VEX 2022-2023

Reverse Engineering Online Challenge:

Deconstruction of an OMRON HEM-7321T-Z(V) Blood Pressure Monitor

95071Z:

Syntax Error

Saratoga, California, United States of America

Gonzalo Fernandez da Ponte: Project Manager and Main Deconstructor (9th grade)

Katherine Zeng: Presentation Layout Manager (9th grade)

Mridhula Vudali: Image Manager and Main Photographer (9th grade)

Word Count: 493

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1. Introduction

Hello! We are 95071Z, a team located in Saratoga, California. All of our six members are Freshmen at Saratoga High School and have a deep passion for robotics.

To fuel our love for engineering, we decided to join the **Reverse Engineering Online Challenge**. This would not only be beneficial for our team, but it would allow us to increase our understanding of real-world engineering.

The device that we chose to take apart was a broken **blood pressure monitor**. These devices are extremely vital to tracking people's well-being as well as being a common example of home medical equipment. However, we, like most people, have limited knowledge of the inner workings of these monitors. By disassembling this device, we hope to learn about its importance and the components that allow it to work.

2. Deconstruction Process

First, we planned out what our steps would be regarding the deconstruction:

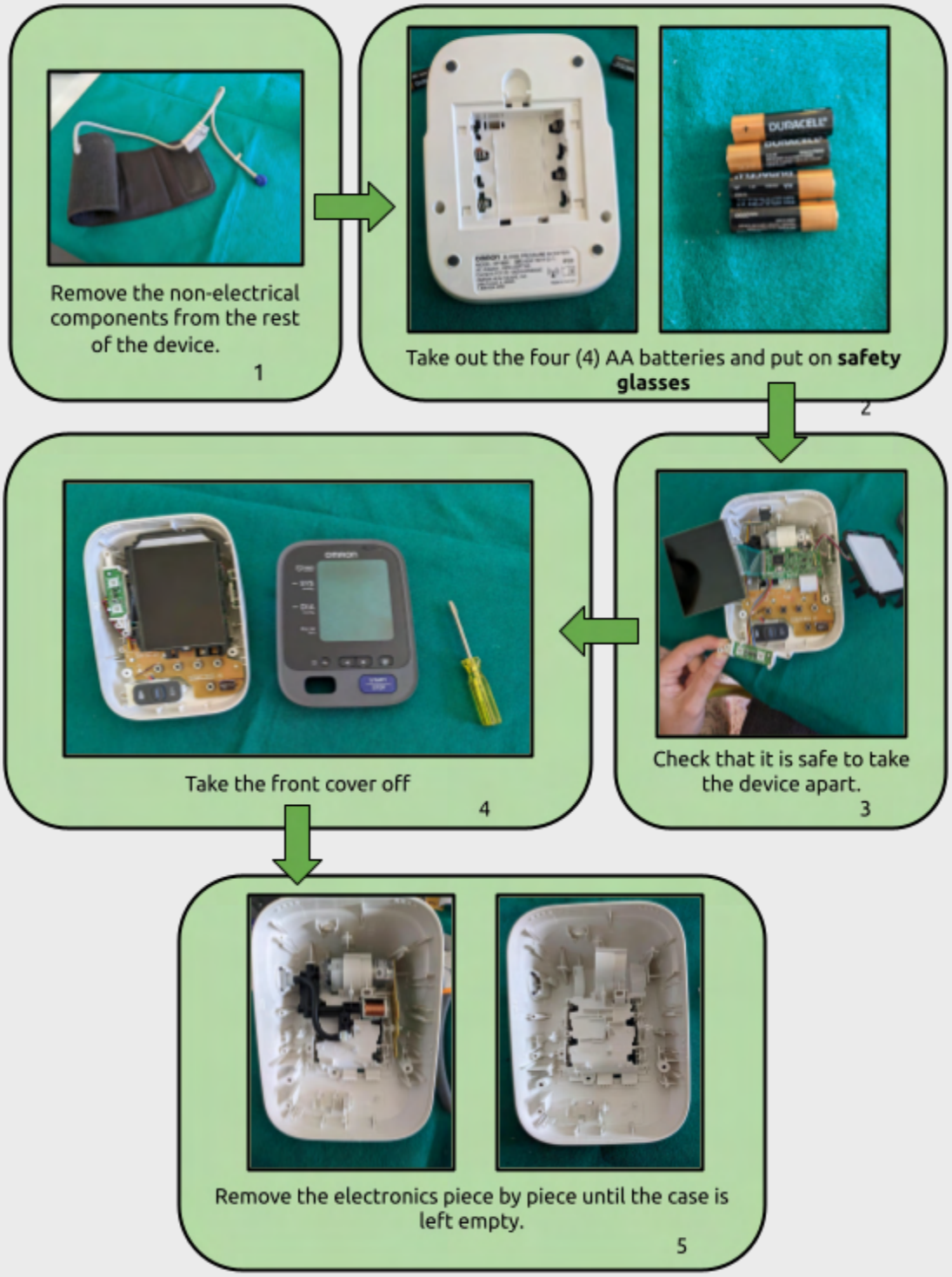


Figure 1: Deconstruction Action Plan

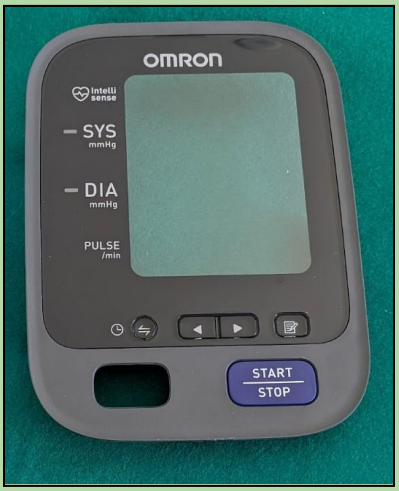
3. Device Components

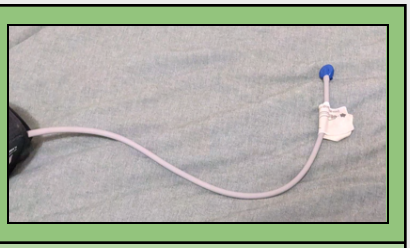
Once the device had been taken apart, we had to sort our components.

To do this we would:

1. Sort the electrical and non-electrical components
2. Separate the electronics into different subsystems based on function (i.e. Motherboard, Screen subsystem, etc.)
3. Research the components

3.1. Non-electrical components

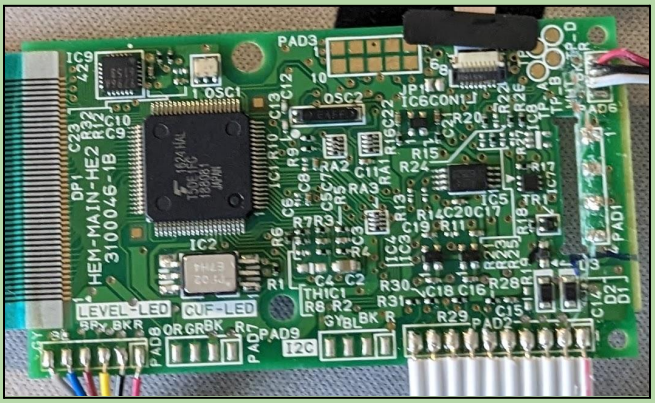
Name	Purpose	Photo
Case	The **Case** is the container that **holds all of the electronics**.	
Cover	The **Cover** is used to **protect** the electrical components and make the machine **easier for humans to use**. There are labeled buttons on the **Cover** as well as a screen protector.	

