$H_2\Omega$

GROUP B

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Matthew Peterson - CpE
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Project Description

- Device will read the amount of water in the bottle to the nearest fluid ounce
- Has a self-sanitizing mechanism that can eliminate bacteria
- A portable water bottle that is highly durable to the outside world
- Bottle will connect to a mobile device so the user can track their personal water consumption
- Mobile application will store the users daily water consumption so they can view their progress

Motivation

- To accurately track water consumption throughout the day
- Self-sanitizing bottle to keep water free from bacteria
- Help people with liquid restrictive diets
- Assist the elderly in remembering to drink enough water
- No need to use plastic water bottles
- Get people excited about drinking water!

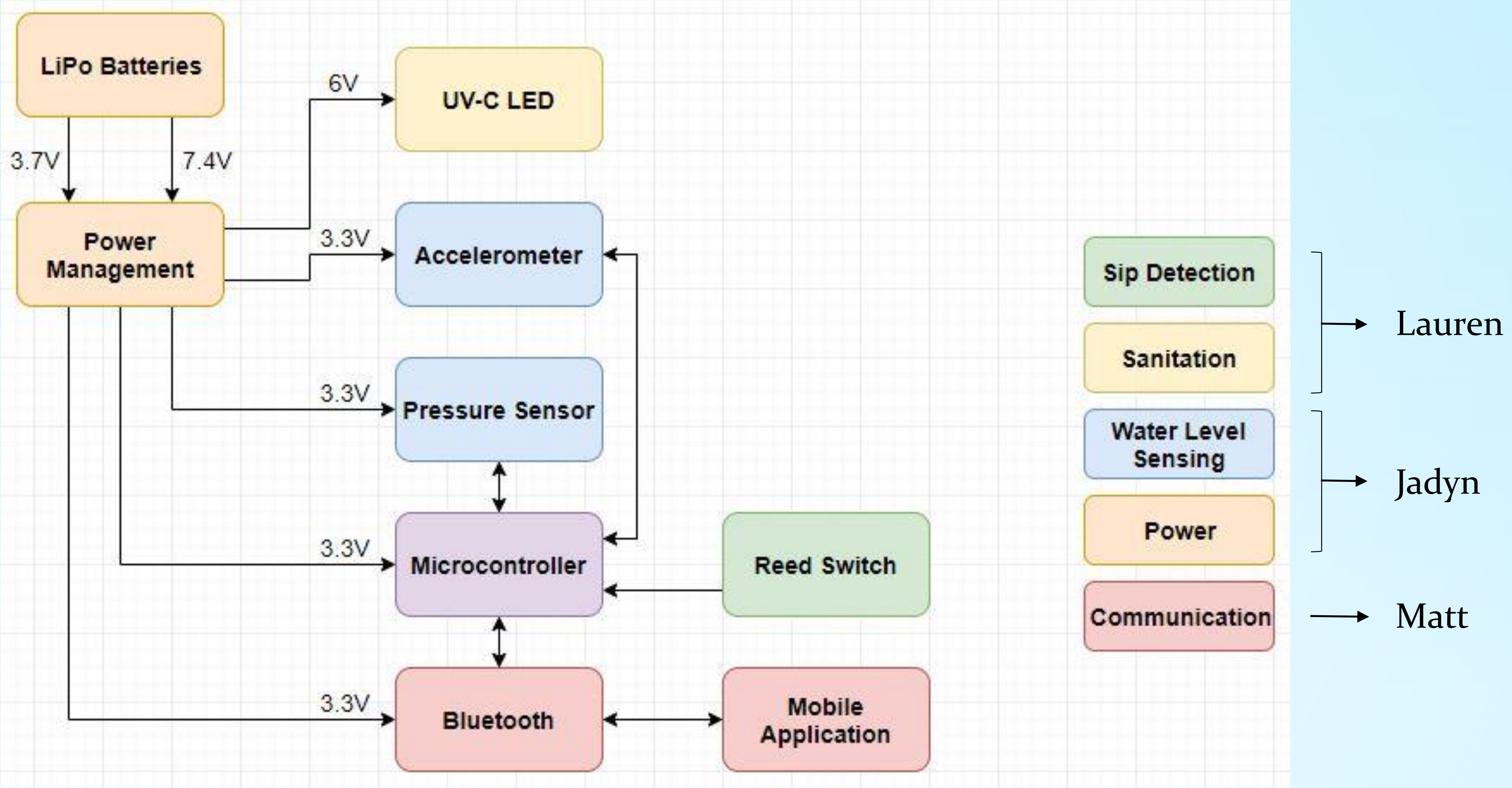
Goals & Objectives

- Sanitize
- Track water consumption
- Reduce Cost
- Low Energy

Specifications & Requirements

Category	Metric	Requirement
Cost	USD	≤ 150
Charge Lifespan	Week	≥ 1
Connectivity Distance	Feet	≥ 4
Pairing Time	Seconds	≤ 20
Sensing Accuracy	Ounce	Nearest Ounce
Bottle Size	Ounce	≥ 12
Sanitation Duration	Seconds	120

Hardware Block Diagram



Water Level Sensor Selection

- The crux of the project
- Pros and cons of each method
- Accuracy and user friendliness

	eTape Liquid Level Sensor	Load Sensor	Pressure Sensor	Flow Meter	Ultrasonic TOF Sensor
Cost	< \$60	< \$20	< \$30	< \$30	< \$20
Accuracy	1cm	1.0±0.1 mv/V (±5%)	0.1mbar	2oz	1mm
Power	< 0.5W	≈15mW	≈14.4μW	≈75mW	≈27.75mW
Waterproofing	Easy	Easy	Medium	Medium	Easy
Calibration	Easy	Medium	Medium	Hard	Hard
User Friendliness	Bulky	Requires hard surface	Hand wash	Dish washer safe bottle	Hand wash

Pressure Sensor – MS5837-02BA

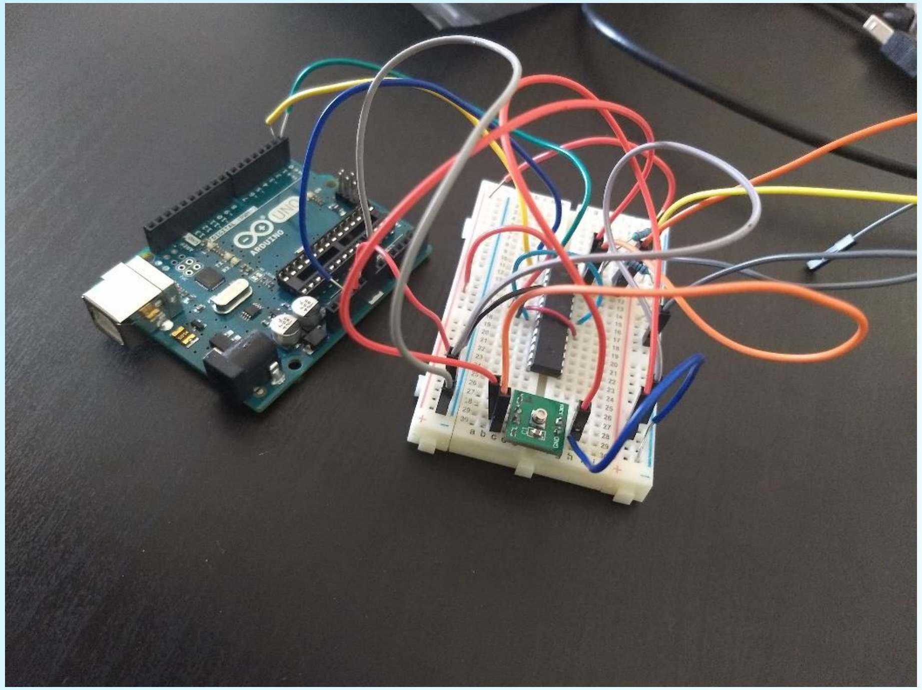
- Used to measure water level in the bottle
- Accurate to the nearest ounce
- 3 measurements are taken and then averaged

