For **LO**wering Household **W**ater Usage

SDP Team 9

FPR

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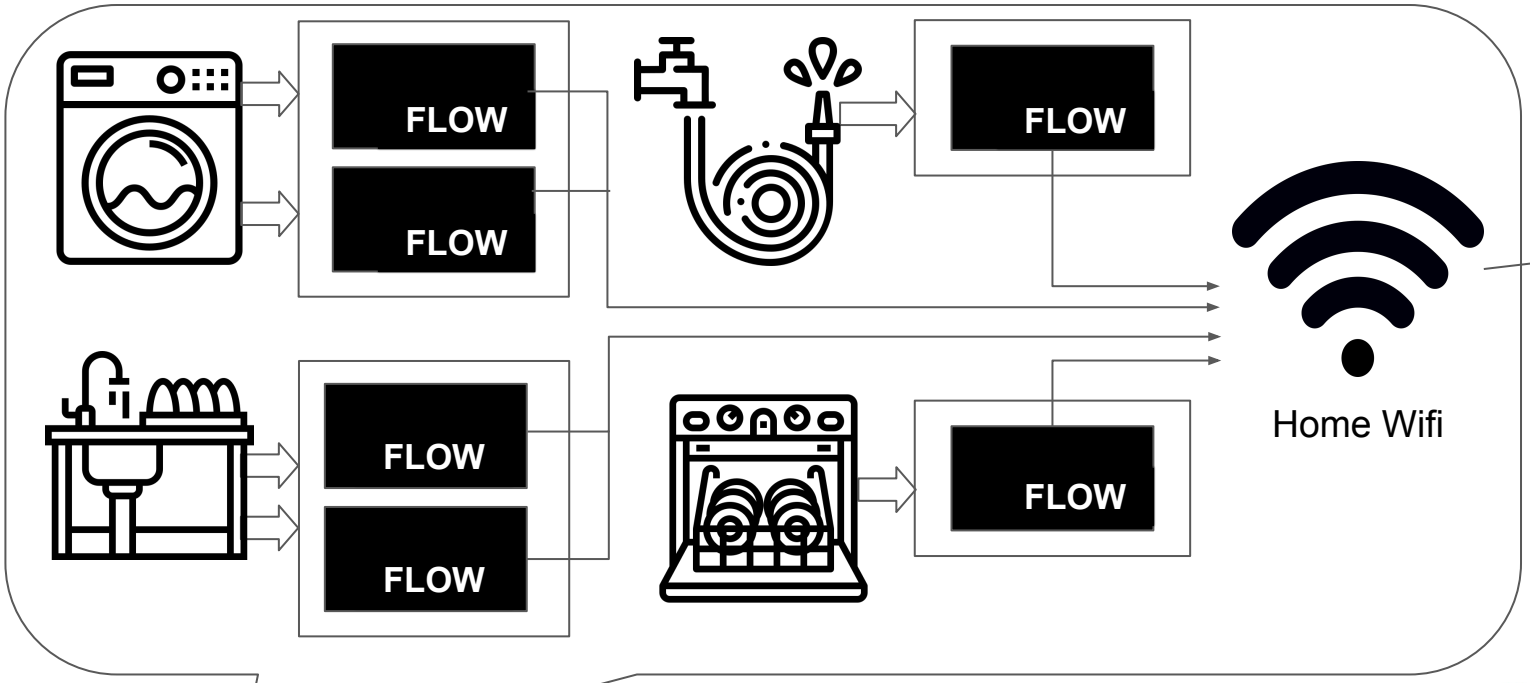
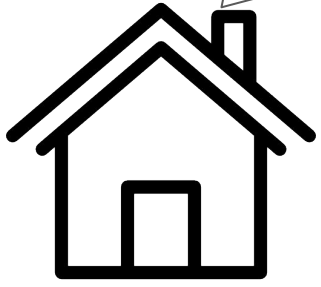
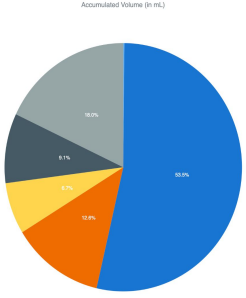
Problem Statement

According to the United States Geological Survey, each person uses about 80-100 gallons of water per day for indoor home uses [1]. The majority of the households cannot monitor which home fixture or water outlet dispenses the most amount of water. **The system we aim to create will measure the quantity of by each water outlet**. Users can view their monthly water consumption from an app to which the sensor nodes are connected. The data will allow users to learn their water consumption behaviour.

