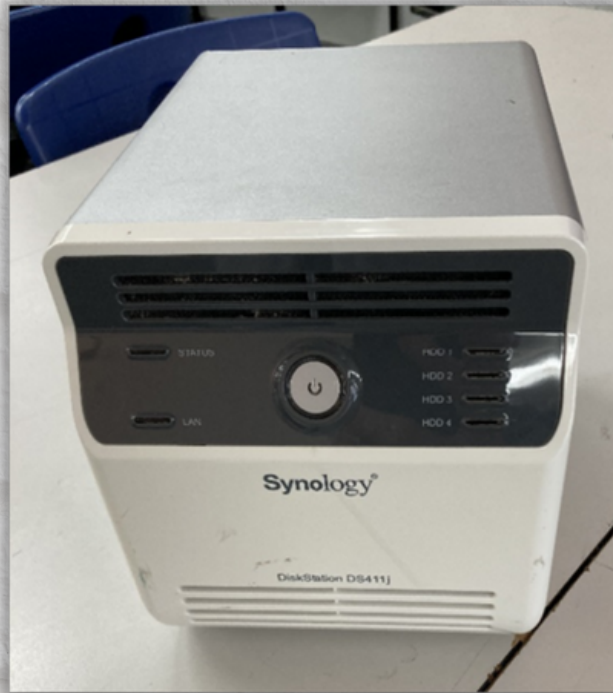


2023 VRC - REVERSE ENGINEERING CHALLENGE



Synology DiskStation DS411j

Team 1002T – [LETHAL PRESENCE]

**Templestowe College, Templestowe
Lower, VIC, Australia**

By: Thomas Radford

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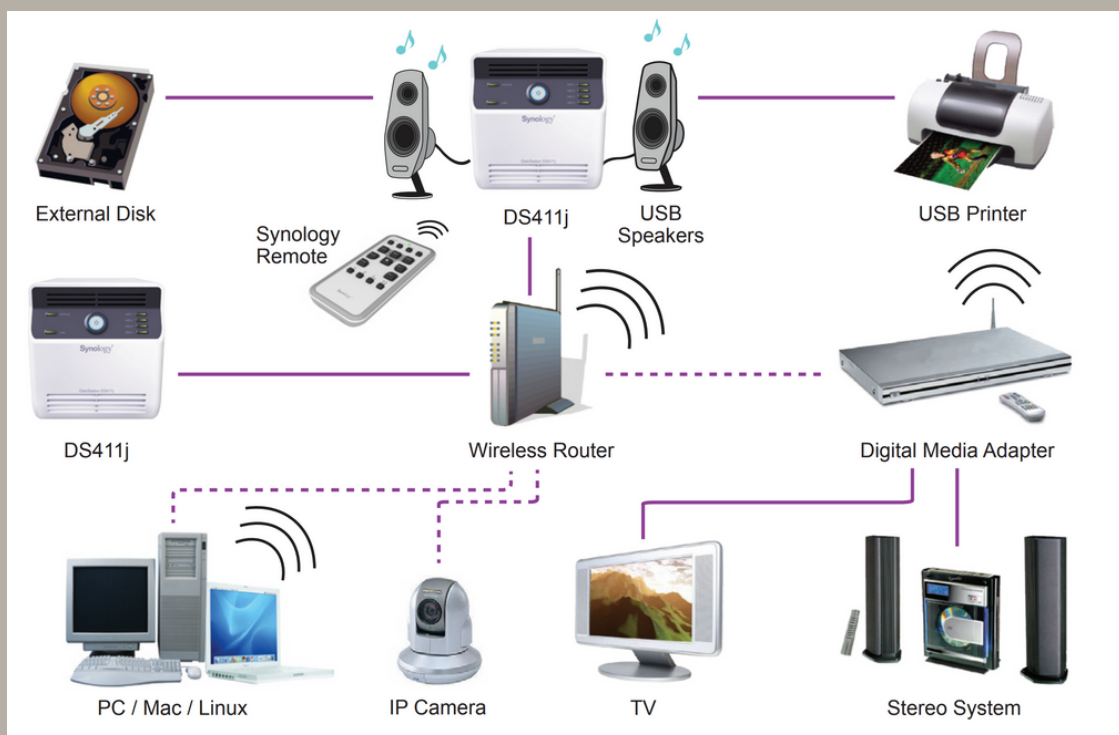
Introduction

For my 2023 Reverse Engineering submission I chose to take apart an old NAS device and document my findings. I considered taking apart an old MacBook but I was offered my dad's old NAS; something a little less complex. I chose to investigate the NAS as it was old and had a good combination of hardware and software.

A NAS (Network-attached storage) provides fast, secure, and reliable storage services to private networks.

The Synology DiskStation DS411j holds 4 hard drives (2.5/3.5"), providing personal users or small businesses with cost effective storage. We used this personally to store music and photos in a RAID 1 array. All 4 hard drives were mirror images of each other, so if one failed, the others can replace it. This prioritised reliability over storage capacity.

