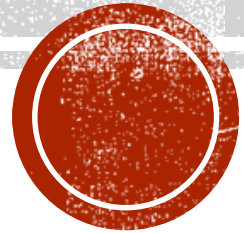
GROUP 10

AUTOMATIC BREWER



UCF

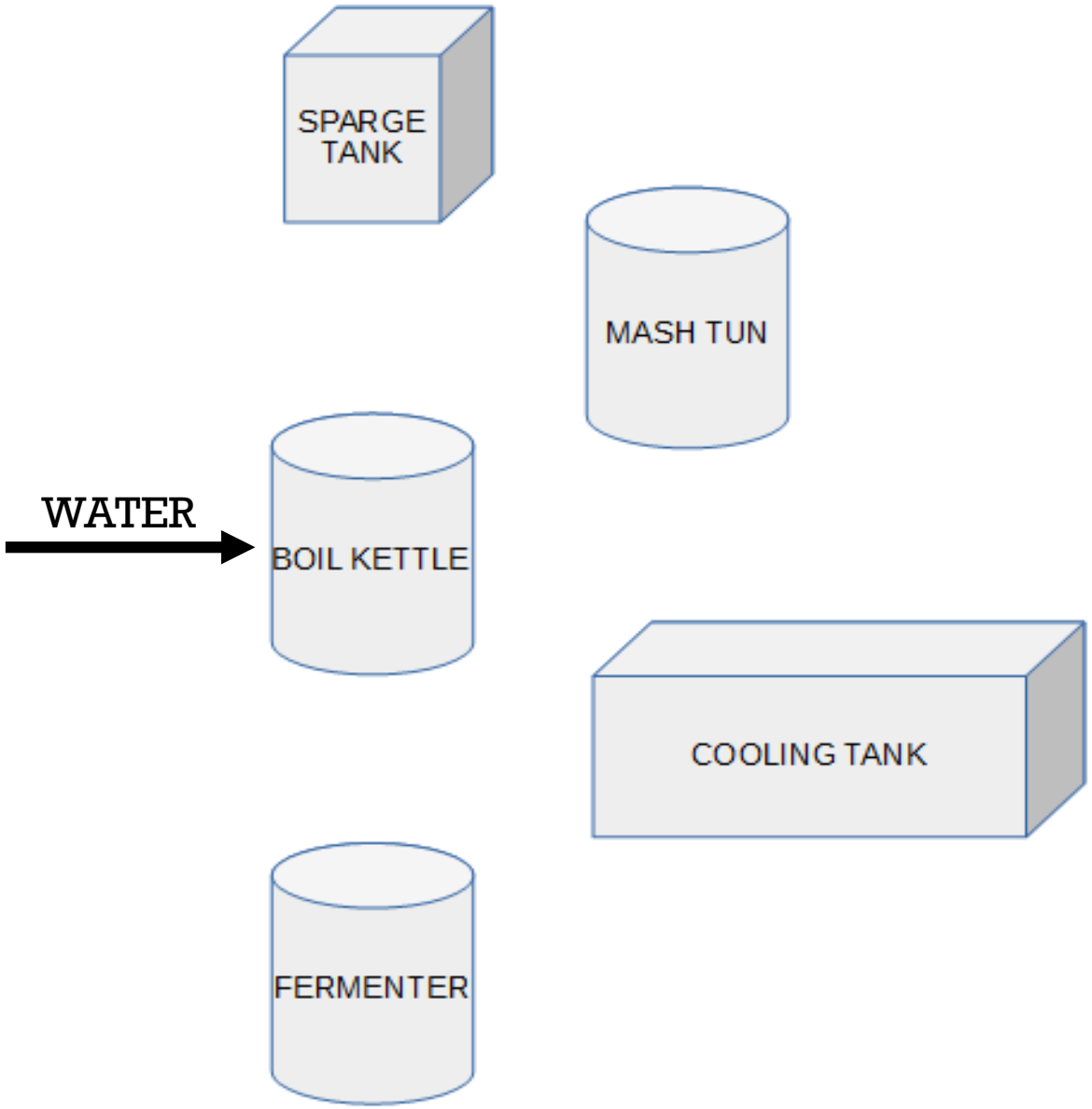
COLLEGE OF ENGINEERING & COMPUTER SCIENCE

Robert Bower (EE)
Alonzo Ubilla (ME/EE)
Kleber Valencia (EE)
David Rodriguez (CE)

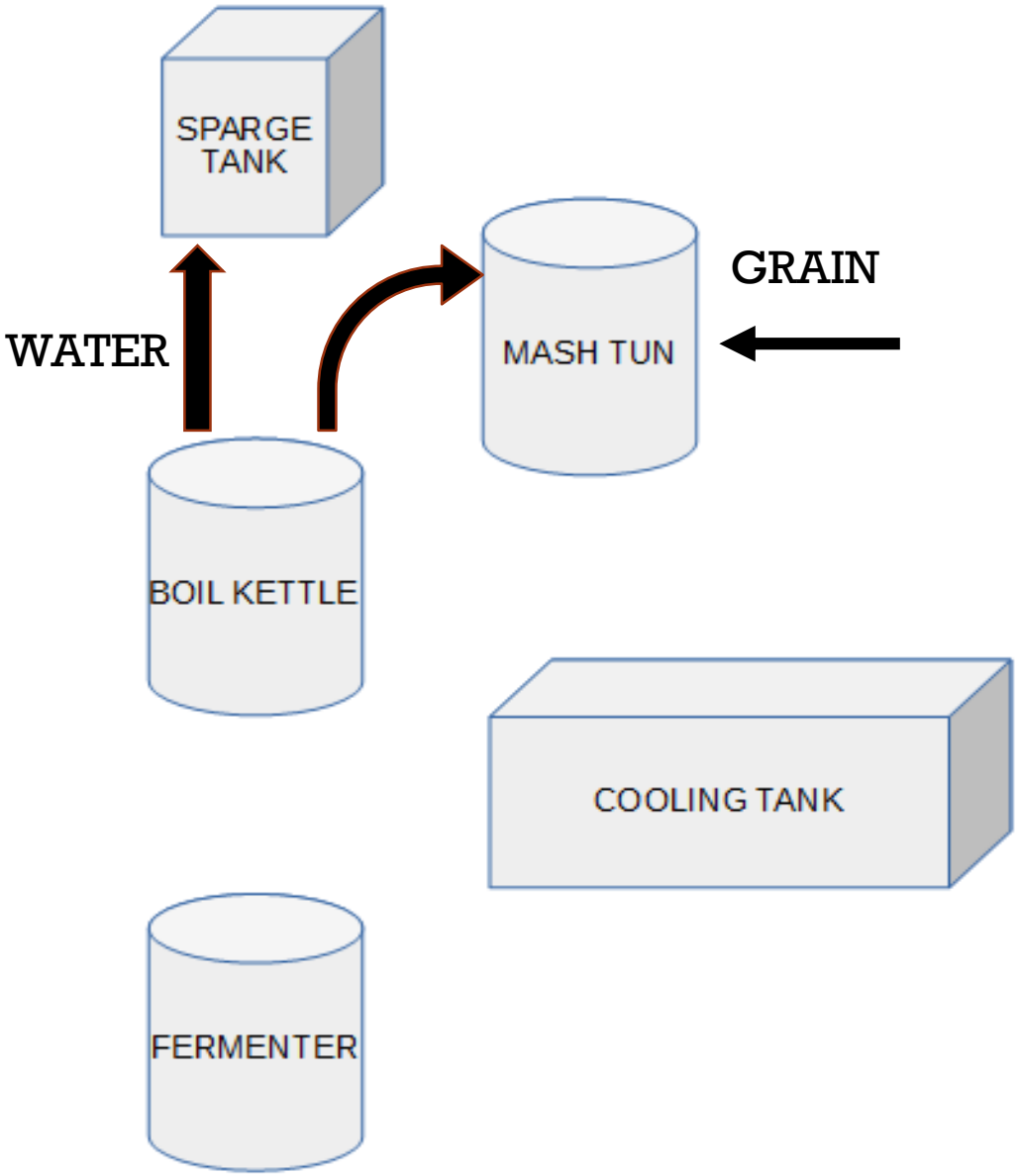
MAKING BEER

- Basic ingredients (water, barley, hops, and yeast)
- Process:
  - Step 1: Mash
  - Step 2: Sparge
  - Step 3: Boil
  - Step 4: Cool
  - Step 5: Fermentation