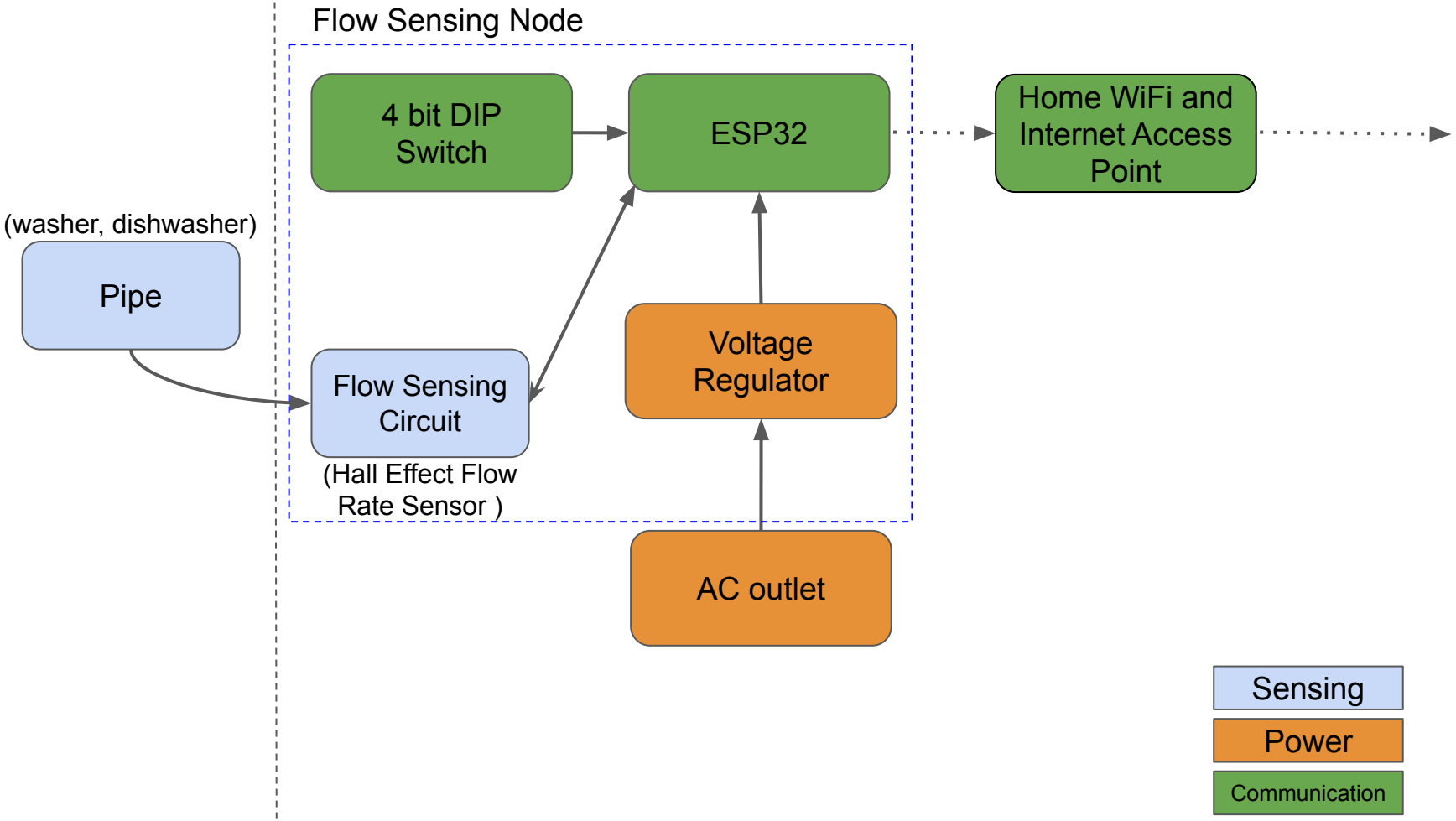

FLOW
FLOW
FLOW
FLOW
FLOW
Home Wifi
WWW



FLOW


Accumulated Volume (in mL)
55.0%
18.0%
9.1%
8.7%
10.8%


Sensor A: 63
Sensor B: 22192
Sensor C: 5229
Sensor D: 2789
Sensor E: 3768
Sensor F: 7463


Flow Sensing Node
4 bit DIP Switch
ESP32
Home WiFi and Internet Access Point
(washer, dishwasher)
Pipe
Flow Sensing Circuit
(Hall Effect Flow Rate Sensor)
Voltage Regulator
AC outlet
Sensing
Power
Communication

System Specifications (FPR)

Functional Specification	Characteristic Specification	Performance Requirement	*Design Goal*
• Measure the **quantity** of water coming out of each water outlet • Web App to display information to user showing water usage for each outlet in real time	• Installation of the flow sensor nodes by the homeowner, without requiring a plumber • Low voltage ~~battery~~ operated system • Flow sensor nodes output is communicated wirelessly through the house • Data transfer via home WiFi and internet access point to the cloud	• Flow sensor nodes measure quantity of water with an accuracy of **90%** • Flow sensor node lifetime exceeds 36 months • System capability is up to **6** flow sensor nodes per house	• Installation on the outside of the pipe and out of view of the user

