



VEX VRC – 2021 / 2022

Reverse Engineering Online Challenge

Summary Report



NDS Robotics
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Word count: 471 (without title page and image captions)

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1. Introduction

Our VEX team consists of seven (7) members. We are all hard-working students, and we are dedicated at every practice, and for every project. Due to the rigorous requirements of robotics competitions, we often enjoy a nice cup of coffee to keep us focused. During one of our robotics practices, our coach's coffee machine broke down and dried up our supply of coffee. That was a very tragic moment.

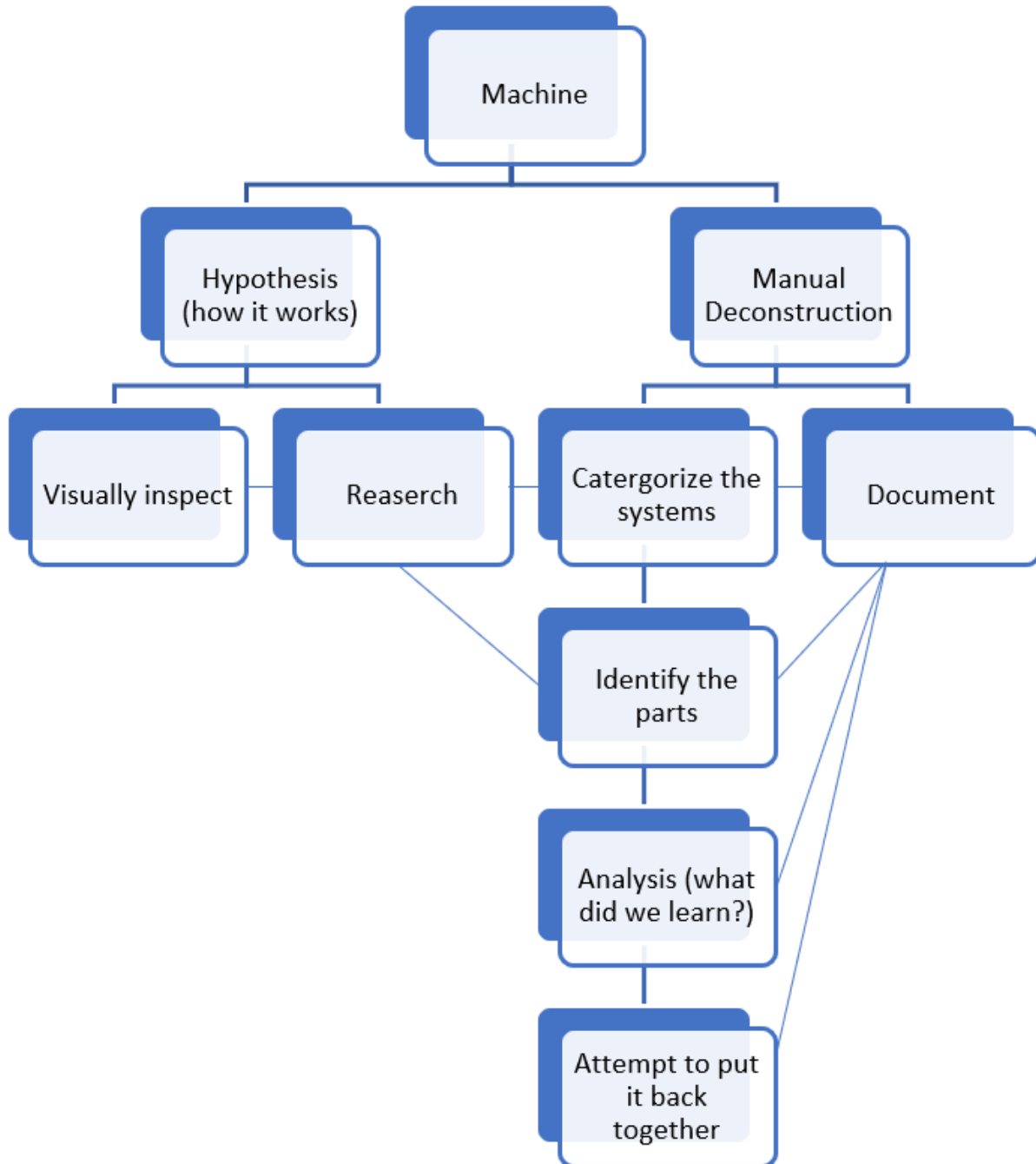
Alas, came the Reverse Engineering Challenge. We took this opportunity, with out coach's permission, to use the coffee machine for the Reverse Engineering Challenge with the hopeful outcome of finding the problem and getting it fixed! Other items we considered for this challenge included an X-Box and an old iPhone. None however provided the opportunity to fix a broken machine, and restore balance to our robotics team with a proper cup of java.



Figure 1: Team..."Why does this coffee machine not work?"

2. Approach

The first step was to establish the steps for the project as a team.