Synology DiskStation DS411j Networking

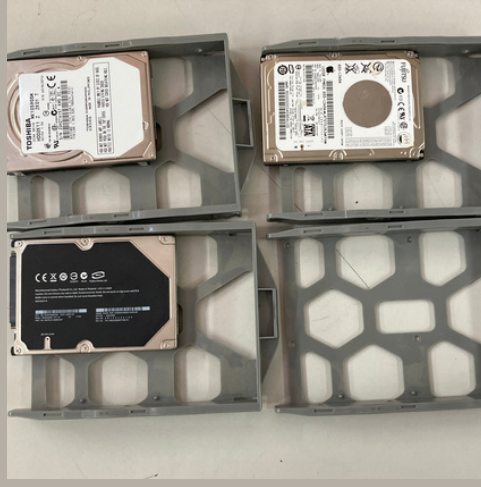


Disassembly Process

1. Unscrewed 4 thumb screws on the back



2. Removed the 4 hard drive trays



3. Removed the top cover



4. Removed the fan covers and battery from Mother Board



5. Removed the front panel



6. Removed the Status Board



7. Disassembled the front panel



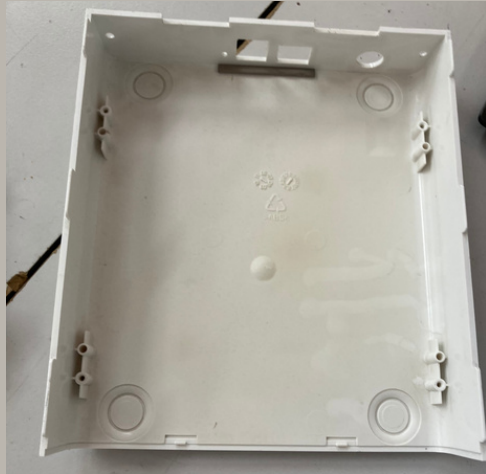
8. Removed the fans



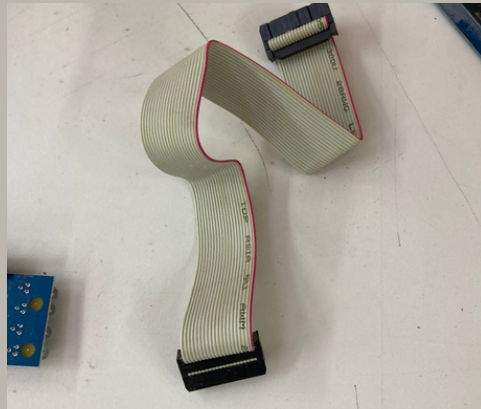
9. Removed the Hard Drive Board



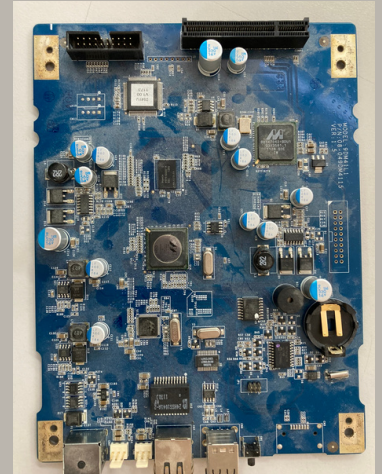
10. Removed the bottom cover



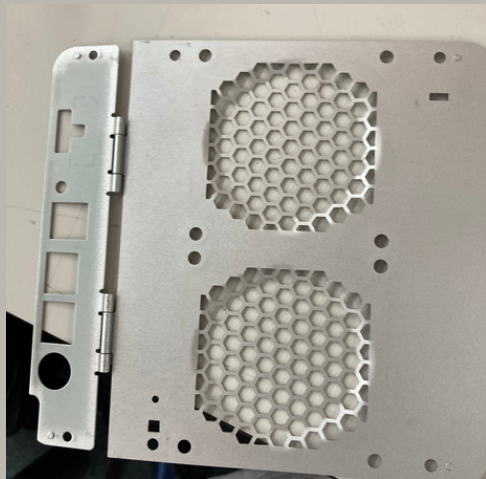
11. Separated the cable between the Status Board and the Mother Board



12. Removed the Mother Board



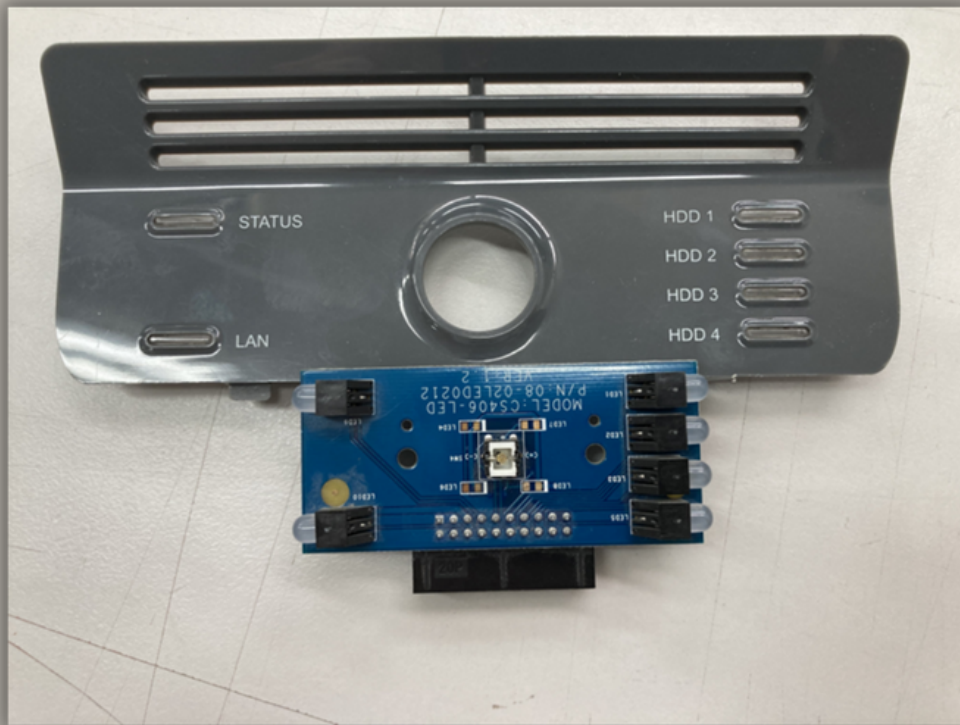
13. Removed the back grate



Finished Dissassembly



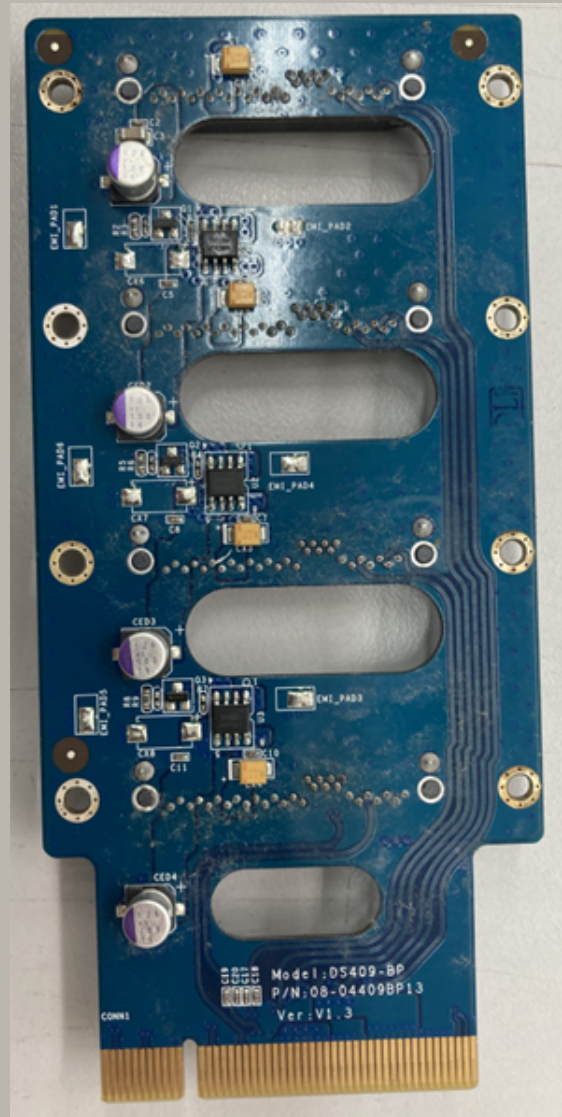
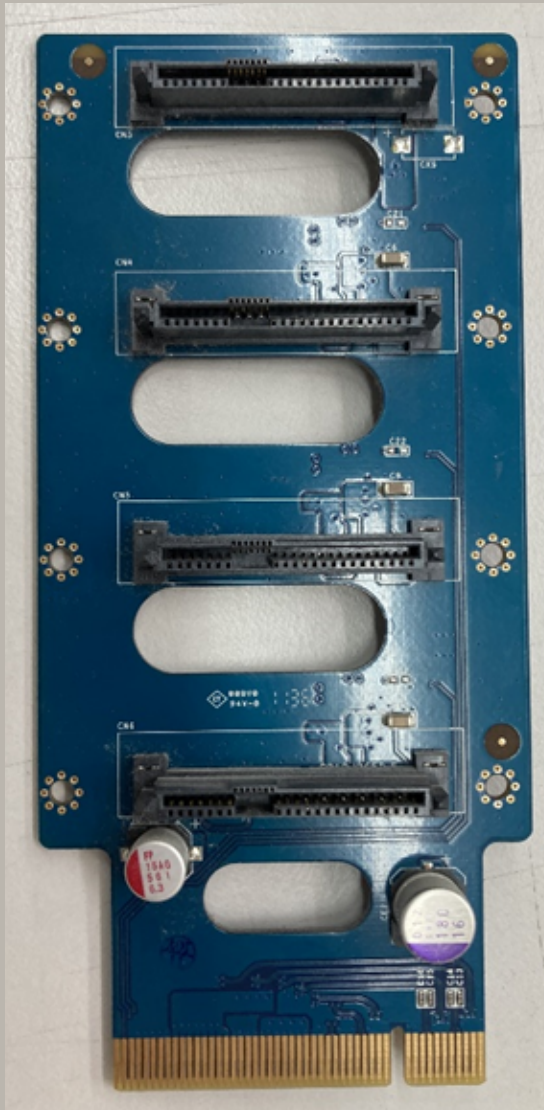
Status Board



