

AcSample-5m

In situ Pumped triplicate eDNA Sampler, 5 m max depth

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System Description



Above: (left) AcSample-5m box with marked key components, (middle left) AcSample-5m mounted to baseboard as shipped with weight and float, (middle right) inlet filter attachment and mounting of Smith-Root filter holders, (right) outlet filter attachment and mounting of Wilderlabs filters.

The AcSample-5m is the Acbotics Research triplicate, in-situ eDNA sampler for shallow applications. 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.

Timing	Internal RTC
Maximum Depth	5 m
Sensor Logging	RTC Time, Flow per pump, Current per pump, External pressure/temperature
Pumps	G928, 24V high flow peristaltic, 600 mL/minute free flow.
Flow sensors	FM-HL2124, +/- 5% accuracy.
Battery	56 Wh NiHM Rechargeable; 90 minutes continuous or 18x 5-minute pump cycles.
Mode Options	<ol style="list-style-type: none"> 1) Depth Triggered/Time triggered Autonomous 2) Matched Volume Autonomous 3) Duty Cycled Autonomous 4) Serial Controlled
Data Offload & charge	Offload: Shore cable console (recommended) or SD card. Charging: via Shore cable.
Filter attachment	Luer lock inlet and outlet
Filter compatibility	Filter-agnostic, but the selected filter WILL impact flow <i>Note: do not use with desiccant/self persevering filters if the system is being submerged for operation!</i>
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
Example outlet flow rates (neg control)	Wilderlabs syringe filter: 420 mL/minute

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AcSample-5m Quick Reference

In the box:



Contents of AcSample-5m box: Shore Cable, Toolkit and sterilization kit; Sampler; Base Board with float and weight. Depending on requested configuration, a filter kit may also be included with 6x filter holders as 12 x MCE hydrophilic 1.0 um filters.

Tool & sterilization kit:

1. Shore Cable
2. Pliers & diagonal cutters
3. Phillips head screwdriver (#2)
4. micro-SD card reader
5. Tweezers
6. Inlet/outlet tubes
7. Filter negative control adapter tube
8. Spare luer attachments
9. Spare ¼" tubing
10. Vacuum pump
11. Vacuum adapter
12. Jugs & syringes

On power up, the AcSample-5m will by default:

1. Boot microcontroller, initialize SD card (LED OFF)
2. Run startup pulse (10 s all pumps on) (LED double pulse/2s off, pumps ON)
3. Turn off pumps
4. Wait until 60 s have elapsed (LED 1s On/1s OFF, pumps OFF)
5. Run all 3 pumps until each has reached 1 L pumped fluid or for **10 minutes** (LED 3x flash, pumps ON)
6. After 10 minutes have elapsed or volume is met, the pumps will turn off. A flicker LED indicates timeout trigger, solid LED indicates desired volume has been met.

Warnings & Underwater Pre-Deployment Checklist:

- | | |
|--|---|
| <input type="checkbox"/> Data offloaded and SD card cleared (if desired) | <input type="checkbox"/> Filters are new and dry (if wet, air cannot be cleared from the inlets on startup) |
| <input type="checkbox"/> Battery Charged | <input type="checkbox"/> System sterilized (if required) |
| <input type="checkbox"/> System configured as desired | <input type="checkbox"/> Dummy plug installed in console connector |
| <input type="checkbox"/> Box sealed and holds vacuum | |

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.

WARNING: When using a filter on the outlet, allow 10 s startup pulse to complete BEFORE installing filters. This will ensure filters are not wet prior to deployment.

NOTE: when used as a benchtop sampler, limit inlet tubes to 16 inches (0.4 m). Longer tubing will result in head loss and inadequate flow rates, especially for filters used on inlets.

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!

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, system will pump until each channel measures that 1 L has been pumped.
- 5) Recover system; use LED indicators to determine if fault was identified.



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.

Default Operation: Outlet Filters

Deploy Operation

- 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; use LED indicators to determine if fault was identified.



Between Deployments

- 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.

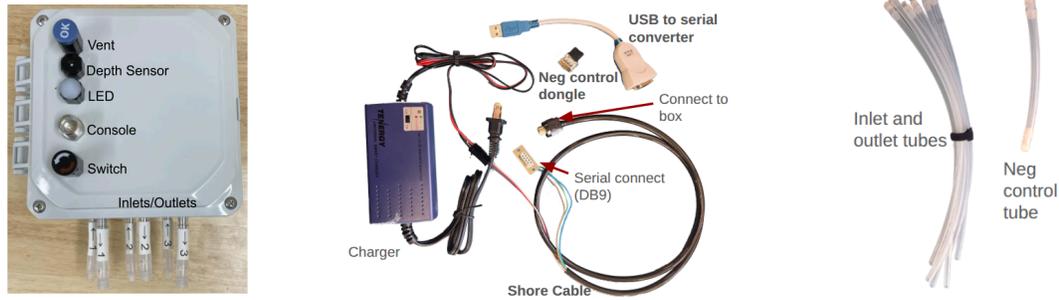
Each Day

- 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.

