

VEX VRC – 2023 / 2024 Reverse  
Engineering Online Challenge  
Analyzing and Understanding A  
Computer

Seaquam Robotics  
Kirby 9181K



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# Progress Documentation

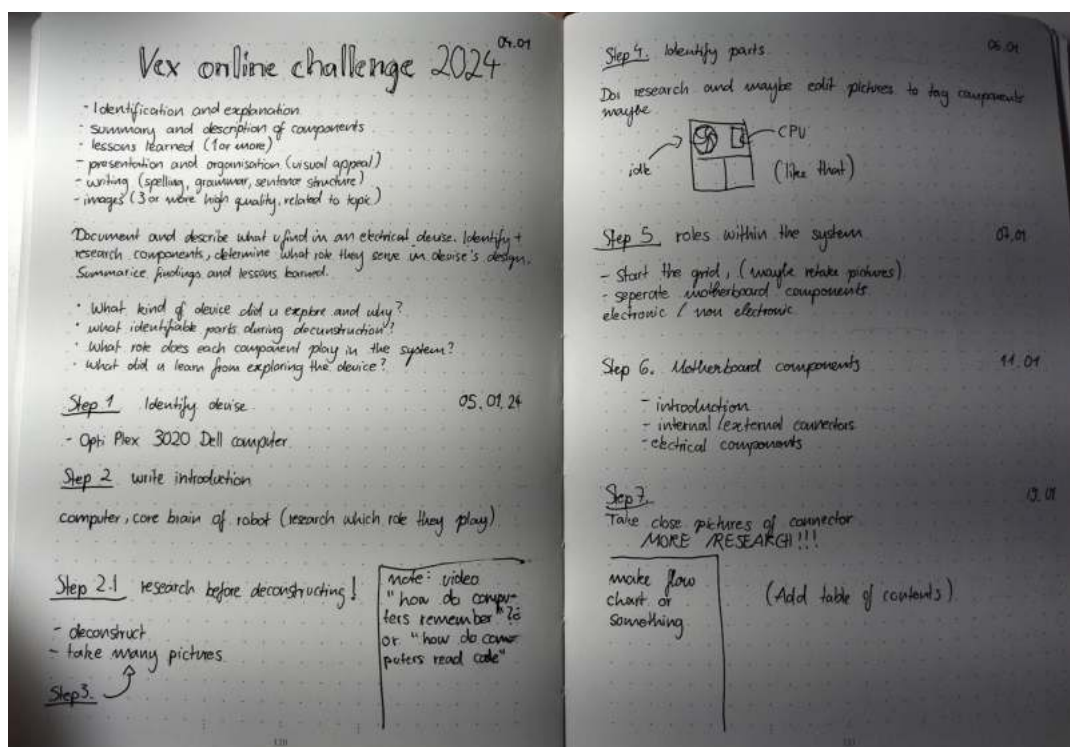
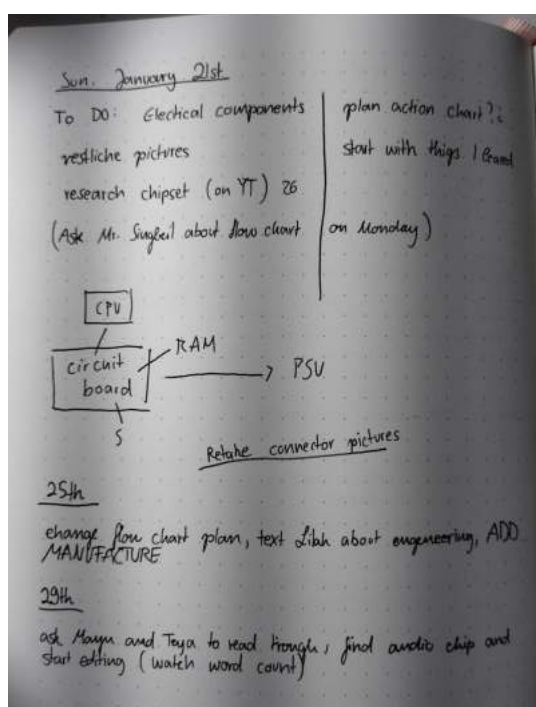


figure 1/2: images of my notebook pages



At the start of this challenge, I decided to keep track of the things I wanted to do and still have to do, to have a better overview. So I used my notebook to keep record of the progress I've already made.

## Introduction:

The electronic device I choose is the Dell Optiplex 3020 SFF Desktop PC, launched in September 2017. I chose this device, because I'm interested in the working ways of a computer and a personal goal of mine is to build my own computer in the near future. (I also came across YT videos of how computers remember and read code) and I saw this as a great opportunity to gain

