Team 2420D

VEX IQ Reverse Engineering Challenge 2024

Disassembly and Analysis of a Canon imageCLASS D480 Multifunction Printer

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1.0 Summary Report

Laser printers are common devices used for producing high-quality printed documents in both home and office environments. They operate based on a technology called xerography. Xerography is a process for copying printing material using light and an electrically conductive surface to adhere toner to a page.

The Canon imageCLASS D480 is an example of this technology. It is a laser printer that includes print, copy, scan, fax, and network hardware. Because of this, it has many subsystems, and mechanical components that we took apart and analyzed.

The team learned a lot with the analysis of the printer. We learned printers are extremely complex machines like robots since they combine aspects of physical and digital technology. Digital technology like integrated circuits (ICs), sensors, capacitors, transistors, resistors, and transformers are used to power and communicate with the printer. Physical technology like motors, axles, gears, and belts and pulleys are used to give the printer movement. One example of these aspects of technology is gear ratios, where the principles used in the printer can be implemented to make a robot drivetrain move faster. Another example is sensors, where certain types of sensors like light sensors can help make an accurate autonomous program. Disassembly of this printer helps us understand that modern technology is extremely complex, and that hardware, such as a printer, has thousands of parts that all function together.

Our team had to use the skills of teamwork and problem solving. During disassembly, there were multiple team members helping each other disassemble the printer and finding ways around the disassembly restrictions, like security screws and parts that were glued together. We had to disassemble around the security screw and cut and pry off multiple parts. We also learned that because of this, this printer is not very repairable. It would be extremely difficult to take apart a printer with only one person. Additionally, team members also helped with the analysis of the components and creation of this report since there were countless electronics and mechanical components in the printer.

Disassembly of the printer taught us skills with physical and electrical mechanisms as well as teamwork and problem solving. As a printer has multiple subsystems, our knowledge gained can be used in the VEX IQ robotics program, specifically with the use of gears and feeder system. The team learned a lot from this experience.

Word Count: 391

2.0 The Device Chosen

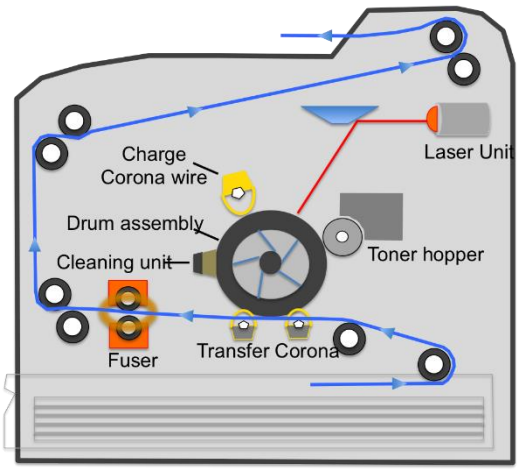
The device chosen was a Canon imageCLASS D480. It is a multifunction laser printer with print, copy, scan, fax, and networking hardware.

Printers are present everywhere today. However, even though they are common, printers are extremely complex and require many moving parts to function. Laser printers include gears, rollers, drums, multiple control boards, lasers, belts, and pulleys. Many of these components are found in robotics and in industrial applications. Disassembling and analyzing a printer can help get a better understanding of how printers work and how some of these mechanisms can be applied in other areas of STEM.

3.0 Background Information

Laser printers are common devices used for producing high-quality printed documents in both home and office environments. They operate based on a technology called xerography. Xerography is a process for copying printing material using light and an electrically conductive surface.

Laser printers use a laser beam to form an electrostatic image on a photosensitive drum or belt. The printer drum is then coated by the toner hopper with toner, a fine powder made up of pigment and plastic particles. The toner is electrically attracted to the charged areas on the drum because of the transfer corona running electricity to it, forming the desired image. The paper is then fed from the paper tray and rolled over the drum, pressing the image onto the paper. It is then fused by the fuser.



The global laser printer market was valued at $2.01 billion at the beginning of 2022. The market leaders are HP, Canon, Samsung, Brother, and Xerox. Laser printers are the fastest growing printer market out of all printer types.

Disassembling a laser printer typically involves removing the outer casing and exposing the internal components. Special attention should be given to components like the fuser unit, toner cartridge, transfer corona and laser unit, as these are crucial components of the printer. They also may have electrical charges. Documenting the order and method of disassembly is crucial for reverse engineering.

4.0 The Exterior

Figure 4.1 The front of the printer

Figure 4.2 The left side of the printer

Figure 4.3 The right side of the printer

Figure 4.4 The top of the printer

Figure 4.5 The back of the printer

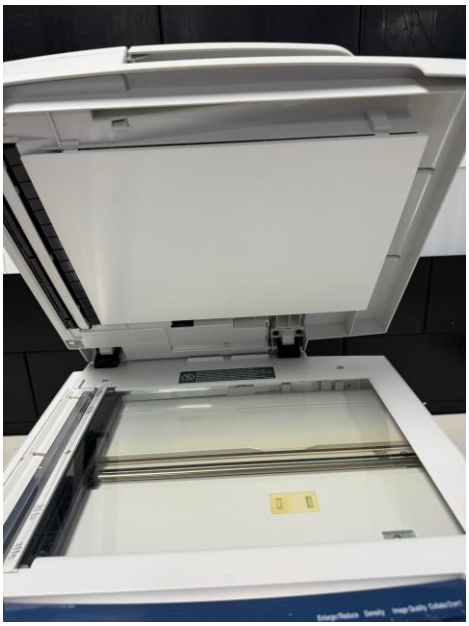
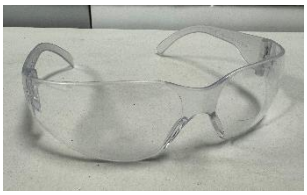


Figure 4.6 The scanner portion of the printer

5.0 Disassembly

5.1 Equipment Needed

- Philips head screwdriver
- Precision screwdriver set
- Wire cutters
- Needle-nose pliers
- Safety glasses
- Gloves

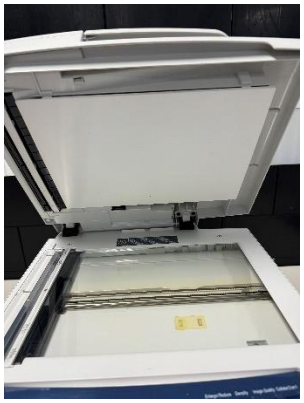


5.2 Step-by-Step Instructions on Disassembly

Step 1: Make sure the device has been unplugged for at least 10 minutes to remove all residual electrical charge, and that all necessary safety equipment such as safety glasses are used.

