Automated Boba Machine

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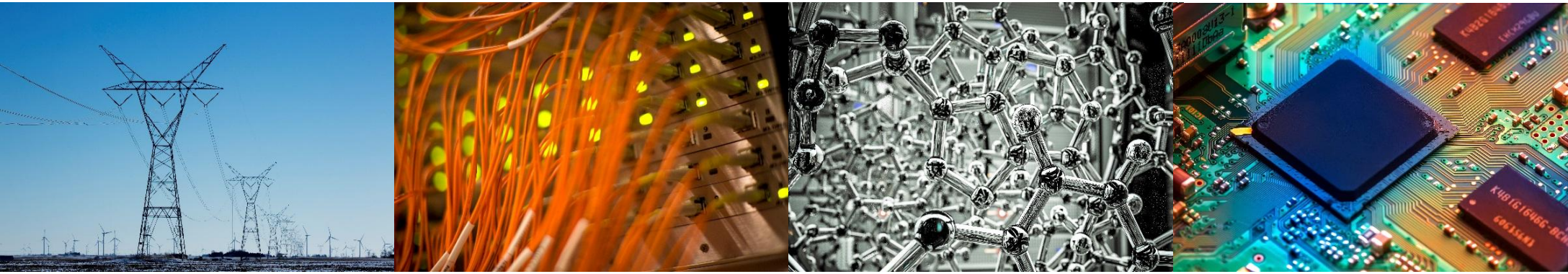
Team 49



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Introduction

- The Boba Craze
- All made Manually
  - Food waste
  - Inconsistent taste
  - Can we make this process more efficient?

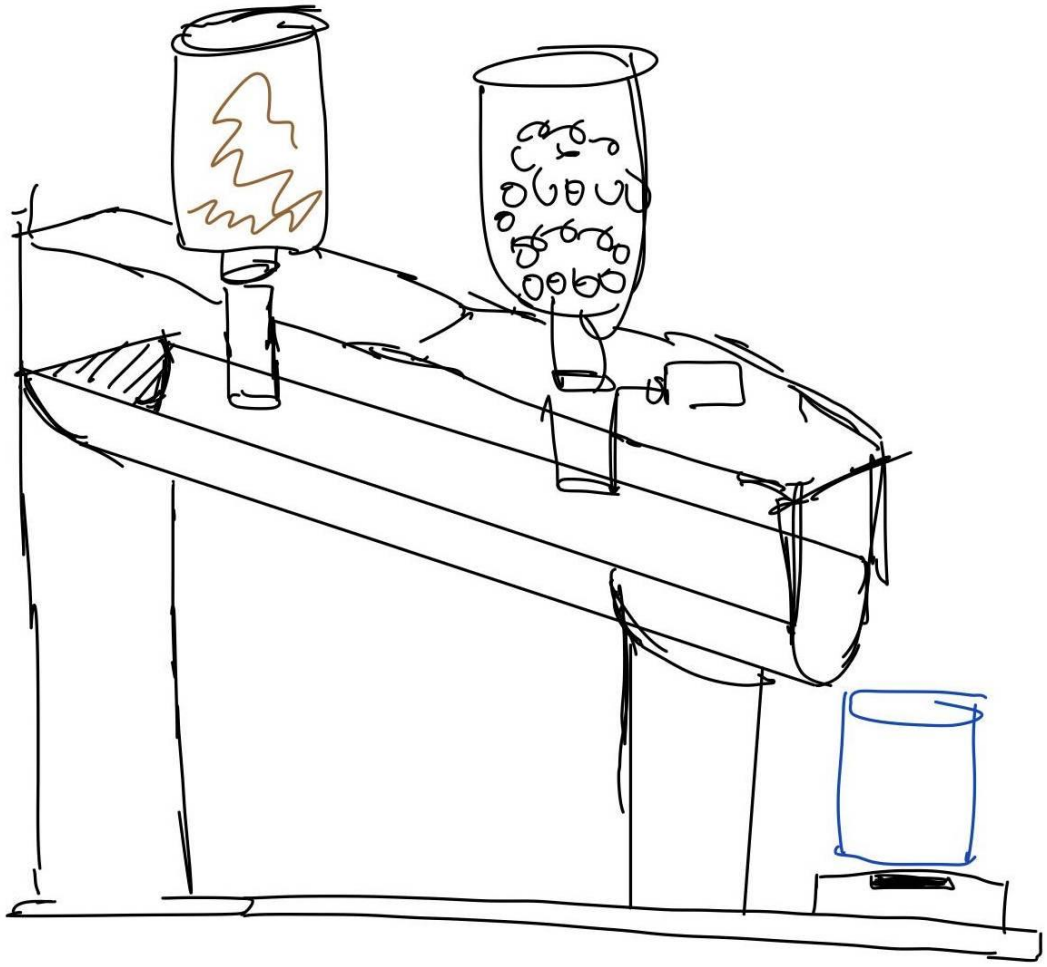
Overall Objectives

- Accurate dispensing of ingredients to create best drink possible every time
- Allow wide permutation of drinks and ingredients
- Easy to use interface that requires little technological literacy

