Hyper-a
Hyperspectral Absorption Sensor

User's Manual

Version 1.3

August 2024

Store Software USB Card Here

SEQUOIA

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Hyperspectral Absorption Sensor

Technical assistance

For technical assistance please contact your local Distributor or Sequoia. Please be sure to include the instrument serial number with any correspondence.

Warranty

See Sequoia Scientific's standard warranty terms at
www.sequoiasci.com/support/warranty

Sequoia Scientific, Inc. contact information:
Telephone: +1 (855) 753-3313
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I. Introduction

A. General Description

Instrument Description

The Hyper-a is designed for precision absorption measurements of dissolved and suspended material in water (bulk properties). The instrument features an enclosed flowthrough integrating sphere attached to one end. Two quartz windows inside the sphere are used to emit light into the sphere and record the resulting spectrum. An external submersible pump is used to flow water through the integrating sphere.

The Hyper-a uses a broadly emitting xenon arc lamp as a light source. A spectrometer viewing the interior of the integrating sphere measures the light level at sub-nanometer resolution. A second spectrometer views the light source internally, providing a reference.

WARNING: The instrument should NEVER be operated with the Sphere Cavity removed and the user should NEVER attempt to look into the Sphere Cavity (e.g. through the inlet/outlet ports) when the instrument is operating as the xenon arc lamp outputs a significant amount of UV light that can be harmful.

Included Accessories

Included with the instrument are a USB power and communication cable, power supply, instrument stands, User's Manual and USB card with software.

The LISST File Transfer software is included on the USB card. This software can be used to communicate and download files from the instrument. Additionally, MatLab functions and examples are included for processing data files or collecting data in real time.

II. Operation Details

Section Organization

This section contains detailed instructions for performing various procedures. These are either in the form of step-by-step instructions or detailed descriptions of the various aspects of instrument operation (e.g. command list, instrument handling and maintenance).

General Precautions

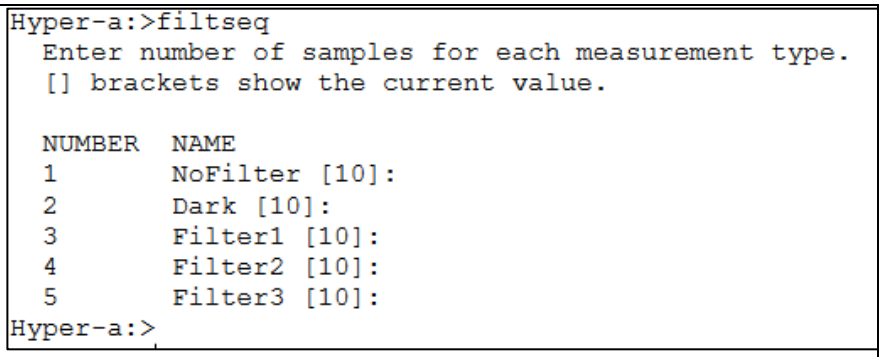
- Hyper-a is a sensitive optical instrument - please handle it gently as you would handle an expensive camera. Evidence of shock/rough handling will void the warranty.
- Whenever in transit, store the instrument in the provided padded shipping case.
- Clean and dry the instrument, including the windows, before storage.
- WARNING: The xenon arc lamp outputs a significant amount of UV light that can be harmful. The instrument should therefore only be operated as instructed in this document and never outside of its specifications. Operating the Hyper-a outside of the standard procedure detailed here and/or its specifications risks exposing the user and bystanders to harmful UV radiation.

B. Instrument Configuration

The instrument is configured through the command line interface accessible via USB serial port. The LISST File Transfer software can be used for automatic connection to the instrument. A terminal window can be opened by navigating to ‘Communication -> Open Terminal’.

The ‘help’ command lists all the available commands. The relevant commands used for instrument configuration are explained below.