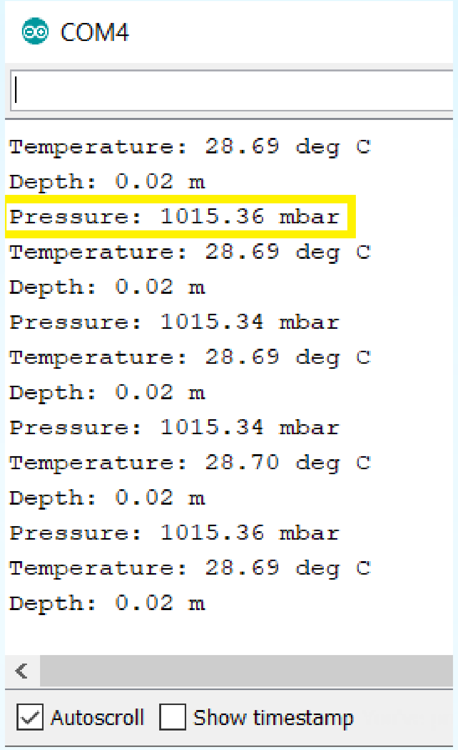
$$P = \rho g h$$
$$h = \frac{P}{\rho g}$$

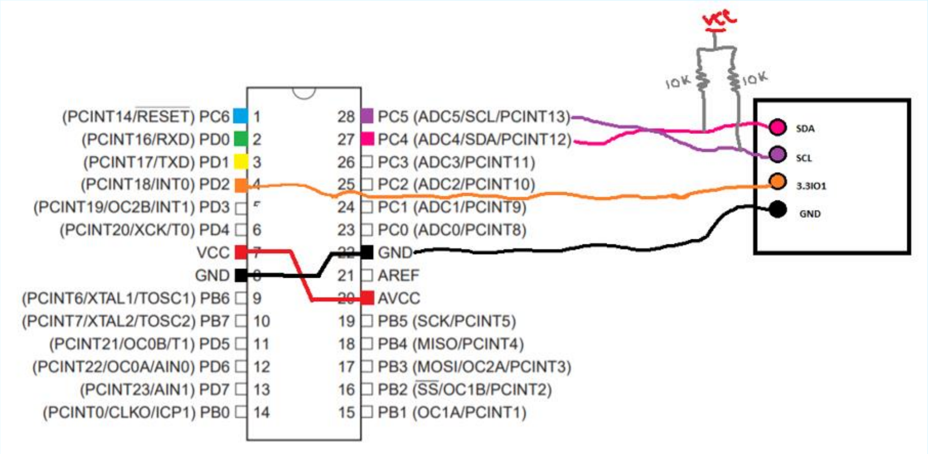
$$\rho = desity\ of\ water = 1000 kg/m^3$$
$$g = acceleration\ of\ gravity = 9.81 m/s^2$$
$$P = Pressure\ read\ from\ sensor$$

	MS5837-02BA	MS5803-02BA	MS5540C
Cost	$18.72	$10.72	$22.99
Pressure Range	300-1200mbar	300-1000mbar	10-1100mbar
Resolution	0.11mbar	0.13mbar	0.1mbar
Supply Voltage	1.5-3.6V (typ. 3V)	1.8-3.6V (typ. 3V)	2.2-3.6V (typ. 3V)
Conversion Current	1.25mA	1.4mA	1mA
Normal Current	0.63µA	0.9µA	4µA
Standby Current	0.1µA	0.14µA	0.1µA
Output Type	I^2C	I^2C & SPI	Digital
Output Bits	24-bit	24-bit	16-bit
Temperature Sensing	Yes	No	Yes
Waterproofing	Easy	Medium	Medium
Size (LxWxH)	3.3x3.3x2.75mm	6.4x6.2x2.88mm	6.4x6.2x2.88 mm