LED Status Meaning

<i>LED State</i>	<i>Pump State</i>	<i>Meaning</i>	<i>Notes</i>
Rapid even flash	All pumps On	Negative control/ ALL ON state	Your negative control dongle is attached OR you set neg control in console
2s flicker/5s OFF	All pumps OFF	Fault	Make sure SD card is fully plugged in
Double flash/2 s OFF	All pumps ON	Startup pump	Should run on regular start depending on config
0.5 s flicker/ 2 s OFF	All pumps OFF	Debug state	Instantiated through console
1s ON/1s OFF	All pumps OFF	Wait for startup trigger	Waiting for depth and/or time trigger depending on config
Triple flash/2 s OFF	1 or more pumps on	Single Cycle or Duty cycle ON	Observe if duty cycle OFF occurs to determine which.
4x flash/2 s OFF	All pumps OFF	Duty cycle OFF	
LED ON Solid	All pumps OFF	Done/success	Cycle completed meeting all enabled depth and volume triggers.
LED rapid flash	All pumps OFF	Done/Timeout	Cycle completed due to timeout.

Default Operation Key Components



Components of AcSample-5m box, shore cable and accessories, and tubes for sterilization and negative control.

Turning ON/OFF

Turning ON: Turn switch on electronics housing towards the right until it is fully engaged; the LED should turn ON, then start flashing once data start recording

Turning OFF: Turn switch on electronics housing towards the left; the LED should turn OFF.

Charging the Battery

- 1) Remove Dummy Plug; Plug in shore cable.
- 2) Plug charger into wall; this will charge the battery. Once LED on charger turns green, battery is charged.

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.

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.

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) Unplug dummy plug, plug in shore cable.
- 5) Detach serial cable from console. Plug in negative control dongle.
- 6) Turn ON; unit will run continuously as negative control/continuous ON dongle is plugged in. Turn OFF once desired volume is pumped through filter.

Opening and closing the box

Opening the box

- 1) Unscrew all 4 phillips head screws on box.
- 2) Open lid.

Closing the box

- 1) Close box, ensuring no wires are pinched
- 2) Tighten all 4 phillips head screws radially until full tight.

After closing/prior deploy

- 1) Attach vacuum pump to vacuum port.
- 2) Pull vacuum; let sit 10 minutes.
- 3) Confirm vacuum remains.

Observing and Modifying Configuration:

- 1) Remove Dummy Plug; Plug in shore cable
- 2) Connect USB to serial converter into your computer. Turn on unit. **WARNING: system may spit water; make sure this won't cause a problem!**
- 3) Connect to attached Serial port via Putty or other console application (Baud rate 115200, flow control off).
- 4) See "Most Common Serial Commands" below for a short list, full console documentation for more complete serial interface.

Offloading Data:

- 1) Remove Dummy Plug; Plug in shore cable
- 2) Connect USB to serial converter into your computer. Turn on unit. **WARNING: system may spit water; make sure this won't cause a problem!**
- 3) Connect to attached Serial port via Putty (Baud rate 115200, flow control off). Make sure you have the serial application configured to write to a file, e.g. "sdump.txt" (see "Configuring Putty" for more info).
- 4) Once a connection is established, type ":LD". This will dump the entire log to the file indicated in (3).

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.

Filter Kit Quick Reference

In the Filter Kit

- 6x Smith-root filter holders with male luer lock attachment
- 12x 1.0 um pore MCE hydrophilic 47 mm disc filters
- (Compatible with other 47 mm diameter filters)



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.

Filter (use)

Stiffener paper (throw away)

Place filter paper in filter holder.

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

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

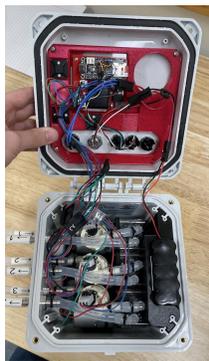
Opening the Box

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 screw 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



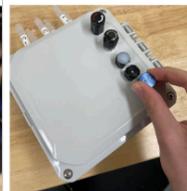
4) Ensure the dummy plug is inserted; you are ready to go!



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.



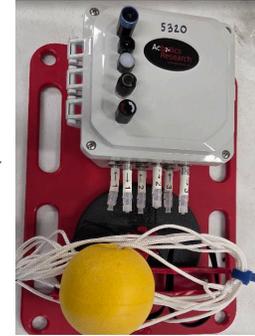
(Left) Instructions for units with pressure relief valve (Right) instructions for units with “OK” plug

Base Board Assembly and Use

A base board is provided with some AcSense-5m units to make it easier to deploy the unit with attached filters for shallow water bottom sampling or moored operation.

Note: the maximum depth rating of the unit is 5m. Deeper deployment may result in leaks!