Command	Arguments	Description
help	None	Displays a full listing of available commands. Only a subset of commands are listed in this table.
ds	None	Displays an overview of the instrument status and configuration.
date	[<yyyy/mm/dd hh:mm:ss>]	Show or set the date/time
filtconfig	None	Displays a listing of the measurement types. The ID number is used to identify the different measurement types in the binary data file. Hyper-a:>filtconfig NUM NAME ID POSITION 1 NoFilter 10 0 2 Dark 999 0 3 Filter1 45 50 4 Filter2 34 100 5 Filter3 85 150 Hyper-a:>
filtseq	None	Provides an interface to enter the number of samples collected for each measurement type. Entries can be skipped by entering zero. During sampling, the instrument will repeatedly cycle through the specified sequence.

		
autostart	[0|1]	Turn on/off auto start. This will initiate sampling as soon as the instrument is powered on.
usepump	[0|1]	Sets if the pump will run during measurements.
pumpflush	[<seconds>]	Sets the number of seconds to run the pump before measurements are started.
serialout	[off|binary]	Set serial output to off or binary transmission of data (used for real time data collection).
savedata	[0|1]	Turn on/off saving of data files onboard the instrument. Defaults to on (1) when instrument is powered up. Can be turned off when data is recorded in real time via the serial connection.
si	[<seconds>]	Show or set the filter sequence interval in seconds. This is the number of seconds from the start of one filter sequence to the start of the next.
bi	[<minutes>]	Show or set the burst sampling interval. This is the number of minutes from the start of a measurement burst the start of the next burst. Set to zero to disable burst sampling.
sb		Show or set the number of filter sequences per burst.

C. Scheduling Sampling

Filter sequences can be collected at fixed sampling rate or in a bursts of samples. If the time between filter sequences is long enough, the Hyper-a will go into a low power state between measurements.

1. Nonstop Measurements

Data can be collected at full speed with no delays by setting the sequence interval ('si' command) to 0 seconds and the burst interval ('bi' command) to 0.

2. Fixed Interval Measurements

A single filter sequence can be collected at a fixed interval by adjusting setting the sequence interval ('si' command). The sequence interval (set in seconds) is the time between the start of one filter sequence and the start of the next sequence. For example, 'si 60' would start a new filter sequence measurement every 60 seconds.

3. Burst Interval Measurements

Burst sampling is when a set number of filter sequences is collected at a fixed time interval. The number of filter sequences to collect during a burst is set using the 'sb' command. The number of minutes from the start of one burst to the start of the next burst is set using the 'bi' command. For example:

SI 0
BI 60
SB 5

Under this configuration the instrument will collect 5 filter sequences every 60 minutes with no delay between sequences.
Set burst interval ('bi') to '0' to disable burst sampling.

D. How to Collect Data

1. Command Line

The primary method of communicating with the Hyper-a is through the serial to USB communication cable. The Hyper-a communicates via the serial port at 19200 baud (no parity, 8 data bits, 1 stop bit, no flow control). The LISST File Transfer software provides a convenient way to connect and communicate with the instrument. A terminal window can be opened by navigating to 'Communication -> Open Terminal'.

When collecting data by issuing commands at the command line, data will be stored internally in binary files (.bin).

Data can be collected by issuing one of two commands:

measfilt <FilterNumber> <NumMeasurements>

OR

meas <NumFilterSequences>

The '**measfilt**' command provides a way to collect measurements at a single filter position. The position is specified as the first argument and the number of measurements to collect is the second argument. Leave the number of measurements arguments blank to measure indefinitly. The measurements can be ended at any time by pressing 'ctrl-c'. For a listing of the installed filters and the corrisponding filter number (NUM), you can send the 'filtconfig' command:

```
Hyper-a:>filtconfig
  NUM       NAME              ID    POSITION
  1         NoFilter          10    0
  2         Dark              999   0
  3         Filter1           45    50
  4         Filter2           34    100
  5         Filter3           85    150
Hyper-a:>
```

The '**meas**' command will collect measurements while cycling through the various filter positions. The number of measurments to collect at each position is specified in the 'filtseq' command. The example below shows the output of the 'filtseq' command. In this example, 10 measurement will be collected at each position.

```
Hyper-a:>filtseq
  Enter number of samples for each measurement type.
  [] brackets show the current value.

  NUMBER  NAME
  1       NoFilter [10]:
  2       Dark [10]:
  3       Filter1 [10]:
  4       Filter2 [10]:
  5       Filter3 [10]:
Hyper-a:>
```

Filters can be skipped by entering a zero for the position in the ‘filtseq’ command. Once the sequence completes, it starts again from the beginning. The number of filter sequences can be specified as an argument to the ‘meas’ command. Leave the argument black to measure indefinitly. The measurements can be ended at any time by pressing ‘ctrl-c’.

