610B REVERSE ENGINEERING CHALLENGE

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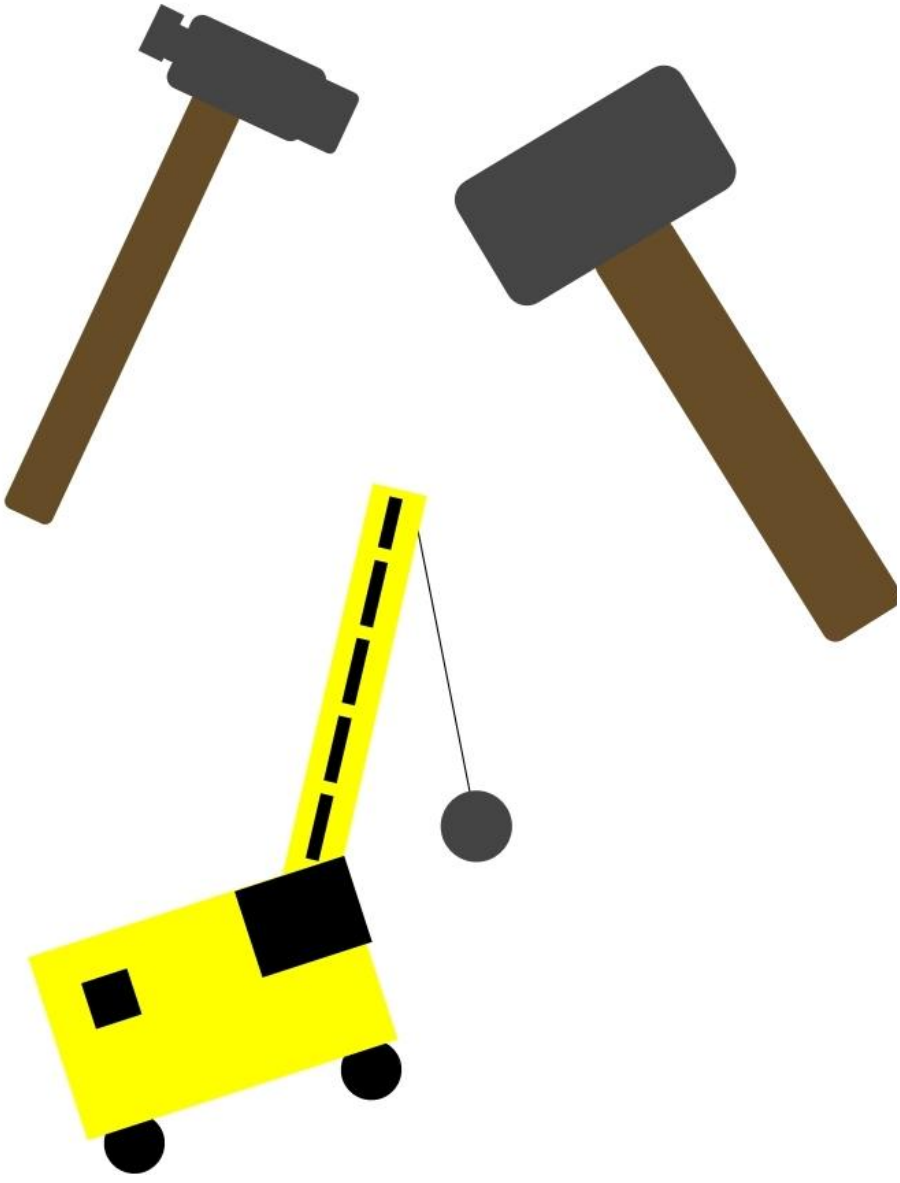


Introduction

Our chosen device for this challenge was the HP 22-3109 All-in-One (AIO) Desktop PC. Released in 2015 by tech conglomerate **HP**, it serves as an AIO PC, meaning that **all of the functions needed in a computer such as a monitor, speakers, and peripherals are included in a single machine.**