Warning: always make sure dummy plug and blue vacuum port plug are installed prior to deployment. If box has been opened, always follow “sealing the box” instructions and check vacuum.



For rivers/streams or other shallow water deployment: attach a disc weight of at least 5 lb (2.2 kg) using the mount fixture. Attach a rope or rope and float appropriately sized for your application to one of the corners of the Base Board. Follow instructions for deployment of your selected type of filter. Lower system to bottom manually, allow to remain desired time. Recover using the rope.

For deeper or moored deployment: Attach to mooring line. One way to do this is to create an eye in the line, then clip the AcSample-5m base board to the line at the top and bottom. Follow instructions for deployment of your selected type of filter. Weight may be removed in this case if desired.

Installing the weight:

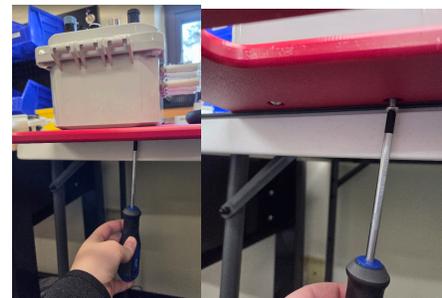


Installing weight on Base Board: 1) Remove screw fixture. 2) Place disc weight over bolt. 3) Screw in screw fixture until fully tightened. 4) Install AcSense-5m box.

Installing the box to the base board:

The box is mounted with 4x screws through the base board. We recommend working over the edge of a table, one or two screws at a time.

- 1) Set base board on the edge of a table. Poke one of the screws up through the hole using a phillips head screwdriver.
- 2) Align the associated screw hole in the AcSample-5m box with the screw; screw in loosely
- 3) Align a second screw on the edge.
- 4) Tighten both of the initial pair of screws.
- 5) Rotate the base board to attach the second pair of screws.



Installing filters:



Attach first filter to inlet 1



Attach velcro strap



Repeat for remaining inlets



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.

Inlet filter flow rates		
Filter Type	mL/s (tap water)	mL/min (tap water)
Cobetter filter holder w/ MCE hydrophilic .45 um pore, 47 mm diameter filter	4.3	258
Sterivex 0.22 um pore	2.4	144
Smith-Root Glass Fiber non-self-preserving filter	8.2	600
33 mm diameter, 0.45 um pore PES hydrophilic	3.3	198
Wilderlabs syringe filter (NOTE: use only on outlet!)	0	0

Outlet filter flow rates* +		
Filter Type	mL/s (tap water)	mL/min (tap water)
Wilderlabs syringe filter*	7	420

* 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

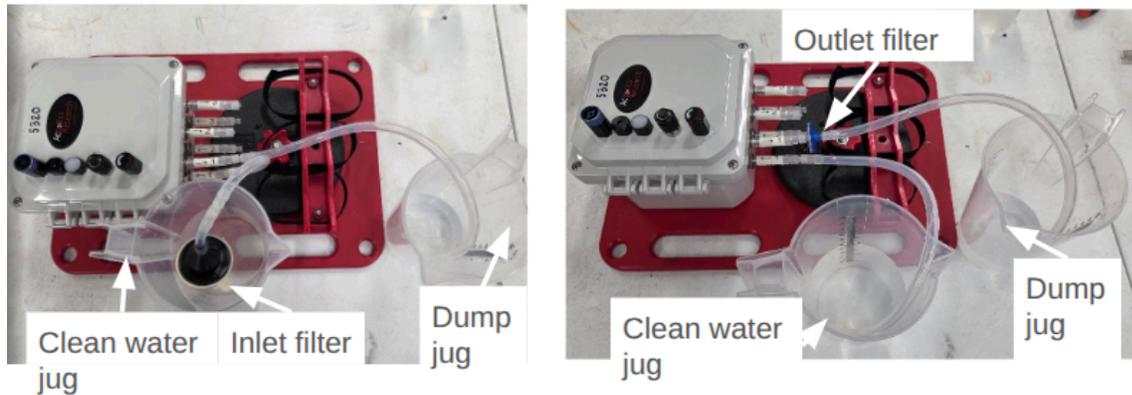
+ When using filters on outlet, follow tube sterilization instructions between uses.

Charging the Battery

<p>1) Disconnect dummy plug from console connector</p> 	<p>2) Plug in console cable. Make sure you fully tighten cable collar to get a good connection.</p> 	<p>3) Plug console wall-wort into an outlet. LED on either charger type should be RED to indicate charging.</p> 	<p>4) Allow to chage until LED turns Green to indicate the battery is fully charged.</p> <p>5) Remove console cable, re-insert dummy plug and tighten.</p> 
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Negative Control

After negative control sample is acquired, follow “preserving filters on recovery” steps; preserve sample as desired or recommended by analysis laboratory.