Filter sequences will be collected according the schedule set by the sequence interval (si), burst interval (bi), and sequences per burst (sb) commands (see ‘Scheduling Sample’ section).

Offload the binary data files using LISST File Transfer and read the data into MatLab using HyperA_ReadBin.m.

2. Real Time

Data can be collected and viewed in real time using the provided MatLab functions on the USB card. These functions configure the instrument to transmit binary data over the serial connection during sampling.

Hypera_RealTimeExample.m

Example script showing how to use Hypera_Configure and Hypera_CaptureSpectrum functions. This script will collect and plot some data in real time.

Note that this script changes the baud rate the Hyper-a to speed up the real time data transfer. The baud rate is restored to the orginal default value at the end of the script. This can lead to confusion if the script is only partially executed. If you find yourself unable to communicate with the Hyper-a after experimenting with this script, just power cycle the instrument and the default settings will be restored. Rebooting the instrument will always revert the baud rate back to 19200

CAUTION: In the Hypera_RealTimeExample the ‘SaveDataFiles’ setting is turned off. This increases measurement speed by not saving data to the internal memory. Onboard data logging is not nessesary if data are already recorded using

'Hypera_CaptureSpectrum'. This setting will always revert back to true (data is saved) when the instrument is reboot.

Hypera_Configure

This function allows for configuration of the instrument prior to collecting data. See the command help or the example code on the USB card.

Hypera_CaptureSpectrum

This command primarly accepts a filter postion and number of measuremnts. Data will be collected at the specified filter postion and transmitted over the serial port. The data is output as a table. The spectrums can be plotted in real time by specifying one of the optional plotting arguments. See the command help or the example code on the USB card.

3. External Magnetic Switch

The external magnetic switch on the connector endcap can be used to initate sampling. The switch must be moved from the '0' to the '1' postion while the instrument is powered on. If the instrument is powered on with the switch already in the '1' position, it will not start sampling (as a safety feature to prevent unexpected lamp output at startup). In this case, toggle the switch from '0' to '1' to start samping.

You can confirm sampling has started by viewing the connector endcap LED. The LED will blink blue when sampling has started.

Switch start is identical to sending the 'meas' command. The instrument will begin cycling through the filter wheel postions, measuring them according to the settings in the 'filtseq' command.

Filter sequences will be collected according the schedule set by the sequence interval (si), burst interval (bi), and sequences per burst (sb) commands (see 'Scheduling Sample' section).

Offload the binary data files using LISST File Transfer and read the data into MatLab using HyperA_ReadBin.m.

4. Auto Start (Power Switching)

The 'autostart' setting configures the instrument to begin measurements once power is applied and continues for as long as the instrument is powered.

After power up, a 10 second delay and 5 lamp pulses are emitted as a warning before sampling begins. During this delay it is possible to cancel autostart in the terminal window by sending Ctrl-C.

Autostart is identical to sending the ‘meas’ command. The instrument will begin cycling through the filter wheel postions, measuring them according to the settings in the ‘filtseq’ command.

Filter sequences will be collected according the schedule set by the sequence interval (si), burst interval (bi), and sequences per burst (sb) commands (see ‘Scheduling Sample’ section).

Offload the binary data files using LISST File Transfer and read the data into MatLab using HyperA_ReadBin.m.

E. Data Processing

Calculation of the absorption coefficient by the Hyper-a generally follows the calculations outlined in Rottgers et al. 2005. The equations in Hypera_lib.m can be referenced in this paper.

