Moka

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Motivation

Quick and easy way to buy fresh coffee

- Reduce lines at coffee shops
- Convenient way to obtain coffee in the workplace

Goals and Objectives

Physical Device

- Implement a reliable control system to produce fresh coffee for every user
- User able to use any cup with their RFID sticker
- Display relevant brewing information to user

Mobile App

- User friendly interface
- Eliminates need for physical payment method

Requirements & Specifications

Specification	Value
Size	25” x 25” x 30”
System Input Voltage	120V
RFID Frequency	13.56 Mhz
App Compatible Devices	iOS, Android
Optimal Brewing Temperature	92°C

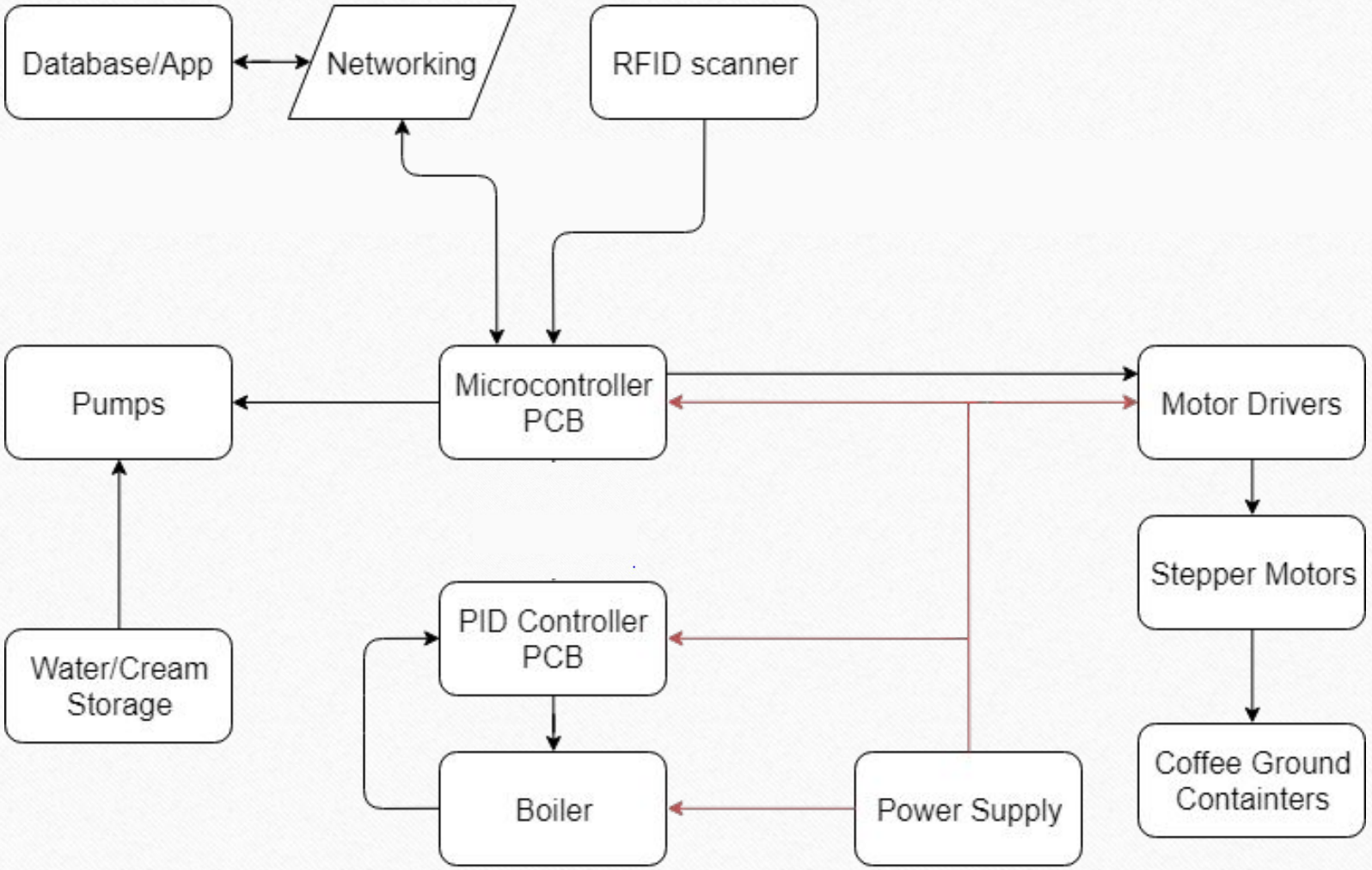
Potential Microcontrollers

Specifications	ATSAMW25	ATmega32P	Particle Photon
Processor	48MHz – SAMD21 Cortex-M0+ 32bit ARM	20MHz - L106 32-bit RISC	120MHz - STM32F205 core
Memory	256 KiB Programmable Flash 32 KiB SRAM 1MiB Flash Memory	32 KiB Programmable Flash 1 KiB EEPROM 2 KiB SRAM	128 KiB RAM 1MiB Flash Memory
Communication	SPI, I^2C, UART 802.11b/g/n	SPI, I^2C, UART	SPI, I^2C, I^2S, UART 802.11b/g/n
Internal Wifi Module	Yes	No	Yes
Cost	~$12	~$2	$10

ATSAMW25

- Low power Wi-Fi module composed of three blocks
  - SAMD21 Cortex-M0+ 32bit low power ARM MCU
  - WINC1500 low power 2.4GHz IEEE® 802.11 b/g/n Wi-Fi
  - ECC508 CryptoAuthentication
    - Supports SHA-256

High Level System Block Diagram



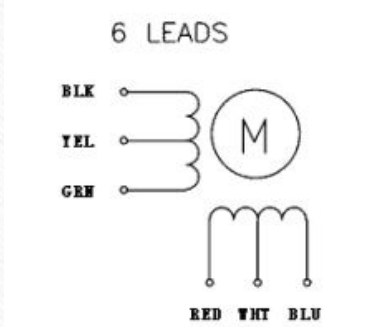
Coffee Ground Dispenser

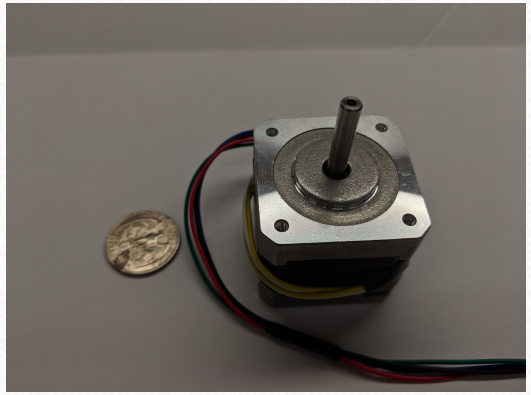
- Objective
  - Accurately dispense one to two tablespoons of coffee grounds
- Automate Zevro coffee ground dispenser
  - Internal component measures out the grounds into 1 tbsp. servings dispensed with each pull of the handle
  - Use a stepper motor to automate this process

Stepper Motor

- Soyo 12V 0.4A 36oz-in Unipolar Stepper Motor
  - 6 Leads, but we will only be using 4

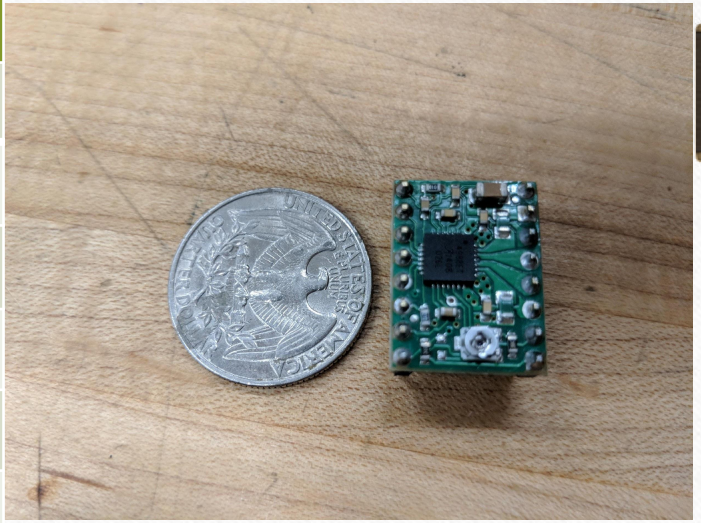
Specifications	Soyo 12v 0.4A 36oz-in Unipolar Stepper Motor	Soyo 12V 0.6A 84oz-in Unipolar Stepper Motor
Rated Voltage	12V	12V
Rated Current	0.4A	0.6A
Step Angle	1.8º	1.8º
Torque	36oz-in	84oz-in
Precision(Full Step)	±5%	±5%
Cost	$15.35(Donated)	$35.99