This custom board has LEDs for the Status, LAN, and the 4 Hard Drives.

If data is being sent to or from the hard drive, then the light will be flashing. The power switch has an LED inside it too, to show if its on or off. The Status Board connects to the Mother Board via 20 pin connectors.

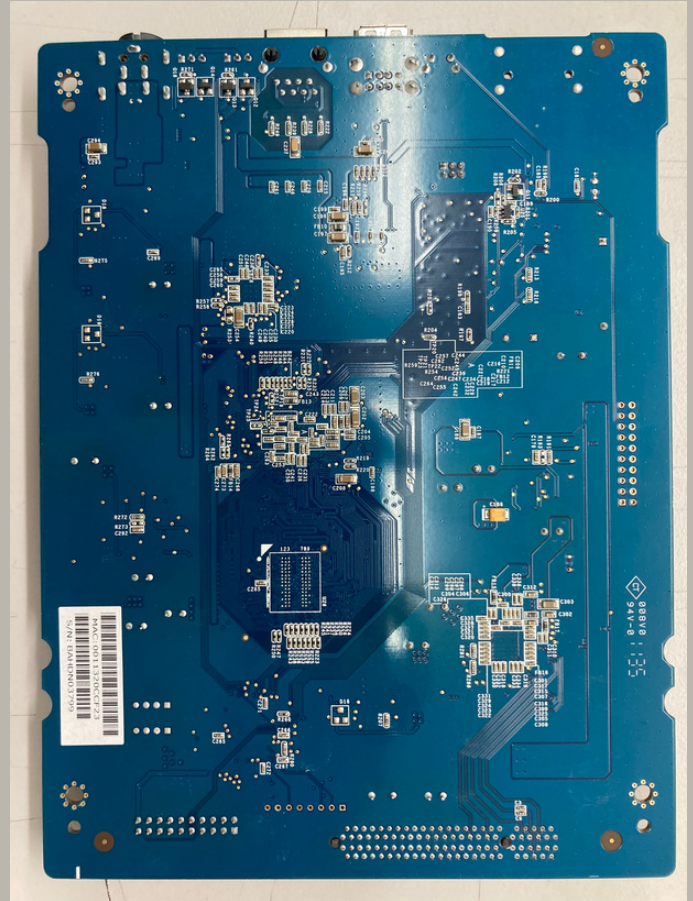
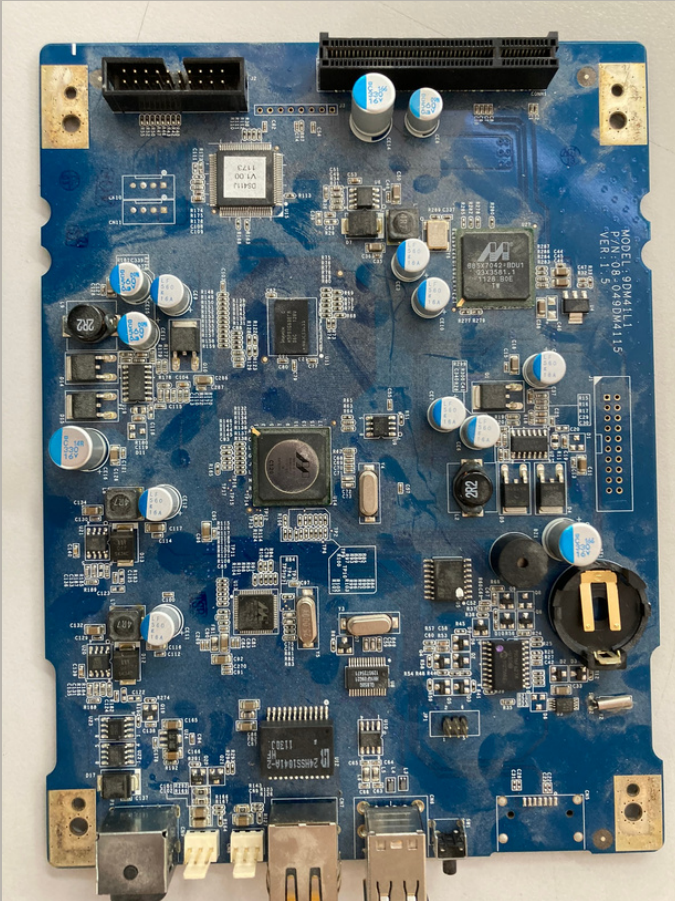
Hard Drive Board



This custom board's only functionality is to provide an easy interface for the end user to plug in up to 4 hard drives, via the hard drive trays.

Each connector on the Hard Drive Board connects to the SATA Power and SATA Data of a hard drive. The data and power of the hard drive is then routed through the connector at the bottom of the Hard Drive Board so the Mother Board can communicate with the hard drives.

Mother Board



This custom board serves as the main board of the device. It hosts the Input/Output (I/O) ports of the device and connects to all other boards.

The Mother Board holds a 3V Lithium Battery. This is because the memory for this device (DDR2 SDRAM) is volatile (needs power to maintain its memory).