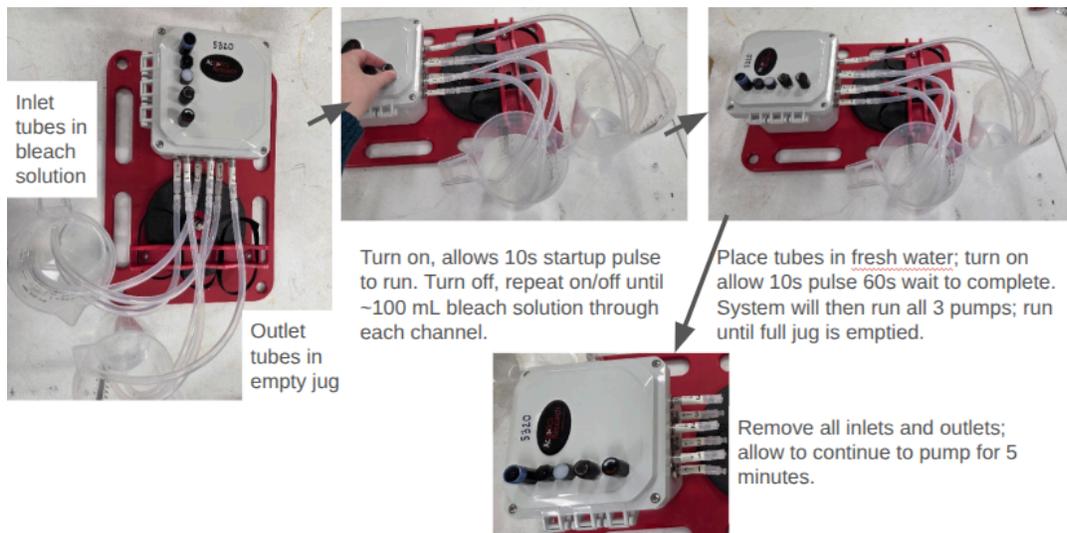


- 1) *For inlet filter:* attach negative control tube to desired inlet and to filter or filter holder; *Install outlet tube. For outlet filter:* attach inlet tubing on one channel, install filter on outlet then attach outlet tubing.
- 2) Fill 1 jug with 1000 mL (or desired volume) DI water.
- 3) Place inlet tube in water jug. Place outlet tube in a second jug or bucket.
- 4) Unplug dummy plug, plug in shore cable.
- 5) Detach serial cable from console. Plug in negative control dongle.
- 6) Turn ON; unit will run continuously as negative control/continuous ON dongle is plugged in. Turn OFF once desired volume is pumped through filter.

Sterilization

Sterilization of tubes

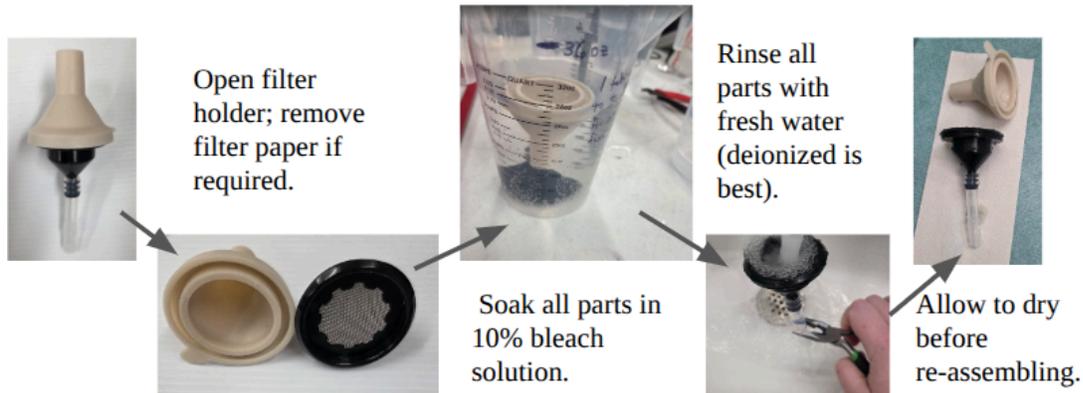
Prepare jug with 10% bleach solution (½ cup bleach or 1 tablet bleach to 32 oz water). Then:



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

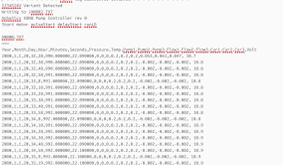
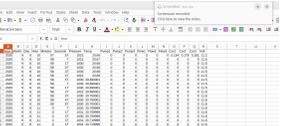


Copying off and clearing data

Recommended: 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 or another serial console installed and configured as indicated in the “Console Operation” section.