Flow Chart 1: Reverse Engineering Action Plan for Coffee Machine

3. Disassembly

We disassembled the coffee machine making sure we took lots of photos.

Tools needed:

- Safety Glasses
- Phillips screwdriver
- Hex screwdrivers

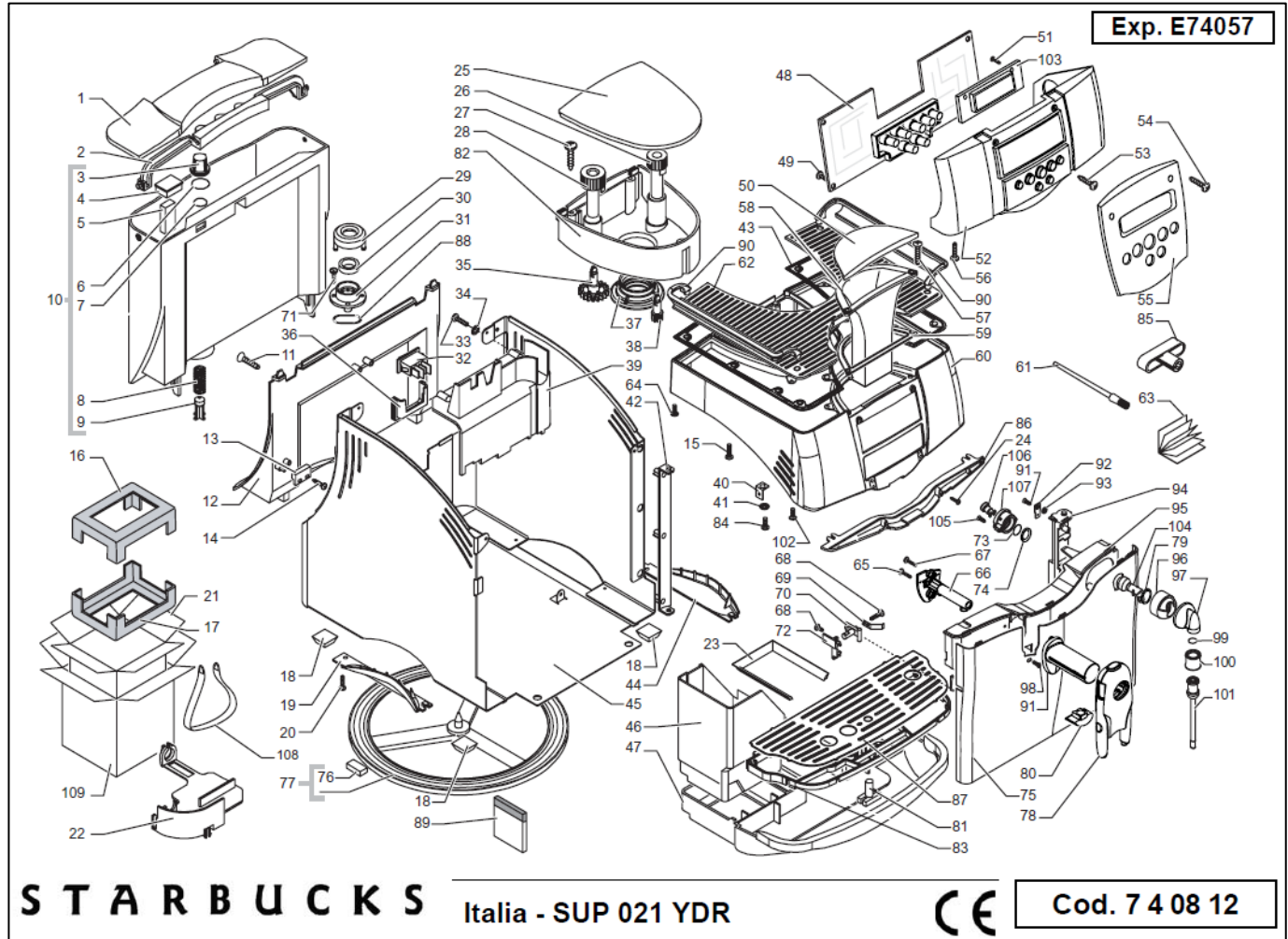


Figure 2: Parts Schematic of Coffee Machine



Figure 3: Coffee Machine before disassembly

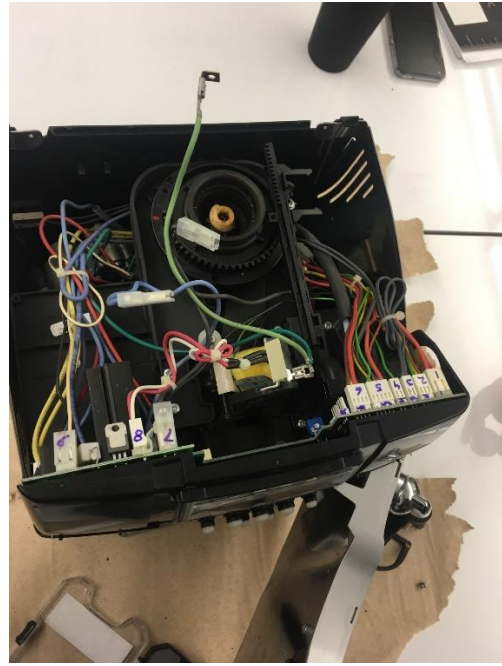


Figure 4: Coffee Machine with top off

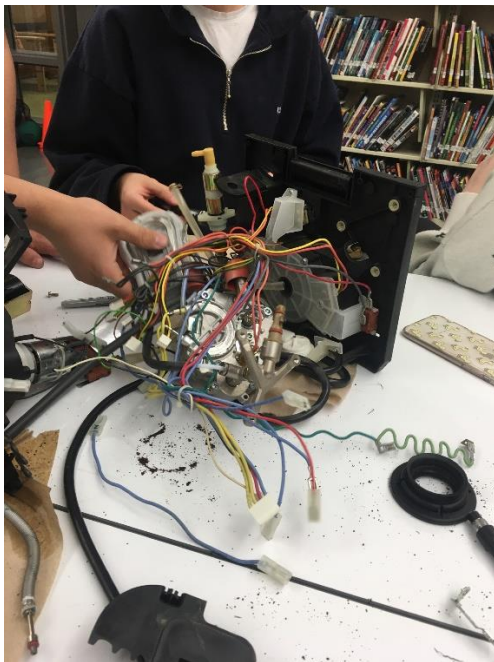


Figure 5: The "innards" of the Coffee Machine

4. Device Components

4.1. Non-Electronic Components

Description	Photo
Water Reservoir (holds water for making coffee)	
Grinder Unit (grinds the coffee beans into a powder)	
Brew Unit (compresses the grinded coffee beans into a puck)	
Water Pump (pumps water from the reservoir to the Boiler Unit)	
Boiler Unit (heats the water from the water reservoir before pumping it to the Brew Unit)	