The Device

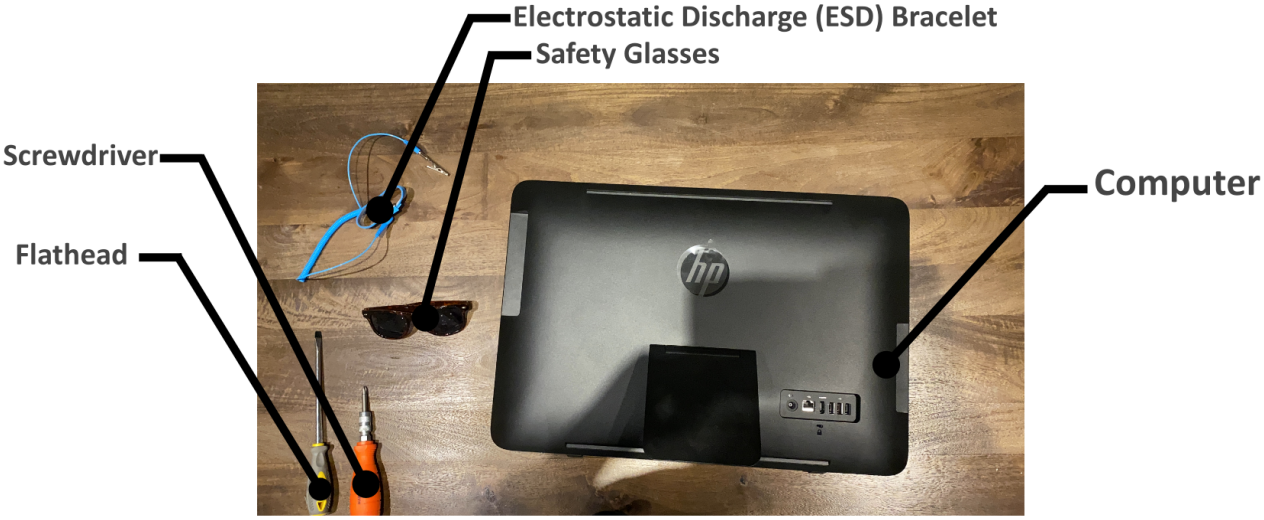
HP 22-3109 All-in-One Desktop PC
RELEASE DATE: 2015

Why We Chose This Device

We chose to reverse engineer (RE) this device as **deconstructing it would provide us with valuable skills regarding the internal components and function of a machine that we use everyday - a personal computer. Being able to have hands-on experience with the device allows us to further understand how the personal computers we use everyday work, along with being a fun way to learn skills such as troubleshooting a computer, which may help us in the future.**