Unresolved Issues from CDR

- Sensor Accuracy with derived Calibration Factors
- Finalizing PCB
- Packaging

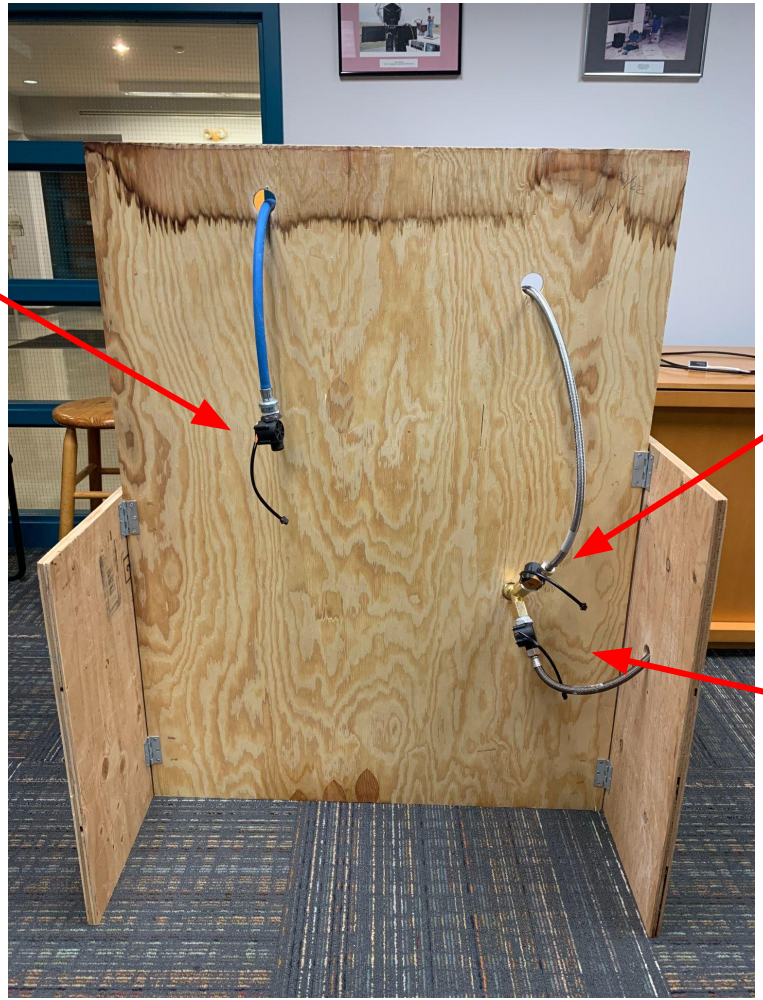
Orientation and Calibration

- Vertical up (water flowing vertically and upward)
- Vertical down (water flowing vertically and downward)
- Horizontal (water flowing horizontally)
- A 4 bit DIP switch is placed on the PCB for users to determine which orientation their sensor is in

$$calibration\ factor = \frac{pulse\ count}{time\ (seconds)} * \frac{1}{flow\ rate\ (L/min)}$$

https://docs.google.com/spreadsheets/d/1K6irMV7HSS9KohmgTR-hn4Gaswl9F7rIqph3x_uw2vk/edit#gid=0

Vertical down



Vertical up

Horizontal

Calibration Procedure

- Obtain the calibration for each sensor in each orientation using the equation
- Validate that the accuracy of the sensor with the derived calibration factor is within 95% accuracy
- This process would theoretically be done at the factor before the sensors are sent out to the homeowner

Calibration Factor Derivation

$$Flow\ Rate = \frac{1000}{msec} * \frac{pulse\ count}{calibration\ factor}$$

$$Flow\ Rate = \frac{1000}{msec} * pulse * \frac{L}{min} * \frac{second}{pulse} = \frac{L}{min}$$

$$Flow\ Rate = \frac{1000}{msec} * pulse\ count * \frac{1}{calibration\ factor}$$

$$calibration\ factor = \frac{pulse\ count}{time\ (seconds)} * \frac{1}{flow\ rate\ (L/min)}$$

The pulse count in the original equation is # pulses/second.