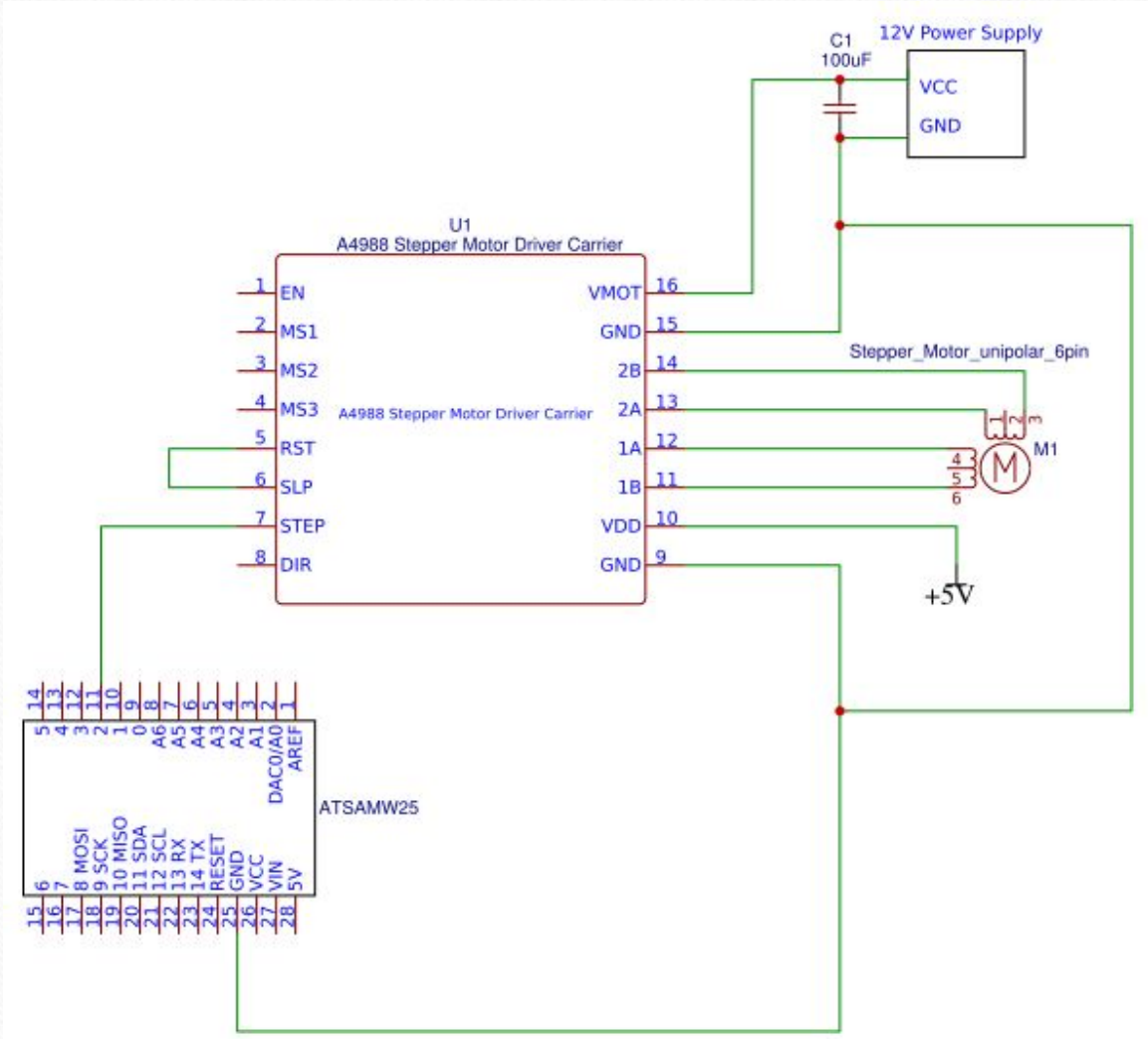


Stepper Motor Driver

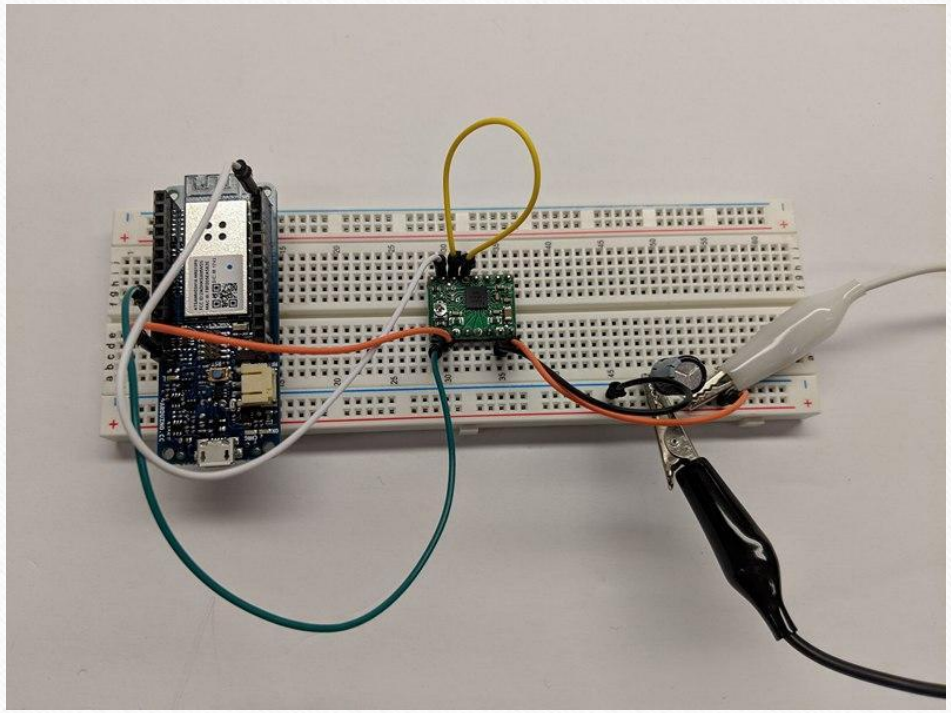
Specifications	A4988	DRV8825
Operating Voltage	8-35 V	8.2-45V
Continuous current per phase	1 A	1.5 A
Maximum current per phase	2 A	2.5 A
Microstep Resolutions	Full, ½, ⅛, 1/16	Full, ½, ⅛, 1/16, 1/32
Logic Voltage Range	3-5.5 V	2.5-5.25 V
Cost	$5.99(Donated)	$8.39