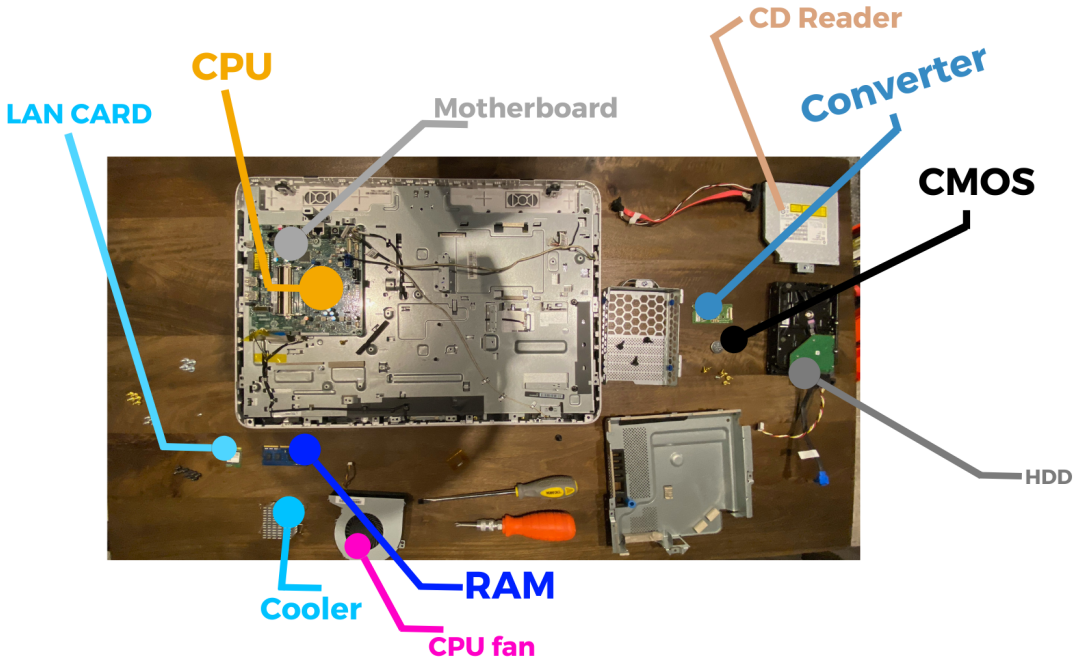
DECONSTRUCTION PREP

The following are the materials needed to begin deconstructing the computer, including safety goggles to protect against shrapnel, the computer itself, and an ESD bracelet to stop the flow of electricity into both my body and the computer by grounding myself to a part of the device. A screwdriver and flathead are also needed during the reverse engineering process

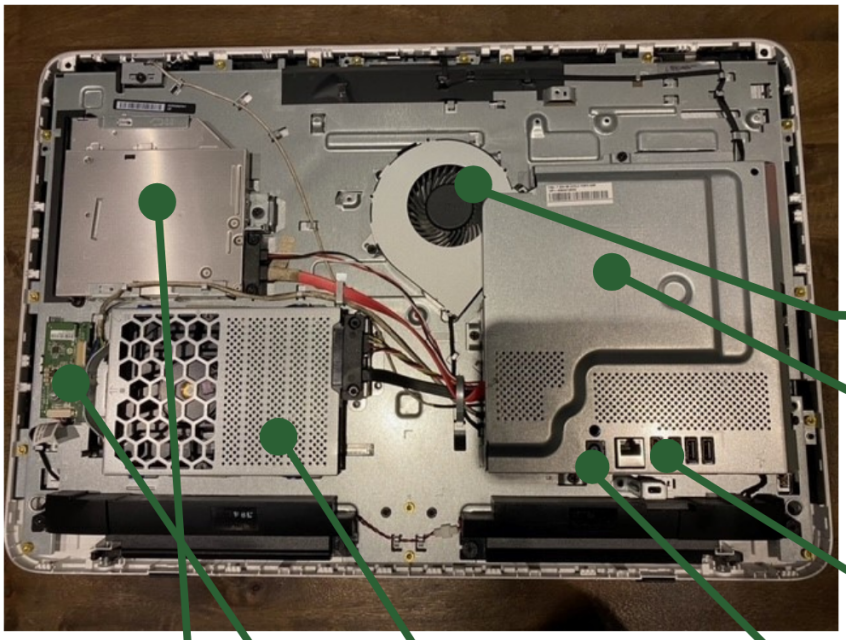


Before beginning to deconstruct, I (Andrew) had to ensure that I would be safe throughout the entire process. Above are the materials I used to ensure this.

Parts List:



Summary of Components Found Inside the Computer & Research and Roles Played (See image captions)



Step 1 - Backplate Removal

-Reveals internal components, below is a general summary, **PLEASE READ FURTHER FOR AN IN-DEPTH ANALYSIS OF FINDINGS.**

Fan - Assists the metal plate in cooling by **exhausting warm air out of the case.**

Motherboard Cover/Passive Cooling - The components under this plate (and in the rest of the machine) **run HOT.** For example, the computer that I (Andrew) am writing this on is currently running at **80˚C.** As a result, the **engineers at HP had to find a power-efficient and effective cooling solution to assist the fan in it's cooling efforts. To do this, they covered the motherboard in a metal plate.** The metal plate **allows for heat to rise UP and into the plate, where the metal (material known for it's heat absorption) will both absorb and distribute the heat, helping cool the components.**

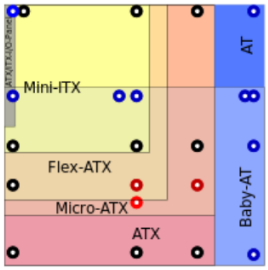
I/O (Input/Output) Ports such as **USB** are **used to connect peripherals** (Mouse/Keyboard) and other devices.