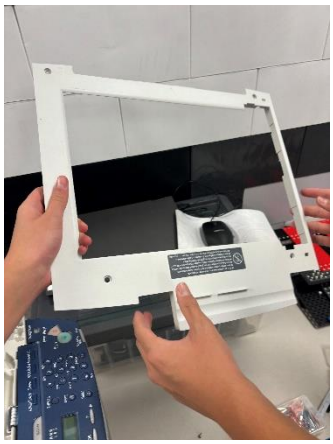
Step 2: Remove exterior plastic paneling from the top of the printer by opening the copy tray and unscrewing the hidden screws. Additionally, remove plastic paneling from the bottom of the copy tray to expose more hidden screws.

Step 3: Once exterior pieces are removed, start removing the top of the input paper tray by lifting the scanner and unscrewing the four main screws on the hinge.



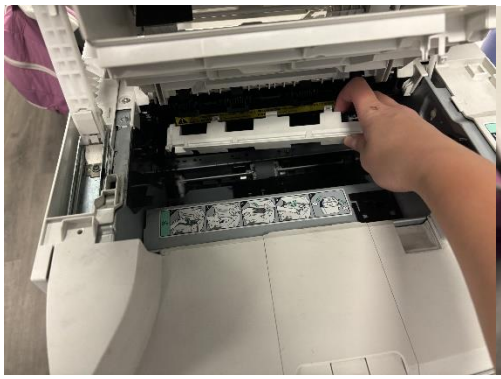
Step 4: Remove the screws for a plastic panel that hides two more screws to hold the top of the printer and unscrew them. Cut the wire that attaches to the tray. Set the tray aside.

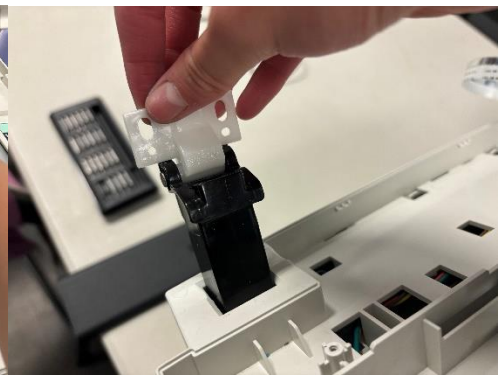
Step 5: Start disassembling the top of the printer scanner by removing the four screws on the frame for holding in the glass.



Step 6: Carefully remove the glass panel by lifting it from the (now) top of the printer and set it aside.

Step 7: Remove the interior plastic pieces inside the output tray.

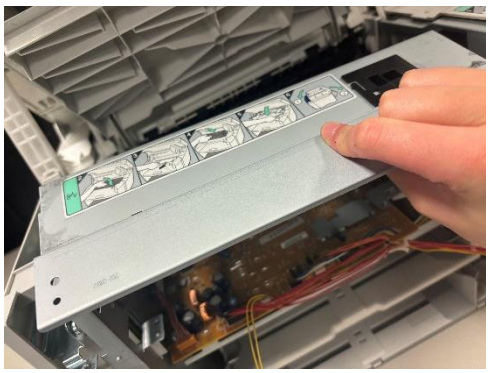




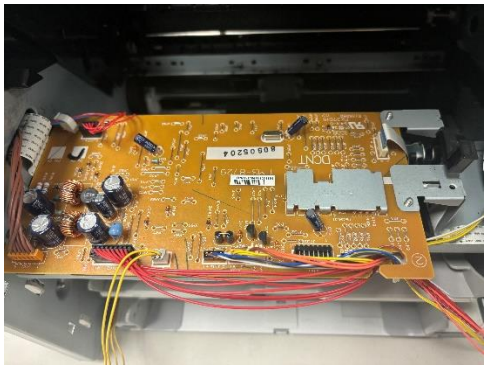
Step 8: Pull off the front covering for the display board and remove the buttons.

Step 9: Pull off the plastic front faceplate of the front of the printer.

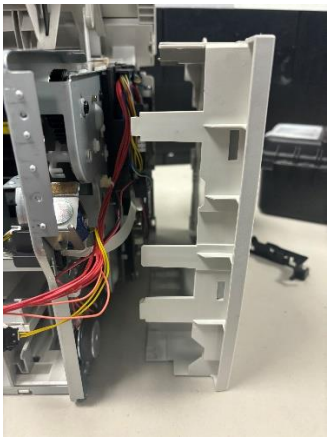
Step 10: Remove the metal bars at the front and on top of the printer by unscrewing five screws. A brown circuit board will be revealed.



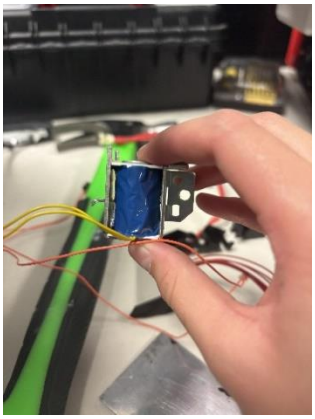
Step 11: Unscrew the three screws on the brown circuit board and carefully remove them. Set it aside.