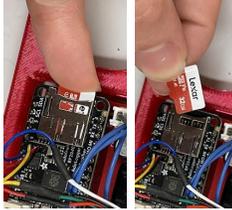
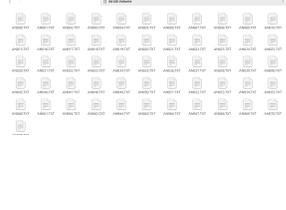
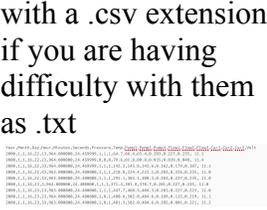
WARNING: When you turn the unit on if it has been in water, IT WILL SPIT WATER EVERYWHERE! Place somewhere that won't matter.

<p>1) Disconnect dummy plug from console connector</p> 	<p>2) Plug in console cable. Make sure you fully tighten cable collar to get a good connection.</p> 	<p>3) Plug USB to serial converter into console, and USB into your computer.</p> 	<p>4) Open Putty & connect to the USB device (see Console config if it is the first time)</p> 
<p>5) Turn on system; you should see something like below:</p> 	<p>6) In the putty console, type: :SD (then press enter) This puts you in debug mode so the motors don't keep running.</p>	<p>7) Next, dump the logs by typing the following into putty: :LD (Then press enter) This will dump the data to a file.</p>	<p>8) Open the file printed from the serial console. Mine looks like this:</p> 
<p>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.</p>	<p>10) Confirm all data copied and parsed correctly! The files should look like this:</p> 	<p>11) <i>If desired:</i> Delete data on SD card by typing the following into putty: :LNUKE I MEAN IT (Then press enter). This will delete all data.</p> 	<p>12) Turn the system off. Remove console cable, re-insert dummy plug and tighten.</p>

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 following 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.

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

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.

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	

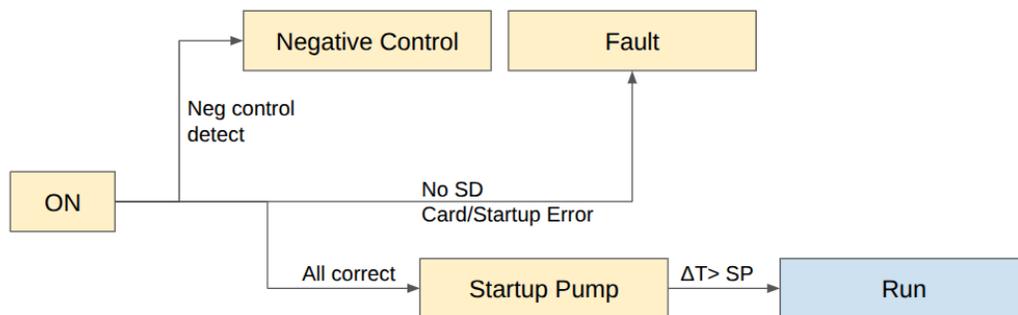
State Machine

State	LED Behavior	Pump Behavior
Negative Control	Rapid even flash	All pumps ON
Fault	2s flicker/5s OFF	All pumps OFF
Startup Pump	Double flash/2 s OFF	All pumps ON
Debug	0.5 s flicker/ 2 s OFF	All pumps OFF
Wait for Startup Trigger	1s ON/1s OFF	All pumps OFF
Single Cycle	Triple flash/2 s OFF	All pumps ON unless volume or time criteria met
Duty Cycle		
Duty Cycle: ON	Triple flash/2 s OFF	All pumps ON unless volume or time criteria met
Duty Cycle: OFF	Quadruple flash/2 s OFF	All pumps OFF
Done/Success	LED ON Solid	All pumps OFF
Done/Timeout	LED rapid flash	All pumps OFF

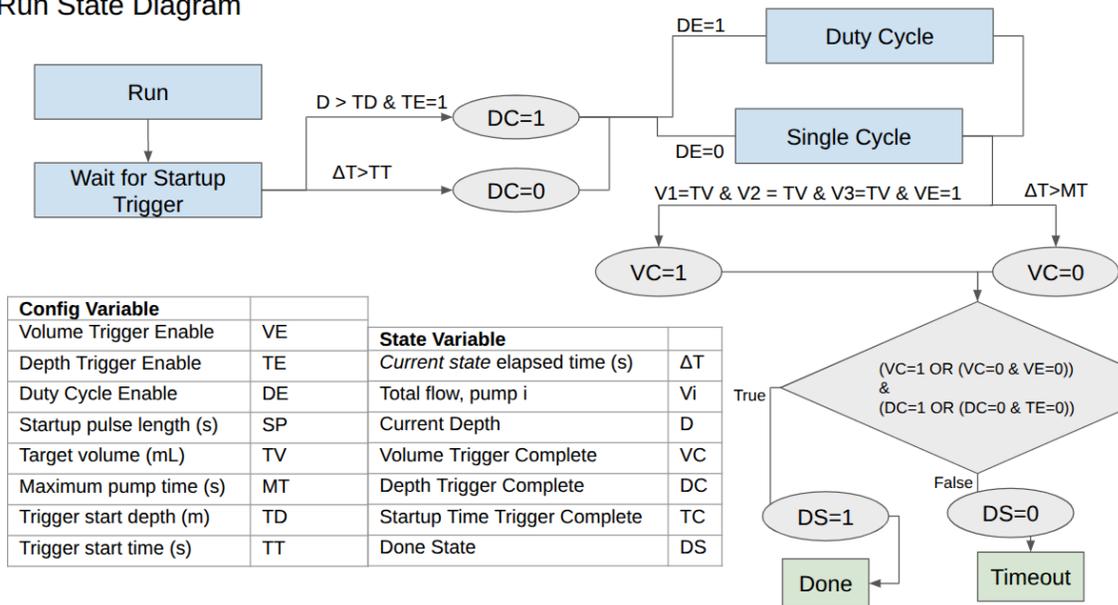
The state machine for the AcSample-FAST-5m includes startup, run, and complete states. The below diagrams show the logic associated with state transitions within the state machine, including criteria to exit each state. Color indicates type of state, with yellow for startup, blue for run, and green for complete states. Logic transitions are indicated by arrows with text, or in the case of complete states, with a diamond indicate 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 reach the desired depth, failed to pump the desired volume on one or more of the pump channels, or multiple of the above.