Tube	The **Tube** is passed through a hole in the side of the case and connects to the **Bladder**. It leads air into the **Bladder**.	
Bladder	The **Bladder** is the mechanism that **fills up with air** and constricts the movement of blood in the patient's arm. This is what **allows the device to read blood pressure**. It is connected to the **inside** of the **Cuff**	
Cuff	The **Cuff** is what **keeps the Bladder stable**. It wraps around the outside of the **Bladder** and **holds it onto the patient's arm**.	

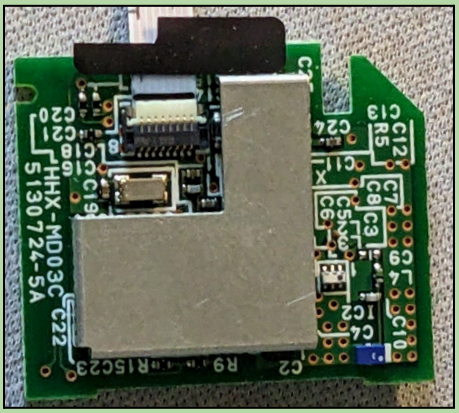
3.2. Electrical Components

3.2.1. Boards

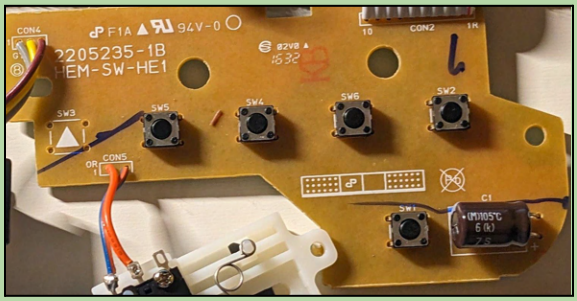
The device came with five Boards:



Motherboard (Motherboard Subsystem)

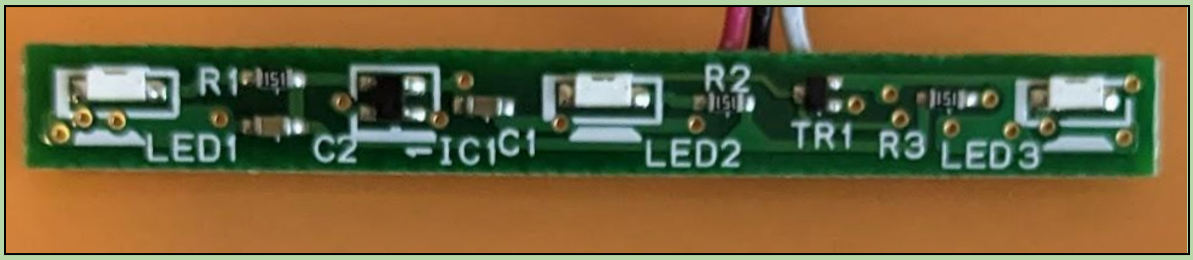


BD1 (Motherboard Subsystem)



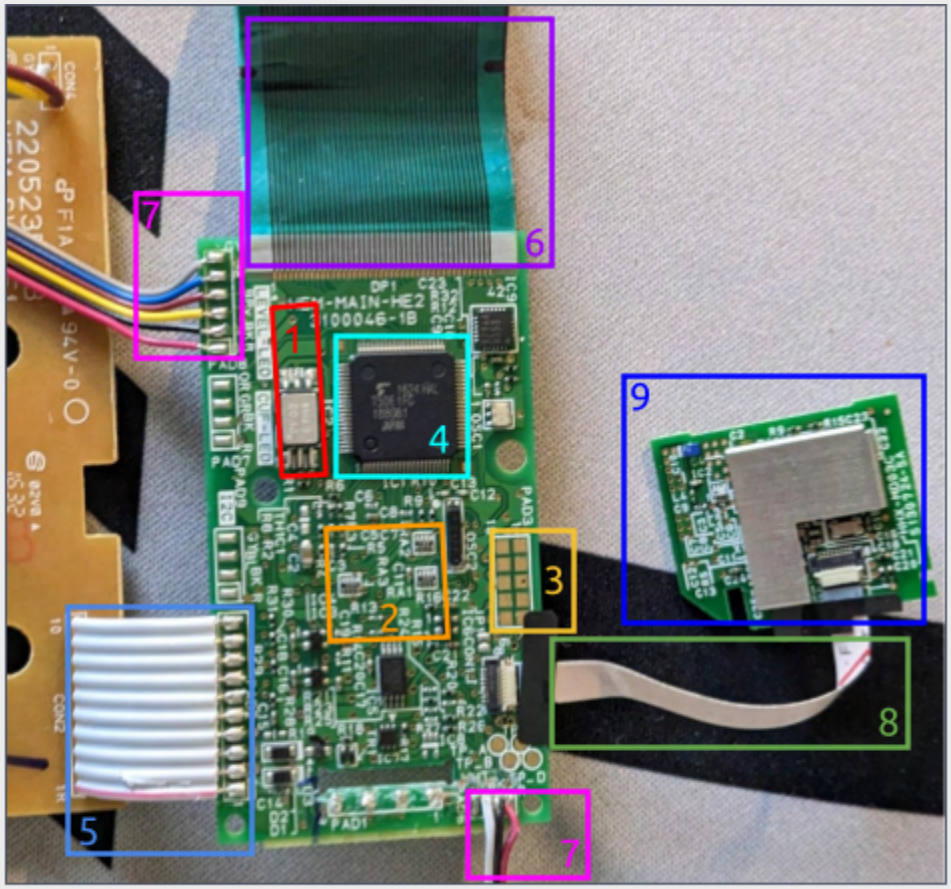
BD2

BD3 (Screen Subsystem)



BD4 (Screen Subsystem)