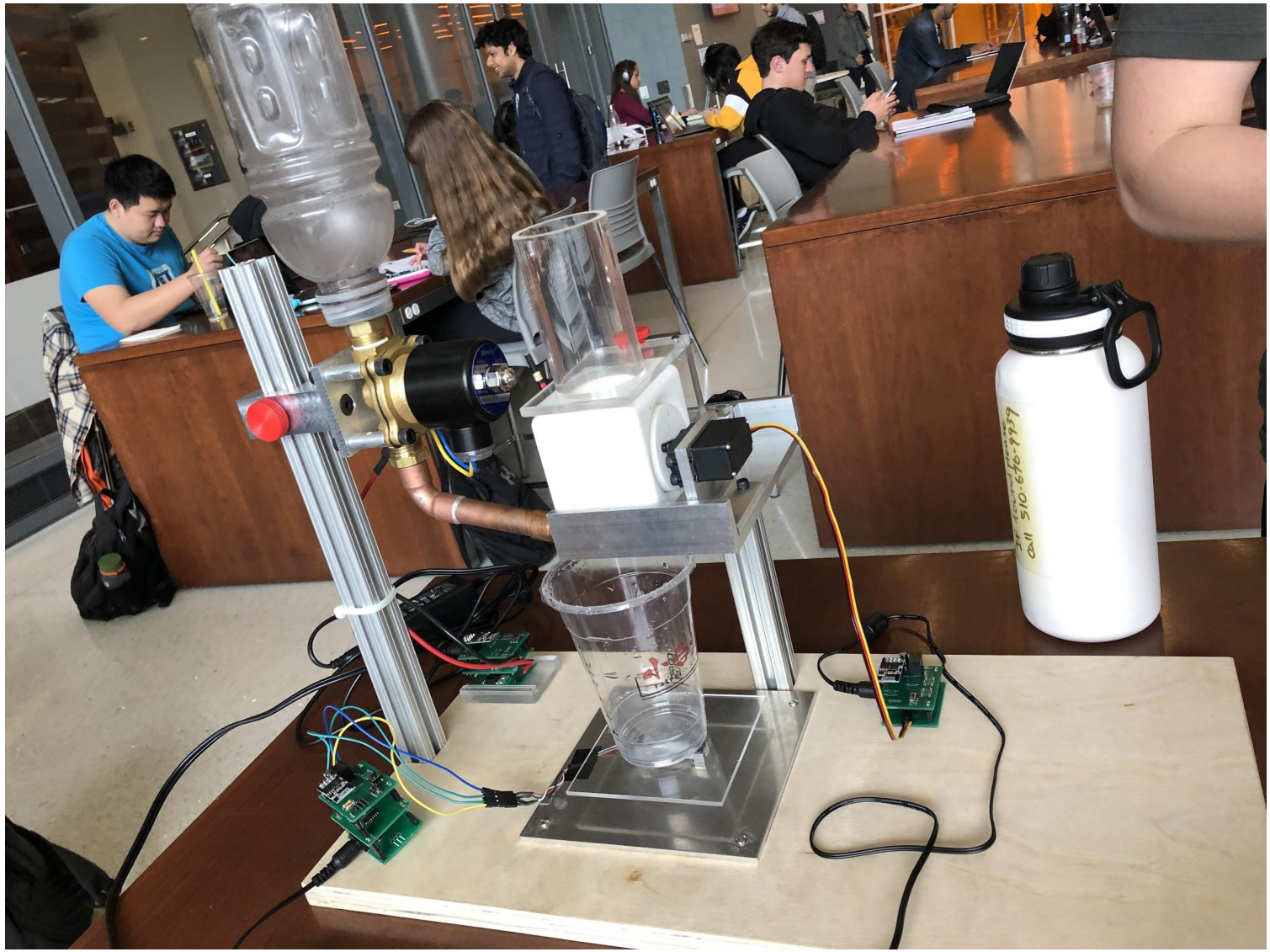
Concrete Objectives

- Have at least 2 dispensers
  - milk tea (liquid)
  - tapioca pearls (solid)
- Dispense a user-specified amount of milk tea
  - less than ±10% error in mass
- Web interface to control the amount of liquids/solids dispensed