Power Input Port (PIP) - Due to the fact that **this is an AIO PC, the engineers at HP did not have much space to fit all of the parts they needed into a single machine.** To compromise, **rather than using an internal Power Supply Unit (PSU)** which typically powers the system while acting as an internal component, **HP chose to use an external power supply that draws power from a wall outlet.**

Hard Drive Disk (HDD) - This acts as the **storage** for the computer.

Converter Board - Converts motherboard signals to **power the screen.**

CD Disk Reader - As this computer is quite old, it has the ability to **read CD disks** with this component.



Step 2- Motherboard

Reveals the **MOTHERBOARD**, **see below for the breakdown of other motherboard parts**

Motherboard

After unscrewing the metal plate, I discovered the **motherboard (commonly referred to as "mobo").** The mobo **acts as the centerpiece of the computer - it is what connects each component of the computer together and allows them to function in harmony. Without the mobo, the computer would simply be a bunch of loose parts.**

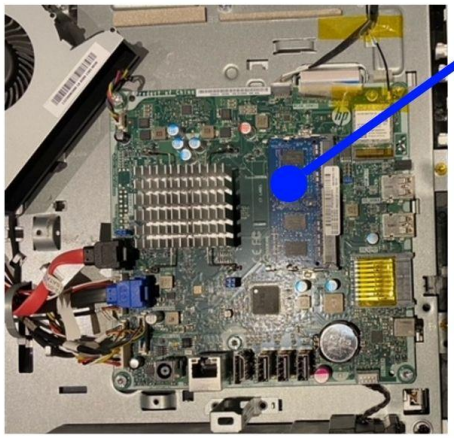
While looking at the labels and size of the mobo, I recognized it as the **HP AMP-DP** - exclusive to this line of AIO desktops. In addition, it's small size led me to recognize it as an **Mini-ITX** motherboard.

Source: https://www.hp.com/us-en/shop/tech-takes/what-does-a-motherboard-do#:~:text=The%20motherboard%20is%20the%20backbone,a%20computer%20to%20work%20well.

Step 3- RAM

Actual Memory

Pins to connect to mobo



RAM

Speed	Generation	Amount
1600Mhz	DDR3	4GB

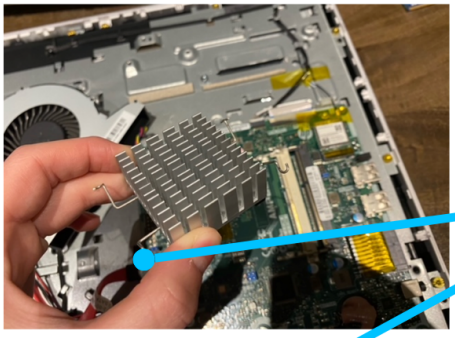
After looking at the motherboard, the first component I recognized was the stick of **Random-Access Memory (RAM)** . **RAM acts as the memory of the computer, storing temporary/short-term data.** Without RAM, the computer wouldn't be able to "remember" anything and therefore would be unable to complete any tasks. **For example, when opening an app, the RAM needs to hold and process the information of that app**.

Since this computer is quite old, it has a mere **4 Gigabytes (GB, amount) of DDR3 (Generation) RAM at 1600Mhz (Speed). Compared to todays technology, this is considered to be extremely slow. For example, the computer I am writing this on has 32GB of DDR4 RAM and 3200Mhz, which is more than 4x better than the RAM shown above.**

Source: https://www.intel.ca/content/www/ca/en/gaming/resources/how-much-ram-gaming.html#:~:text=RAM's%20purpose%20is%20to%20store,time%20the%20system%20is%20rebooted.

