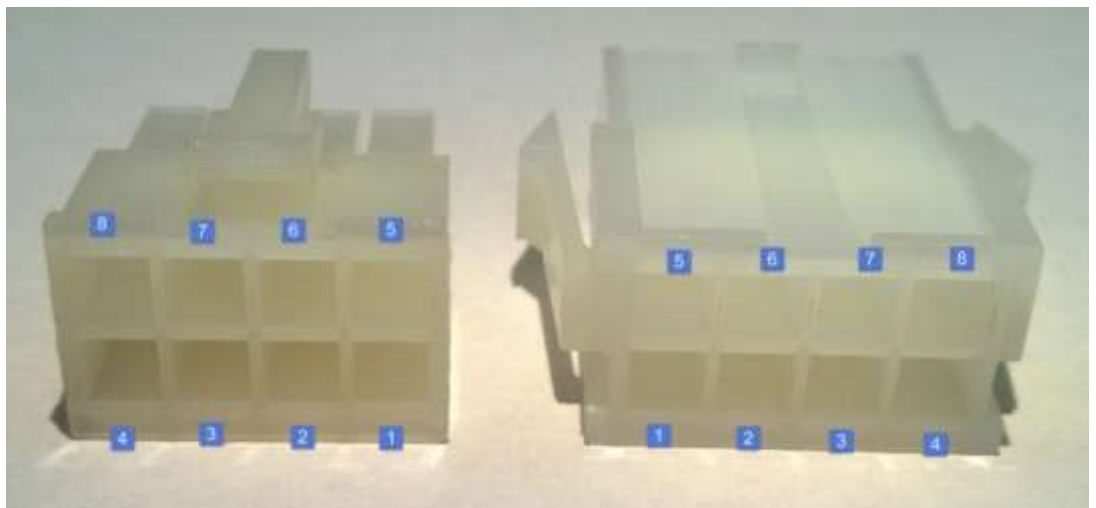
Cable Connector Numbering



Sequoia offers cables for the LISST-ABS in lengths from 5 to 50 meters. These cables include an underwater connector is spliced to a longer cable which is terminated with a white plastic Molex connector. When purchasing the long cable multiple mating cables are provided for different datalogger connections. There are pigtail ends for SDI-12 connections, RS232 connections, Analog Output connections, and a USB Cable for use with a PC. The table below shows the wiring details.

MCBH8M on ABS			RS232 pigtail	SDI-12 pigtail	Analog pigtail
Pin	Function	Subconn pigtail color*	Wire color	Wire color	Wire color
1	Common	Black	Black	Black	Black
2	V+ (10 to 18V)	White	Red	Red	Red
3	Common	Red	-	-	-
4	RS232 transmit	Green	Yellow	-	-
5	RS232 receive	Orange	Blue	-	-
6	SDI-12 data	Blue	-	Green	-
7	Analog out	White/ Black	-	-	Green
8	Reserved	Red/ Black	-	-	-

* Prior to November 2020, pigtails were from Teledyne Impulse, with different color code



The long cable is terminated with a Molex Mini-Fit Jr Female connector (Molex # 0039012081 with Molex # 0039000431 pins). The mating pigtail cables use a male connector with a latch (Molex 0039012080 with Molex #0039000073 sockets). Both connectors have labels for the pin numbering molded into the plastic body of the connector. The pin number is also shown above.

Appendix B: Converting Uncalibrated Concentration to Concentration

Formula The relationship between Uncalibrated Concentration (C_u) and suspended concentration (C) is

$$C = C_u * \text{Cal Factor}$$

Where CalConst is characteristic of a sediment size and type. All LISST-ABS instruments are calibrated using glass spheres between 75 and 90 microns. They are configured so that Cal Const = 1 for these particles. This makes individual LISST-ABS sensors interchangeable.

Note that Cal Factor is the only variable that changes upon recalibration. Also, the Cal Factor is not stored in the LISST-ABS itself. It must be stored and applied either by the Sequoia's LISST-ABS software, or through a method provided by the user.

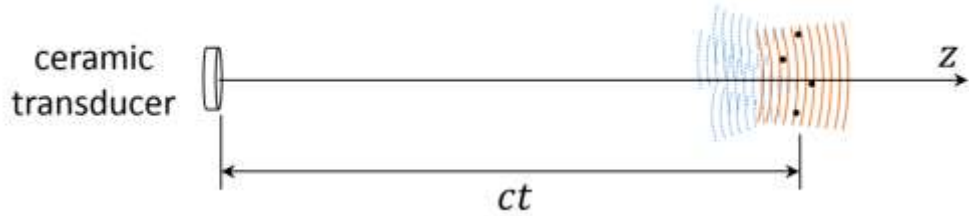
Recalibration Recalibration of the sensor for different size or types of particles involves finding a new value for Cal Factor. Recalibration can be done using the provided Windows software, and an experimental setup that is tailored to the user's requirements and capabilities.