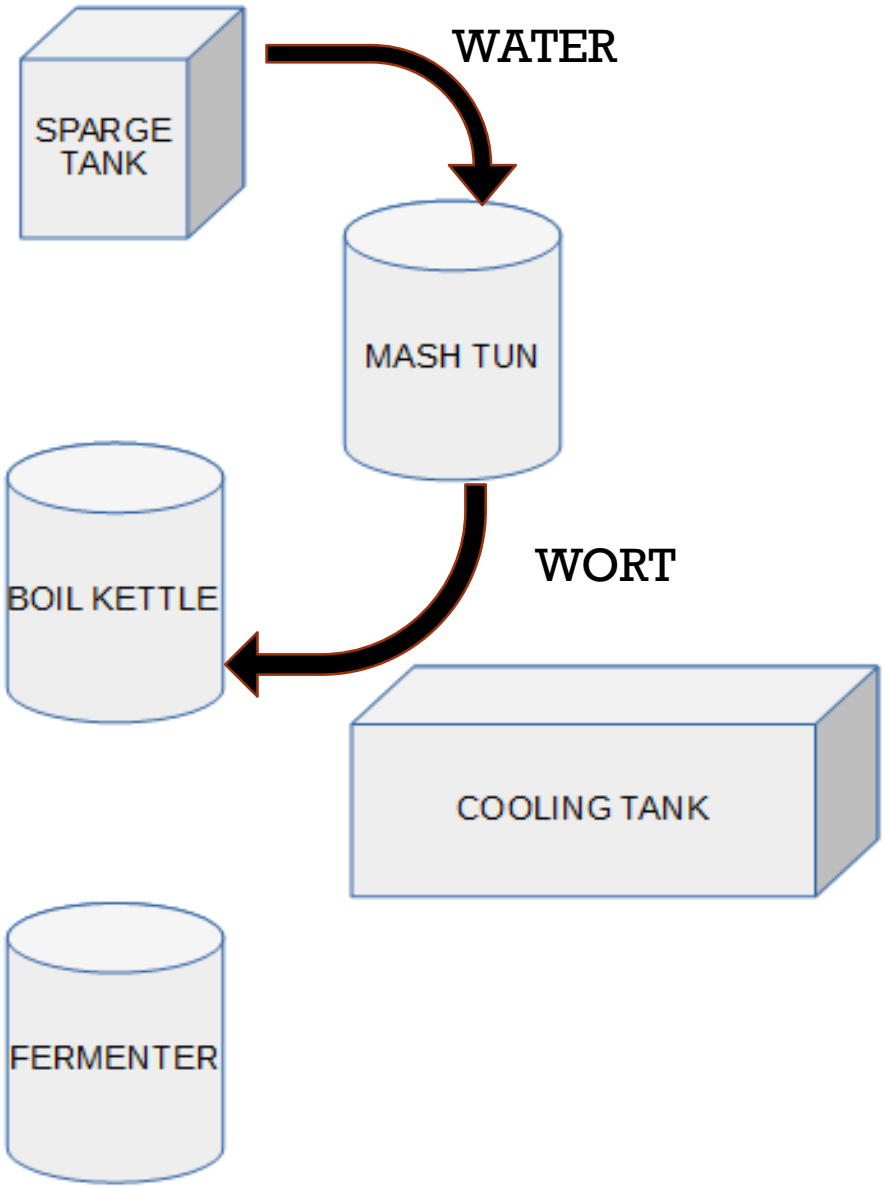
MASH


SPARGE TANK
MASH TUN
WATER
BOIL KETTLE
COOLING TANK
FERMENTER

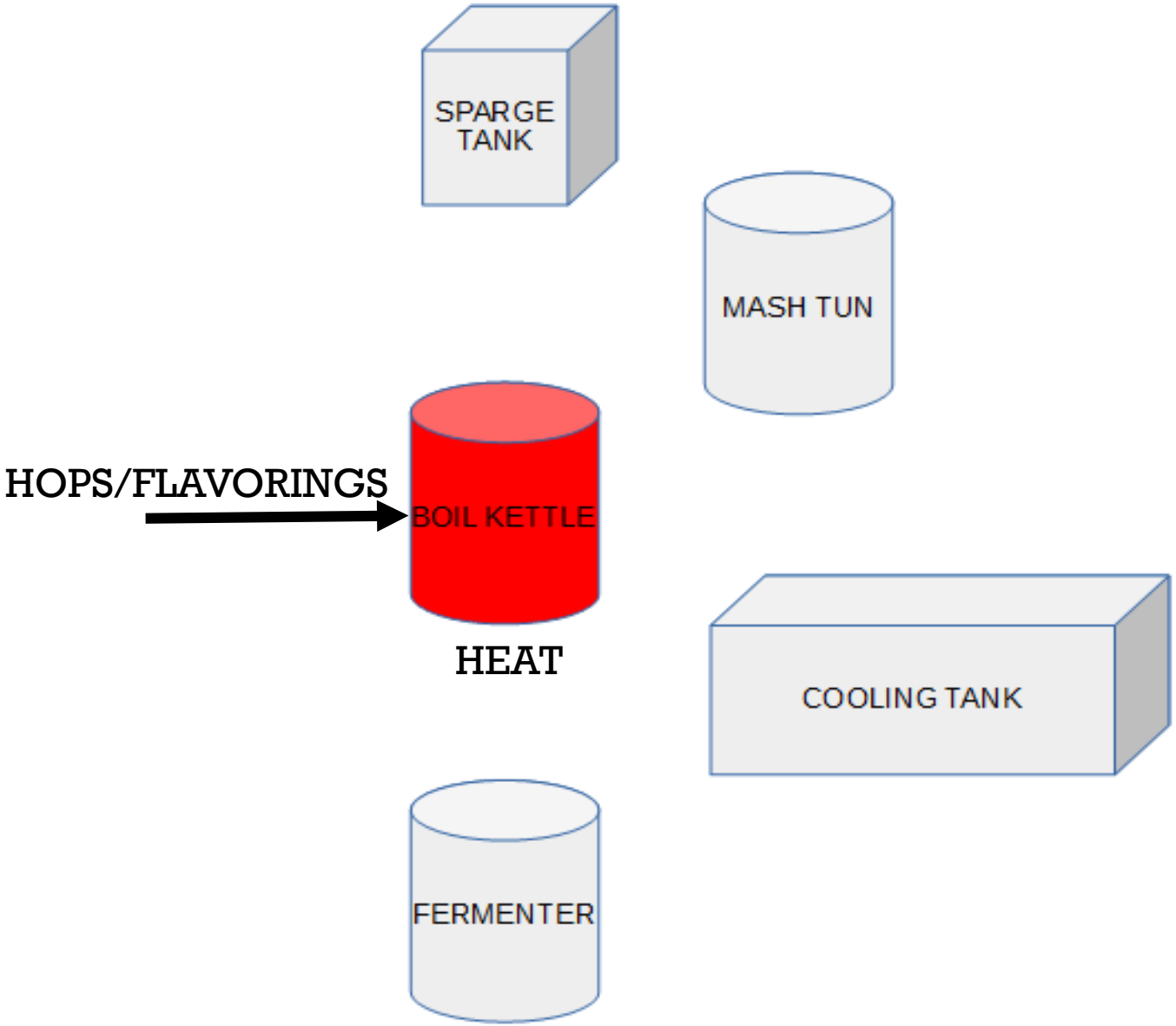
MASH


SPARGE TANK
WATER
MASH TUN
GRAIN
BOIL KETTLE
COOLING TANK
FERMENTER

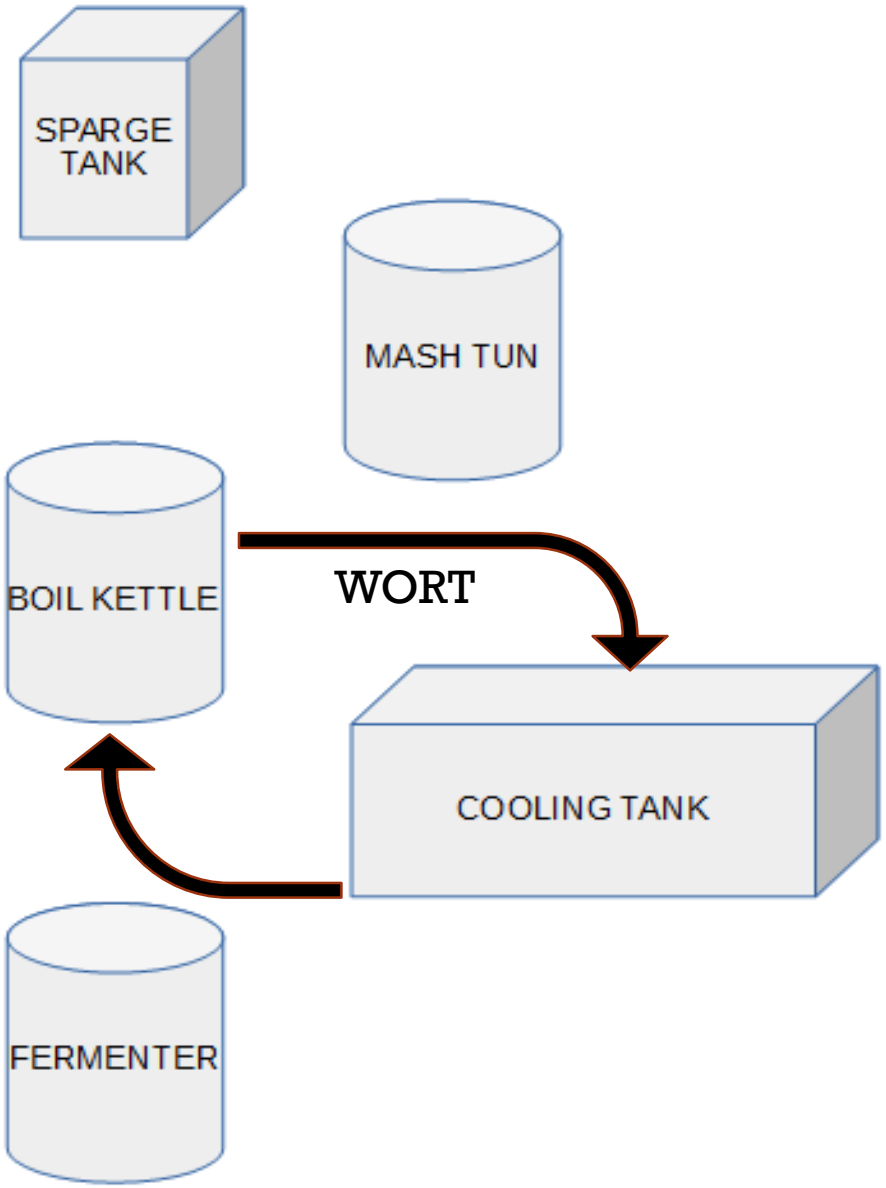
SPARGE


SPARGE TANK
WATER
MASH TUN
BOIL KETTLE
WORT
COOLING TANK
FERMENTER

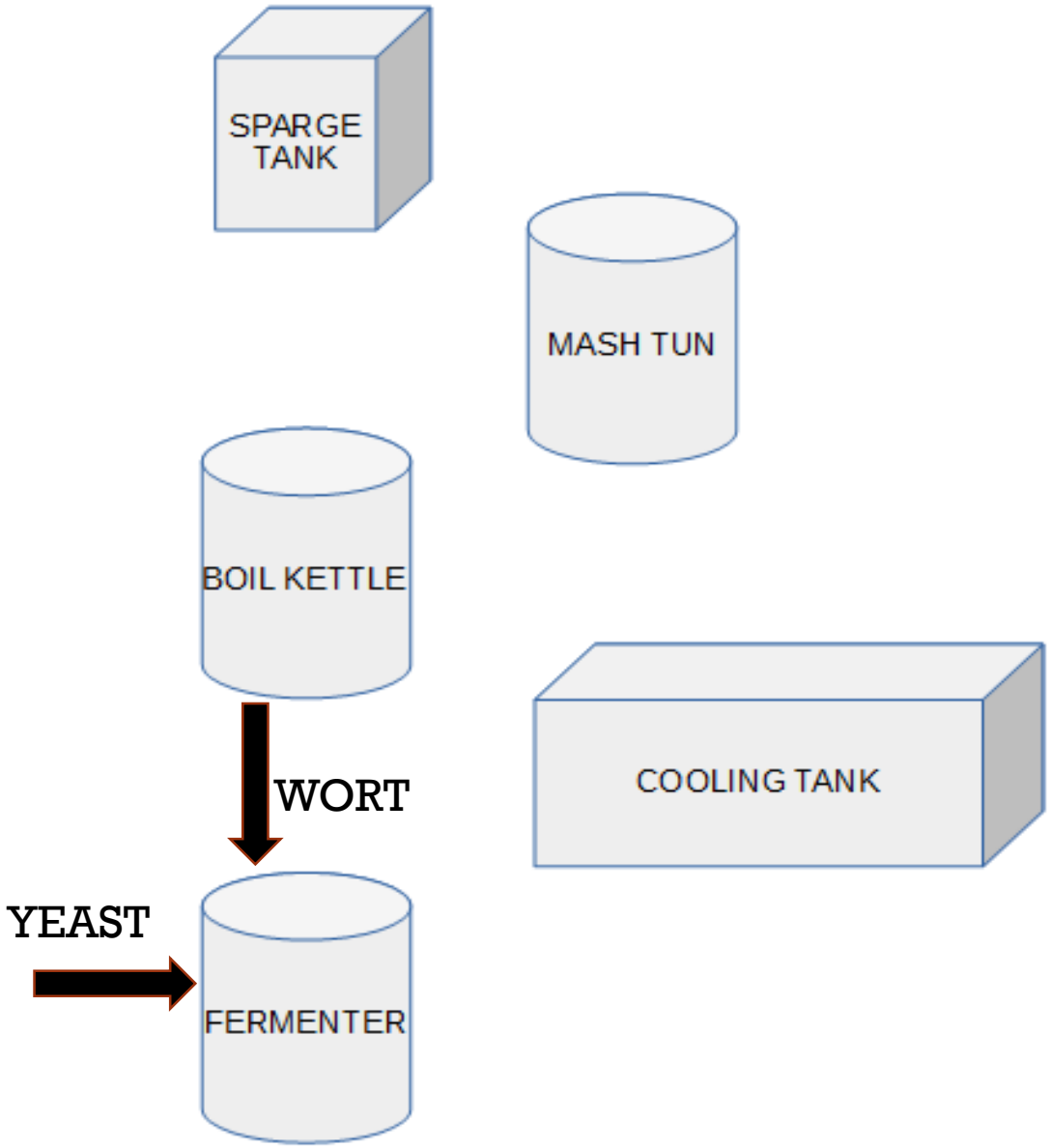
BOIL


SPARGE TANK
MASH TUN
HOPS/FLAVORINGS
BOIL KETTLE
HEAT
COOLING TANK
FERMENTER

COOLING AND TRANSFER



COOLING AND TRANSFER



PROJECT GOALS

- Process:
  - Step 1: Mash
  - Step 2: Sparge
  - Step 3: Boil
  - Step 4: Cool

  } Automate wort making process

  - Step 5: Fermentation
- Data collection
- Provide supervisory control
- Add connectivity (Bluetooth, Wi-Fi)

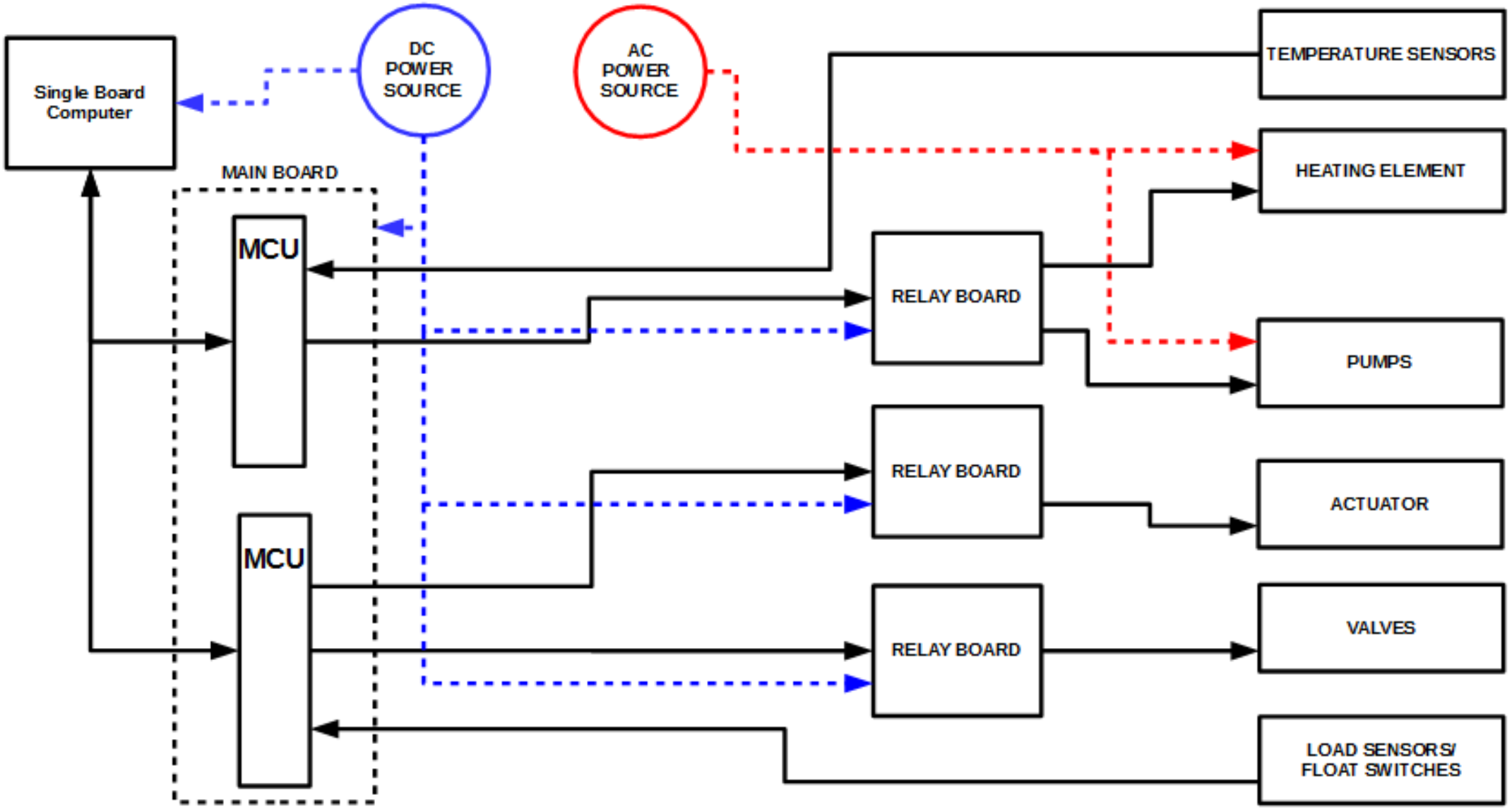
REQUIREMENTS

- Provide accurate temperature control
- Provide fault detection within the system
- Provide fluid level control
- System must operate within user defined variables
- System must produce a safe, consumable product
- System must collect process data

MOTIVATION

- Move focus towards process variables instead of the process
- Accurately document process variables
- Make process accurately repeatable

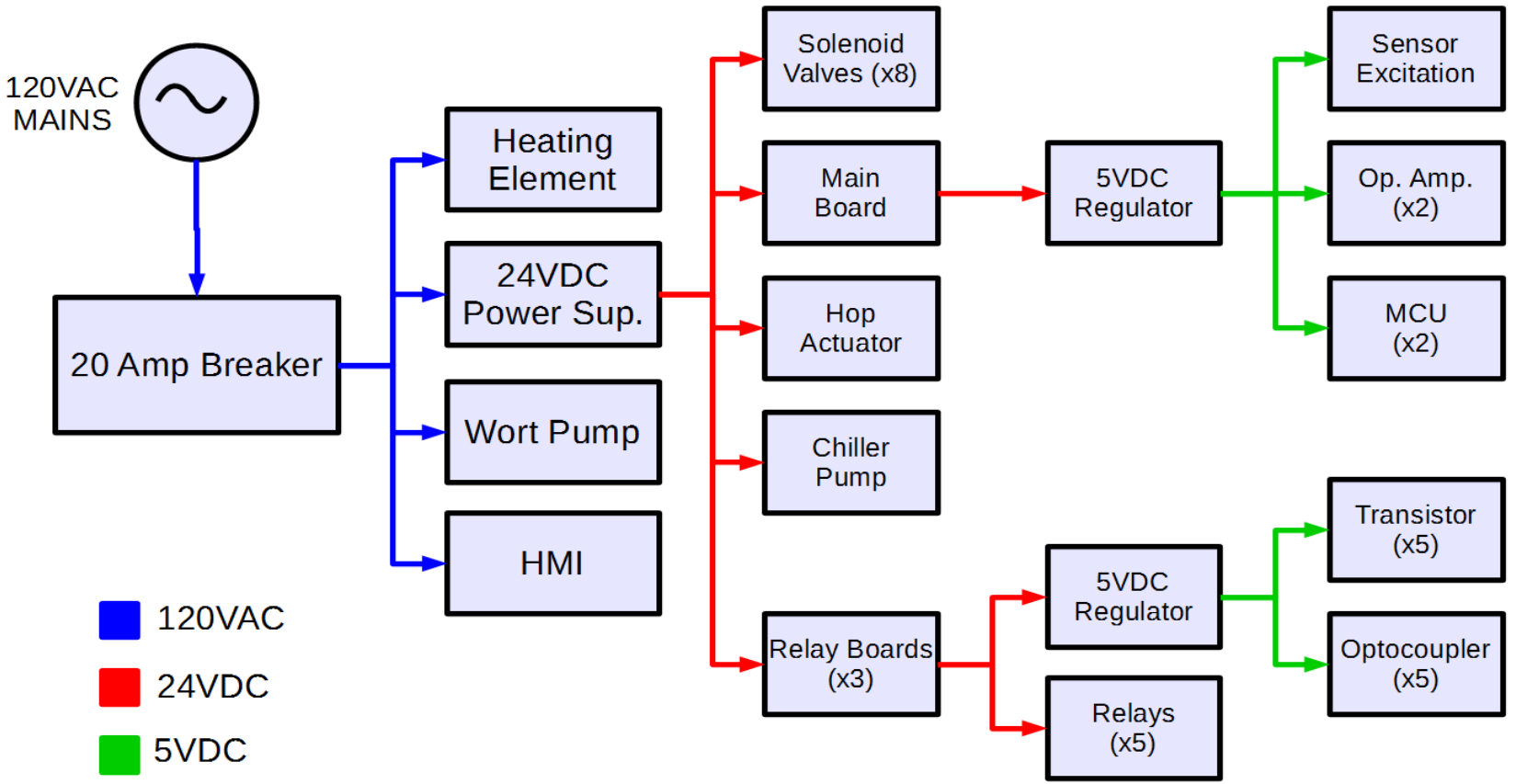
OVERALL SYSTEM



COMPONENTS AND POWER CONSUMPTION

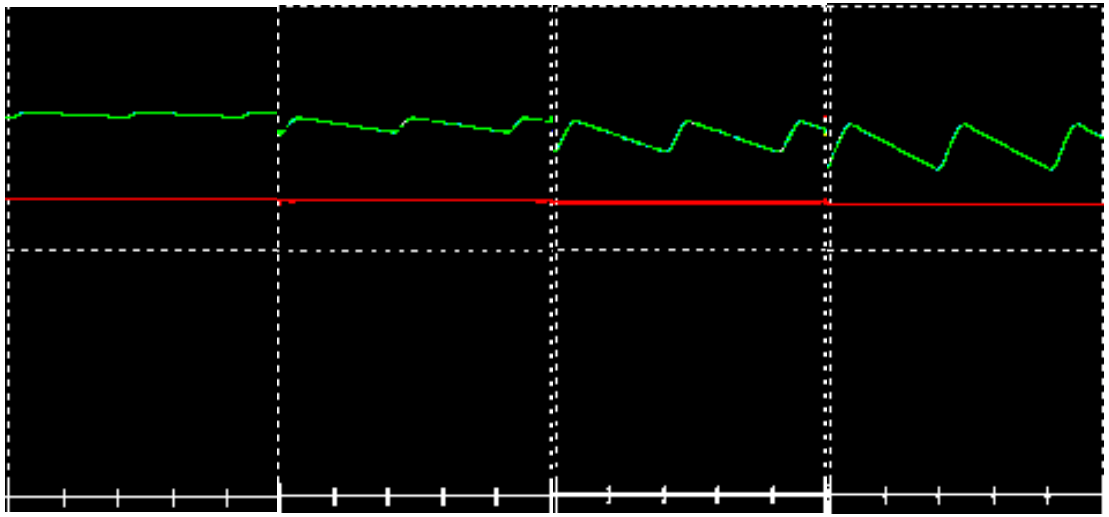
COMPONENT	OPERATING VOLTAGE	POWER CONSUMPTION
Heating Element	120 VAC	1500 W
Wort Pump	120 VAC	160 W
HMI	120 VAC	100 W
Chiller Pump	24 VDC	20 W
Actuator	24 VDC	17 W
Solenoid Valve (x8)	24 VDC	7.2 W (57.6 W)
Slim Relays [low power] (x12)	24 VDC	0.2 W (2.4 W)
Relays [high power] (x3)	24VDC	0.8 W (2.4 W)
Relay Control Board (x3)	5 VDC	4.8W (14.4 W)
MCU/Main Board	5 VDC	10 W
TOTAL		**~1900 W**