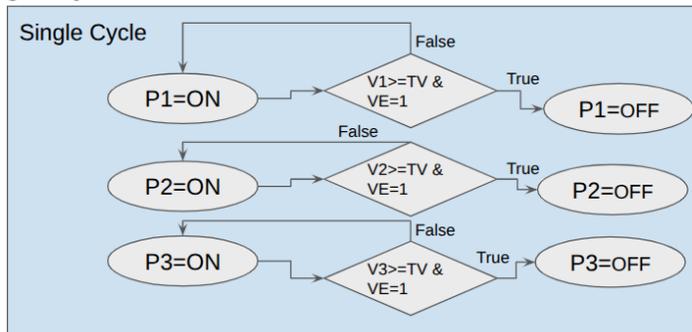
Startup States



Run State Diagram



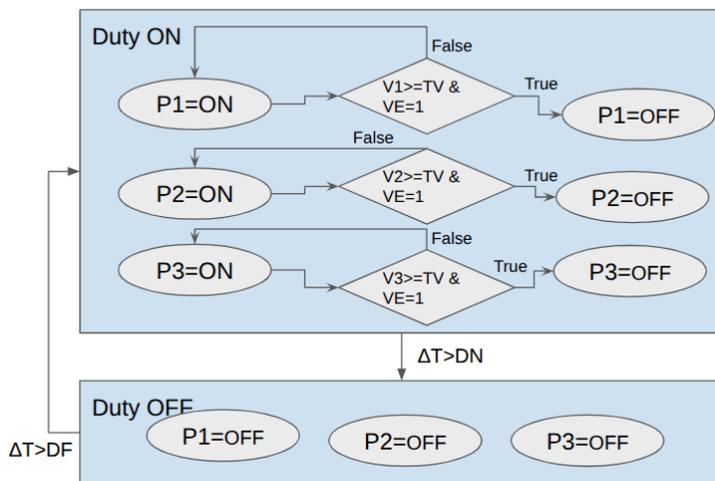
Single Cycle State



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

State Variable	
Total flow, pump i	V_i
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	V_i
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

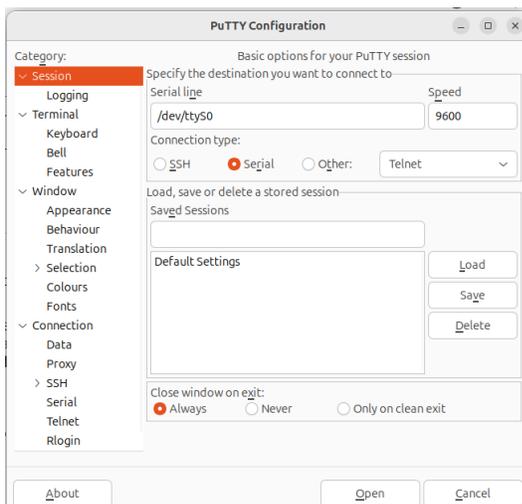
The USB connector on the shore cable should be connected to a computer with a serial console. We recommend the user install Putty as a good cross-platform tool that allows for Serial configuration and comms, as well as data offload to file. For information installing putty, put the following in your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

putty.software

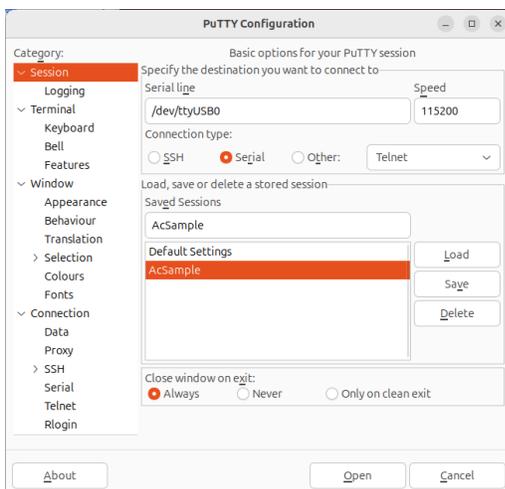
Once putty is installed, it will open up to a configuration menu.