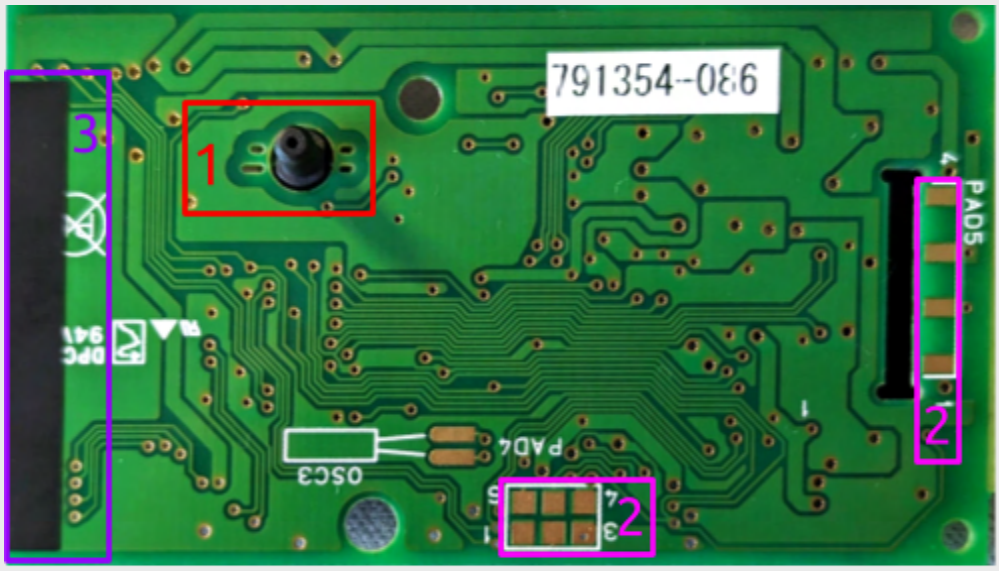
3.2.2. Motherboard Subsystem



Key

1. Gauge Pressure Sensor
2. Surface Mount Resistors
3. Connection Pad
4. Microprocessor
5. Ribbon Wire *(to BD1)*
6. RIbbon Wire *(to Screen Subsystem)*
7. Colored Wires *(to Screen Subsystem)*
8. Bando Ribbon Wire *(to BD2)*
9. BLE module/BD2

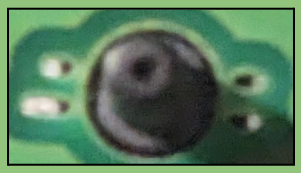
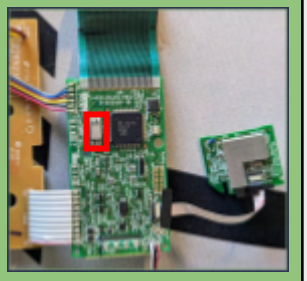
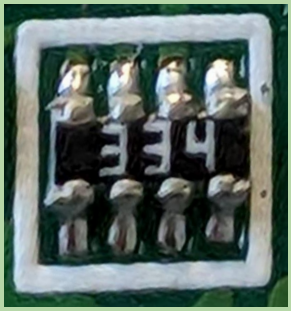
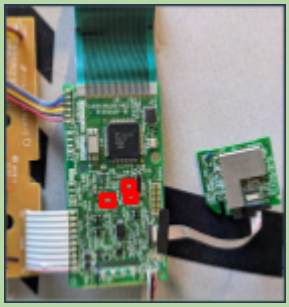
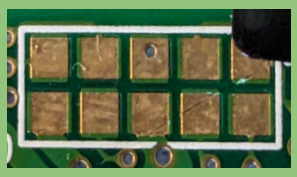
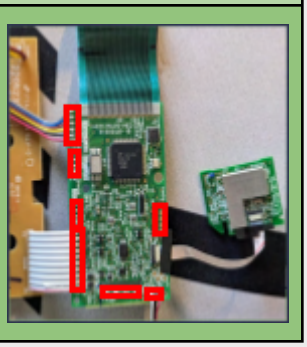
Figure 2: Front of the Motherboard, labeled

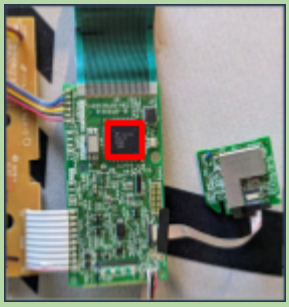
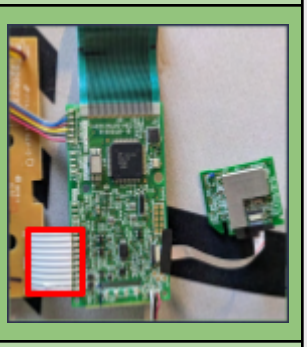
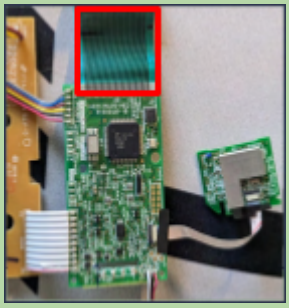
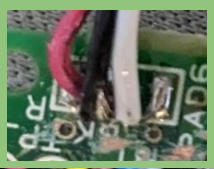
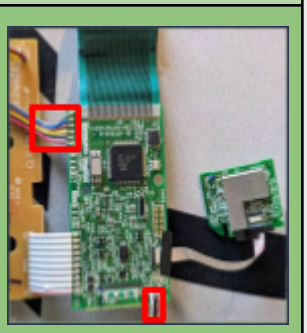


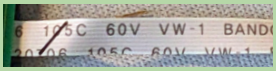
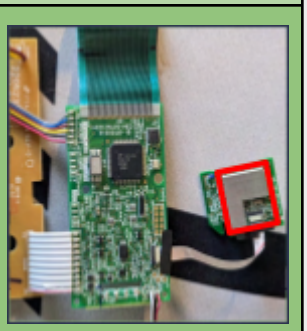
Key

1. Gauge Pressure Sensor
2. Connection Pad
3. RIbbon Wire *(to Screen Subsystem)*

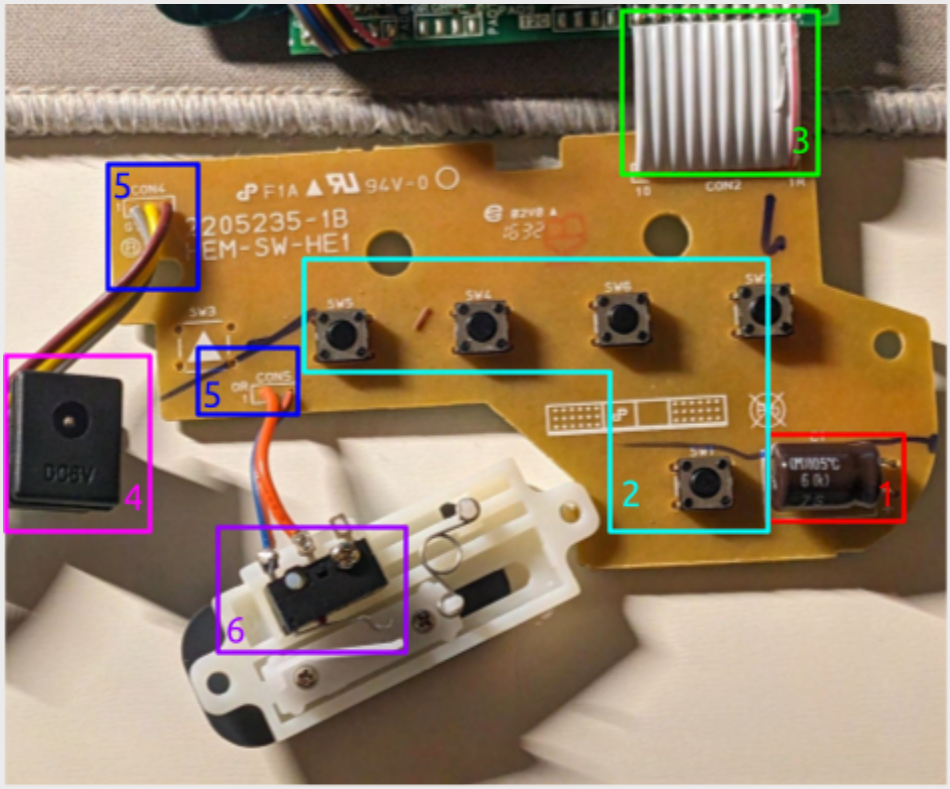
Figure 3: Back of the Motherboard, labeled

