The OPEnSampler: A Low-Cost, Low-Weight, Customizable and Modular Open Source 24-Unit Automatic Water Sampler

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ABSTRACT AND PURPOSE:

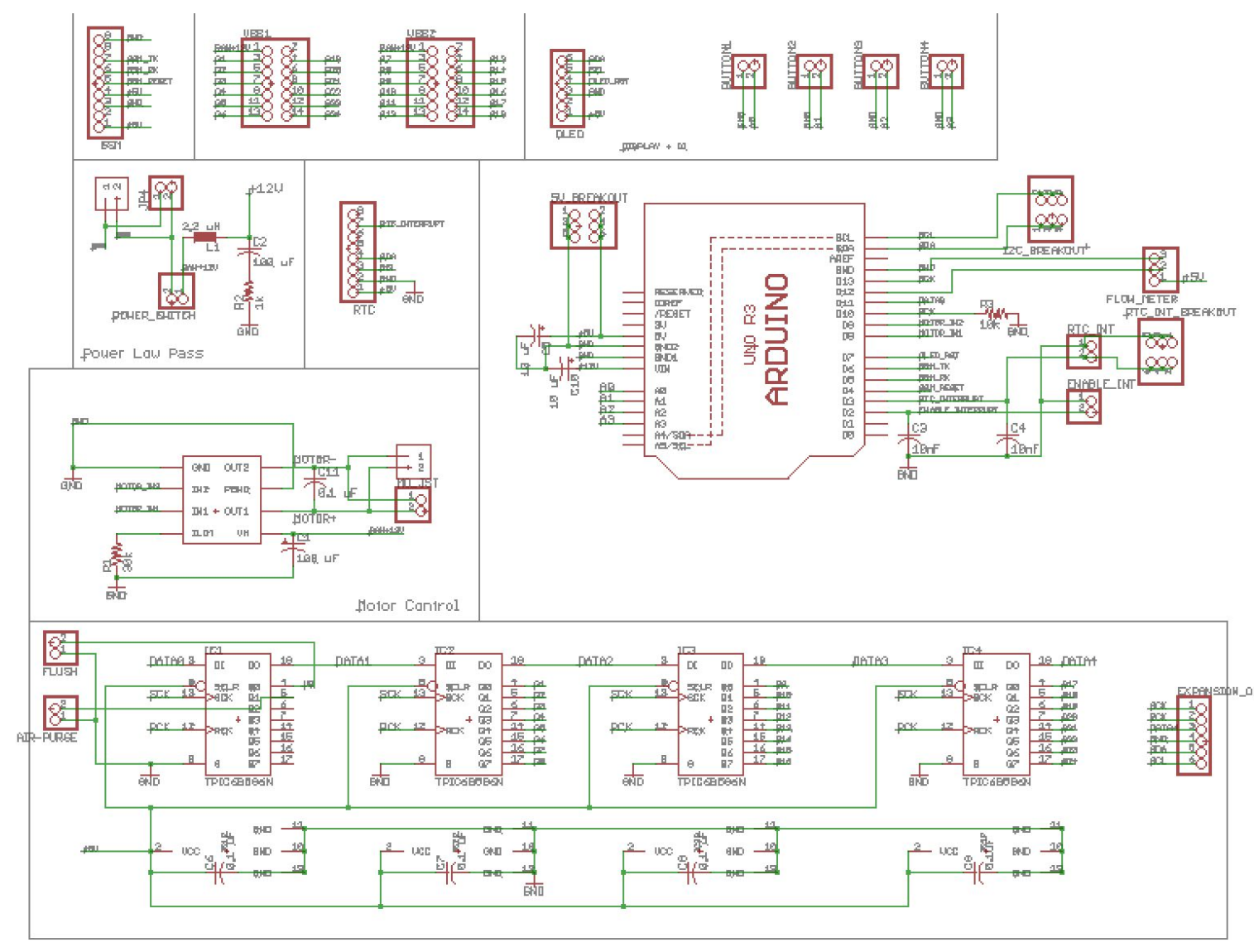
Commercially available water samplers can be expensive investments and often provide little(limited, sounds better) customizability. The OPEnSampler was designed to allow direct customization by the user both when choosing parts for assembly and before field use via the programmable microcontroller while preserving the low cost of DIY samplers in addition to the wide range of applications of many commercial samplers.