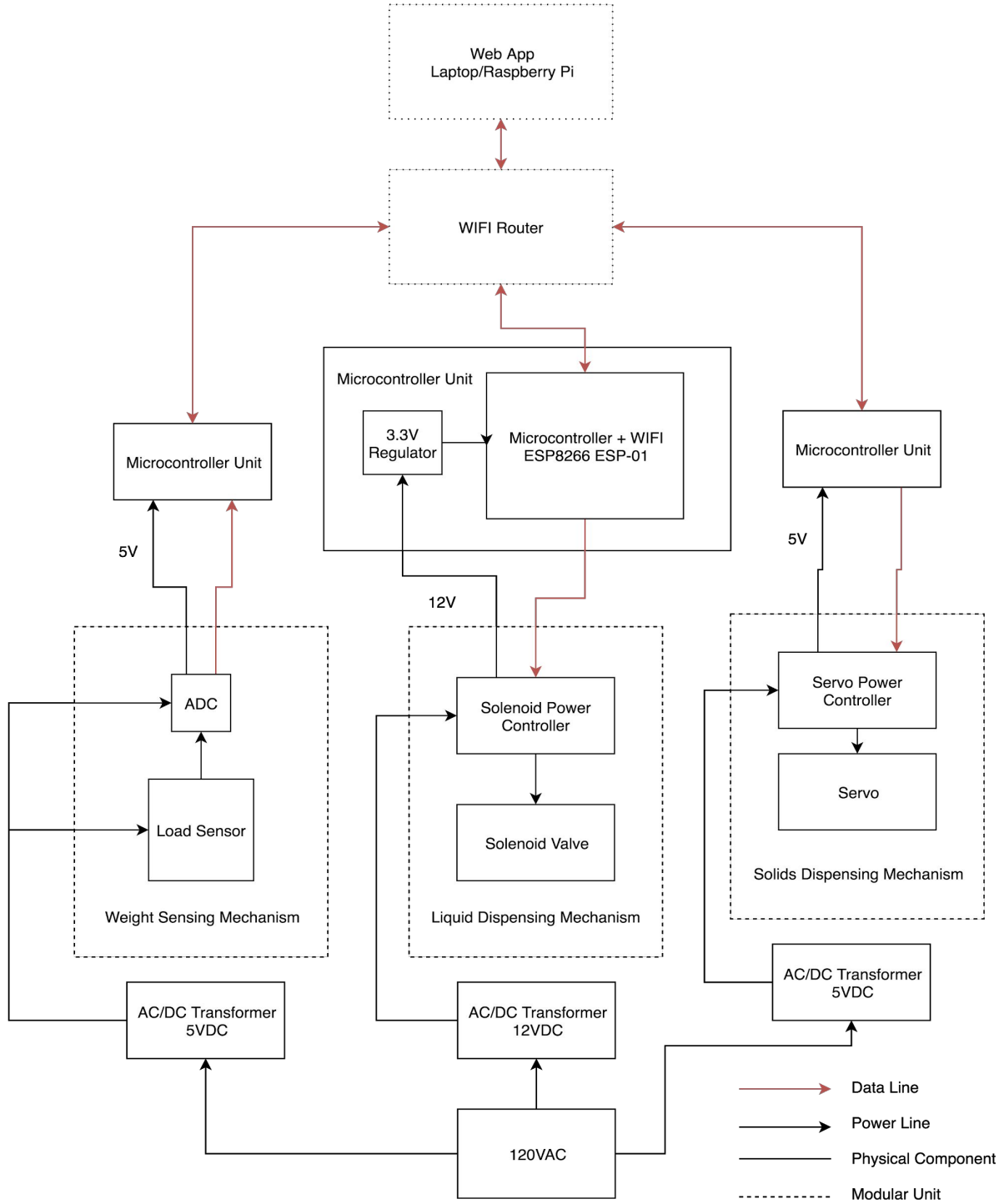
Original Physical Design

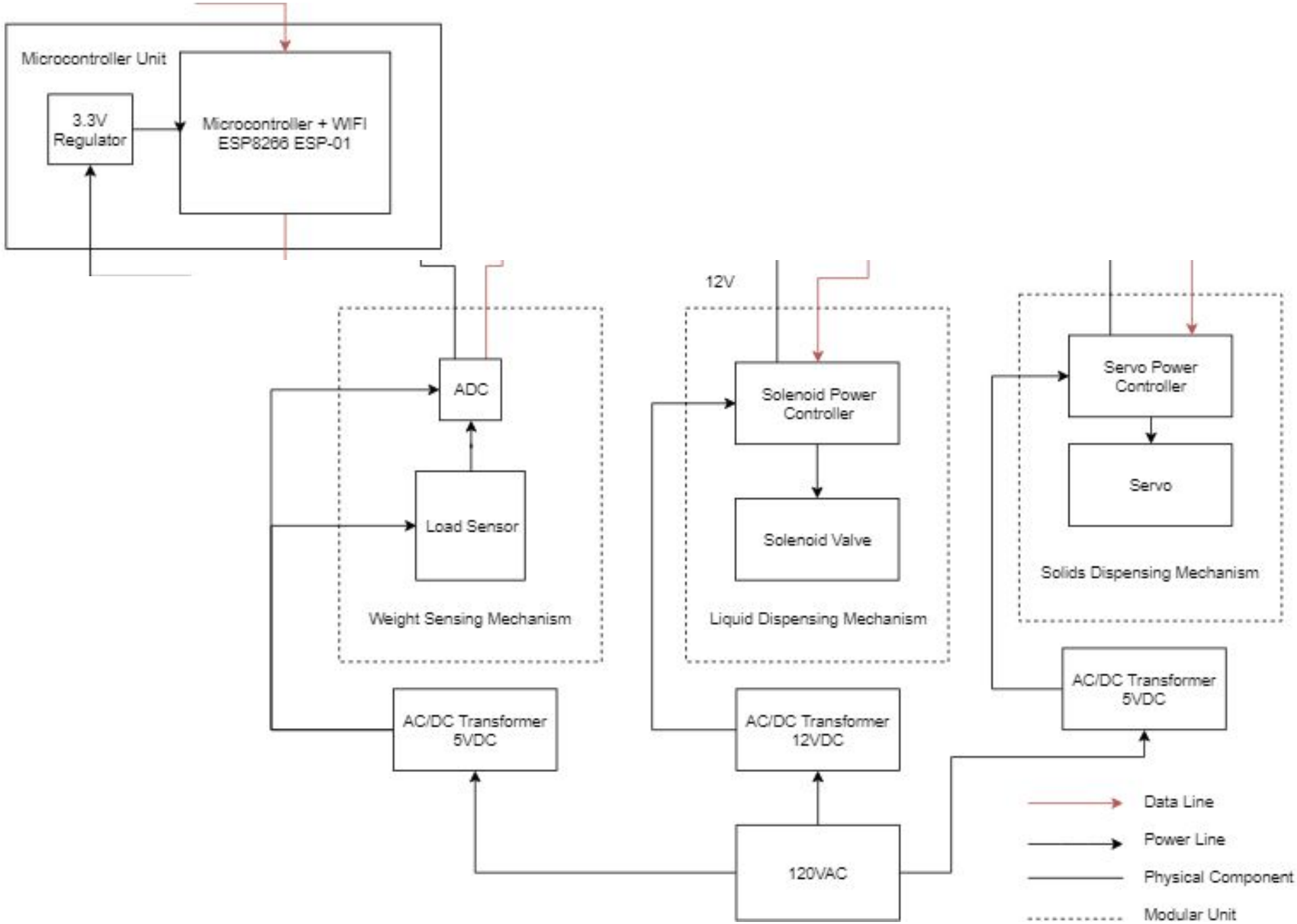


The machine



Block Diagram




Microcontroller Unit
3.3V Regulator
Microcontroller + WIFI ESP8266 ESP-01
12V
ADC
Load Sensor
Weight Sensing Mechanism
Solenoid Power Controller
Solenoid Valve
Liquid Dispensing Mechanism
Servo Power Controller
Servo
Solids Dispensing Mechanism
AC/DC Transformer 5VDC
AC/DC Transformer 12VDC
AC/DC Transformer 5VDC
120VAC
Data Line
Power Line
Physical Component
Modular Unit