Configuring Putty and Saving Configuration:

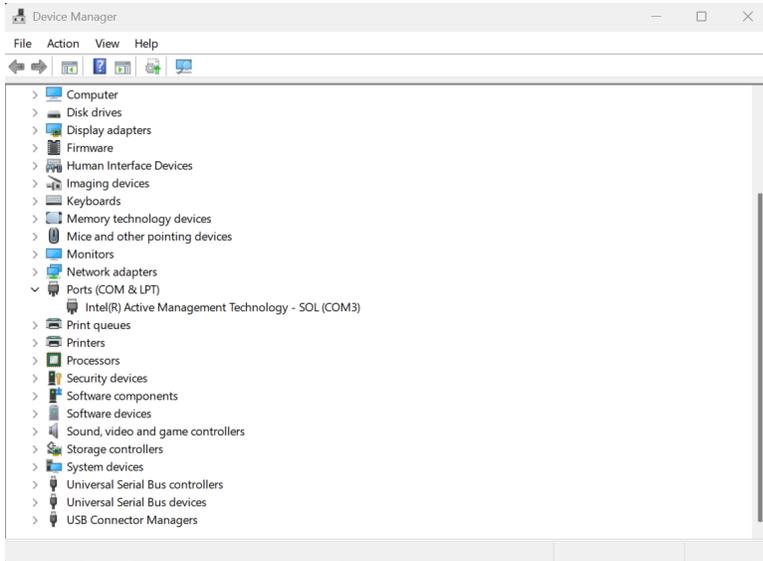
Select the “Serial” radio button:



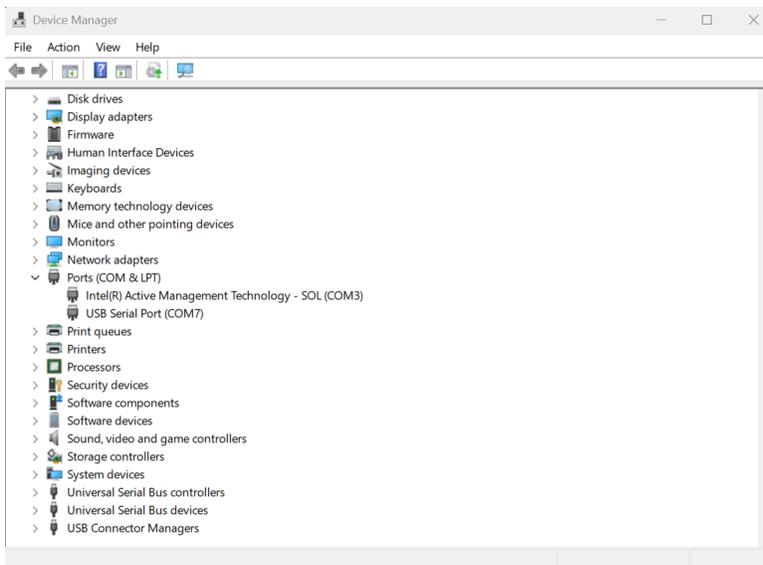
Next, update the Serial Line and Baud to match the correct values (115200 baud)



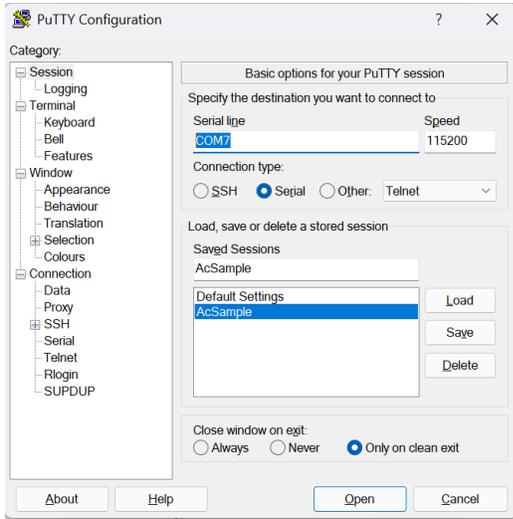
On a Windows device, you will need to determine which Serial Line is connected to the USB. To do this, first open the “Device Manager” without the shore cable plugged into your Windows device, scroll down to “Ports (COM & LPT)”, and select the drop down. This will show you the devices currently plugged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