The Mother Board contains the processing power of the device and allows all components to communicate with each other at close proximity.

**All printed circuit boards have a silk screen. This indicates where a part will go and what type of part it is.
eg. U11, Q3, D10**

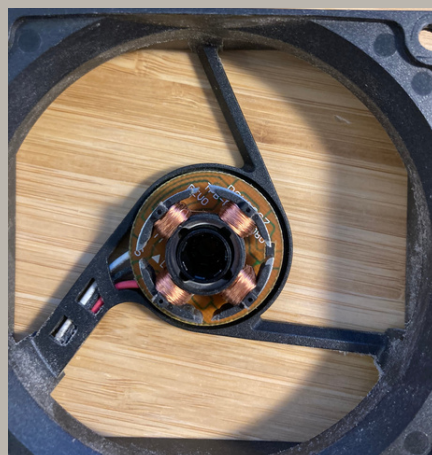
Fans



There are 2 fans located at the back of device. Their purpose is to exhaust waste heat out of the device. Fans start automatically when the device starts. If a fan is malfunctioning, the buzzer will beep.

They are square fans with dimensions 80mm x 80mm x 20mm. They have fan covers on them to protect your fingers.

This is a DC brushless fan. It uses brushless DC motors that are arranged in a cross pattern of four permanent magnets mounted on the sides of the rotor. They are much more efficient than a regular induction fan.



20 Pin Ribbon Cable






This cable is used to connect the Status Board to the Mother Board.

Via the Jacks at J2 on the Mother Board and at J3 on the Status board, the wire plugs into the secure 20 pin electrical connectors.

This cable is not specifically designed for this device as they are manufactured for a wide range of electrical appliances. This means there is a lot of spare cable length hidden under the box.

Mother Board Components

Integrated Circuits (U)	Image
<p>Hynix H5PS1G63EFR-S6C (U11)</p> <ul style="list-style-type: none">• This is the <u>memory IC</u>• Made of millions of semi conductors, it can store data or run code• Random Access Memory (RAM) Size: <u>DDR2 128MB</u> <u>Data Sheet</u>	
<p>MARVELL 88F6281A1-C120 (U14)</p> <ul style="list-style-type: none">• This houses the Sheeva™ Central Processing Unit (CPU)• it provides the instructions and processing power the circuit needs <u>Data Sheet</u>	
<p>Lattice LC4064V-75TN100I (U15)</p> <ul style="list-style-type: none">• This is a Complex Programmable Logic Device (<u>CPLD</u>)• Includes a programmable AND/OR array (can perform a multitude of logic functions)• And a bank of 64 macrocells (functional blocks that perform combinatorial or sequential logic) <u>Data Sheet</u>	

Genesys Logic GL850G HH1GF09G21
(U8)

- This is a USB 2.0 HUB Controller
- Monitors the activity and controls the power to the USB 2.0 ports
Data Sheet



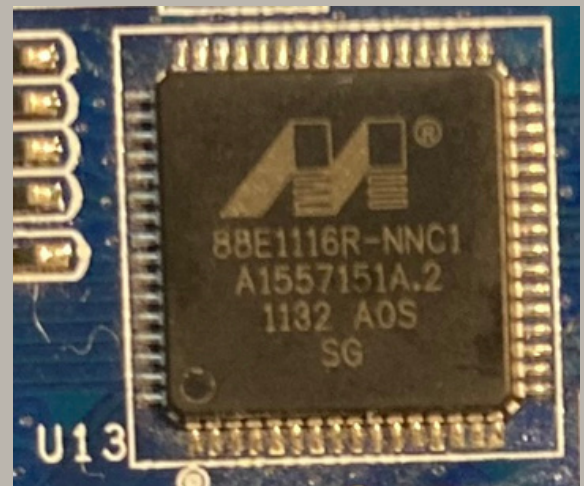
Bothhand USA 24HSS1041A-2 HF
(U12)

- This is an Ethernet (LAN) transformer
- Positioned right behind the LAN port, it filters common mode noise
- It also separates the transmit device from the cabling
- This negates high voltage signals from damaging receiving devices
Data Sheet



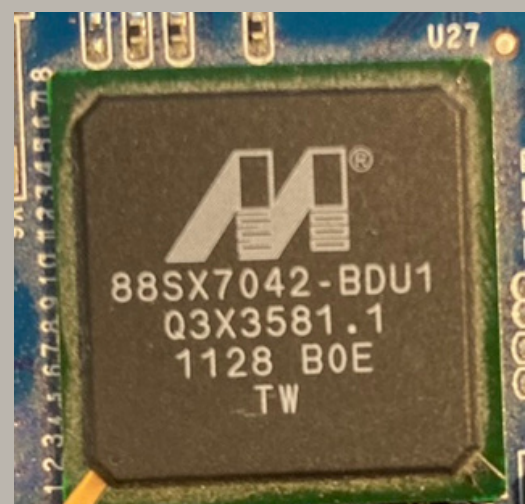
MARVELL 88E1116R-NNC1
(U13)

- This is a single Gigabit Ethernet transceiver
- It links the electronic devices to the Ethernet circuitry
- 1GB Ethernet = Ethernet frames at a rate of a gigabit per second
Data Sheet



MARVELL 88SX7042-BDU1
(U27)

- This is a Serial Advanced Technology Attachment (SATA) Port Multiplier (PM)
- It allows communication with up to four device ports (the hard drives)
Part Info

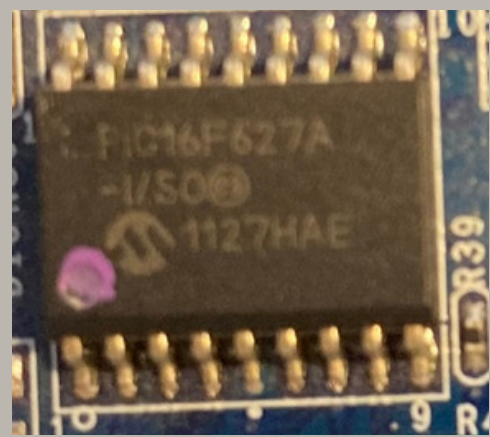


Microchip PIC16F627A-I/SO

(U18)

- This is an 8-Bit PIC microcontroller
- Using the 8 input and 8 output pins, it inputs data and outputs instructions to other devices

Data Sheet

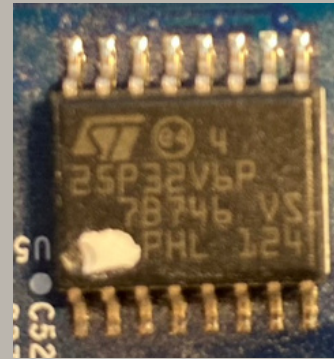


STMicroelectronics 25P32V6P

(U5)