Name & Details	Total Amount Photo	Purpose	Location
1. Gauge Pressure Sensor (2SMPP-02) **Datasheet**: https://omronfs.omron.com/en_US/ecb/products/pdf/en-2smpp-02.pdf	**1**  Front  Back	The **Gauge Pressure Sensor** measures gauge pressure (pressure relative to atmospheric pressure). As the arteries in the arm beat, the pressure sensor **reads the pulses and can calculate blood pressure.** Connects to the **Pneumatic Tubing** through the back tube of the pressure sensor.	
2. Surface Mount Resistors 103 Resistor: Resistance: 10.000 kΩ **Datasheet**: https://www.yageo.com/upload/media/product/productsearch/datasheet/rchip/PYu-AC_51_RoHS_L_9.pdf 334 Resistor Resistance: 330.000 kΩ **Datasheet**: https://www.yageo.com/upload/media/product/productsearch/datasheet/rchip/PYu-RT_1-to-0.01_RoHS_L_13.pdf	**6**  	They are **resistors** that are soldered directly onto the **Motherboard**. They **regulate the electrical currents in a circuit**. The numbers on them represent **how much they can slow down an electric current**.	
3. Connection pad **Inner part of the PCB, no datasheet**	**9** 	**Pads** are exposed pieces of metal on the **Motherboard** where **other parts can be soldered onto**. Some of the pads are used and others are not.	

4. Microprocessor **Datasheet**: https://toshiba.semicon-storage.com/info/TMPM4G8F10FG_datasheet_en_20190326.pdf?did=60732&prodName=TMPM4G8F10FG	**1** 	The **Microprocessor** is the central unit of the **Motherboard**. It **performs logic and arithmetic operations** depending on the instructions it's given. It physically consists of **thousands of resistors, transistors, and capacitors** grouped on a small piece of **semiconductor material**, such as silicon.	
5. Ribbon Wire (10 conductors) **Datasheet**: https://multimedia.3m.com/mws/media/223680/3mtm-round-conductor-flat-cable-3604-series-ts0653.pdf	**1** 	This **Ribbon Wire** connects to **BD2** and **allows electricity to transfer** between it and the **Motherboard.**	
6. Ribbon Wire (40 conductors) **Datasheet**: https://www.molex.com/pdm_docs/sd/1000570112_sd.pdf	**1** 	This **Ribbon Wire connects** the **Screen Subsystem** to the **Motherboard**.	
7. Colored wires (set of 6 and set of 3) **Unlabeled**	**14**  	The **Wires connect** the **Motherboard** to **BD3** and **BD4**, which are part of the **Screen Subsystem.**	

8. Bando Ribbon Wire (8 conductors) **Datasheet**: https://multimedia.3m.com/mws/media/223680/3mtm-round-conductor-flat-cable-3604-series-ts0653.pdf	**1** 	This **Ribbon Wire connects** to **BD1** and lets its electrical signals travel to the **Motherboard** and vice versa.	
9. BLE Module (HHX-MD03C) **Datasheet**: https://industrycanada.co/10623A-HHXMD03C	**1** 	This is a **Bluetooth Low Energy transceiver**. BLE modules consume less than traditional Bluetooth and are used for **occasional exchanges** of **small pieces of data**. The transceiver part means that it can **both transmit and receive radio signals** from its built-in antenna. This is on **BD1**	

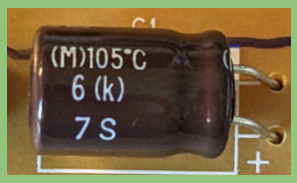
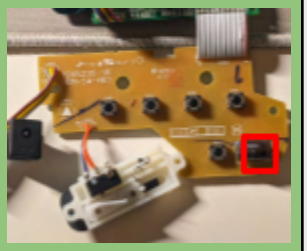
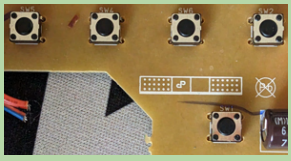
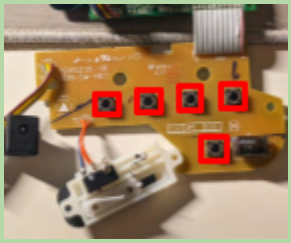
3.2.3. BD2

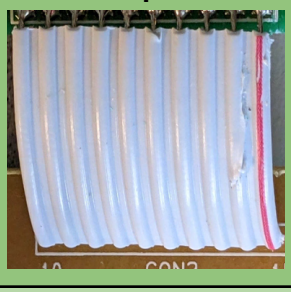
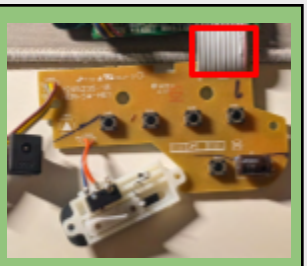
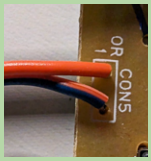
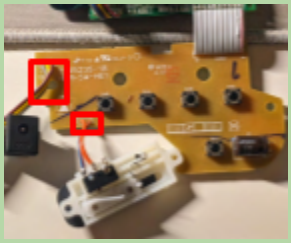
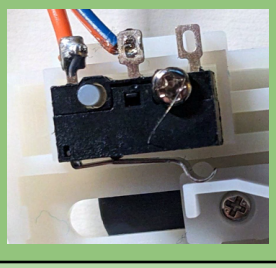
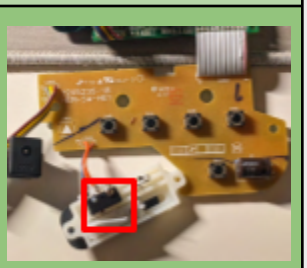
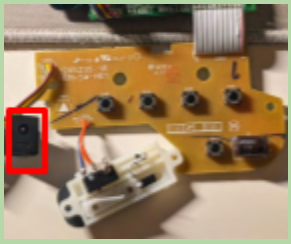


Key

1. Radial Electrolytic Capacitor
2. Pushbutton Switches
3. Ribbon Wire
4. DC6V female barrel jack
5. Colored wires
6. Limit switch

Figure 4: BD2, labeled

Name & Details	Total Amount Photo	Purpose	Location
1. Radial Electrolytic Capacitor Capacitance: 330 uF Voltage: 16V Operating Temp: 105°C **Unlabeled**	**1** 	**Capacitors** store electrical energy by **distributing charged particles** on 2 plates. There are many types of capacitors and they vary by size. The one shown is the **biggest capacitor** on the device and is found on **BD2**.	
2. Pushbutton switches **Unlabeled**	**5** 	**Pushbutton switches open or close a circuit** depending on whether they are pressed down.	

