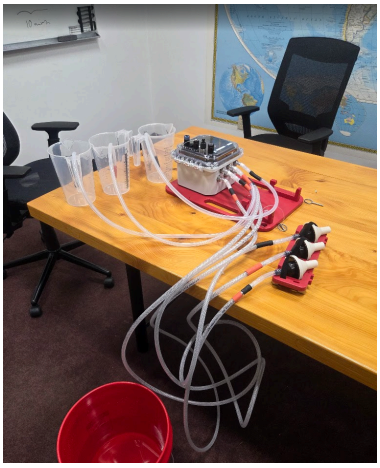
AcSample-VIS

In situ Pumped triplicate eDNA Sampler with LCD screen, Types A/B/D
Document Version: 1.5, **Created:** 5/5/26, Erin Fischell, PhD; **Updated:** 9/12/26
Question? Contact: support@acbotics.com





Above: (left) AcSample-VIS-A during sampling operation with long tubes and weighted filter holder. (middle) mounting of filter into weighted filter holder with long inlet tube. (right) screen view on manager box setting AcSample into debug mode for offload and config.

System Description

The AcSample-VIS is the Acbotics Research triplicate, in-situ eDNA sampler for shallow applications where a surface visual interface is required. It consists of a single box with 3 inlets and 3 outlets, each inlet connected to a peristaltic pump with flow meter. Luer locks provide filter attachment for inlet or outlet filtering. A “Run Dry” switch gives the option of a continuous on mode for the AcSample-VIS without reset. An LCD on the AcSample gives total pumped volume per channel, system status, and time information. The Manager box allows the user to configure the AcSample-VIS sampling cycle, to offload/delete data files, and to set the time on the AcSample. The Battery Box provides backup battery and housing for a USB to serial converter for console operations. A manual run mode is available to turn all pumps on/off.

Timing	Internal RTC, sync to GPS-RTC on Manager Box on user command.
Maximum Depth	5 m (AcSample-VIS-A), 0 m (AcSample-VIS-B), 20 m (AcSample-VIS-D), IP67 (Manager box/Battery Box)
Sensor Logging	RTC Time, Flow per pump, Current per pump
Pumps	G928, 24V high flow peristaltic, 600 mL/minute free flow.
Flow sensors	FM-HL2124, +/- 5% accuracy.
Battery	56 Wh LiPo Rechargeable; 120 minutes continuous or 24 x 5-minute pump cycles.
Data Offload & charge	Offload: Manager box with barrel connect pass-through; shore cable or Battery box console
Filter attachment	Luer lock inlet and outlet
Filter compatibility	Filter-agnostic, but the selected filter WILL impact flow
Example Inlet Flow Rates (neg control)	Cobetter filter holder with 1 um pore 47 mm diameter MCE: 260 mL/minute .22 um pore Sterivex: 140 mL/minute Smith-Root 1.5 um GP non-self-preserving: 600 mL/minute Smith-Root 1.0 um pore 1 um pore 47 mm diameter MCE: 320 mL/minute Sylphium Filter, 1.2 um pore PES: 310 mL/minute
Example outlet flow rates (neg control)	Wilderlabs syringe filter: 420 mL/minute Sylphium Filter, 1.2 um pore PES: 370 mL/minute
AcSample base board configuration	1) Removable weighted filter holder assembly: remove two pins to deploy. 2) Fixed filter assembly: attached to board with screws

AcSample-VIS Hardware Configurations Table

Several hardware configurations are available for the AcSample-VIS:

Series	Acbotics Part #	Release date	Serial Numbers	Power switch	Run dry switch	Volume pump start	Depth Rating
AcSample-VIS-A	101676	5/5/26	6001-6099	Rotary switch	Rotary switch	After time delay	5 m
AcSample-VIS-B	101677	6/12/26	6101-6199	Latching button	Latching button	After time delay	IP67/1 m for 30 minutes
AcSample-VIS-C (other manual)	101678	7/15/26	6201-6299	Latching Button	Latching button	On button press	IP67/1 m for 30 minutes
AcSample-VIS-D	101710	9/1/26	6301-6399	Rotary switch	Rotary switch	After time delay	20 m

Software versions:

- 1.0.0: Prototype release
- 1.1.0: Initial pre-production release, bug fixes
- 1.2.0: Add button start features, bug fixes; compatible with new board design

Manager Box Configurations

The Manager Box (PN 101679 for Lithium batteries, PN ?? for NiMH batteries) has different features/menus based on software versions. If you have questions about which software version you have, contact Acbotics Research at support@acbotics.com.

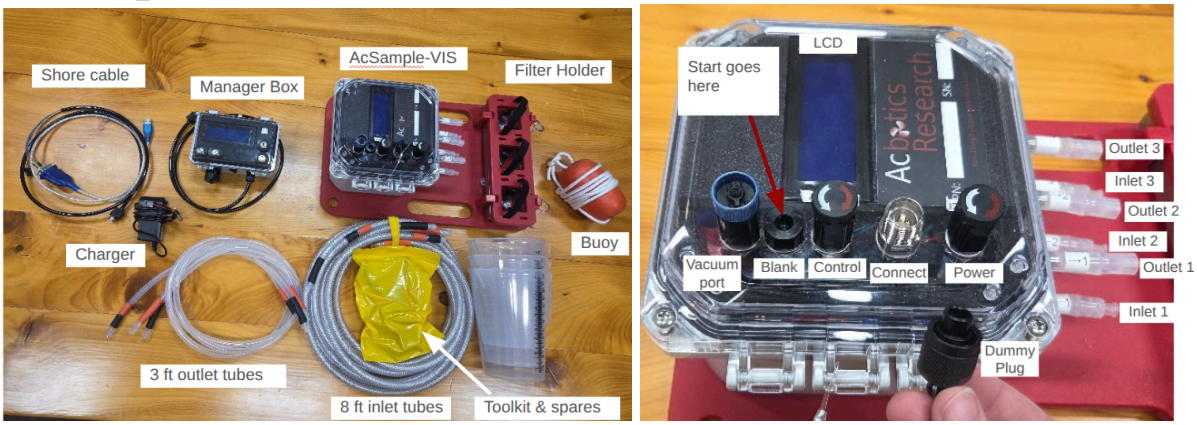
Acbotics Part #	Release Date	Manager Serial Numbers	Software Version	Release Notes
Prototype	5/5/26	None or <1001	1.0.0	Prototype software release.
101679	6/12/26	1001-?	1.0.1	Add “INIT_T” variable to config options on Manager box.
			1.0.2	Add button press to start option (AcSample-VIS-C units)

Battery Box Configurations

Acbotics Part #	Release Date	Manager Serial Numbers	Software Version	Release Notes
Prototype	5/5/26	None or <1001	1.0.0	Prototype software release.

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AcSample-VIS Quick Reference



(Left) Contents of AcSample-VIS box: Shore Cable, manager Box, AcSample-VIS on baseboard with weighted filter holder assembly; Buoy, 3 ft outlet tubes; 8 ft inlet tubes; toolkit & spares bag. (Right) Components of AcSample-VIS.

Accessories:

1. Manager Box or Battery extender (optional)
2. Shore Cable (optional)
3. Charger for shore cable/manager box
4. Pliers & Phillips head screwdriver
5. micro-SD card reader
6. Inlet/outlet tubes
7. Spare luer attachments
8. Spare ¼" tubing

Turning AcSample ON/OFF ("Power" switch)

Turning ON: Turn power switch on electronics housing towards the right until it is fully engaged or press power button; the LCD should turn on and display state.
Turning OFF: Turn power switch on electronics housing towards the left or press power button; LCD will turn OFF.

Default Autosampling Behavior on Power Up

1. **INITIALIZE:** Boot microcontroller, initialize SD card (LED OFF)
2. **START:** Run startup pulse with length **Initialization Pulse Time** (10 s all pumps on) (LED double pulse/2s off, pumps ON). Turn off pumps
3. **WAIT:** Wait until **Startup Delay** (default 10 s) has elapsed
4. **RUN:** Run all 3 pumps until each has reached **Sample Volume** (default 3 L) pumped fluid or until **Max Pump Time** (default 20 minutes) has elapsed
5. **DONE:** After 20 minutes have elapsed or volume is met, the pumps will turn off.

Charging the Battery

1) Remove Dummy Plug; Plug in shore cable or manager box to AcSample. NOTE: AcSample will charge through manager box when manager box is off.
2) Plug charger into wall; this will charge the battery as indicated by a red LED on the wallwort. Once LED on charger turns green, battery is fully charged. Note: LED goes green if the power cable is disconnected.

Turning on Run Dry or taking a negative control ("Control" switch)

At any time, you can turn the "Control" switch. This will switch the box into "Control Mode", intended to be used to dry out filters on the sampler or to turn on all pumps bypassing the default modes. The additional water in the tubing to be counted with the total flow.