- This is a SPI bus interface
- This sends data between the microcontrollers and sensors

Data Sheet



Nisshinbo RS5C372A-E2-F

(U3)

- This is a real-time clock
- It is connected to the CPU via 2-wires
- Sends clock and calendar data to the CPU

Data Sheet

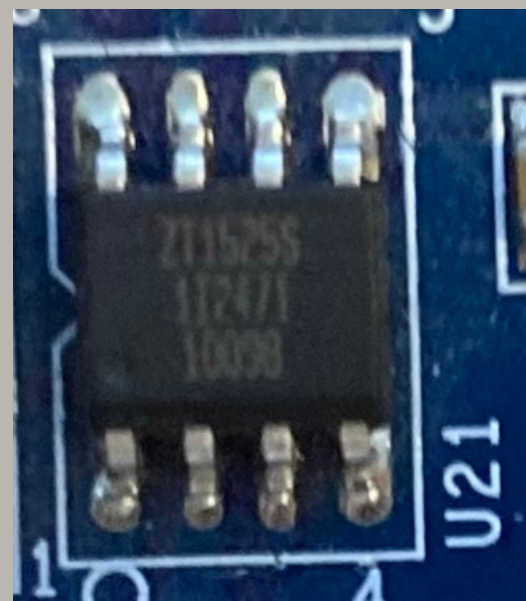


ZILLTEK ZT1525S

(U6, U20, U21)

- This is an Asynchronous Step-Down DC/DC Converter
- It steps down the voltage while stepping up the current
- This is to meet the the voltage requirements of the various components

Data Sheet

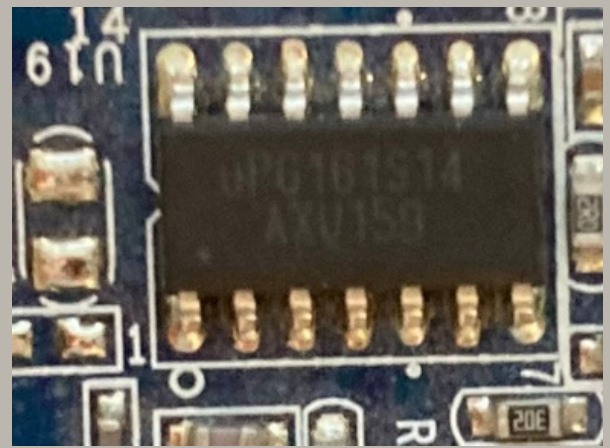


uPI UP6161S14

(U2, U19)

- This is a synchronous-rectified buck controller and a linear-regulator controller
- By changing the resistance based on the input, the linear regulator can output a constant 9V

Data Sheet



GMT G751-2f

(U9)

- This is a temperature sensor with programmable temperature limits
- If the limit is exceeded, the Over temperature Shutdown (O.S.) output pin is activated, draining the temperature

Data Sheet

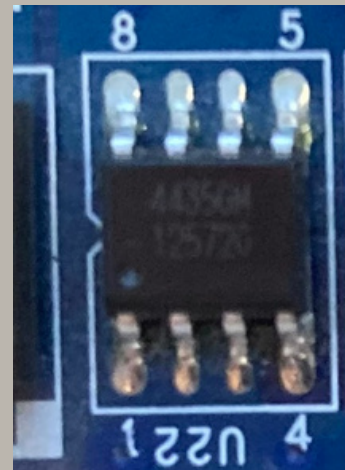


VBsemi 4435GM

(U22, U23)

- This is a Load Switch and a Battery Switch
- Load Switches and Battery Switches disconnect from devices and batteries that aren't needed to save energy and prevent battery malfunctions

Data Sheet

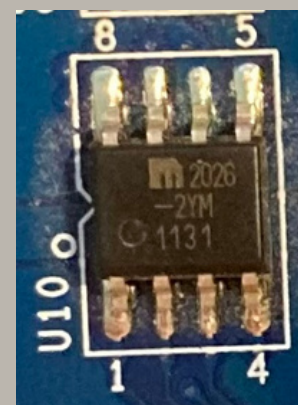




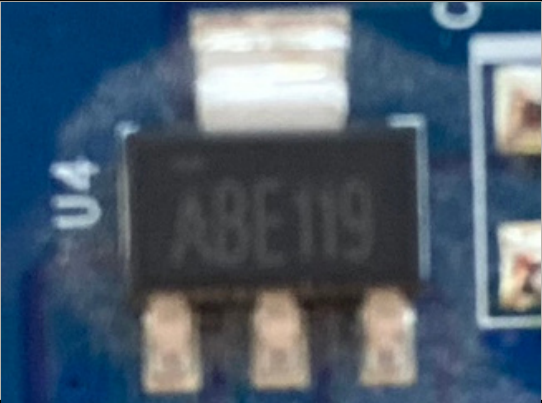
Microchip MIC2026-2YM

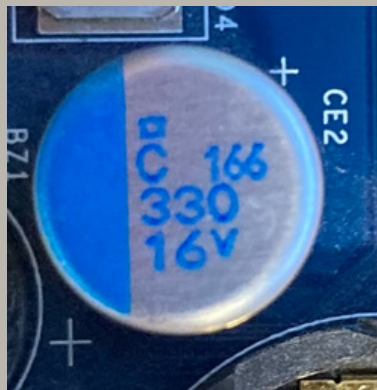


(U10)

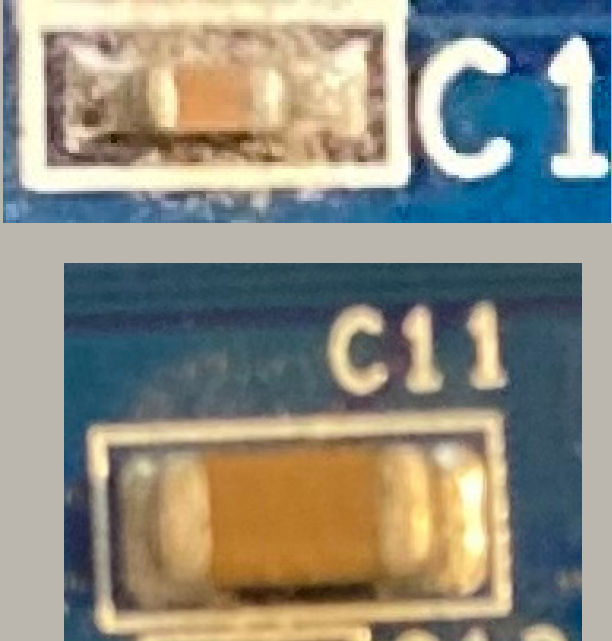

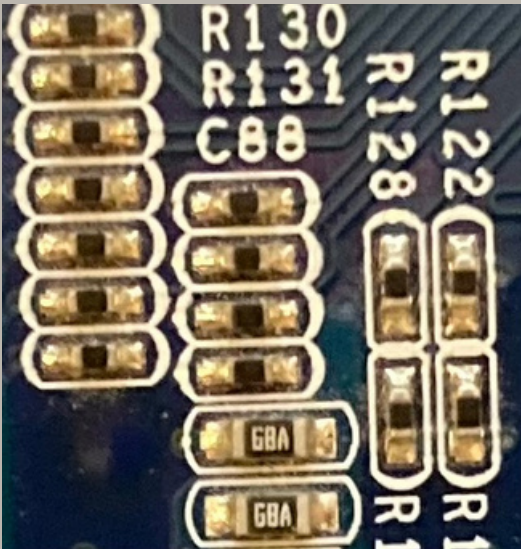
- This is a Power Distribution Switch
- It is used to manage the power from the power supply and shut off the connection if something malfunctions