The OPEnSampler is equipped with 24 foil-lined bags, each storing up to 250mL of sampled water for a maximum of 5.80 L of sample water. The pumps can draw water at a rate of 100mL/minute and solenoid valves, controlled by an Arduino Uno microcontroller, direct the flow into each bag. The pump can be operated in reverse if the bags are oriented upside-down to draw water from specific sample bags for testing. 3D printed mates for mounting components to the aluminum extrusion as well as 3D printed bag caps were designed. All design files are available on our gitHub page, linked in the bottom right corner of this poster.

ELECTRONICS:

The Main Control Board (MCB, *figures 2 and 3*) interfaces the Arduino Uno microcontroller with the rest of the system. A low-pass filter on the power supply limits noise down the line from the motor, and decoupling capacitors stabilize power to the shift registers and interrupt lines. Headers break out the interrupt pins as well as the Arduino's I2C pins for communicating with external sensors.

Figure 2: Schematic of MCB.



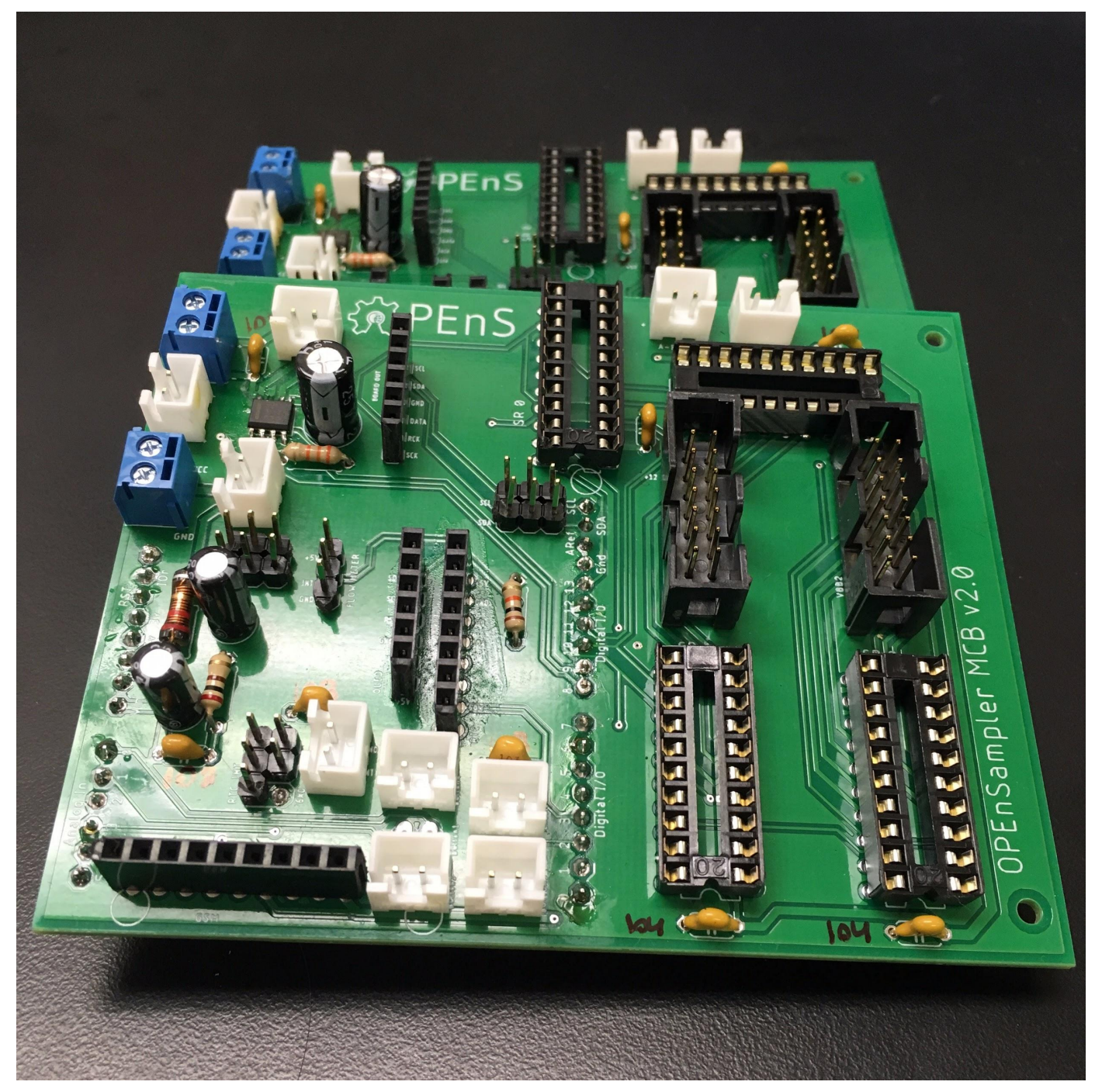
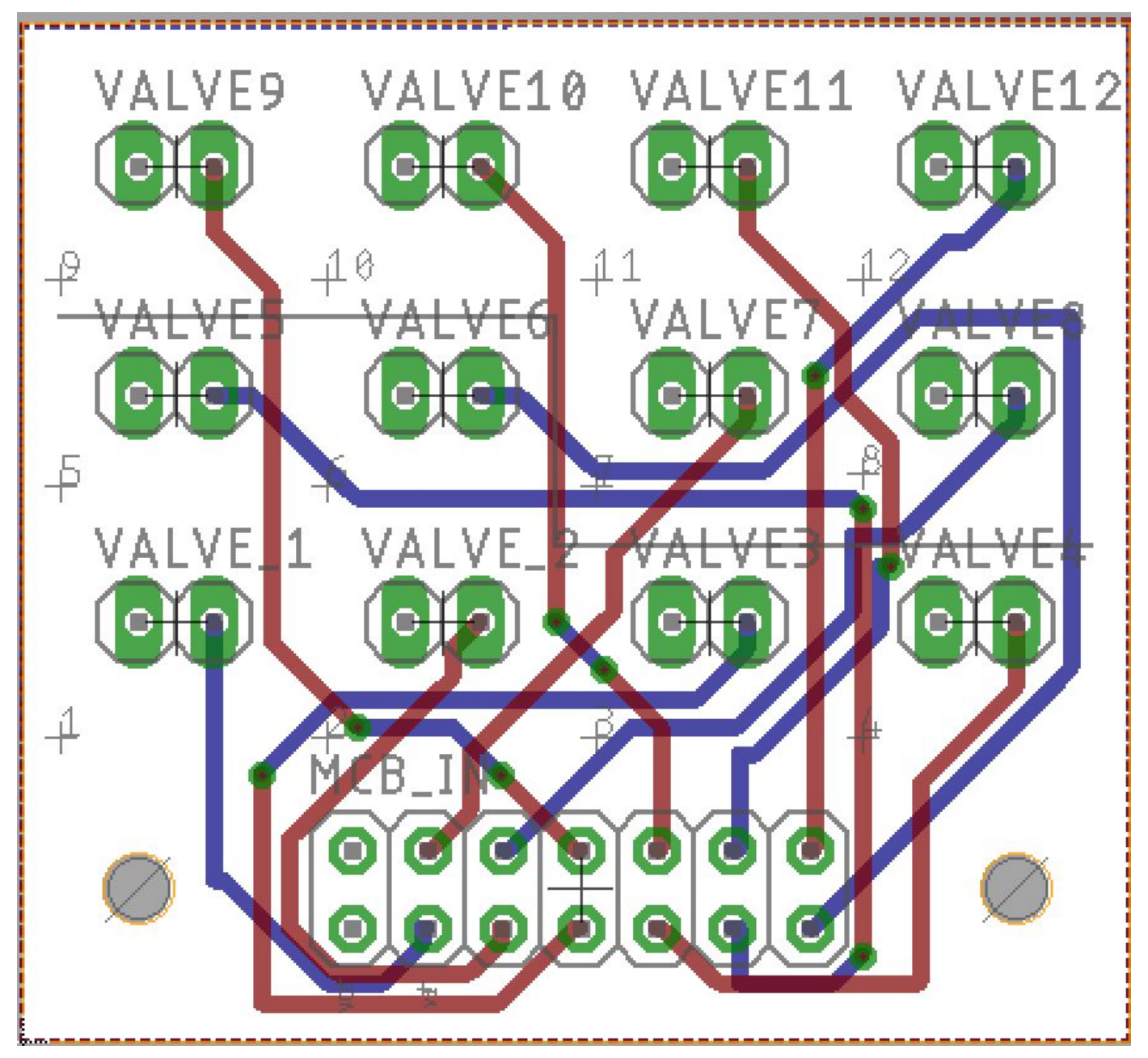