Negative Control

1) *For inlet filter:* attach negative control tube to desired inlet and to filter or filter holder; Install outlet tube.
   For outlet filter: attach inlet tubing on one channel, install filter on outlet then attach outlet tubing.
2) Fill 1 jug with 1000 mL (or desired volume) DI water.
3) Place inlet tube in water jug. Place outlet tube in a second jug or bucket.
4) Turn on AcSample-VIS power switch; turn on AcSample-VIS "Control" switch. Unit will run continuously. Turn OFF once desired volume is pumped through filter.

Default Operation: Inlet Filters

Deploy Operation



1) Install filters on inlets
2) Turn system ON; wait for 10 s startup pulse to complete
3) Deploy system in the water
4) After 60 s or specified delay, system will pump until each channel measures that 1 L or configured volume has been pumped.
5) Recover system and observe volume.

Between Deployments

1) Remove filter holders; preserve and store filters.
2) If re-using filter holders, sterilize filter holders.
3) Prepare filters for next deployment.

Each Day

1) Sterilize tubing and sampler.
2) Sterilize filter holders if using filter holders
3) Transfer filters to more permanent storage (e.g. deep freezer).
4) Charge batteries & offload data.
5) Take negative control.

Example use of AcSample-VIS with Disconnectable Weighted Filter Assembly



Base plate w/ weighted filter holder attached



Remove pins



Tilt up to remove



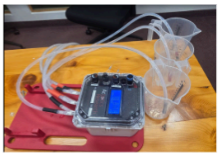
Velcro on filters to weighted filter holder



Filter holder may be re-inserted for transport



Deploy



Run



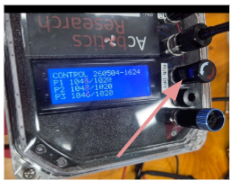
Done



Recover weighted filter holder



Place holder on base if desired



Turn on "Run Dry"; observe volume once tubes clear. Continue to dry as desired.

Configuration Variables

The AcSample-VIS with manager box allows for GUI configuration of Volume, Delay, and Max pump time variables in Volume Mode; software versions 1.0.1 and greater allow for config of the init pulse time in seconds as well.

Variable	Default	Configurable via Manager	Manager Variable
Sample Volume	2000 mL	Yes	VOLUME
Startup delay	600 s	Yes	DELAY
Max Pump Time	1800 s	Yes	MAX_T
Init pulse time	10 s	No (Manager 1.0.0) Yes (Manager >=1.0.1)	INIT_T
Volume Mode	ON	No	—
Duty Cycle	OFF	No	—
Depth Trigger	OFF	No	—

Note: More configuration options on Manager box can be added on request.

NOTE: When using outlet filters, always use init pulse to clear tubes before attaching filters with INIT_T >= 10 s.

Manager Box controller

The manager box allows users to configure AcSample systems, offload, delete, run pumps, and set time.

Observing and Modifying Configuration with manager box:

1) Remove Dummy Plug; Plug in manager box
2) Turn on AcSample-VIS. It should give you the home menu with "Offload/Config/Manual/Time" options.

3) Use menus to navigate to “Config” menu. Adjust each variable as desired, then save.
4) The volume change should immediately be reflected on the AcSample.
5) Turn off or disconnect the manager box, then restart the AcSample to run with updated config.

Offloading Data:

1) Remove Dummy Plug; Plug in manager box
2) Turn on AcSample-VIS. It should give you the home menu with “Offload/Config/Manual/Time” options.
3) Make sure a micro-SD card is in the micro-SD card port.
4) Navigate to Offload -> Offload Data; data will be offloaded to external micro-SD card
5) Plug micro-SD card into phone or computer. A new folder is created every time you offload; a single text file is in that folder that contains a raw dump of all the data on the sampler when the offload is run. The latest directory/file is the one you just created.

Plugging in and turning on:



1) Plug Manager box into AcSample-VIS; turn on AcSample-VIS ON/OFF switch; make sure “Run Dry” switch is OFF.



2) Insert MicroSD card in Manager Box external port.



3) Turn on Manager Box.



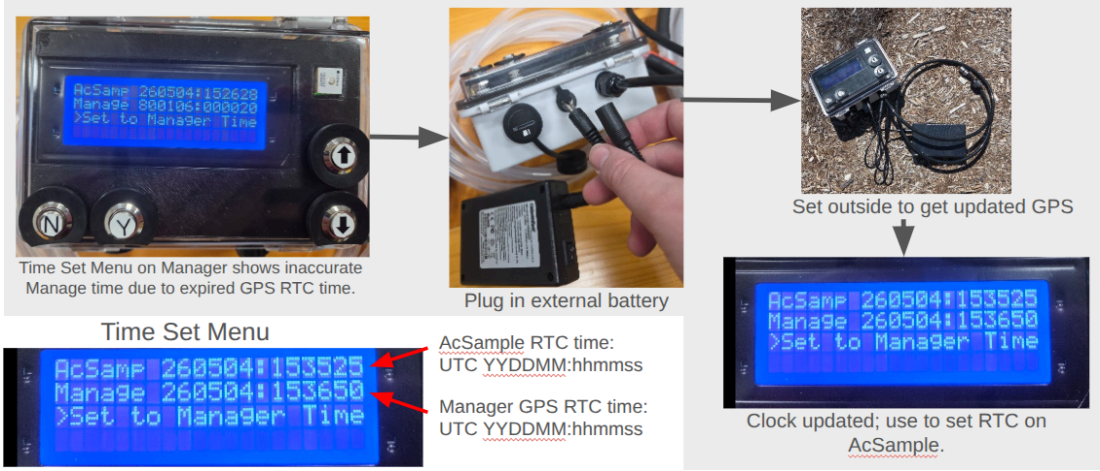
4) Follow menus to offload/config.

Menu	Up/down select	Submenu	Yes select:	No select
DISCONNECT	N/A	None; plug in AcSample	N/A	N/A
Main	Select submenu	Offload	Offload menu	Main
		Config	Config menu	
		Manual	Manual menu	
		Time Set	Time Set menu	
Offload	Select submenu	Offload data	Offload data to microSD	Main
		File List	Lists files on AcSample	
		Delete	Delete confirm menu	
Delete	N/A	Delete confirm	Delete all files on AcSample	Offload
Config	Select config	Volume	Go to Volume var config menu	Main
		Delay	Go to Delay var config menu	
		Max pump time	Go to MAX_T var config menu	
		Init time	Go to INIT_T var config menu	
		YES PROGRAM	Program AcSample	
Var config menu	Increase/decrease value	N/A	Save value	Cancel
Manual Menu	Select submenu	Toggle pumps	Turns all pumps On/OFF	Main
		Reset	Reset AcSample	Main
Time set Menu	N/A	N/A	Set AcSample clock	Main

Time and GPS:

The GPS in the Manager box is used to provide an accurate clock set to the AcSample. All systems use UTC time. The manager box can be taken out independent of the AcSample by using the external battery. To set the GPS clock:

1) Plug battery into Manager box.
2) Take the Manager box outside for 5 minutes or so to get a GPS fix;
3) The “Disconnect” screen includes a print of the GPS time; once correct, you can assume GPS fix!



Tube Sterilization

1) Install inlet and outlet tubes.
2) Prepare 10% bleach solution in jug: 1 bleach tablet or ½ cup liquid bleach to 32 oz water.
3) Place all 3 inlet tubes in bleach solution; place outlet tubes in second jug.
4) Turn unit "ON" such that startup pulse (10 s) runs. Turn OFF, rerun pulse 3x total such that 100 mL of solution passes through each channel (~300 mL total).
5) Place all 3 inlet tubes in fresh water (ideally deionized water) and outlet tubes in an empty jug. Turn ON; unit will pulse, wait 60 s, then run. Allow ~300 mL of water to pass through each channel (900 mL total). Then allow unit to continue to pump air for 5 minutes to dry. Turn OFF.

Checking the seal



1) Install brass tube adapter and red pressure relief adapter on vacuum pump
2) Screw red adapter into blue pressure relief valve.
3) Using hand pump, pull at least 10 inHg vacuum
4) Let sit 5 minutes; if vacuum has remained approximately the same, your system is sealed.
5) Unscrew red pressure relief adapter from AcSample-5m; ensure blue pressure relief valve is fully inserted.





1) Install brass tube adapter on vacuum pump
2) Remove "OK" plug. Insert brass tube adapter.
3) Using hand pump, pull at least 10 inHg vacuum
4) Let sit 5 minutes; if vacuum has remained approximately the same, your system is sealed.
5) Unplug brass adapter from AcSample-5m; Re-insert and screw in "OK" plug.



(Left) Instructions for units with pressure relief valve (Right) instructions for units with "OK" plug

Warnings & Underwater Pre-Deployment Checklist:

- ☐ Data offloaded and SD card cleared (if desired)
- ☐ Battery Charged
- ☐ System configured as desired
- ☐ Box sealed and holds vacuum
- ☐ Filters are new and dry (if wet, air cannot be cleared from the inlets on startup)
- ☐ System sterilized (if required)
- ☐ Dummy plug installed

WARNING: All tests should start with a DRY filter and clear lines; hydrophilic filters do not work to clear air in lines once wet so once water is put on the inlet to the filters no air can be allowed to enter the system.
NOTE: when used as a benchtop or shore sampler with longer tubes, use "Run Dry" function to ensure accurate volume-through-filter estimates with inlet filters.
WARNING: When using a filter on the outlet, allow 10 s startup pulse to complete BEFORE installing filters.
NOTE: Assume system may spit small amounts of water when powered on; always make sure outlets are pointed away from any electronics or sensitive components!