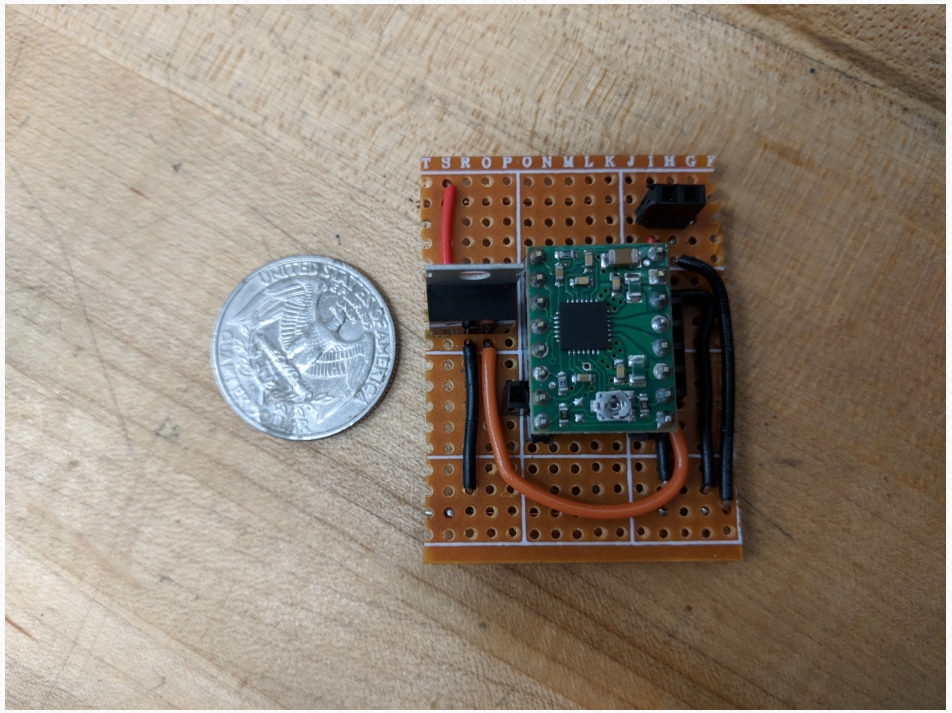


Coffee Dispenser Wiring

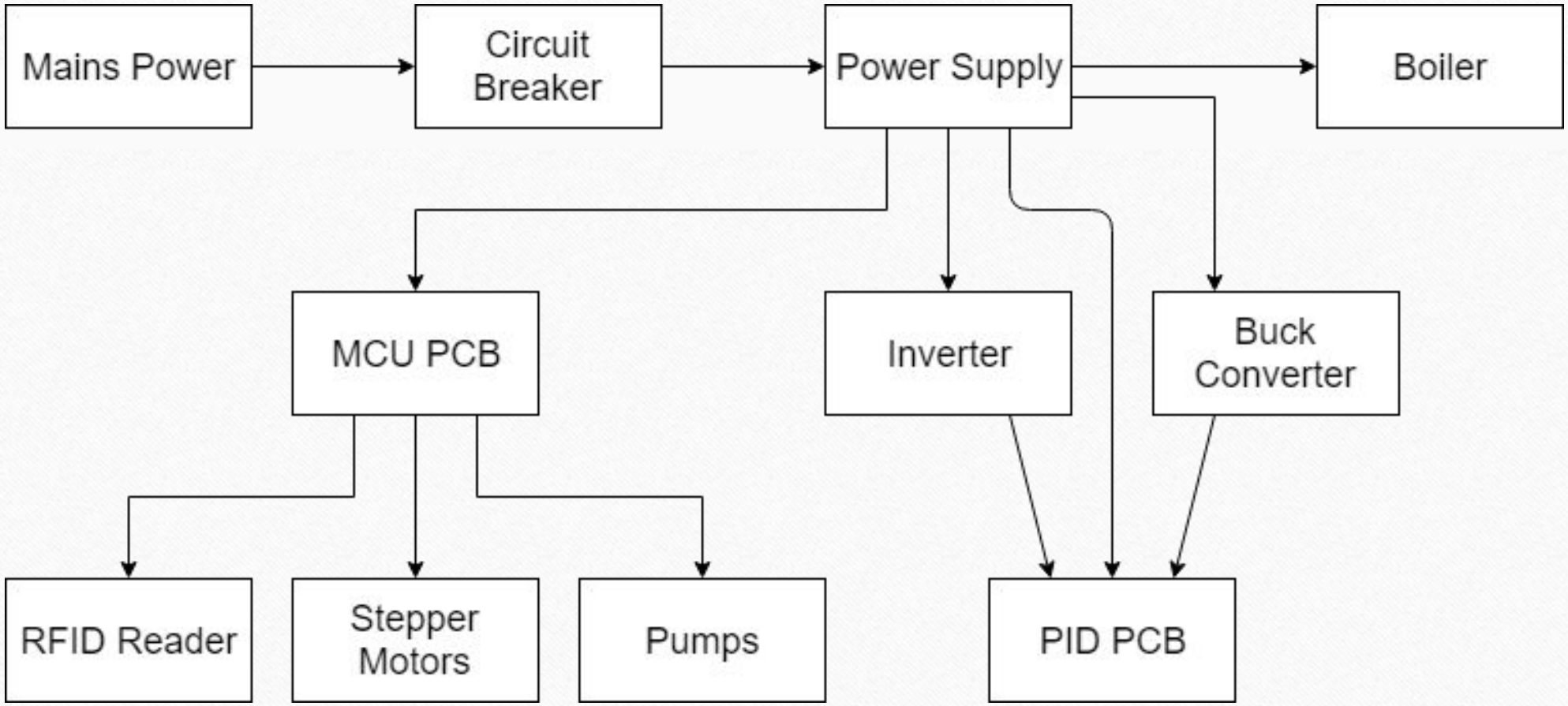


Motor Driver Prototypes



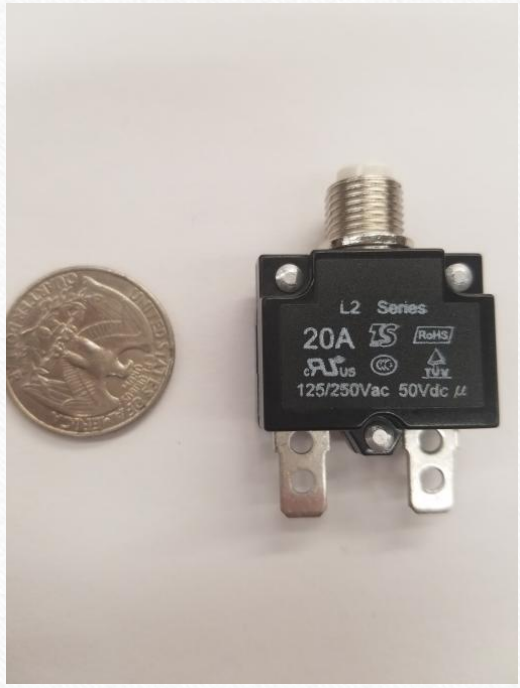


Power Systems Diagram



Overcurrent Protection

Glass Fuses	Circuit Breakers
One-time use	Multiple uses
Low current applications	Able to use on higher currents
$7	$10



Power Supply

Specifications	SUPERNIGHT 12V 30A Switching Power Supply	MK320s012
Output Watts	360 W	300 W
Output Volts	12 V	12 V
Output Current	30 A	25 A
Input Voltage Range	90 – 264 VAC	90-264 VAC
Frequency Range	47-63 Hz	47-63 Hz
Operating Temperature	-10 to 60°C	-10 to +60 C
Size	7.8 x 4 x 2 “	7” x 4” x 2”
Cost	$20.99	$83.11

DC-to-DC Converter

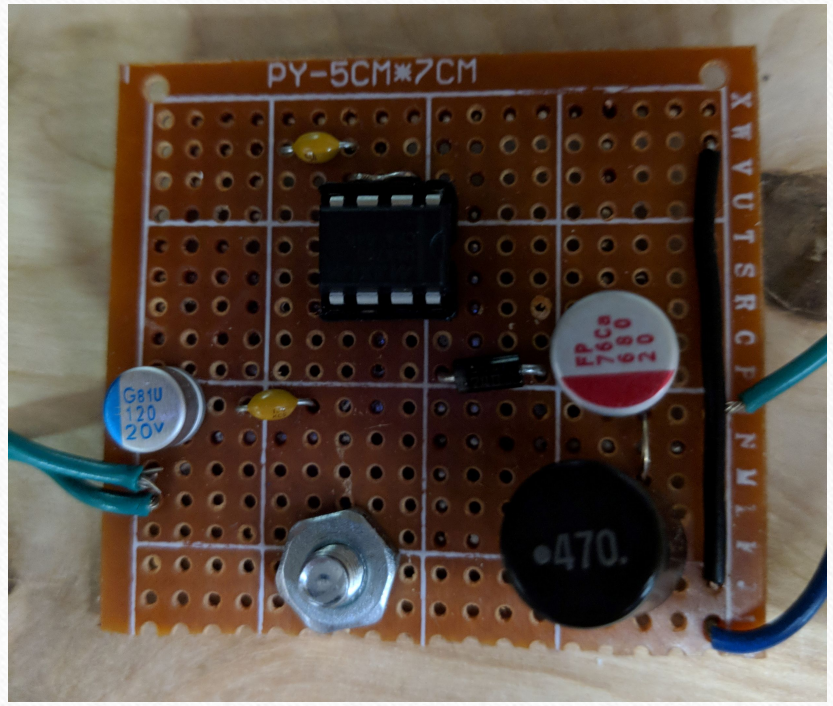
- Some peripherals require 5V to operate.
- Need to lower the voltage output from the 12V power supply.
- Dissipates less heat, draws less power, and overall more efficient than a linear voltage regulator.

Inverter

The MAX 765 is a highly efficient inverting switching regulator.

It outputs -12 V with an input of 5 V

Delivers up to 1.5 W, which is used to power the op-amps.



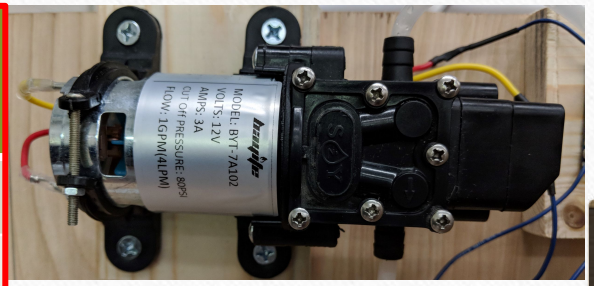
Pump

- Needed a way to deliver a precise amount of water to the boiler, and cream to a customer's coffee.
- Given an input from the microcontroller the pump will dispense the correct amount of liquid.
- Food grade material for tubing.

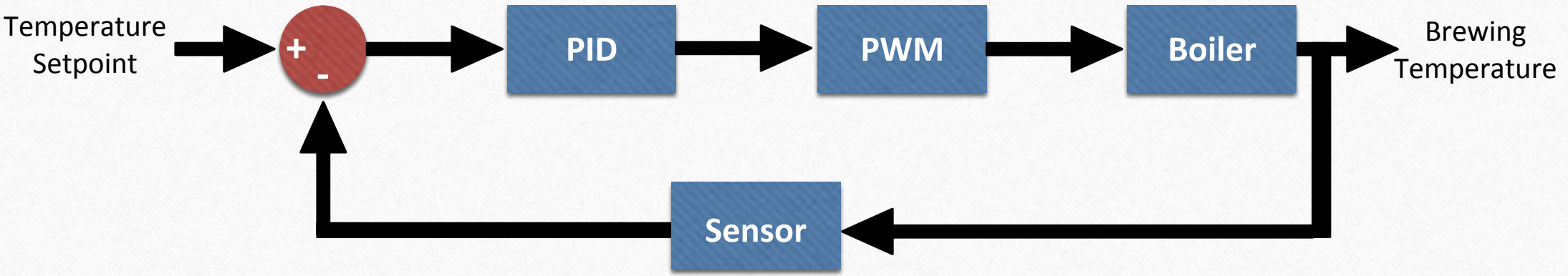
Pump Choices

- Two different pumps chosen, one for water and the other for cream.

Specifications	Gikfun 12V DC Dosing Pump Peristaltic	12V Large Flow Rate DC Motor Peristaltic Vacuum Pump	bayite 12V DC Fresh Water Pressure Diaphragm Pump
Operating Voltage	12 V	12 V	12 V
Flow Rate	0 - 100 ml/min	0 - 400 ml/min	0 - 4 L/min
Tubing Material	Silicone	Silicone	Silicone
Current Draw	200 mA	1.4 A	3 A
Weight	0.07 Kg	0.28 Kg	0.65 Kg
Cost	$12.98	$30.90	$21.99



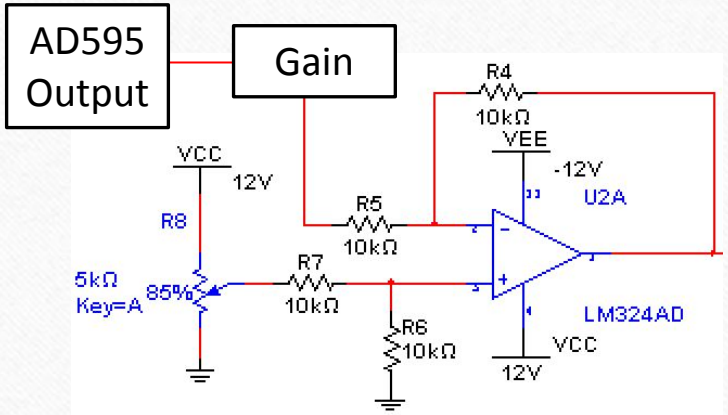
Control Loop Block Diagram



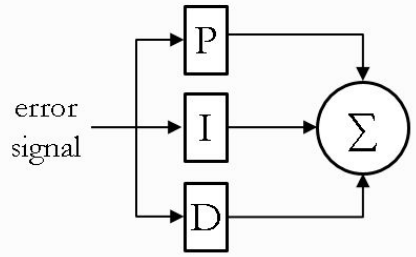
Inputs

- The set temperature is a potentiometer voltage divider.
- Measured temperature uses AD595 instrumentation amplifier and k-type thermocouple with fiberglass braid. A non-inverting amplifier is used for gain.