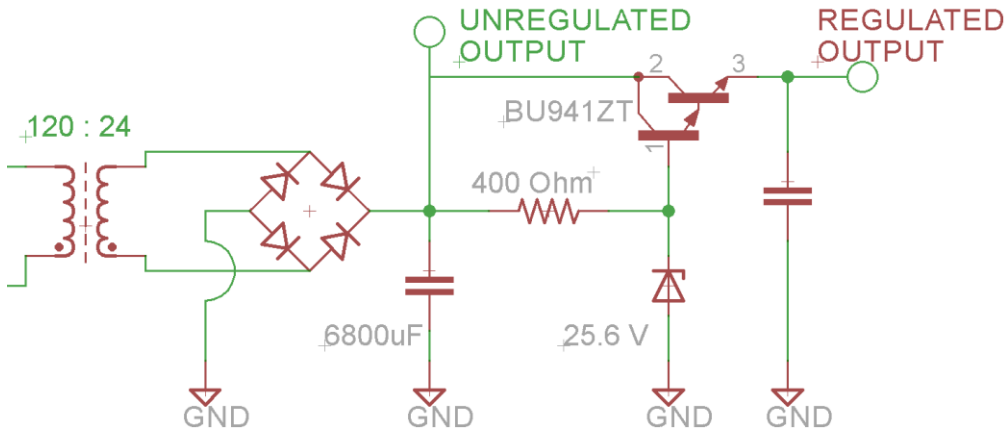
POWER DISTRIBUTION



POWER DISTRIBUTION – PSU PERFORMANCE

LOAD	REGULATED VOLTAGE	POWER OUTPUT	TRANSISTOR POWER DISSIPATION
Low – 0.5 Amps	24.21 V	12.1 W	4.5 W
Medium – 1.5 Amps	24.13 V	36.2 W	11 W
High – 3.5 Amps	23.95 V	83.8 W	23 W
MAX – 5.3 Amps	23.83 V	126.3 W	32 W





USER INTERFACE

File Help

AUTO BREW RECIPE INPUT

AUTO MODE

MANUAL MODE

SELECTED MODE:

Enter the name of your recipe:
Test Recipe

Enter the grain type:
grain 1oz

Enter the hops type:
hops 2oz

Enter the yeast type:
yeast #3

MASH STEP

Mash Temperature(Celsius):
95

Mash Time(Minutes):
60

BOIL STEP

Boil Temperature(Celsius):
85

Boil Time(Minutes):
60

HOPS ADD

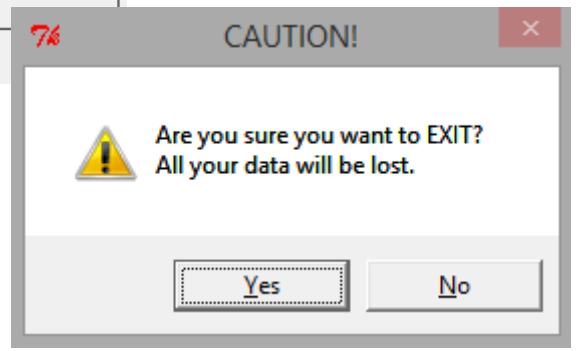
Addition of Hops
(Minutes Remaining):
30

COOLING

Cooling Temperature(Celsius):
32

START

EXIT



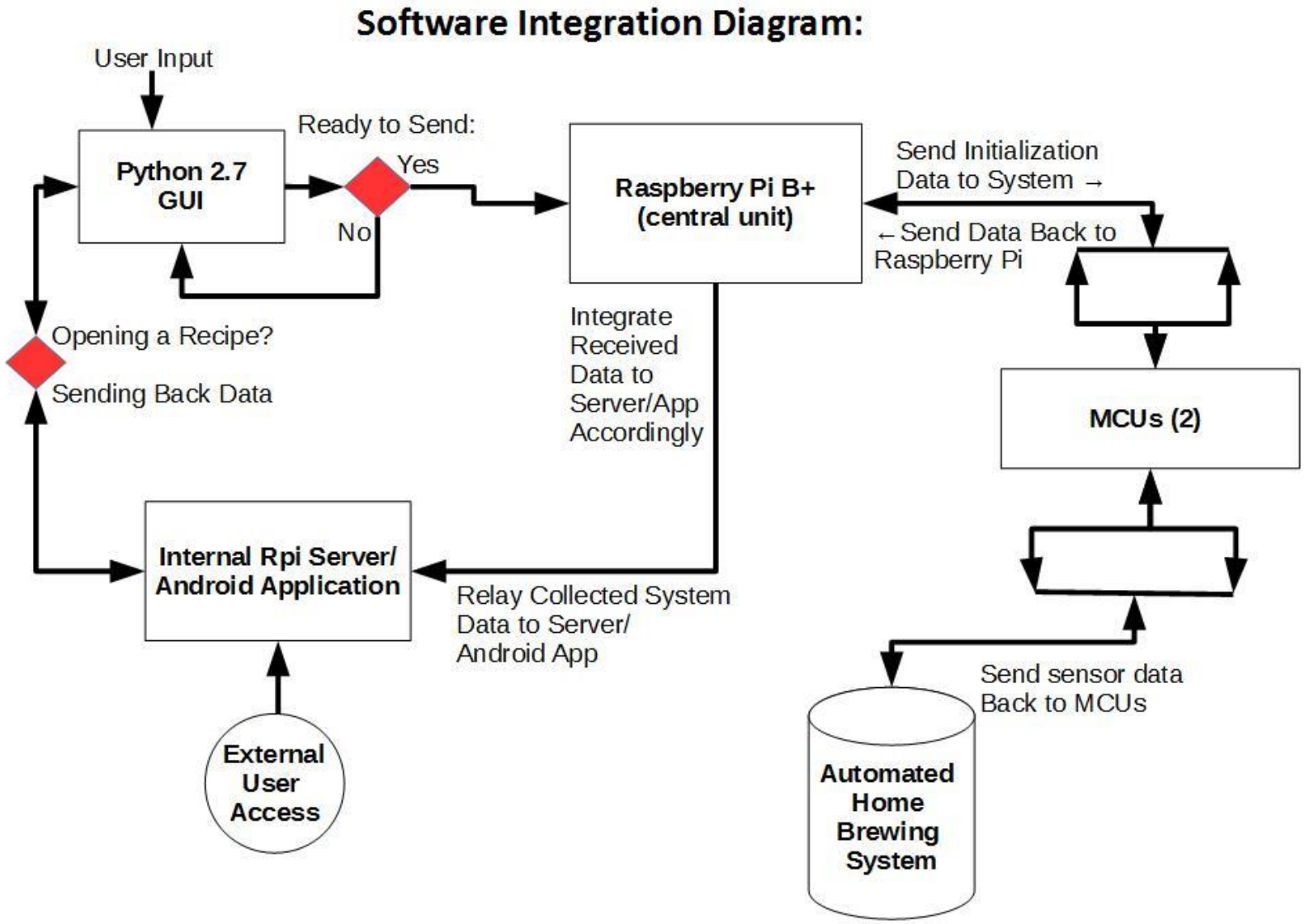
USER INTERFACE

BOIL KETTLE	MASH TUN	COOLING RETURN
TEMP(C) 27	TEMP(C) 28	TEMP(C) 23
LEVEL(%) 41		
TARE		

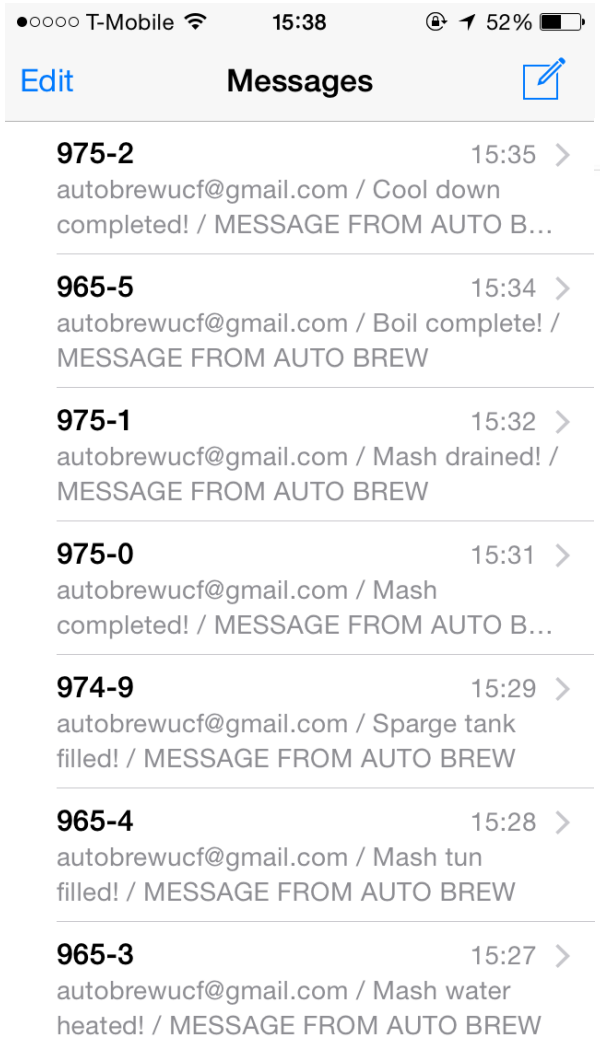
STEP:
Fill Kettle

- PUMP INLET VALVE
- MASH INLET VALVE
- SPARGE INLET VALVE
- SPARGE DRAIN VALVE
- MASH DRAIN VALVE
- COOLING INLET VALVE
- CARBOY FILL VALVE
- TRANSFER PUMP
- COOL PUMP
- HEATING ELEMENT

USER INTERFACE (CONTD.)



SMS/EMAIL NOTIFICATIONS



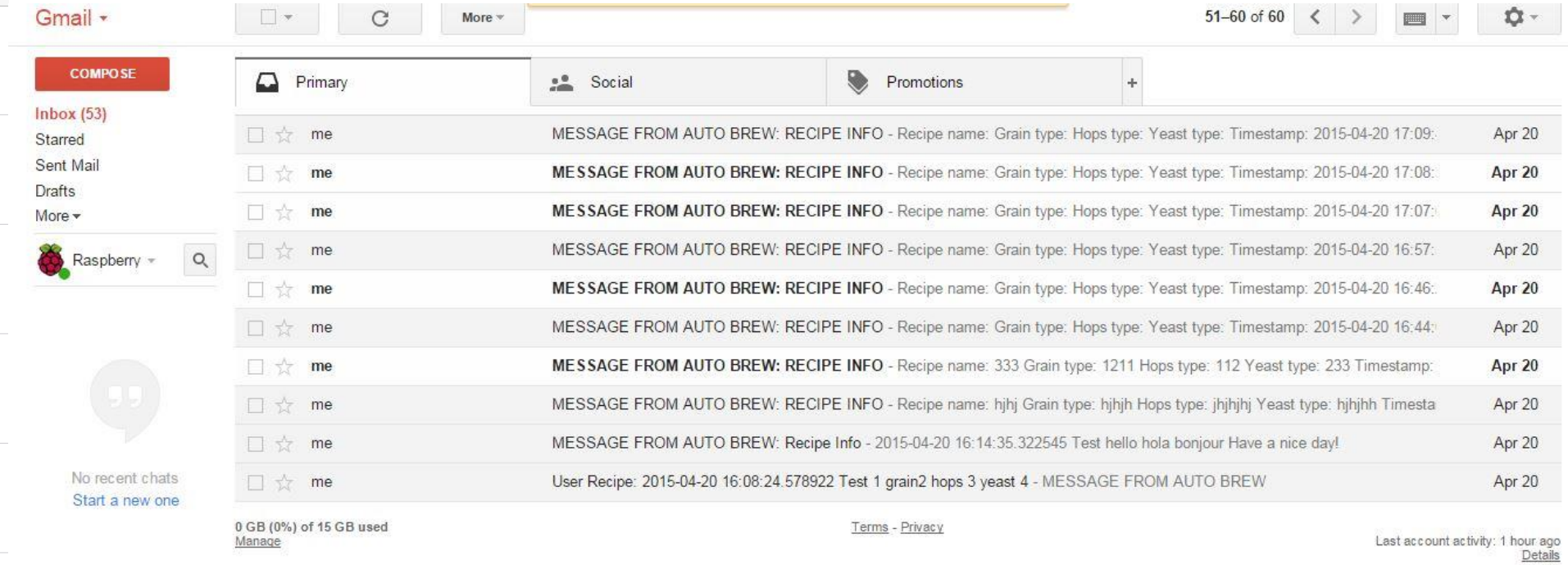


Table 4.6: Raspberry Pi B+ VS. Other Modern Single Board Computer Models (Information for Raspberry Pi courtesy of the Raspberry Pi Foundation, A13-OLinuXino Wi-Fi courtesy of Olimex, Cubieboard2 courtesy of the Element 14 Community, Banana Pi courtesy of Banana Pi)

Single Board Computer Name:	Raspberry Pi Model B+	A13-OLinuXino Wi-Fi Enabled	Cubieboard2	Banana Pi
Developer:	Raspberry Pi Foundation	Olimex	Cubieboard	LeMaker
Release Date:	Summer 2014	April 2012	November 2012	2014
Cost:	$35.00	$68.70	$49.00	$54.99
Processor:	ARM11	ARM Cortex-A8	ARM Cortex A7-Dual Core	ARM Cortex A7-Dual Core
SoC (Software on Chip):	Broadcom BCM2835	Allwinner A13	Allwinner A20	Allwinner A20
GPU:	Dual Core VideoCore IV	ARM Mali-400	ARM Mali-400	ARM Mali-400
Clock Speed:	700 MHz	1.0 GHz	2 x 1.0 GHz	2 x 1.0 GHz
RAM/Memory:	512MB SDRAM / None	512MB / 4GB NAND Flash	1GB DDR3 / 3.4GB NAND Flash	1GB DDR3 / None
OS Image (Linux/Android):	Linux	Android	Linux OR Android	Linux OR Android
Power Supply:	5V, 2A	6-16V (Battery supported)	5V, 1-2A	5V, 2A
GPIO Count:	27	8	-	7
I2C Support:	Yes	Yes	Yes	Yes
HDMI Port:	Yes	No	Yes	Yes
Ethernet Port:	Yes	No	Yes	Yes
USB Port(s):	4 hosts	4 hosts (3 for users)	2 hosts	2 hosts
Video/Audio Out:	Yes	Yes	Yes	Yes
Dimensions:	85mm x 56mm	120mm x 120 mm	100mm x 60mm	92mm x 60mm
Weight:	45g	n/a	n/a	48g

WHY THE RASPBERRY PI B+?