Figure 3 (Above): Finished MCB.

Figure 4 (Below): Board Diagram of VBB..



The Valve Breakout Board (VBB, *Figure 4*) distributes 12VDC to the positive line of 12 valves and connects each valve's ground to an individual pin on a 14-pin rectangular connector. A VBB is positioned on both sides of the MCB, each controlling one half of the sample valves. A ribbon cable connects each VBB to the MCB.

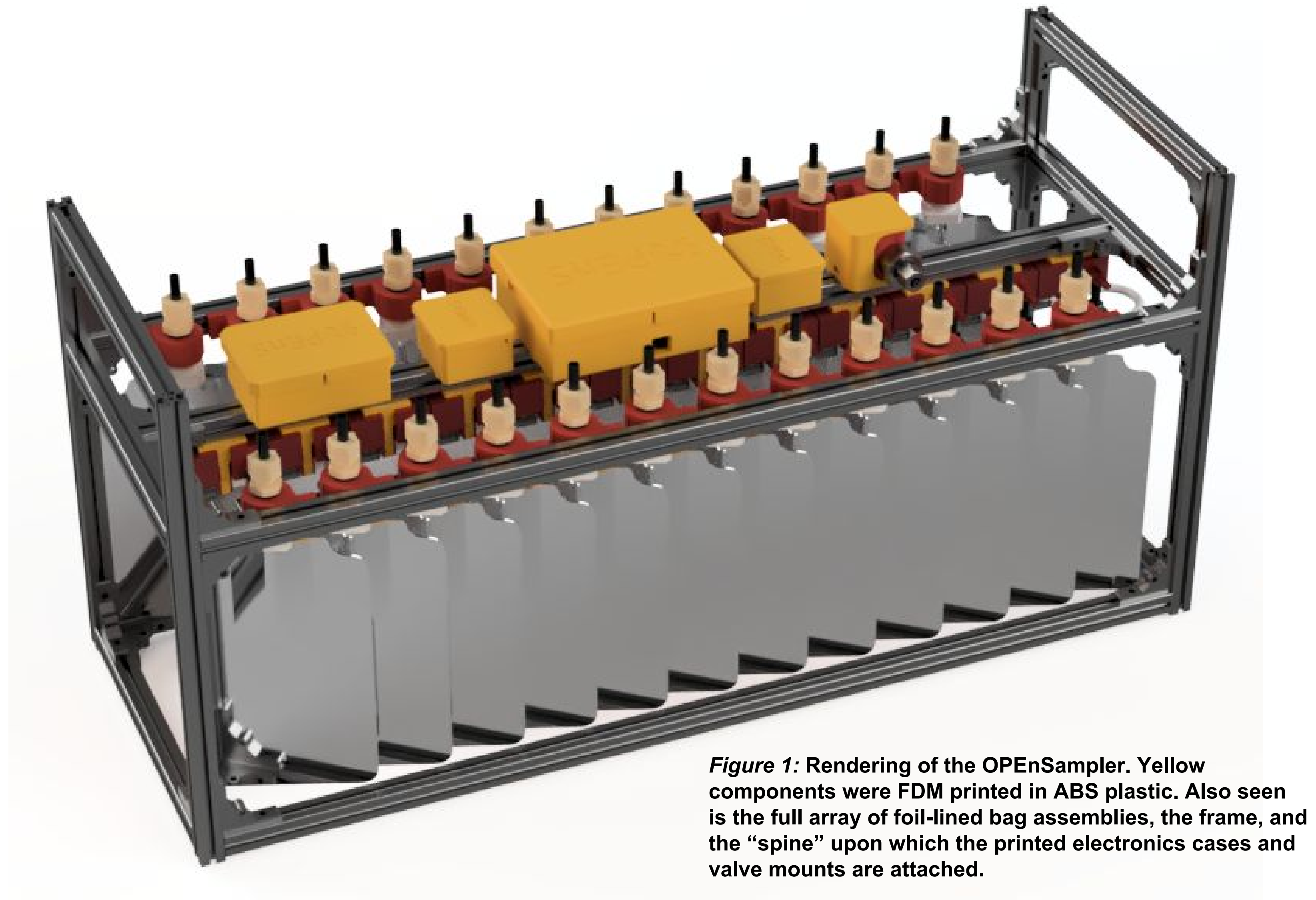


Figure 1: Rendering of the OPEnSampler. Yellow components were FDM printed in ABS plastic. Also seen is the full array of foil-lined bag assemblies, the frame, and the "spine" upon which the printed electronics cases and valve mounts are attached.

METHODS:

The first concept focused on including as many sample containers as possible in a given space. Bottles were arranged in a foam grid, a cheap peristaltic dosing pump was used to move water, and solenoid valves were controlled by an arduino to direct the flow.

The current design uses a rigid frame made with aluminum extrusion cut to length by an online supplier. SLA printed bag caps hold and seal foil-lined mylar bags. Custom PCBs were ordered and hand-soldered. Arduino code was optimized and improved, allowing the user to enter simple Serial commands to perform tasks such as opening a specific valve, powering the pump forward or reverse, and setting the sample interval. An operator interface consists of several buttons and switches, as well as a usb port. The user is able to set up the settings ahead of time such that field initialization consists of switching the power on and pressing a button, though changing settings with a laptop in the field is possible.

FEATURES:

- 24 individual 250mL sample containers, sealed from the environment
- Arduino controlled PCBs
- Battery operated, 24 hours on 2000mAH 12V battery, one week on 8AH
- Customizable, Openly Published designs on gitHub
- Trigger-based sampling enabled for external sensors
- Fluoropolymer tubing for decreased loss of DOCs due to absorption
- Real Time Clock with separate battery keeps time when device is off