Filter Kit Quick Reference

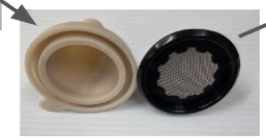
In the Filter Kit

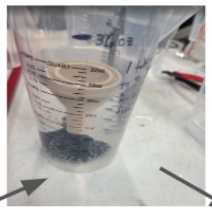
- 3x Smith-root filter holders with male luer lock attachment
- 6x 1.2 um pore PES or 1.0 um pore MCE hydrophilic disc filter 47 mm
- 6x PETE drain disc (mesh spacer) 47 mm

Sterilizing filter holders



Open filter holder; remove filter paper if required.





Soak all parts in 10% bleach solution.

Rinse all parts with fresh water (deionized is best).



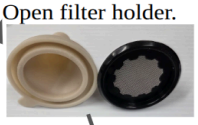


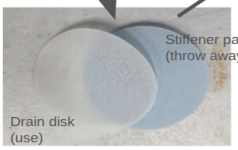
Allow to dry before re-assembling.

Assembling filter holders



Open filter holder.



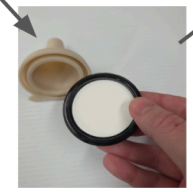


Remove drain disk from packaging; identify as “not blue” disc.



Open 47 mm filter; if there is stiffener paper, identify the filter as the more opaque disc.

Place drain disc, then filter paper in filter holder.





Close filter holder, squeeze shut all the way around.

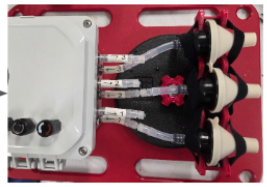
Loading filter holders



Attach first filter to inlet 1



Attach velcro strap



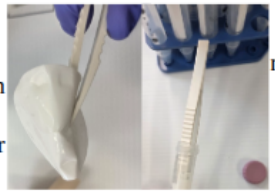
Repeat for remaining inlets



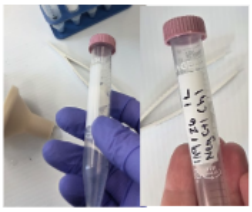
Preserving Filters on recovery



Remove filter from sampler, open filter holder.



Using tweezers, remove filter from filter holder. Using a twisting motion, put in a storage vial.

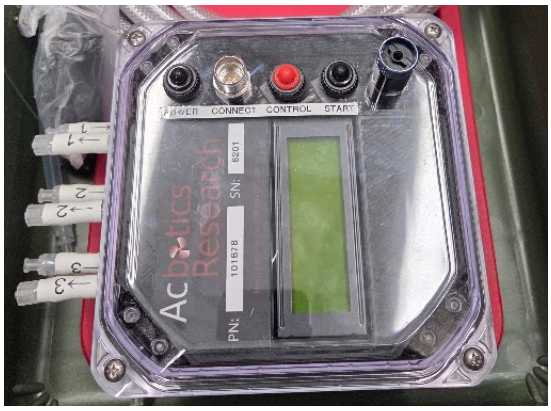


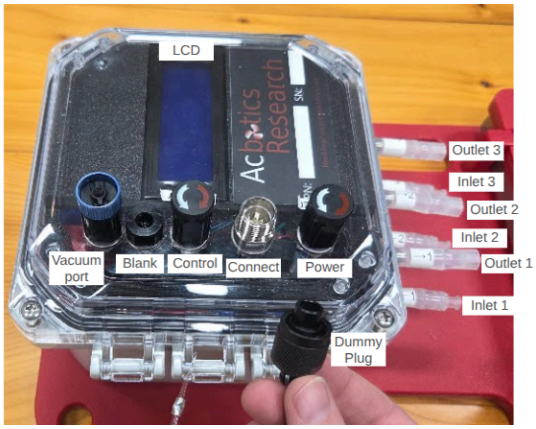
Seal vial, label, and freeze or preserve as indicated by processing lab.

Detailed User Information

Mechanical/electrical components and guide

AcSample-VIS Configurations: Housing

<table>
<tr><td>Sampler</td><td>Configuration</td><td>Photograph</td></tr>
<tr><td>AcSample-VIS-B</td><td>Push-button, IP67/IP6X (30 minute submersion, 1 m)</td><td rowspan="3">


</td></tr>
<tr><td>AcSample-VIS-5m (AcSample-VIS-A)</td><td>Rotary switch, 5m indefinite submersion with or without external depth/temperature sensor</td></tr>
<tr><td>AcSample-VIS-20 m (AcSample-VIS-D)</td><td>Rotary switch, 20 m indefinite submersion with external depth/temperature sensor</td></tr>
</table>

Full System Sterilization

1) Ensure system is sealed and dummy plug is in place.
2) Prepare a large-enough container with 10% bleach solution.
3) Turn system ON. Tie a string to the unit so that it is easy to remove later.
4) Place system in bucket; allow run fully.
5) Repeat with bucket with fresh water.
6) Repeat in air to dry.

Default Operation: Outlet Filters

Deploy Operation **Between Deployments** **Each Day**

1) Turn system ON; wait for 10 s startup pulse to complete
2) **Install filters on outlets**
3) Deploy system in the water
4) After 60 s, system will pump until each channel measures that 1 L has been pumped.
5) Recover system and observe volume.

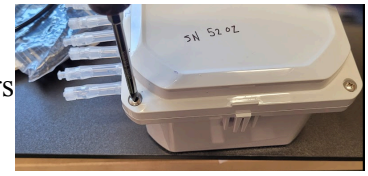


1) Remove filter holders; preserve and store filters.
2) Sampler tube sterilization.
3) If re-using filter holders, sterilize filter holders.
4) Prepare filters for next deployment.

1) Sterilize tubing and sampler.
2) Sterilize filter holders if using filter holders.
3) Transfer filters to more permanent storage (e.g. deep freezer).
4) Charge batteries & offload data.
5) Take negative control.

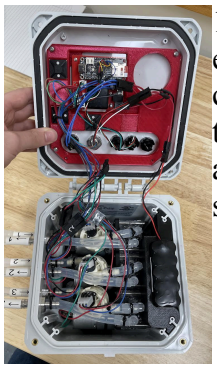
Opening the Box

Ideally the user will not have to open the AcSample-5m, as a console/charge cable is provided. However, if it is necessary the box can be opened by unscrewing all 4 phillips head screws on the corners then opening the box. If you do open the box for any reason, make sure you follow “sealing the box” steps before deploying!



Sealing the box

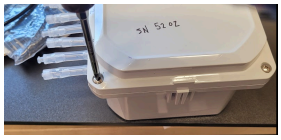
If the box is open for any reason, it will need to be sealed and the seal verified before deploying for underwater operation.



1) Inspect internal electronics: ensure SD card is inserted and that there are no wires near any of the sealing surfaces.



2) Close lid and tighten all 4 philips head screws until fully tight
3) Follow “checking seal” instructions to check the seal with vacuum



4) Ensure the dummy plug is inserted; you are ready to go!



Flow Rate Table

Examples of flow rates measured in our lab; note that flow rates are with clean water, as filters clog flow rates will decrease.

Filter Housing	Filter	Recommend	Inlet Flow	Outlet Flow*+
Smith-root	47 mm, Glass Fiber	Inlet	500 mL/min	-
	47 mm, MCE 1 um	Inlet	320 mL/min	-
Cobetter Filter Holder	47 mm, MCE 1 um	Inlet	260 mL/min	360 mL/min*+
Sterivex GP 0.22 um syringe filter		Inlet/Outlet	120 mL/min	260 mL/min*+