Confidence Interval

$$(\hat{p} - \Delta, \hat{p} + \Delta)$$

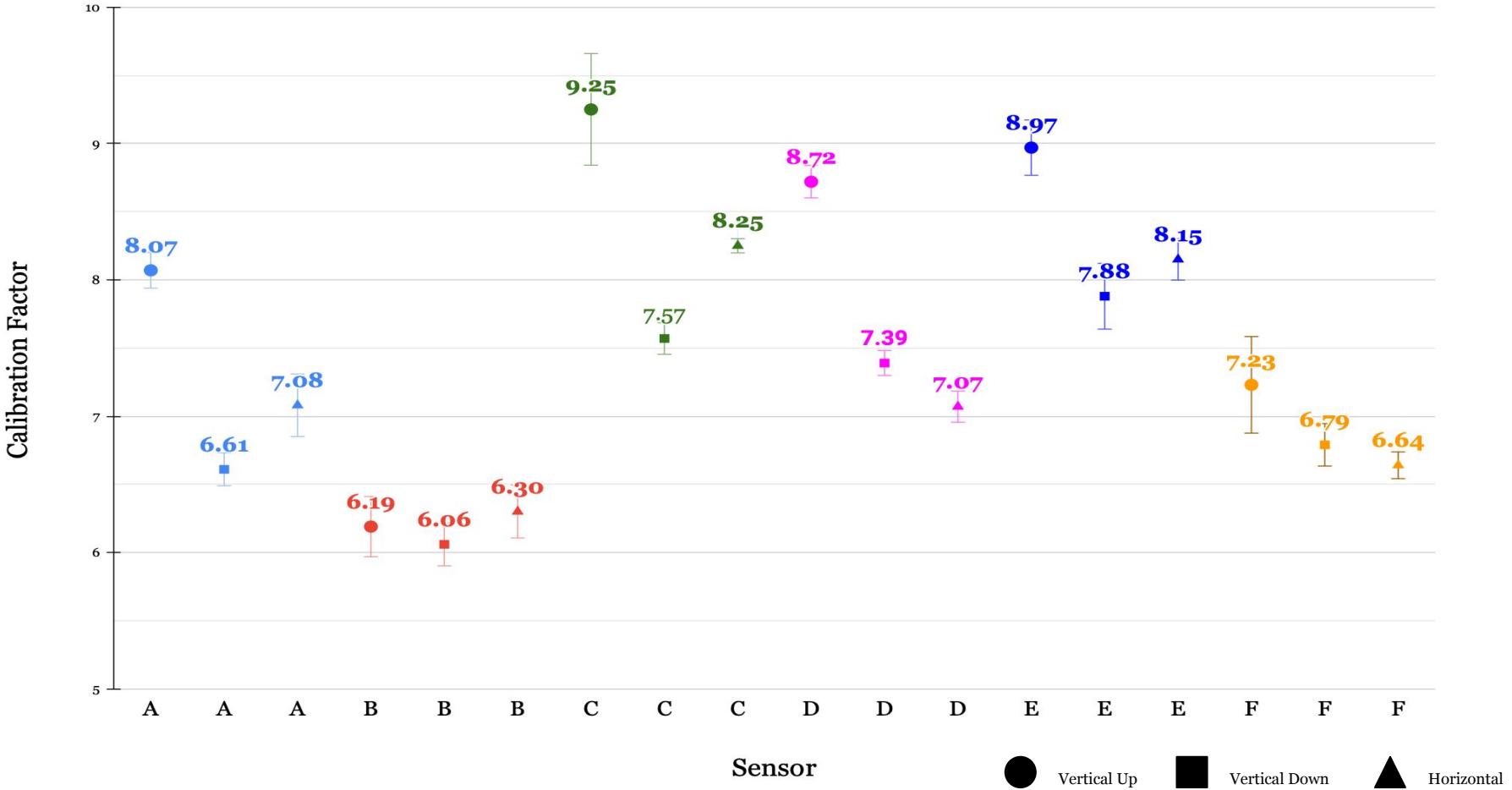
$$\Delta = \sqrt{\frac{\sigma^2}{N}} \Phi^{-1}\left(\frac{1-\alpha}{2}\right)$$

$$E[x_i] = p$$

Confidence Interval

Sensor	Vertical up	Vertical down	Horizontal	CONF	CONF	CONF
A	8.07	6.61	7.08	1.62	1.83	3.24
B	6.19	6.06	6.3	3.57	2.60	3.07
C	9.25	7.57	8.25	4.43	1.53	0.63
D	8.72	7.39	7.07	1.36	1.24	1.61