Pressure Sensor Testing





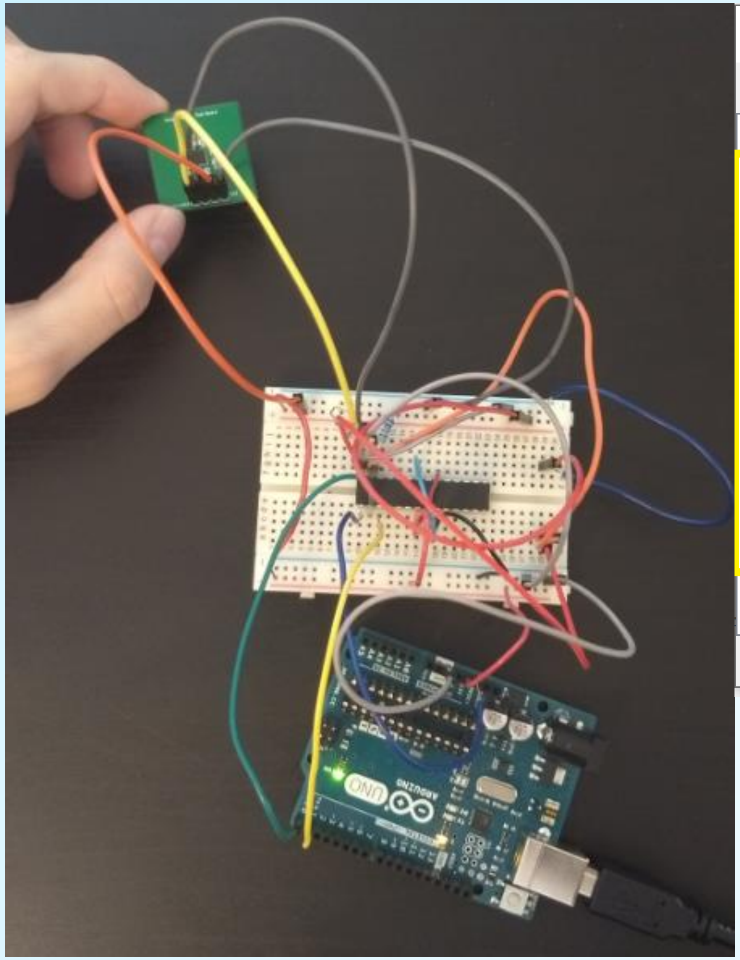


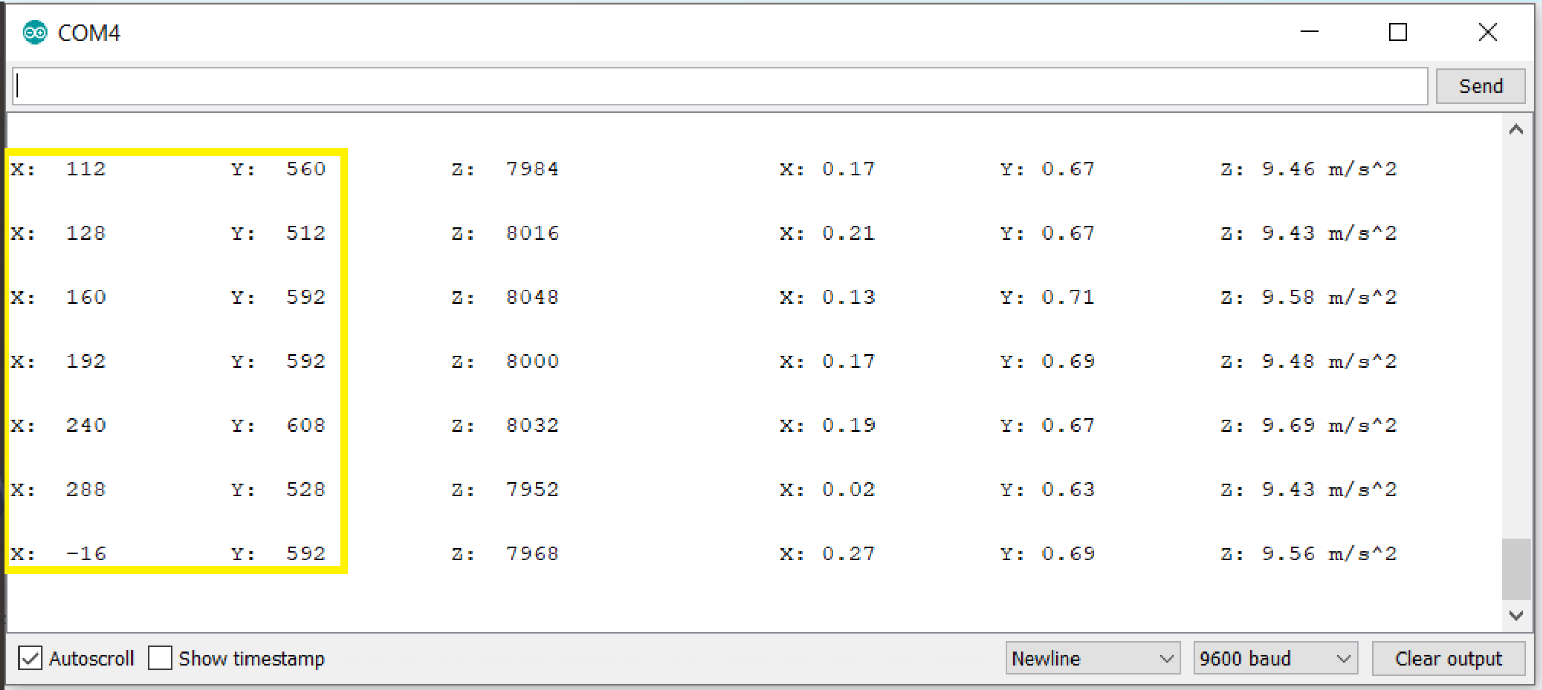
Accelerometer – LIS3DH

- Triggered after a sip is detected
- Used to determine when the bottle is upright
- I2C communication with the microcontroller
- Uses 3.3V logic

	ADXL337	LIS3DH	ADXL335	MMA8451
Cost	\$9.95	\$4.95	\$14.95	\$7.95
Range	±3g	±2g/±4g/±8g/±16g	±3g	±2g/±4g/±8g
Output	Analog	I^2C	Analog	I^2C
Supply Current	300μA	6-11μA	350μA	6-165μA
Supply Voltage	1.8V-3.6V	1.71-3.6V	1.8-3.6V	1.95-3.6V
Size (LxWxH)	3x3x1.45mm	3x3x1mm	3x3x1.45mm	3x3x1mm

Accelerometer Testing





- X and Y values used to determine bottle orientation
- Upright range is -1000 to 1000 for both X and Y

Microcontroller - ATmega328P

- Powers all periphery components
- I2C communication with the accelerometer and pressure sensor
- Store the sequential code and timing of sanitation

	ATmega328P	ATtiny85	ATmega328V	32 bit ARM Cortex-M4
Development Board	Arduino Uno	Adafruit Trinket	LilyPad Arduino 328 Main Board	Teensy 3.2
Cost	$2.04	$1.16	$2.14	$3.57
Digital input/output pins	14	5	14	34
Analog input pins	6	2	6	21
Input Voltage (recommended)	7 V – 12 V	1.8 V - 5.5 V	2.7 V – 5.5 V	1.71 V – 3.6 V
Size (L x W x H)mm	5 x 5 x 0.9	4 x 4 x 0.8	50 (diameter)	10 x 10 x 1.6
Clock Speed	16 MHz	8 MHz	8 MHz	32 MHz
Flash Memory	32 KB	8 KB	16 KB	256 KB
I2C Support	YES	YES	YES	YES
IDE	Arduino	Arduino (limited)	Arduino (0010 or higher)	Arduino (must install Teensyduino)

Sanitization Selection

- Ease of use/implementation
- Electronics application
- Supporting research

	Boiling System	Chemical Treatments	Ultraviolet-C Light
Cost	< $20	< $20	< $50
Effectiveness	Very High	Very High	>98% pure
Power	High	Low	Medium
Waterproofing	Easy	Easy	Medium
Implementation	Hard	Hard	Easy - Medium
User Friendliness	Low, gives user too-hot water to drink	Low, needs user to refill chemicals	High, no interaction needed

UV-C LED – RVXR-280-SB-073105

- Cheapest
- Wide angle of exposure, 120°
- Good design to work with our layout

	MTE280H41-UV	RVXR-280-SB-073105	VLMU60CL00-280-125
Forward Voltage	7 V	7 V	6.2 V
Forward Current	40 mA	100 mA	40 mA
Wavelength	280 nm	280 nm	280 nm
Power Output	1 mW	8 mW	2.4 mW
Mounting Type	Through Hole	Star Board	Surface Mount
Viewing angle	40°	120°	125°
Operating Temp.	-30 ~ +80 C	60 C (JT)	-30°C ~ 80°C (TA)
Manufacturer	Marktech Optoelectronics	RayVio	Vishay
Cost	$ 151.29	$16.45	$39.28

UV-C LED Light Treatment Against E. coli

- LARQ, a 'Smart' water bottle company, also uses a UV-C LED for sanitization
- LARQ had this experiment done in Harrens Lab
- Our UV-C LED is similar to the one used on the LARQ bottle

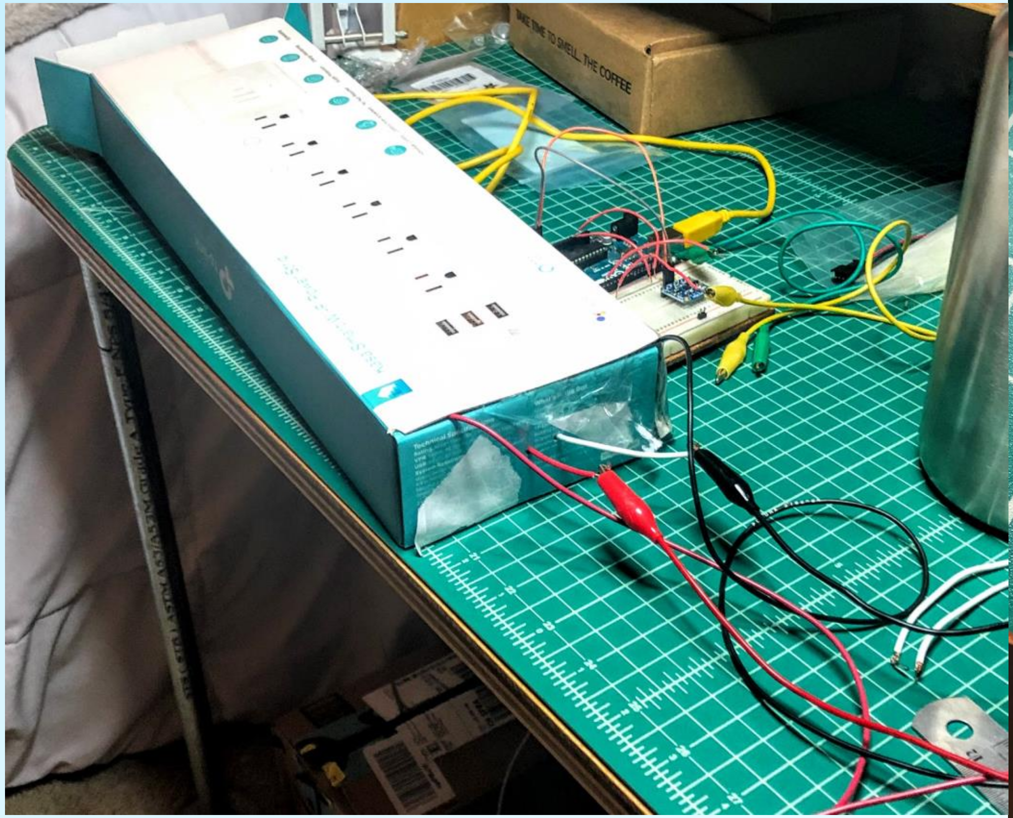
Table 1: Experimental results using 1-min light treatment against *E. coli*