3. Ribbon Wire (10 conductors) **Datasheet**: https://multimedia.3m.com/mws/media/223680/3mtm-round-conductor-flat-cable-3604-series-ts0653.pdf	**1** 	This **Ribbon Wire connects BD2** to the **Motherboard** and allows an electrical current to move between the two.	
4. Colored wires (set of 3 and 2) **Unlabeled**	**14**  	The **Wires connect** the **DC6V Female Barrel Jack** and the **Limit Switch** to **BD2.**	
5. Limit switch **Unlabeled**	**1** 	The **Limit Switch closes a circuit** when its lever is pressed down.	
6. DC6V female barrel jack **Datasheet**: https://www.sparkfun.com/datasheets/Prototyping/Barrel-Connector-PJ-202A.pdf	**1** 	The **DC6V Female Barrel Jack** is used to **receive DC power** and provide it to the circuit board	

3.2.4. Screen Subsystem

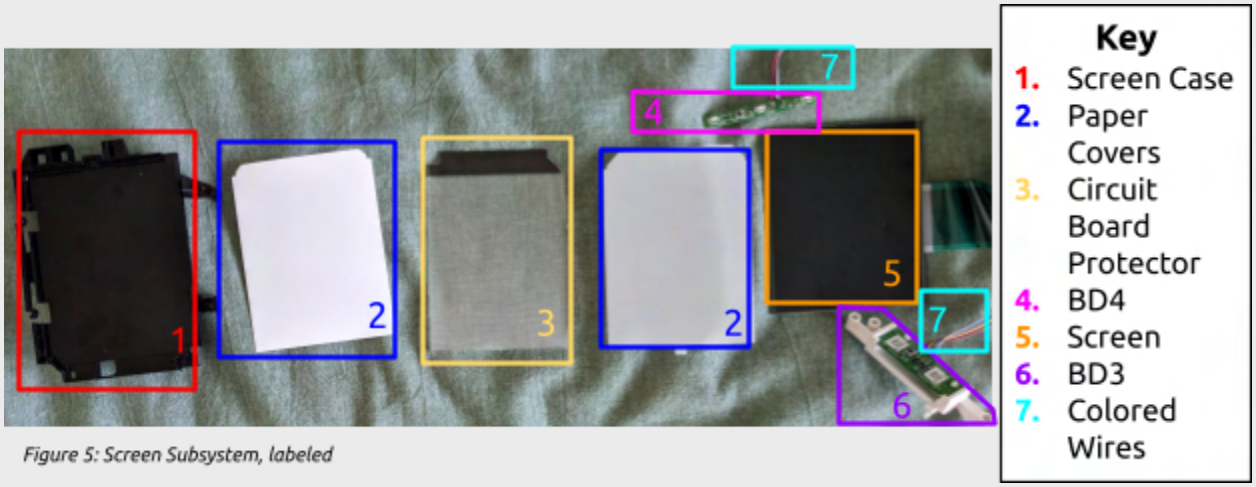


Figure 5: Screen Subsystem, labeled

The components of the Screen Subsystem make a stack that houses BD4 and the Screen. A paper cover goes onto the Screen Case, BD4 on top of that, and so on.