Data Sheet



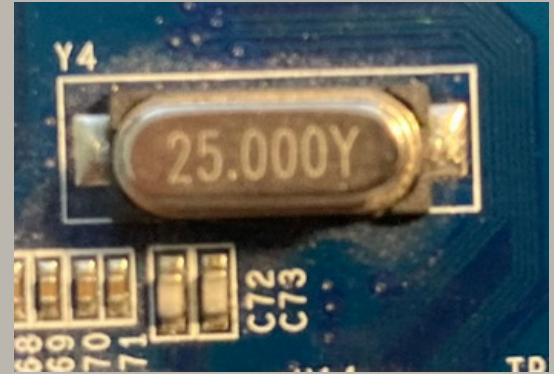
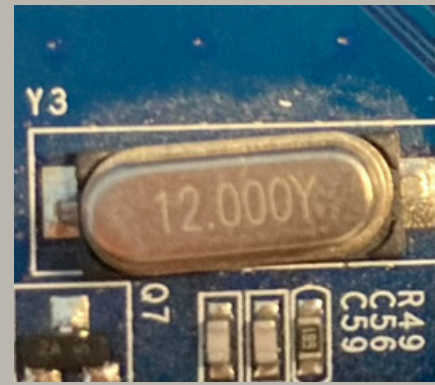
Unidentifiable IC's	Image
AUS31 (U25)	 A close-up photograph of a small, black, square integrated circuit (IC) labeled 'AUS31' mounted on a blue printed circuit board (PCB). The IC is part of a larger assembly labeled 'U25'.
8CBE (U24)	 A close-up photograph of a small, black, square integrated circuit (IC) labeled '8CBE' mounted on a blue printed circuit board (PCB). The IC is part of a larger assembly labeled 'U24'.
ABE119 (U4)	 A close-up photograph of a small, black, square integrated circuit (IC) labeled 'ABE119' mounted on a blue printed circuit board (PCB). The IC is part of a larger assembly labeled 'U4'.

"Condensateur Électrolytique", the French acronym for Electrolytic Capacitor (CE)	Image
<ul style="list-style-type: none"> All components labelled (CE) in this device are <u>Aluminium Organic Polymer</u> Electrolytic Capacitors They use a solid, organic polymer electrolyte as the cathode (rather than a liquid, eg. <u>Tantalum</u>) The use of a solid cathode is more expensive but can be operated at lower temperatures They are used to store electrical energy, referred to as the <u>capacitance</u> Measured in Farads (F) 	
<p>United Chemi Con APSC160ELL331MJC5S (CE2, CE14, CE16) - 16V 330μF <u>Data Sheet</u></p>	
<p>United Chemi Con APSC6R3ELL561MH08S (CE8, CE13, CE15) - 6.3V 560μF <u>Data Sheet</u></p>	
<p>nichicon PLF0G561MDO1 (CE3, CE4, CE6, CE7, CE9, CE10, CE11, CE12) - 4V 560μF <u>Data Sheet</u></p>	

Other Components	Image
<p>Ceramic Capacitors (C)</p> <ul style="list-style-type: none"> There are many of these small <u>ceramic capacitors</u> on the motherboard The different sizes and colours have a different capacitance 	
<p>KEMET T490A107M006ATE800 (C186)</p> <ul style="list-style-type: none"> This is a <u>Tantalum Capacitor</u> They have a high capacitance for their size (100μF) Although labelled as (C) it is a Electrolytic Capacitor (CE) <p><u>Data Sheet</u></p>	
<p>Resistors (R)</p> <ul style="list-style-type: none"> Resistors are used to reduce the current flow by increasing the electrical resistance Measured in Ohms (Ω) A combination of the 3 digit and <u>EIA-96</u> code is used on the resistors found in this circuit The different codes correspond to different levels of resistance 	

Crystal Oscillators (Y)

- Crystal Oscillators use piezo electricity from the quartz crystal inside to maintain a constant frequency
- Measured in Hertz (Hz)
- This oscillation converts DC from the power supply to an AC signal
- (Y3) - 12MHz
- (Y4, Y5) - 25MHz



HELE HSO751S 25MHz

(Y6)

- This is a 25 MHz crystal oscillator
Data Sheet



KDS 1G

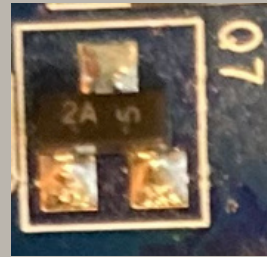
(Y2)

- On the underneath it was labelled as "KDS1G"
- I can only assume this was manufactured by KDS Daishinku Corp and oscillates at a frequency of 1 GHz



Transistors (Q)

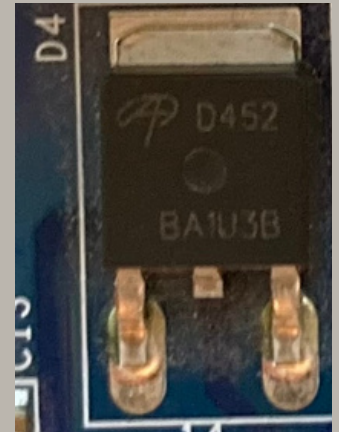
- Transistors regulate the flow of electronic signals
- These use silicon as the semi-conductive material
- Recognised by the 3 terminals for connection (pins)



Alpha & Omega AOD452

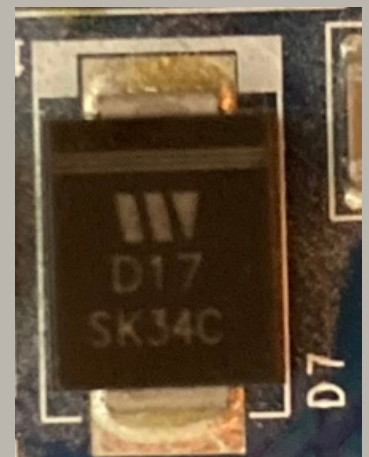
(Q1, Q10, D4, D15)