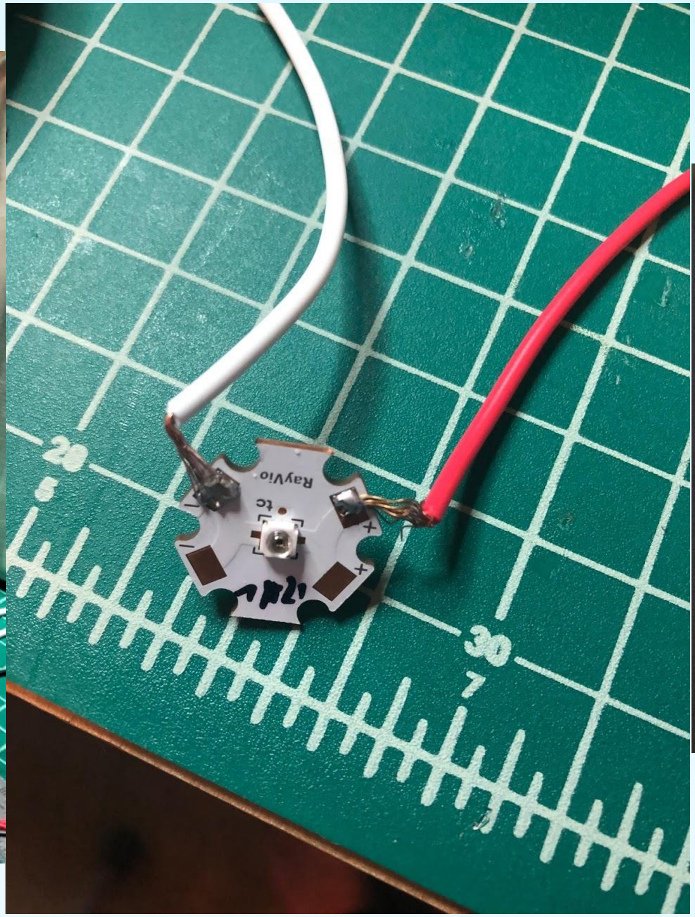
Replicate	Initial Population	T-1 min	Log Reduction (T1)	% Reduction (T1)
1	1.60E+07	2.50E+03	3.81	99.9844
2	6.00E+06	6.80E+02	3.95	99.9887
3	6.00E+06	7.20E+02	3.92	99.9880
4	4.00E+06	2.12E+03	3.28	99.9470
5	5.20E+06	8.80E+02	3.77	99.9831
6	6.50E+06	1.68E+03	3.59	99.9742
Average	7.28E+06	1.43E+03	3.72	99.9775

Table 2: Experimental results using 2-min light treatment against *E. coli*

Replicate	Initial Population	T-2 min	Log Reduction (T2)	% Reduction (T2)
1	5.80E+06	1.00E+01	5.76	99.9998
2	2.90E+06	1.00E+01	5.46	99.9997
3	5.60E+06	1.00E+01	5.75	99.9998
Average	4.77E+06	1.00E+01	5.66	99.9998

UV-C Testing





Reed Switch

- Cheapest
- Shortest operating range
- Smallest part, less noticeable
- Glass body, non-conductive

	MG-A2-5.0-N	59050-030	MK23-80-C-2
Manufacturer	Magnasphere Corp.	Littlefuse, Inc.	Standex-Meder Electronics
Cost	$6.53	$3.50	$1.88
Body Material	Non-ferrous metal (Gold)	Molded body	Glass body
Operating Range (distance required from magnet to close circuit)	14.4526mm	3.81mm	15 – 20 AT
Release Range (distance required from magnet to open circuit)	16.3322mm	16.51mm	-
Contact Rating	20VDC @ 250mA	5W	10W
Length	6.1976mm	22.86mm	7mm
Height	4.445mm	4.57mm	2mm

Reed Switch Testing

Communication to Mobile Device

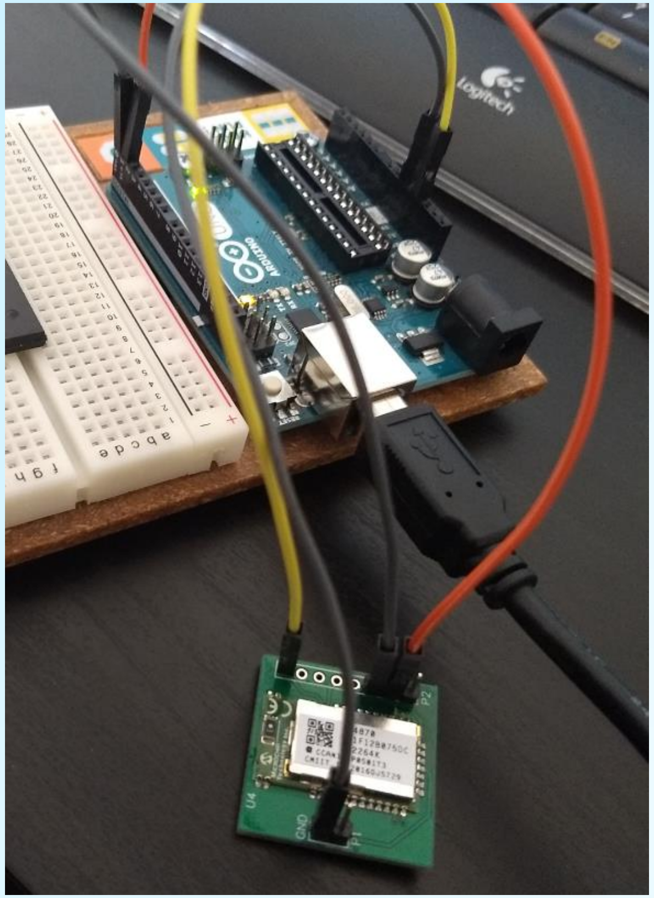
Communication Technologies	User Setup Difficulty	Complexity	Power Consumption	Cost	Size	Mobility
Hardwired	Low	Low	Very Low	Moderate	Small	Very Low
Wifi	High	High	Moderate	High	Large	Limited
Bluetooth	Moderate	Moderate	Low	Low	Small	High