Setup Calibration requires a well-mixed suspension of particles with a known concentration. The particle suspension should match, as well as possible, the composition and size distribution of the particles expected *in-situ*. Ideally, the suspension would be a representative sample from the field site. The particles must be evenly distributed within the vessel used for calibration, through turbulent mixing, and the suspension must be free of bubbles.

Process Insert the instrument face down in the particle suspension. Only the face must be immersed, not the entire sensor. Apply power. The instrument displays Uncalibrated Concentration at the previously held value of Cal Factor. At any time, Press the Recalibrate button and follow instructions. At the end of about a minute, the software computes the new Cal Factor and loads it into the designated box. The measurements that follow use this value of Cal Factor to convert Uncalibrated Concentration to Concentration in mg/L. *This value is not saved on the instrument.* It is only used in the Windows software. Record this value in your notes for future reference.

Appendix C: How the LISST-ABS works

Basics The LISST-Acoustic Backscatter Sensor, LISST-ABS operates in a manner similar to radar. A short pulse of high-frequency sound is transmitted by a ceramic transducer, and the same transducer receives signals reflected by particles.



The pulse travels outward, and its location at any time is at a distance equal to the product of speed of sound in water c , and time t after transmission, ct . Particles in the pulse (called 'cell', 'range cell', 'range bin', or 'sample volume') scatter sound in all directions. Some of this sound travels backward toward the transducer. This scattered sound takes the same amount of time t to reach back to the transmitter. This is the backscatter signal. The total time for this signal out and back is $2t$. Thus, the signal sensed at time $2t$ after pulse transmission corresponds to scattering from a range cell a distance ct from the transmitter. This is the essence of acoustic backscatter. The strength of the backscatter pressure P at the transducer from a range $R = ct$ is related to the outgoing pressure pulse P_0 , the geometric spreading $G(R)$, and attenuation by the combination of water and sediments. It is helpful now to consider the signal via the sonar equation:

$$\log_{10}[P/P_0] = -G(R) - 2[\alpha_w + \alpha_s]R + \log_{10}(\sigma) + N(R) \quad (1)$$

This equation shows the weakening of the signal due to geometric spreading $G(R)$, attenuation by absorption by water (α_w) and sediment (α_s), and a noise floor $N(R)$. The signal of interest is the scattering by particles, σ . The LISST-ABS actually measures the backscatter signal from two range cells located at ct_1 and ct_2 from the transducer, so that it can compensate for attenuation by particles in water. To understand, consider the difference of two signals such as above, but with assumption of equal concentration. By difference, we have:

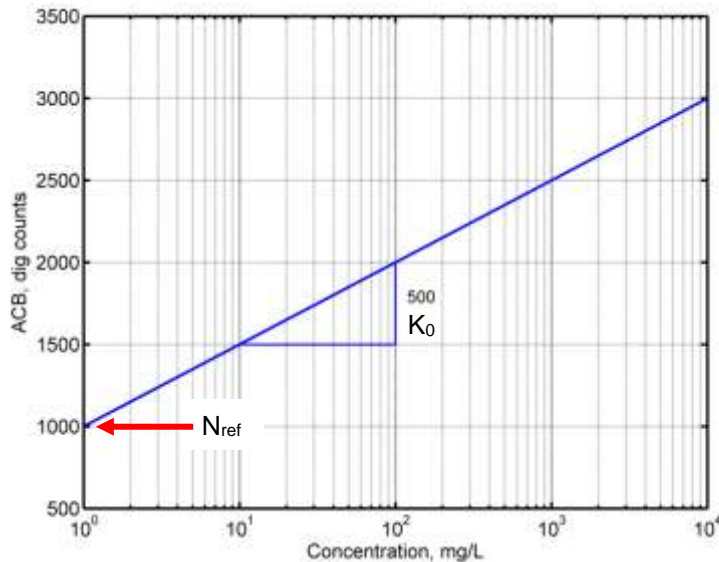
$$\log_{10}[P_1] - \log_{10}[P_2] = [-\Delta G(R) - 2\alpha_w \Delta R] - \alpha_s \Delta R \quad (2)$$

This shows that the difference in signals from two range bins is equal to the geometric spreading factor, and attenuation. The attenuation term is usually very small for LISST-ABS until sediment concentration becomes high, $>1\text{g/L}$. [we ignore noise floor, it is small]. Thus, the two-point backscatter determines the quantity in square bracket. Any increase in the difference determines water attenuation term.

