

## Overview



### Mac Pro (Late 2013) features:

- **Body:** Unified Thermal Core Design with illuminated input/output (I/O) board.
- **Processor:** Intel Xeon E5 chipset (4 to 12 cores)
- **Graphics:** Dual GPUs using AMD FirePro
- **Memory:** Quad channel DDR3 memory
- **Storage:** PCI Express Flash Storage
- **Expansion Ports:**
  - Six Thunderbolt 2 ports
  - Four USB 3 ports
  - Two Gigabit Ethernet ports
  - One HDMI 1.4 port
- **Connectivity:**
  - 802.11ac Wi-Fi
  - Bluetooth 4.0
- **Display Support:** Connect up to three 4K displays or connect up to six Thunderbolt displays
- **Dimensions:** 9.9 inches tall/6.6 inches in diameter
- **Assembly:** Designed and assembled in the U.S.

**Note:** For product configurations, refer to AppleCare Tech Specs at [support.apple.com/specs](http://support.apple.com/specs).

### Training Requirements:

**Important:** Mac Pro (Late 2013) takeapart procedures should only be performed by Apple-certified technicians. For more

information, refer to article [HT202594: Exams for Service Technicians](#).

**Important:** Prior to servicing the Mac Pro, refer to article [TP1350: Mac Pro \(Late 2013\): Safety](#).

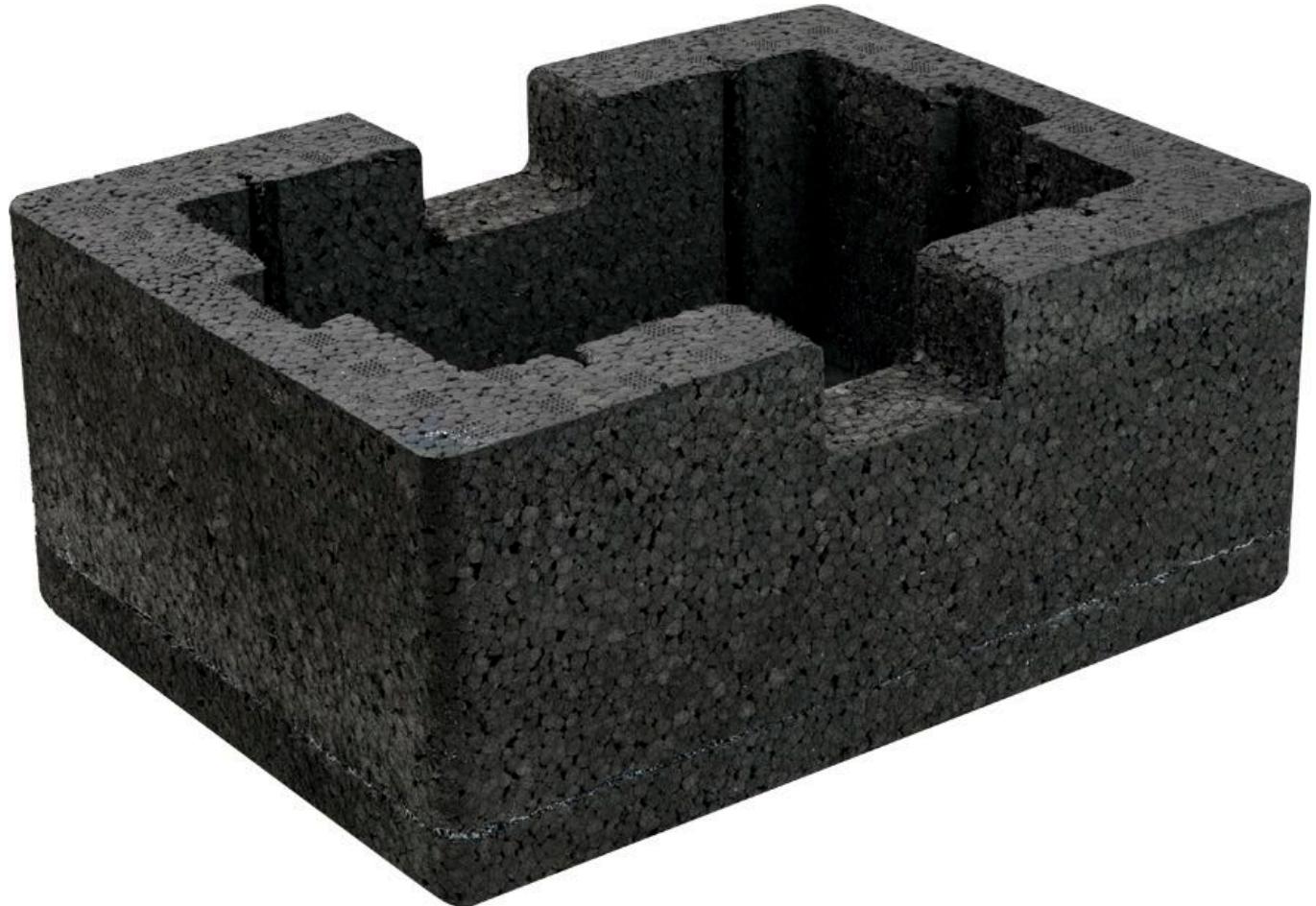
#### **Special Tools and Fixtures:**

Servicing Mac Pro (Late 2013) requires a set of special tools and fixtures, available as a kit. The tools and fixtures are illustrated below. For more information, refer to article [TP1074: Mac Pro \(Late 2013\): General Take Apart Information](#).