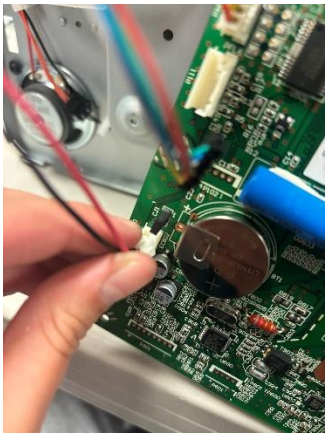
Step 12: Remove three clips on the right side of the printer and lift off the plastic panel.



Step 13: Unscrew the speaker and the transformer.

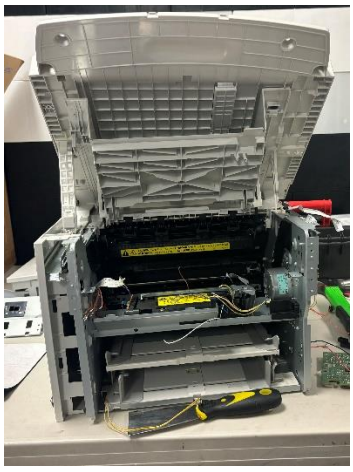


Step 14: Remove the cables from the green motherboard by pulling them out from the clip. When it is soldered in, cut them with the wire cutters.

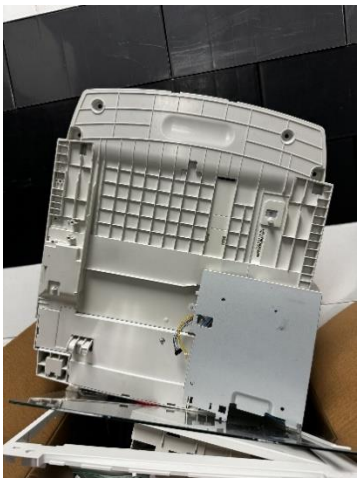


Step 15: Unscrew the four screws on the four corners of the motherboard.

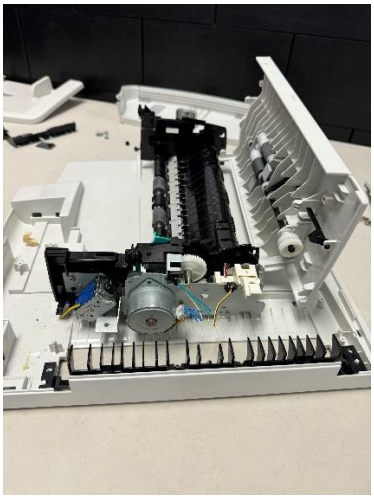
Step 16: Lift the top panel of the printer to reveal the output paper tray and remove the four main screws on the hinge. Pull out the plastic piece that stabilizes the tray.



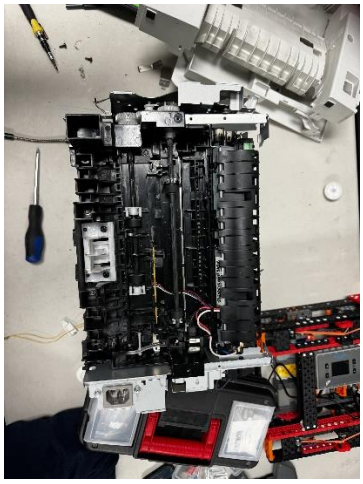
Step 17: Remove the top panel that covers the paper feeder by unscrewing from the hinge.



Step 18: Turn the printer around to the back side and unscrew four screws on the back of the printer to detach the back panel.

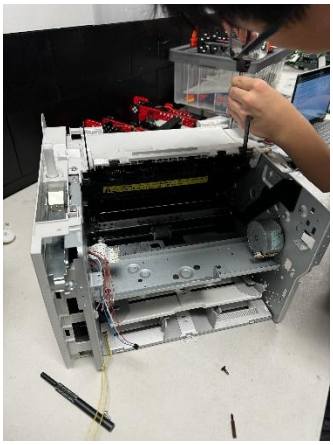


Step 19: Carefully remove the rear part of the printer by unscrewing four more screws attached to the metal frame.



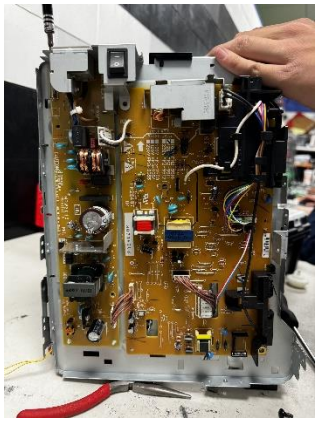
Step 20: Turn the printer to the left side and remove two screw covers on the side of the printer. Unscrew them.

Step 21: Unclip the left side panel of the printer. Carefully start unplugging and cutting wires that lead to the power supply.

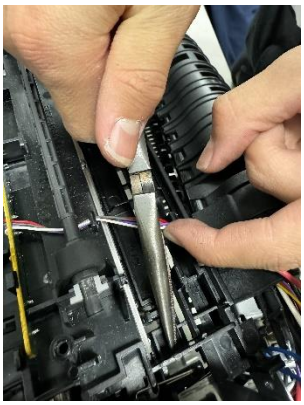


Step 22: Unscrew the power switch from the frame.

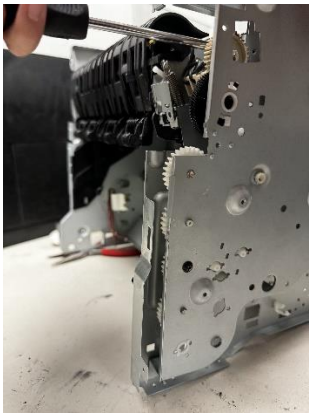
Step 23: Start removing five screws on the large power board and two screws on the small power board.