Modular Design

Standalone design of each module allows customer (shop owner) to

- pick and choose whatever combination of dispensers

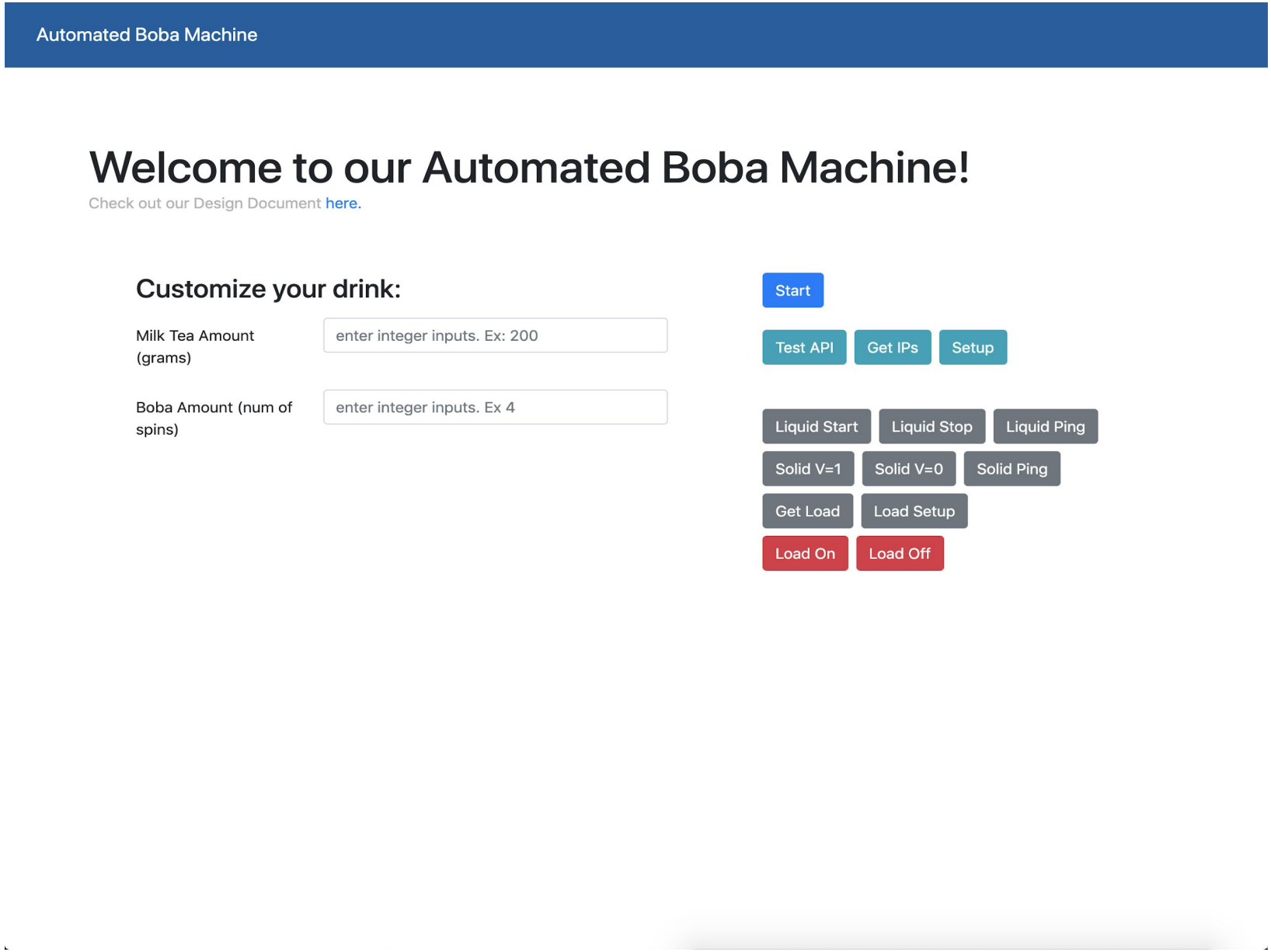
Benefits

- Accommodates wide permutation of drinks
- Lower cost in long run

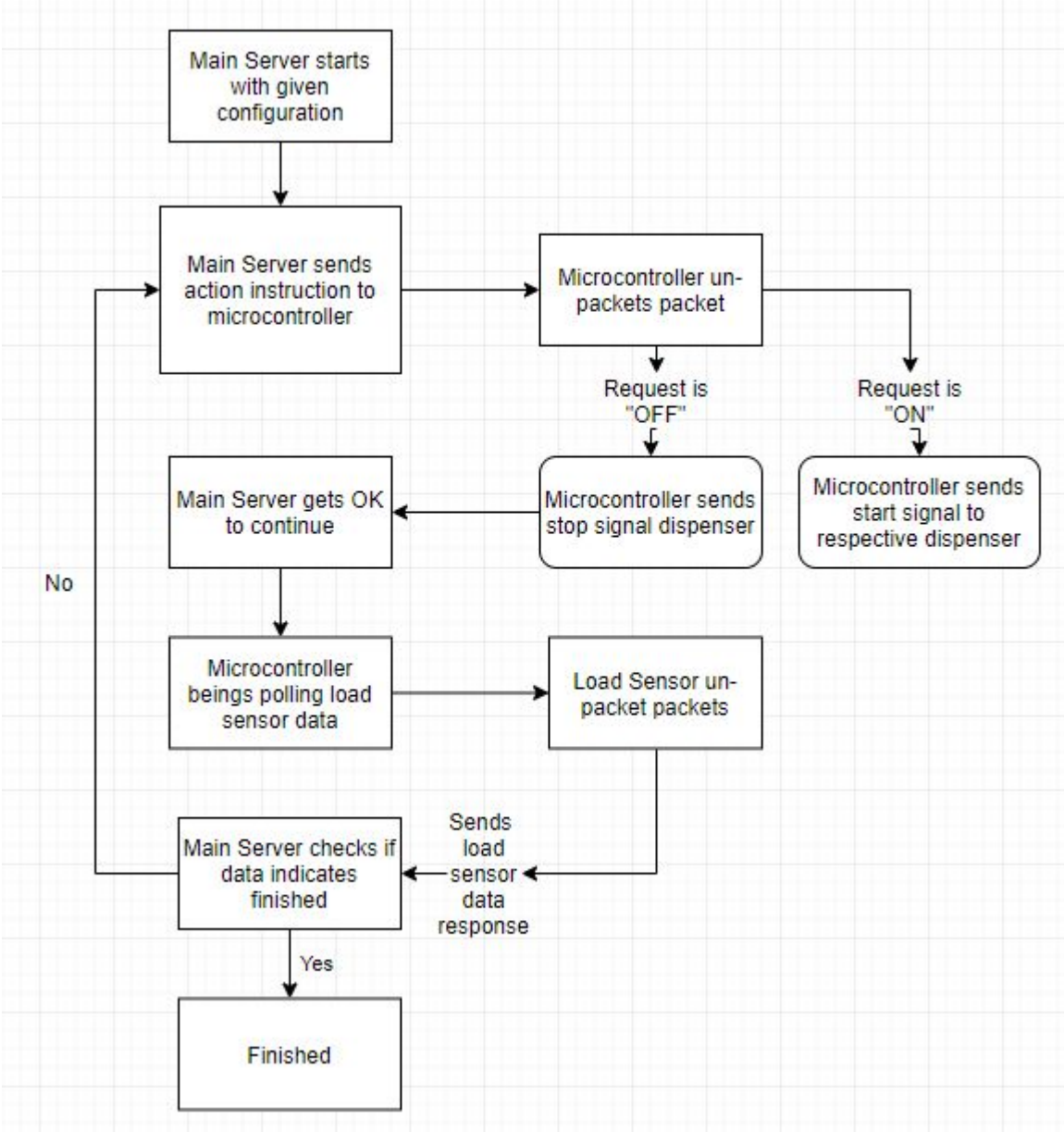
Modular Design

- Wireless
  - Dispensers placed wherever convenient.
  - No need to run wires.
- Over-the-air software updates
  - Updating/Adding features
    - Better dispensing efficiency
  - Same software for all microcontrollers
  - Easier for shop owner

Web Interface



Software Logic

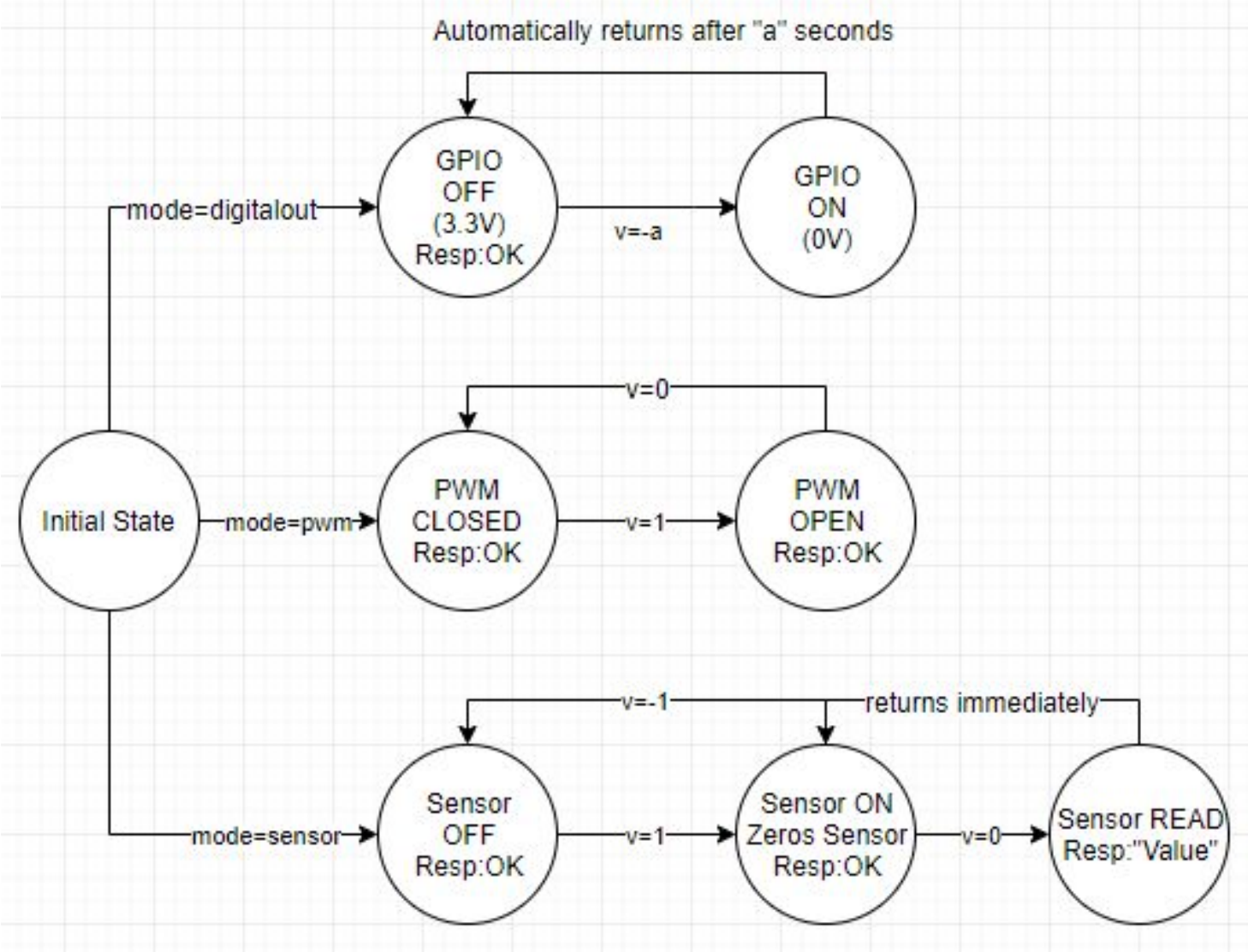


Other Software details

- HTTP Requests
  - Latency 100ms Round trip w/o DNS or SSL
- Automatically searches for modules & configures them
- Proportional control on liquid dispensing
  - based on load & desire load
- Safety Guards
  - Stops entire process whenever one of the Modules dies