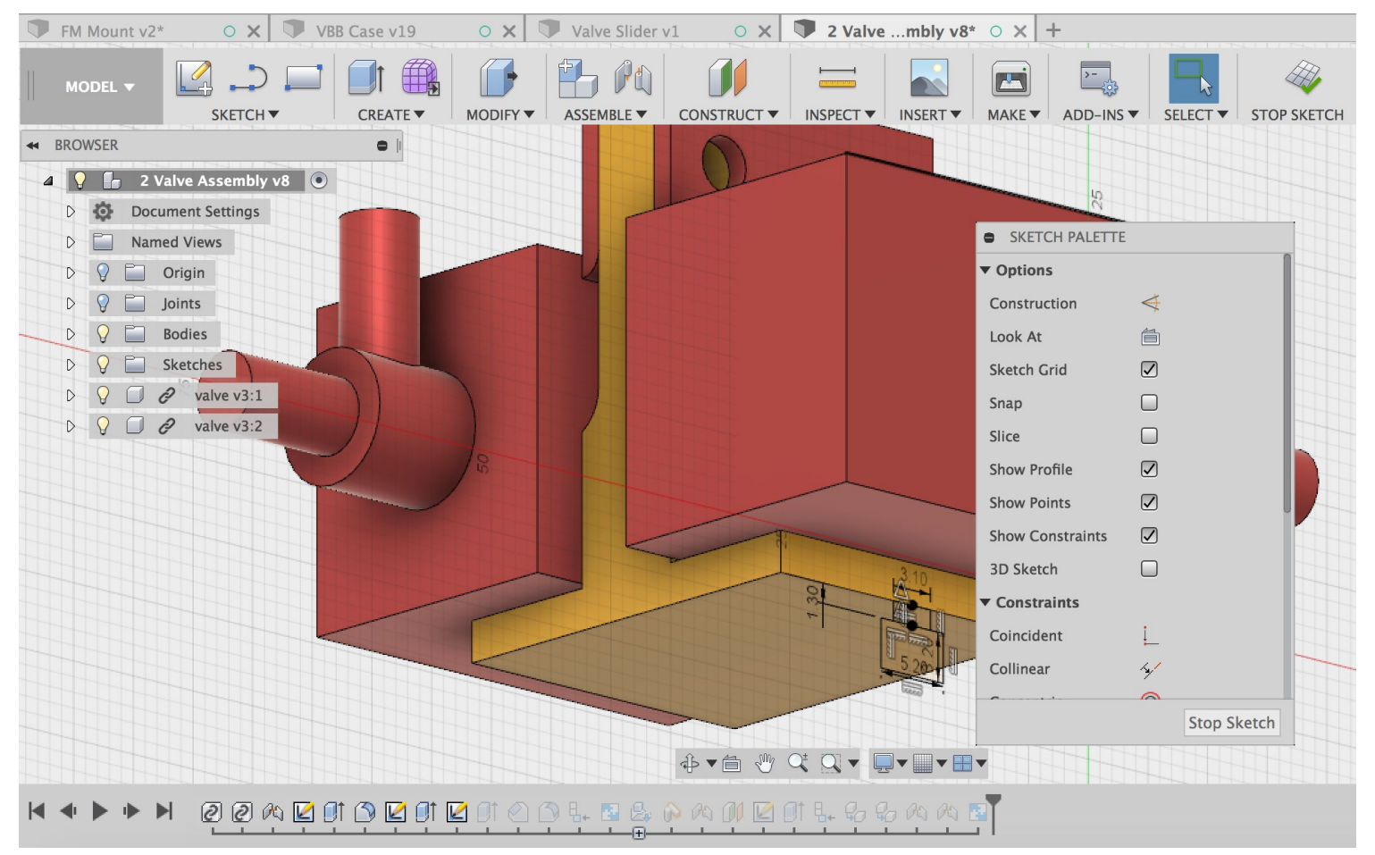
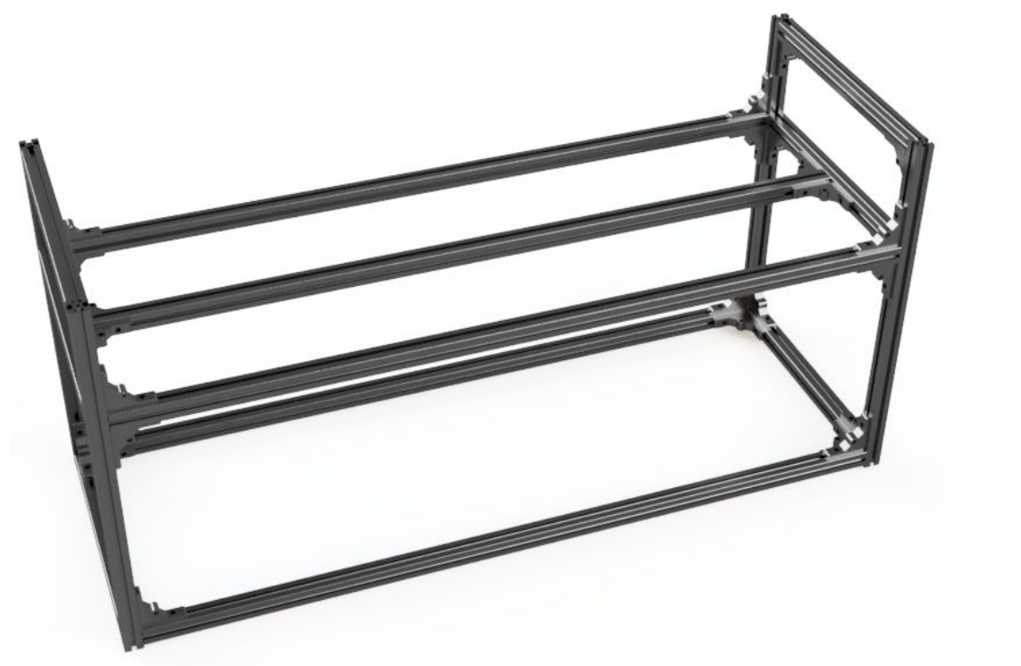