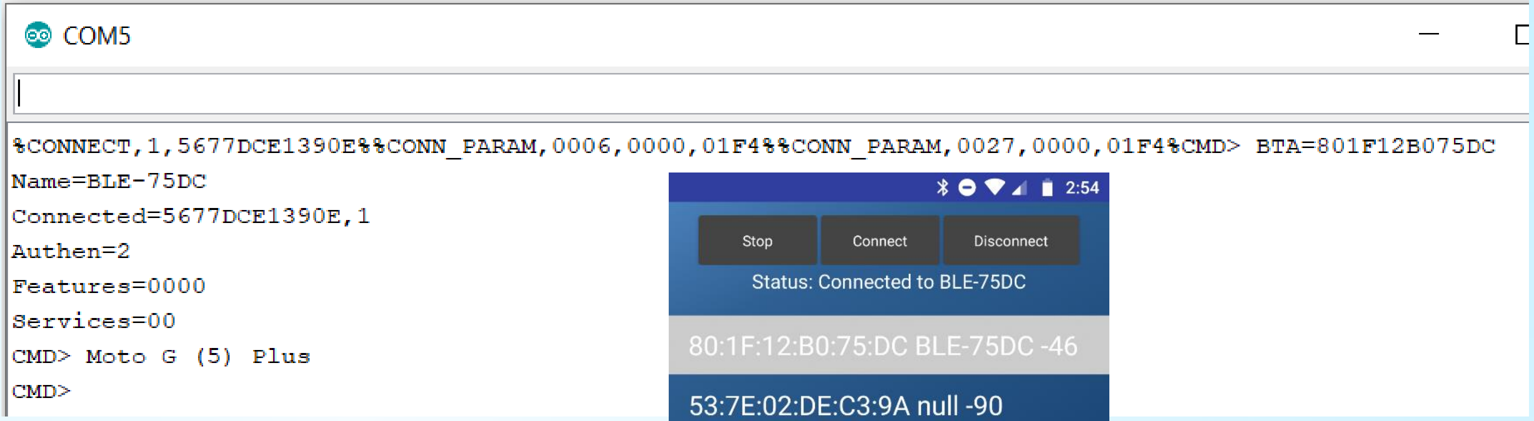
Bluetooth Adapter – RN4870-V/RM118

- Low Cost
- Small Footprint
- Latest Bluetooth version
- Low Power consumption

	BLE113	RN4870-V/RM118	TI CC2640R2F	HC-05
Bluetooth version	V4.0	V4.2	V4.2	v2.0
Size (mm)	9.15 x 15.75	9 x 11.5	7 x 7	27 x 12.7
Current(low-high)	0.4uA - 18.2mA	60uA - 13mA	1.1uA - 9.1mA	unknown
Power(low-high) (3.3V)	1.32uW- 60mW	198uW- 39mW	3.63uW- 30mW	unknown
Cost	$12.67	$7.24	$8.51	$10.57

Bluetooth Testing





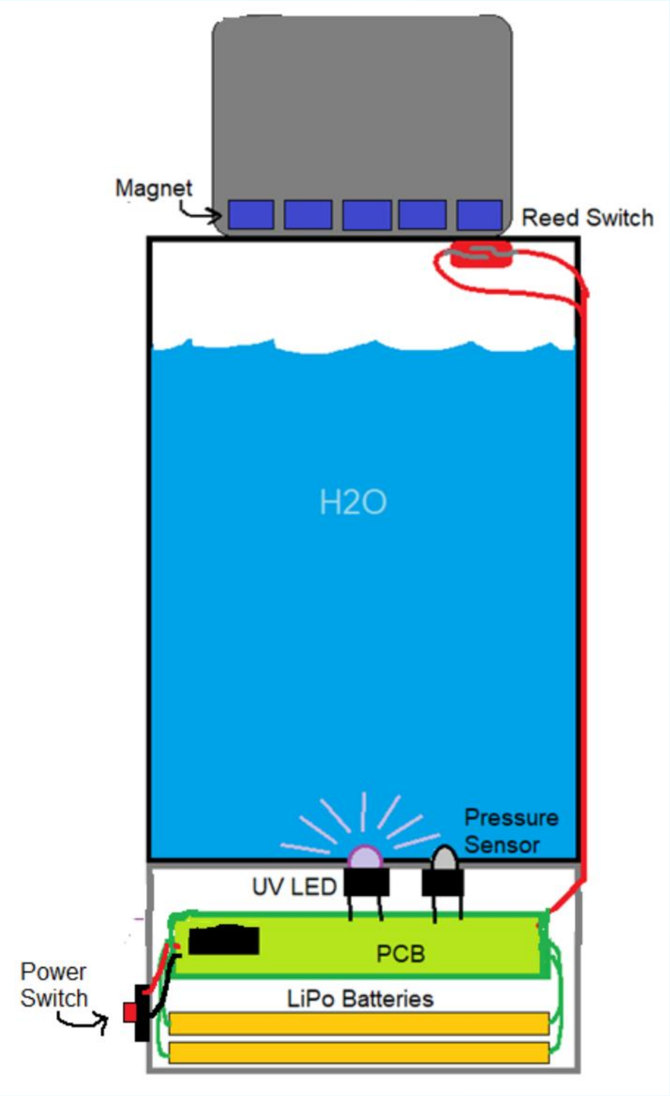
Battery - LiPo

- Used to power 3.3V and 6V
- Two batteries connected in series
- Rechargeable
- Based on a 16hr day with roughly 5 sips per hour and all the components running at max power, 62.13mAh would be needed to run for the entire day.

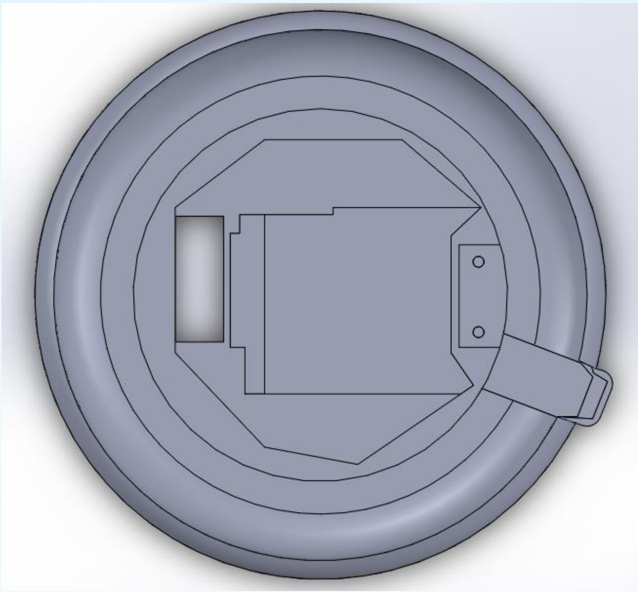
	Coin Cell	LiPo	Round Lithium Ion
Voltage	3.6V	3.7V	3.7V
Milliamp Hrs	120mAh	<1000mAh	<1000mAh
Ease of Charging	Low	High	Medium
Size Estimate	24mm	2.00inx1.32in	2.72in length

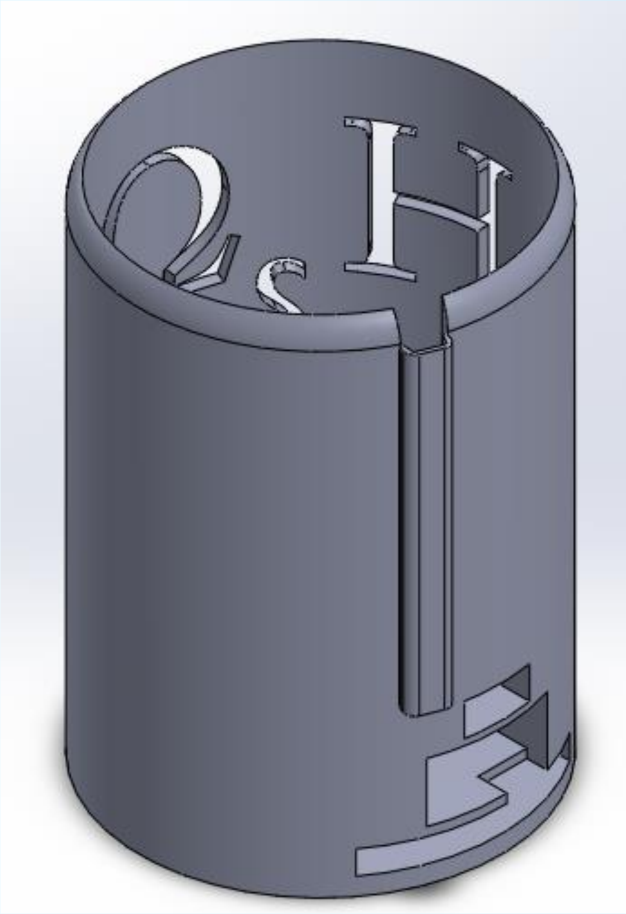
Bottle Design

- Must be durable
- Needs to protect the user's eyes from the UV-C LED
- Bottle must have a wide base to comfortably fit the electrical components
- 3-D Printed base