- 512MB RAM
- 700 MHz clock speed
- Runs Linux OS (Raspbian)
- The most affordable ($35)
- Prior working knowledge of the Raspberry Pi models

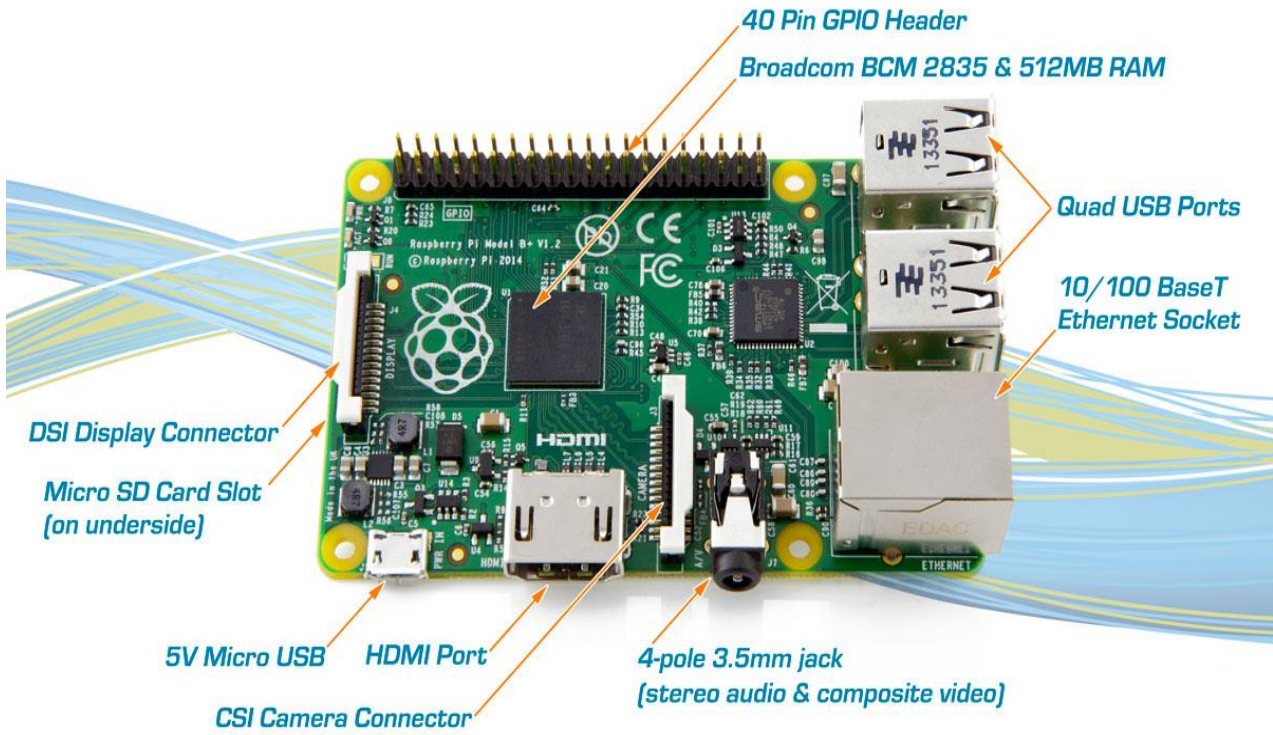
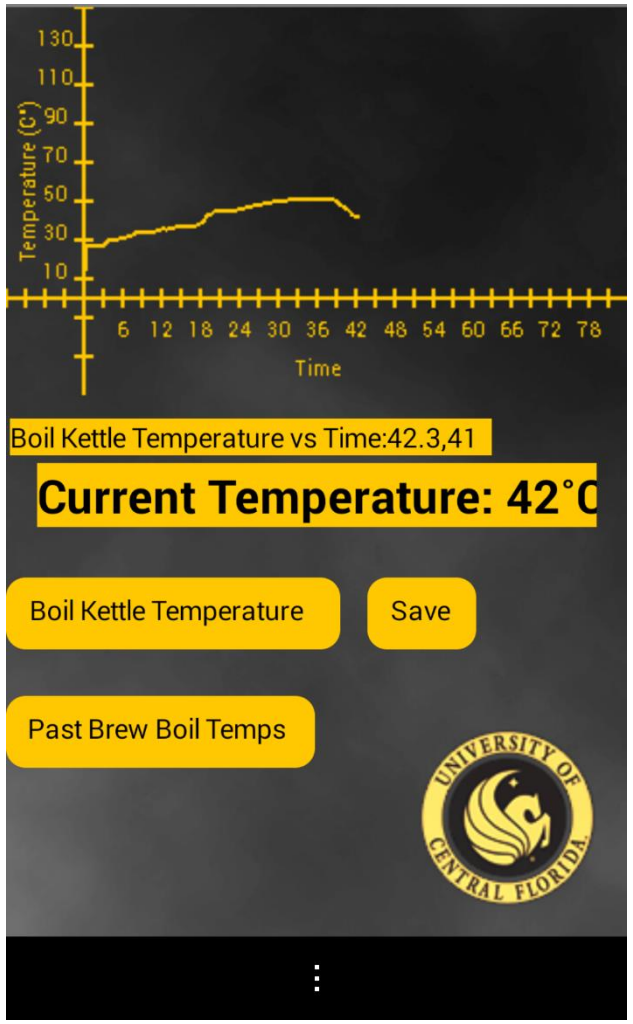


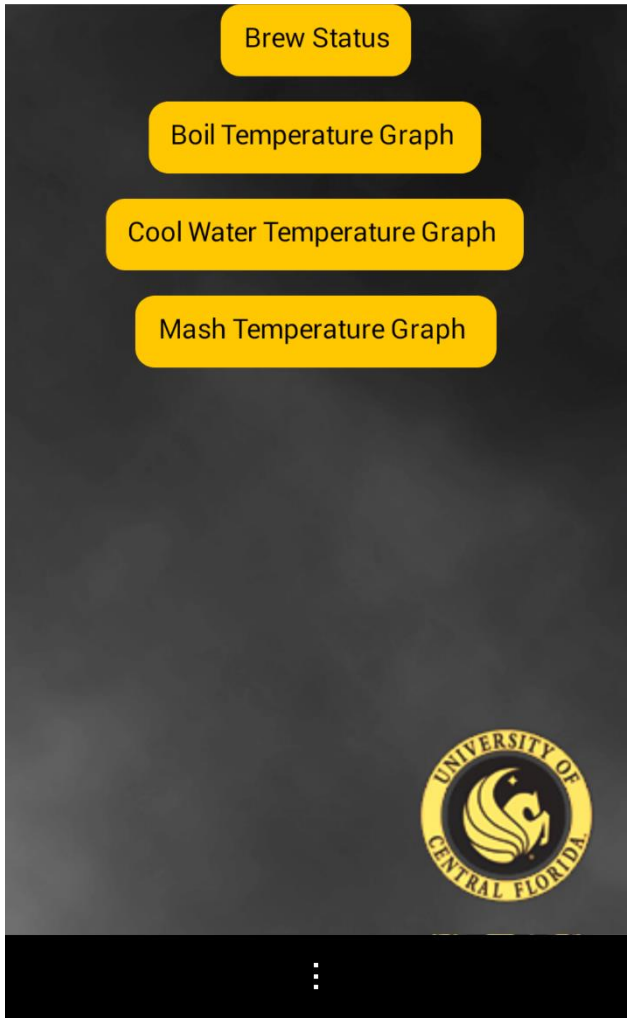
Image Courtesy of: Element14 Community

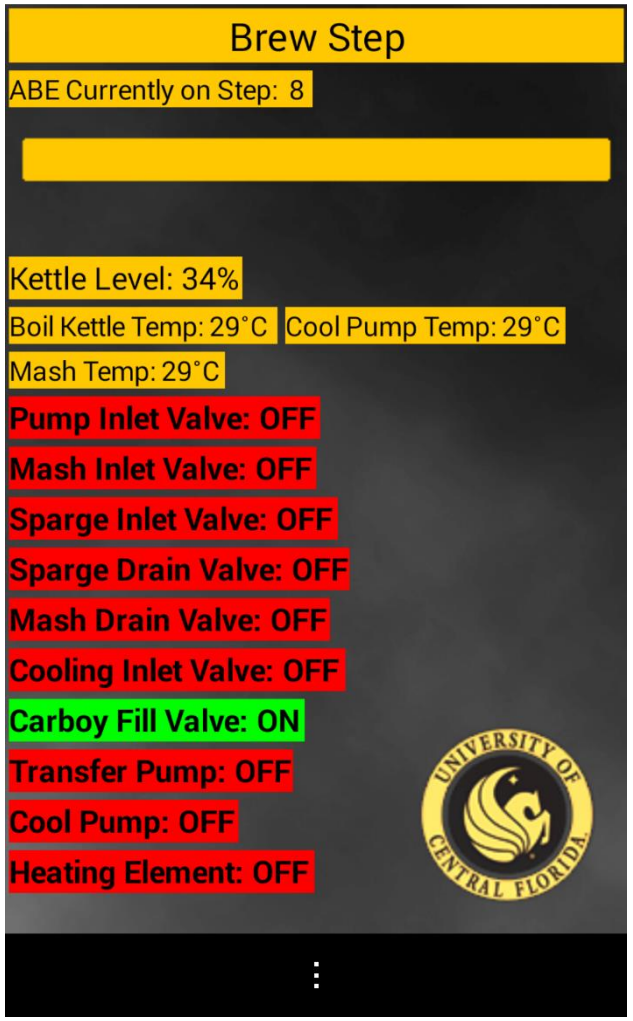
AUTO BREW APPLICATION

- Companion Android Application.
- Bluetooth connectivity to observe the system.
- Save temperature data in the form of graphs

AUTO BREW APPLICATION



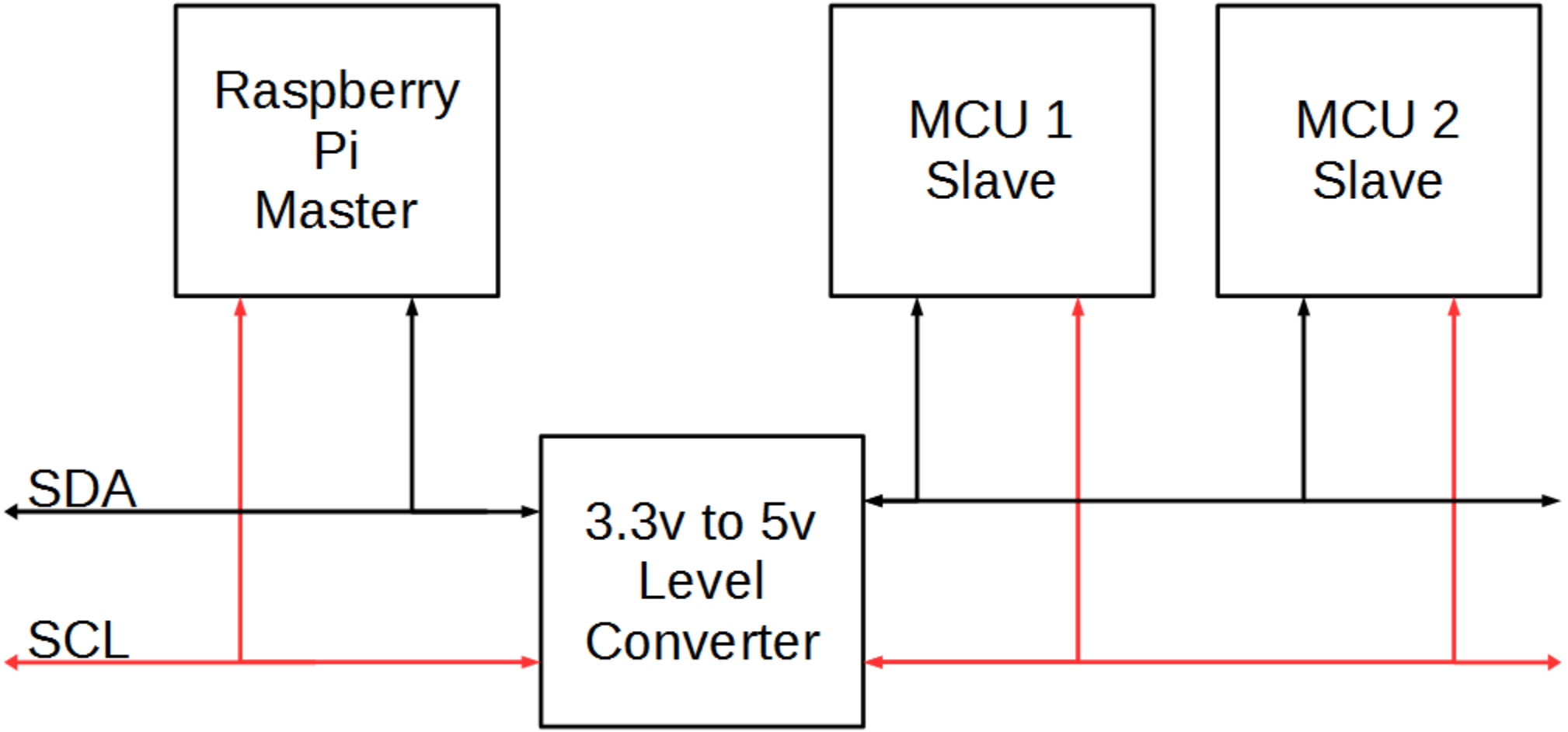




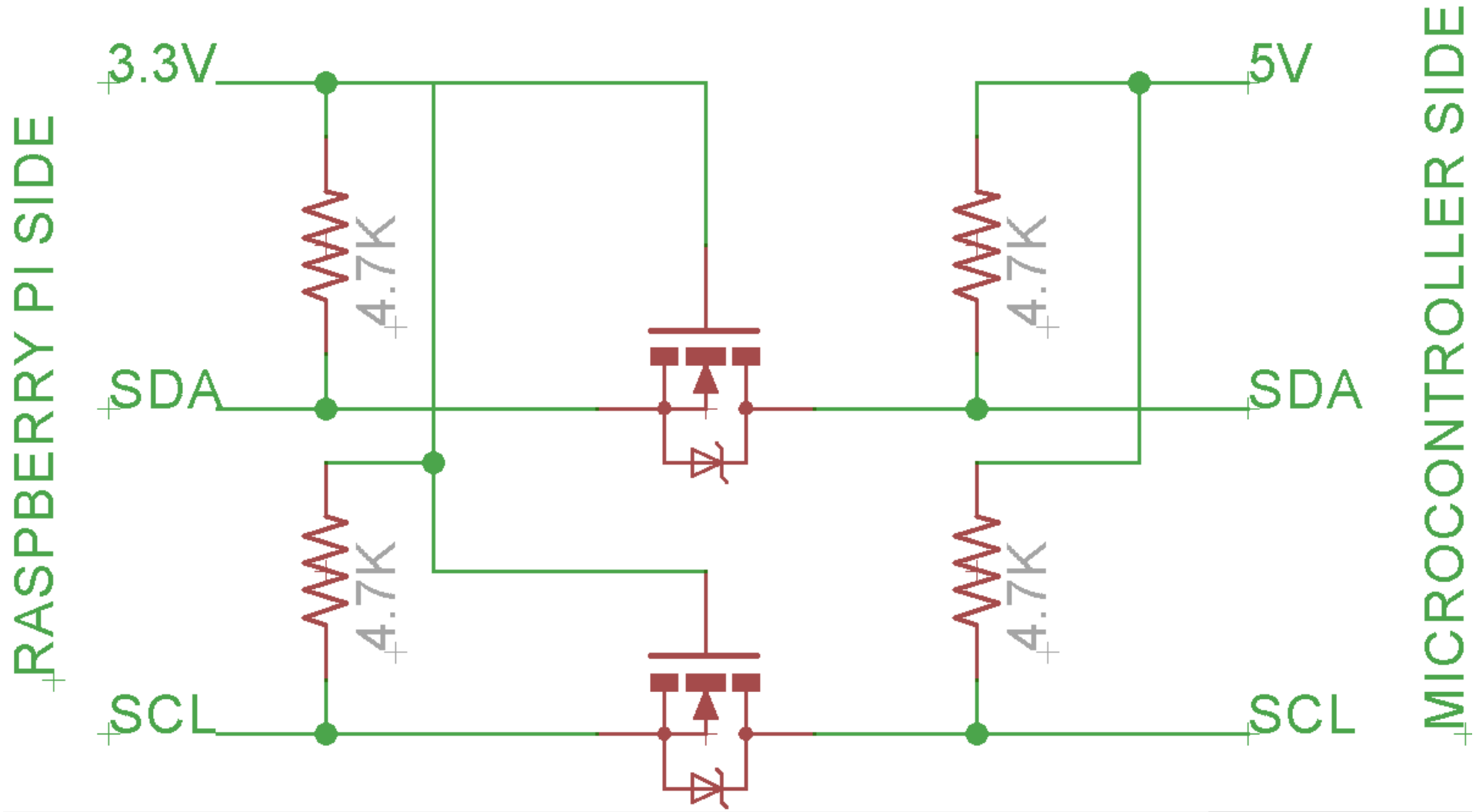
I^2C COMMUNICATION

- Raspberry Pi (Master)
- Two MCU's (Slaves)
- 3.3V to 5V logic level converter
- 3 kHz Clock Rate