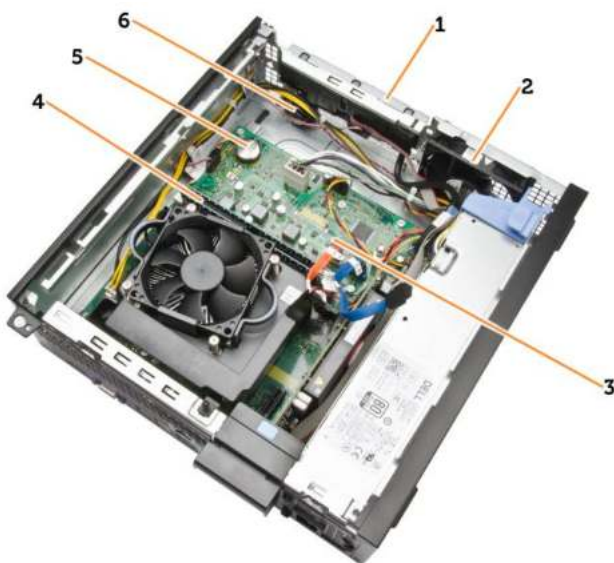
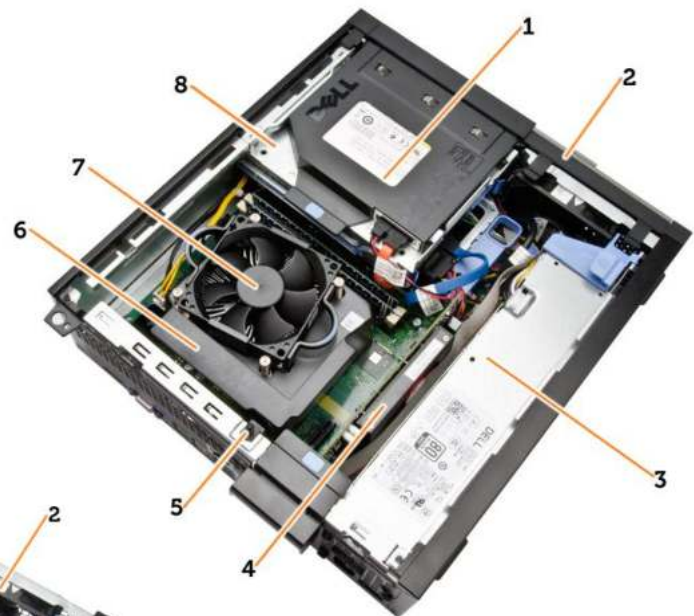
'hands - on' experience and deeper insights into computer hardware, because they play an essential role in industrial automation and robotics. My uncle also simply used to have an old computer lying around and offered it for this challenge, which was very convenient and I couldn't pass up the chance to take a closer look.

## Pre Disassemble Research

I did some prior research before disassembling the pc, to make sure I don't destroy anything and do it properly. I also got familiar with some parts of the computer, so I don't go into the disassembling process completely blindfolded, since I've never disassembled a computer before. I found the official owner's manual [\[1\]](#) and a system board disassembling video [\[2\]](#) for the Dell pc and decided to primarily stick to these instructions for the disassembling process.

## General inside view:

1. optical drive
2. front bezel
3. power supply unit
4. expansion card
5. intrusion switch
6. heatsink cover
7. heatsink
8. drive cage



1. front I/O
2. system fan
3. system board
4. memory module
5. coin cell
6. speaker

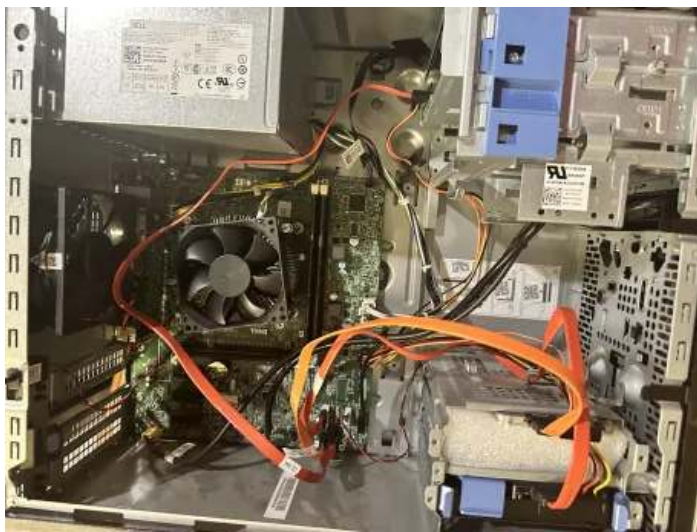
## Disassembling process

### Tools needed:

- Safety glasses
- Phillips head screwdriver
- Containers for screws and the CPU

### Steps:

0. Read safety information
1. Shut down computer properly and disconnect it from the power source.
2. Unscrew side panels and remove computer cover.
3. Disconnect power cables and unscrew components.
4. Gently remove components: Optical drive, Hard drive, SSD, CPU cooler, I/O panel, Power supply unit, Battery, Ram, Cpu, Motherboard,



*Figure 3: Computer case open, before taking out components*

*Figure 4: Computer case open, after taking out components*




## Overview of the Identifiable Components I Found:











- Red: Motherboard
- Orange: Hard Disk Drive (HDD)
- White: CPU Cooler
- Yellow: Central Processing Unit (CPU)
- Black: SATA SSD
- Purple: SDRAM
- Pink: Power Supply Unit (PSU)
- Dark blue: Screws
- Light blue: DVD Player
- Light green: USB Ports
- Dark green: Power Cable
- On the bottom: Computer case