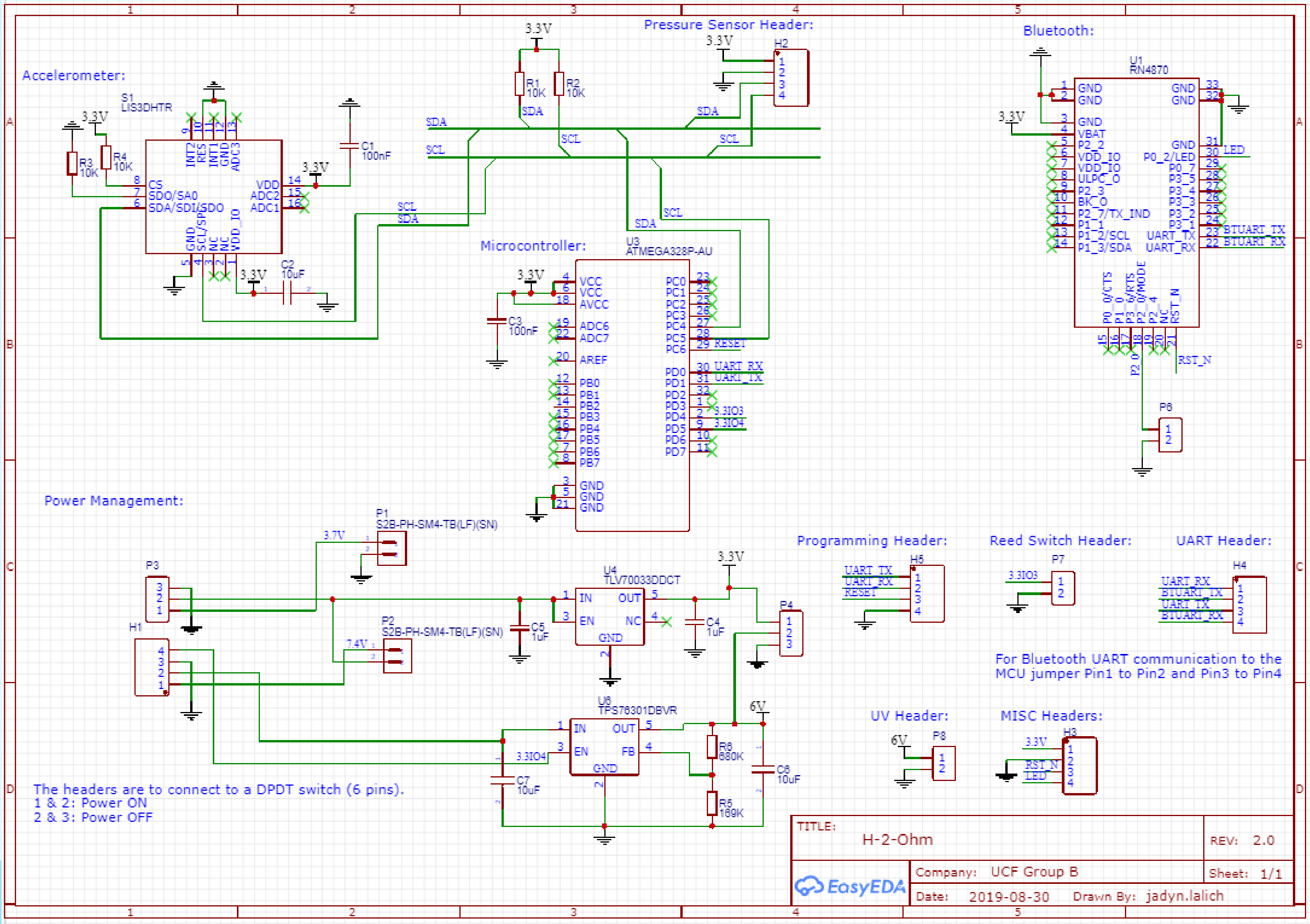


3D Base



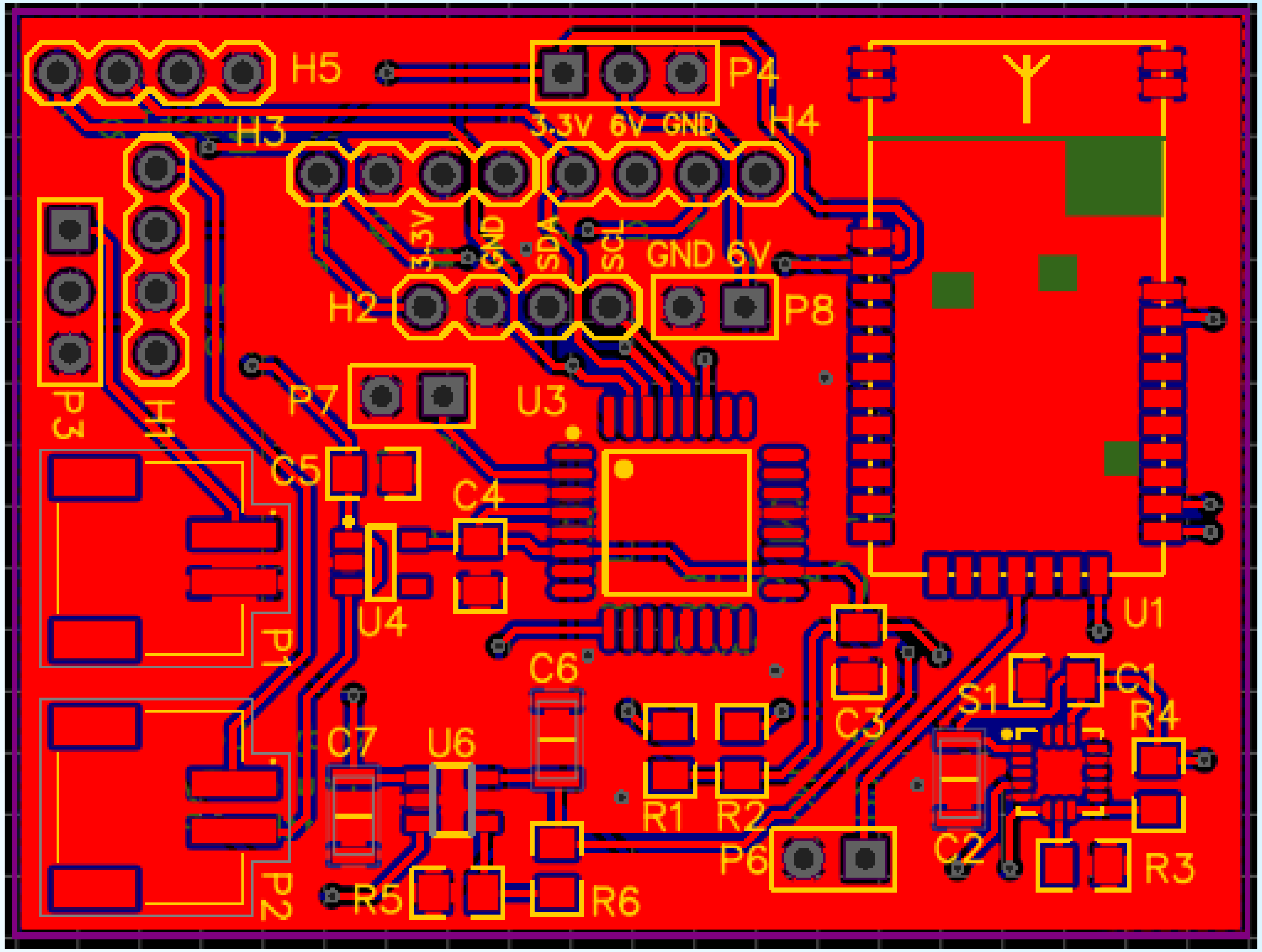


Hardware Schematic

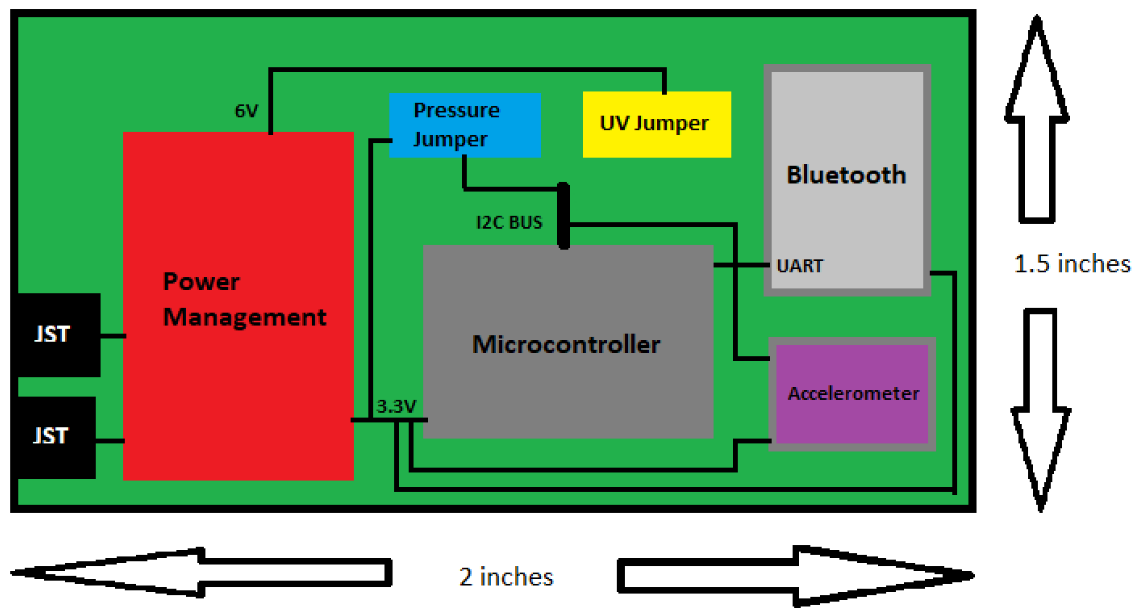


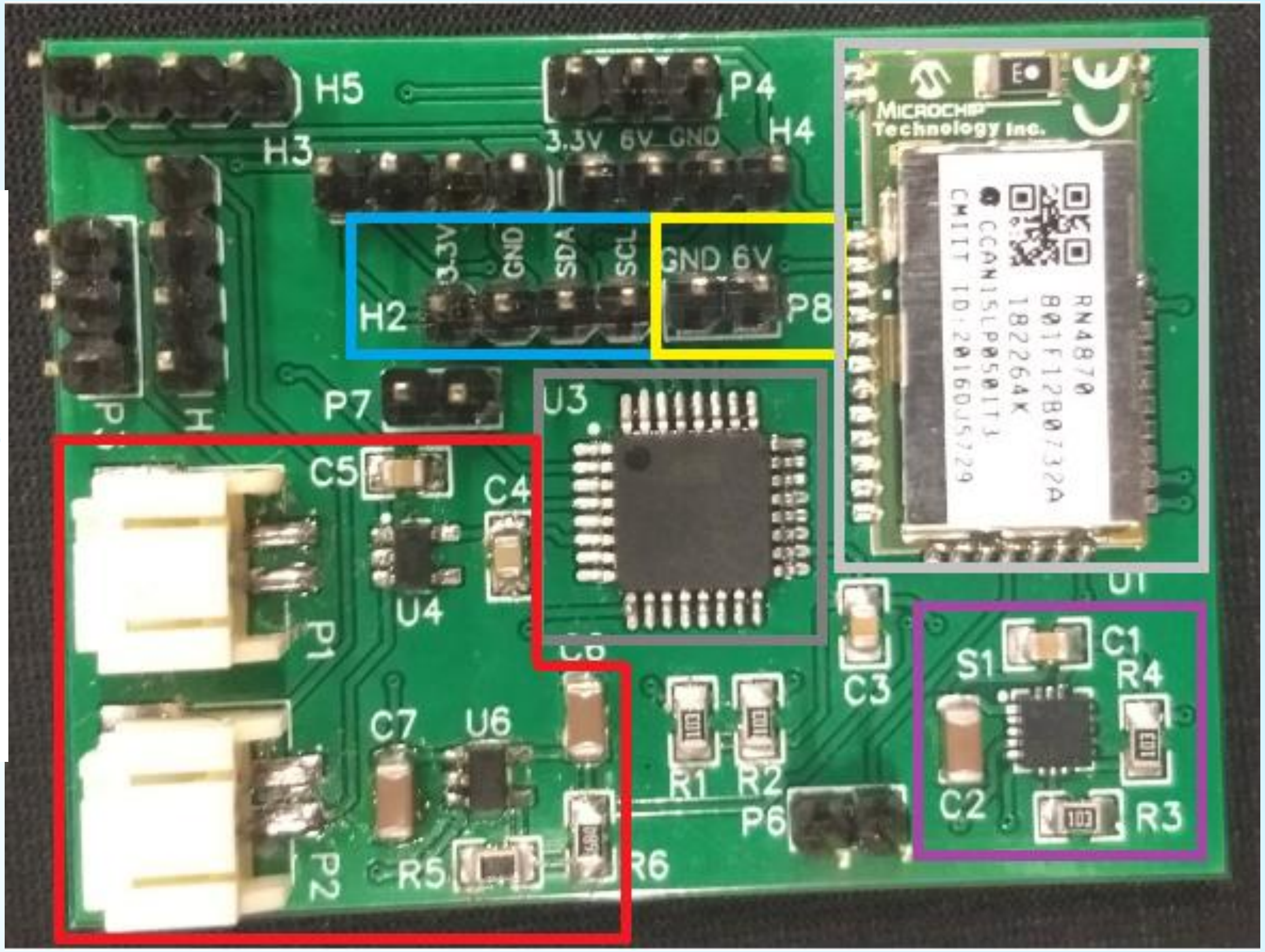
Printed Circuit Board