E	8.97	7.88	8.15	2.26	3.06	1.86
F	7.23	6.79	6.64	4.90	2.29	1.48

Calibration Factor



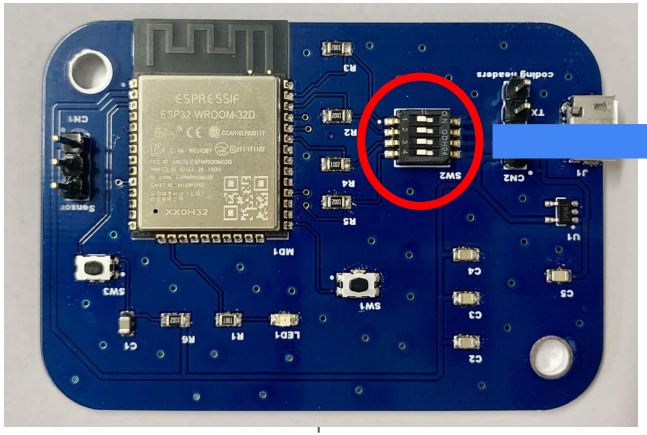
How does the switch work

- Back end (i.e. Factory): determine the calibration factors for each hall effect flow rate sensor and configure the PCB accordingly.
- User side: depending on what orientation the flow rate sensor is installed, they flick one of three switches