Knowing the terms in Eq.(2), we simply project the measurement to a small distance from the transducer, i.e. at $R \sim 0$ in Eq.(1), yielding the concentration term $\log_{10}(\sigma)$. With a little more arithmetic, that is attenuation-corrected backscattering, or ACB.

In short, the combined geometrical and water attenuation are measured once and are fixed. Temperature related changes in α_w are small and applied subsequently. The sediment attenuation is measured by the change in the difference between two range cells. And then, the measurement is projected to the transducer to get ACB which is then converted to Uncalibrated Concentration.

Calibration The idealized relationship between ACB and sediment concentration is shown in the plot below. Note that this is a log-linear relationship, which is helpful for analysis, as well as matching the characteristics of the detection electronics. ACB counts depend on $\log_{10}(C)$. The slope of the calibration line K_0 is fixed by electronics. In practice, the raw signals do not perfectly match this linear characteristic, but each LISST-ABS is calibrated at the factory to measure and correct its non-idealities. The offset at 1mg/L (where $\log_{10}(1) = 0$) is called N_{ref} . For all instruments, $N_{ref} = 1000$.



The factory calibration uses glass beads of diameter 75 to 90 microns, so every LISST-ABS matches this characteristic for those particles. A change in sediment grain-size or other properties does not change the slope, K_0 , only the offset, N_{ref} .

While the logarithmic ACB is helpful for theoretical analysis, the LISST-ABS reports final values as the more intuitive linear quantity, milligrams per liter.

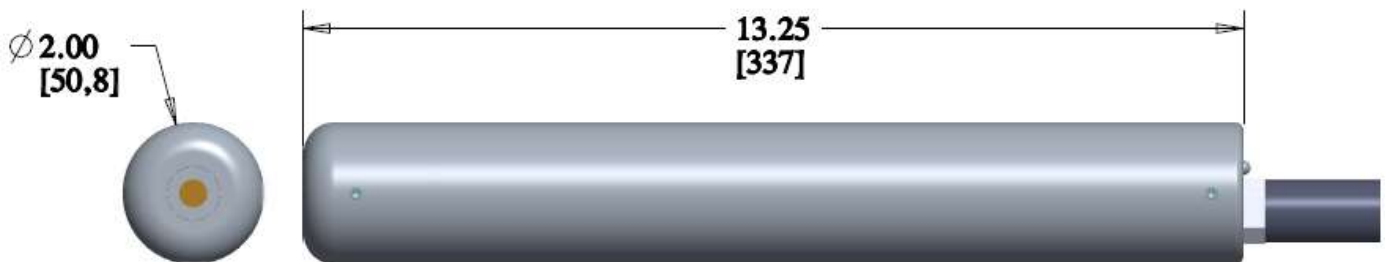
Appendix D: Specifications

Measurement:

- Acoustic Frequency: 8 MHz
- Transducer: 10mm diameter, ceramic
- Sample Volume: approximately 1 cm diameter, 5 to 9 cm from sensor face
- Range (depends on particle size)
 - 1 mg/L to 30 g/L (7 μ m dust)
 - up to 20 g/L (200 μ m sand)
- Outputs:
 - 0-4 V analog
 - SDI-12
 - RS-232
- Sample update rate: 1 per second

Mechanical and Electrical:

- Max. Depth: 100 m
- Diameter: 2.00 in (5.08 cm)
- Length: 13.25 in (33.65 cm)
- Weight: 1 lb. (0.5 Kg) in air
0.5 lb. (0.22Kg) buoyant in water.
- Material: ABS Plastic
- Supply voltage: 10 to 18 V
- Current drain:
 - Serial number 6233+: 50 mA max
 - Serial number <6233: 105 mA max
- Connector:
 - Serial number 6235+: SubConn MCBH8M
 - Serial number <6235: Impulse MCBH8-M-P



Revision history

Version 1.7	Updated software section for LISST-ABS v2.1
Version 1.6	Note change from Impulse to SubConn connectors and change in pin 8 wiring (page 26); update current consumption specification; update Sequoia Scientific's main phone number; general editing.
Version 1.5	Stylistic editing and formatting, remove some obsolete references to ACB, restore GO command, remove incorrect warranty statement (correct statement available on www.sequoiasci.com)
Version 1.4	Update analog output range specification and clarify section 2.4.
Version 1.3	Update maximum concentration specifications. Minor editing & clarifications.
Version 1.2	Deleted GO command (restored in version 1.5)
Version 1.1	Complete revision of software, change standard outputs from ACB to Cu.
Version 1.0	First released version.