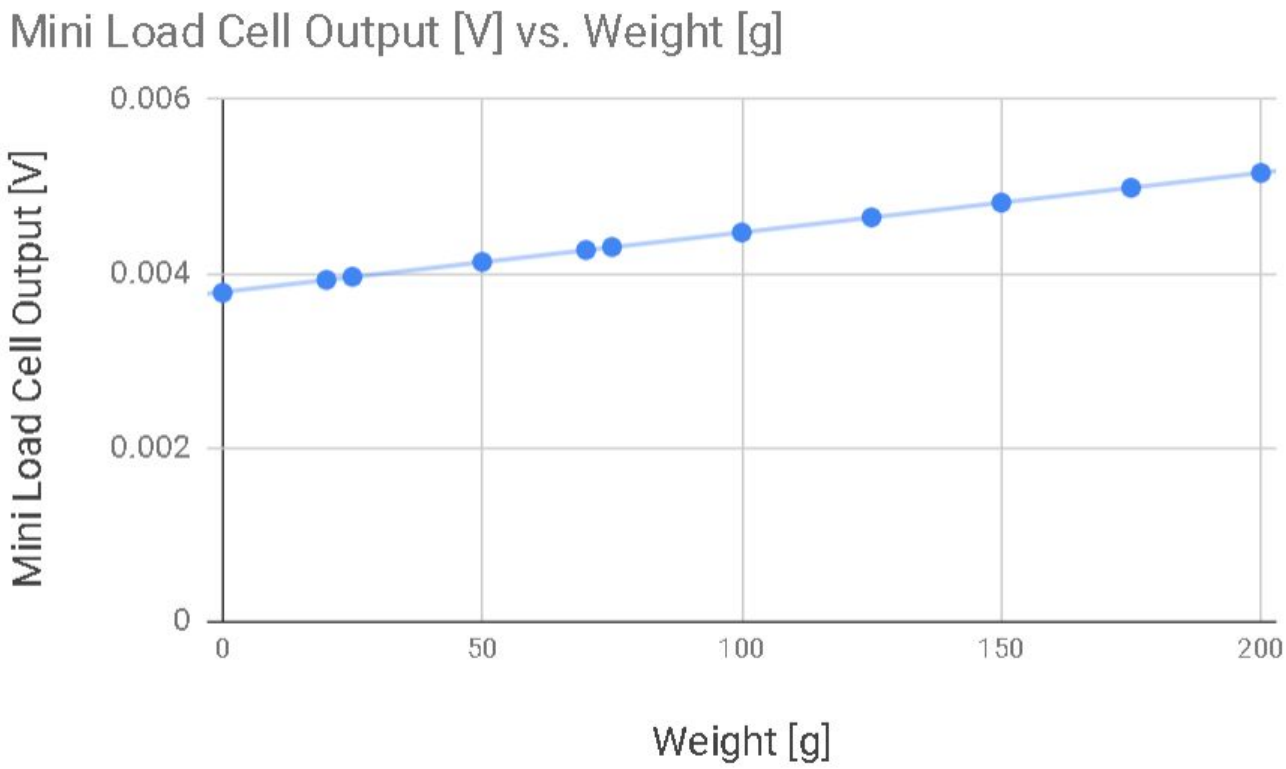
Microcontroller

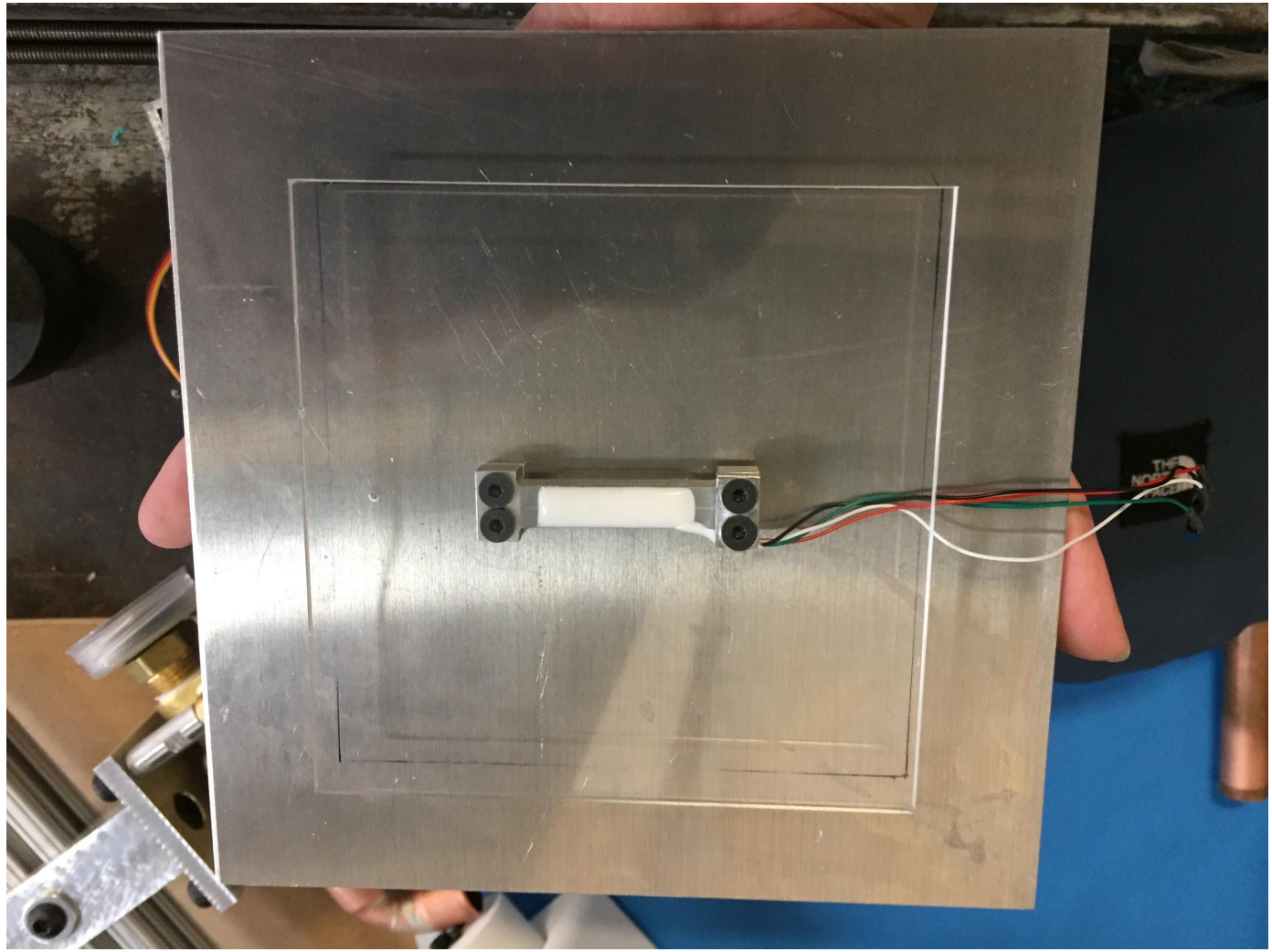
- ESP8266-01 Module
  - Only 2 GPIOs
  - Step down to 3.3V via TSR1-2433
- MicroPython Firmware
  - WebREPL interface
  - Eliminated USB serial programming


Automatically returns after "a" seconds
GPIO
OFF
(3.3V)
Resp:OK
mode=digitalout
v=-a
GPIO
ON
(0V)
v=0
Initial State
mode=pwm
PWM
CLOSED
Resp:OK
v=1
PWM
OPEN
Resp:OK
v=-1
returns immediately
Sensor
OFF
Resp:OK
mode=sensor
v=1
Sensor ON
Zeros Sensor
Resp:OK
v=0
Sensor READ
Resp:"Value"