- Dimensions: 2 in x 1.5 in
- Layers: 2
- Top and bottom copper ground plane
- Vias utilized to connect top and bottom layers as well as GND
- Debugging and programing headers



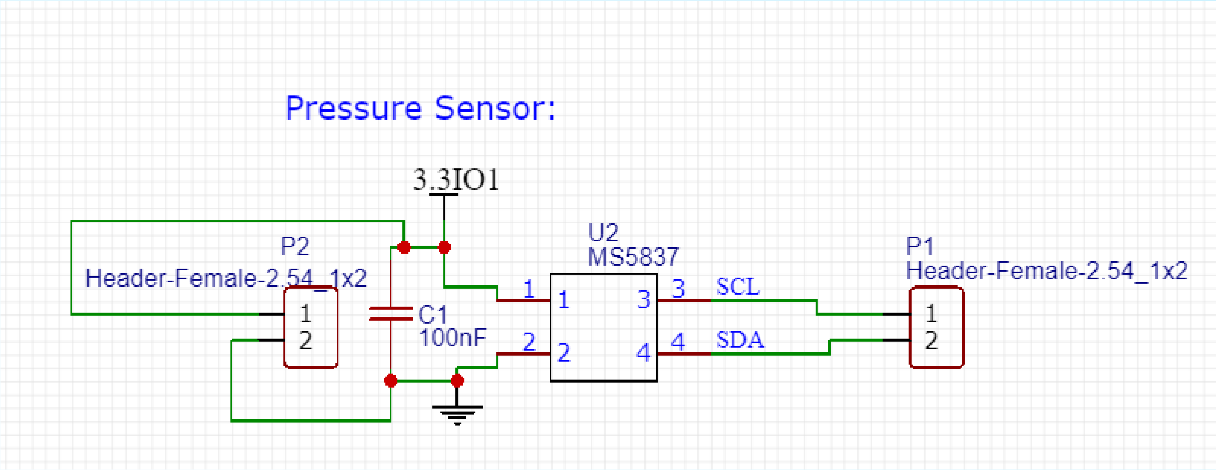
Printed Circuit Board (cont.)