Back end
(i.e. Factory)

User end

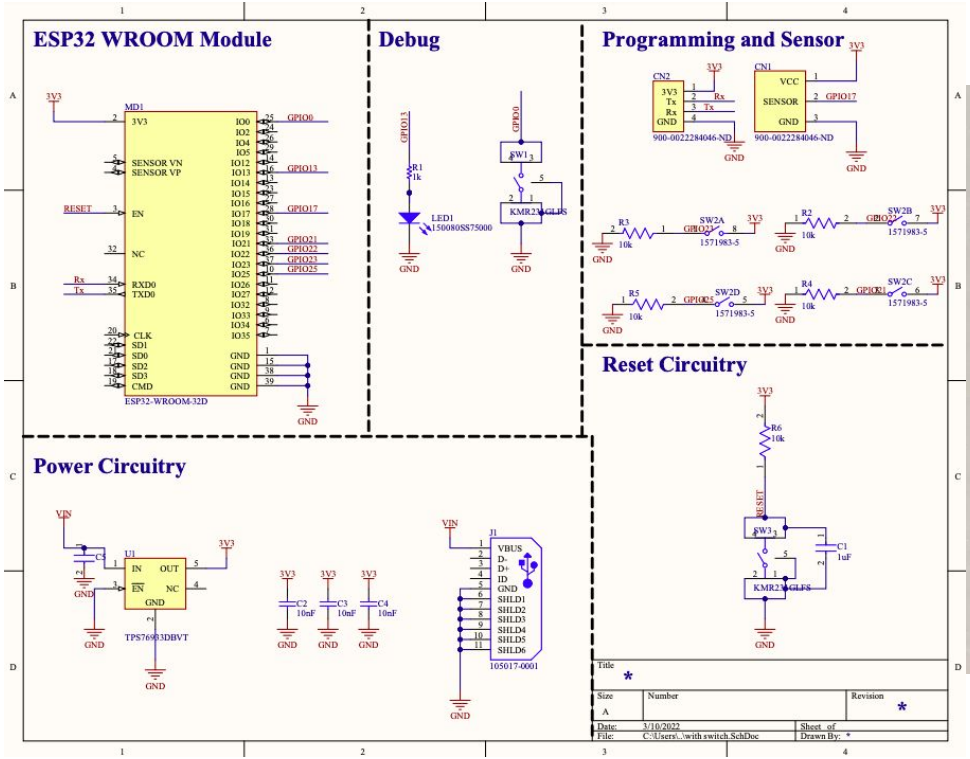
Calibrated in three orientations
(95% accuracy or higher)