*Figure 5: overview of all disassembled parts*





## The Role of Each Compound in the System

<p>CPU</p> <p>Intel Core i3 series</p> <p>up to 8MB cache</p>	<p>Called 'brain' of the computer, located inside the motherboard. It performs most of the calculations that enable a computer to function, by using program instructions from RAM, it interprets and processes them and sends back results for relevant components to carry out the instructions</p> <p>Note: CPU's processing speed is measured in megahertz (MHz) and gigahertz (GHz)</p>	
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<p>RAM</p> <p>up to 1600 MHz DDR3 Synch DRAM Non-ECC memory</p> <p>capacity: up to 8GB</p>	<p>System's short-term memory. It stores the code and data that are being actively accessed by the CPU. The short-term memory disappears when the computer is turned off.</p> <p>Note: RAM is measured in megabytes (MB) or gigabytes (GB)</p>	
<p>SATA SSD</p> <p>480 GB storage.</p>	<p>Used to store the operating system and frequently used applications, since SSD cards offer faster data access and quicker booting times due to their chip than Hard Disk Drives. Typically smaller storage capacities</p>	
<p>HDD SATA</p> <p>3TB storage</p> <p>HD rotational speed: 7200 RPM</p>	<p>System's long-term storage, the data is still saved even after turning off or unplugging the computer. Software, documents, and other files are stored in the HDD. Commonly used as secondary storage alongside the SSD, providing space for less accessed data.</p>	
<p>Motherboard</p> <p>Genuine Dell Optiplex 3020 SFF Desktop Motherboard 4YP6J</p>	<p>Main circuit board. Holds important parts, e.g. CPU, memory, connectors for hard drive. It connects to other parts of the computer including the CPU, the RAM, the disk drives (CD, DVD, hard disk) and directly or indirectly to every part of the computer.</p>	

<p>PSU</p>	<p>The PSU converts alternating current (AC) electric power to low-voltage direct current (DC) power for the computer. It sends power through cables to the motherboard and other components.</p>	
<p>CPU Cooler</p>	<p>It maintains the optimal operating temperature of the CPU, to prevent overheating and potential damage to the hardware.</p>	
<p>USB Port</p>	<p>USB ports are often used as adaptable connectors to transfer data between devices. They are for example connected to many wired keyboards and mice or to printers, smartphones and webcams.</p>	
<p>DVD Player</p>	<p>Used to read and play optical media such as DVDs and CDs</p>	



<p>Computer Case</p> <p>height: 290.00 mm (11.41 inches) width: 92.60 mm (3.64 inches) dept: 312.00 mm (12.28 inches) weight: 5 kg (11.02 lb)</p>	<p>The case encloses most of the components of the system. It provides mechanical support and protection for internal elements (such as motherboard, power supplies) and controls and directs cooling air over internal components.</p>	
<p>Power / network Cable</p>	<p>Power cables connect the computer to electrical outputs and work as power supply and component power, which means that they connect the power supply to components such as the motherboard and HDs. Network cables are for data transfer between computer and network devices, to enable access to local area networks</p>	
<p>Screws</p> <p>ST4 x 13 mm</p>	<p>Screws play a crucial role for securing various components, such as the motherboard, PSU, and the computer case.</p>	
<p>Fan</p>	<p>Case fans are responsible for circulating air within your computer case, ensuring that cool air enters and warm air is expelled. This prevents the buildup of hot spots and keeps temperature levels within acceptable ranges</p>	

## External Connectors

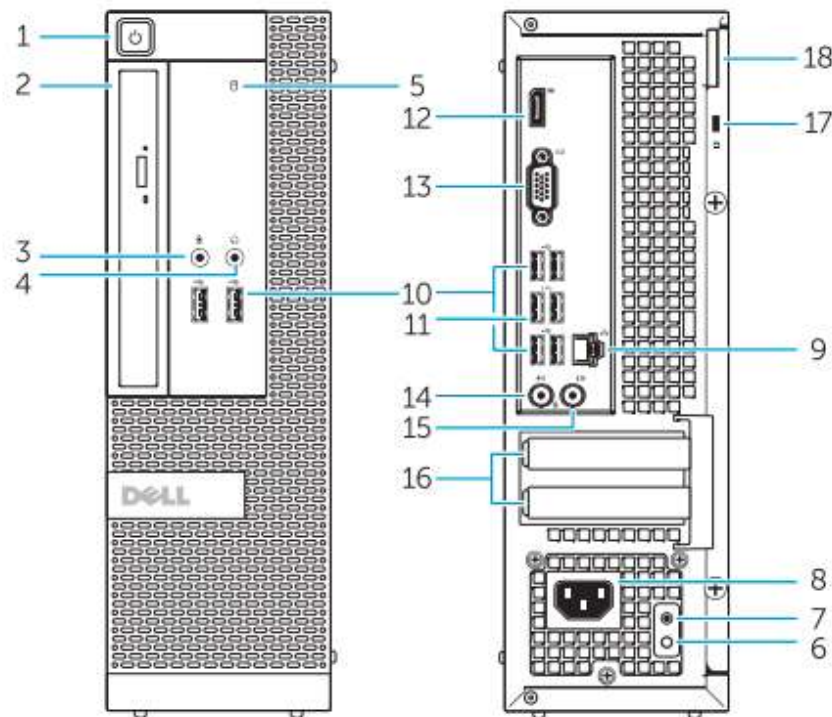


Figure 5: Layout of the external connectors of the Dell pc [3].

1. Power button/Power light
  - turns the computer on/off
  - indicates the status of the computers power (if it's on or off)
2. Optical-drive/hard-drive bay
  - Slot to install an optical disc drive, such as a CD/DVD drive
3. Microphone connector
  - Used to connect an external microphone to the computer for audio input
4. Headphone connector
  - Used to connect headphones or external speakers for audio output
5. Hard-drive activity light
  - Shows when the hard drive is actively reading or writing data
6. Power-supply diagnostic light
  - Provides diagnostic information about the power supply status
7. Power-supply diagnostic button
  - makes it possible to manually check the status of the power supply
8. Power cable connector
  - Connects the power cable from the power source to the computer
9. Network connector
  - Connects the computer to a network, often an Ethernet port for wired connections
10. USB 2.0 connector
  - Used for connecting USB 2.0 devices such as keyboards, mice
11. USB 3.0 connector
  - Used for connecting USB 3.0 devices (providing faster data transfer rates compared to USB 2.0.)
12. DisplayPort connector
  - Connects the computer to a display device, like a monitor or projector