4.2. Electronic Components

4.2.1. Circuit Board

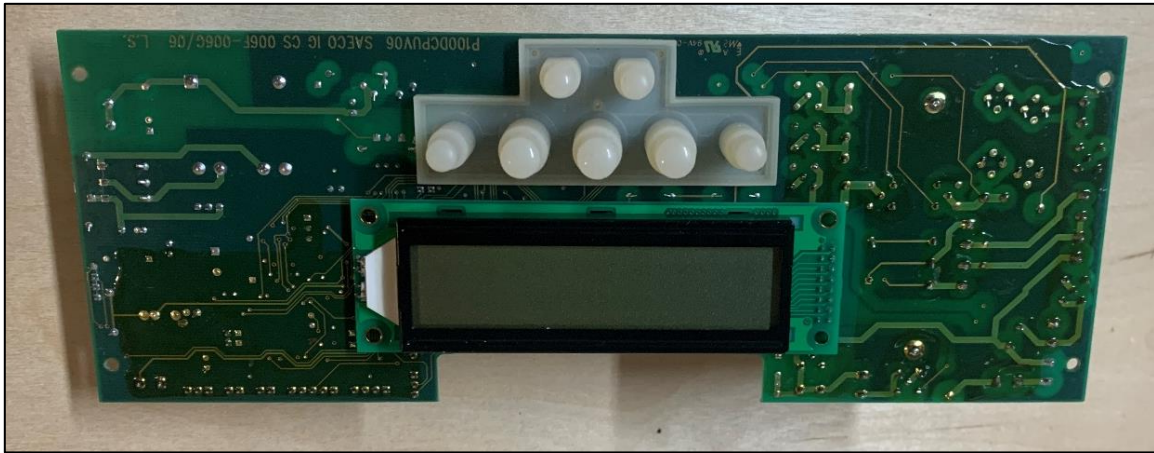


Figure 6: Back side of circuit board with buttons and LCD Display

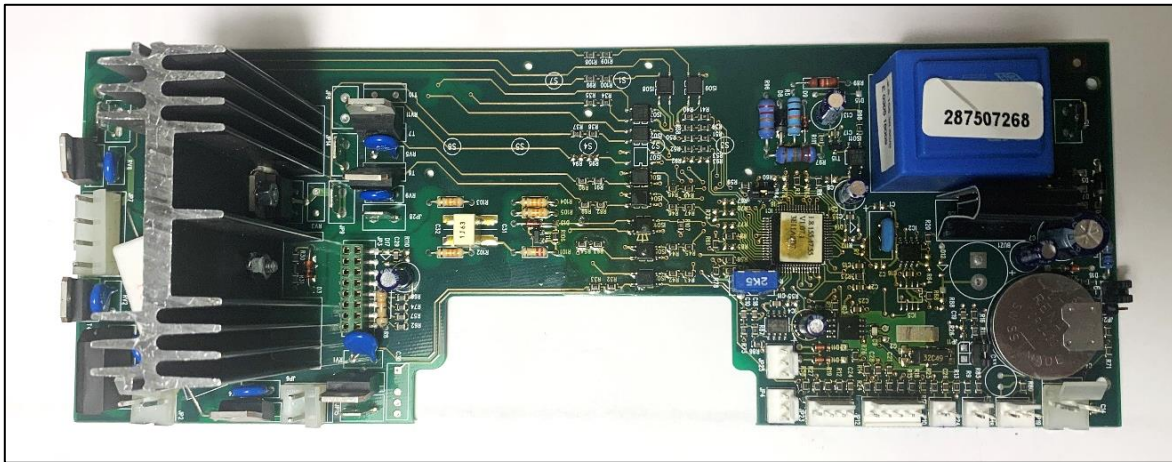


Figure 7: Front side of circuit board

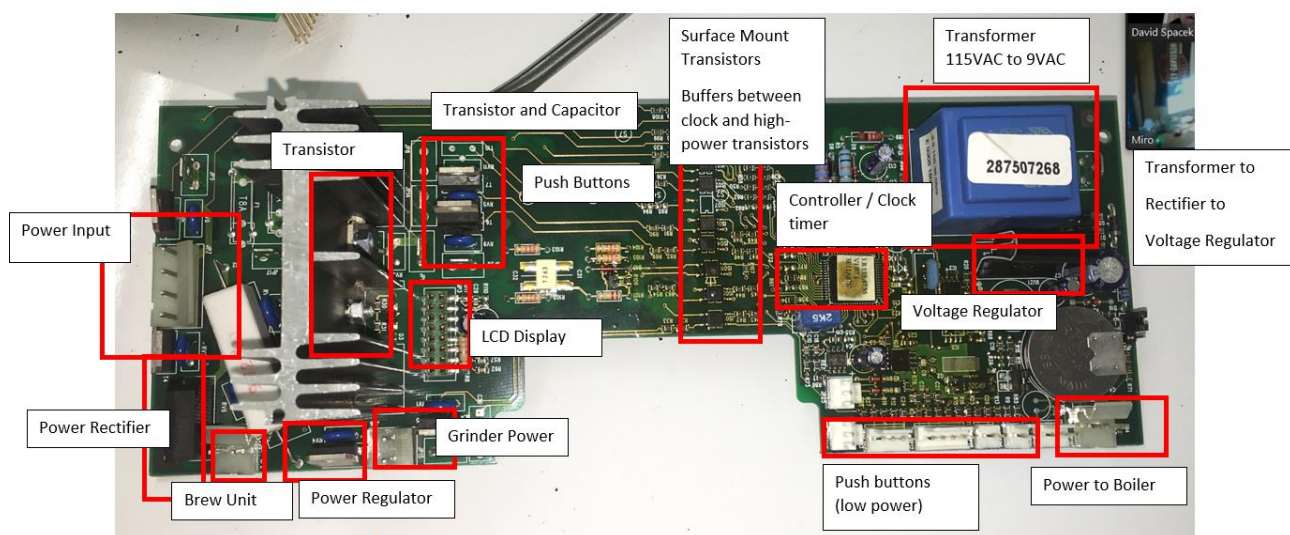
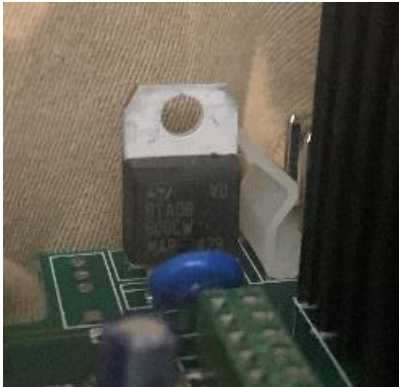


Figure 8: Circuit Board Components

4.2.2. Circuit Board Components

Part and Description	Image	Location
BTA08 Triac Thyristor This triac is designed for high performance full-wave ac control applications where high noise immunity and commutating are required. Data Sheet https://www.littelfuse.com/media?re sourcetype=datasheets&itemid=30e3f086-1f52-4529-bd90-cc46200e5faf&filename=littelfuse-thyristor-bta08-600bw3-d-datasheet		
32C49 IC This is a 32768 Hz crystal for the Clock. Data Sheet https://www.rockbox.org/wiki/OlympusMR100HardwareComponents At 16bits, it will count up to 32,768 every second, which is the speed of the clock oscillator.		
7705AC (IC) Supply-Voltage Supervisors Data Sheet https://www.digchip.com/datasheets/parts/datasheet/477/7705AC.php		

4-Strip Resistors

Orange and Gold resistors (R104, R105)