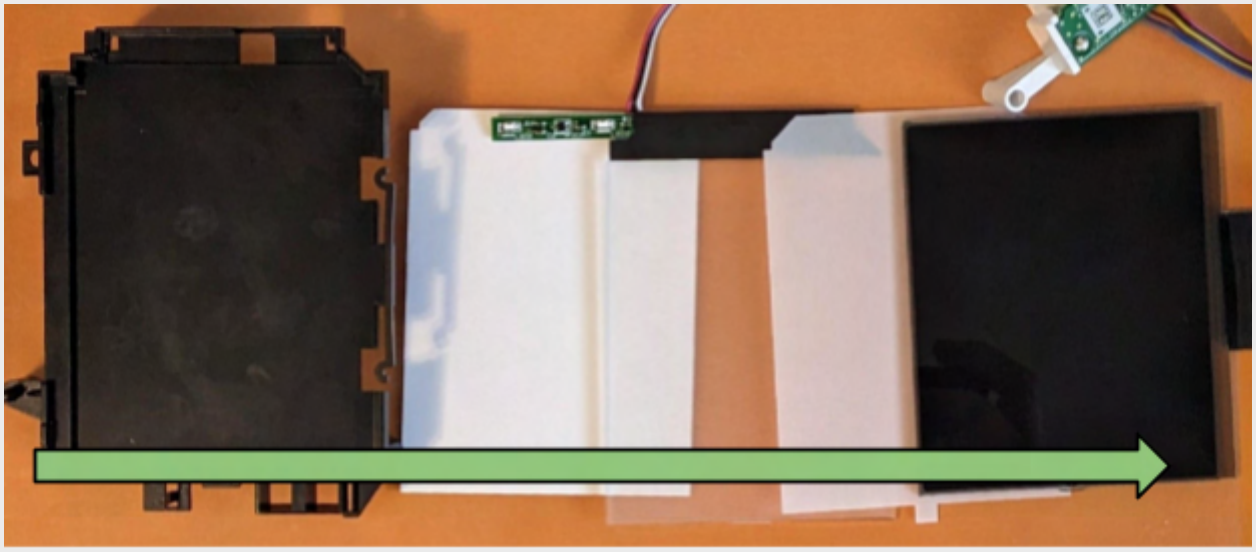


Figure 6: Order of objects in the Screen Subsystem

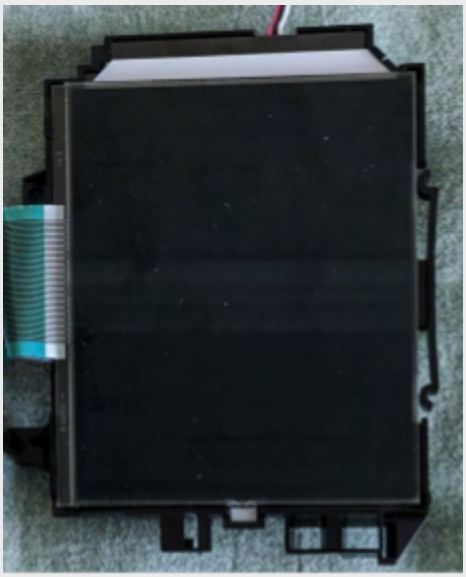


Figure 7: Complete Screen Subsystem, top view

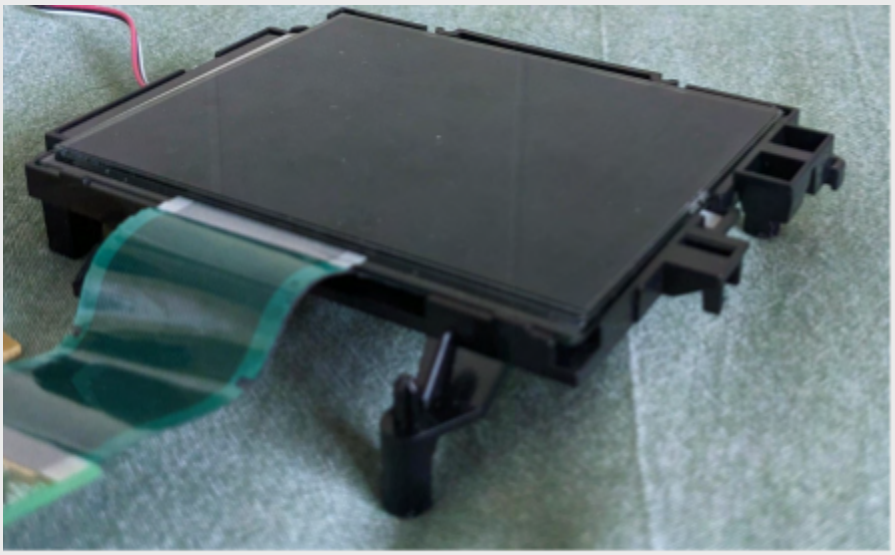
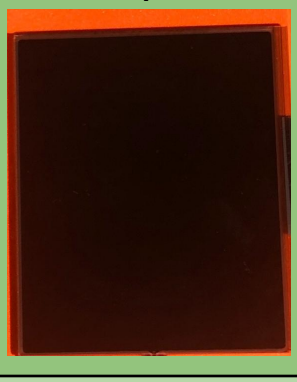
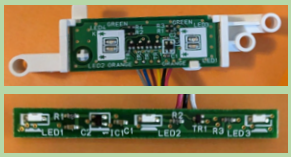
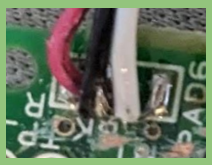
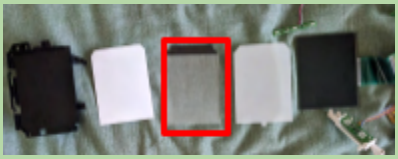
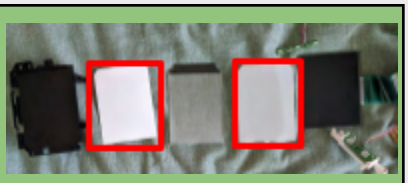


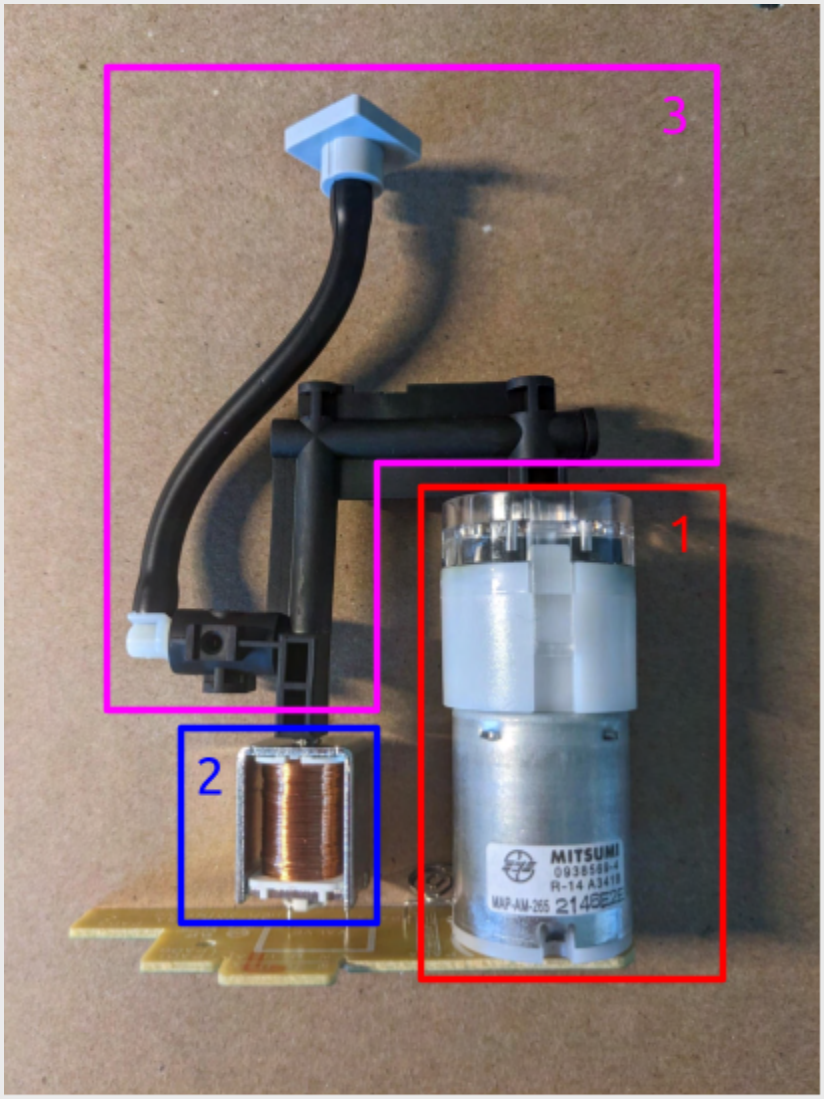
Figure 8: Complete Screen Subsystem, isometric view

Name & Details	Total Amount Photo	Purpose	Location
1. LED Screen 3.75in by 4.25in **Datasheet**: https://newhavendisplay.com/content/specs/NHD-320240WX-CoTFH-VI041.pdf	**1** 	The **LED Screen displays the monitor's results** based on information given by the circuit boards.	
2. Circuit Boards (BD3 and BD4) **Custom made**	**5** 	The **Circuit Boards** have the **information used by the LEDs** that display information on the screen.	

3. Colored Wires (Set of 6 and 3) **Unlabeled**	**14**  	The **Wires** are used for **connecting** the **BD3** and **BD4** to the **Motherboard**.	
4. Ribbon Wire (40 conductors) **Datasheet**: https://www.molex.com/pdm_docs/sd/1000570112_sd.pdf	**1** 	The **Ribbon Wire connects** the **Motherboard** to the **LED Screen**.	
Non-electronic Parts			
5. Screen Case **Not an electrical part**	**1** 	The **Screen Case holds** the rest of the **Screen Subsystem**.	
6. Circuit board protector **Not an electrical part**	**1** 	The **Circuit Board Protector** lies on top of **BD4** and **prevents it from moving** around or being **damaged**.	