13. VGA connector
  - Connects to a display device using VGA (Video Graphics Array) technology. (It's an older standard compared to DisplayPort or HDMI)
14. Line-in/microphone connector
  - Connects external audio sources or microphones for input
15. Line-out connector
  - Connects external speakers or audio devices for output
16. Expansion card slots
  - Slots on the motherboard for adding expansion cards such as graphics cards, sound cards, or network cards
17. Security cable slot
  - Used for attaching a security cable to physically secure the computer
18. Padlock ring
  - Physically secures the computer if you attach a padlock to prevent unauthorized access

## Overview of the System Boards Components




Because the motherboard connects all the components and communicates between different parts of the computer, I saw it as crucial to generally understand its connections and working ways, to understand the working way of the computer in general. I looked separately at its components, internal connectors, external connectors and electrical components, to get an easier overview of the different elements.






*Figure 6: Picture the of frontside of the motherboard*


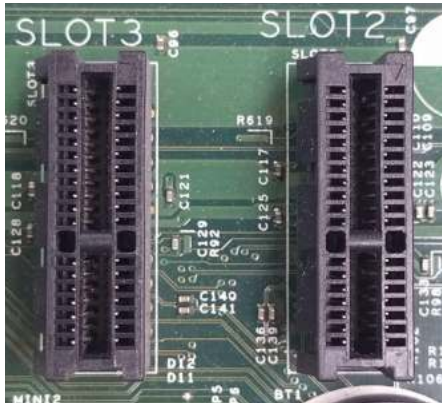


*Figure 7: Picture of the backside of the motherboard*

Part	role	Picture
<p>GPU Integrated: Intel HD Graphics 4600/ HD</p> <p>Integrated in the CPU</p>	<p>Graphics Processing Unit (GPU), information from the CPU chip is “imaginative”. Data sent to the CPU is sent to the GPU. That data is then translated and displayed. Integrated GPU (iGPU) shares power and space with the CPU chip.</p>	
<p>CPU chip</p> <p><a href="#">datasheet</a></p>	<p>All Information and data is processed through the Computer Processing Unit (CPU). This is the primary component that makes a computer operational. The CPU goes through Co.D.E. to process information.</p> <p>Collect- information is retrieved from RAM</p> <p>Decode- information is decoded for other systems to understand</p> <p>Execute- instructions are carried out/executed</p> <p>4 cores are contained within the chip allowing multiple instructions to be carried out.</p>	
<p>Audio chip</p> <p>SMSC SCH5553-nu</p> <p><a href="#">datasheet</a></p>	<p>This chip is integrated with the motherboard, generating and recording audio. Built-in audio chips are beneficial because they use up less space.</p>	

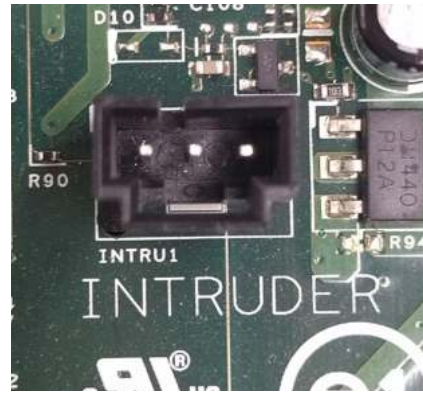
Part	role	Picture
Lithium Ion Batterie <a href="#">datasheet</a>	Model: KTS Lithium Battery CR2032  The CMOS battery uses a small amount of power to run CMOS even when the computer is off. The CMOS stores the time, date and other data.	
Mouse and Keyboard Ports	Ports connect mouse and keyboard using Universal Serial Bus, more commonly known as USB ports.	
CPU Socket LGA 1155 <a href="#">datasheet</a>	Holds CPU chip in a land grid array (LGA) and requires little force to insert chip (zero intersection force).	

## INTERNAL CONNECTORS

Name and description	Picture
<p><u>PCI Express x16 connector</u></p> <p>PCIe, or peripheral component interconnect express, is an interface standard for connecting high-speed input output (HSIO) components. Slot can be used to add GPUs, RAID cards, WiFi cards, or SSD PCIe x16: these slots are used for cards that require a high bandwidth like GPUs.</p>	
<p><u>PCI Express x1 connector</u></p> <p>These are the smallest PCIe slots, used for almost any other cards like average network adapters and USB expansion cards.</p>	

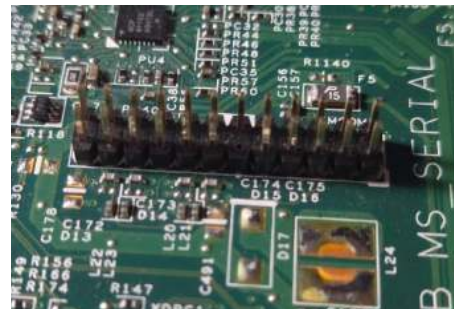
intrusion-switch connector

A connector that supports a chassis security feature that detects if a chassis component is removed or replaced, in which case an alarm sound is heard through the onboard speaker or PC chassis speaker if present



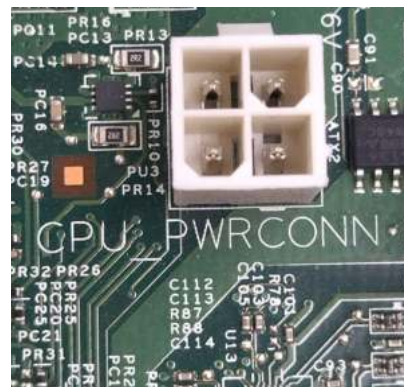
PS/2, serial connector

Legacy connectors for connecting peripherals like keyboards (PS/2) and serial devices (serial connector).



power connector

Connects to the main power connector that supplies power to the motherboard. It comes from the computer's power supply unit (PSU)



CPU fan connector

This connector provides power to the CPU fan, ensuring that the processor stays cool during operation.



memory module connectors

These are slots where RAM modules are installed to provide temporary storage for the system.