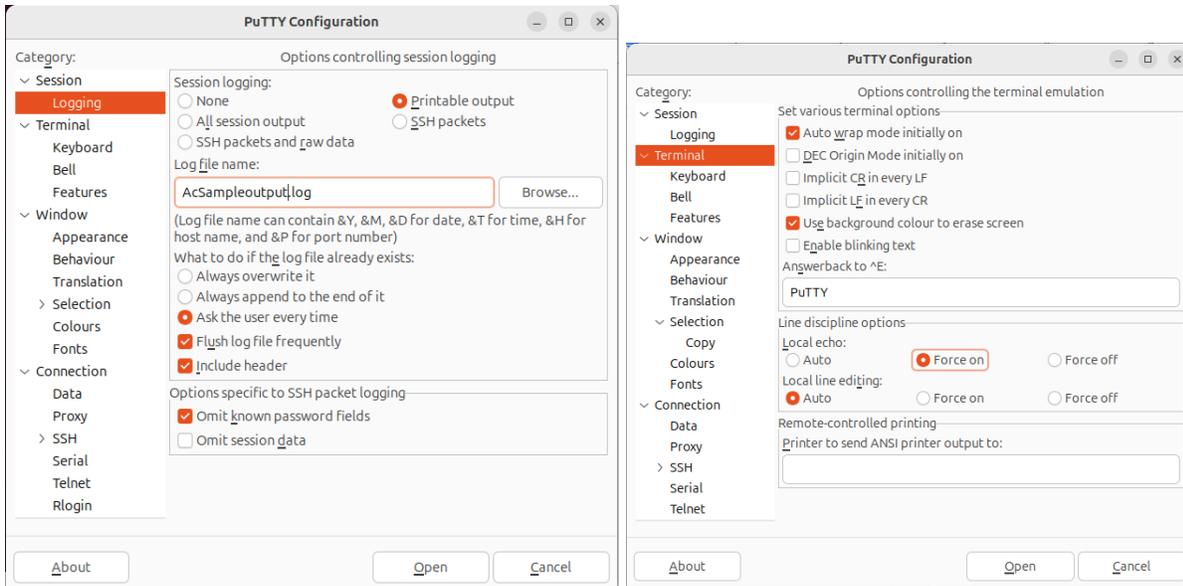
Next, plug in the shore cable, and scroll back down to the “Ports (COM & LPT)” drop-down. You should now see a new “USB Serial Port” item under the drop-down menu. This is your AcSample device.



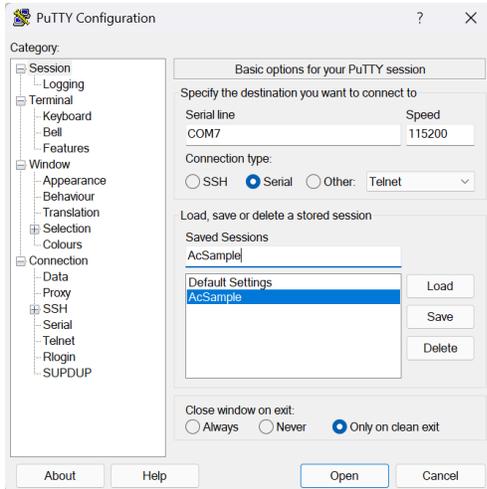
Take the port name in parentheses (ex. COM7) and paste it into the Serial Line field in the PuTTY Configuration. This should now allow you to connect to your AcSample.



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.

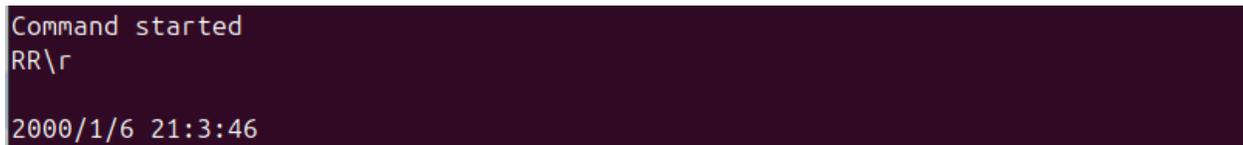
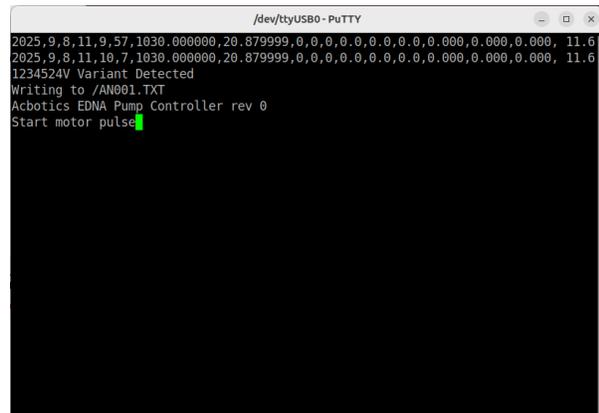
NOTE: if you see the error “PuTTY: unable to load font "server:fixed””, navigate to “Fonts” in the bar to the left and change the font to something on your system.

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:




```

# 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
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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	:CSSP=10	Sets the startup pulse length

s>		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