Resistance: 33.00k Ohms

Tolerance: $\pm 5\%$

Minimum: 31.350000k Ohms

Maximum: 34.650000k Ohms

Red, Yellow and Gold resistor (R101)

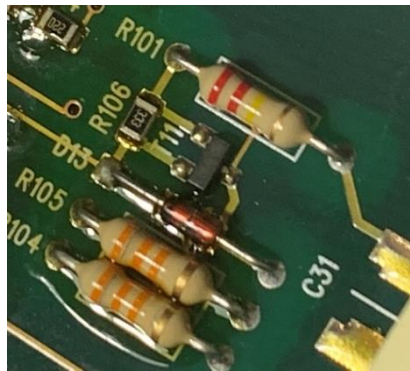
Resistance: 220.00k Ohms

Tolerance: $\pm 5\%$

Minimum: 209.000000k Ohms

Maximum: 231.000000k Ohms

[Resistor Color Code Calculator and Chart \(4-band, 5-band or 6-band\) - Electrical Engineering & Electronics Tools \(allaboutcircuits.com\)](#)

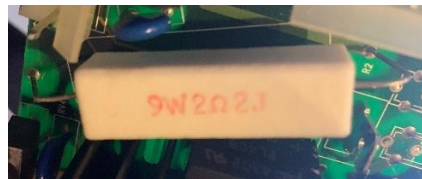


High-current resistor

9 Watts, 2 ohms

Data Sheet

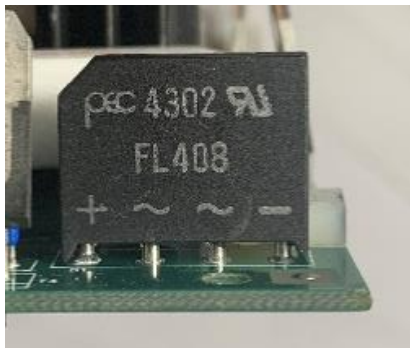
https://www.pcboard.ca/technical_notes/power_resistors.pdf



FL408 Bridge Rectifier – In line miniature single phase silicon Bridge
Surge overload rating 200 AMP peak,
ideal for printed circuit boards

Data sheet

<https://www.digchip.com/datasheets/parts/datasheet/352/FL408-pdf.php>

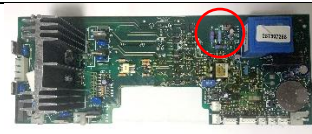
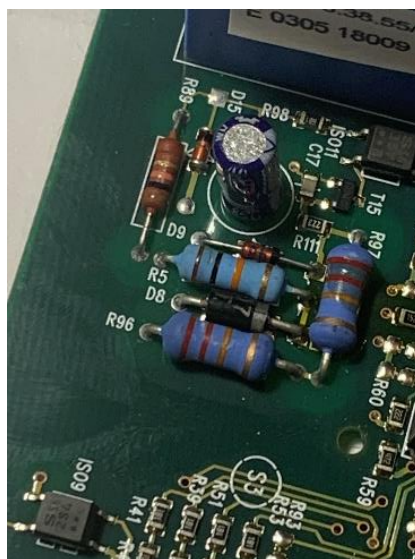


HVR37 Vishay Resistor

High voltage Metal Film Leaded Resistors feature high pulse loading (up to 10kV). The Vishay / BC Components HVR25, HVR27 Metal Film Leaded Resistors are ideal for power supplies, electronic ballast, white goods, and television.

Data sheet

[HVR3700007153FR500 datasheet - The Vishay / BC Components HVR25, HVR27 high ohmic \(digchip.com\)](#)

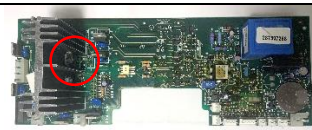


BTA16 Triac

Suitable for general purpose applications where high surge current capability is required. Applications such as phase control and static switching on inductive or resistive load.

Data sheet

[BTA16 pdf](#), [BTA16 description](#), [BTA16 datasheets](#), [BTA16 view ::](#)
[ALLDATASHEET ::](#)



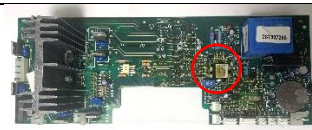
IC1 - Microcontroller

Could not find manufacturer.