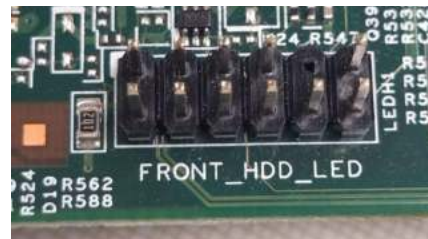
[The right way to put RAM in your pc's memory sockets](#)



HDD LED & chassis detect connector

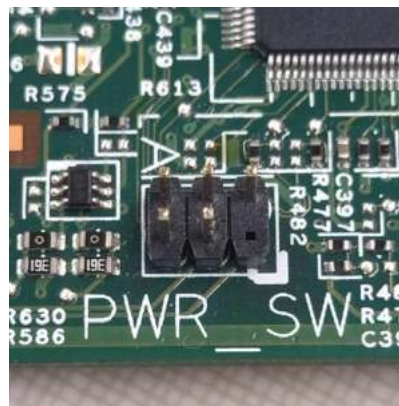
The HDD LED connector connects to the hard disk drive (HDD) activity indicator on the front panel.

The chassis detect connector is used for detecting whether the computer case is closed or open for security reasons.



power switch connector

This is where the power button from the computer case is connected to the motherboard to turn the system on or off.





system power connector

Additional power connector on the motherboard, used for providing additional power to the system



system fan connector

This connector supplies power to additional cooling fans within the computer case.



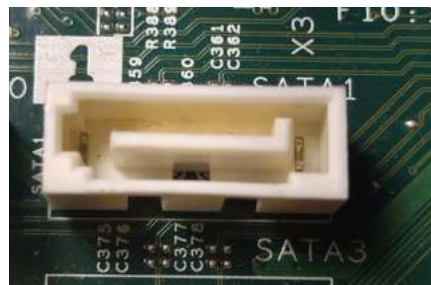
RTC reset jumper

Jumper to reset the Real- Time Clock, which is responsible for keeping track of date and time even when the computer is turned off.



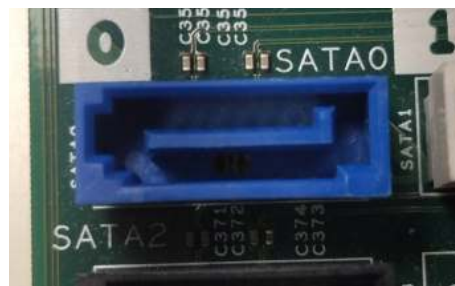
ODD SATA connector

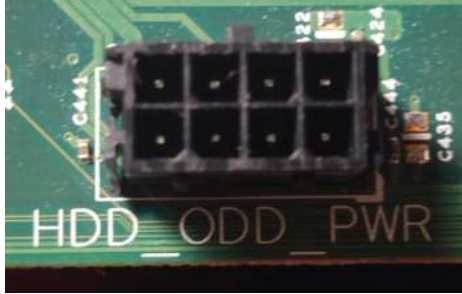


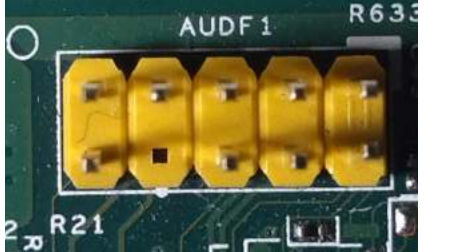

Used for connecting an optical disk drive (ODD), such as a DVD or Blu-ray drive, using the SATA interface.



HDD SATA connector

Used for connecting a hard disk drive (HDD) using the SATA interface.



<p><u>power connector</u></p> <p>Power connector for the optical drive and hard drive</p>	
<p><u>front i/o connector</u></p> <p>Links the front panel of the computer case to the motherboard, including USB ports, audio jacks, and other front-panel features.</p>	
<p><u>internal speaker connector</u></p> <p>Connects a small, internal speaker on the motherboard that can provide beep codes during the boot process for diagnostic purposes.</p>	
<p><u>front audio connector</u></p> <p>Connects the front panel audio jacks on the computer case to the motherboard for audio input and output.</p>	
<p><u>password reset jumper</u></p> <p>Small connector that's used to reset the BIOS or CMOS password, by moving it to a specific position</p>	