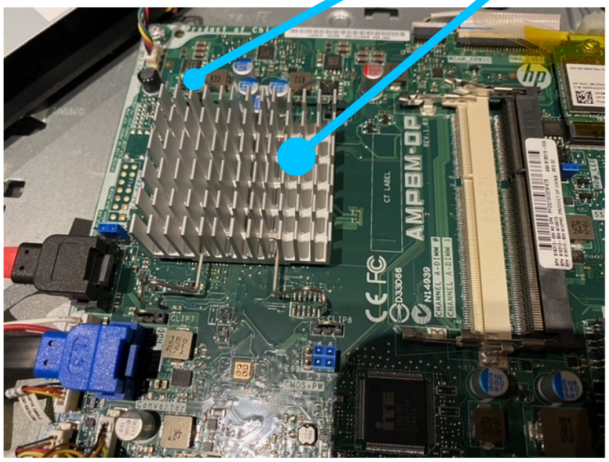
Step 4 - CPU Cooler

See below for **BREAKDOWN OF CPU**



Pins to connect to mobo

Cooling Fins



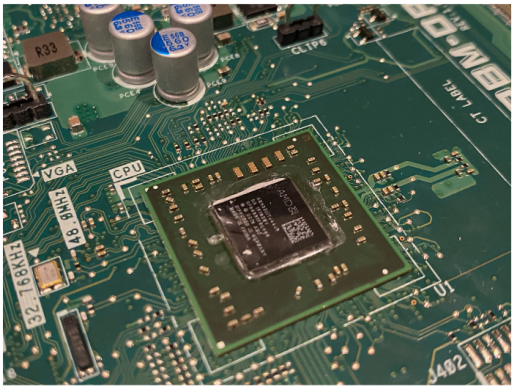
The second component I had noticed was the **CPU Cooler (referred to as cooler).** As stated previously, **the lack of an integrated Power Supply Unit (PSU) had forced the HP engineers to use simple, passive cooling to conserve energy.**

With the cooler, **it's metal design allows for heat to rise up into it and be absorbed and distributed by the fins.**

Source: General Knowledge

Step 5 - CPU

CPU

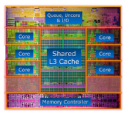


After removing the CPU cooler, I examined the most important and most exciting part of the computer - **the CENTRAL PROCESSING UNIT (CPU).** The CPU is **an incredibly complex piece of silicon (see "die" diagram below) that acts as "the brain" of the computer. The CPU gives instructions (information) to other parts along with providing the power needed to process information.**

This machine is equipped with **an AMD A6-6310,** a processor released by **AMD** as a part of their "**A" series.** The **6310 was considered to be "low-end" even when it first launched in 2014, having only 4 cores (part of CPU that performs tasks) and 4 threads (part of the CPU that manages cores) running at a clockspeed of 1,8 gigahertz (Ghz, unit of CPU speed measurement).** Compared to AMD's current industry-dominant **RYZEN series, the A6-6310 is a relic from the past.**

Continuing the trend of saving space within the machine, the HP engineers tasked with designing this computer chose to **sacrifice having a discrete (dedicated) GRAPHICS Processing Unit (GPU, allows the computer to display video output) by choosing a CPU that has integrated graphic capabilities. Having integrated graphics allows the CPU to display video without a discrete GPU.**

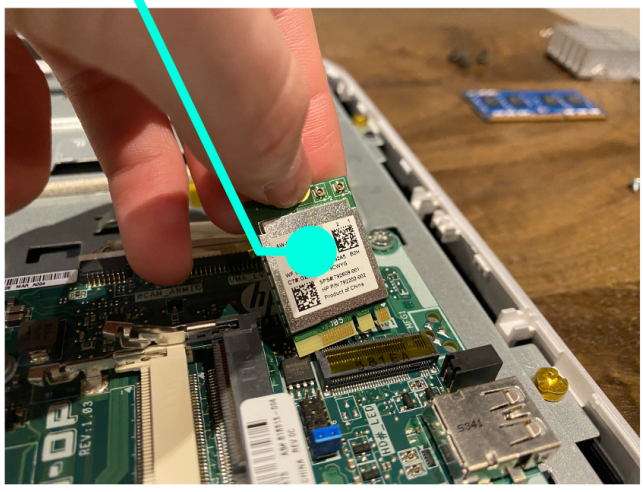
Note: While removing the CPU from it's cooler, I noticed that there was some thermal paste (substance on CPU that typically helps move heat between CPU and cooler) stuck on the cooler. Conveniently, I had a bottle of computer-grade isopropyl alcohol that I used to clean the paste off the CPU and obtain a better view of the component.