Weight Sensing - Load Cell

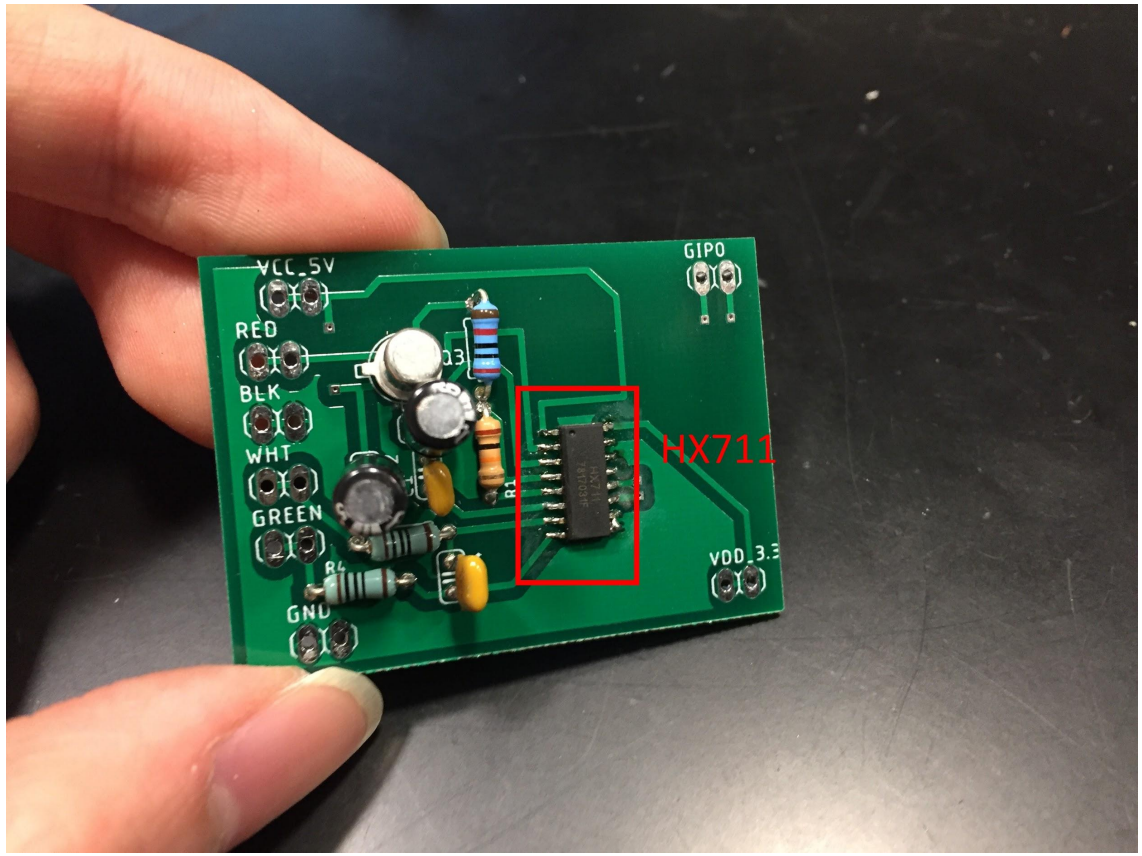
- Accurate
- Outputs a tiny voltage increasing with weight





Weight Sensing - Signal Processing

- An HX711 chip amplifies its input, then converts it to a digital value



Liquid Dispensing Mechanism

Objectives:

- Dispense liquid with +/- 10% error in mass

Result:

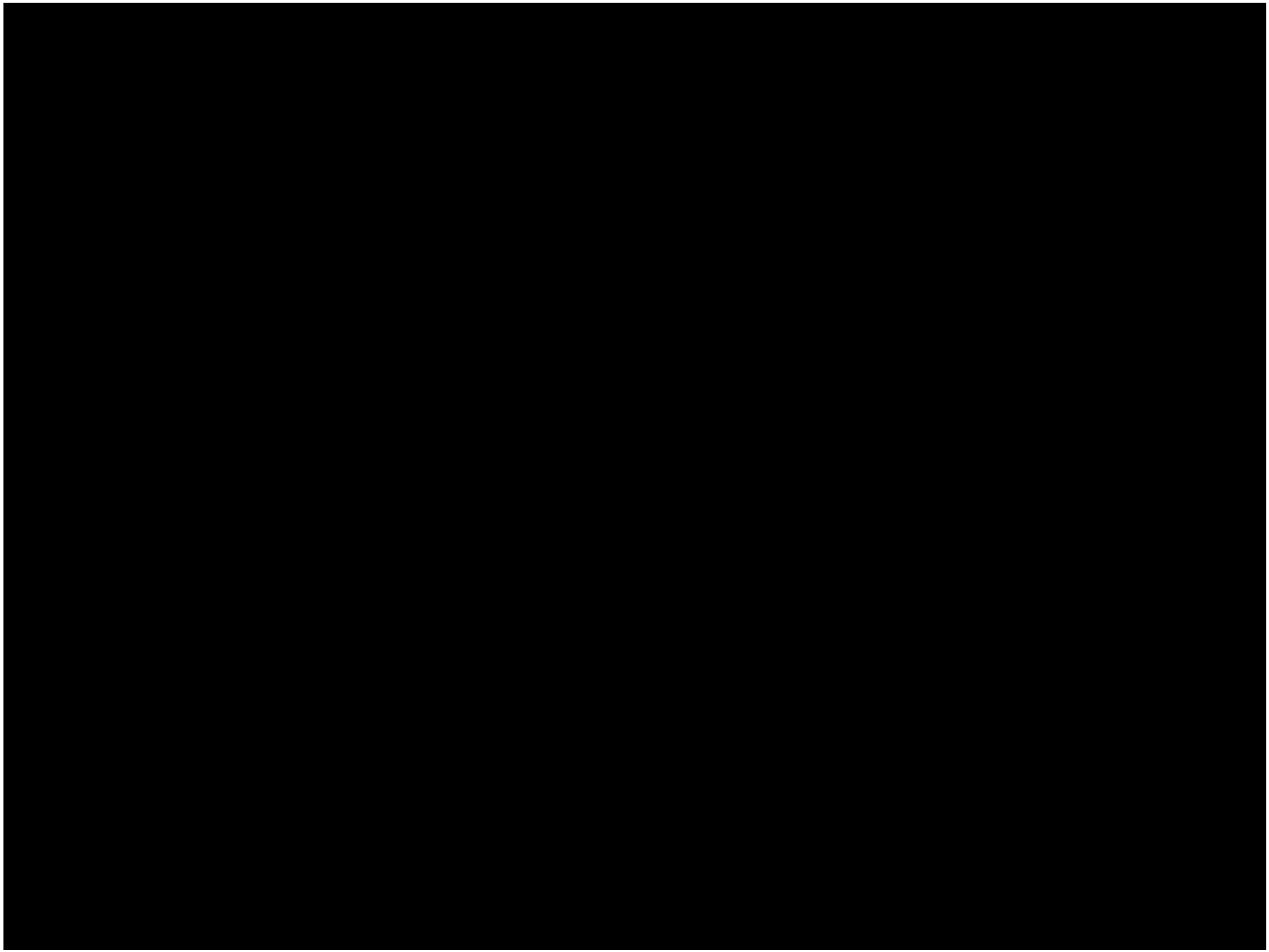
- +/- 1mL for any mass.
  - < 1% error in mass in typical scenario