Thermocouple Temperature (°C)	Type K Voltage (mV)	AD595 Output (mV)
25	1.000	250
30	1.203	300
40	1.611	401
50	2.022	503
60	2.436	605
80	3.266	810
100	4.095	1015



PID



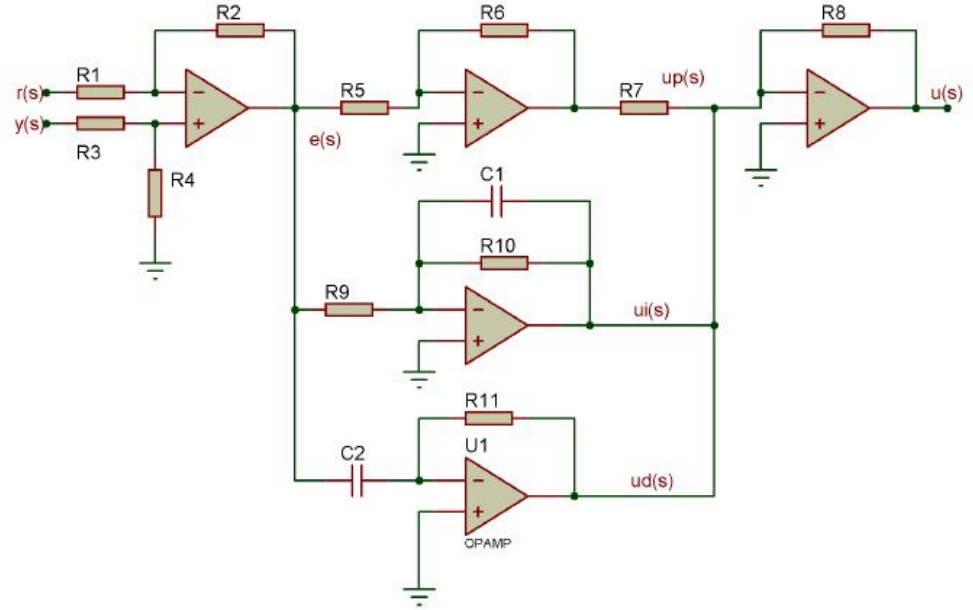
$$u(t) = K_\mathrm{p} e(t) + K_\mathrm{i} \int_0^t e(t')\,dt' + K_\mathrm{d} \frac{de(t)}{dt}$$

P: $\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_{in}}$

I: $\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_{in}}\left(\frac{1}{R_f C s+1}\right) = -\frac{1}{sCR_{in}}$

D: $\frac{V_{out}}{V_{in}} = -\frac{sCR_{in}}{R_f C s+1}$

Sum: $Vout = -R_f\left(\frac{V_{outP}}{R_P} + \frac{V_{outI}}{R_I} + \frac{V_{outD}}{R_D}\right)$



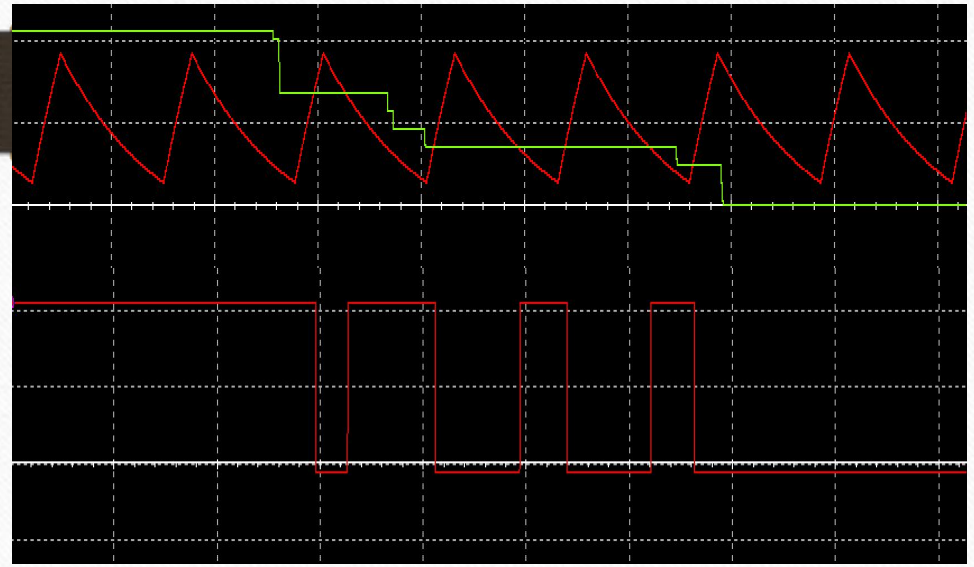
Op-Amps Considered:

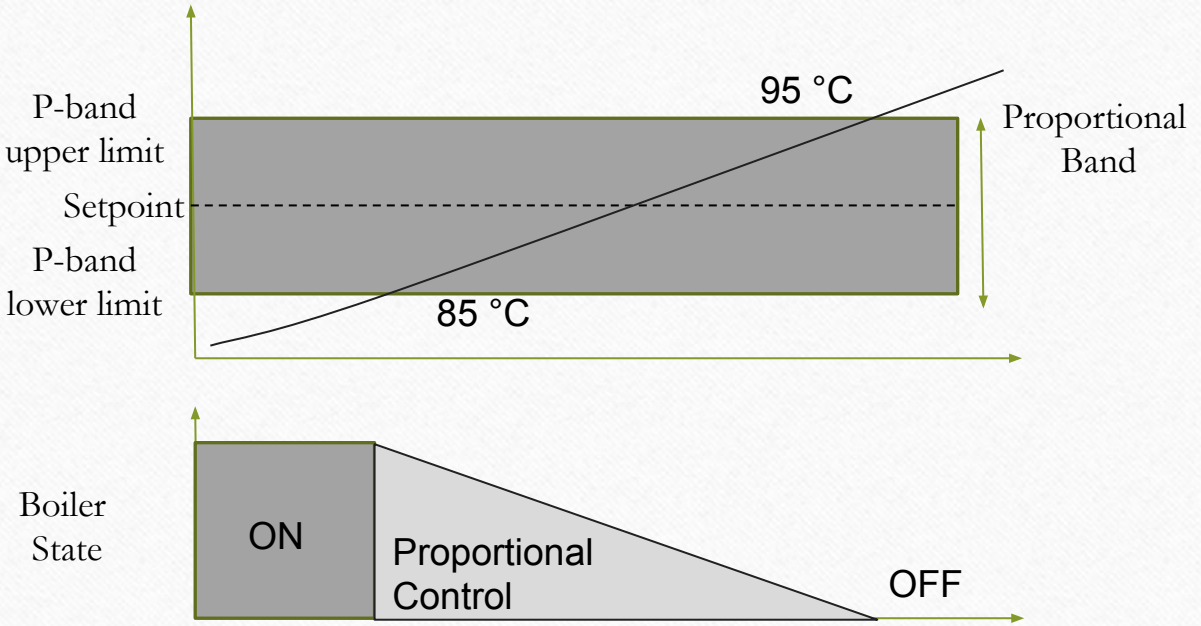
-NE 5532: 5 nV/√Hz, 22 V/µs, $1.01

-OPA 350: Single Supply, 5 nV/√Hz, 22 V/µs, $1.38

-LM 2902: quad op-amp, wide power supply range, good for high temperatures, $0.45