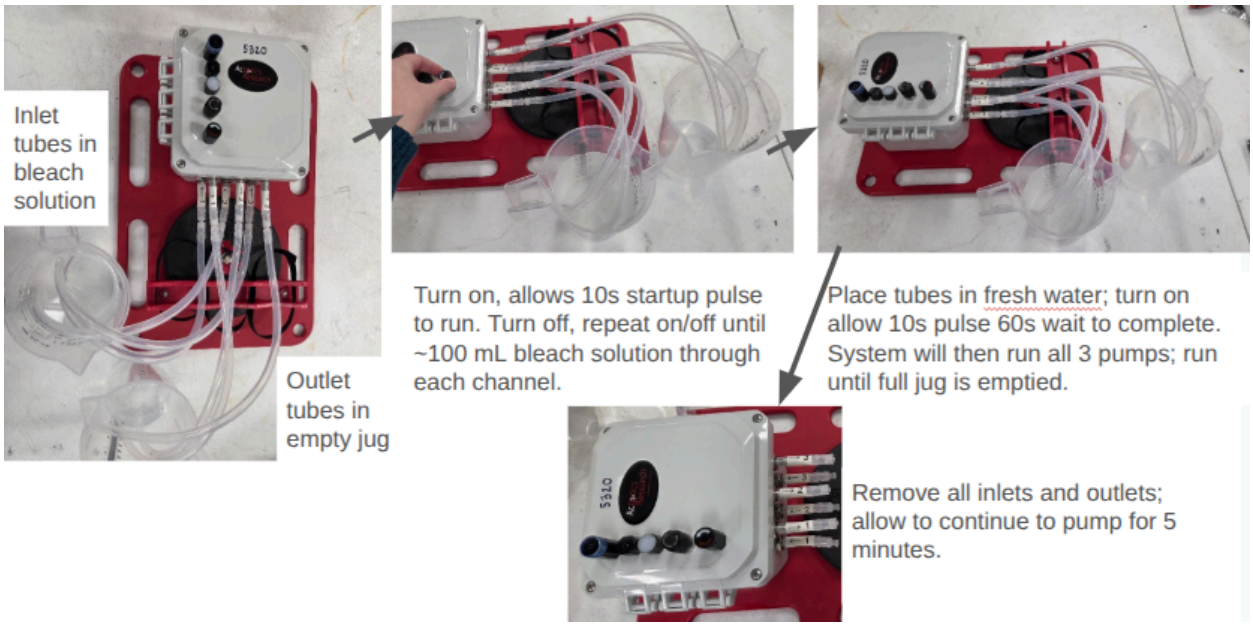
33 mm diameter PES, 0.45 um syringe filter	Inlet/Outlet	160 mL/min	260 mL/min*+
Wilderlabs CA 1.2 um syringe filter	Outlet	-	350 mL/min*+
Sylphium 1.2 um PES	Inlet	**310 mL/min**	370 mL/min*+

* ALWAYS use a clean, dry filter. Use with a wet filter, or one that has already pumped water through, may damage the sampler when used on the outlet
+ When using filters on outlet, follow tube sterilization instructions between uses.

Sterilization

Sterilization of tubes

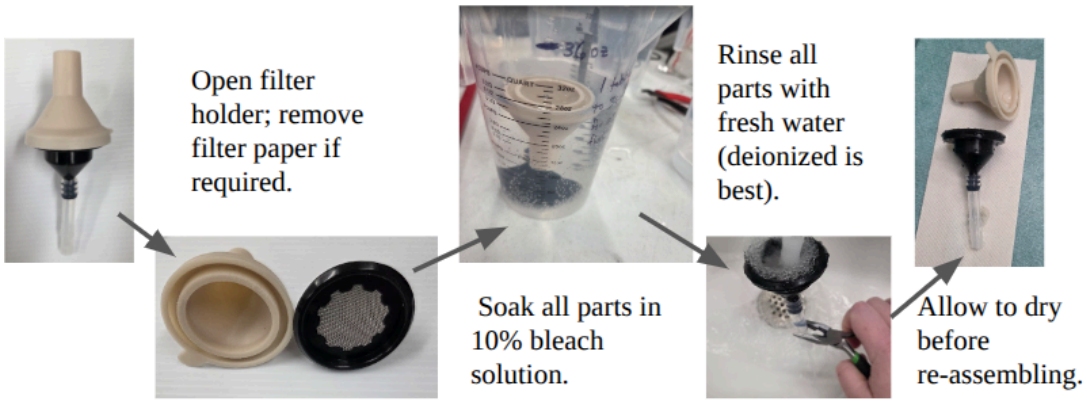
Prepare jug with 10% bleach solution (½ cup bleach or 1 tablet bleach to 32 oz water). Then:



Sterilization of sampler (prior to storage)

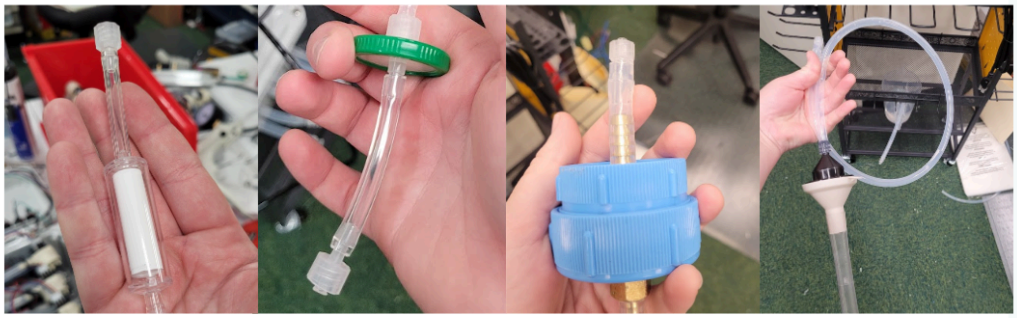
Remove all pieces from base board. Submerge all components in 10% bleach solution. Rinse with DI water, and allow to dry before re-assembly.

Sterilization of reusable filter holders



Adapting filters for use with the AcSample

The AcSample inlets and outlets are luer lock, so most filters can be adapted to attach. Below are example attachment photos for several types of filters for the inlet using a male luer lock:



Sterivex | 33 mm syringe filter | 47 mm filter holder | Smith-Root

The outlets are also luer lock. Wilderlabs filters (or other similar small disc filters) typically have a female luer lock on the inlet, and are best used on the outlet with a sterilization step between uses; the wilderlabs syringe filters connect directly to the outlet of the AcSample without adaptation. Other filters may be adapted to the outlet using a luer lock adapter.

Advanced Functions and Programming: Via console connection

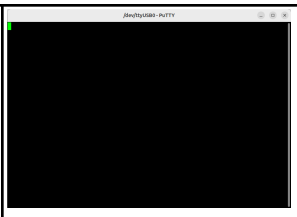
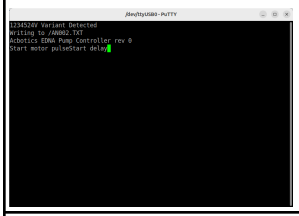
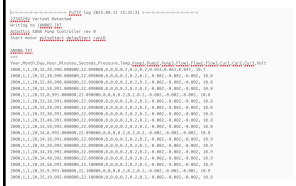
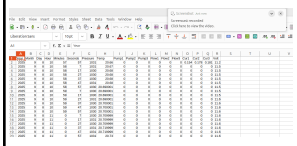
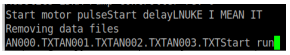
Useful serial commands:

Command	Use	Notes
:RR	Print RTC	Use to print out current RTC datetime.
:RW<YYmmdd:HHMMSS>	Set datetime on RTC	E.g. :RW260119:150000 would set it to Jan. 19 2026, 15:00:00
:PA ON :PA OFF	Turn all pumps on/off	:P1 ON would work for pump 1, :P2 for pump 2 etc.
:CP	Print current config	
:CR	Reboot the system	
:CW	Write config to RAM	**Unless this command is run, your config changes will not apply!!**
:CL	Load config	Load config from RAM
:CSTT=<time in integer s>	Set trigger time	Time system waits after startup pulse before starting pumping.
:CSSP=<startup pulse integer s>	Set startup pulse length	Time system runs startup pulse before waiting for timeout or depth trigger.
:CSMT=<max runtime integer s>	Set max runtime of any pump	Set maximum time any pump will run
:CSVE=0 :CSVE=1	Enable/disable volume mode	If off, will use time only (or depth/time if depth is enabled)
:CSTV=<mL volume>	Set target volume on system	E.g. :CSTV=1000 Sets 1000 mL as the target volume
:LL	List files	
:LD	Dump data	Dump all files on SD card to serial terminal.
:LNUKE I MEAN IT	Delete everything	Delete all files on system to clear SD Card, you have to mean it!
:SD	Debug state	Put system in debug state.
:SC	Continuous ON state	Put system in neg control state, i.e. always ON all pumps.

Copying off and clearing data, Advanced: Via Serial

Note: You can offload data on a daily or weekly basis depending on your needs and whether you require debug information. **To copy off data, you will need a computer with Putty (see pages 16-20 for information on how to install and configure Putty) or another serial console installed and configured as indicated in the "Console Operation" section. WARNING: When you turn the unit on if it has been in water, IT WILL SPIT WATER EVERYWHERE! Place somewhere that won't matter.**

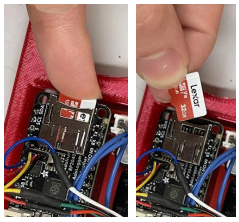
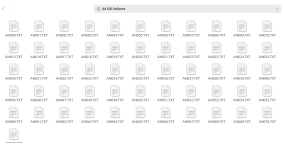
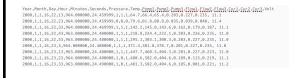
1) Disconnect dummy plug from console connector	2) Plug in console cable. Make sure you fully tighten cable collar to get a good connection.	3) Plug USB to serial converter into console, and USB into your computer.	4) Open Putty & connect to the USB device (see Console config if it is the first time)

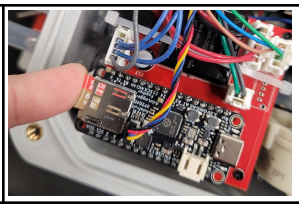
			
5) Turn on system; you should see something like below: 	6) In the putty console, type: :SD (then press enter) This puts you in debug mode so the motors don't keep running.	7) Next, dump the logs by typing the following into putty: :LD (Then press enter) This will dump the data to a file.	8) Open the file printed from the serial console. Mine looks like this: 
9) Convert the dumped data to csv using the python script provided; we can also parse the files for you if you are having trouble.	10) Confirm all data copied and parsed correctly! The files should look like this: 	11) *If desired:* Delete data on SD card by typing the following into putty: :LNUKE I MEAN IT (Then press enter). This will delete all data. 	12) Turn the system off. Remove console cable, re-insert dummy plug and tighten.