Clockspeed	Cores and Threads	Power Draw
1.8Ghz	4	15 Watts

Source- https://www.intel.com/content/www/us/en/business/small-business/resources/am-vs-processor.html#:~:text=%20the%20Processor.-,The%20processor%2C%20also%20known%20as%20the%20CPU%2C%20provides%20the%20instructions,computer%20think%20and%20work%20faster.

LAN CARD



Step 6 - LAN Card

The part I noticed was one that was quite unfamiliar to me - the **Local Area Network (LAN) Card. LAN cards allow computers to connect to WiFi networks. Without this component, the computer would only be able to connect to a network through Ethernet (wired connection).**

The presence of this part surprised me as **the LAN card has become mostly irrelevant since 2015 with the invention of integrated WiFi, allowing computers to connect to networks without a LAN card.**

Source: https://www.realtek.com/en/products/communications-network-ics/item/rtl8188ee

Step 7 - CMOS Battery

The **CMOS (Complementary Metal-Oxide-Semiconductor) Battery** is a **lithium battery that typically powers the part of the mobo that stores BIOS (Basic Input-Output System) of the computer.** The BIOS is **essentially the "settings" menu** for the computer **hardcoded into the CPU.** It controls what speed fans spin at, what speed RAM runs at, how information is processed and much more.

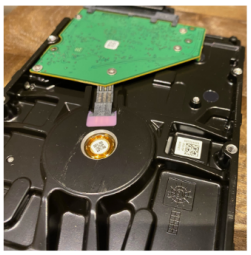
Source:
https://www.intel.ca/content/www/ca/en/support/articles/000025368/processors.html#:~:text=What%20is%20CMOS%3F,memory%20chip%20on%20the%20motherboard.

Step 8 - CPU fan

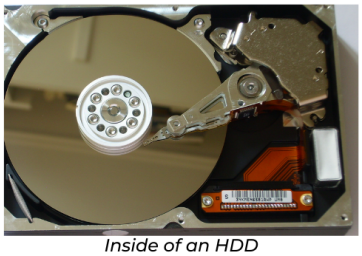
The **fan** assists the passive cooling plates in cooling down components by exhausting warm air out of the computer. Without cooling, the **CPU may reach dangerous temperatures of over 100˚C.**

Source:
General Knowledge

Step 9 - Hard Drive



Back of HDD, circle is the middle of the platter



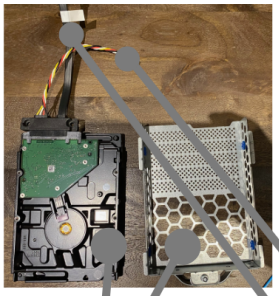
Inside of an HDD

The **Hard Disk Drive (Referred to as HDD)** acts as the **storage** for a computer. It is an extremely complicated system of **magnets**, **platters** and **arms** that **read and write data as 1s and 0s (binary code).** In an HDD, the **platters (discs) are made up of millions of nanometer-sized magnets that are assigned values of either 1 or 0, representing data points. As the arm (head) spins around the platter, it reads each 1 and 0 based off of it's magnetic polarization. Without a hard drive, the computer would not be able to store any data.**

Unfortunately, **HDDs are slow, inefficient and inconvenient due to their mechanical nature.** Thankfully, in recent years, **the majority of computers have implemented a new, MUCH (up to 100x) faster storage device known as a SOLID STATE DRIVE (SSD), which uses a complex electronic system to store data.**