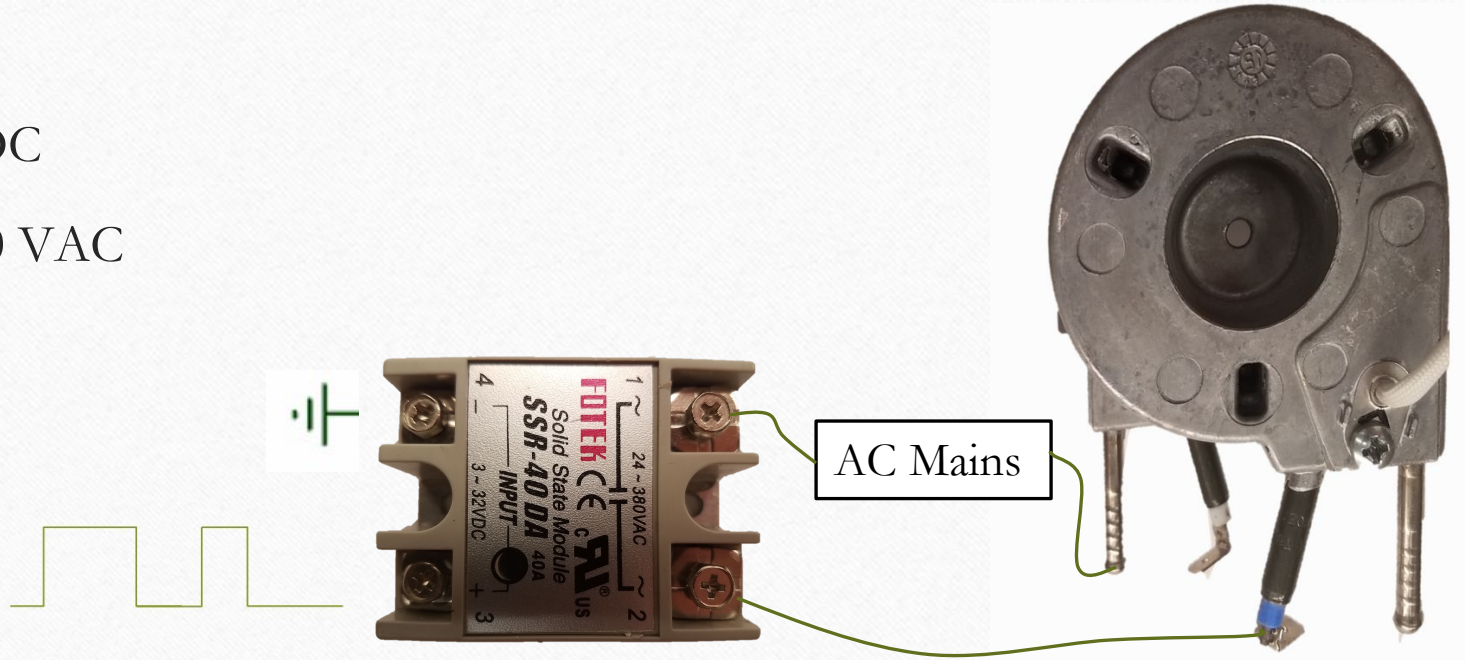
Generating a PWM



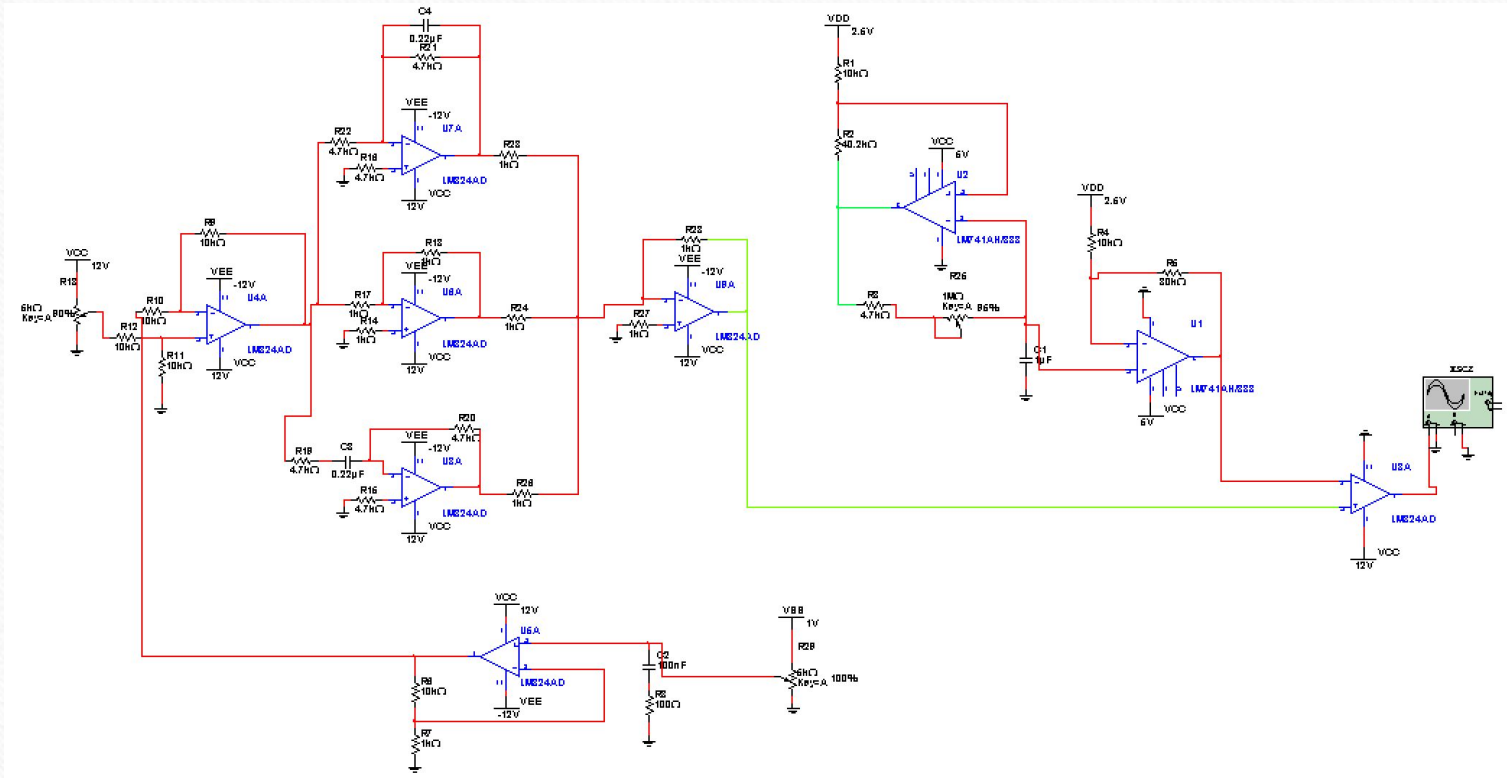


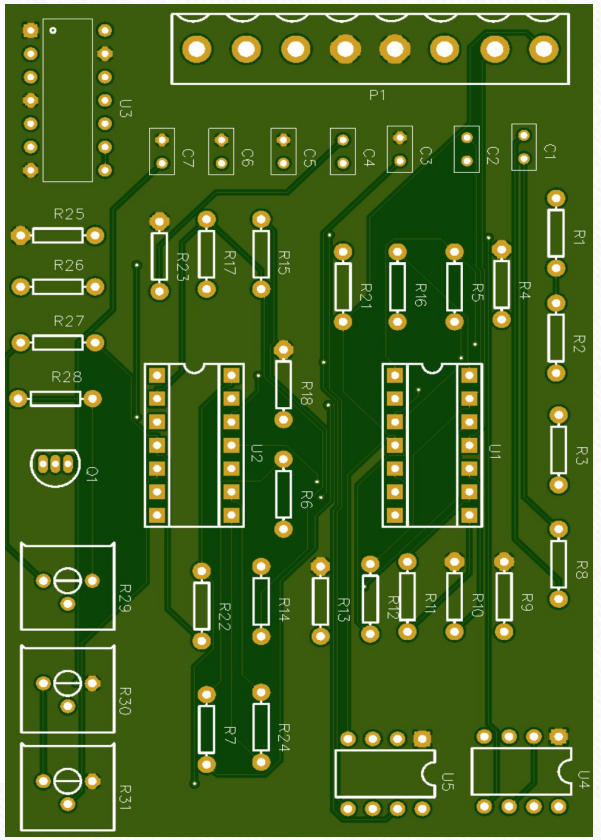
Boiler

- SSR-40 DA
  - Input Voltage: 3-32 VDC
  - Output Voltage: 24-380 VAC
  - Output Current: 40 A
- Saeco J-Boiler
  - 120 V, 1500 W