#### **Mezzanine Connector Removal Tool**



**Core Cradle**



**Core End Caps**



**CPU Riser Cover**



**CPU Riser Spring Press (shown in cradle)**



**Roof Alignment Fixture**



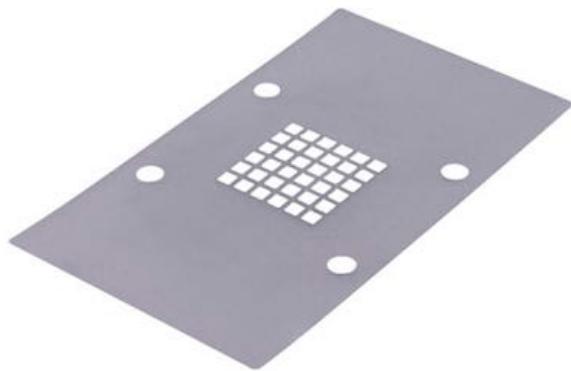
I/O Wall Stand



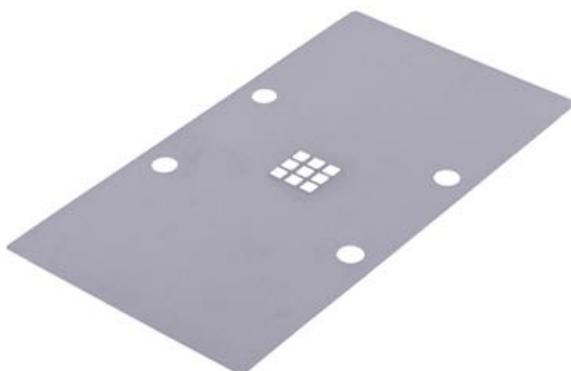
Suction Cup



**CPU Grease Stencil**



**GPU Grease Stencil**



**Torque Driver (shown with T8 security bit)**



**Service Considerations:**

**Software:**

This computer ships with a CPU-specific version of the operating system. Check article [HT204319: Mac OS X versions \(builds\) for computers](#) to make sure system build is correct for this computer model. Using Software Update, check for and apply the latest software and firmware updates.

**Serial Number Location:**

The serial number is located on the inlet on the bottom of the computer.



- Mac Pro (Late 2013) is organized into four main assemblies of parts, which appear as headings in the Take Apart section of the Service Guide table of contents:
    - Housing / Memory / Storage / Logic Board
    - Exhaust Assembly
    - I/O Wall and Power Supply Assembly
    - Core Assembly
  - The computer enclosure is polished aluminum that must be handled with care to avoid scratching.
  - When replacing a part, you must use the screws shipped with the replacement part, both for the new part installation and for reinstalling parts included in the procedure's "First Steps" (see "Screws" in [General Take Apart Information](#)).
  - When replacing a part that requires removing the roof, a new roof must be installed. The replacement roof comes with the service part.
  - The power button is not a service part. To replace the power button, you must replace the I/O wall.
  - Screws for logic board and bus bars must be tightened to specified torque values. A torque driver with required bits is available through Apple (see "Tools" in [General Take Apart Information](#)). Torque values for all screws are listed in the [Mac Pro \(Late 2013\) Screw Chart](#).
  - Graphics board cables and I/O board cable use mezzanine connectors, which require special handling and a mezzanine connector removal tool (see "Mezzanine Connectors" in [General Take Apart Information](#)).
  - After reassembling a Mac Pro (Late 2013) for a graphics board or CPU riser card repair, you must run Cooling System Diagnostic (CSD) to ensure correct thermal operation.

# General Troubleshooting

## Update Software and Firmware

**Important:** Before you begin troubleshooting, ensure the correct version of OS X is installed, and check for and apply the latest software and firmware updates. Computers sometimes exhibit symptoms that indicate the wrong version of OS X system software is installed. Check article [HT204319: OS X versions and builds included with Mac computers](#) to make sure system build is correct for this computer model.

Firmware is the name given to software that is written into memory circuits such as flash memory, that will hold the software code indefinitely, even when power is removed from the hardware. Firmware on Intel Mac computers is designed to be updated if necessary by running the OS X Software Update check (available in the Apple (⌘)menu) while computer is connected to the Internet.

For more information about firmware updates, refer to articles [HT1557: About firmware updates for Intel-based Macs](#) and [HT201518: About EFI and SMC firmware updates for Intel-based Mac computers](#).

## Troubleshooting Theory

More information about troubleshooting theory is located online at [atlaslms.apple.com](#). Sign in to the Apple Technical Learning Administration System (ATLAS) with your Apple ID and password and search for "troubleshooting."

## Hardware vs. Software

To isolate a hardware issue from a software issue, refer to article [HT203161: Isolating issues in Mac OS X](#).

To troubleshoot a software issue, refer to article [HT201861: About incompatible software on your Mac](#).

## Quick Check Procedures

The following procedures are often helpful in troubleshooting Mac Pro issues.

### 1. Resetting the System Management Controller (SMC)

- The SMC controls all power functions for the computer. If the computer is experiencing any power issue, resetting the SMC may resolve it. The SMC controls several functions, including:
  - Telling the computer when to turn on, turn off, sleep, wake, and idle.
  - Handling system resets from various commands.
  - Controlling the fans.

**Note that resetting the SMC does not reset the NVRAM (Non-Volatile Random-Access Memory).** Resetting the SMC will not resolve issues in which the computer is unresponsive. In these situations, restarting the computer generally works. If the computer isn't responding, perform these steps one at a time, in the following order, until the issue has been resolved.

- Force Quit (Option-Command-Escape)
- Restart (Control-Command-Power)
- Force Shut Down (press the power button for 10 seconds)

Resetting the SMC can resolve some computer issues such as not starting up, not displaying video, sleep issues, fan noise issues, and so forth. If the computer still exhibits these types of issues after you've restarted the computer, try resetting the SMC by removing AC power.

- From the Apple menu, choose Shut Down (or if the computer is not responding, hold the power button until it turns off).
- Unplug the AC power cord.
- Wait at least 15 seconds.
- Plug the power cord back in, making sure the power button is not being pressed at the time.
- Press the power button to start up the computer.

For more information refer to article [HT201295: Reset the System Management Controller \(SMC\) on your Mac](#).

### 2. Resetting the NVRAM

Reset NVRAM by holding down Command-Option-P-R keys while rebooting, until you hear the startup sound for the second

time.