Pure water (the purest water you can acquire) is used as the reference solution. Pure water can be measured with the Hyper-a before and after sampling with the instrument (in the lab or in the field). It is recommended that the cavity be filled with highly filtered DI water for 24 hours before measurements start. Temperature and salinity should be carefully measured for both the pure water and sample measurements.

Hyper-a data processing is done in Matlab using functions provided by Sequoia Scientific. Processing functions and calibration files for the instrument are included on the USB card included with the instrument.

Each data record is stored with a 'Record ID', which indicates the type of measurement. The 'filtconfig' command will print a table that shows the measurement (filter) type and the corresponding record ID. Here are typical record IDs and their corresponding measurement types:

Record ID	Measurement Type	Notes
10	No Filter	Measurement with unfiltered the light source
999	Dark	Measurement with light source off
601*	EO600*	Measurement with Edmunds 600nm Short pass PN 47-814 over light source*

*600nm short pass filter is included for removal of fluorescence from the absorption measurement. This has NOT been implemented in the current processing software. This will be included in a future software update.

See Hypera_DataProcessingExample.m for an overview of the data processing. This script will import and prepare data for processing. It will compute the absorption using the functions in Hypera_lib.m and plot the results. Example data is included for you to test the processing script.

The output of the Hypera_Process function is the absorption coefficient of the sample in inverse meters (1/m). Absorption by water has been removed from the spectrum using theoretical calculations for water absorption (according to values in IOCCG Protocol Volume 1).

A brief description of each matlab function or script is below. See the help documentation at the beginning of each function/script for more information:

Hypera_DataProcessingExample.m

Script for processing the example data included with the instrument. It can be adapted to fit your own data processing needs.

Hypera_ReadBin

Reads in the binary file (.bin) produced by the Hyper-a. Produces a data table containing the data records and a configuration structure containing instrument information/settings.

Hypera_lib

Several core functions that are used for processing Hyper-a data. You will see these functions used in 'Hypera_DataProcessingExample.m'.

Hypera_RealTimeExample

Script that shows how to collect data in real time with the Hyper-a and Matlab (see 'How to Collect Data' section).

Hypera_Configure

Function used for configuring the Hyper-a via Matlab.

Hypera_CaptureSpectrum

This command primarly accepts a filter postion and number of measuremnts. Data will be collected at the specified filter postion and transmitted over the serial port. The data is output as a table. The spectrums can be plotted in real time by specifying one of the optional plotting arguments.

Hypera_SendCommand

Function for sending commands to the Hyper-a from Matlab.

F. Instrument Maintainance

1. Cleaning Sphere Cavity Before and After Deployment

After deployment, the sphere cavity should be thoroughly flushed with filtered DI water multiple times. It is also recommended that the instrument not be stored with moisture in the cavity. Before storing, it is recommended that the cavity be opened and left to air dry in a clean environment before re-assembly and storage. See the instructions below for opening the cavity.

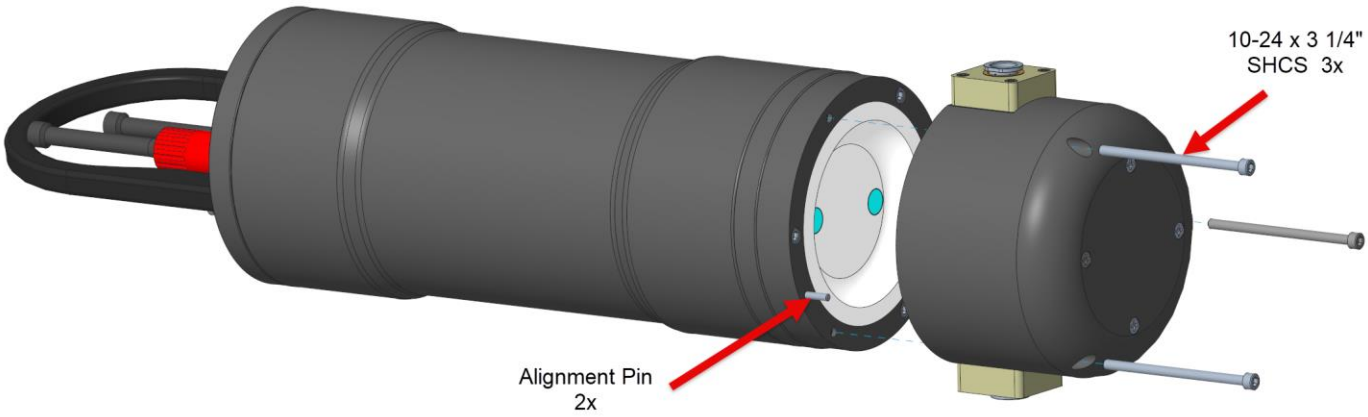
Also note that it is recommended that the cavity be filled with highly filtered DI water for 24 hours before measurements start. This will allow the cavity to get fully wetted before sampling begins. Therefore, it might be desirable to store the instrument for short periods of time with the cavity filled with DI water. But for periods of time longer than a day or two, it is recommended to fully dry out the cavity.