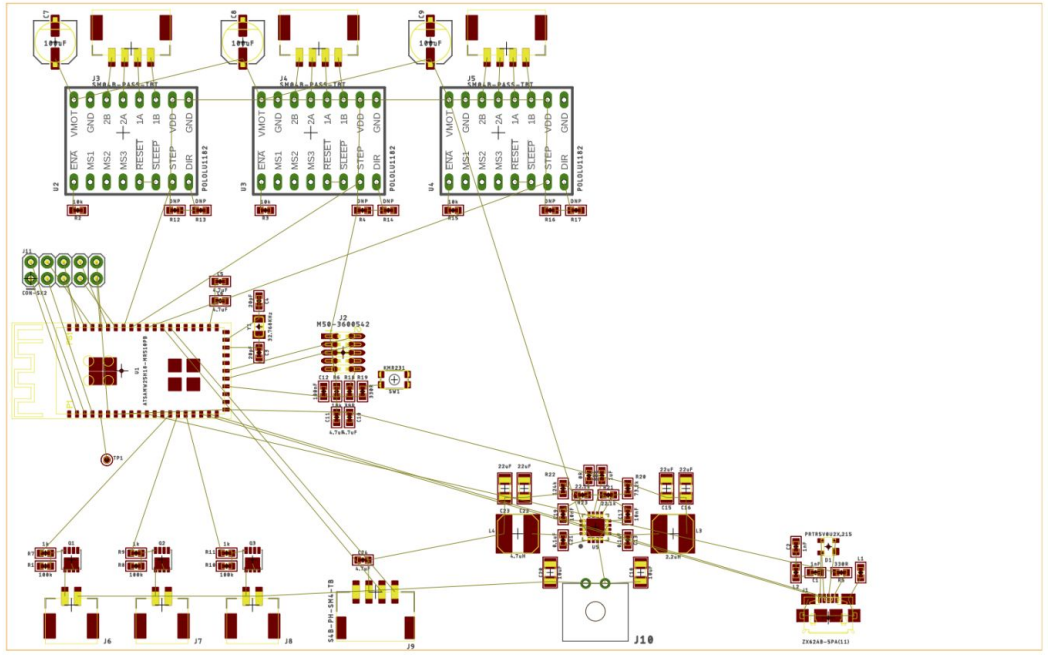


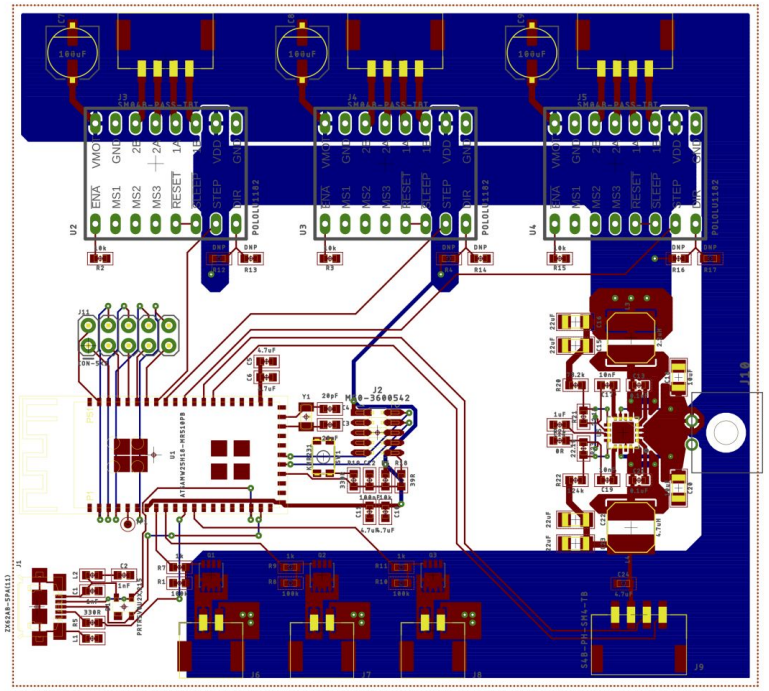
Full Schematic & PCB



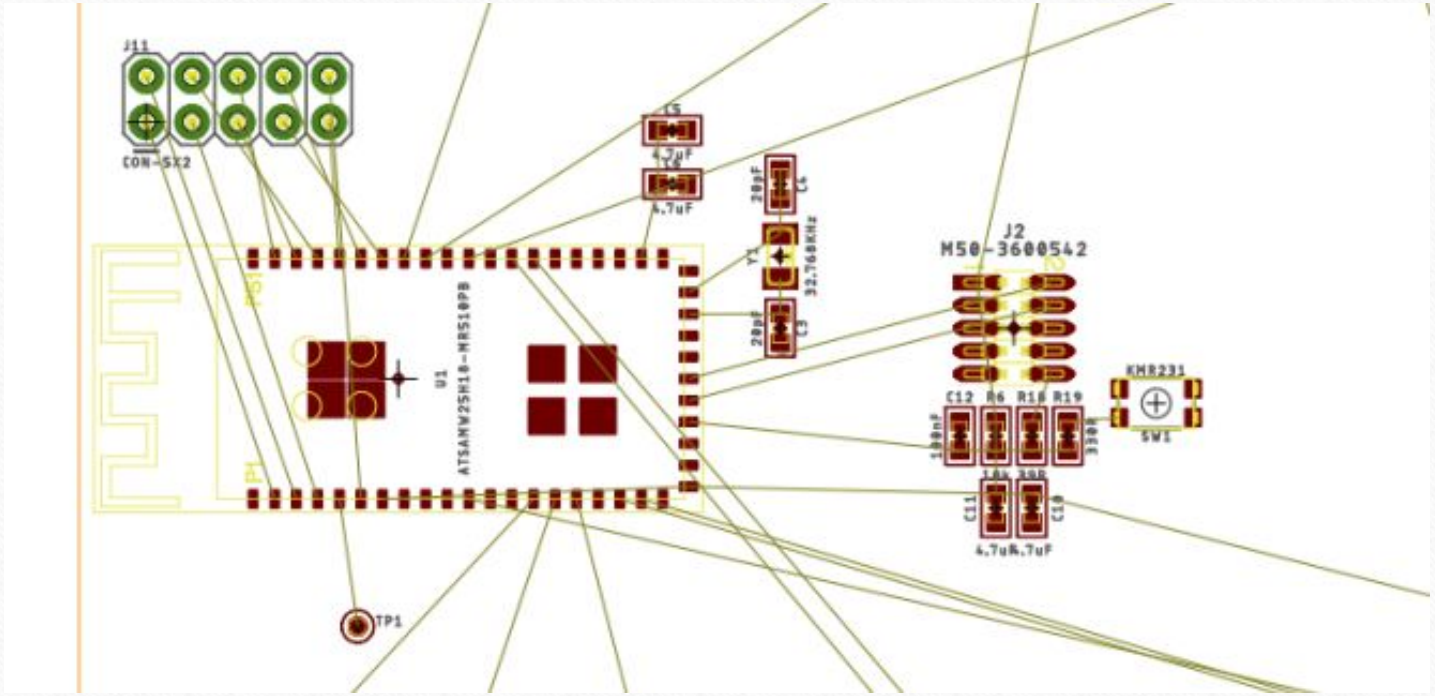


Microcontroller PCB Schematic

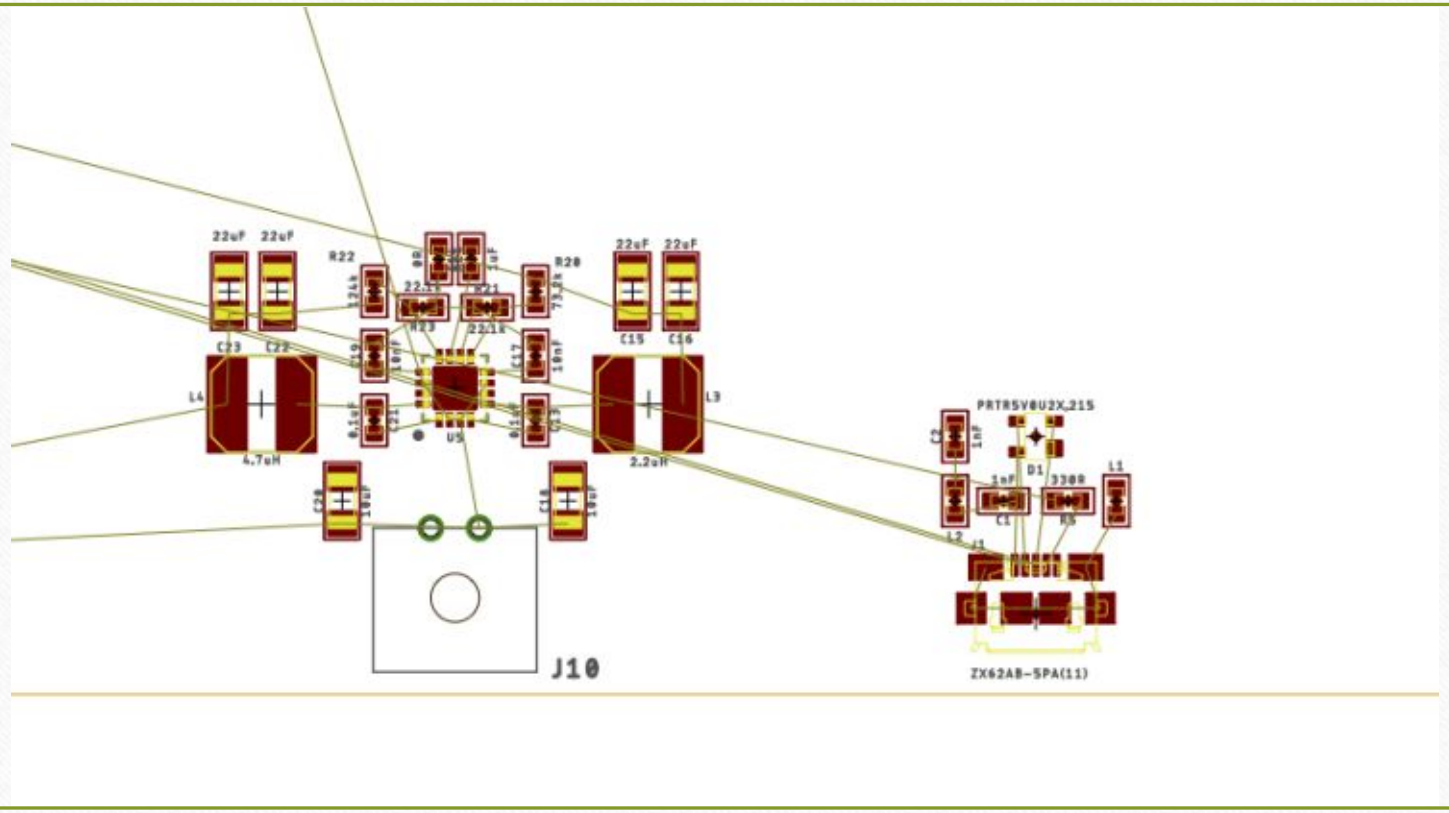




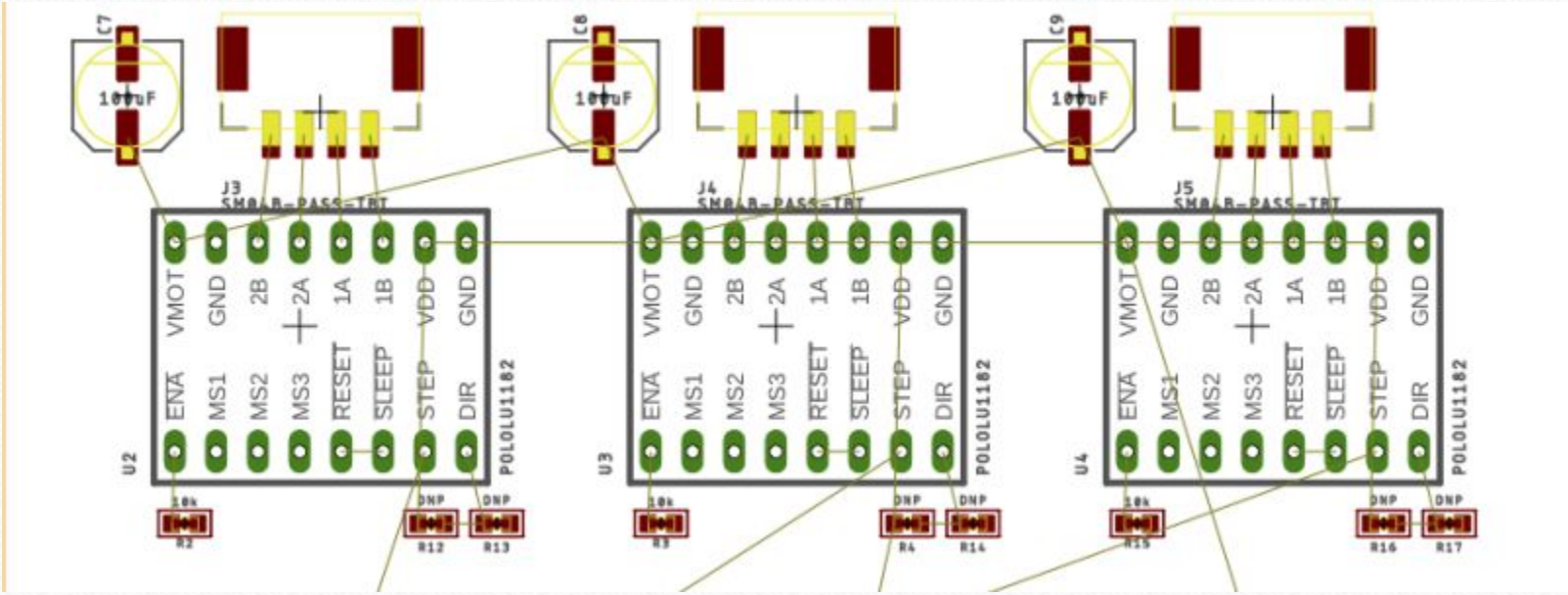
ATSAMW25


J11
CON-SX2
C5
4.7uF
C4
4.7uF
20pF
C4
Y1
32.768KHz
20pF
C3
U1
ATSAMW25H18-MRS10PB
J2
M50-3600542
KMR231
SW1
C12
R6
R16
R19
100nF
330R
C11
C10
4.7uF
4.7uF
TP1