7. Paper covers **Not an electrical part**	**2** 	The **Paper Covers go over and under** the **Circuit Board Protector**	
8. BD3 case **Not an electrical part**	**1** 	The **BD3 Case holds BD3** in place	

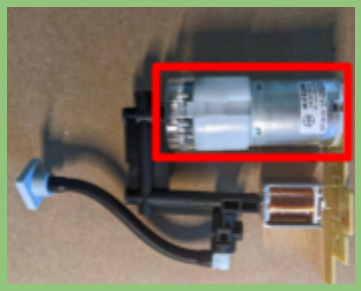
3.2.5. Pumping Subsystem:

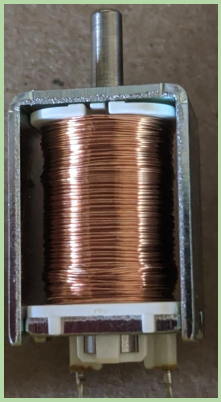
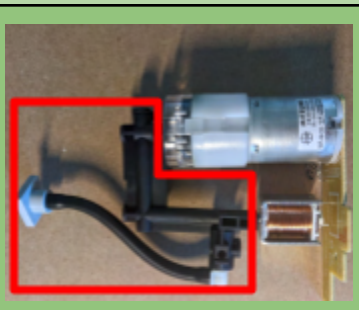


Key

1. Air Pump Motor
2. Solenoid Valve
3. Pneumatic Tubing

Figure 9: Pumping Subsystem, labeled

Name & Details	Total Amount Photo	Purpose	Location
1. Air pump motor (DC) Volts: 6.0V Current: 200mA **Datasheet**: https://media.digikey.com/pdf/Data%20Sheets/Mitsumi%20Elect/MAP-AM-265-MITSUMI.pdf	**1** 	The **Air Pump Motor** is a motor with an **air pump attachment**. It is the main mechanism that allows the **Bladder** to fill up. It does this by **pumping air into the Pneumatic Tubing System.**	

2. Solenoid valve (DC) **Unlabeled**		The **Solenoid Valve** is connected to the **Pneumatic Tubing System** and can be either **open or closed**. When open, it lets **air go in and out** of the tubing, but when it is closed, **it does not**. This way, when the valve is on, **pressure starts to build up** as the **Air Pump Motor** starts pushing air into the system.	
3. Pneumatic tubing system **Not an electrical part**		The **Pneumatic Tubing System** is a tube that **allows air to pass into the Bladder**. It has **three openings**: one that leads to the **Air Pump Motor**, another that leads into the **Solenoid Valve**, and a third that goes into the **Gauge Pressure Sensor** on the **Motherboard**. It also has a slab at the end, which can **slide into the inside wall** of the **Case** and connects it to the external **Tube**.	

4. Analysis

To get a deeper understanding of the device, we counted the number of electrical parts on the boards and their distribution:

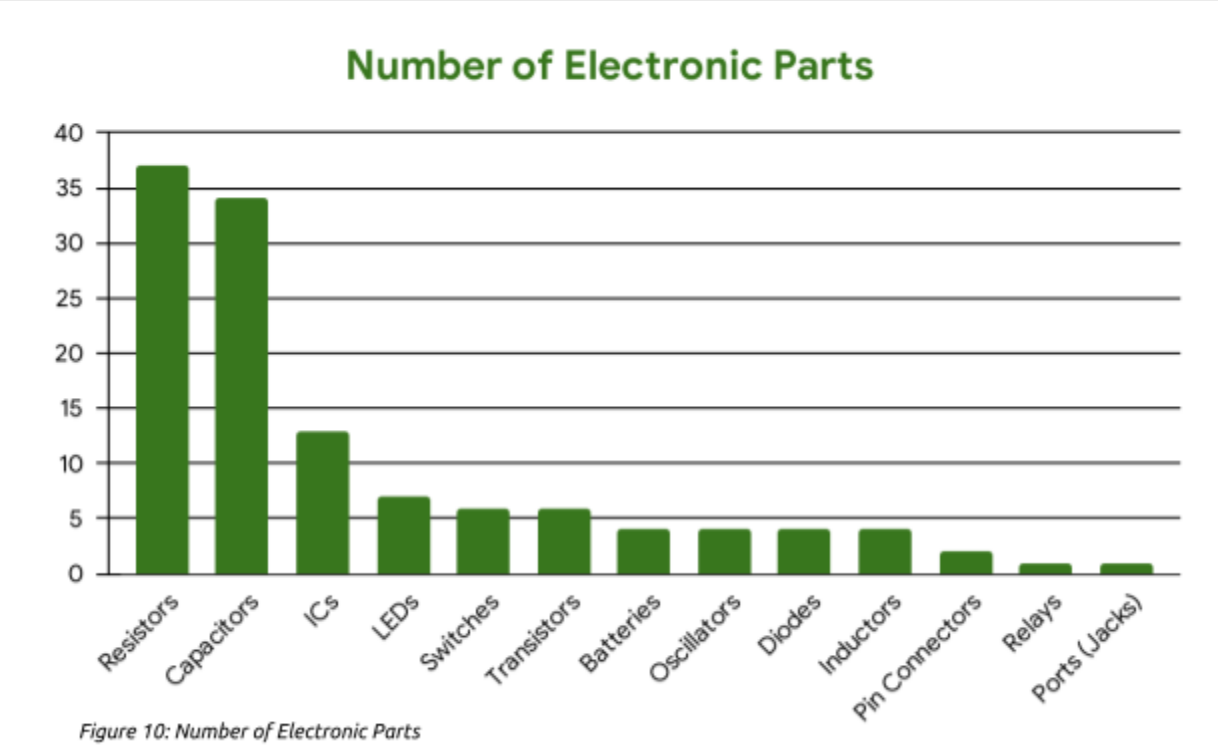


Figure 10: Number of Electronic Parts

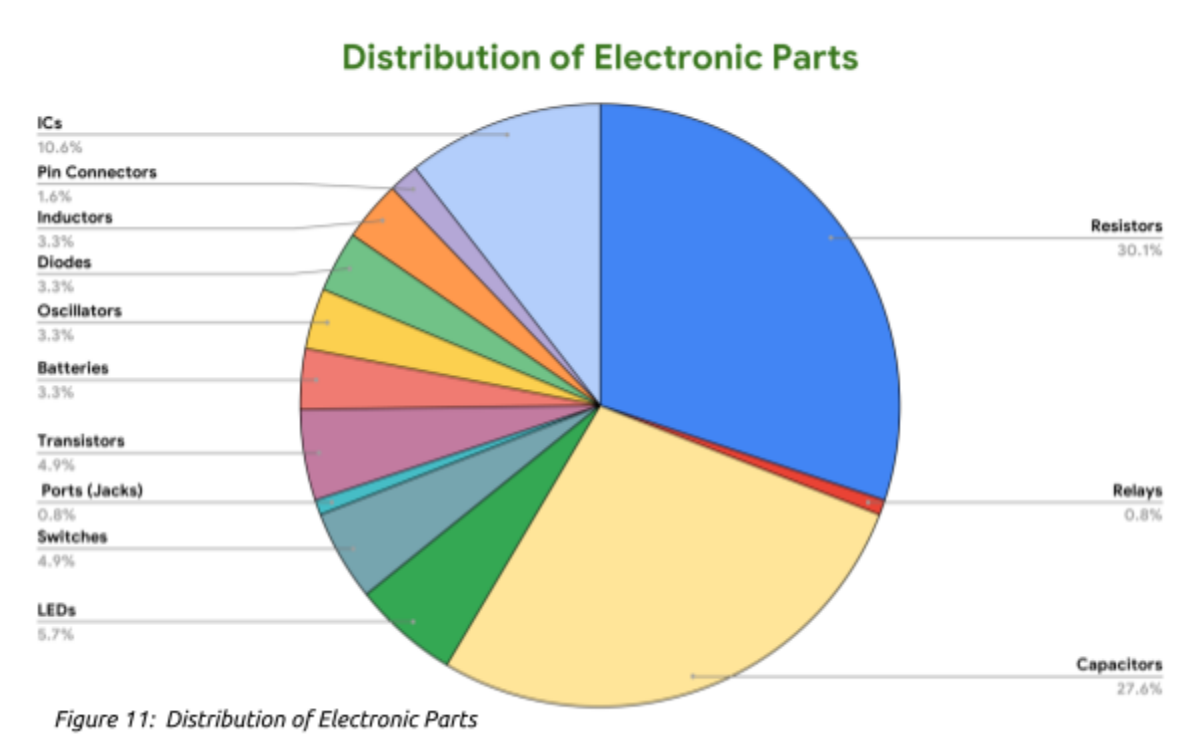


Figure 11: Distribution of Electronic Parts

5. Control-Flow Diagram

After finding the amount and distribution of the electrical components across the device, we created a **Control-Flow Diagram**, which presents the steps the device carries out:

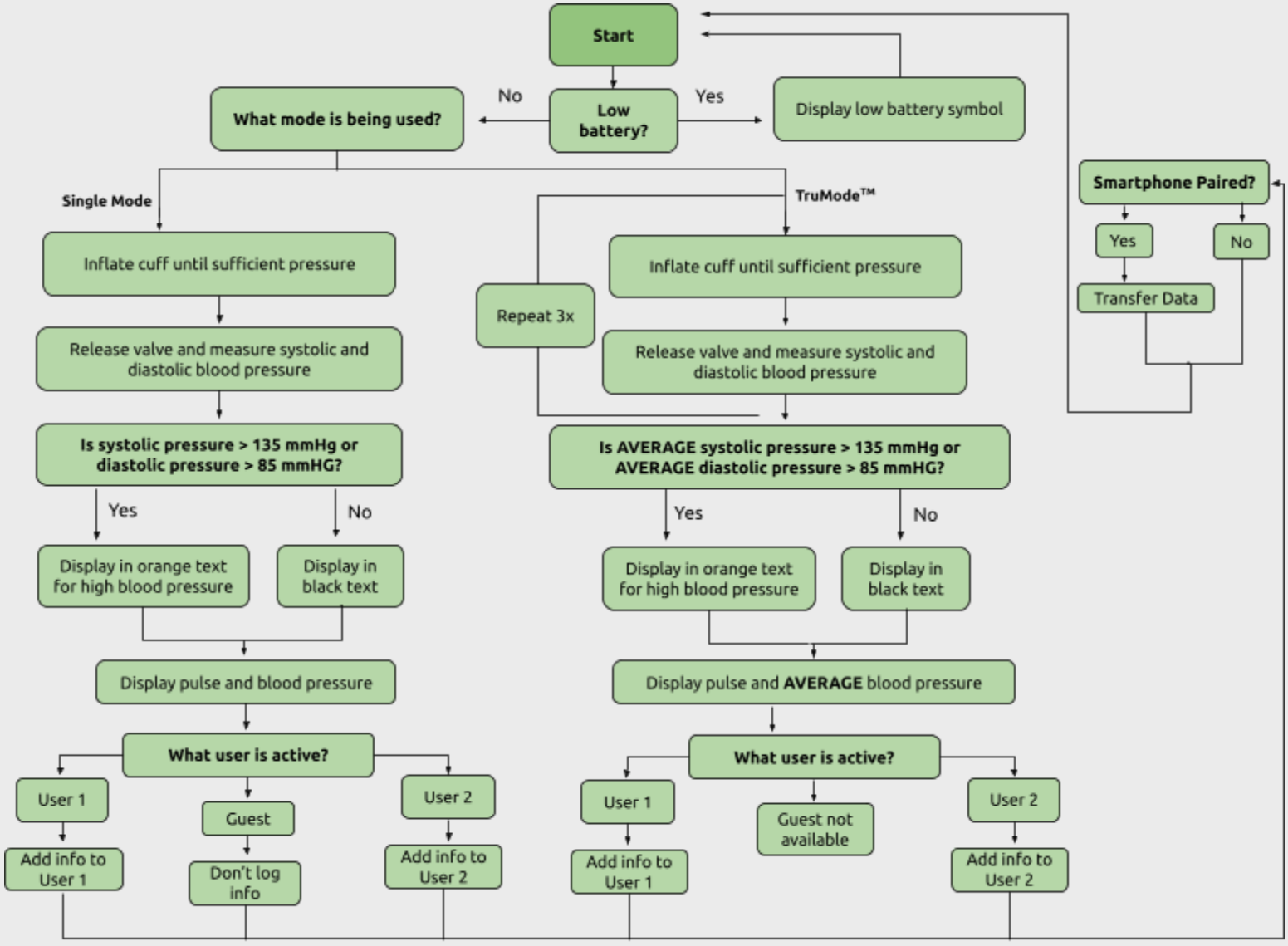


Figure 12: Control-Flow Diagram

6. Conclusion

This project allowed us to gain a deeper understanding of how electrical systems function and how different mechanisms work together to make a device operate. We also learned how to work together to get tasks done more efficiently and the importance of proper planning. The blood pressure monitor we took apart was made up of many different components, and it was interesting to see how they worked both by themselves and with each other.

Since none of us were very knowledgeable about how electrical circuits function, a lot of research was needed. In the end, this has helped us better understand how everyday appliances work. Just like the blood pressure monitor, our team is a system. Each member's help is vital, and without everybody's contribution, this research project could not have come together as it did. Ultimately, we hope to apply the information and lessons we have learned to the rest of our time in VEX, our individual lives, and eventually, our careers.

7. Citations and Resources (Not datasheets)

"SMD Resistor Code Calculator." Conversion Calculator SMD Resistor Code | DigiKey Electronics, Digikey Electronics, https://www.digikey.com/en/resources/conversion-calculators/conversion-calculator-smd-resistor-code.

axcontrol, Author. "How to Identify Components on Printed Circuit Boards." AX Control, Inc., AX Control, Inc., 13 Oct. 2021, https://www.axcontrol.com/blog/2021/how-to-identify-components-on-printed-circuit-boards/06/07/.

"Omron Blood Pressure Monitors | Health & Wellness Products." OMRON Healthcare, OMRON, https://omronhealthcare.com/wp-content/uploads/BP786N-IM_EN.pdf.

Awati, Rahul. "What Is an Integrated Circuit (IC)? A Vital Component of Modern Electronics." WhatIs.com, TechTarget, 29 Sep. 2021, https://www.techtarget.com/whatis/definition/integrated-circuit-IC#:~:text=An%20IC%20can%20function%20as,of%20all%20modern%20electronic%20devices.