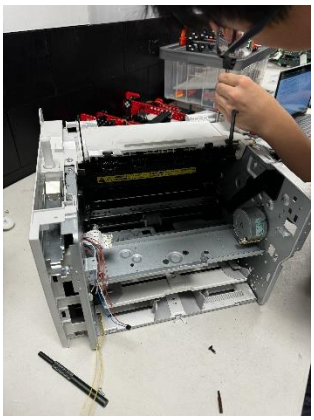
Step 24: Cut the wire leading to the printer drum.



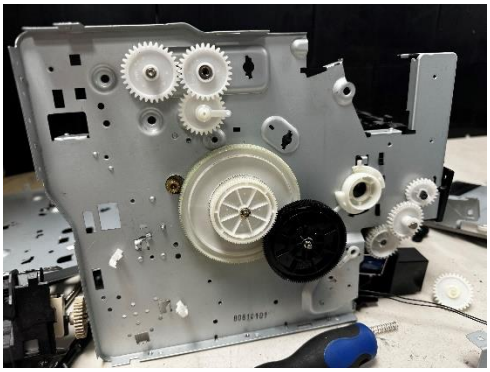
Step 25: Remove four screws that lead to the printer drum, and gently lift it out of the area.



Step 26: Unscrew the first layer of the right-side metal frame of the printer.



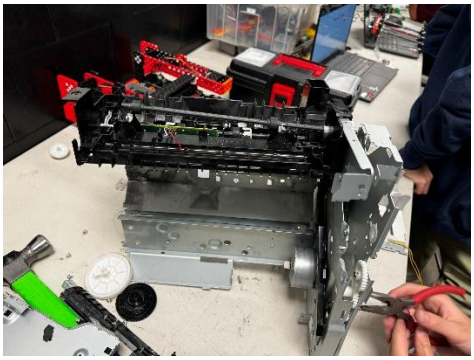
Step 27: Unscrew and then remove the printer feeder gears and set them aside.



Step 28: Unscrew the second layer of the right frame of the printer.

Step 29: Unscrew the first layer of the metal frame of the printer.

Step 30: Unscrew the second layer of the last metal sheet of the printer. All pieces should now be detached.