For more information refer to article [HT204063: How to Reset NVRAM on your Mac](#).

### 3. Starting Up in Safe Mode

Hold Shift key during startup to put computer into Safe Mode.

**Note:** The Shift key should be held as soon as possible after the startup tone but not before.

For more information refer to article [HT201262: Try safe mode if your Mac doesn't finish starting up](#).

### 4. Power-On Self-Test

When the computer is started up after being fully shut down, a self test in the computer's ROM is automatically run. (The test is not run if the computer is only restarted.)

If the test detects a problem, the system indicator light (located within the power button) flashes in the following ways:

- One (1) Flash: No RAM is installed or detected.
- Three (3) Flashes: A RAM bank failed extended memory testing.

Reseat the memory DIMMs. Check memory installation instructions for proper installation order. Swap affected DIMM with known good DIMM.

**Note:** The status LED lights up when the power button is depressed at startup and when the system detects movement. Do not count this light as one of the diagnostic flashes.

### 5. Real Time Clock (RTC) Reset

RTC is a chip on the I/O board that controls the date and time functions of the computer. Resetting the RTC may resolve startup issues.

1. From the Apple menu, choose Shut Down (or if the computer is not responding, hold the power button until it turns off).
2. Unplug the AC power cord.
3. Remove the housing and DIMMs 1 and 2.
4. Using a black stick, press the RTC reset button located on the logic board (directly under DIMMs 1 and 2) for 1 second.

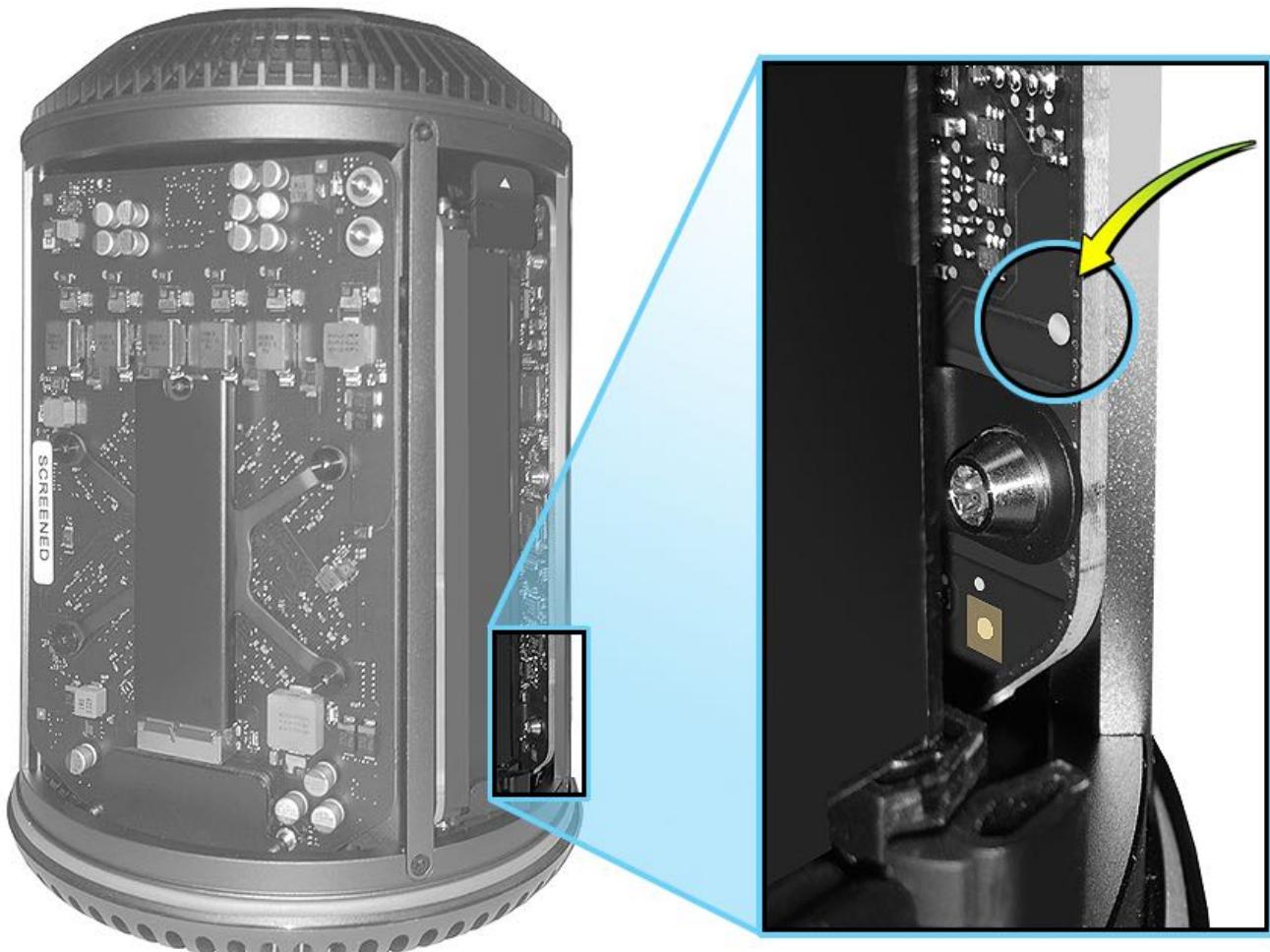
Alternatively, you can remove the coin cell battery located on the I/O board to reset the RTC.

### 6. Coin Cell Battery Check

As with all batteries, it may become necessary to replace the coin cell battery when the computer can no longer keep the time and date as expected. It is possible to check the voltage of the coin cell battery using a multimeter.

1. From the Apple menu, choose Shut Down (or if the computer is not responding, hold the power button until it turns off).
2. Unplug the AC power cord.
3. Remove DIMMs 3 and 4.
4. Using a multimeter, measure the voltage of the coin cell battery using the coin cell battery test point located on the I/O board.