- This is a Field Effect Transistor (The FET from MOSFET)
- It uses an electric field to control the flow of current within the semi-conductor (silicon)
- Can be used as a Diode
Data Sheet



Diodes (D)

- Diodes allow current to flow easily through one direction but limit the other
- Recognised by the 2 terminals for connection (pins)
- The **SK34C** is the only actual diode here; the others are transistors acting as diodes (or labelled as)



Alpha & Omega AOD472

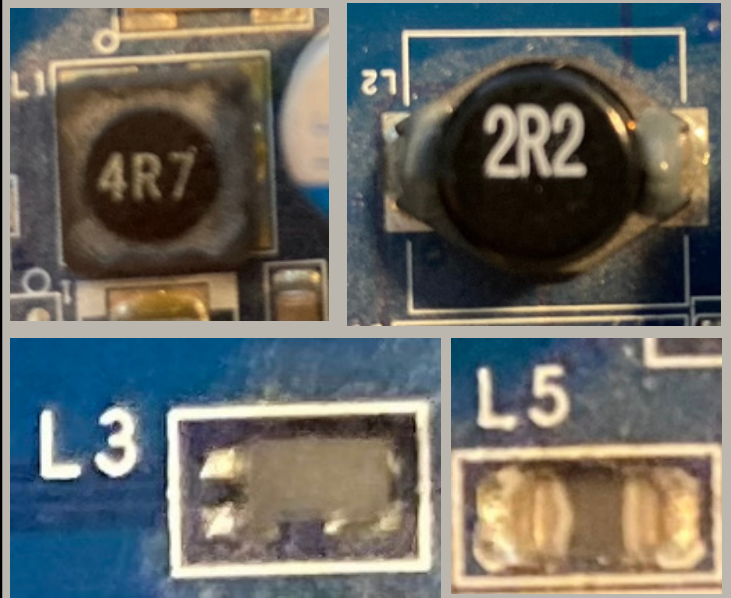
(D5, D14)

- Slightly different model to the **AOD452**
Data Sheet



Inductors (L)

- When electricity is applied to an inductor it stores energy in the form of magnetic energy
- An insulated wire is wrapped around a central core
- The structure, shape and size of the wire and core determine the inductance
- Measured in Henrys (H)
- (L1, L7, L8) - 4.7 μ H
- (L2, L9) - 2.2 μ H



ARIOSE LF-MT12D02

(BZ1) [Buzzer]

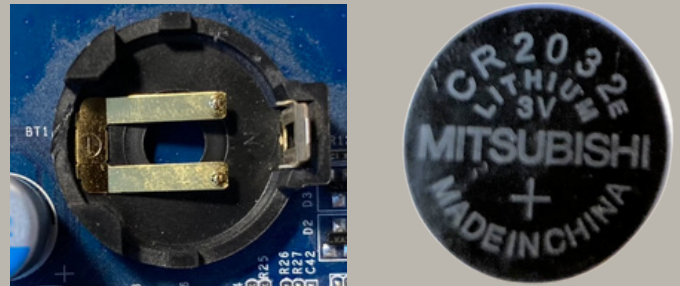
- Makes a beep when the device is being powered off
 - Also known as a Magnetic Transducer
- [Data Sheet](#)



3V Lithium Battery Holder

(BT1) [Battery]

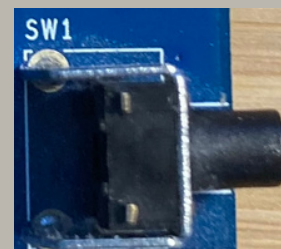
- This is used to hold the 3V Lithium Battery



Right Angle Tactile Switch

(SW1) [Switch]

- This is the reset button
- Resets admin account info



2x3 Male Jumper

(JP1) [Jumper]

- I believe this would of been used during manufacturing to test the product, as it doesn't seem to have a purpose



Test Points (TP)

- Test points are used to inject test signals.
- Useful during manufacturing to test the product
- Can be used when repairing the device if it malfunctions to test the replaced components



Ferrite Beads (FB)

- Ferrite Beads are used to suppress any high-frequency electronic noise in the circuit
- Filters out AC and slows the transition of DC signals.
- Similar to inductors



20 Pin Status Board Connector

(J2) [Jack]

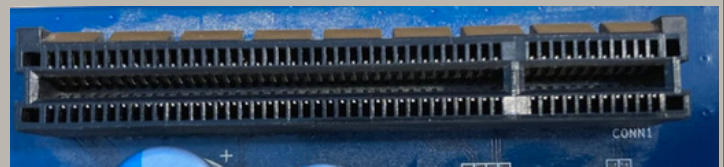
- Connects Mother Board to Status Board through a 20 Pin Ribbon Cable



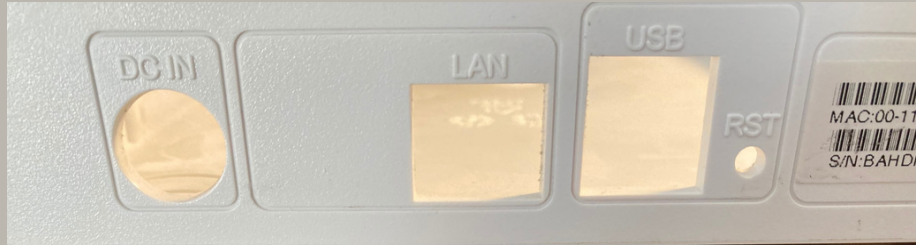
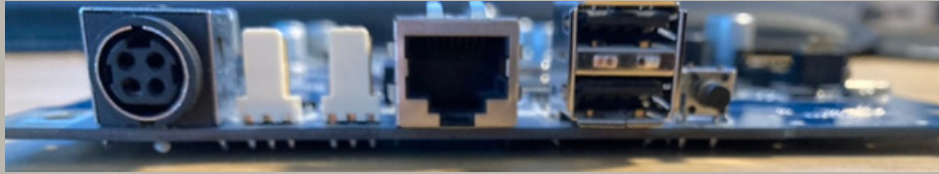
Hard Drive Board Connector