Copying off and clearing data, Not Recommended: By Micro-SD card

Alternatively if a serial console is not possible, the box can be opened and data copied off the micro-SD card directly to a computer. Note that if you choose to do this, you need to follow instructions for "sealing the box and checking vacuum" afterwards.

To access data this way, you will need a philips head screwdriver and a micro-SD adapter for your computer.

1) Unscrew all 4 screws on box using a philips head; open box 	2) Locate Micro-SD card on arduino; push to remove from slot 	3) Plug into your computer; copy off all files. 	4) Confirm files can be read; they should be able to be renamed with a .csv extension if you are having difficulty with them as .txt 
5) *If desired:* Delete all files on micro-SD card, and empty the trash on your computer.	6) Remove microSD from your computer.	7) Plug microSD back into box.	8) Seal box (see "sealing the box and checking vacuum")

Typical configuration examples

The AcSample is configurable via console cable for a variety of modes, with start triggers based on time and/or depth, end triggers based on time and/or volume, and duty cycle options. Full details can be found in the Console Operation part of this document. Most users will want to run in a more basic configuration, e.g. 1000 mL volume pumped per sample with a maximum pump time of 600 s. Three example configurations and the resulting behavior are shown below:

Config Variable	Var	Value	Behavior/Logic
Volume Trigger Enable	VE	1	When turned on: 1) Startup: All pumps ON for SP = 10 s 2) Wait: All pumps OFF TT = 60 s 3) Single cycle: Each pump ON until: a) pumped volume = TV = 1000 mL b) elapsed time = MT = 600 s
Depth Trigger Enable	TE	0	
Duty Cycle Enable	DE	0	
Startup pulse length (s)	SP	10	
Target volume (mL)	TV	1000	
Maximum pump time (s)	MT	600	
Trigger start depth (m)	TD	1	
Trigger start time (s)	TT	60	

Config Variable	Var	Value	Behavior/Logic
Volume Trigger Enable	VE	0	When turned on: 1) Startup: All pumps ON for SP = 10 s 2) Wait: All pumps OFF TT = 60 s 3) Single cycle: Each pump ON until elapsed time = MT = 600 s
Depth Trigger Enable	TE	0	
Duty Cycle Enable	DE	0	
Startup pulse length (s)	SP	10	
Target volume (mL)	TV	1000	
Maximum pump time (s)	MT	600	
Trigger start depth (m)	TD	1	
Trigger start time (s)	TT	60	

Config Variable	Var	Value	Behavior/Logic
Volume Trigger Enable	VE	0	When turned on: 1) Startup: All pumps ON for SP = 10 s 2) Wait: All pumps OFF until: a) depth >= TD= 1 m b) elapsed > TT = 60 s 3) Single cycle: Each pump ON until elapsed time = MT = 600 s
Depth Trigger Enable	TE	0	
Duty Cycle Enable	DE	1	
Startup pulse length (s)	SP	10	
Target volume (mL)	TV	1000	
Maximum pump time (s)	MT	600	
Trigger start depth (m)	TD	1	
Trigger start time (s)	TT	60	

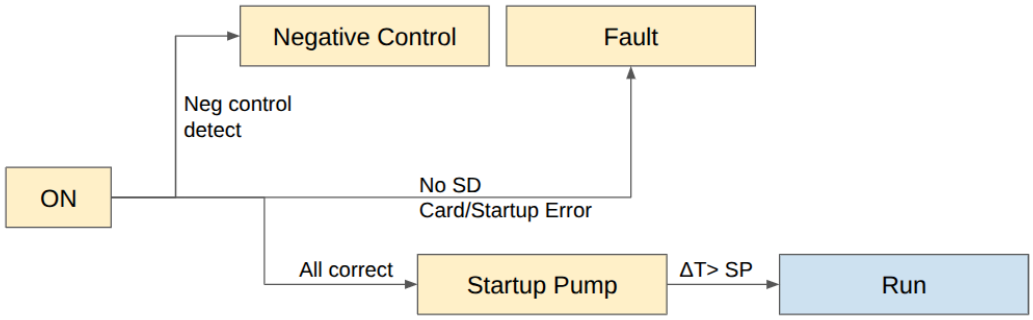
State Machine

State	Pump Behavior
Negative Control	All pumps ON
Fault	All pumps OFF
Startup Pump	All pumps ON
Debug	All pumps OFF
Wait for Startup Trigger	All pumps OFF
Single Cycle	All pumps ON unless volume or time criteria met
Duty Cycle	
Duty Cycle: ON	All pumps ON unless volume or time criteria met
Duty Cycle: OFF	All pumps OFF
Done/Success	All pumps OFF
Done/Timeout	All pumps OFF

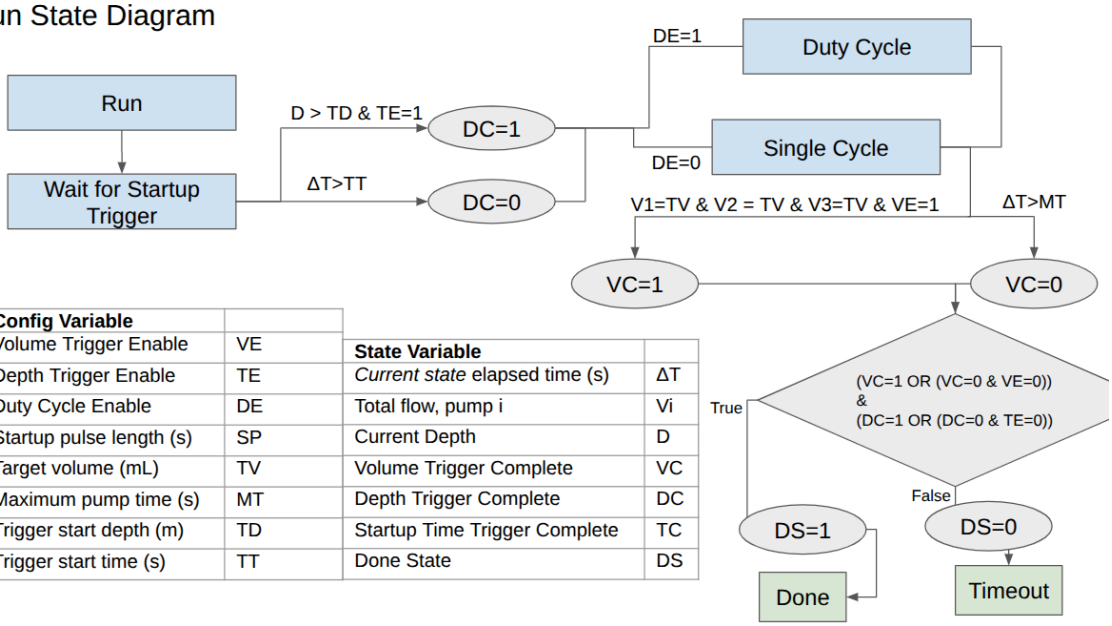
The state machine for the AcSample-FAST-5m includes startup, run, and complete states. The below diagrams show the logic associated with state transitions within the state machine, including criteria to exit each state. Color indicates type of state, with yellow for startup, blue for run, and green for complete states. Logic transitions are indicated by arrows with text, or in the case of complete states, with a diamond indicating the logic statement that is used to determine if the system has met all trigger criteria during operation.

The theory behind the “done” versus “timeout” states is that if the system indicated via the LED indicator that all trigger criteria are met, it may not be necessary for the user to look at the log data. If “timeout” state is indicated, the user should check the logs to determine if the system never reached the desired depth, failed to pump the desired volume on one or more of the pump channels, or multiple of the above.