The coin cell voltage should read 2.7v or higher. When the voltage drops below 2.7v, the coin cell battery will need to be replaced.



### Minimum Configuration Testing

The following procedure can help you troubleshoot a No Power or other startup related symptom.

The method gradually builds up the system from a minimum configuration and verifies expected behaviors at each step. This approach helps determine which modules function together. The goal is to identify which module(s) cause a symptom to recur when they are added. This method may also help you discover a loose or faulty cable or connector. If you encounter unexpected behavior during a step, you should investigate the last module you re-installed. Backtrack to the previous step, remove the last installed module, and re-verify the expected behavior.

**Note:** Minimum configuration testing may not be practical for every repair. Refer to other troubleshooting sections in this manual for additional direction.

To test with minimum configuration remove all parts except:

- Power Supply
- One (1) RAM DIMM
- Graphic B Card
- I/O Board
- AC Inlet
- CPU Riser Card
- Main Logic Board

## Recovering a Lost Firmware Password

Only Apple Retail Stores or Apple Authorized Service Providers can unlock the following Mac models when protected by a firmware password:

- iMac (Mid 2011 and later)
- iMac Pro (2017)
- MacBook (Retina, 12-inch, Early 2015 and later)
- MacBook Air (Late 2010 and later)
- MacBook Pro (Early 2011 and later)
- Mac mini (Mid 2011 and later)
- Mac Pro (Late 2013)

Refer to the technician instructions in article [HT204455: How to set a firmware password on your Mac](#).

# Diagnostic Software

Here are the appropriate diagnostic software versions for the Mac Pro (Late 2013):

- **Apple Service Diagnostic (ASD):** version [3S159](#)
- **Apple Diagnostic (AD):** version 1.0.6

## Apple Service Toolkit (AST)

AST is a suite of diagnostic tools that checks Intel-based Mac hardware components, and provides detailed diagnostic logs for review. AST runs on a local server, managing multiple Ethernet clients via NetBoot.

For more information, refer to articles:

- [OP476: SERVICE: Latest Apple Service Toolkit download links and documentation](#)
- [TP586: AST Reference Guide Table of Contents](#)

## Mac Resource Inspector (MRI)

MRI, which is part of AST, is a quick triage tool that checks for the presence of hardware and reports sensor readings. Sensors are located on a variety of parts, including cables, fans, storage devices, power supply, display panel, and logic board. Use MRI to help isolate failures and avoid unnecessary part replacements. MRI complements ASD, which is a more in-depth repair verification tool.

**Note:** If all AST checks pass and a component is still suspected of fault, then verify with other diagnostic tools.

## Cooling System Diagnostic (CSD): Standard

CSD evaluates thermal sensors, fans, and heat sinks. It either confirms correct operation or helps diagnose service issues. CSD is useful when assisting users with questions about fan noise.

## Thermal and Electrical Sensors

The Mac Pro contains many thermal and electrical sensors that ensure safe and efficient operation of the computer. The tables below list the sensors that are tested as part of Apple Service Toolkit (AST), Apple Diagnostics, and Apple Service Diagnostic (ASD).

### Thermal Sensors

Sensor	Description	Sensor Location
TA0p	Ambient MLB	Logic Board
TA1p	Ambient 2	Logic Board
TA2p	Ambient 3	Logic Board
TC0p	CPU Proximity 0	CPU Riser Card
TC1p	CPU VCC VR Proximity	CPU Riser Card
TCXr	ACPU Relative Die Sensor	CPU Riser Card
Te0t	PCIe Switch Diode	I/O Board
TG0d	GFXA Die Diode	Graphics Board A
TG0p	GFXA GPU Proximity	Graphics Board A
TG0r	GFXA VR Proximity	Graphics Board A
TG1d	GFXB Die Diode	Graphics Board B
TG1p	GFXB GPU Proximity	Graphics Board B
TG1r	GFXB VR Proximity	Graphics Board B
TI0p	I/O Board Proximity	I/O Board
TI0t	Right Rear AB Thermal Diode	I/O Board
TI1p	5V/3V3 VR Proximity	I/O Board
TM0p	CPU SO-DIMM Proximity	CPU Riser Card
Tm0p	MLB Proximity	Logic Board
TM0r	CPU DIMM_01 VR Proximity	CPU Riser Card
TM1p	CPU DIMM_23 top Proximity	CPU Riser Card
TM1r	CPU DIMM_23 VR Proximity	CPU Riser Card
Tp0t	PSU Secondary H/S Temp Diode	Power Supply

### Voltage and Current Sensors

Sensor	Description	Sensor Location	Type
IC0C	CPU Core lowside current	CPU Riser Card	Current
IC0S	CPU VSA lowside current	CPU Riser Card	Current
ICTR	CPU Riser 12V highside current	CPU Riser Card	Current
IMTR	MEM 12V highside current	CPU Riser Card	Current
VC0C	CPU Core lowside voltage	CPU Riser Card	Voltage
VC0S	CPU VSA lowside voltage	CPU Riser Card	Voltage
VCTR	CPU Riser 12V highside voltage	CPU Riser Card	Voltage
IH0R	SSD 3.3V lowside current	Flash Storage	Current
VH0R	SSD 3.3V lowside voltage	Flash Storage	Voltage
IG0C	GPU_A core lowside current	Graphics Board A	Current
IG0R	GFXA Riser 12V highside current	Graphics Board A	Current
IG0S	GPU_A VDDCI lowside current	Graphics Board A	Current
VG0C	GPU_A core lowside voltage	Graphics Board A	Voltage
VG0R	GFXA Riser 12V highside voltage	Graphics Board A	Voltage
VG0S	GPU_A VDDCI lowside voltage	Graphics Board A	Voltage
IG1C	GPU_B core lowside current	Graphics Board B	Current
IG1R	GFXB Riser 12V highside current	Graphics Board B	Current
IG1S	GPU_B VDDCI lowside current	Graphics Board B	Current
VG1C	GPU_B core lowside voltage	Graphics Board B	Voltage
VG1R	GFXB Riser 12V highside voltage	Graphics Board B	Voltage
VG1S	GPU_B VDDCI lowside voltage	Graphics Board B	Voltage
II0R	IO Board 12V highside current	I/O Board	Current
VI1R	IO Board 11V highside voltage	I/O Board	Voltage
VD2R	IO Board 11V highside voltage	Power Supply	Voltage