6.0 Analysis

6.1 Electronic Analysis

Figure 6.1.1 Main Motherboard

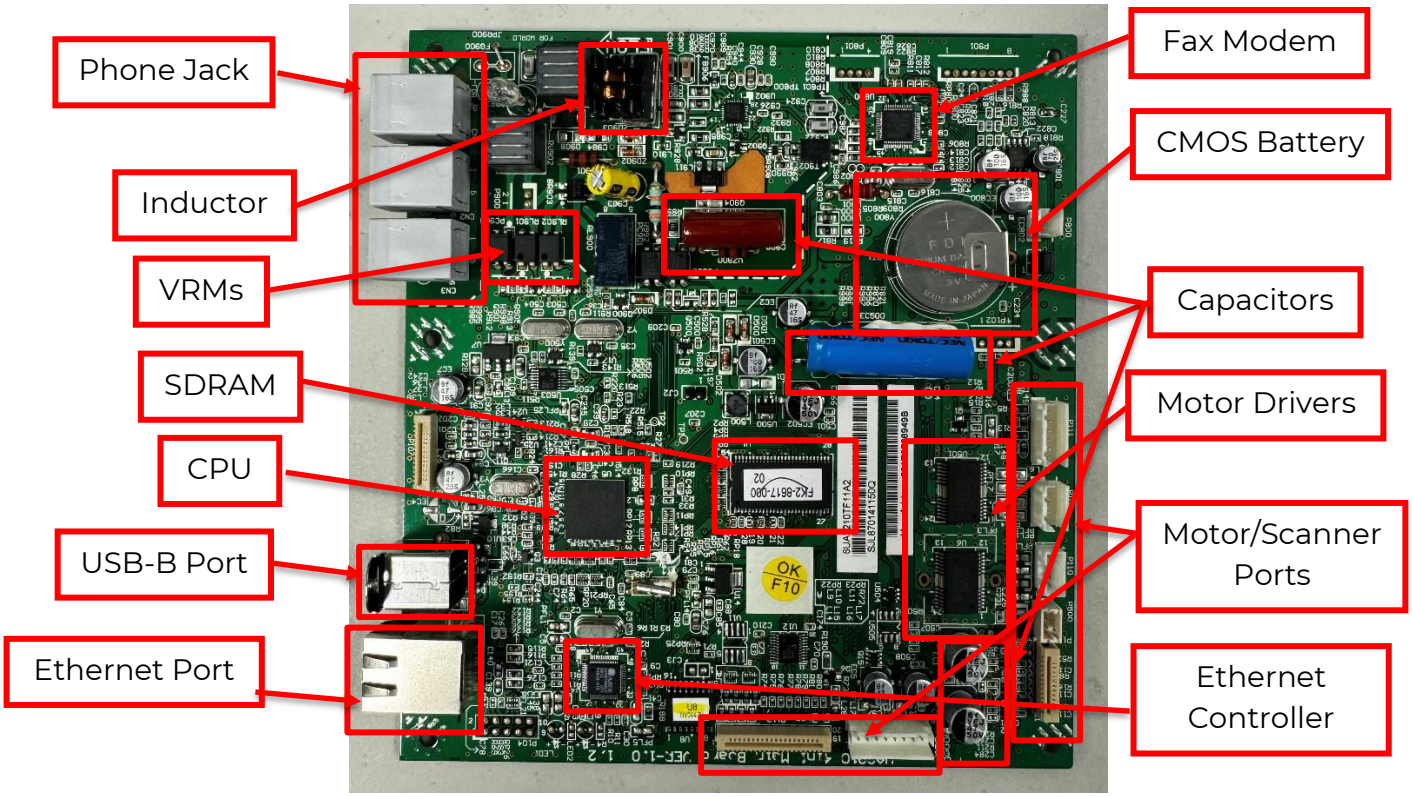


Figure 6.1.2 Motor Control Board

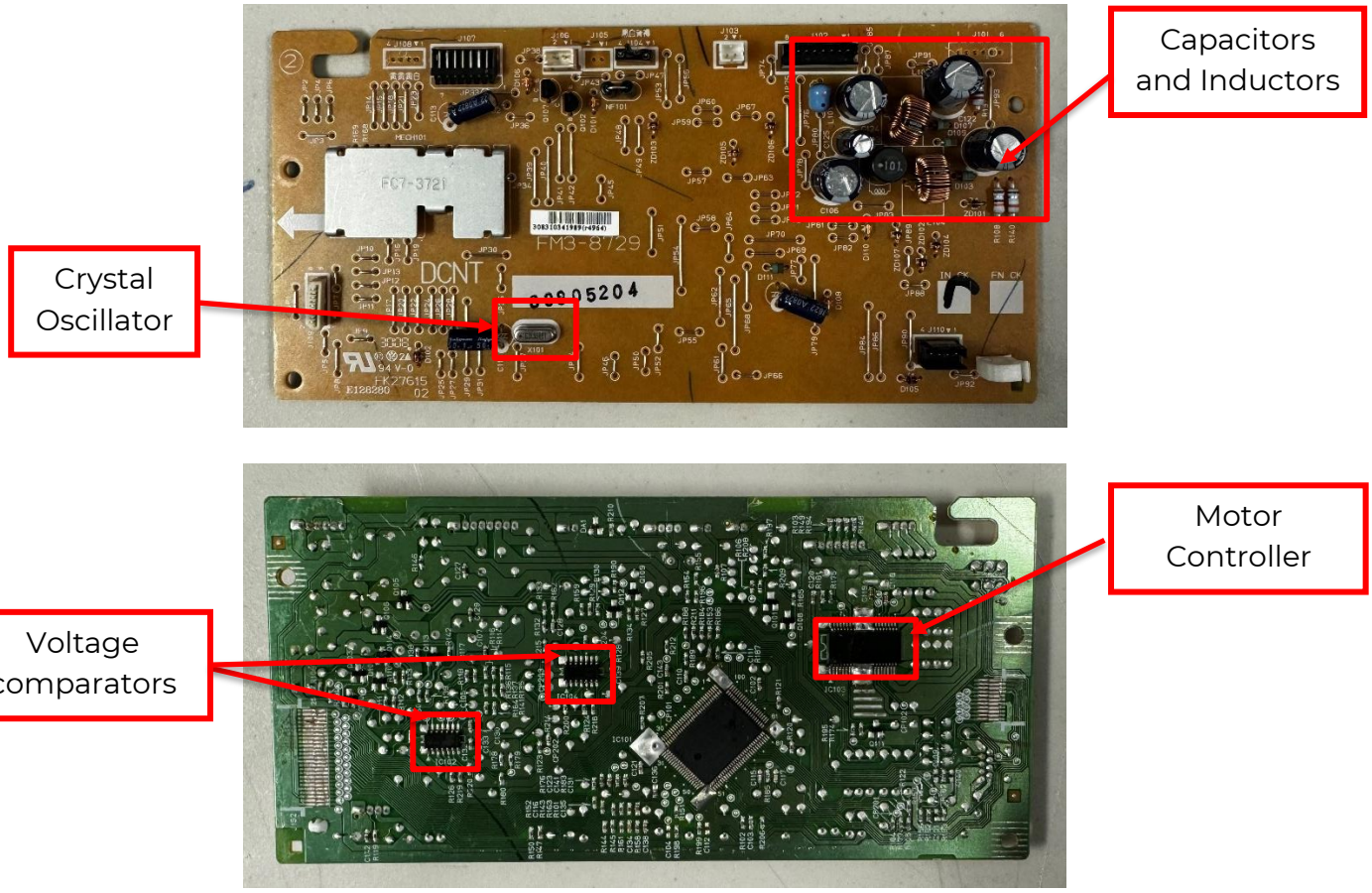


Figure 6.1.3 Display Panel