The HDD in this machine is a generic **1000GB (1 Terabyte) drive from Seagate, one of the biggest storage device manufacturers in the world.** Due to the fact that HDDs rely on delicately placed magnets to read and write data, even the slightest of damages can destroy hundreds of gigabytes worth of data by messing up the polarization of the platter. As a result, most HDDs **come with a cage that stops them from vibrating, helping prevent data loss.**

Note: While I would enjoy examining the interior of the HDD, the interior of a mechanical drive contains many dangerously sharp metallic pieces such as springs, platter edges and arm bases. In addition, some older drives may even contain toxic chemicals such as mercury and lead.



Power Cable (Powers HDD)

HDD

SATA Cable (To mobo, transmits data from HDD to motherboard)

HDD Cage

Size	Device Type
1 Terabyte (TB, 1000 Gigabytes)	HDD

Source:
General Knowledge + https://www.cohenusa.com/recyclable-items/hard-drives/ +
https://en.wikipedia.org/wiki/Hard_disk_drive_platter
+https://www.ontrack.com/en-gb/data-recovery/hard-drive/how-do-hard-drives-work

Step 10 - Converter Board

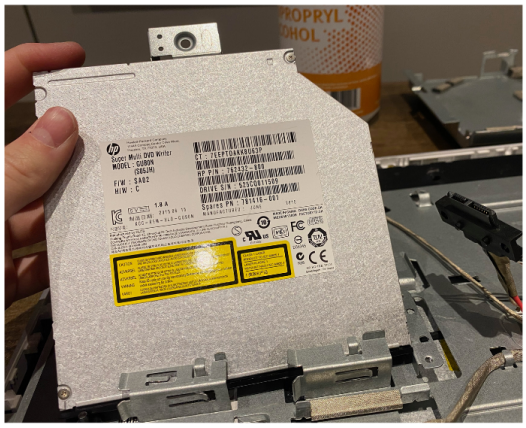
This component was **COMPLETELY unfamiliar** to me, as I had never considered about how **the screen in an AIO is powered.**

This is done with a **Converter (Screen Inverter) Board.** Which takes **Direct Current (DC, electrons flowing in a single direction)** signals from the motherboard and **converts them into Alternating Current (AC, electrons flowing in 2 directions) to power the screen. Through my research, I also found out that laptops use similar converter boards to power their screens.**

This computer is equipped with a **generic HP converter board.**

Source:
https://www.easytechjunkie.com/what-is-a-screen-inverter.htm#:~:text=A%20screen%20inverter%20is%20a,motherboard%20into%20an%20alternating%20current.

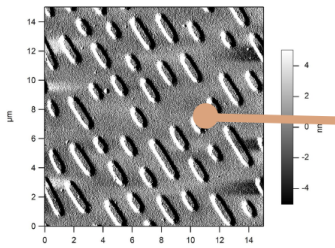
Step 11 - CD Reader



This component serves as evidence that this computer is old, as **the Compact Disc (CD) has fallen into complete irrelevance in the past 10 years. This CD reader allows the computer to read and write data off of CDs.**

A CD **works by reflecting a laser through a thin disc made of a material known as polycarbonate. On the polycarbonate are nanometer-sized bumps, and as the laser scans them, it recognizes the difference between flat areas and bumps (by measuring light reflection length) as a data point.**

This computer is equipped with a **generic HP CD reader.**



Bumps on a CD

Source:
https://en.wikipedia.org/wiki/Compact_disc#:~:text=A%20CD%20is%20read%20by,way%20the%20light%20is%20reflected.