# Diagnostic LEDs and Test Points

The Mac Pro (Late 2013) contains several diagnostic LEDs and test points to assist in troubleshooting:

- Status LEDs are green, and do not illuminate unless the DIAG button (refer to the I/O Board LEDs topic) on the I/O board is being pressed. This type of LED is only found on the I/O board. They are used to identify power states and are useful in troubleshooting the startup sequence.
- Error LEDs are red, and illuminate continuously when there is a problem.
- Warning LEDs are yellow, and illuminate continuously when a thermal problem is detected. This type of LED is only found on the CPU riser card.

## Using Diagnostic LEDs for Troubleshooting

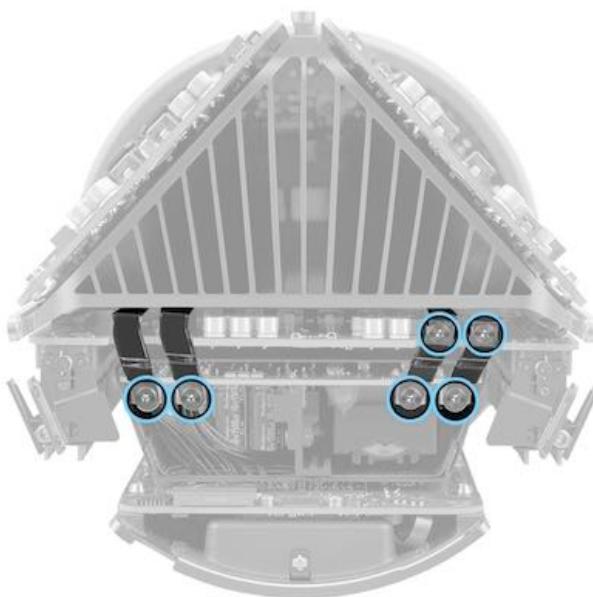
The Mac Pro (Late 2013) contains a Hall Effect sensor that will prevent operation of the computer with the housing removed. For the purpose of viewing diagnostic LEDs only, it is possible to briefly operate the computer with the housing removed.

1. From the Apple menu, choose Shut Down (or if the computer is not responding, hold the power button until it turns off).
2. Remove the AC power cord and all cables and peripherals that might be connected to the system.
3. Remove the housing.
4. Connect the AC power cord.



**Warning:** To prevent injury, avoid contact with the bus bars and the bus bar screws (shown below) when the computer is plugged in and powered on. The bus bars and the bus bar screws, located at the top of the main boards, have enough energy to cause a burn if they are bridged with metal (such as a ring or other jewelry).

Avoid contact with I/O board bus bars and bus bar screws:



Avoid contact with Graphics board A bus bar screws:



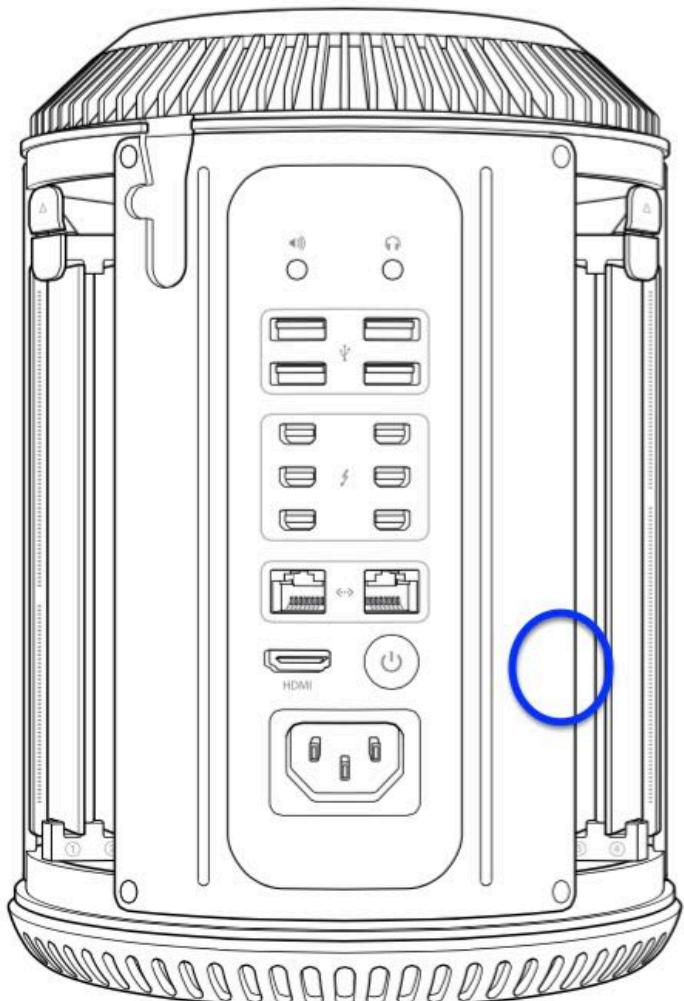
Avoid contact with Graphics board B bus bar screws:



**Warning:** Operating the computer with the housing removed for purposes other than viewing diagnostic LEDs is not recommended. Do not disassemble the system, other than removing the outer housing, with the safety interlock defeated.