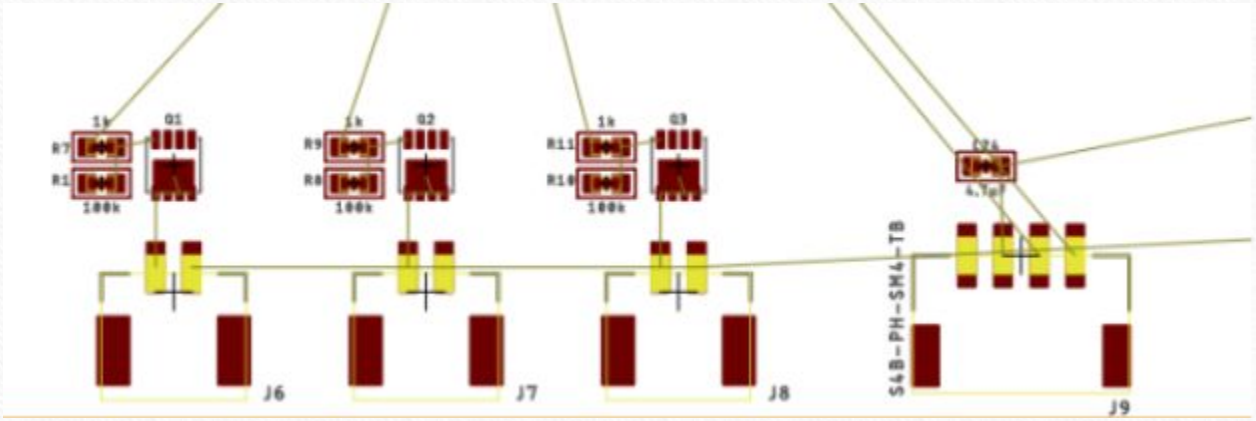
USB + Buck Converter



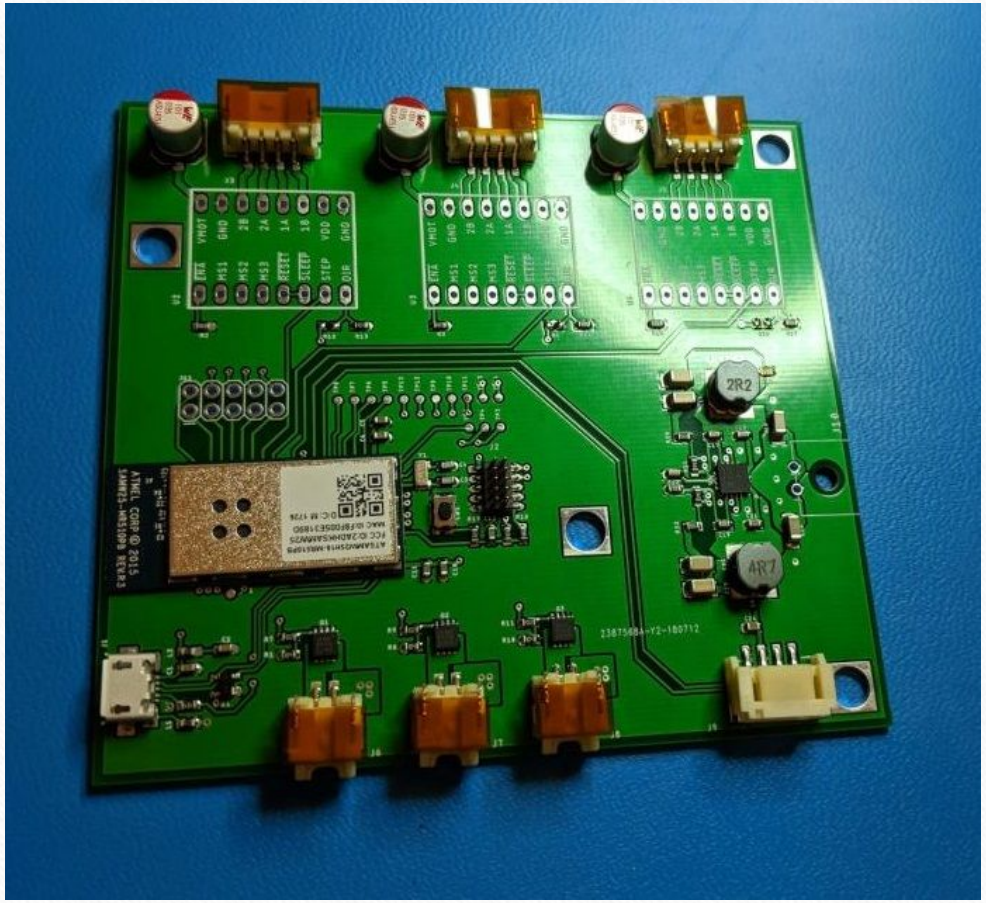
Motor Drivers



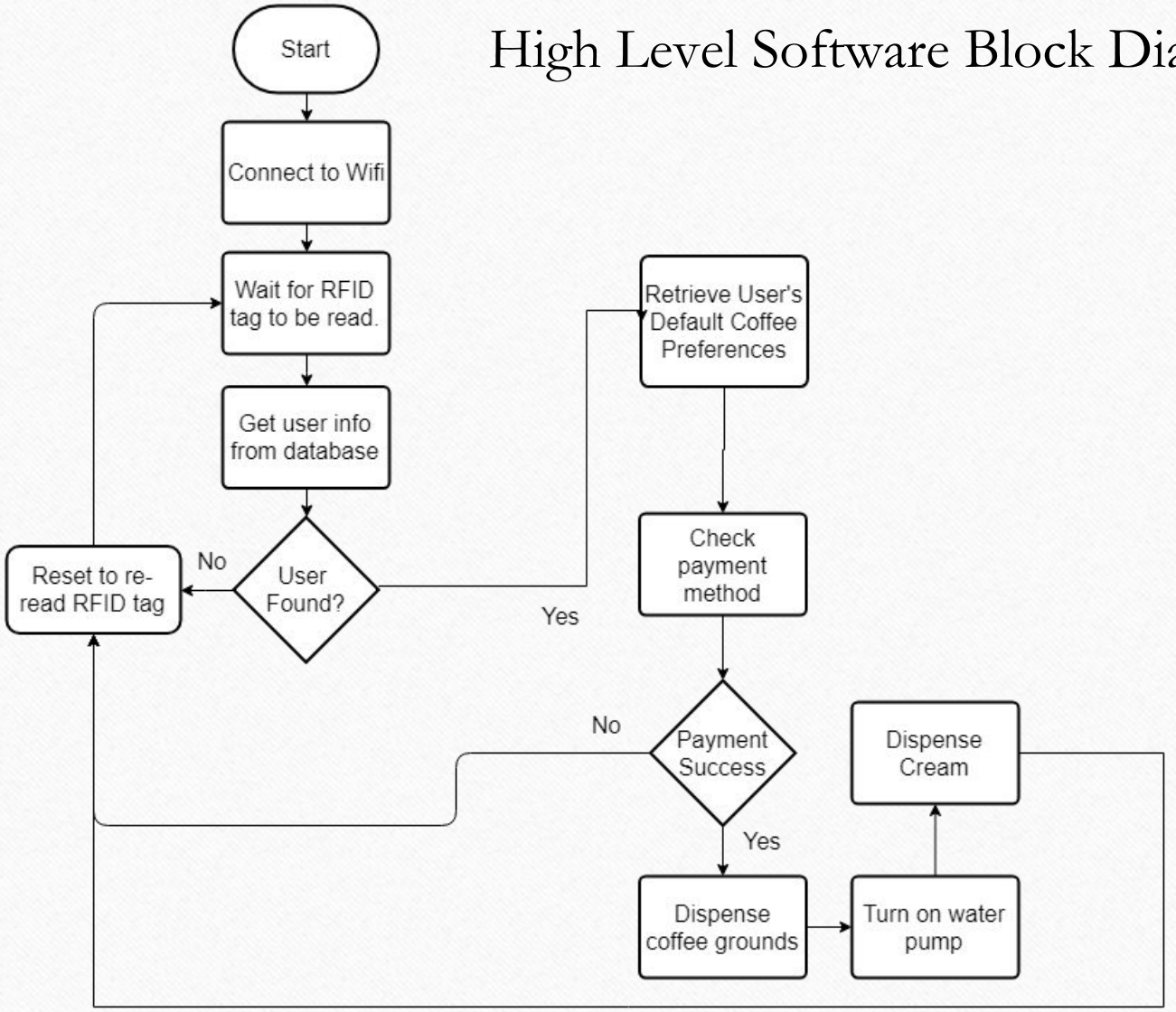
Pump & RFID



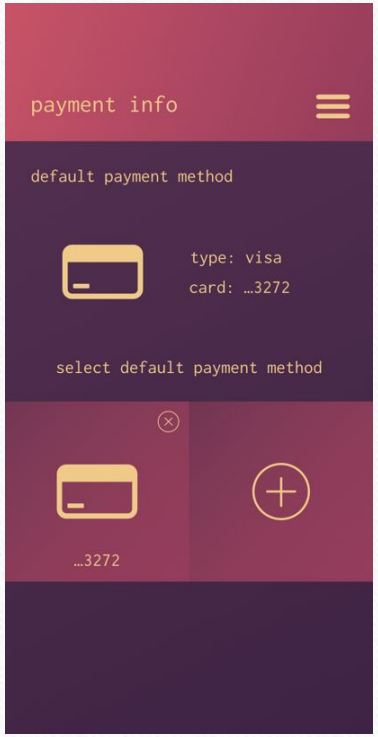
Completed PCB



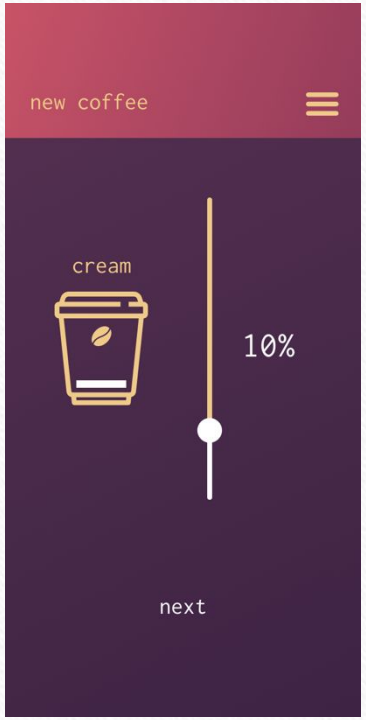
High Level Software Block Diagram



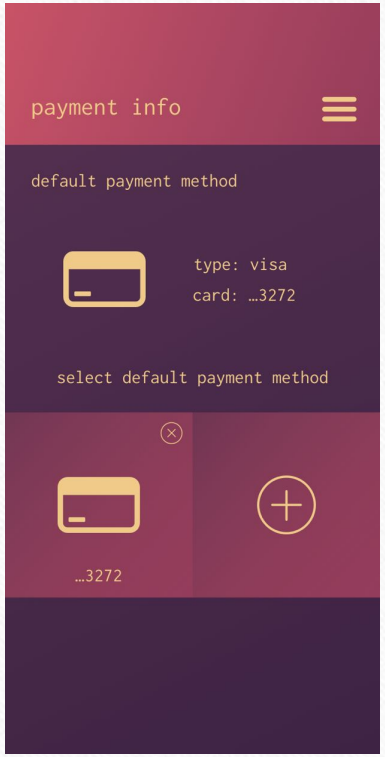
App Main Menus

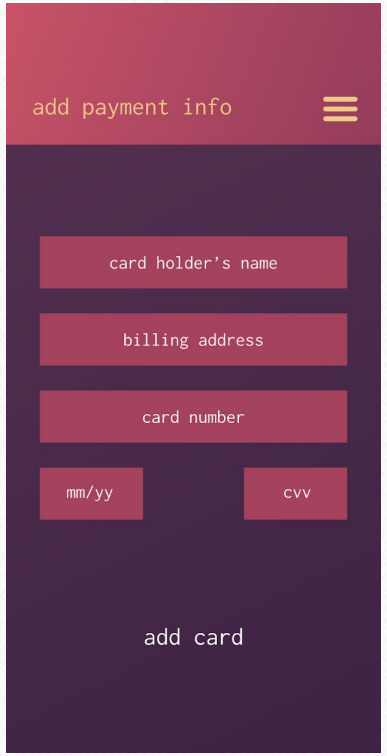


Add New Coffee Preference

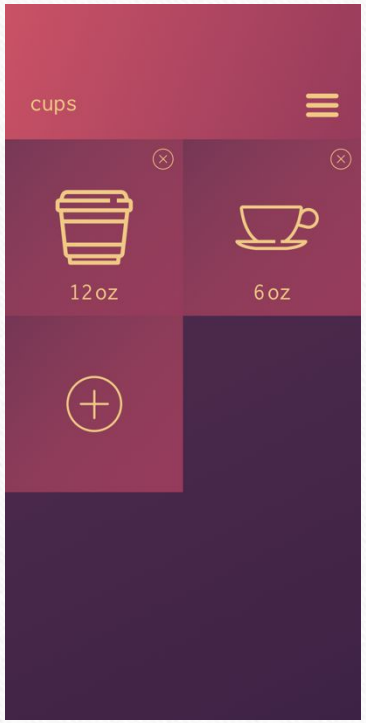


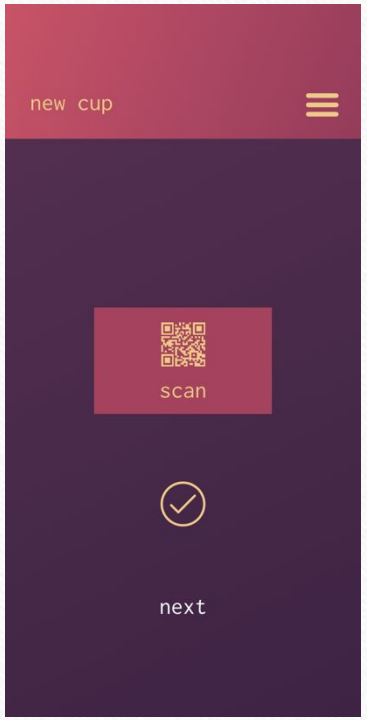
Add New Payment Method





Add New Cup





Backend Design

Nodejs

- Light weight
- Very Customizable
- Easily create RESTful APIs with Express

MongoDB

- Allows us to store user data as JSON objects

User Model Detail

Field	Data Type	Required
_id	ObjectId	Y
name	String	Y
email	String	Y
password	String	Y
payment_info	Array[Object]	
payment_info.name	String	Y
payment_info.address	String	Y
payment_info.cardNumber	String	Y
payment_info.expiration	Date	Y
payment_info.cvc	String	Y
cups	Array[Object]	
cup.uid	String	Y
cup.size	Number	Y
coffee_prefs	Array[Object]	
coffee_pref.type	Number	Y
coffee_pref.cream	Number	Y
coffee_pref.sugar	Number	Y
tokens	Array[String]	Y

Authentication Routes

Request Type	Route	Description
POST	/login	Verifies user with the provided email and password. If the user is authenticated successfully, this route will return a JWT authentication token for the user to use for all future requests. If not, this route will return an error.
DELETE	/logout	Deletes the given JWT token from the tokens array in the user document. This route returns a successful message if successfully logged out or an error if unable to delete the token.

User Specific Routes

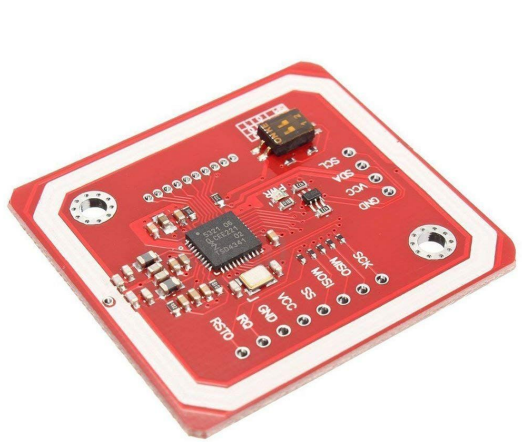
Request Type	Route	Description
GET	/users	Returns a list of all users and all of their coffee information (useful for developers who want to take advantage of our API to gather statistical or analytical data).
POST	/users	Creates a user with the given data. The user data provided must adhere to the model detailed in the data models section. This route will return the new user as a response or an error if the data provided is invalid.