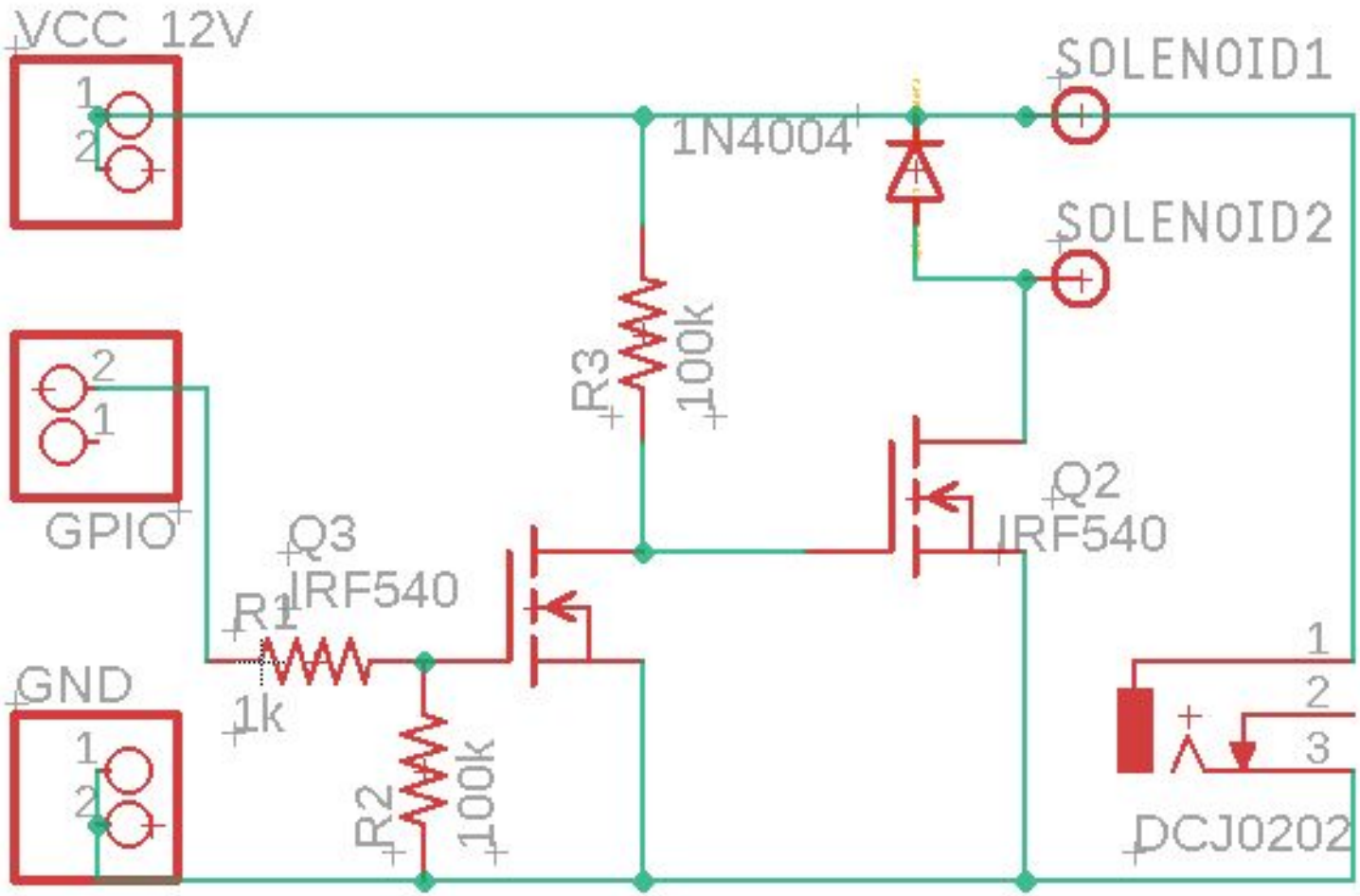
Liquid Dispensing Issues

- Original design had TIP120 NPN Darlington transistor as suggested by the datasheet.

V_{BE}	V_{CE}
0V	12V
3.3V	~4V

- $V_{CE(ON)}$ was around 4V.
  - 3A current draw of solenoid
  - Package was dissipating 12W. (Very Hot)