Startup States



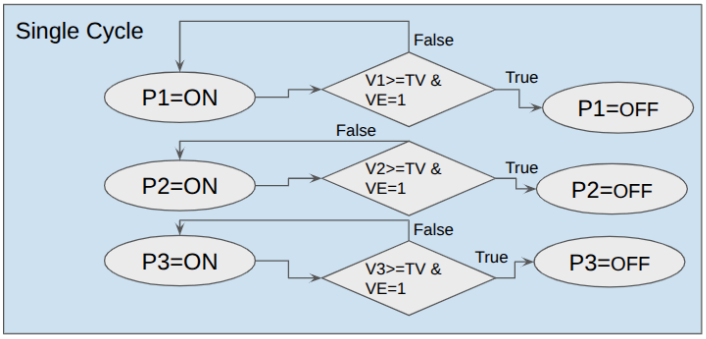
Run State Diagram



Config Variable	
Volume Trigger Enable	VE
Depth Trigger Enable	TE
Duty Cycle Enable	DE
Startup pulse length (s)	SP
Target volume (mL)	TV
Maximum pump time (s)	MT
Trigger start depth (m)	TD
Trigger start time (s)	TT

State Variable	
Current state elapsed time (s)	ΔT
Total flow, pump i	Vi
Current Depth	D
Volume Trigger Complete	VC
Depth Trigger Complete	DC
Startup Time Trigger Complete	TC
Done State	DS

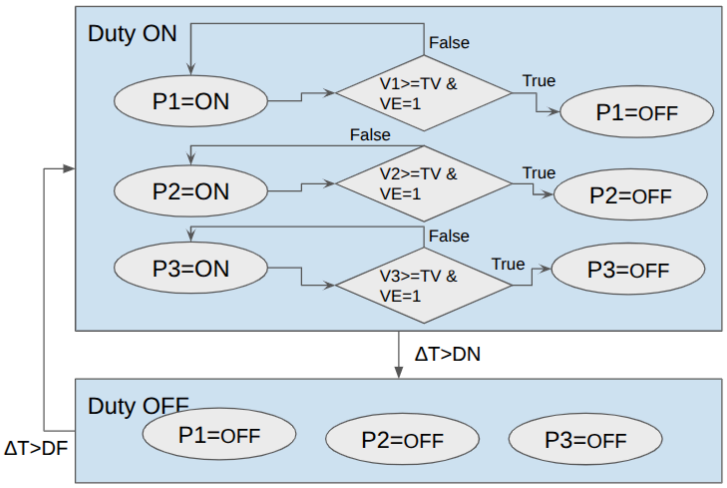
Single Cycle State



Config Variable	
Volume Trigger Enable	VE
Target volume (mL)	TV

State Variable	
Total flow, pump i	Vi
Pump 1 State (On/OFF)	P1
Pump 2 State (On/OFF)	P2
Pump 3 State (On/OFF)	P3

Duty Cycle State



Config Variable	
Volume Trigger Enable	VE
Target volume (mL)	TV
Duty Cycle ON time (s)	DN
Duty Cycle OFF time (s)	DF

State Variable	
Total flow, pump i	Vi
Pump 1 State (On/OFF)	P1
Pump 2 State (On/OFF)	P2
Pump 3 State (On/OFF)	P3
Current state elapsed time (s)	ΔT

Console Operation

The serial console provides three functions:

1) System diagnosis/control
2) System configuration and calibration
3) System data offload

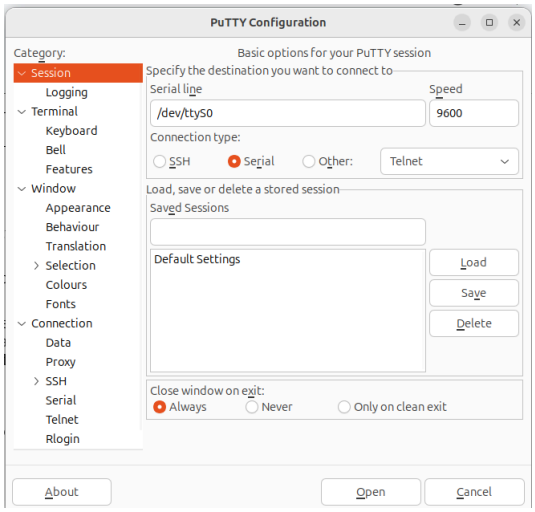
The USB connector on the shore cable should be connected to a computer with a serial console. We recommend the user install Putty as a good cross-platform tool that allows for Serial configuration and comms, as well as data offload to file. For information on installing putty, put the following in your web browser:

putty.software

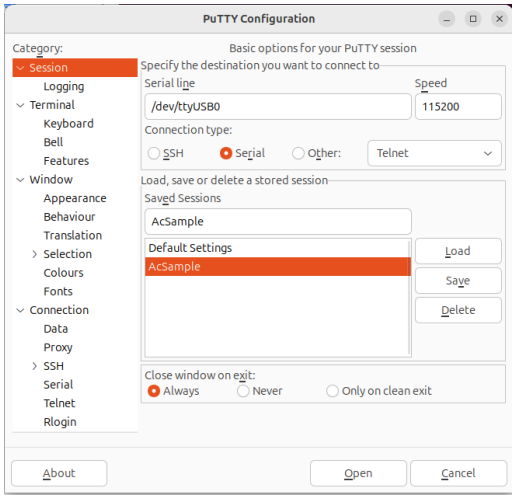
Once putty is installed, it will open up to a configuration menu.

Configuring Putty and Saving Configuration:

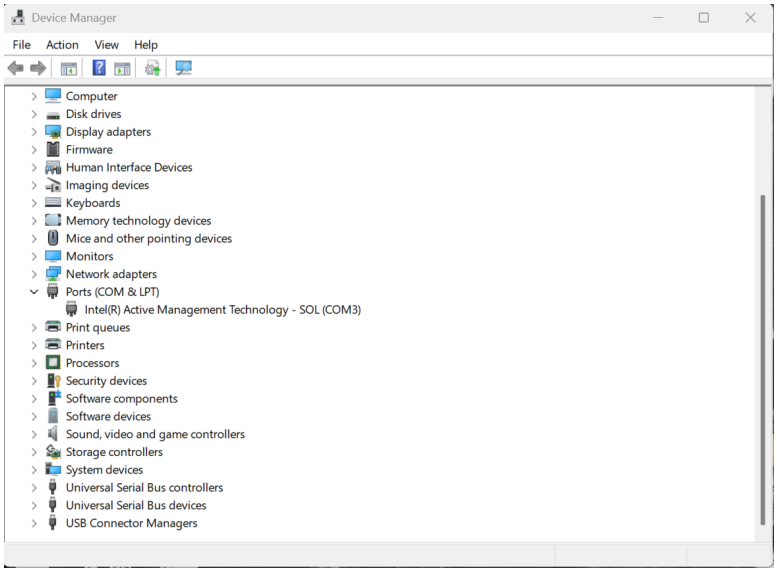
Select the “Serial” radio button:



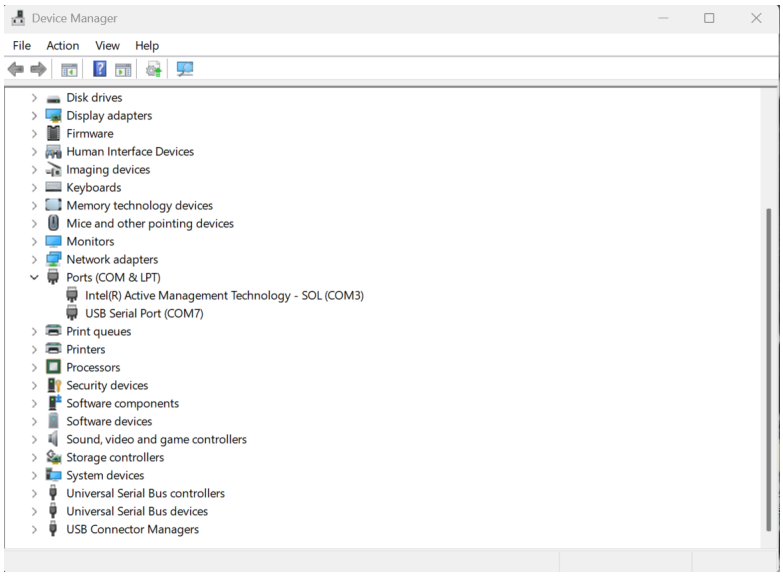
Next, update the Serial Line and Baud to match the correct values (115200 baud)



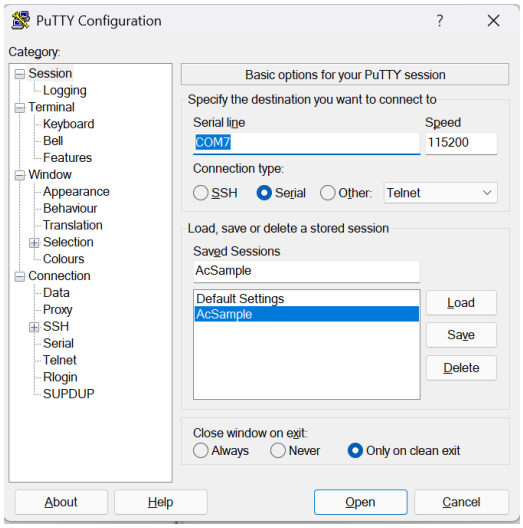
***On a Windows device**, you will need to determine which Serial Line is connected to the USB. To do this, first open the "Device Manager" without the shore cable plugged into your Windows device, scroll down to "Ports (COM & LPT)", and select the drop down. This will show you the devices currently plugged into your computer.*