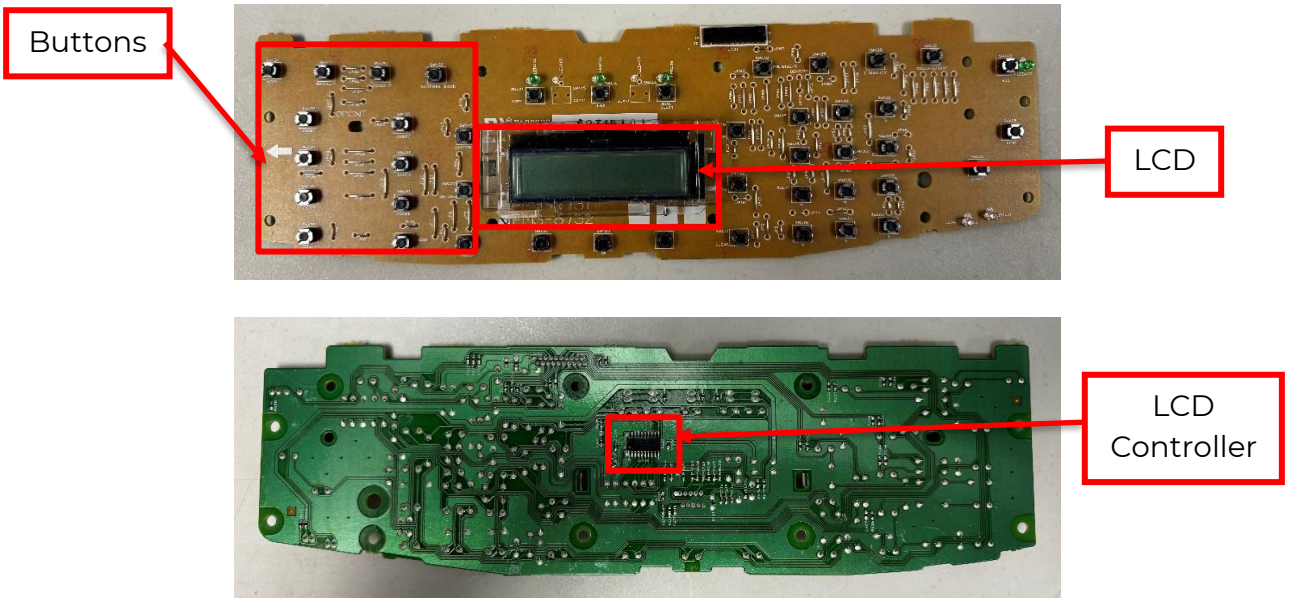


Figure 6.1.4 Power Supply Board 1

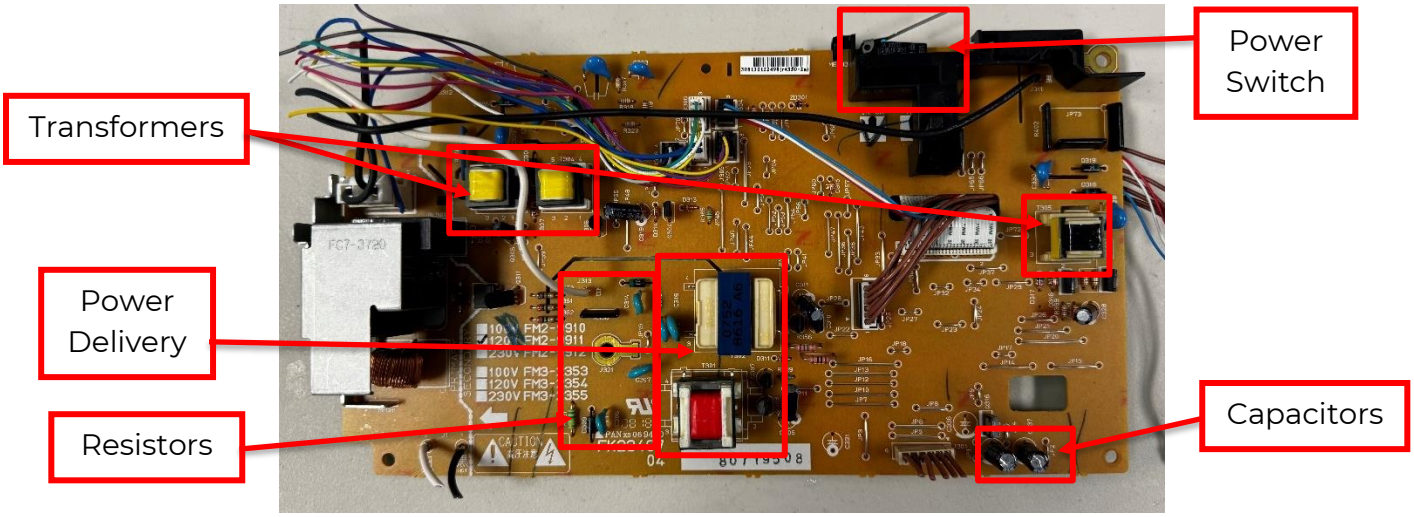
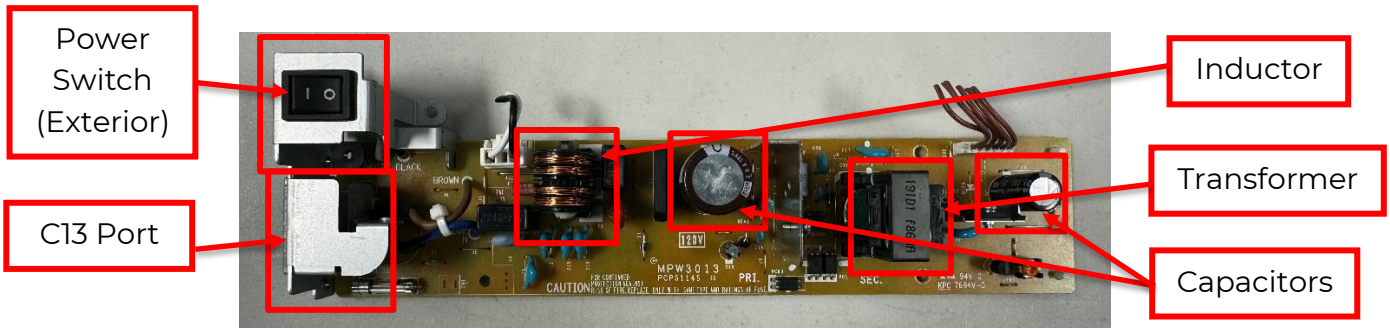
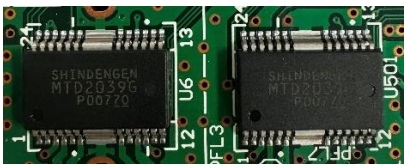