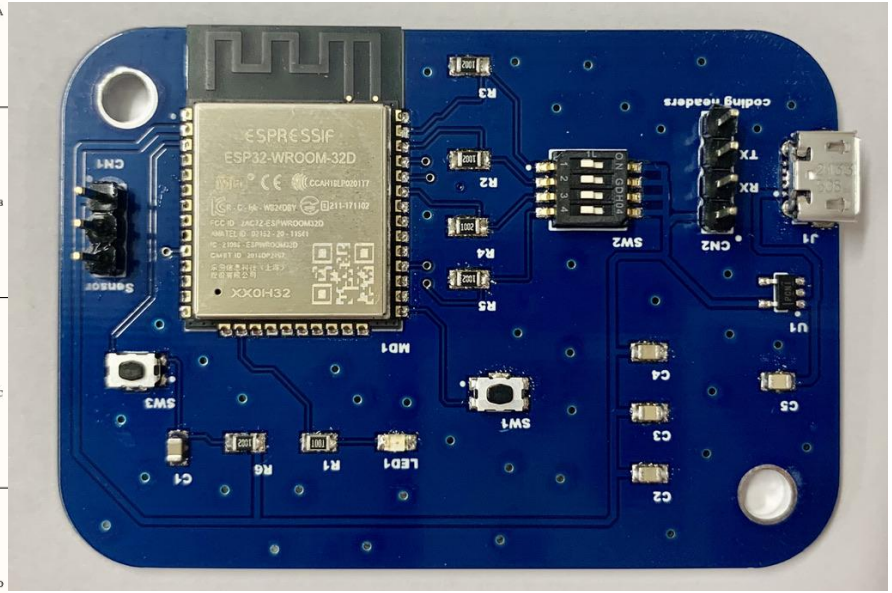


User selects one of the switches to indicate the orientation of installation

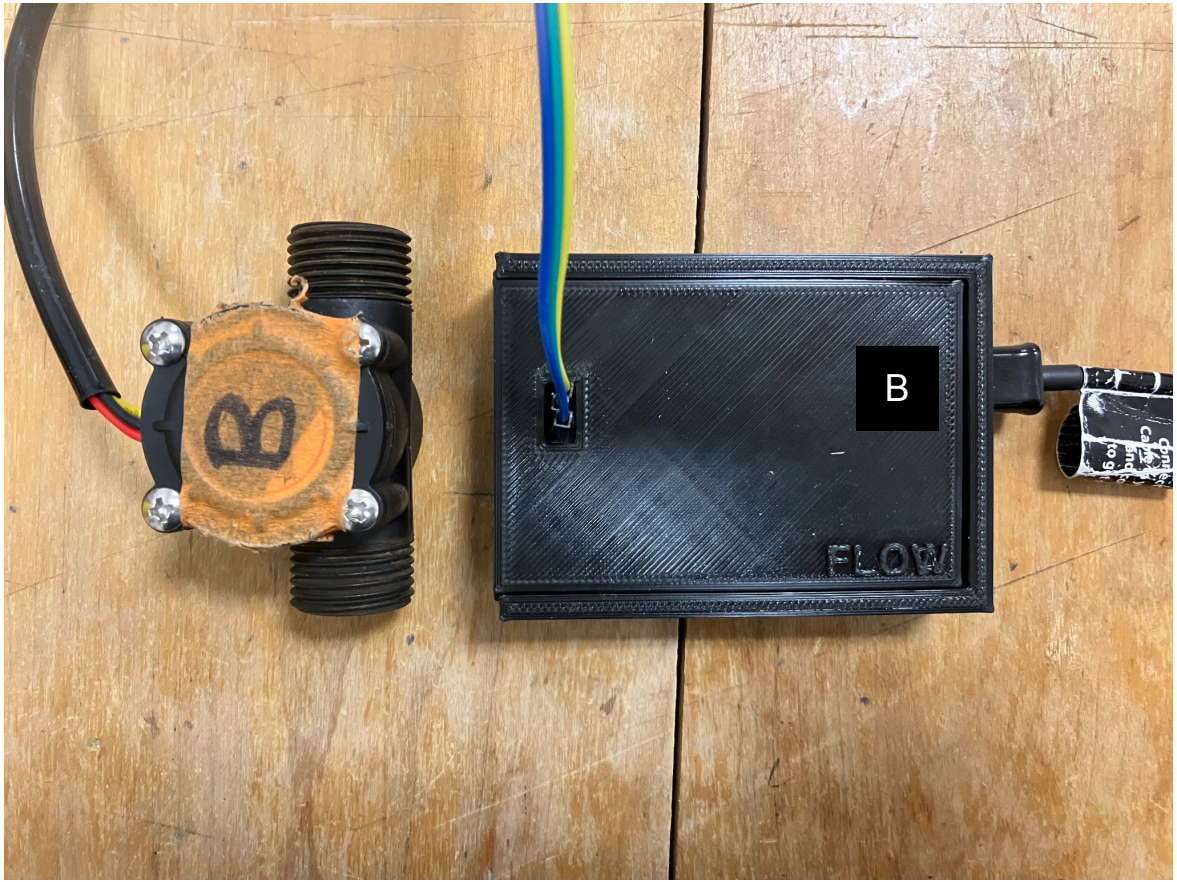
Orientation	Vertical Up	Vertical Down	Horizontal
Switch Number	1	2	3