Likely a programmable processor
(with the program version number on
the sticker)

Data Sheet

Not found – likely a custom microcontroller specific for this application



IC4 - Texas Instruments 7705AC Supply Voltage Supervisor

The TL77xxA family of integrated-circuit supply voltage supervisors is designed specifically for use as reset controllers in microcomputer and microprocessor systems

Data Sheet

https://www.ti.com/lit/ds/symlink/tl7712a.pdf?ts=1638029408960&ref_url=https%253A%252F%252Fwww.google.com%252F



FL408 Bridge Rectifier – In line miniature single phase silicon Bridge
Surge overload rating 200 AMP peak, ideal for printed circuit boards

Data Sheet

<https://www.digchip.com/datasheets/parts/datasheet/352/FL408-pdf.php>



Surface Mount Resistors

R82, R69, R91, R90

SMD Chip Resistor 22 ohm 22R 220 1W
5% Electronic Passive Component



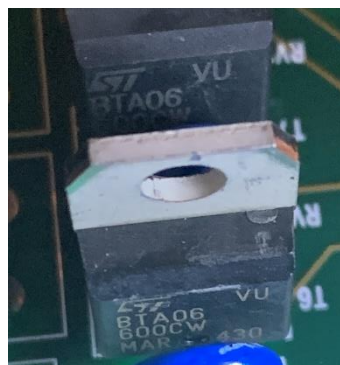
Thyristors

Model BTA06 600CW

They can be used as an ON/OFF function in applications such as static relays, heating regulation, induction motor starting circuits

Data Sheet

<https://www.mouser.ca/datasheet/2/389/cd00000670-1795558.pdf>



Varistor

A varistor is an electronic component with an electrical resistance that varies with the applied voltage. This type is commonly known as the **metal-oxide varistor** (MOV).

Data Sheet

<https://www.farnell.com/datasheets/2015602.pdf>



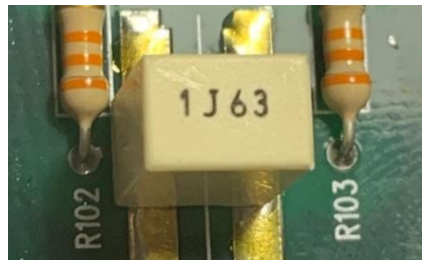
C32 Capacitor

1J63 Capacitor

1 μ F 63V P=5mm J=5% Capacitor

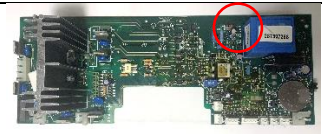
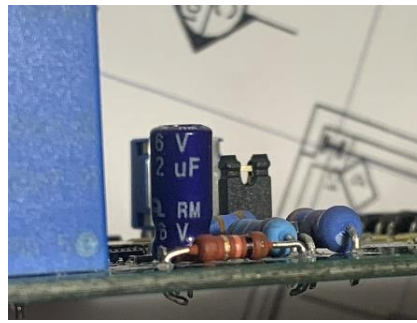
Data Sheet

https://www.aliexpress.com/item/4001177227002.html?src=google&src=google&albch=shopping&acnt=708-803-3821&slnk=&plac=&mtctp=&albbt=Google_7_shopping&albagn=888888&isSmbAutoCall=false&needSmbHouyi=false&albcpr=9604672960&albag=100679328364&trgt=294682000766&crea=en4001177227002&netw=u&device=c&albpg=294682000766&albpd=en4001177227002&gclid=Cj0KCQiAy4eNBhCaARIsAFDvtIOlBYpGO-YFJgTA5B9zHe4lMwSGhq6XMbCBf8NTqYCyimjIW059jDkaAgQ_EALw_wcB&gclsrc=aw.ds&aff_fcid=02ef1bb729cb4eeb842ba368aad2295c-1638061611388-09286-UneMJZVf&aff_fsk=UneMJZVf&aff_platform=aaf&sk=UneMJZVf&aff_tracekey=02ef1bb729cb4eeb842ba368aad2295c-1638061611388-09286-UneMJZVf&terminal_id=d2804ce32de4d1f8d3428eb3c07aaea



Capacitor

There are various capacitors on the circuit board. These are used to store small amounts of electrical energy.



Transformer

Primary: 115V AC

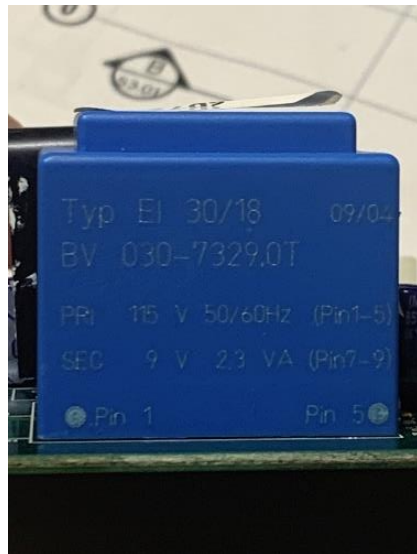
Secondary: 9V AC

This is used to transform a higher voltage (115 Volts) down to a lower voltage (9V).

Note: the output is still AC power.