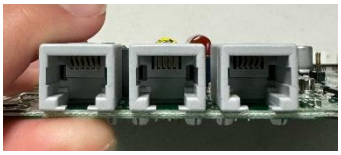
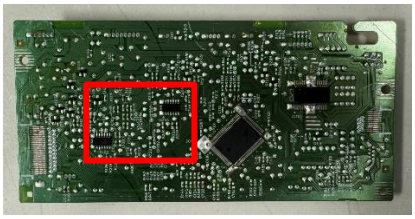
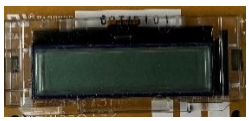
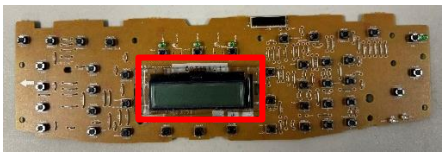
Figure 6.1.5 Power Supply Board 2

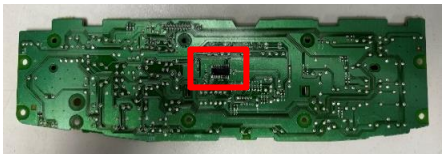
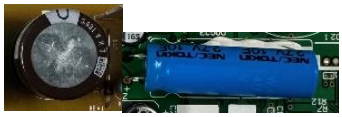
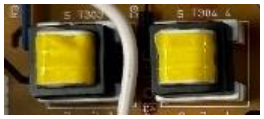


6.2 Individual Electrical Component Analysis

Part and Description	Picture	Location(s)
Central Processing Unit IALE 1AX00105S1996 Controls all the subsystems on the printer, performs calculations and computations.		
Ethernet Controller ASIX AX88796BLF Communicates data from a computer to the printer and vice versa over an Ethernet connection.		
Synchronous Dynamic-Random Access Memory FK2-8617-000 02 Efficient form of RAM, stores temporary data used by the CPU.		

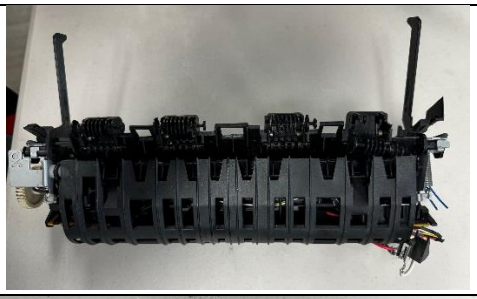
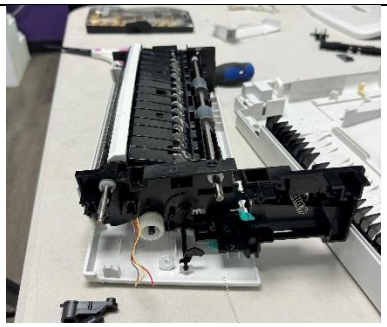
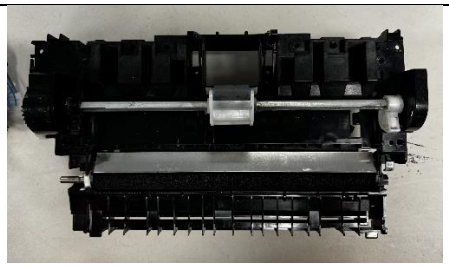
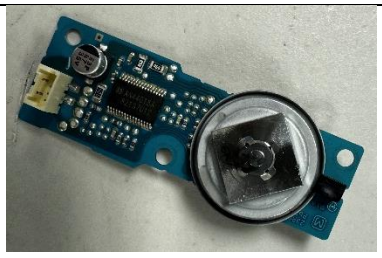
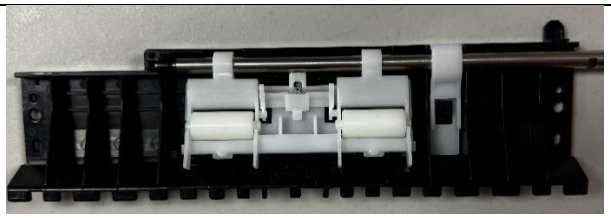
Fax Modem Conexant SFX336 CX86710-12 Communicates data from a computer to the printer and vice versa over a Fax connection.		
Motor Drivers Shindengen MTD 2039G Controls all motors on the printer, sending electricity and executes commands from CPU.		
USB-B Port Allows connection of the printer to outside devices.		

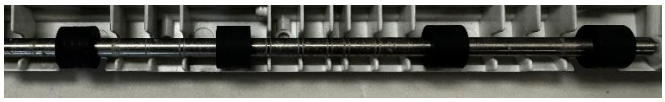
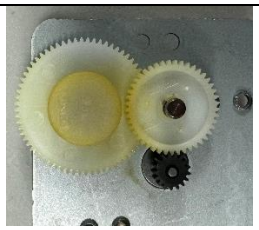
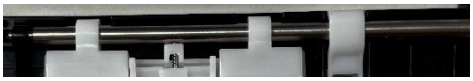
Ethernet Port Allows connection of the printer to outside devices and the Internet.		
Fax Port Allows connection of the printer to other printers over phone lines.		
C13 Port Allows connection of the printer to an electrical source (AC power).		
Voltage Comparator Compares two input voltages and outputs the signal of the larger one. Used for controlling motors.		
Liquid Crystal Display A device that presents data visually using a liquid crystal.		