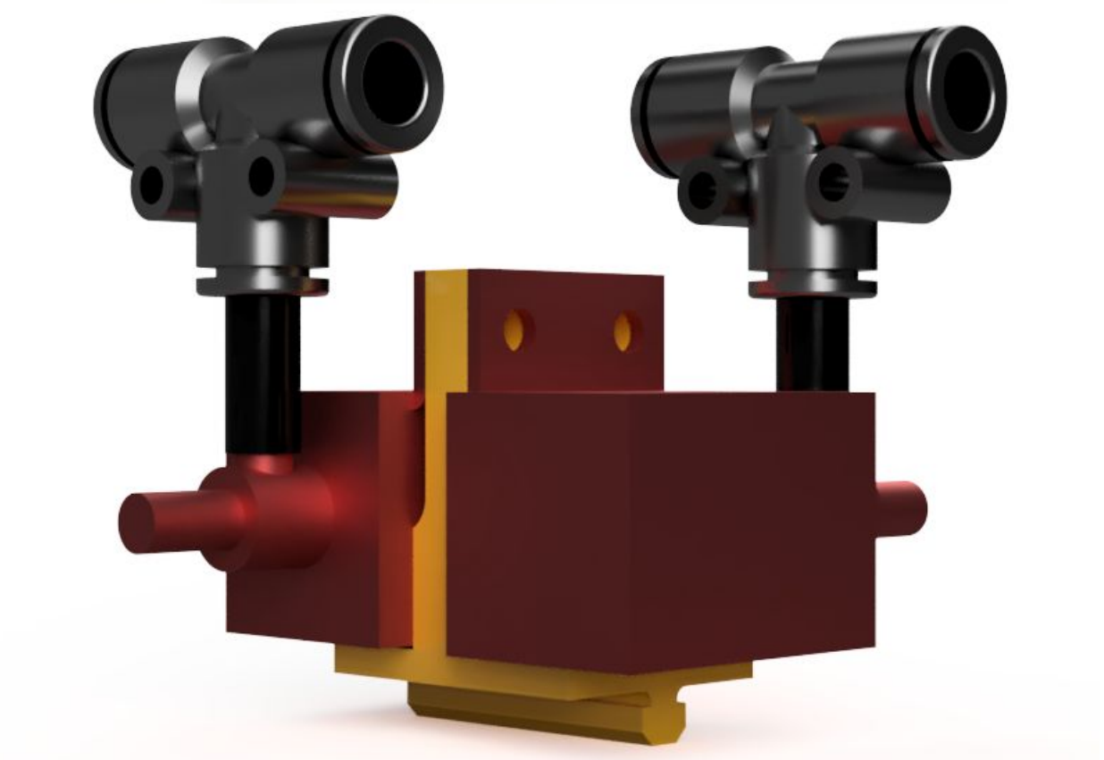