## Layout of the system boards connectors.

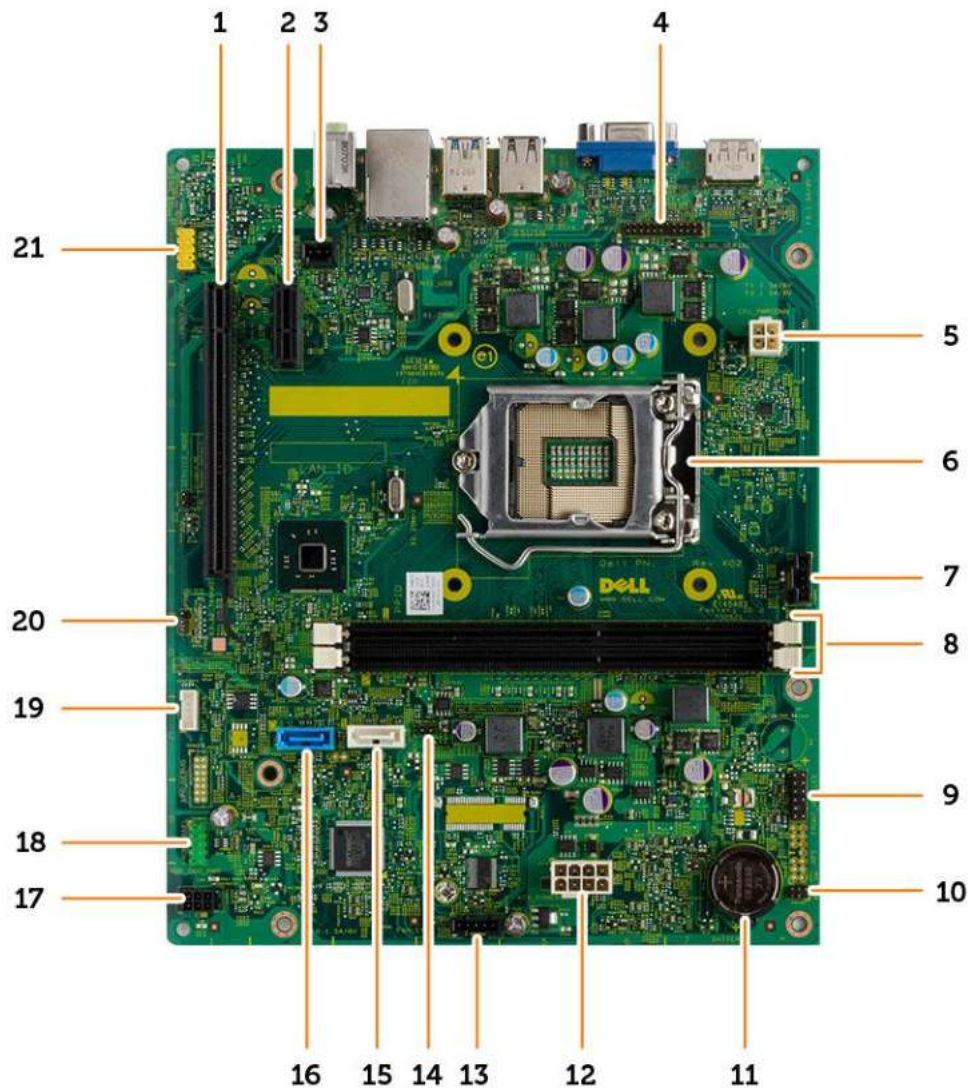
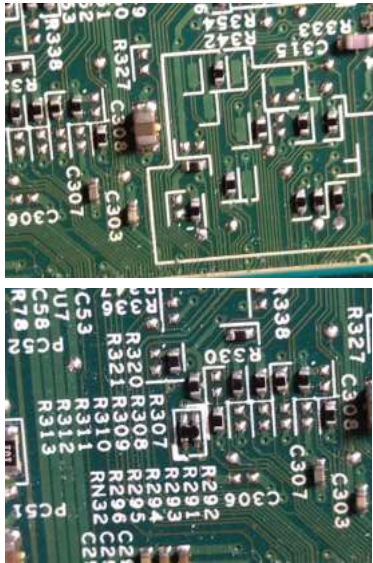
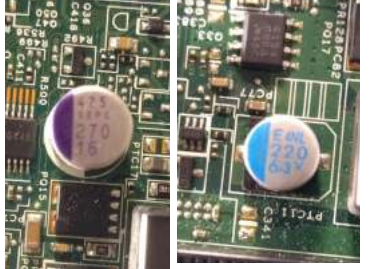





Figure 8: Layout of the system boards connectors [4].

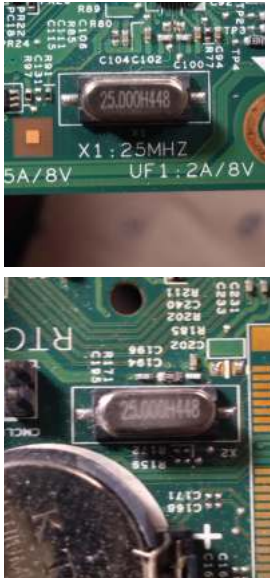
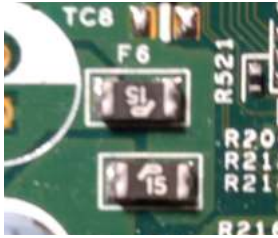


1. PCI Express x16 connector
2. PCI Express x1 connector
3. intrusion-switch connector
4. PS/2, serial connector
5. power connector
6. processor socket
7. CPU fan connector
8. memory module connectors
9. HDD LED & chassis detect connector
10. power switch connector
11. coin-cell battery
12. system power connector
13. system fan connector
14. RTC reset jumper



- 15. ODD SATA connector
- 16. HDD SATA connector
- 17. power connector
- 18. front i/o connector
- 19. internal speaker connector
- 20. password reset jumper
- 21. front audio connector

**ELECTRICAL COMPONENTS**

<p>Resistors</p>	<p>A resistor is a passive electrical device that manages current flow, divides voltage, and resistor-capacitor networks, so other components don't overheat</p>	
<p>Capacitors</p> <p>Panasonic SEPC Series Aluminum Organic Polymer Capacitors</p> <p><a href="#">datasheet</a></p>	<p>A capacitor is a passive two-terminal electrical component that stores energy in an electric field electrostatically. It basically works as a small rechargeable battery that stores electricity, but it can charge and discharge in the split of a second.</p>	