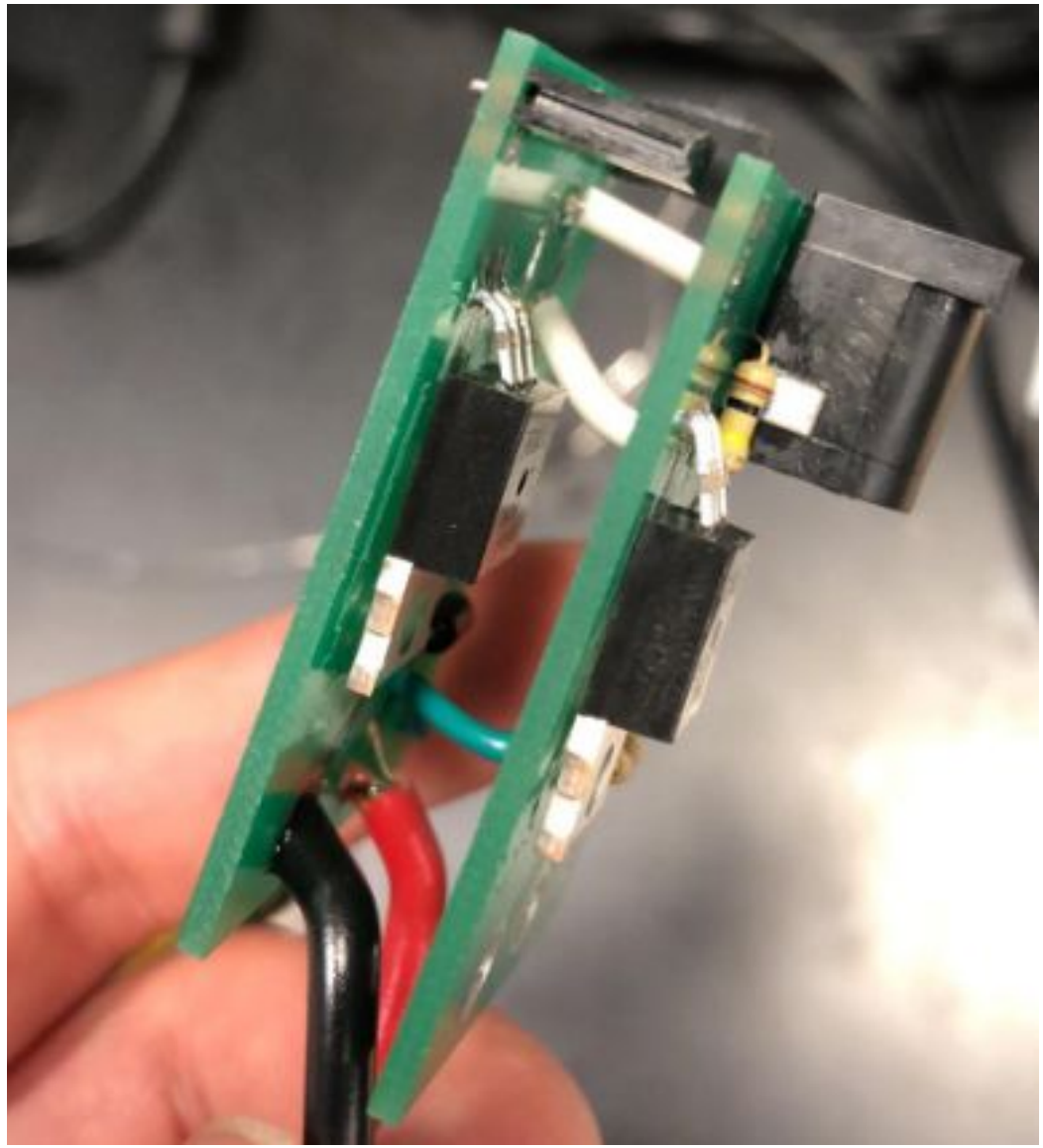

VCC 12V
1
2
SOLENOID1
1N4004
SOLENOID2
R3
100k
2
1
GPIO
Q3
IRF540
Q2
IRF540
R1
1k
GND
1
2
R2
100k
1
2
3
DCJ0202

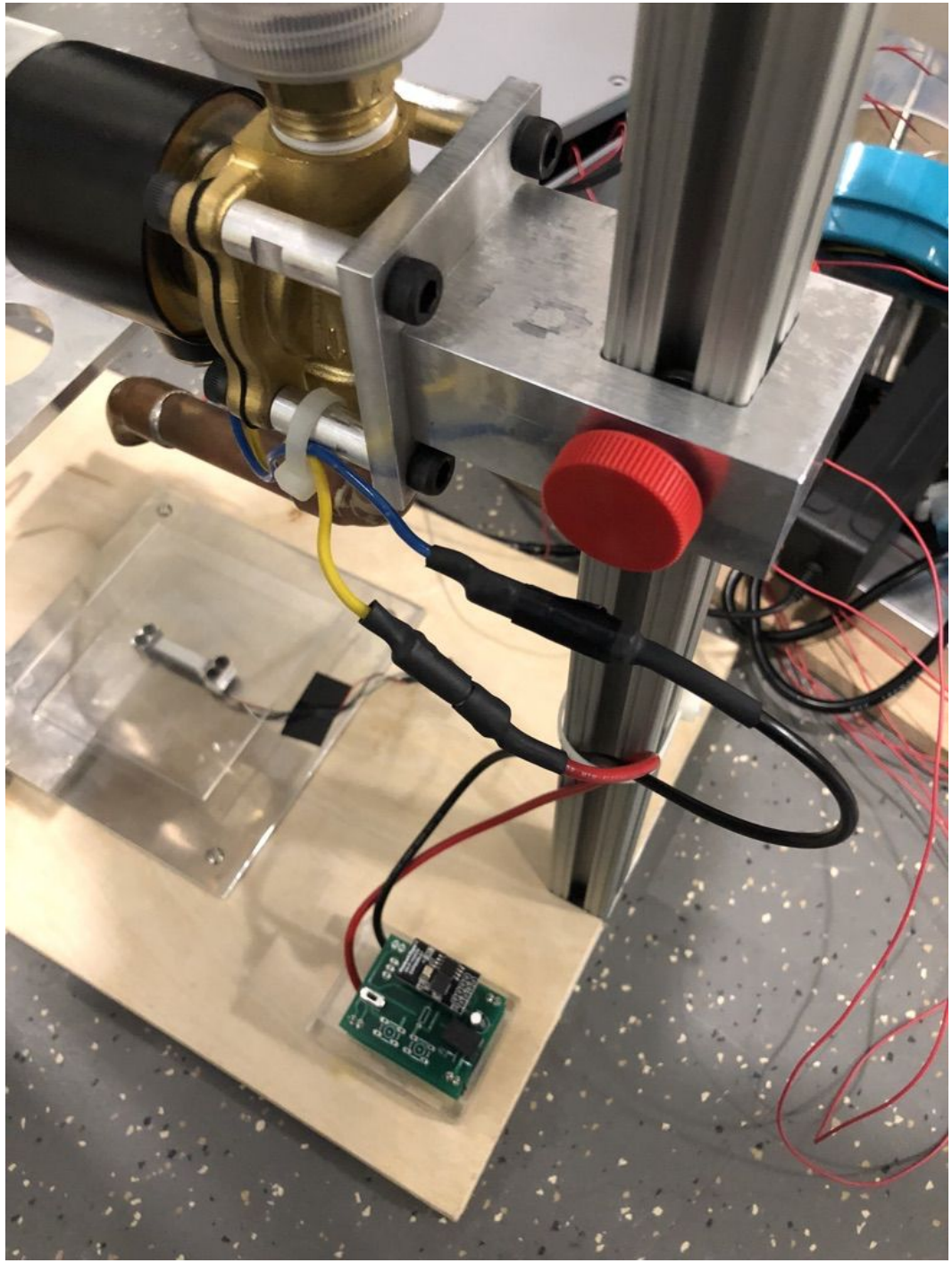
Liquid Dispensing Solutions

- Use 2 RFP30N06LE
  - 1 as gate driver.
- Resistor choice crucial to ensure staying under $V_{GS(MAX)}$ = 10V and saturation.

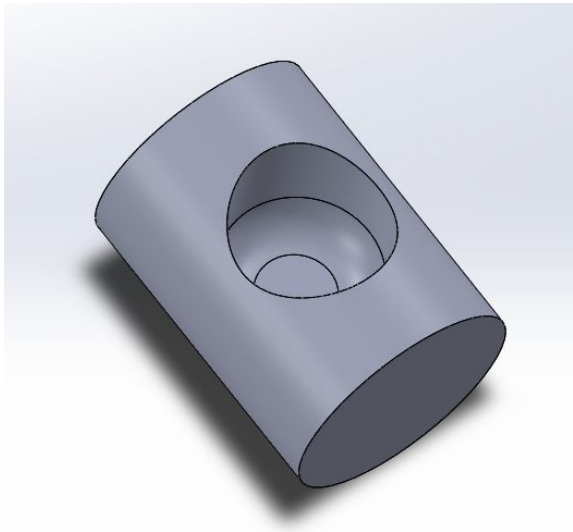
$V_{GS(Driver)}$	$V_{GS(Valve)}$	$V_{DS(Valve)}$
0V	~5.8V	~1V
3.3V	0V	12V

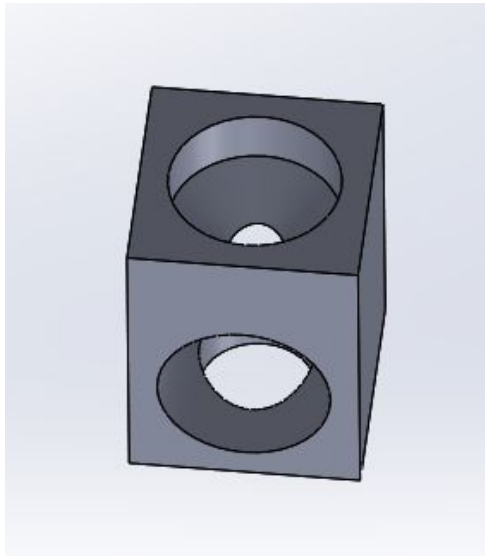
- Reasonable power dissipation of 3W.





Solid Dispensing Mechanism

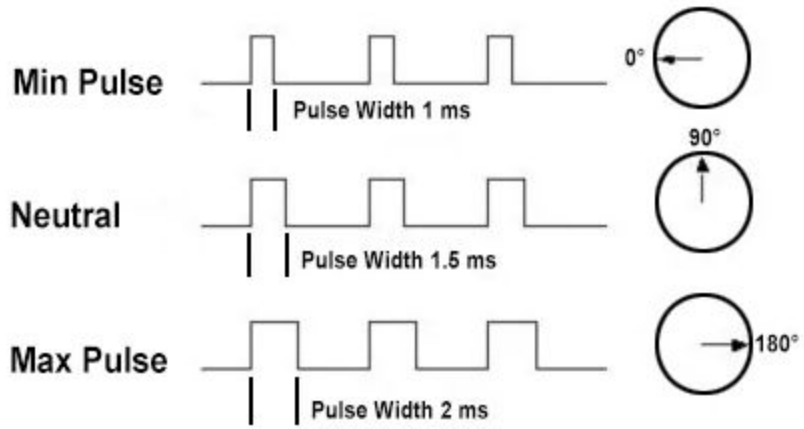




$150 later...

Solid Dispensing Mechanism

- Rotates tube with servo motor
- 3.3V logic level can control 5V servo
  - Min = 4% Duty at 50Hz
  - Max = 12% Duty at 50Hz



Solid Dispensing Issues

- Cost
- Loose tolerance
  - Liquids leak out the side
- Clumped up Boba causing dispenser to jam up
  - Micro-servo in original design destroyed
  - Upgraded to standard-size servo for more torque.

Boba Consistency….

Solid Dispensing Issues (cont.)

- Boba blocked each other laterally during dispensing
  - Stopping each other from entering rotating compartment.

Solid Dispensing Solutions

- Dispenser made using injection moulding for low cost
- Leakage prevention
  - Tighter tolerance in design
  - Seal with rubber O-rings.
  - Stronger servo motor to account for the friction.

Solid Dispensing Solutions (cont.)

- Extra liquid dispenser on top of solid dispenser to flush Boba and prevent clumping.
- Vibration mechanism to “shake up” the Boba to prevent lateral jamming.

Video

Conclusion

- Our objectives have been met.
  - Has at least two dispensers working.
  - A web interface can control amounts of liquids and solids dispensed.
  - Machine can dispense user-specified amounts of liquid and solids within ±10% error.

Thank You