I²C BUS


Raspberry
Pi
Master
MCU 1
Slave
MCU 2
Slave
SDA
SCL
3.3v to 5v
Level
Converter

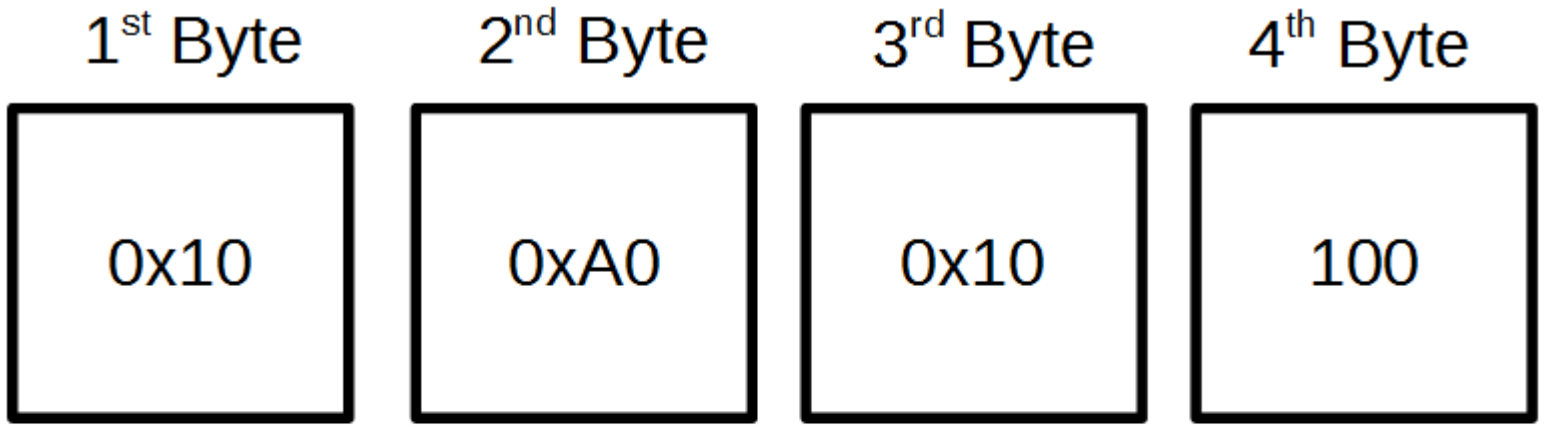
LOGIC LEVEL CONVERTER



BUS CAPACITANCE CALCULATIONS

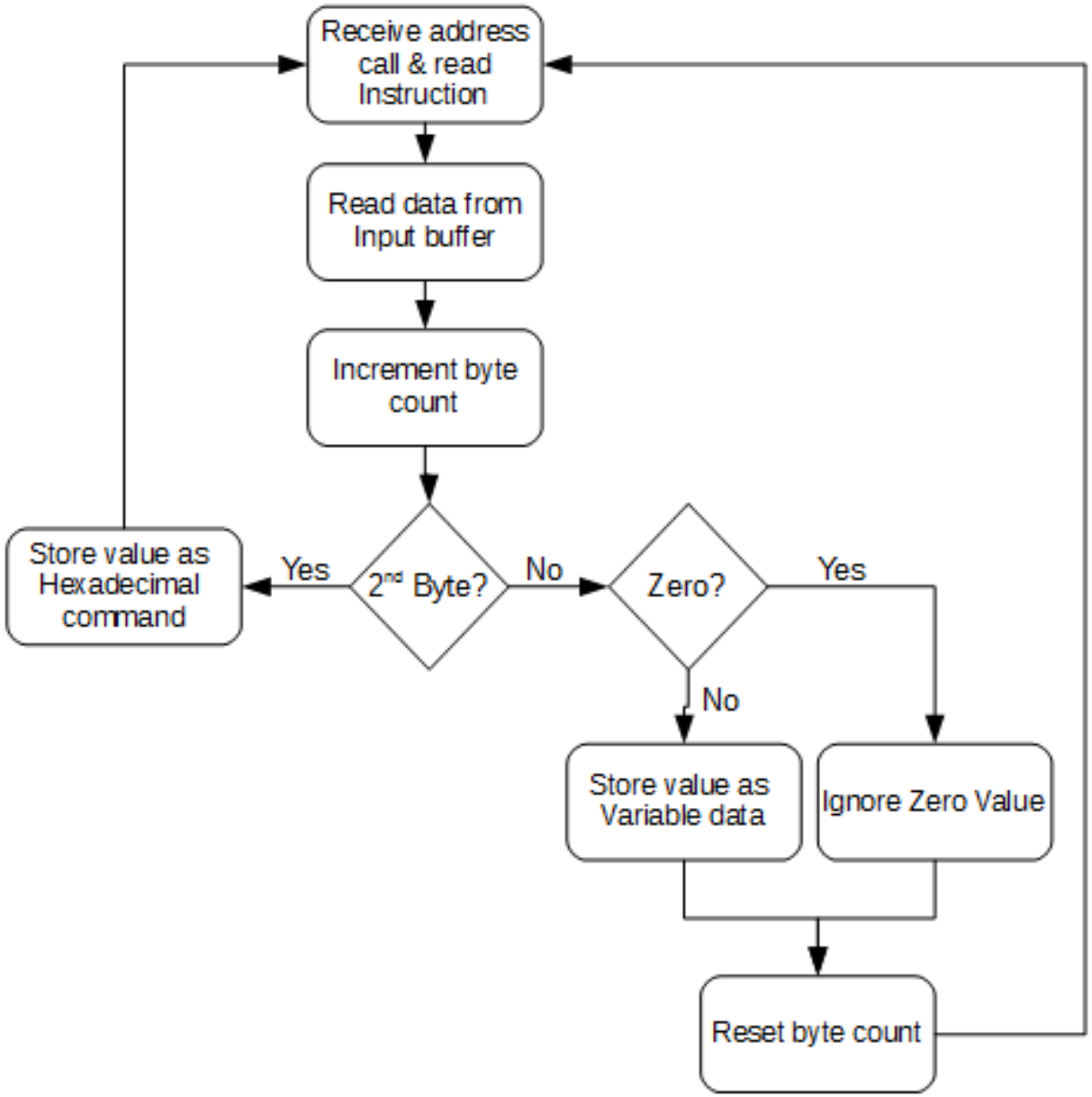
$f_{SCL} \leq 100\ kHz$	$\boldsymbol{R_p = \frac{V_{cc} - 0.4}{3mA}}$	$\boldsymbol{R_p = \frac{1000ns}{C_b}}$

SENDING DATA TO MCU'S

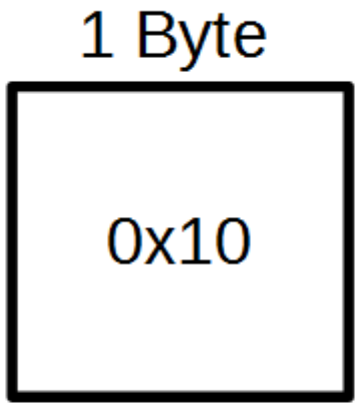


1st Byte: 7 bit MCU address & R/W bit
2nd Byte: Hexadecimal command
3rd Byte: 7 bit MCU address & R/W bit
4th Byte: Variable Data

READING DATA AT MCU'S

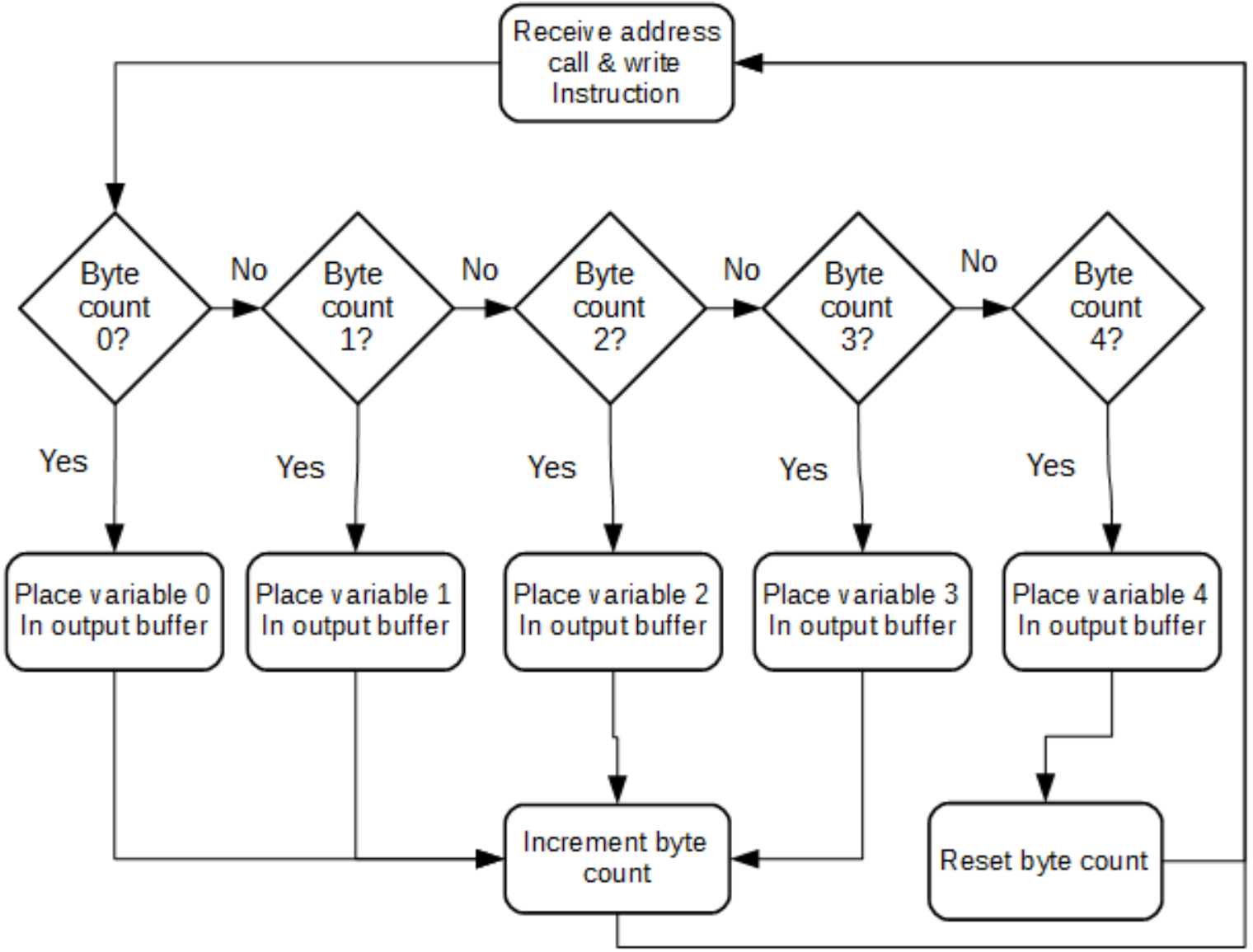


RETRIEVING DATA FROM MCU'S



7 bit MCU address & R/W bit

SENDING DATA FROM MCU'S



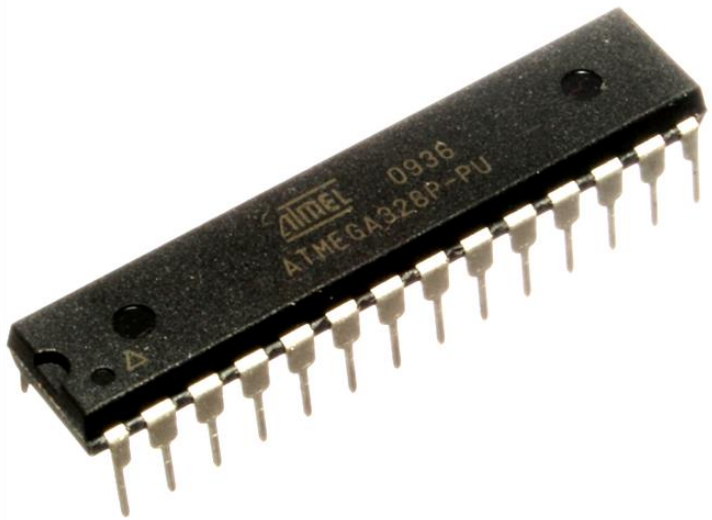
MICROCONTROLLER

Requirements

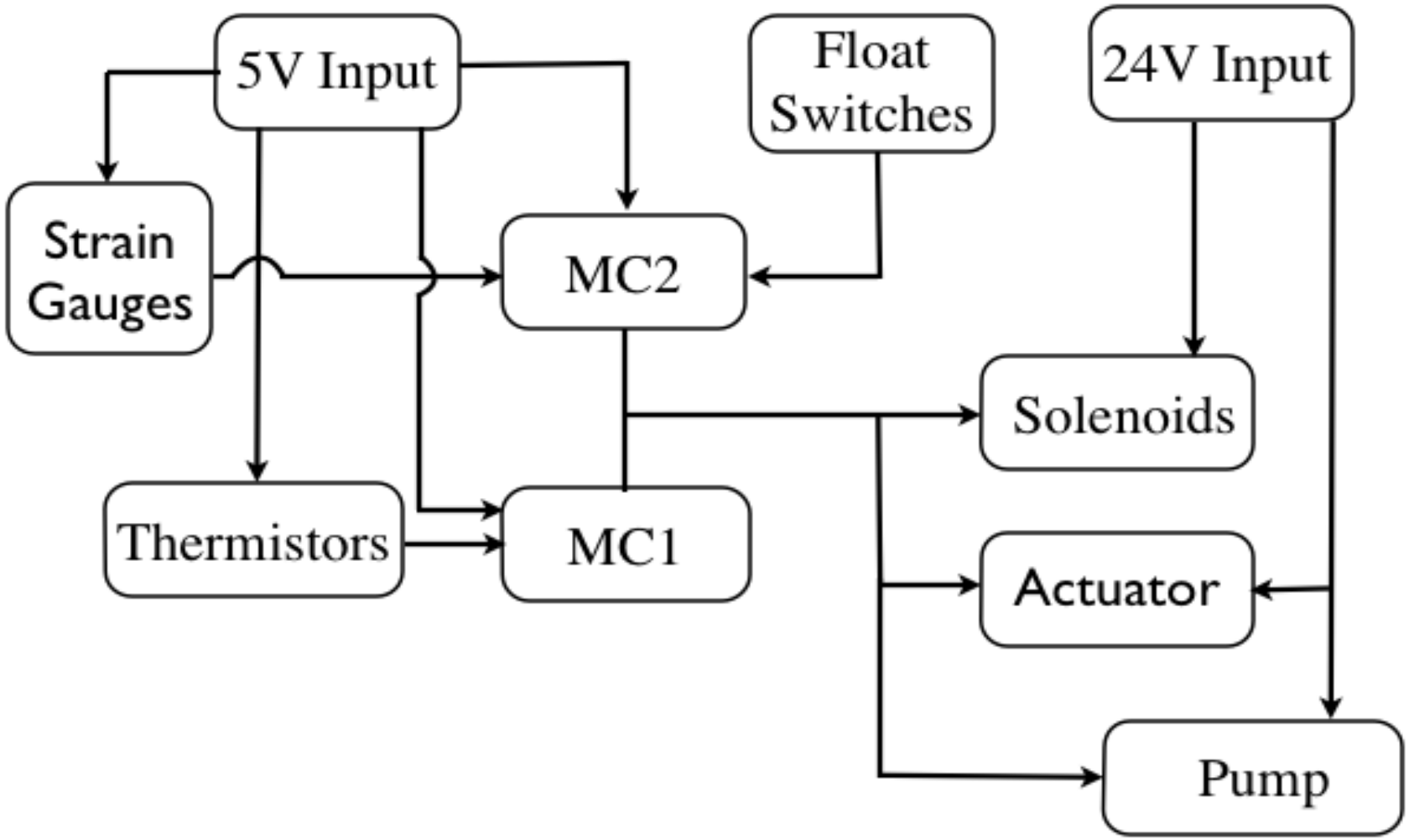
- 5+ Analog to Digital Converters
- 13+ I/O Ports
- I^2C Capability
- Large RAM and Program Memory Capacity
- 5V Operation
- DIP Packaging