		
<p>Inductors</p>	<p>This device stores energy in its magnetic field, returning it to the circuit whenever required</p>	
<p>Diodes</p>	<p>A diode is a device that allows electric current to flow in only one direction. It is commonly used to convert an Alternating Current (AC) into a Direct Current (DC). It is mostly made of a semiconductor material (semiconductor diode) nowadays.</p>	

<p>Crystal/ Oscillator</p>	<p>Oscillators convert DC signals to periodic AC signals which can be used to set frequency, be used for audio applications, or used as a clock signal. It uses a piezoelectric crystal (most commonly a quartz crystal) as a frequency-selective element. They convert DC signals to periodic AC signals which can be used to set frequency, since all microcontrollers and microprocessors require an oscillator to set the clock signal in order to function.</p>	
<p>Transistors</p>	<p>Transistors function as both switches and amplifiers in most electronic circuits. It can turn a small current into a much larger one..</p>	
<p>Integrated Circuits</p>	<p>is a small electronic device made up of multiple interconnected electronic components such as transistors, resistors, and capacitors. These components are etched onto a small piece of semiconductor material, usually silicon</p>	
<p>Microprocessor s</p>	<p>A microprocessor is a computer processor that handles tasks like calculations, overall system control and data manipulation. It also contains the</p>	

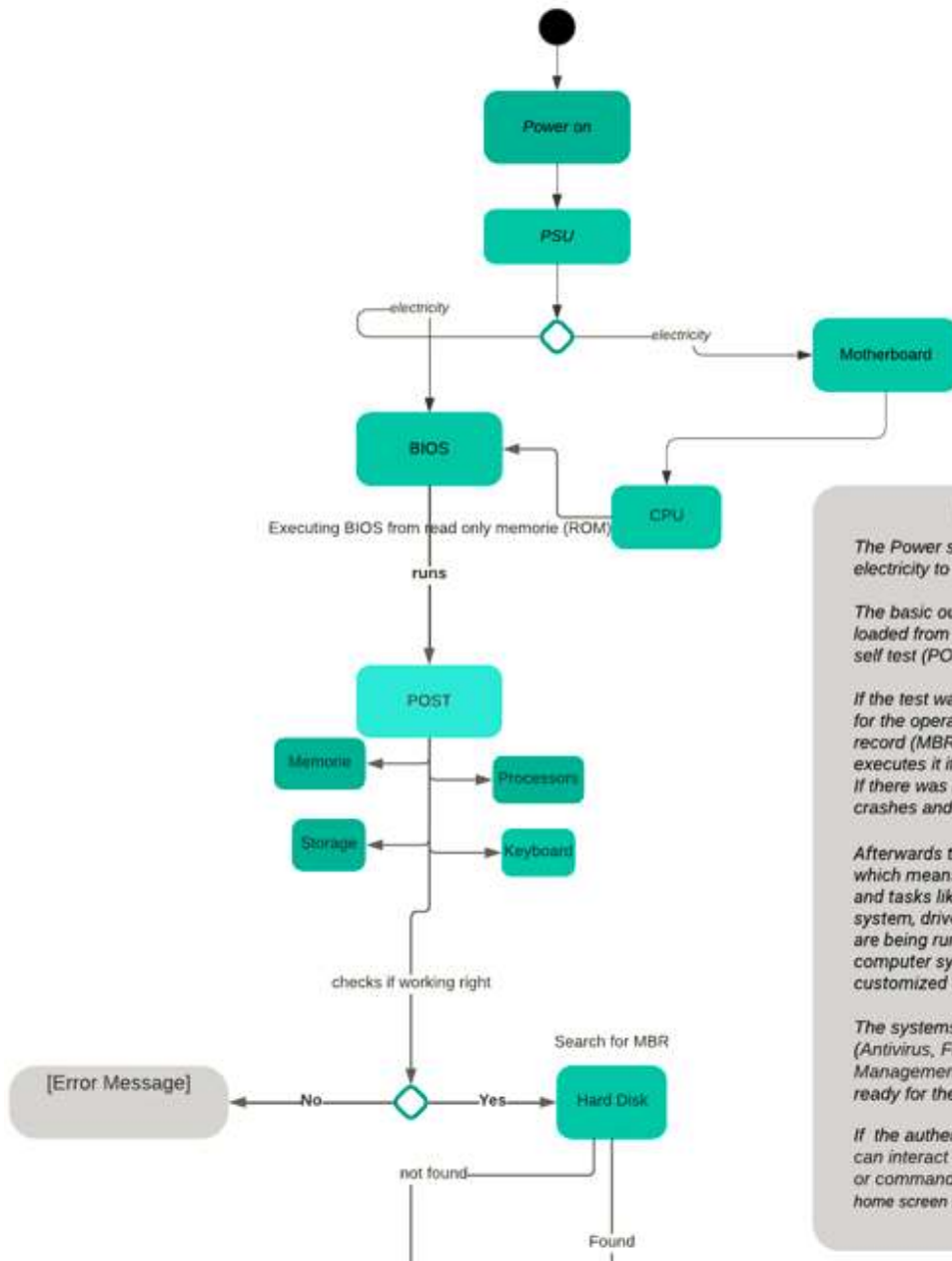
<p>Intel H81chipset</p> <p><a href="#">product specifications</a></p>	<p>arithmetic, logic, and control circuitry required to perform the functions of a computer's CPU.</p> <p>This motherboard uses the IntelH81 Chipset, which is one chip that works as a traffic controller between the CPU, GPU, RAM, storage, and peripherals.</p>	
<p>Conducting traces</p>	<p>The electric current flows through the conducting traces. They are copper sheets laminated onto a non-conductive substrate.</p>	

## Booting flow chart

Based on the things I learned so far, I challenged myself to dive deeper and try to understand how each component works together to boot up the system. I created a flow chart that should show the basic steps and things needed to boot a computer system.