Data Sheet

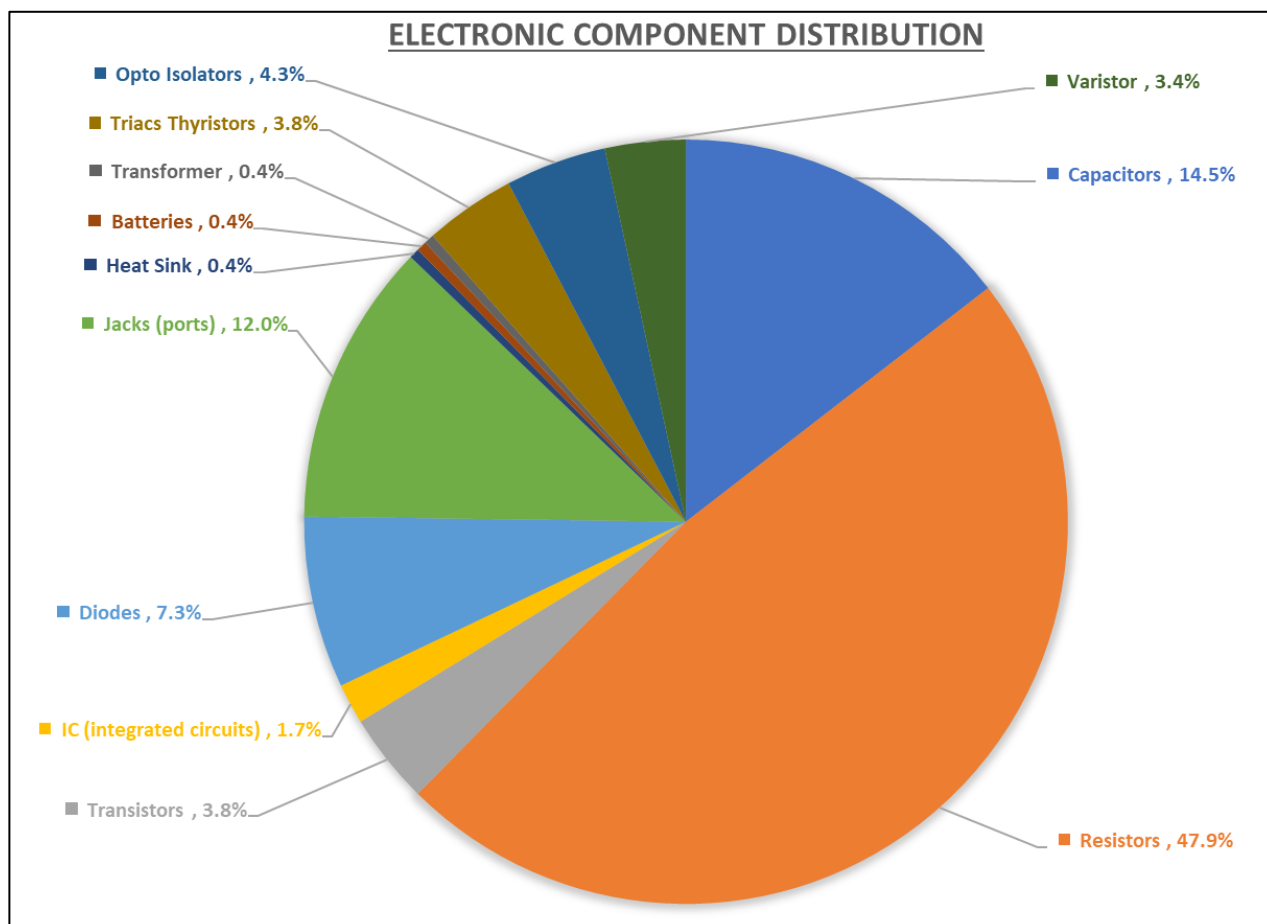
<https://www.mouser.com/datasheet/2/336/Pulse%20030-1199213.pdf>



4.2.3. Component Analysis

We counted the number of components to get an idea of distribution on the circuit board. The results are shown below.

Component	Quantity
Capacitors	34
Resistors	112
Transistors	9
IC (integrated circuits)	4
Diodes	17
Jacks (ports)	28
Heat Sink	1
Batteries	1
Transformer	1
Triacs Thyristors	9
Opto Isolators	10
Varistor	8



Graph 1: Electronic Component Distribution

5. Findings

After reviewing the purpose and function of the circuit board components, we were able to establish the Power Flow Chart as well as the Control Flow Chart for the coffee machine. The Flow Charts are shown below.

After some further research online, we were able to determine the coffee machine had a faulty ground wire connection.