2. Opening Sphere Cavity

If necessary, the sphere cavity can be opened for inspection or for cleaning the windows. The inside of the cavity is made from a special highly reflective (Lambertian) material that is very soft and easily damaged. Great care should be taken when handling the open cavity. It is recommended that gloves be worn when handling as oils from fingerprints can damage the material, however even with gloves on one should avoid touching the material if possible. It is also very soft and can be easily scratched or dented.

WARNING: The instrument should NEVER be operated with the Sphere Cavity removed and the user should NEVER attempt to look into the Sphere Cavity (e.g. through the inlet/outlet ports) when the instrument is operating as the xenon arc lamp outputs a significant amount of UV light that can be harmful.

To open the sphere cavity, remove the three 10-24 x 3 ¼” screws on the outside edge of the cavity as shown below. NOTE: the four Philips head screws closer to the center of the cavity should NEVER be removed. After the screws are removed the cavity should come free from the instrument. A captured O-ring should remain attached to the cavity.



To re-install the sphere cavity, start by inspecting the O-ring on the face of the sphere cavity to make sure it is fully inserted into the O-ring groove and if free of debris. Line up the holes in the edges of the Cavity with the two Alignment Pins. The cavity can only be installed one way. Insert and tighten the three 10-24 x 3 ¼" screws making sure to tighten the screws evenly.

3. Seabird 5M Pump Notes

A SeaBird 5M Pump is included with the Hyper-a to pump water through the sphere cavity. This pump is a magnetically coupled pump that requires some back pressure to function correctly. When testing the pump when not connected to the sphere cavity it may require a restriction in the inlet and outlet before it will function correctly. An unrestricted pump will make noise but not pump water as the impellor will decouple quickly. Placing a finger over the outlet can provide enough restriction for testing the pump operation.

Warning: The pump should never be allowed to run dry. It should always be submerged in water when running.

From the command line interface use the '**pumppow 1**' command to turn on the pump and the '**pumppow 0**' command to turn it off.