Figure 5: An example of modifying the dimensions of the valve assembly. All components are available on our gitHub as STL files and also as AutoDesk Fusion 360 files.

ASSEMBLIES:



The Frame: The frame is assembled from various lengths of 15mm square aluminum extrusion. Its purpose is to provide a solid mounting system that can be easily manipulated and customized to fit to different containers and applications. 3D printed mounts for components interface with the aluminum extrusion.

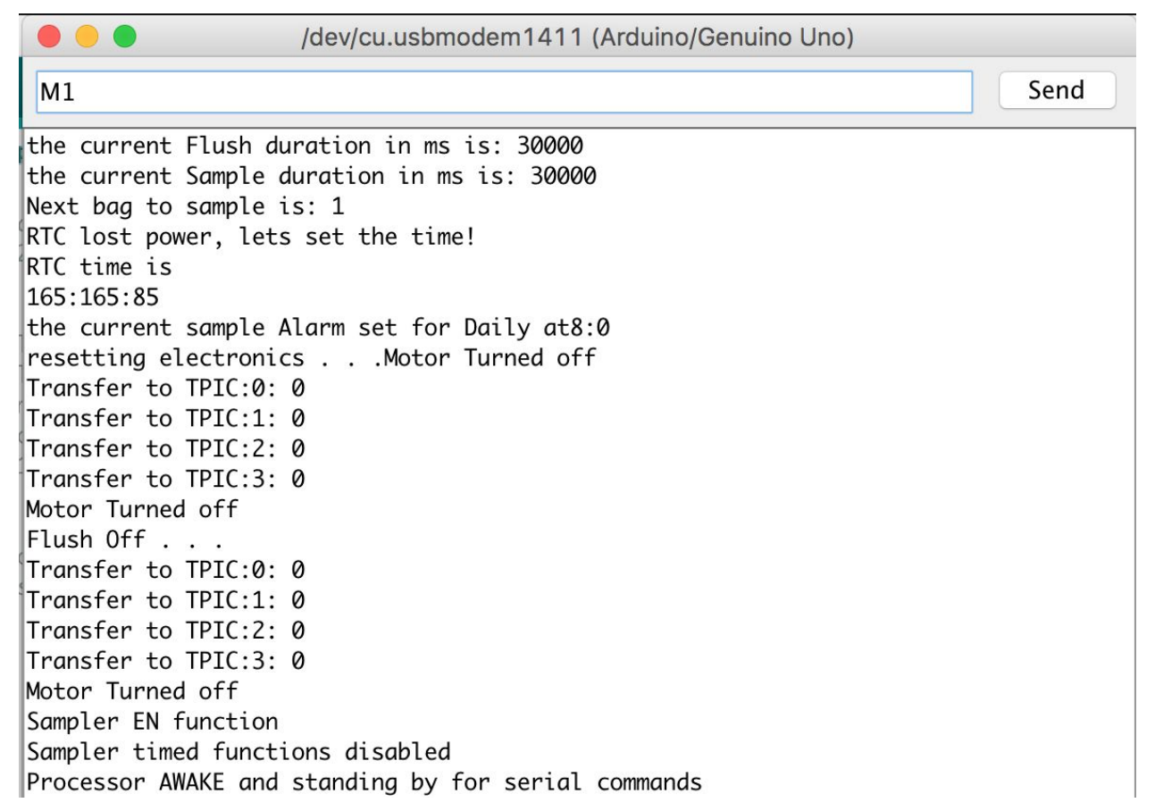


3D Printed Components: Bag caps, valve mounts, and electronics containers were 3D Printed. The caps were printed with an SLA printer and the remaining parts were printed on an FDM printer in-lab. Parts were post-processed with acetone vapor, threaded inserts, o-rings, and Loctite.

The Hydraulics: A peristaltic pump pulls sample water into the device through an inlet port. A flow meter tracks the flow velocity to estimate the net water intake. Water flow is directed into one of 24 sample bags via corresponding solenoid valves or is pushed out of the device if the flush valve is opened. All interior tubing is PVDF, a smooth fluoropolymer. The sample bags are sealed to the environment when their respective valve is closed.

SERIAL INTERFACE:

The Arduino Serial Interface allows the user to operate the device from a computer through a USB cable. Settings can be changed by looking up the preset commands specified in the "Serial Command Defs" file. The device outputs the current settings as well as which valves are open and what is currently enabled, then waits for commands.



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M1
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the current Flush duration in ms is: 30000
the current Sample duration in ms is: 30000
Next bag to sample is: 1
RTC lost power, lets set the time!
RTC time is
165:165:85
the current sample Alarm set for Daily at8:0
resetting electronics . . .Motor Turned off
Transfer to TPIC:0: 0
Transfer to TPIC:1: 0
Transfer to TPIC:2: 0
Transfer to TPIC:3: 0
Motor Turned off
Flush Off . . .
Transfer to TPIC:0: 0
Transfer to TPIC:1: 0
Transfer to TPIC:2: 0
Transfer to TPIC:3: 0
Motor Turned off
Sampler EN function
Sampler timed functions disabled
Processor AWAKE and standing by for serial commands
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CONCLUSIONS:

Each iteration of the OPEnSampler creates additional opportunities for further development. External sensor integration, long-distance device-to-user communication, and flow-proportional sampling are just some of the many improvements we are planning on making to the OPEnSampler. Because the design is available online, anyone can be a collaborator and create their own branch of the OPEnSampler with improvements specific to their own research.

OPEnS Website

GitHub Page

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