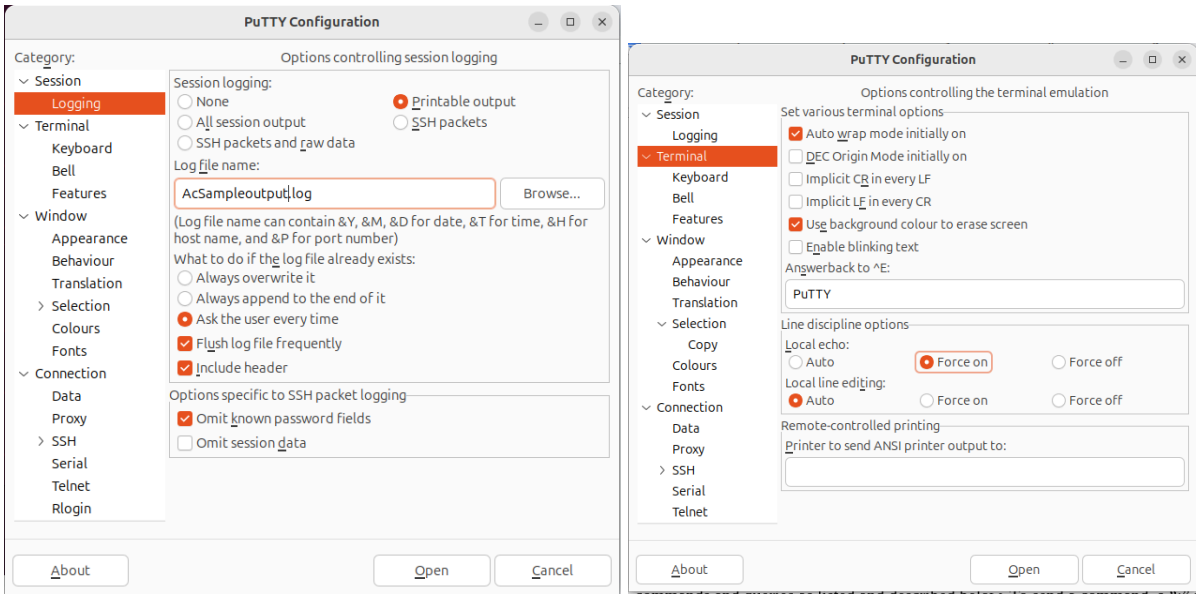
Next, plug in the shore cable, and scroll back down to the "Ports (COM & LPT)" drop-down. You should now see a new "USB Serial Port" item under the drop-down menu. This is your AcSample device.



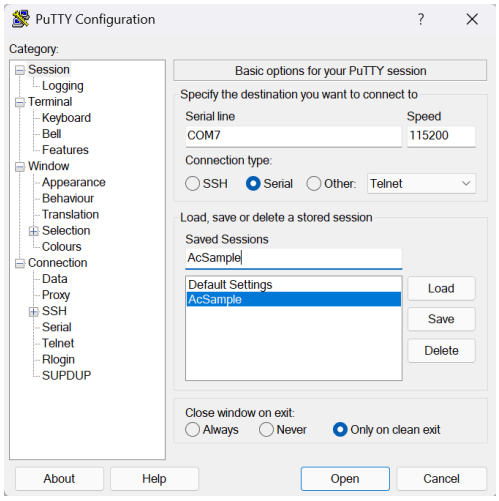
Take the port name in parentheses (ex. COM7) and paste it into the Serial Line field in the PuTTY Configuration. This should now allow you to connect to your AcSample.



Update the “logging” configuration, selecting where you want data to be printed and the printable output option; we also recommend turning on the local echo in “terminal” tab.



Finally, to save your configuration, return to the Session tab, type “AcSample” under the “Saved Sessions” field, and click the save button. When you load PuTTY in the future to connect to your AcSample device, you can simply use the “load” button to load all of the settings you set above.

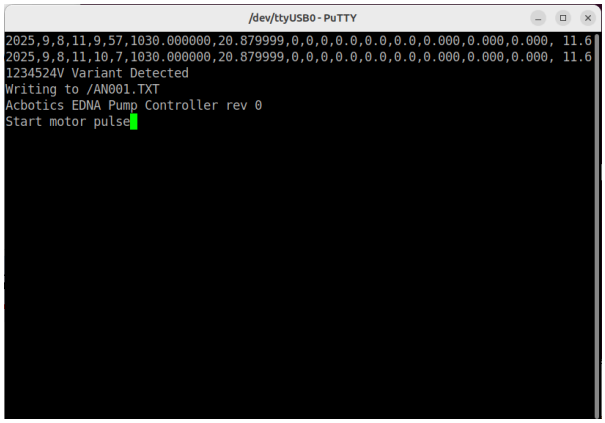


Next, press “Open”; this will start a putty session and will look something like the above screenshot.

NOTE: if you see the error “PuTTY: unable to load font "server:fixed"”, navigate to “Fonts” in the bar to the left and change the font to something on your system.

Sending Commands

To send commands to the serial port, you can either echo them in a command line, or type into your serial terminal e.g. Putty or Minicom. We recommend using Putty as instructions below will reflect that. To echo in a command line, e.g. to query the current RTC time, you would type the following into your terminal and then press enter:



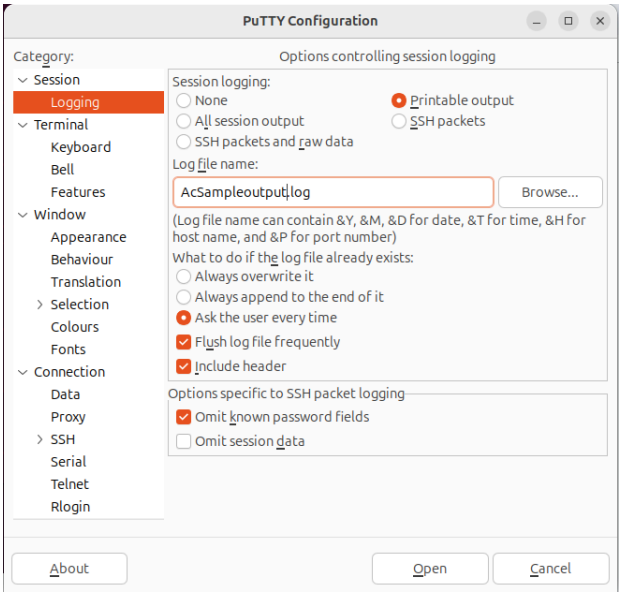

```
echo ":RR\r" > /dev/ttyUSB0
```

Make sure either a return or newline follows your serial command to enter it. If you are monitoring the serial port, you will then see the response:

```
Command started
RR\r

2000/1/6 21:3:46
```

Offloading data



To offload data, configure putty as shown above including creating a log file. Then, press the “open” button to start a session.

Once the session has started, type the following into the Putty terminal followed by an “enter”:

:LD

This will stream the data to the serial terminal; this data will also be copied to the file you indicated in your putty logging configuration.

The output file is a text file that will look something like this:

```
=~=~=~=~=~=~=~=~=~=~= PuTTY log 2025.09.08 11:24:59 =~=~=~=~=~=~=~=~=~=~=

2025,9,8,11,23,55,1031.000000,21.059999,0,0,0,0.0,0.0,0.0,0.000,0.000,0.000, 11.7

:Command started
LD
LD

AN000.TXT
===
Year,Month,Day,Hour,Minutes,Seconds,Pressure,Temp,Pump1,Pump2,Pump3,Flow1,Flow2,Flow3,Cur1,Cur2,Cur3,Volt
2025,9,8,10,57,57,1031.000000,20.660000,0,0,0,0.0,0.0,0.0,0.154,0.178,0.181, 11.2
2025,9,8,10,58,7,1031.000000,20.670000,0,0,0,0.0,0.0,0.0,0.000,0.000,0.000, 11.5
2025,9,8,10,58,17,1030.000000,20.680000,0,0,0,0.0,0.0,0.0,0.000,0.000,0.000, 11.5
2025,9,8,10,58,27,1030.000000,20.680000,0,0,0,0.0,0.0,0.0,0.000,0.000,0.000, 11.5
2025,9,8,10,58,37,1030.000000,20.680000,0,0,0,0.0,0.0,0.0,0.000,0.000,0.000, 11.5
2025,9,8,10,58,47,1031.000000,20.680000,0,0,0,0.0,0.0,0.0,0.000,0.000,0.000, 11.5
2025,9,8,10,58,57,1030.000000,20.690001,0,0,0,0.0,0.0,0.0,0.000,0.000,0.000, 11.5
2025,9,8,10,59,7,1030.000000,20.690001,0,0,0,0.0,0.0,0.0,0.000,0.000,0.000, 11.5
2025,9,8,10,59,17,1030.000000,20.690001,0,0,0,0.0,0.0,0.0,0.000,0.000,0.000, 11.5
2025,9,8,10,59,27,1031.000000,20.690001,0,0,0,0.0,0.0,0.0,0.000,0.000,0.000, 11.6
2025,9,8,10,59,37,1030.000000,20.700001,0,0,0,0.0,0.0,0.0,0.000,0.000,0.000, 11.6
2025,9,8,10,59,47,1030.000000,20.700001,0,0,0,0.0,0.0,0.0,0.000,0.000,0.000, 11.6
2025,9,8,10,59,57,1030.000000,20.700001,0,0,0,0.0,0.0,0.0,0.000,0.000,0.000, 11.6
2025,9,8,11,0,7,1030.000000,20.709999,0,0,0,0.0,0.0,0.0,0.000,0.000,0.000, 11.6
2025,9,8,11,0,17,1031.000000,20.709999,0,0,0,0.0,0.0,0.0,0.000,0.000,0.000, 11.6
2025,9,8,11,0,27,1030.000000,20.709999,0,0,0,0.0,0.0,0.0,0.000,0.000,0.000, 11.6
```