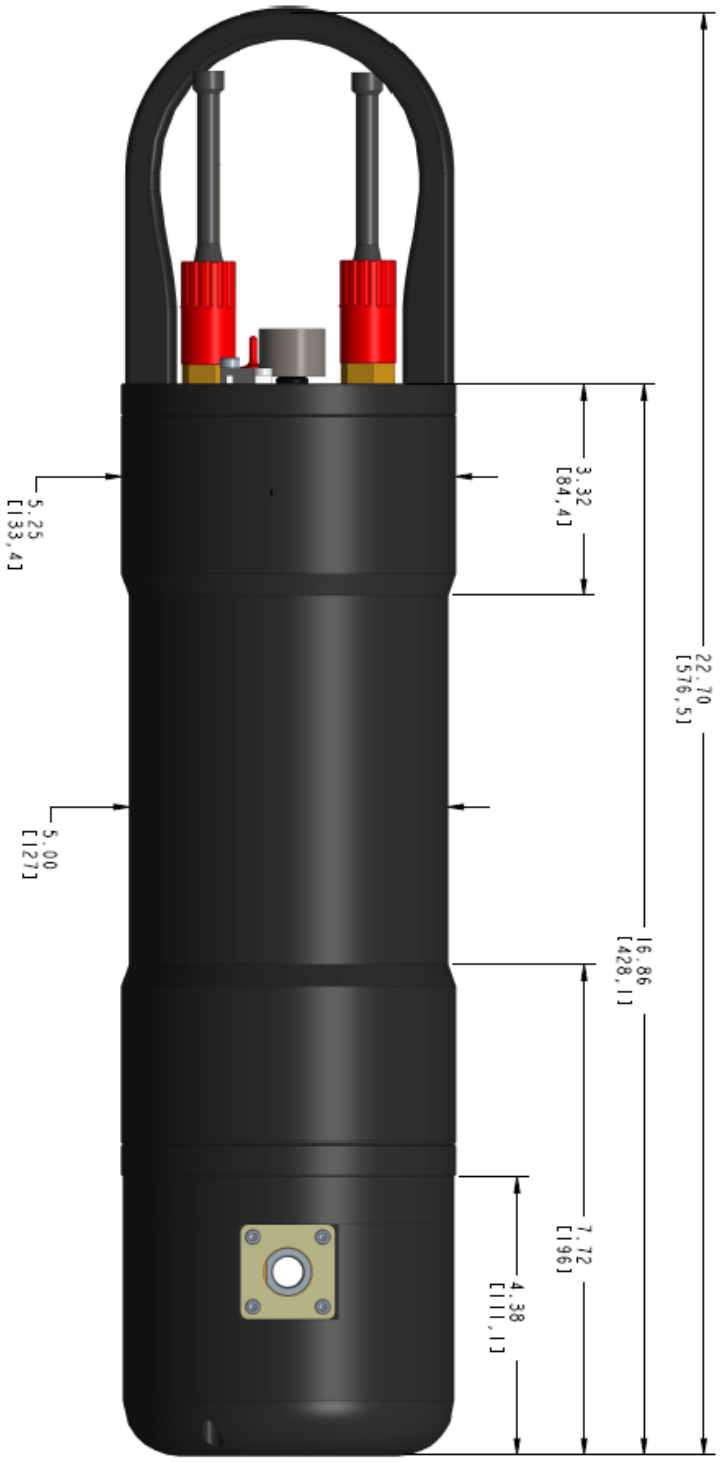
Appendix A: Technical Specifications

General / Electrical

Parameters measured/derived	Absorption Coefficient (1/m)
Data interface	RS-232 serial, 19200 baud, 8 bits, no parity, 1 stop
Sample rate	Sampling rate will vary with signal level
Input voltage	9 to 30 V
Current draw @12 V	Max 2.5 amps.

Mechanical / Environmental

Operational temperature range	-3 to 40 °C
Storage temperature range	-20 to 60 °C
Dimensions (See figure on following page)	576,5 X 133,4 [22.7 X 5.25]
Weight in air	-
Weight in water	-
Depth maximum	600 meters


22.70
[576.5]
3.32
[84.4]
5.25
[133.4]
5.00
[127]
16.86
[428.1]
7.72
[196]
4.38
[111.1]

Appendix B: Electrical Connections

Communications and Power Connector (5 pin connector)

Bulkhead connector: SubConn MCBH5M
Mating cable connector: SubConn MCIL5F

Bulkhead Endview

Cable Endview

Connector Pin #	Use
1	Power/Serial Ground
2	External Power In (+9 to 24 V)
3	Power/Serial Ground
4	Serial Out (to DB-9 Pin 2)
5	Serial In (to DB-9 Pin 3)

Pump Connector (2 pin connector)

Bulkhead connector: SubConn MCBH2M
Mating Cable Part Number: SubConn MCIL2F

Connector Pin #	Use
1	Ground
2	+12V Power Out

Revision History

Version 1.0 November 2023	Initial release with prototype.
Version 1.1 December 2023	Added dimensional drawing.
Version 1.2 May 2024	Add sections on sample scheduling, data processing, and instrument maintenance.
Version 1.3 August 2024	Updated section on Matlab data processing.