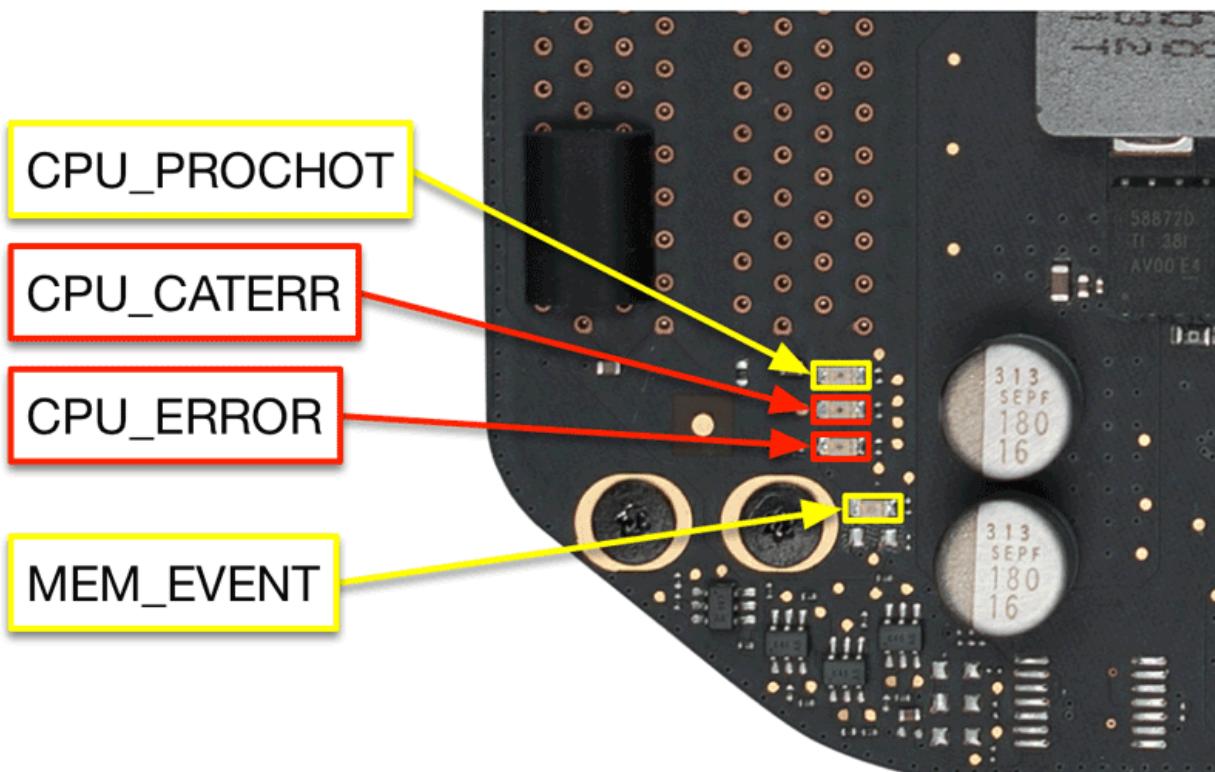
Placing a magnetic source (as described below) to view the diagnostic LEDs, with the Mac Pro housing removed and the computer turned on, will override the safety interlock system and energize the output of the main power supply. Remove the magnetic source as soon as possible to minimize risk of injury.

To view the diagnostic LEDs with the housing removed, hold a magnetic source (such as a Wiha Magnetizer/Demagnetizer) approximately one inch to the right of the power button, indicated by the blue circle below. Press the power button, keeping the magnet in place to view the LED status. Removing the magnet will immediately turn off the computer.



#### CPU Riser Card LEDs

The CPU riser card has four diagnostic LEDs that indicate errors with the CPU and thermal issues.



#### CPU Riser Card Warning LEDs

- **CPU\_PROCHOT:** This indicates that an overtemp condition has been detected by the CPU or SMC. It may also be

triggered by the total system power exceeding its specified limit. Use MRI or ASD to further isolate the issue.

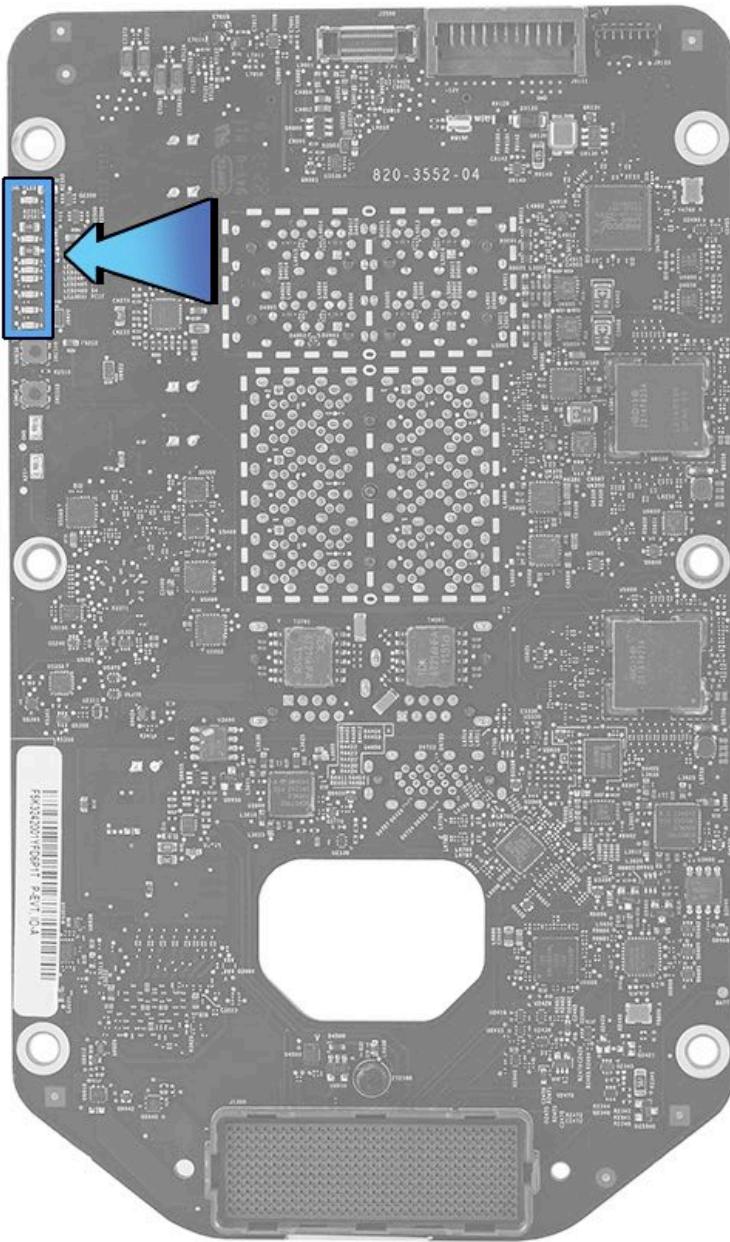
- **MEM\_EVENT:** This indicates that an overtemp condition has been detected in a DIMM. Use MRI or ASD to further isolate the issue.