PCB Schematic and Board

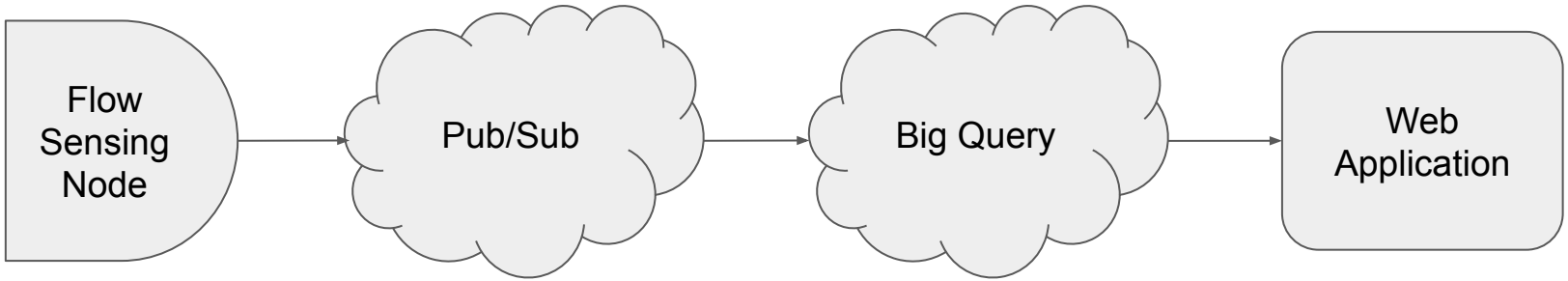




Packaging

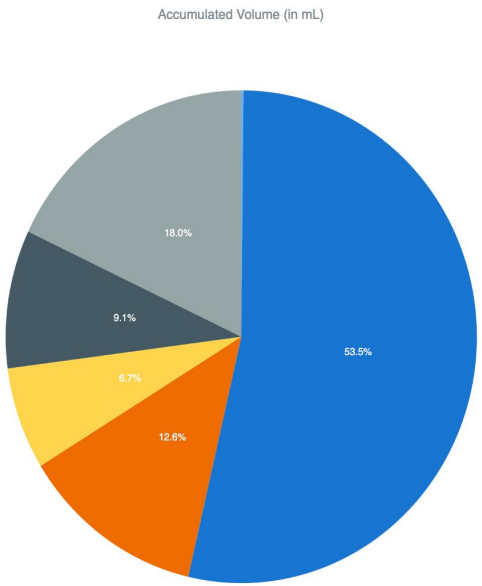


Software Design



Web Application

FLOW



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Consumption Rankings

Highest to Lowest

01 Sensor F: 0 Liters

02 Sensor E: 0 Liters

03 Sensor D: 0 Liters

04 Sensor C: 0 Liters

05 Sensor B: 0 Liters

06 Sensor A: 0 Liters

Project Expenditures

Item	Cost
Hardware	$180.73
PCB	$63.06
PCB components	$116.14
Misc.	$26.18
Total	$386.11

DEMO

Works Cited

[1]https://www.usgs.gov/special-topic/water-science-school/science/water-qa-how-much-water-do-i-use-home-each-day?qt-science_center_objects=0#qt-science_center_objects.

[2] https://www.electronicshub.org/arduino-water-flow-sensor-interface/

[3]https://www.energybot.com/electricity-rates/massachusetts/#:~:text=Massachusetts%20Energy%20Market%20Data,-Last%20updated%20February&text=The%20average%20Massachusetts%20residential%20electricity,higher%20than%20the%20national%20average).

[4]https://cavisynth.com/product/ftdi-programmer/

[5] https://www.thespruce.com/diy-washer-repairs-prevent-service-call-2147303

[6]https://structuretech.com/dishwasher-drains/

Thank you!
Any Questions?

Self Installation