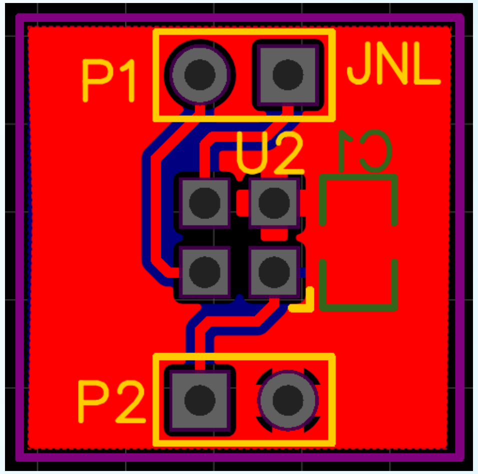




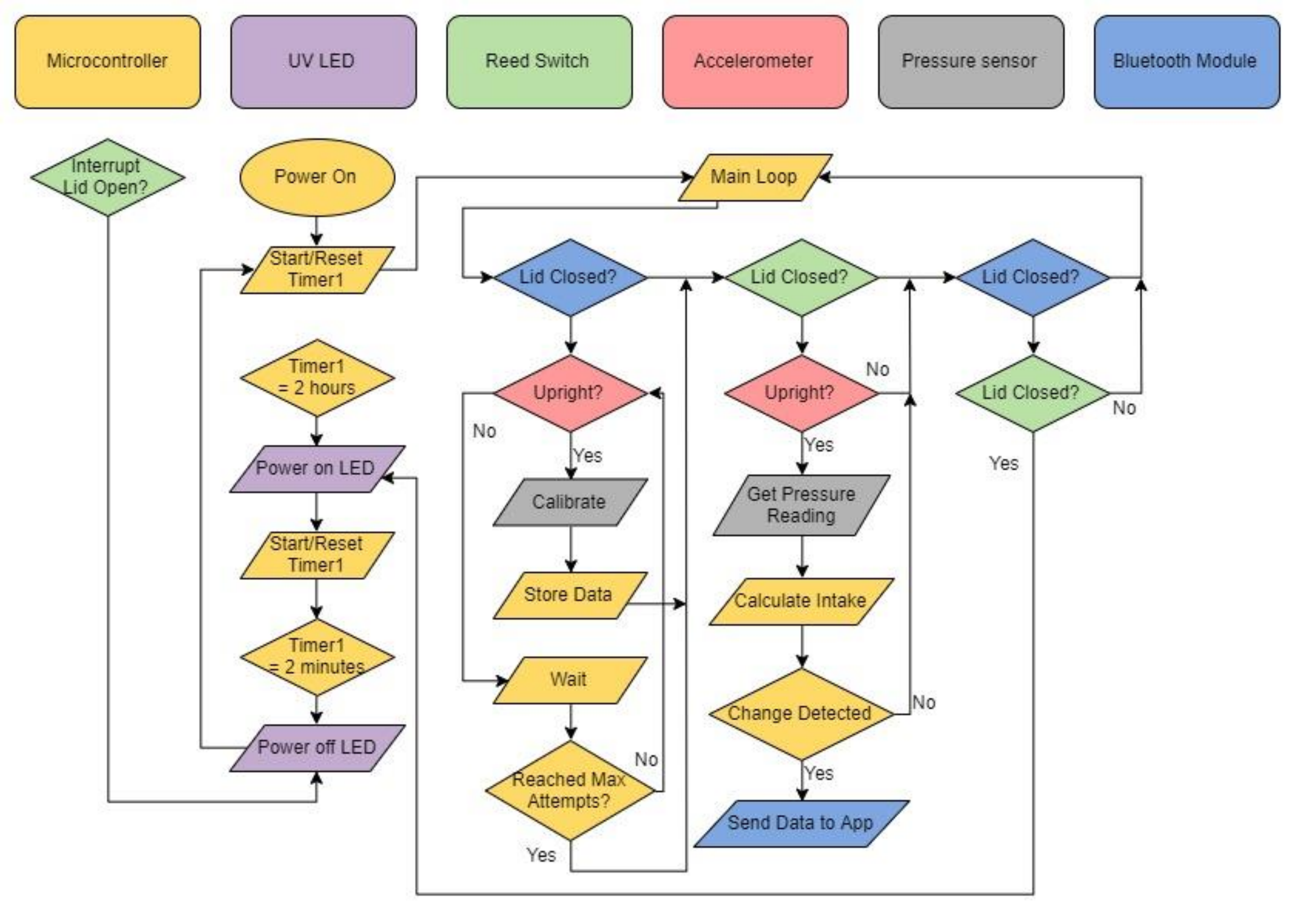
Pressure Sensor Design

- Dimensions: 0.5 in x 0.5 in
- Layers: 2
- 4 pins: VCC, GND, SCL, and SDA
- Mounted at the base of the bottle using USDA Approved Silicon Sealant
- Headers P1 & P2 allow wires to connect to the main PCB





Software Block Diagram

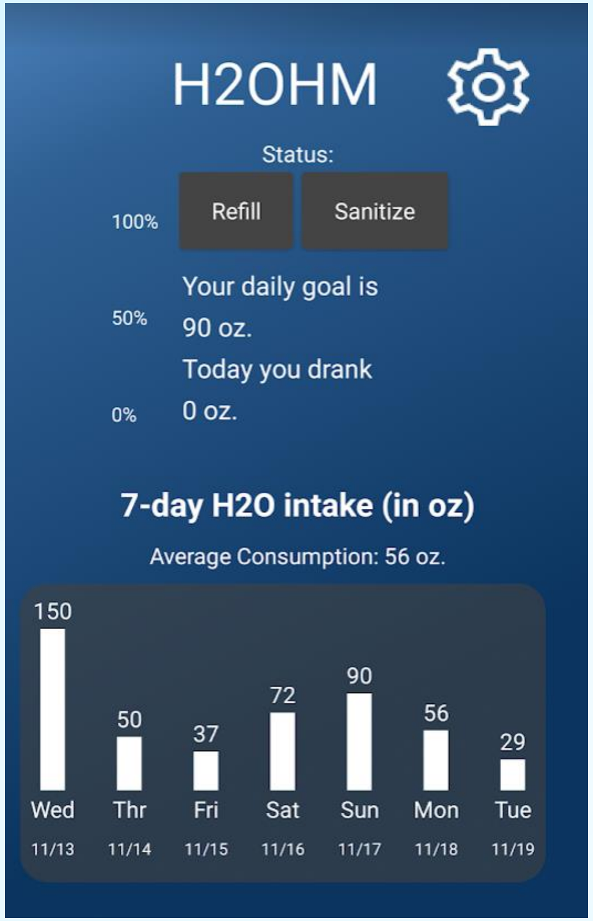


Mobile Application Design

Today's Water intake

Weekly Average

Water intake over the past week



Division of Work

	Jadyn Lalich	Matthew Peterson	Lauren Tyler
PCB Design	Primary		Secondary
Mobile Application	Secondary	Primary	
Water Level Sensor	Primary	Secondary	
Sip Detection		Secondary	Primary
Sanitization	Secondary		Primary
Communication	Secondary	Primary	Secondary
Power	Primary		Secondary
Housing	Secondary		Primary

Budget

- Completely self-funded
- Allows for more creative freedom and less stress for the team
- Many of the components used during prototyping were previously owned
- Overall this was an inexpensive project

Part	Quantity	Cost (each)	Total Cost
Bluetooth Module	1	$7.24	$7.24
Power Supply	2	$9.95	$19.90
Pressure Sensor	1	$16.67	$16.67
Reed Switch	1	$1.88	$1.88
UV-C LED	1	$16.45	$16.45
Microcontroller	1	$2.14	$2.14
PCB	1	$5	$5
Water Bottle	1	$35.98	$35.98
Accelerometer	1	$1.53	$1.53
System Housing	1	$10	$10
ON/OFF Switch	1	$4.01	$4.01
Miscellaneous Components	-	-	$10
TOTAL			$130.80

Questions?