### CPU Riser Card Error LEDs

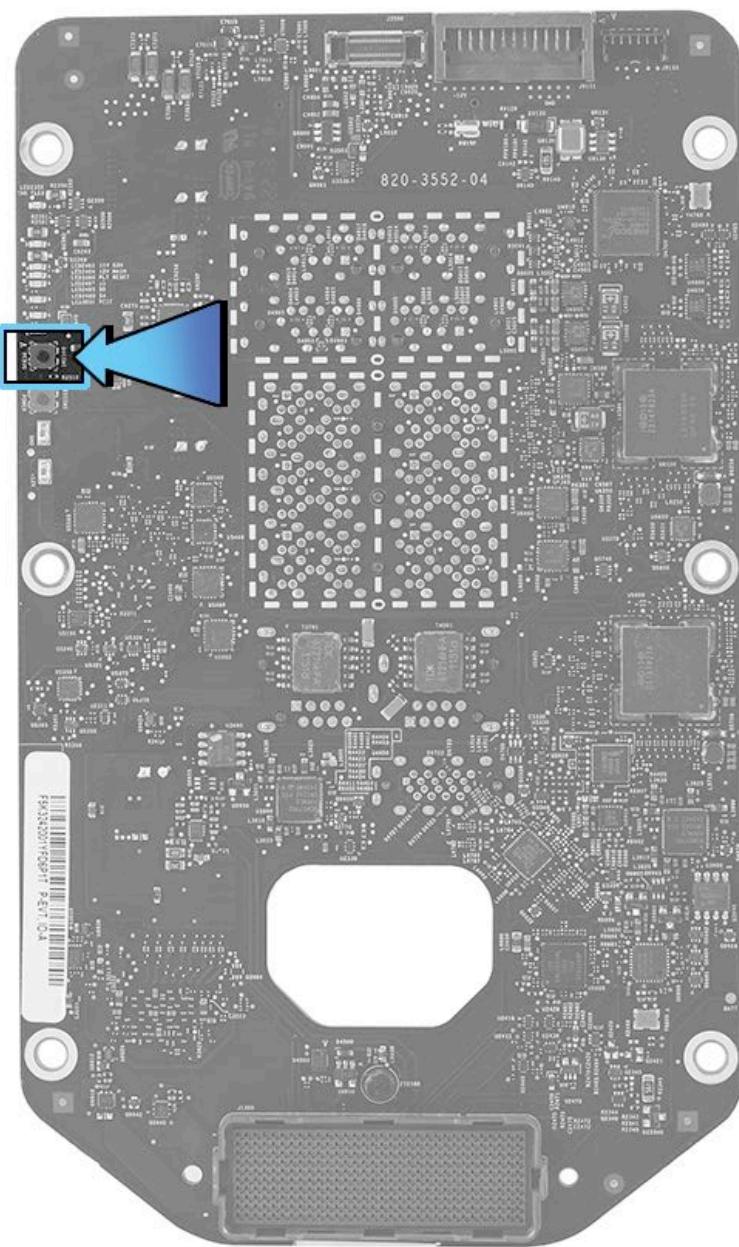
- **CPU\_CATERR:** This indicates that the CPU has reported a catastrophic error. The system software will be unresponsive in this state. This may be caused by an unexpected power off of components connected to the CPU, or an error in EFI during startup.
- **CPU\_ERROR:** This indicates that the CPU has encountered a fatal error. The system software is unresponsive.

### I/O Board LEDs

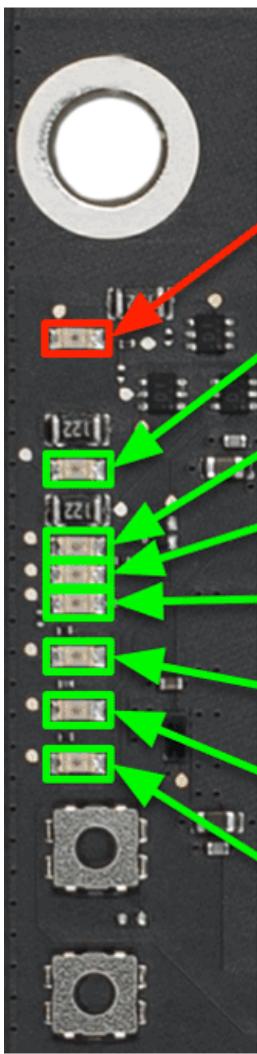
The I/O board has eight diagnostic LEDs located on the rear of the board, facing the power supply. They can be used to troubleshoot power and startup issues. The LEDs do not illuminate unless the DIAG button (refer to next graphic) is pressed.



To activate the LEDs, press the DIAG button with a black stick.



This is a close up of the I/O board's diagnostic LEDs.



#1: Flex Check

#2: 11V Power

#3: 12V Power

#4: Platform Reset Release

#5: S5 Power State

#6: S0 Power State

#7: S4 Power State

#8: PCIe Switch Status

#### I/O Board Error LED

- #1: **Flex Check:** This indicates that there is a connection issue between the logic board and the I/O board. Check the mezzanine connectors on both the logic board and I/O board to be sure the connections are fully seated.