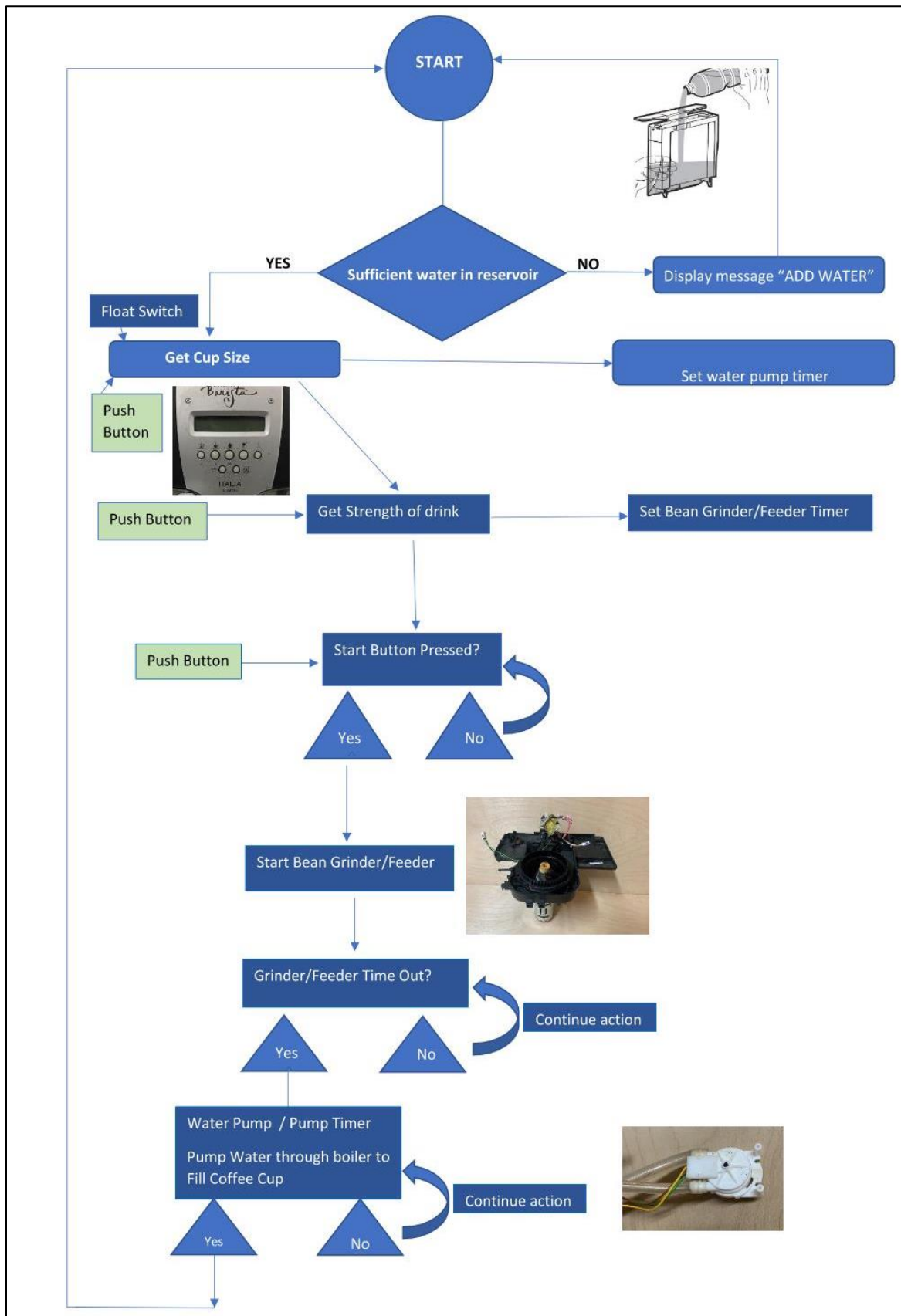
5.1. Power Flow Chart

The incoming power for the coffee machine is 115 volts AC, however the control circuits required 5 volts DC. From researching the components, we were able to determine how the power is converted as shown below.



Flow Chart 2: Power Flow Chart for Coffee Machine

1.1. Control Flow Chart



6. Conclusions and Lessons Learned

Throughout this project, we learned how to take apart a coffee machine in a safe manner. We also learned as a team how to organize and plan for this project appropriately. The coffee machine is composed of many different systems such as electrical, mechanical, and electronic systems. It was important to understand all the components. To do this, we learned about circuit boards and their individual components using internet resources and we also consulted with an Electrical Engineer who was very insightful.

Lessons Learned:

- We learned how circuit boards worked
- We learned the components of a circuit board (and what each component does)
- We learned it's important to develop a flowchart to help understand the machine
- learned that Teamwork is important to split up the tasks

7. References and Sources

(other sources, such as Data Sheets are included in the component descriptions)

1. <https://somanylech.com/9v-to-5v-converter-circuit/>
2. https://espressoresourcesnw.com/wp-content/uploads/2017/02/Italia_User-Manual1.pdf
3. <https://guide-images.cdn.ifixit.com/igi/m4mkLANxNA2m25F3.full>
4. https://cdn.shopify.com/s/files/1/0563/7370/6916/files/Italia_Digital_SUP_021_YDR_Parts_Diagram.pdf?v=1621427703
5. https://cdn.shopify.com/s/files/1/0563/7370/6916/files/Starbucks_Italia_Digital_SUP021YDR_Parts_Diagram.pdf?v=1621435752