MICROCONTROLLER

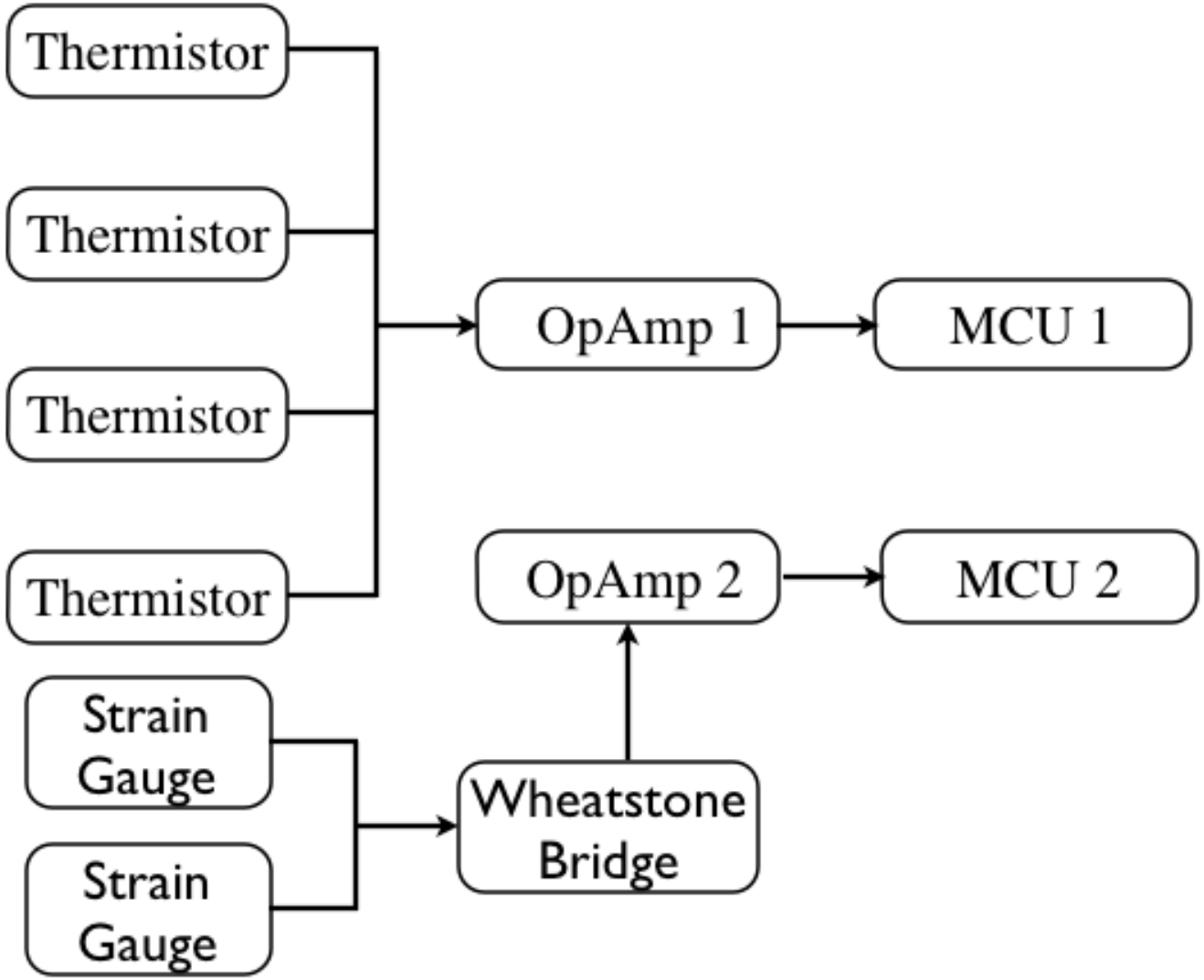
Hardware Comparison of Select Microcontrollers				
	Texas Instruments MSP4302553	Freescale Semiconductor MC9S08SE8CRL	Microchip Technologies PIC16C73B	Atmel ATMEGA 328P-PU
Package	PDIP-20	PDIP-28	PDIP-28	PDIP-28
ADC Channels	8	10	5	6
ADC Bit Size	10	10	8	10
I/O	16	24	22	23
Communication	I^2C, UART, SPI, IrDA	SCI	I^2C, USART, SPI	I^2C, USART, SPI
Supply Voltage	1.8 - 3.6 V	2.7 - 5.5 V	4.0 - 5.5 V	1.8 - 5.5 V
Timers	2	2	3	3
RAM size	512 Byte	512 Byte	192 Byte	2 kByte
Program Memory	16 kByte	8 kByte	4 kByte	32 kByte
Max Clock Freq.	16 MHz	20 MHz	4 MHz	20 MHz