PATCH	/users/:id	Modifies the user with the given ID. This route will be used by the mobile application to modify user payment information, coffee preferences and other information such as email or phone number. This route will return the modified user as a response or an error if the data provided is invalid.
DELETE	/users/:id	Deletes a user with the given ID. This route will return the deleted user as a response or an error if the user is not found.

Coffee Routes

Request Type	Route	Description
GET	/coffee/:cupId	Returns the user's default coffee preferences. This route will be utilized by the coffee machine whenever the user puts their cup on the scanner. The server will find the user based on the cup ID provided. This route will also trigger the payment processing API to execute a payment. If the payment is unsuccessful, an error will be returned instead of the user's coffee preferences
DELETE	/coffee/:cupId	Deletes the cup with the given cup ID from the list of cups for the user.

RFID Module

Specifications	Solu Mifare RC522	Grove - NFC	PN532 NFC NXP RFID Module V3
Communication	SPI	I^2C, UART	I^2C, UART, SPI
Working Voltage	3.3 V	3.3 V	5 / 3.3 V
# of pins	5	2	2
Frequency	13.56 Mhz	13.56 Mhz	13.56 Mhz
Cost	$6	$21.50	$9.99



Issues

- Wrong kind of boiler
- Electromagnetic Fields
- Mechanical Issues

Division of Labor

Team Member	Application /Server	Firmware	PCB	Power	Peripherals
Dylan Kirke	S	**P**			**P**
Alessandro Vecchi	**P**	**P**	**P**		S
Guilherme Carvalho			S	**P**	**P**
Daniel Betancourt			**P**	S	S

Budget

Item	TotalCost
Silicone Tubing 4mm x 6mm 8M	15.69
Silicone Tubing ⅜" 10'	11.99
16-Gauge Bulk Spool	9.8
5V 5A Converter Step Down Regulator (x2)	17.18
50 ft 12-gauge solid Wire	10.99
RFID Reader/tags	9.99
	7.99
12V 30 A 360W Switching Power Supply	20.99
On off AC Rocker 5 PCS	11.99
Funnels	6.29
Metal Coffee Filter	9.97
12 V DC Diaphragm Pump	21.99
12 V DC Peristaltic Pump	12.98

Item	Total Cost
Stepper Motors (x2)	30.68
Stepper Motor drivers (x2)	12
Motor Mounting Hub	10
Motor Mounting Bracket	6.74
ATSAMW25 Microcontroller	11.7
Thermoblock Boiler	35.95
Type-k Thermocouple	9.95
PCB Cost	97
PCB Components Total	97.33
AD595	9.99
MAX675	6.23
SSR	8.99
Exterior	80

Total Spent: $594.39

Questions?