Liquid Crystal Display Controller Controls what information is displayed on the LCD of the printer.		
Crystal Oscillator A device that uses a quartz crystal to create a timed electrical signal.		Multiple
CMOS Battery A battery that provides power to a device when off to store information like date and time.		
Capacitors Device that stores electrical energy for the printer.		Multiple
Inductors Device that stores electrical energy in magnetic form for the printer.		Multiple
Resistors Device that introduces electrical resistance into a circuit.		Multiple
Transformers Device that transfers electrical energy from one circuit to another circuit.		Multiple

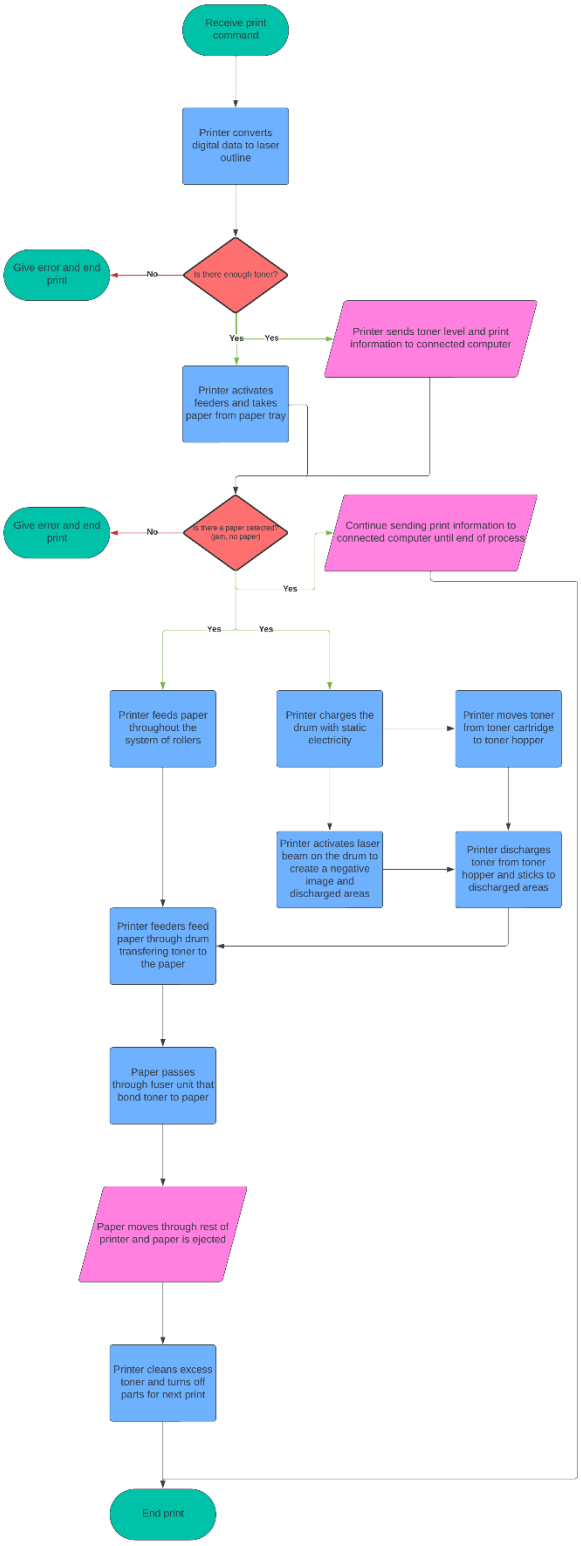
Voltage Regulator Modules Decreases and regulates voltage for the CPU		
Wires Connects and transfers electrical energy from one place to another		Multiple

6.3 Individual Electromechanical Component Analysis

Part and Description	Picture
Drum A device that transfers toner onto the paper via heat and pressure	
Toner Cartridge Holds powder and pigments inside a plastic casing	
Fuser Unit A device that fuses toner onto the paper	
Toner Hopper A device that takes toner from the toner cartridge and stores it	
Laser Unit Converts image from a digital source into a laser image to be printed	
Transfer Corona A device that negatively charges the drum and draws toner from the hopper to the paper	

Charged Corona Wire A wire that uses static electricity to positively charge the drum and draws the toner to the drum	
Paper Feeders Feeds paper through the printer and carries it throughout the printing process	
Stepping Motor Mitsumi M42SP-5K FK2-7626 Drives all the gears in the printer	
Gears Component that rotates that causes motion in a device	
Axles The central shaft for rotating gears	

6.4 Printing Process Analysis



7.0 Conclusion

The team learned a lot with the analysis of the printer. We learned printers are extremely complex machines that combine aspects of physical and digital technology. Printers use a variety of integrated circuits (ICs) and thousands of transistors, resistors, and diodes. Printers also use gears, drums, belts and pulleys, lasers, and sensors. Disassembly of this printer helps us understand that technology should not be taken for granted, and that hardware, such as a printer, has thousands of parts that all function together to create a device that people rely on for their work and daily life.

Analysis of this printer also helped us understand that a laser printer is like a small robot. Electrical components like capacitors, transistors, resistors, and transformers are used to power the printer, as they take AC power and store and filter it to be used by other parts of the printer. Communication systems like Ethernet and fax are used to control the printer, as other devices can communicate to the printer as an input. A wire can be used to transfer information and files to be printed. Mechanical components like motors axles, and gears are used to perform the printing and create a paper with readable text and pictures. All these examples of systems are used in VEX IQ, especially gears. With gears, gear ratios were employed in the feeder mechanism for the paper. 2:1 (32:16) and 1:4 (12:48) gear ratios were seen throughout the printer, mainly to drive the paper feeders. These examples of gear ratios can be used to make a robot drivetrain move faster or make a robot shooter mechanism more accurate.

Additionally, this experience also taught us the importance of teamwork and problem solving. During disassembly, there were multiple team members helping each other disassemble the printer and finding ways around the disassembly restrictions. One example of this was the large amount of security screws and parts that were glued together. We overcame this by disassembling parts attached to the piece. One instance was that we had to disassemble the backplate to remove the printer drum rather than disassembling from the left or right-side plates, as they had security screws. Our team learned it would be extremely difficult to take apart a printer with only one person. Additionally, team members also helped with the analysis of the components since there were countless electronics and mechanical components in the printer.

Disassembly of the printer taught us skills of disassembly and physical mechanisms as well as teamwork and problem solving. We were able to use skills learned from this report in

VEX IQ. This has been a fantastic way to apply our knowledge of robotics and learn new skills to gain great experience.

8.0 References

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