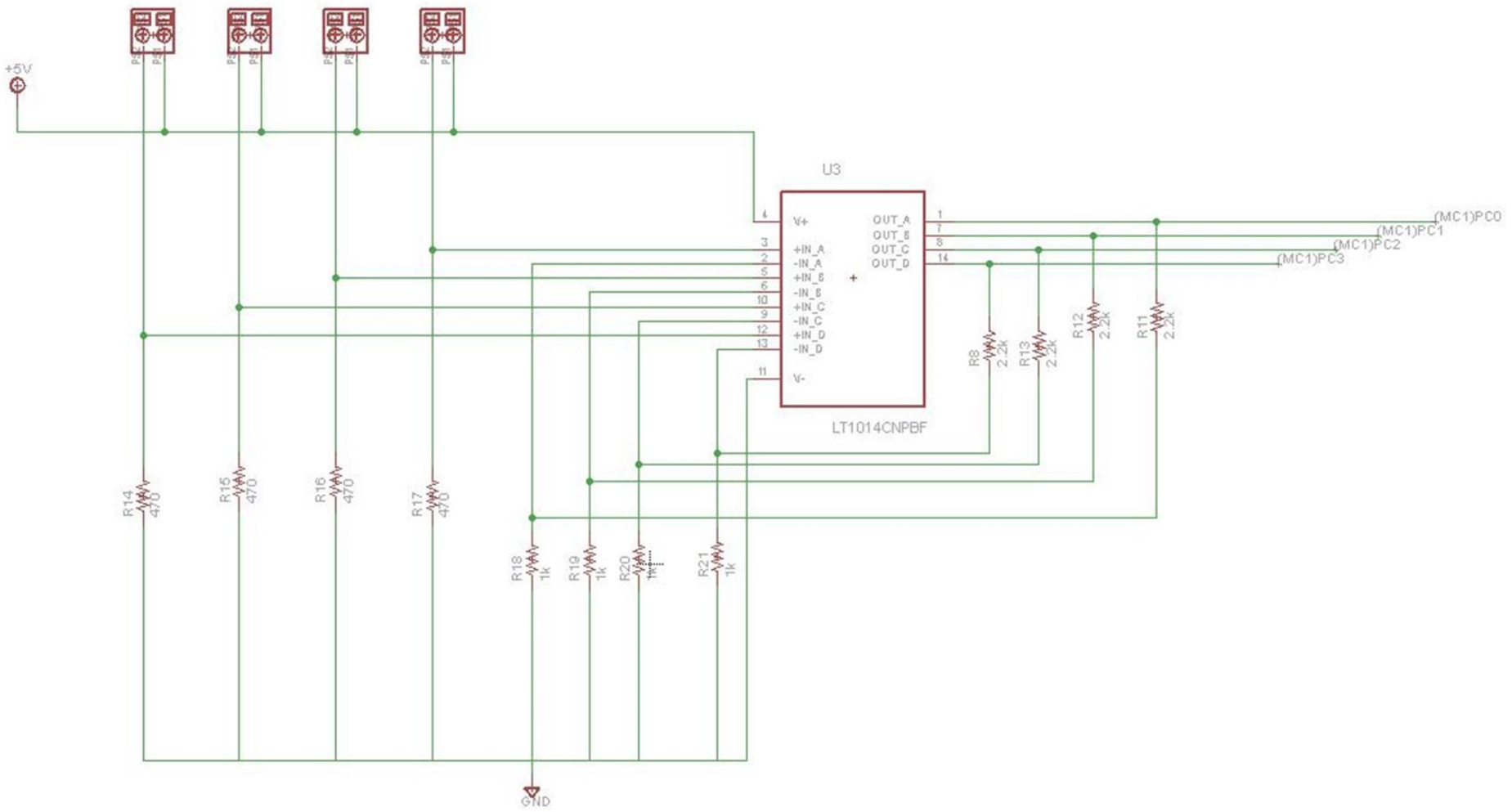
DATA ACQUISITION



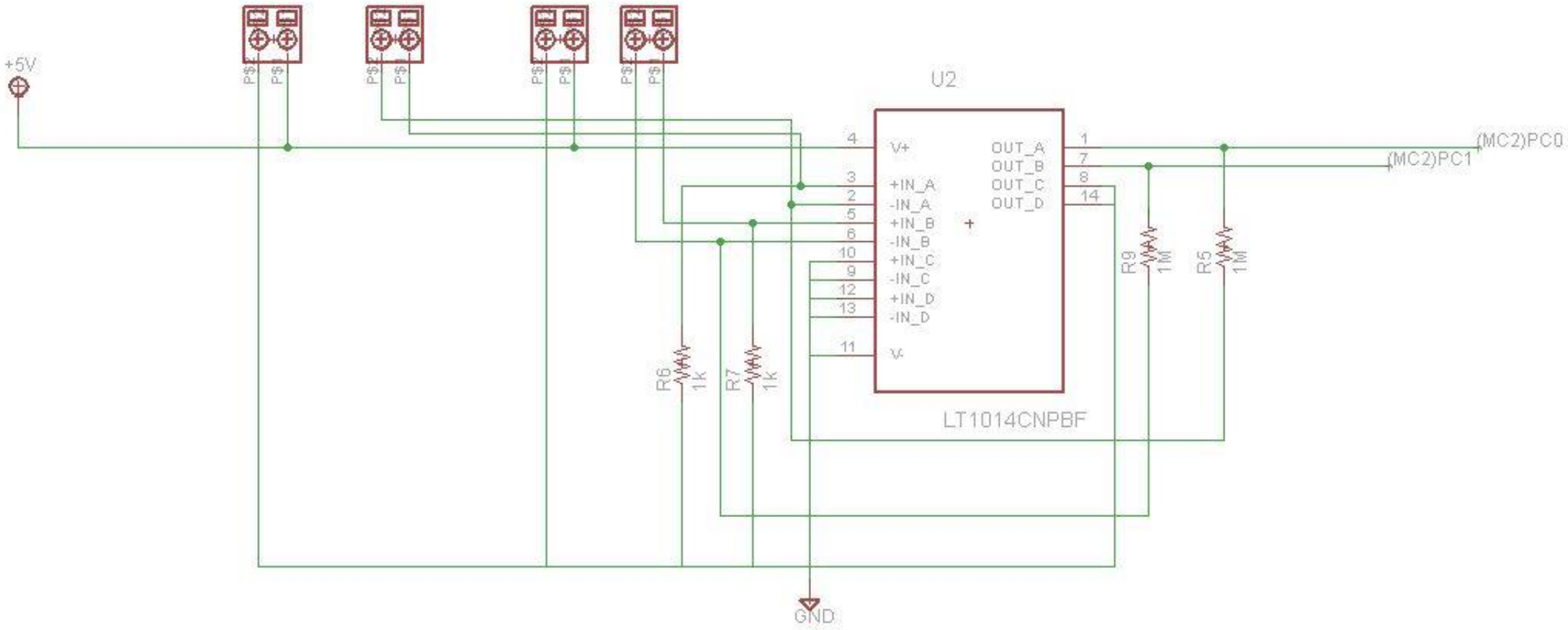
DATA ACQUISITION



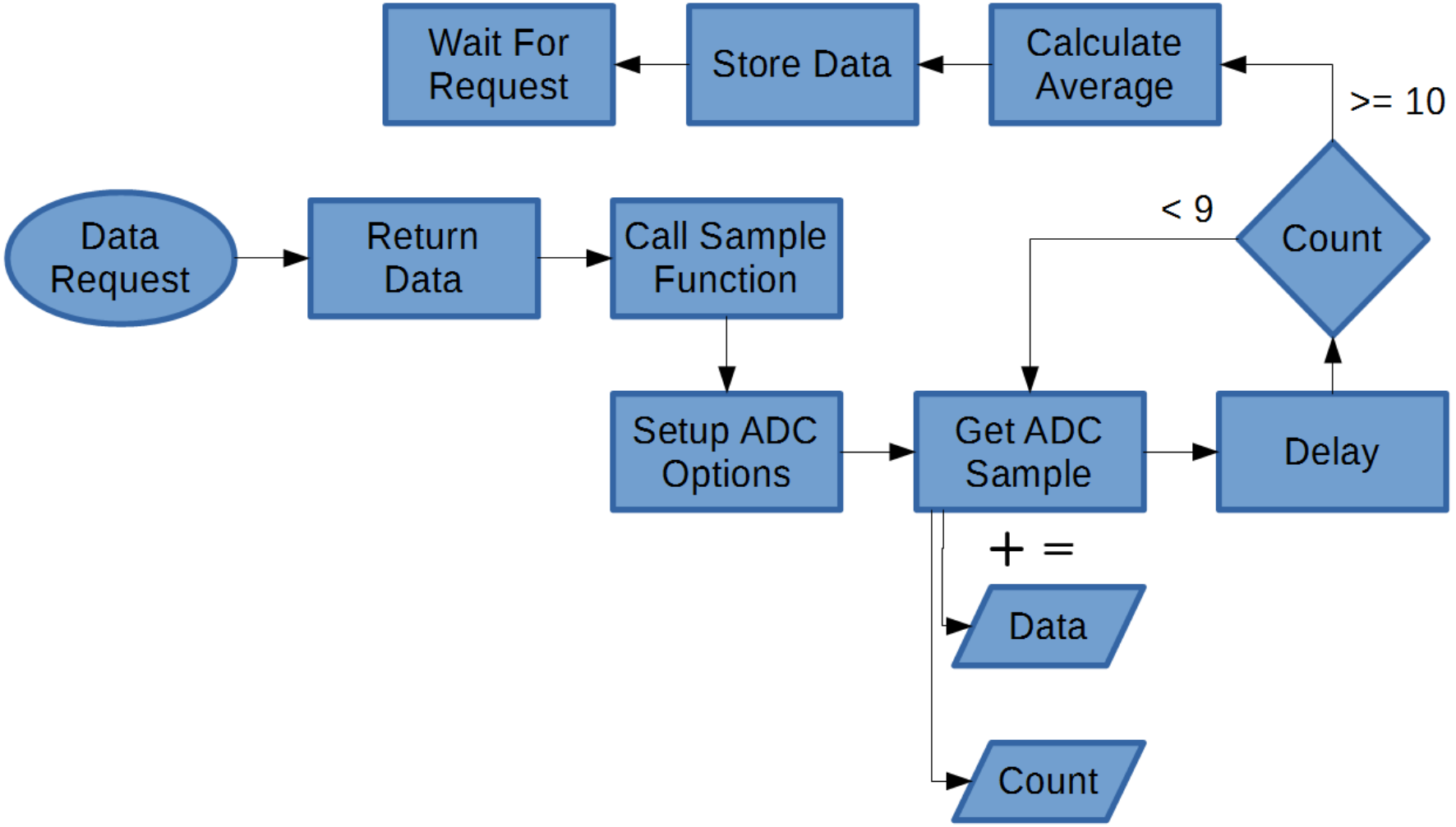
TEMPERATURE SENSOR CIRCUIT



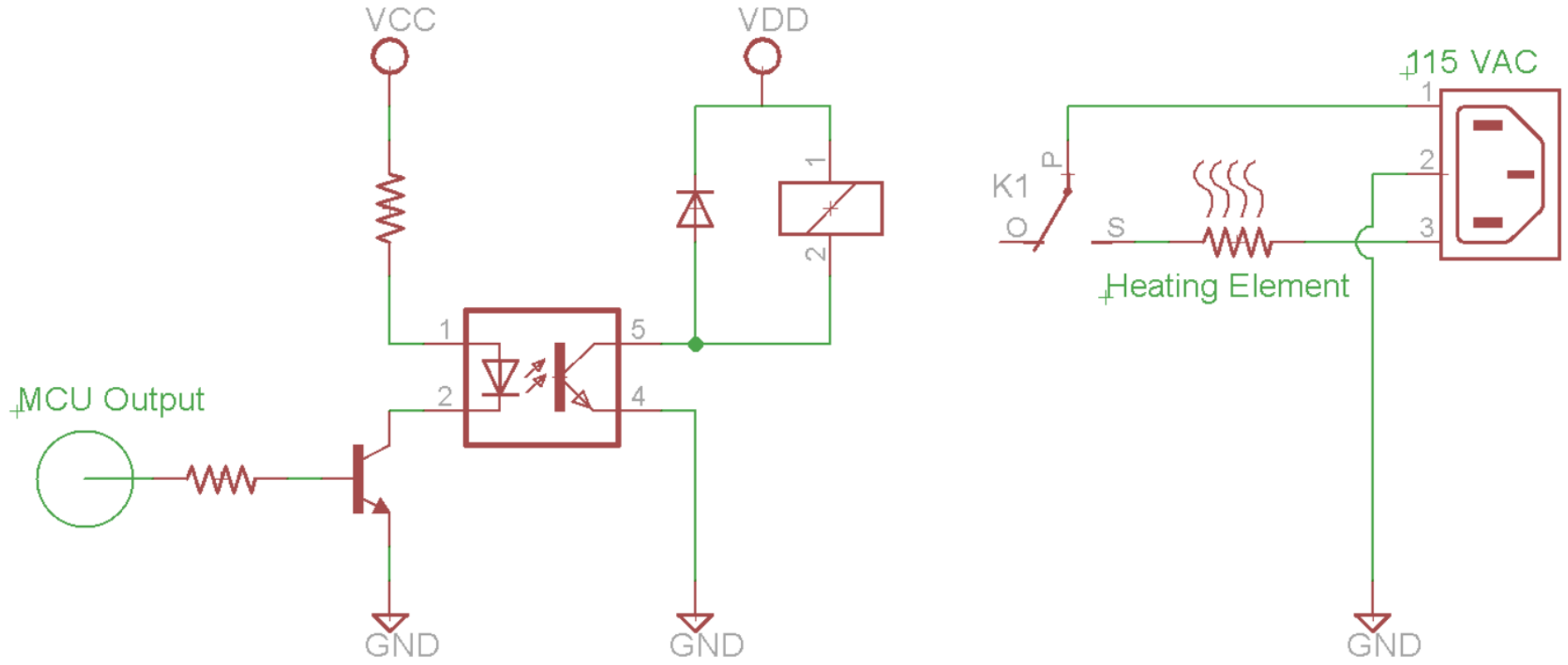
WEIGHT SENSOR CIRCUIT



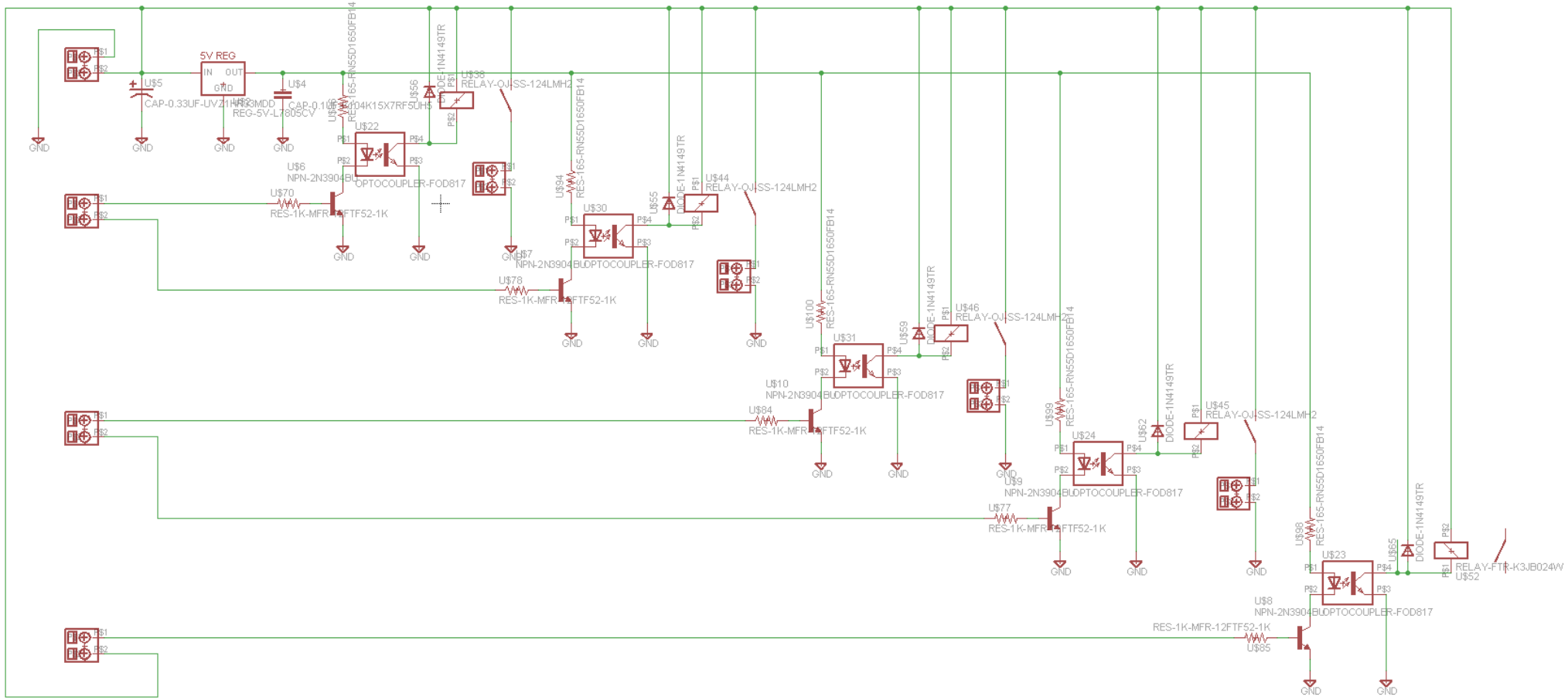
MICROCONTROLLER SAMPLE PROCESS

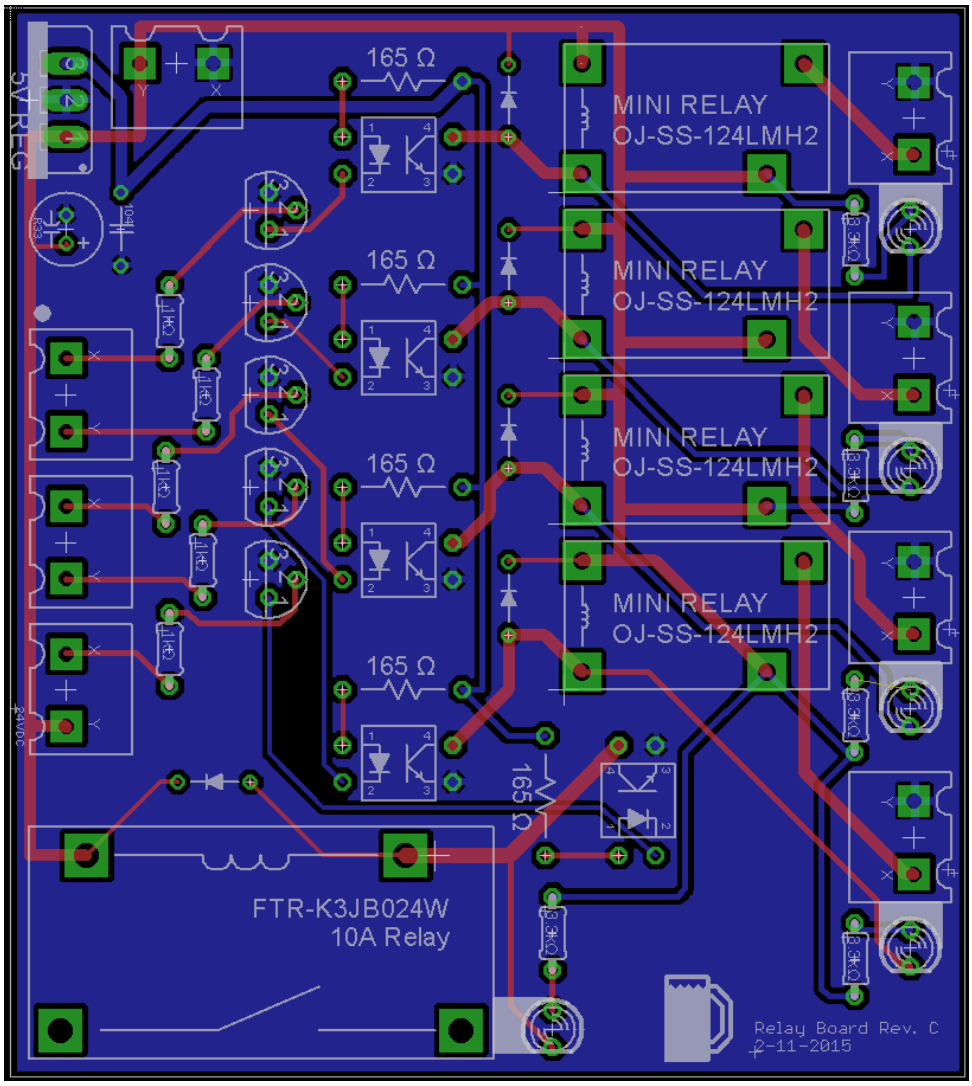


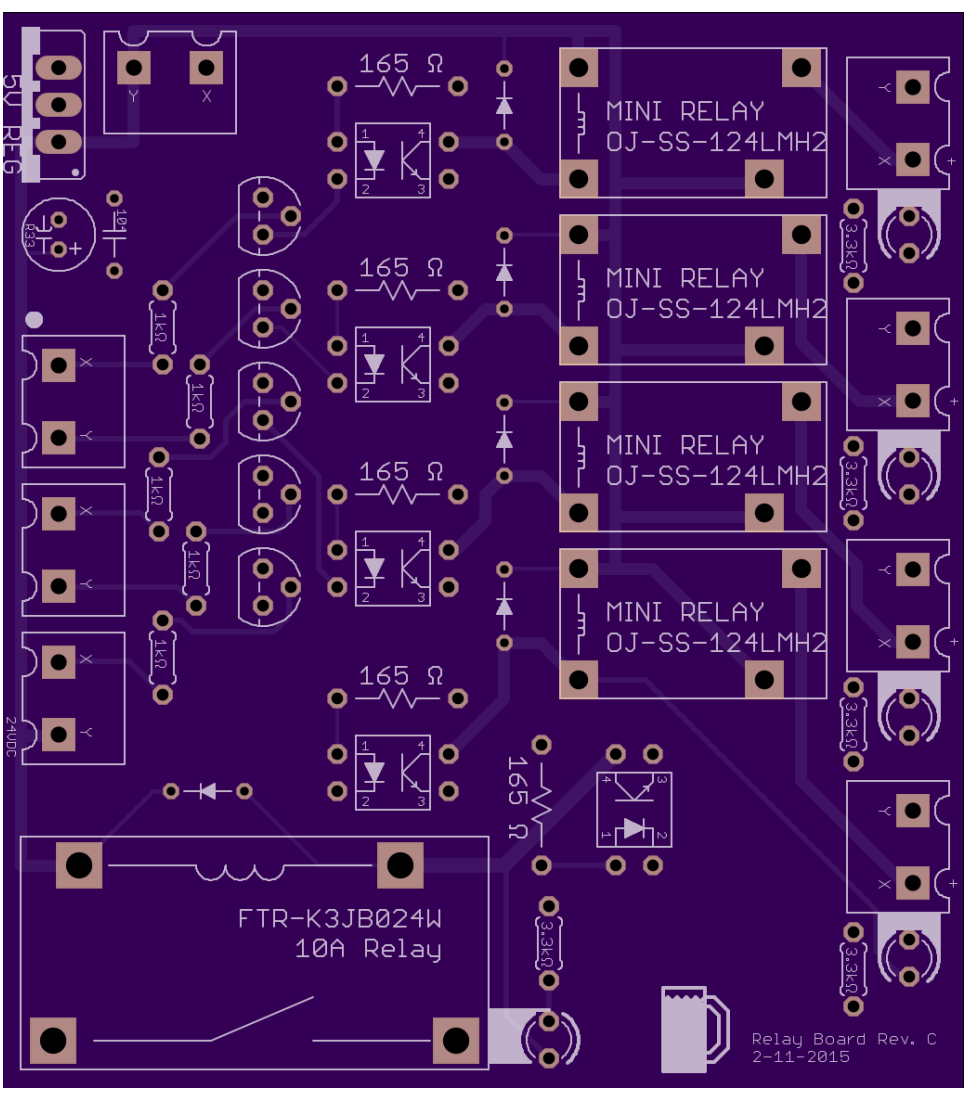
MICROCONTROLLER - SWITCHING HIGH POWER COMPONENTS