CONCLUSION AND LESSONS LEARNED:

Throughout the reverse engineering of this computer, I learned many valuable skills about the internal components of a computer and other devices, along with learning about how far technology has improved in the mere 7 years since the release of the device I dissected. **For example, when looking at the machine after removing the backplate, I was amazed at how the HP engineers had managed to fit very powerful (for the time) parts into such a small machine. This made me reflect on 610B's robot, and upon how we can apply the same principles used by HP engineers in 2015 to compact their machine to our own robot.** Furthermore, **learning about the intricacies of technologies like the CD and HDDs was very interesting.** Prior to this report, **I did not even begin to think about the specific convolutions of something as seemingly simple as a CD**. Learning about how magnetic polarization is used to read and write data in an HDD is fascinating, and made me think about the genius that went into inventing these wonderfully complicated pieces of technology.

Furthermore, this report allowed for me to have hands-on experience with reverse engineering a real, everyday device. **Being able to interact with and study each individual component helped me understand their functions and how they all work in harmony to create such a powerful machine. This understanding of a computer's components may be useful in the future if I ever encounter an issue with a PC, or if I ever find myself working in a career that revolves around them.**

In addition, as a middle school student, I found **the connection between the material I study in science class and my findings** here to be interesting. For example, being able to apply **my knowledge of heat to understanding how a CPU cooler works is quite fascinating** to me.

In conclusion, this report was an enjoyable way to learn about the internal components of a computer, along with a way to apply my knowledge of VEX IQ and science to something in the real world.

Appended Citations:

"HP 22-3019 All-In-One Desktop PC Product Specifications | HP® Customer Support." Hp.com, 2023, support.hp.com/ca-en/document/c04758936. Accessed 3 Jan. 2023.Knerl, Linsey.

"What Does a Motherboard Do?" Hp.com, HP, 17 Oct. 2019, www.hp.com/us-en/shop/tech-takes/what-does-a-motherboard-do#:~:text=The%20motherboard%20is%20the%20backbone,a%20computer%20to%20work%20well.. Accessed 3 Jan. 2023.

"How to Choose RAM." Intel, 2023, www.intel.ca/content/www/ca/en/gaming/resources/how-much-ram-gaming.html. Accessed 3 Jan. 2023.

"Ram vs. Processor." Intel, 2018, www.intel.com/content/www/us/en/business/small-business/resources/ram-vs-processor.html#:~:text=of%20the%20Processor-,The%20processor%2C%20also%20known%20as%20the%20CPU%2C%20provides%20the%20instructions,computer%20think%20and%20work%20faster.. Accessed 3 Jan. 2023.

"How to Clear CMOS to Reset BIOS Settings in Systems with Intel®..." Intel, 2020, www.intel.ca/content/www/ca/en/support/articles/000025368/processors.html#:~:text=What%20is%20CMOS%3F,memory%20chip%20on%20the%20motherboard.. Accessed 3 Jan. 2023.

"Hard Drive Recycling - Cohen." Cohen, 5 July 2022, www.cohenusa.com/recyclable-items/hard-drives/. Accessed 3 Jan. 2023.

Wikipedia Contributors. "Hard Disk Drive Platter." Wikipedia, Wikimedia Foundation, 28 Dec. 2022, en.wikipedia.org/wiki/Hard_disk_drive_platter. Accessed 3 Jan. 2023.

"How Do Hard Drives Work | Ontrack." Ontrack, 2023, www.ontrack.com/en-gb/data-recovery/hard-drive/how-do-hard-drives-work. Accessed 3 Jan. 2023.

"What Is a Screen Inverter?" EasyTechJunkie, 3 Dec. 2022, www.easytechjunkie.com/what-is-a-screen-inverter.htm#:~:text=A%20screen%20inverter%20is%20a,motherboard%20into%20an%20alternating%20current.. Accessed 3 Jan. 2023.

Wikipedia Contributors. "Compact Disc." Wikipedia, Wikimedia Foundation, 19 Dec. 2022, en.wikipedia.org/wiki/Compact_disc#:~:text=A%20CD%20is%20read%20by,way%20the%20light%20is%20reflected.. Accessed 3 Jan. 2023

系統管理員. *"RTL8188EE - REALTEK." Realtek.com, 2019, www.realtek.com/en/products/communications-network-ics/item/rtl8188ee. Accessed 3 Jan. 2023.*