# Computer booting system

Reverse Engineering Online Challenge



## Description

The Power supply unit (PSU) converts the electricity to the right voltage

The basic output/ input system (BIOS) gets loaded from a microchip and the power on self test (POST) gets executed

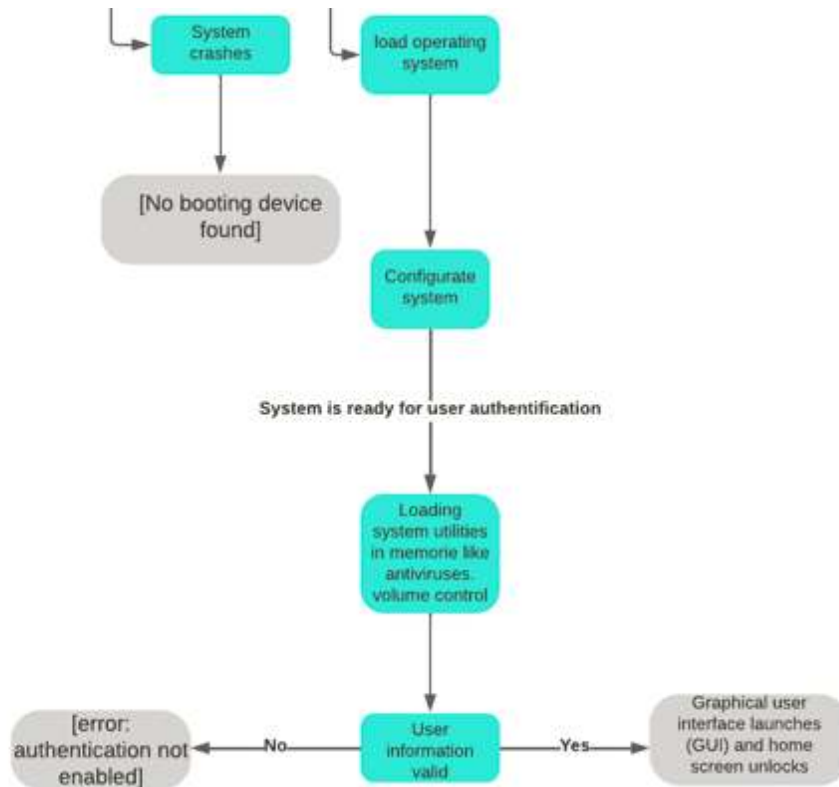
If the test was successful, the cpu searches for the operating system, Master boot record (MBR) on the hard drive and executes it if found. If there was no MBS found, the system crashes and it shows an error message.

Afterwards the system gets configured which means that hardware, gets set up and tasks like installing the operating system, drivers, and necessary applications are being runned. This ensures the computer system is functional, secure, and customized to meet user requirements.

The systems utilities is being loaded (Antivirus, File Management System ,Disk Management tools, etc..) and the system is ready for the user to authenticate.

If the authentication was valid, the user can interact with the graphical user interface or command-line interface. And if not, the home screen stays unattainable





## Summary

The things I learned

Even if the computer model I chose wasn't the newest or best one, I was able to find and identify the main parts of it. I could learn a lot from it about the different hardware components (e. g. `CPU, GPU, RAM) that are essential for any computer.

As our team's coder, I work with computers every day, so I was surprised by how little about computer hardware I actually knew. So this project taught me the basics of electrical components and gave me an overall understanding of which parts play which role and how much is actually going on behind our screens.


I also got a small glimpse of electrical engineering and system design of computers, which I found really interesting and will take with me. I got a good basic understanding of the computer system and I feel really confident to identify each computer part, to hopefully put together my own system in the future.

And even if it was hard to work on this challenge alone, with only a little help from my classmates and instructor, I broadened my technical knowledge and I was also able to enhance my documenting and researching skills, as I came around various knowledge gaps that I needed to fill with the help of others.

In the end I am glad that I took this opportunity even if it was hard and I needed to push my boundaries, since I learned that exploring and deepening my understanding of computer hardware will not only be helpful with my work as a coder, but also contribute to my overall proficiency in the field.

(word count: 274)

## Resources

Branch Education. *How does Computer Hardware Work?*  [3D Animated Teardown]. [Retrieved online 07.01.2024 from: <https://www.youtube.com/watch?v=d86ws7mOYlg>]

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[2]. DellTechnologies. *Optiplex 3020: MT System board disassembly video*. [Retrieved online 09.01.2024 from: <https://www.dell.com/support/contents/en-ca/videos/videoplayer/optiplex-3020-mt-system-board-disassembly-video/6079794913001>]

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[3]. Dell OptiPlex 3020 Quick Start Guide. *Optiplex 3020*. [Retrieved online 18.01.2024 from: [https://downloads.dell.com/manuals/all-products/esuprt\\_desktop/esuprt\\_optiplex\\_desktop/optiplex-3020-desktop\\_setup%20guide\\_en-us.pdf](https://downloads.dell.com/manuals/all-products/esuprt_desktop/esuprt_optiplex_desktop/optiplex-3020-desktop_setup%20guide_en-us.pdf)]

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