The python code below (also available in github here:) provides a parser for the output file to .csv:

```
# parse and save files in AcSample console dumped raw files
import os

############################
# USER UPDATE THESE
# directory containing the data from Putty or other serial dump
data_directory = "/home/efischell/AcSampleDump/"
# filename you want to parse
filename_data = "testfilelog.txt"
#
############################
# Create file name:
fname = os.path.join(data_directory, filename_data)
fname_new = None
# read the file, finding triple === to indicate start/end of the files.
try:
   with open(fname, "r") as file:
       last_line = ""
       for line in file:
           # Optionally remove leading/trailing whitespace, including newline characters

           if "===" in line and fname_new is None:
```

```
                # write a file
                fname_new = os.path.join(data_directory, last_line) + ".csv"
                ff = open(fname_new, "w")
            elif "===" in line:
                fname_new = None
                ff.close()
            else:
                if fname_new is not None:
                    ff.write(line)
            last_line = line
except FileNotFoundError:
   print("Error: The file " + fname + "was not found.")
except Exception as e:
   print(f"An error occurred: {e}")
```

Software Subsystems

The software includes ability to interact with and command multiple subsystems via the console. Each subsystem has a prefix used when sending commands and queries as listed and described below. To send a command, a ":" is sent followed by the prefix of the subsystem and the command to the subsystem.

System	Prefix	Description
RTC	:R	Real time clock subsystem
Pump	:P	Pump subsystem (commands the 3 pumps)
State	:S	General system state/mode, lets you command debug, regular, or negative control
Log	:L	File system and other log info
Config	:C	Configuration for the system, lets you adjust non-volatile memory variables and general system behavior
System Config	:X	NOT FOR GENERAL USERS: calibration, serial number and version set by manufacturer
Debug	:D	NOT FOR GENERAL USERS: Query system state in a machine-parsible manner; used in manufacturer testing and calibration

Subsystem: RTC

The RTC on the system holds system time used in logs; typical use includes querying and setting values.

Command	Example pipe to serial	Description

R	:RR	Read
W<YYmmdd:HHMMSS>	:RW250908:101800	Write

Subsystem: Pump

The Pump on the system manages/controls the 3 pumps in the AcSample.

Command	**Example pipe to serial**	**Description**
<pumpID> <pump command>	:PA ON :PA OFF :P1 ON :P1 OFF :P2 ON :P2 OFF :P3 ON :P3 OFF	Turn all pumps on Turn all pumps off Turn pump 1 on Turn pump 1 off Turn pump 2 on Turn pump 2 off Turn pump 3 on Turn pump 3 off
<pumpID> S	:P1 S :P2 S :P3 S	Return if pump 1 is on or off Return if pump 2 is on or off Return if pump 3 is on or off

Subsystem: State

The state subsystem lets you configure the overall state of the AcSample, putting it into debug or negative control state.

Command	**Example pipe to serial**	**Description**
D	:SD	Put system into debug state; this will turn off pumps and prevent state machine from advancing
C	:SC	Put system into negative control state; turns all the pumps on. This state is also triggered when the negative control dongle is attached to the serial port.

Subsystem: Log

The log subsystem lets you get the logged values on the sampler.

Command	Example pipe to serial	Description
ON	:LON	Turn logging on
OFF	:LOF	Turn logging off
L	:LL	List all files on the SD card
D	:LD	Dump all the files on the SD card to the console; this is used for data offload! See data offload below
SON	:LSON	Turn on the data stream to the console; i.e. every time data would be written to the SD card, that data will also be echoed to the console
SOF	:LSOF	Turn off the data stream to the console
NUKE I MEAN IT	:LNUKE I MEAN IT	Delete all files on the system to clear SD card; if you don't type "I MEAN IT", it will give you an error that you have to mean it to delete files. NOTE: This stops all logging and reboot is required before continuing.

Subsystem: Config

The config subsystem lets the user configure the sampler for desired operation behavior.

Command	Example pipe to serial	Description
W	:CW	Write the current configuration into non-volatile memory. **Unless this command is run, config changes made in the console will be lost in reset!!!**
P	:CP	Print the current config out of RAM

D	:CD	Load the default manufacturer's configuration into RAM
L	:CL	Reload the config from non-volatile memory into RAM. **THIS will overwrite any changes you made in the console!!!**
R	:CR	Reboots the system
S<Param info>	:CS<parameters>	Sets parameters; see below
SDE=<0 or 1>	:CSDE=0 :CSDE=1	Disable duty cycle mode Enable duty cycle mode
TV=<int target volume mL>	:CSTV=1000	Sets target volume for sampling, example for 1 L sample volume. Sample volume behavior: pumps will stop once flow sensor indicates sample volume achieved. This is used to get the same volume on all inlets.
MT=<int max time in s pump will run for>	:CSMT=300	Sets maximum time any of the pumps will run
TD=<int trigger depth in m>	:CSTD=1	Sets the trigger depth for the system to start sampling at. If trigger depth is not achieved by timeout interval, pumps will run anyway.
TT=<int trigger time in s>	:CSTT=300	Sets the trigger/timeout time in seconds; once this amount of time has elapsed since start, system will begin sampling regardless of whether trigger depth has been achieved.
SP=<startup pulse length in s>	:CSSP=10	Sets the startup pulse length in seconds. The startup pulse runs on power on to indicate system functioning to the user

		and/or to pull pre-flush water into the system if that is required for a given filter type.
DN=<duty on time in seconds>	:CSDN=10	Sets the duty cycle ON time for duty cycle mode
DF=<duty off time in seconds>	:CSDF=100	Sets the duty cycle OFF time for duty cycle mode
TE=<0 or 1>	:CSTE=0 :CSTE=1	Disable depth trigger mode Enable depth trigger mode If enabled: will trigger at depth if it gets depth before timeout; if enabled, success LED indicator requires depth trigger. If disabled: will just use the time.
VE=<0 or 1>	:CSVE=0 :CSVE=1	Disable volume run mode Enable volume run mode If enabled: will stop each pump as it reaches desired volume; in enabled, success LED indicator requires all 3 pumps to meet selected volume. If disabled: will use pump max time

Subsystem: System Config

NOT FOR GENERAL USERS: calibration, serial number and version set by manufacturer

Command	**Example pipe to serial**	**Description**
W	:XW	Write the current system configuration into non-volatile memory. **Unless this command is run, config changes made in the console will be lost in reset!!!**

P	:XP	Print the current system config out of RAM
D	:XD	Load the default manufacturer's configuration into RAM
L	:XL	Reload the system config from non-volatile memory into RAM. **THIS will overwrite any changes you made in the console!!!**
R	:XR	Reboots the system
S<commands>	:XS<commands>	Sets parameters; see below
SSN	:XSSN=<integer>	Sets serial number (use int)
SV1=<major version>	:XSV1=1	Sets major version number
SV2=<minor version	:XSV2=2	Sets minor version number
SF1=<float>		Set conversion from float count on pump flow sensor 1 to mL default=0.225
SF2=<float>		Set conversion from float count on pump flow sensor 2 to mL default=0.225
SF3=<float>		Set conversion from float count on pump flow sensor 3 to mL default=0.225
SO1=<float>		Set conversion for offset for the ADC count for current measurement on pump 1 default=5
SO2=<float>		Set conversion for offset for the ADC count for current measurement on pump 2 default=5

SO3=<float>		Set conversion for offset for the ADC count for current measurement on pump 3 default=5
SS1=<float>	:XSS1=<float>	Set slope in amps/count for current sensor pump 1 default=0.000667
SS2=<float>		Set slope in amps/count for current sensor pump 2 default=0.000667
SS3=<float>		Set slope in amps/count for current sensor pump 3 default=0.000667
SVO=<float>		Set offset for the voltage channel; units ADC counts default=5
SVS=<float>		Sets slope in volts/count for voltage measurement Default 0.035714