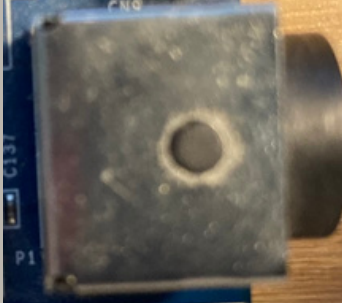

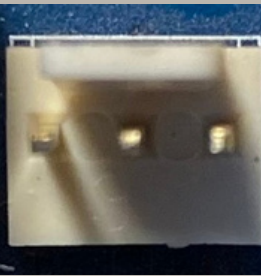
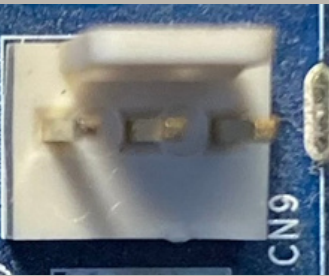
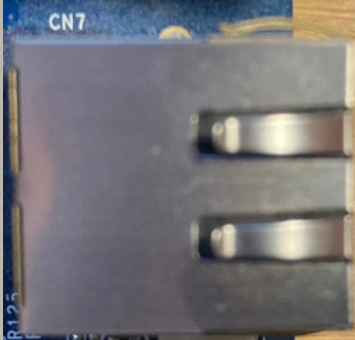
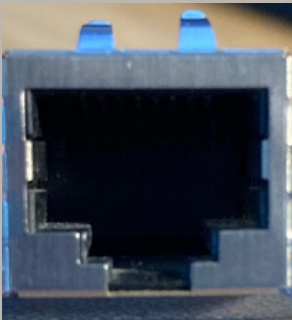

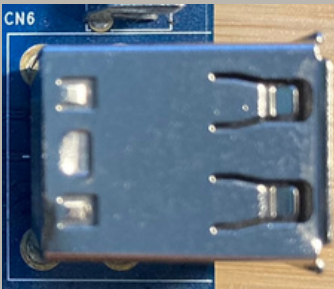
(CONN1)

- Connects Mother Board to Hard Drive Board
- Transfers the information from the hard drives to the Motherboard

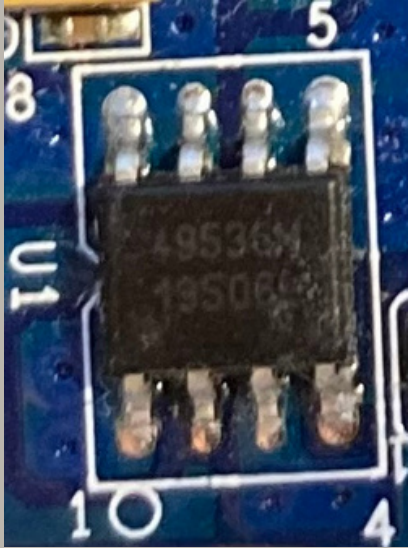



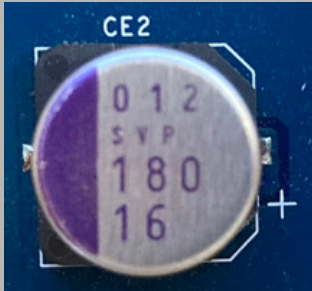


Mother Board Ports



Ports	Image
AC Input (P1) <ul style="list-style-type: none">AC Input Power Voltage: 100V to 240V	 
3-Pin Male Fan Connector (CN8, CN9) <ul style="list-style-type: none">Connects the two <u>Fans</u> to the <u>Motherboard</u>	 
LAN (CN7) <ul style="list-style-type: none">1 GB EthernetDevice comes with 2 metre RJ-45 LAN cable	 
USB 2.0 (CN6) <ul style="list-style-type: none">2 USB 2.0 portsUsed for adding additional external hard drives, USB printers, or other USB devices	 

Hard Drive Board Components

Components	Image
<p>Advanced Power Electronics Corp AP4953GM (U1, U2, U3)</p> <ul style="list-style-type: none"> This is a <u>Power MOSFET</u> It is designed to handle higher power levels than a normal MOSFET Although labelled as (U) it is a <u>Transistor (Q)</u> <u>Data Sheet</u> 	
<p><u>Transistor</u> (Q1, Q2, Q3)</p>	
<p>Panasonic 16SVPC100M (CED1, CED2, CED3, CED4) - 16V 100μF</p> <p>Same as other <u>CE</u>'s but labelled CED as there is 1 per hard drive <u>Data Sheet</u></p>	
<p>nichicon RS80J561MDN1JT (<u>CE1</u>) - 6.3V 560μF <u>Data Sheet</u></p>	
<p>Panasonic 16SVP180MX (<u>CE2</u>) - 16V 180μF <u>Data Sheet</u></p>	

Hard Drive Ports

(CN3, CN4, CN5, CN6)

- SATA Data and SATA Power ports for the hard drives to plug into



Mother Board Connector

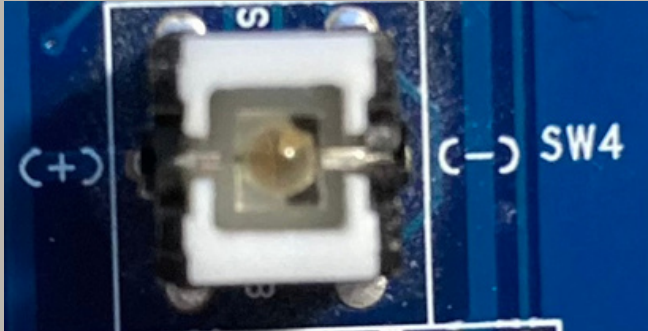

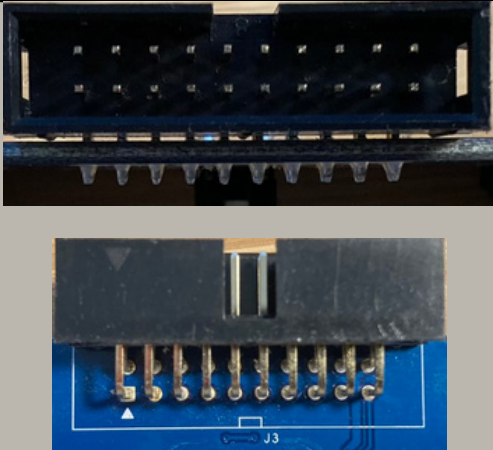
(CONN1)

- Connects Mother Board to Hard Drive Board



Hard Drive Board also includes Ceramic
and Tantalum Capacitors and Resistors

Status Board Components

Components	Image
multicomp PRO TLL-62BG (SW4) <ul style="list-style-type: none">On/Off Button with an LED inside to display On/Off status Data Sheet	
Clear LEDs (LED1, LED2, LED3, LED5, LED9, LED10) <ul style="list-style-type: none">Used to display the Status, LAN, and the 4 Hard Drives status	
20 Pin Connector (J3) <ul style="list-style-type: none">Connects Status Board to Mother Board	

Summary

Exploring the inside of technology from over a decade ago has definitely showed me how much technology has come in such a short span of time.

Researching and finding the origins of every part was enjoyable but tough at times. I only scraped the surface of how circuit boards work but feel like I have learnt so much.

I have realised than even an object this large has such an intricate design, with how each component must work and communicate with the rest of the device.

I learnt how:

- to read a silk screen
- components communicate to each other
- to investigate components purpose
- a NAS/RAID arrays work

References

- DiskStation DS411j Datasheet
- DiskStation DS411J Manual
- DC Brushless Fan
- Reference Designators

And any additional citations in the parts list