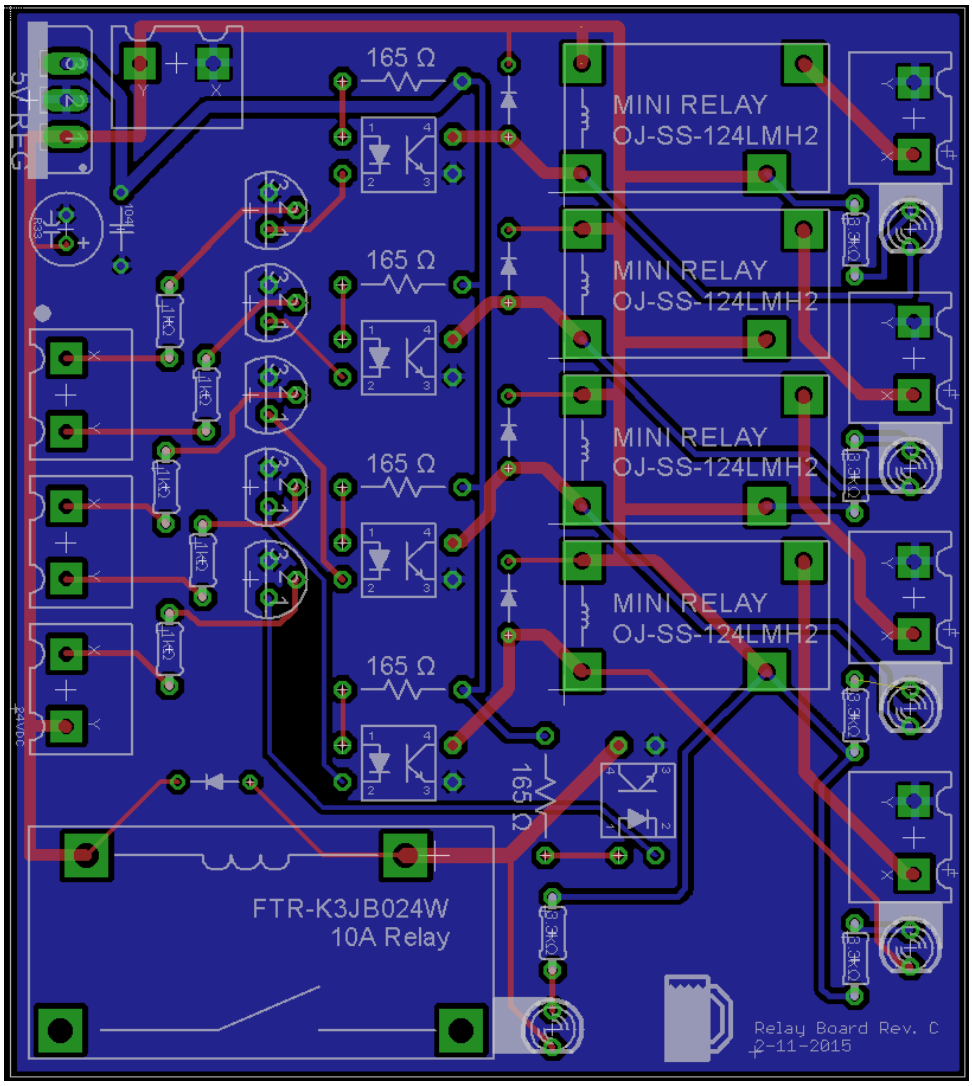


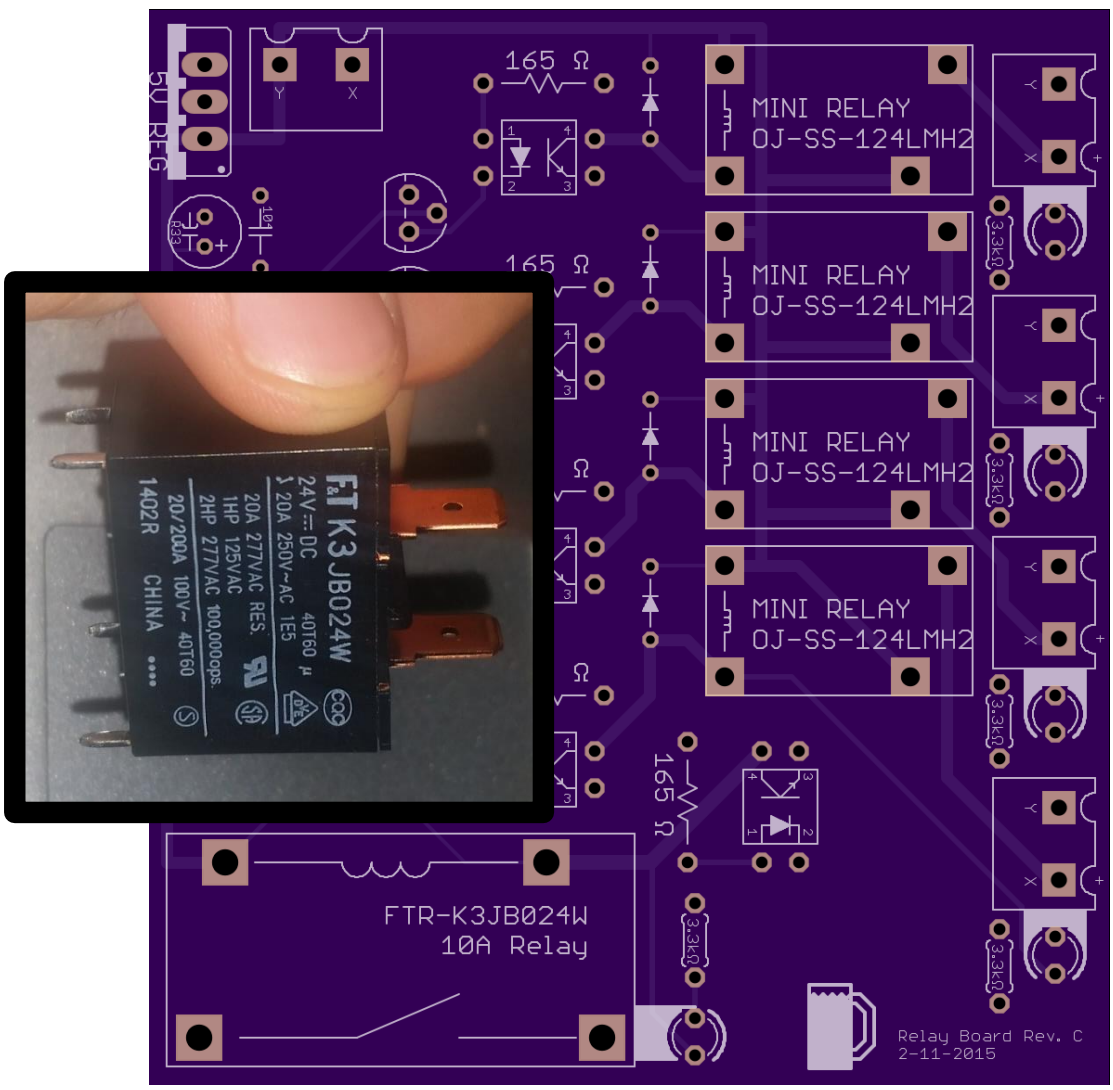
MICROCONTROLLER - SWITCHING HIGH POWER COMPONENTS



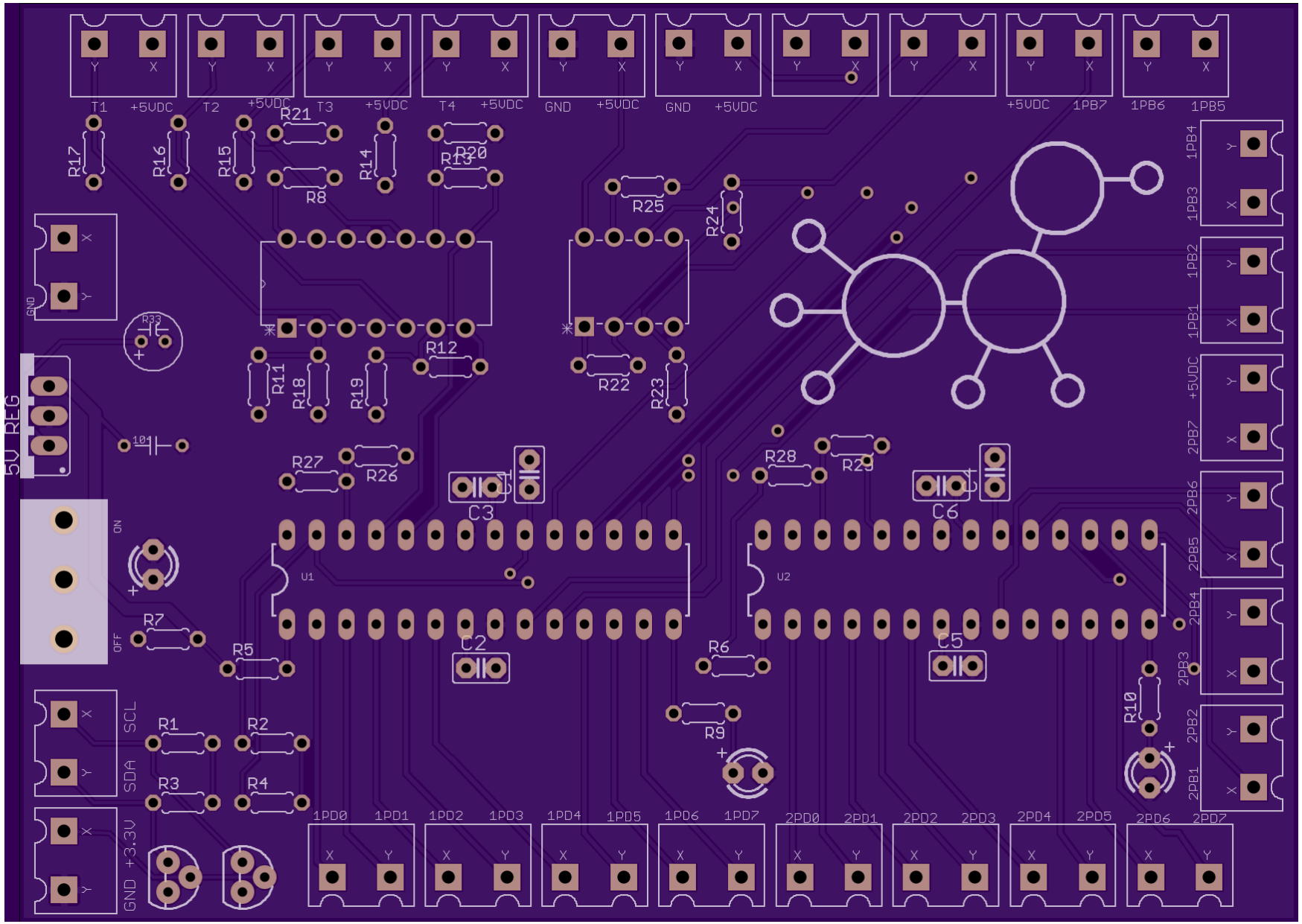

5V REG
165 Ω
MINI RELAY
OJ-SS-124LMH2
FTR-K3JB024W
10A Relay
Relay Board Rev. C
2-11-2015

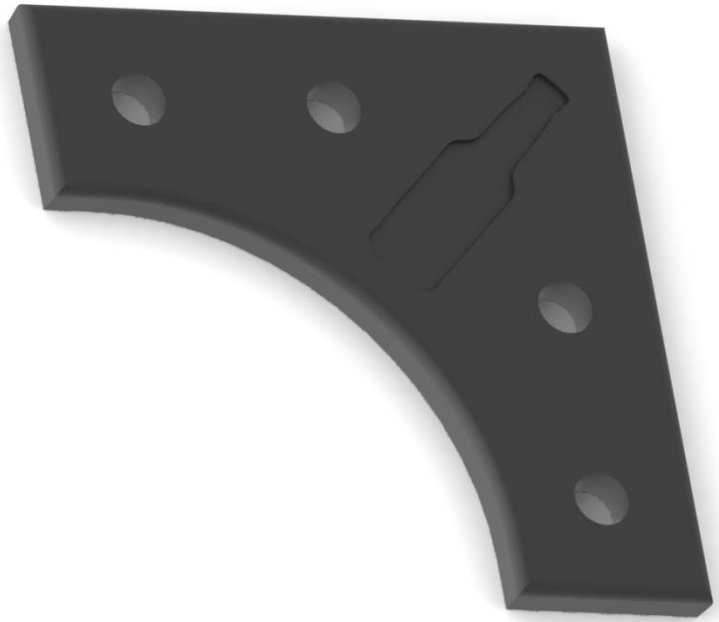

5V REG
165 Ω
MINI RELAY
OJ-SS-124LMH2
FTR-K3JB024W
10A Relay
Relay Board Rev. C
2-11-2015

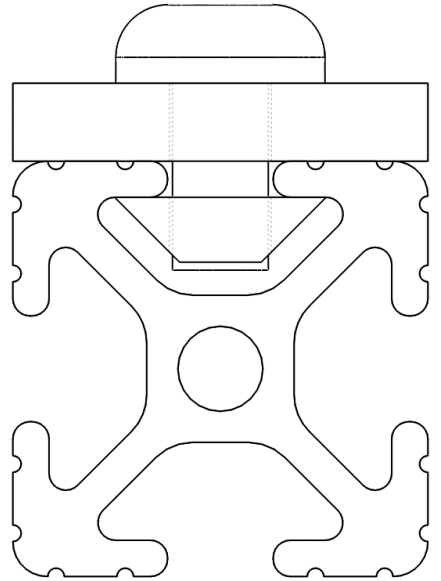

5V REG
165 Ω
MINI RELAY
OJ-SS-124LMH2
FTR-K3JB024W
10A Relay
Relay Board Rev. C
2-11-2015


5V REG
165 Ω
MINI RELAY
OJ-SS-124LMH2
FTR-K3JB024W
10A Relay
Relay Board Rev. C
2-11-2015

MAIN BOARD LAYOUT







RESPONSIBILITIES

Group Member	Primary	Secondary
Rob	Controls/Communication	UI
Alonzo	Sensor Design/Programming	Structure Design
David	User Interface	Data Logging
Kleber	Sensor Design	Android App

BUDGET(NEED TO UPDATE)

Item	Supplier		Spent	Budget
Structure				
Dunkelweizen Beer Kit	Brock's Hombrew		$ 38.15	
Coleman 2-Gallon cooler	Walmart		$ 14.70	
2 Gallon Stainless Steel Kettle	Northern Brewer		$ 22.98	
1 Gallon Clear Glass Carboy	Northern Brewer		$ 27.95	
Solenoid Valve (x4)	eBay(valves4projects)		$ 97.00	
Solenoid Valve (x4)	eBay(u-like-buy)		$ 24.92	
Heat Exchanger	eBay(dudadiesl)		$ 45.95	
Hose & Fittings	US Plastics		$ 37.37	
SS NPT Barb Adapters	eBay(dailydeal*2013)		$ 19.80	
Aluminum Extrusion & Hardware	Amazon (8020 Inc.)		$ 124.57	
Coolers	Target		$ 15.49	
		Subtotal	$ 468.88	$ 600.00
Electrical Components				
LT1014DN Op Amp(x2)	Linear Technology		$ 24.80	
NTCAIMME3C90373(Thermistorx4)	Mouser Electronics		$ 15.51	
Relay Board Components	Mouser Electronics		$ 47.54	
Voltage Regulators & Caps	Mouser Electronics		$ 23.98	
Terminal Blocks (x48)	eBay (szyuhua)		$ 7.75	
PCB Relay Board Rev B	OSH Park		$ 37.50	
Heating Element	Amazon		$ 21.57	
Dip Socket	Newark		$ 3.30	
Main Board Components	Newark		$ 43.29	
PCB Main Board	Osh Park		$ 65.43	
		Subtotal	$ 290.67	$ 400.00
		Total	**$ 759.55**	**$ 1,000.00**

PROJECT DIFFICULTIES

- Solenoid valves clogging
- Blown power supply
- Data types in python (combining GUI software and control software)
- Stable Bluetooth communication
- Sealing the insulated tanks (coolers)
- Faulty equipment
  - Pumps
  - Solenoid valves
- Faulty electronic hardware
  - Op-Amps
  - Relays

PROJECT SUCCESSES

- I^2C communication
- SMS notifications
- Email notifications
- Process control
- Temperature control
- Fluid level control
- Android application
- User interface
- High power switching