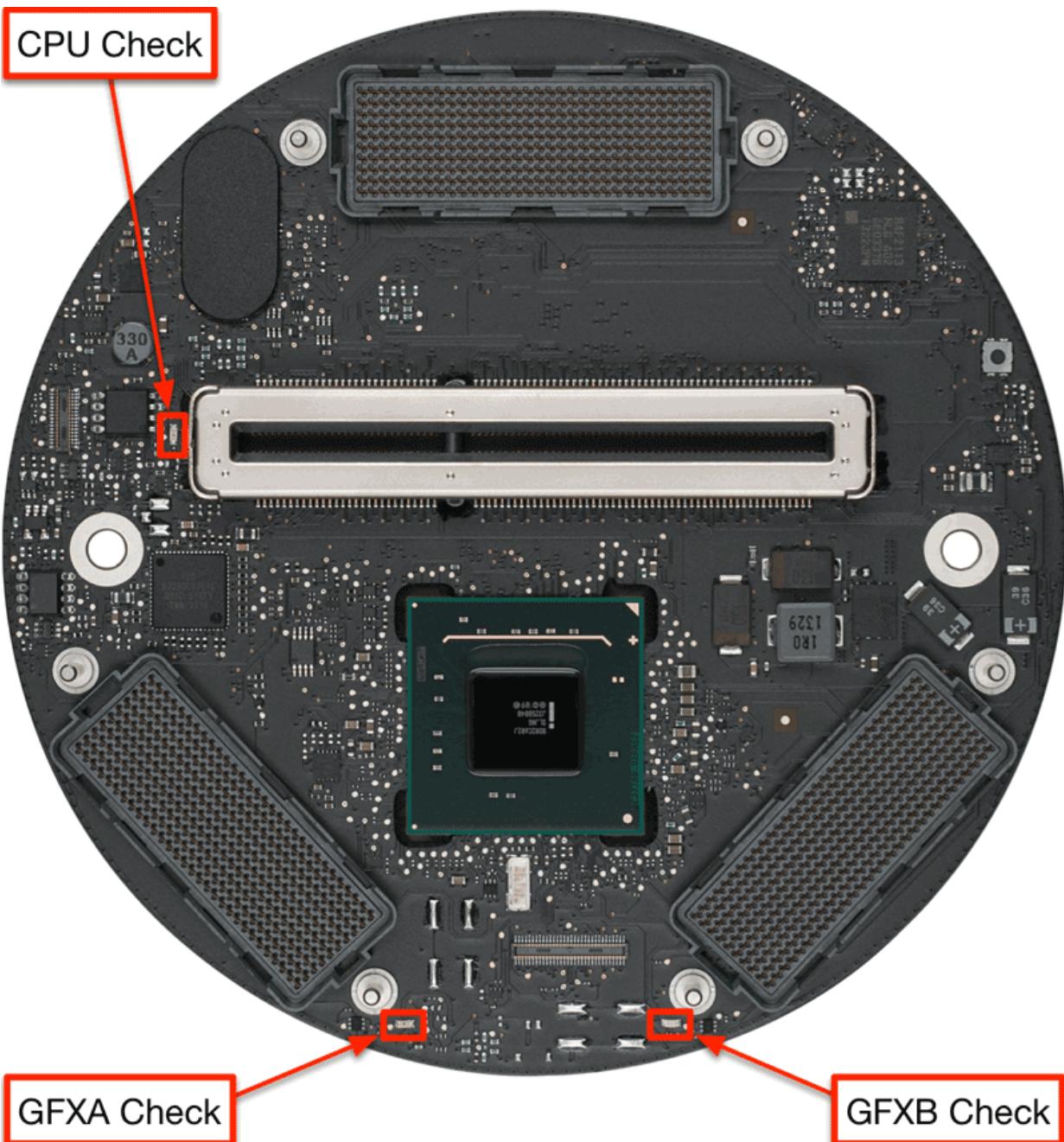
#### I/O Board Status LEDs

- #2: **11V Power:** This indicates 11V power from the power supply. It should remain illuminated whenever AC power is connected.
- #3: **12V Power:** This indicates 12V main system power. It should illuminate once the power button has been pressed, and should remain on while the system is powered on and not in sleep mode. If high-power USB or Thunderbolt devices are connected prior to sleep, this LED will remain illuminated during sleep.
- #4: **Platform Reset Release:** This indicates that the system has transitioned to a fully running power state (S0). During startup, this indicates that the system can transition to EFI Boot.
- #5: **S5 Power State:** This indicates that the S5 (soft power off) state is available. It will illuminate at all power states, until the computer is fully shut down. If the computer is scheduled to turn on at a certain time in the Energy Saver preference pane, this LED will still illuminate after the computer has been shut down.
- #6: **S0 Power State:** This indicates that the S0 (full power) state is available. It will illuminate once the computer begins the startup sequence, but does not necessarily indicate that computer has successfully started up.
- #7: **S4 Power State:** This indicates that the S4 (hibernate) state is available. It should illuminate at the same time as the S0 LED. If, during startup, this LED illuminates without S0 illuminating, it may indicate an issue.
- #8: **PCIe Switch Status:** This indicates the status of the link from the PCIe switch on the I/O Board to the CPU. During startup, this indicates that the system has reached EFI Boot. If the link to the PCIe switch is not operating in PCIe v3 mode, this LED will blink. A fast blink indicates v2 mode, while a slow blink indicates v1 mode. These states may correlate to issues with Thunderbolt or USB devices.

**Important:** Be sure to remove any magnetic source used in step 6 (above) to re-enable the safety interlock circuit as soon as possible, to minimize risk of injury from contact with the bus bars and bus bar screws.

#### Logic Board LEDs

The logic board has three diagnostic LEDs that indicate connection errors to other boards.



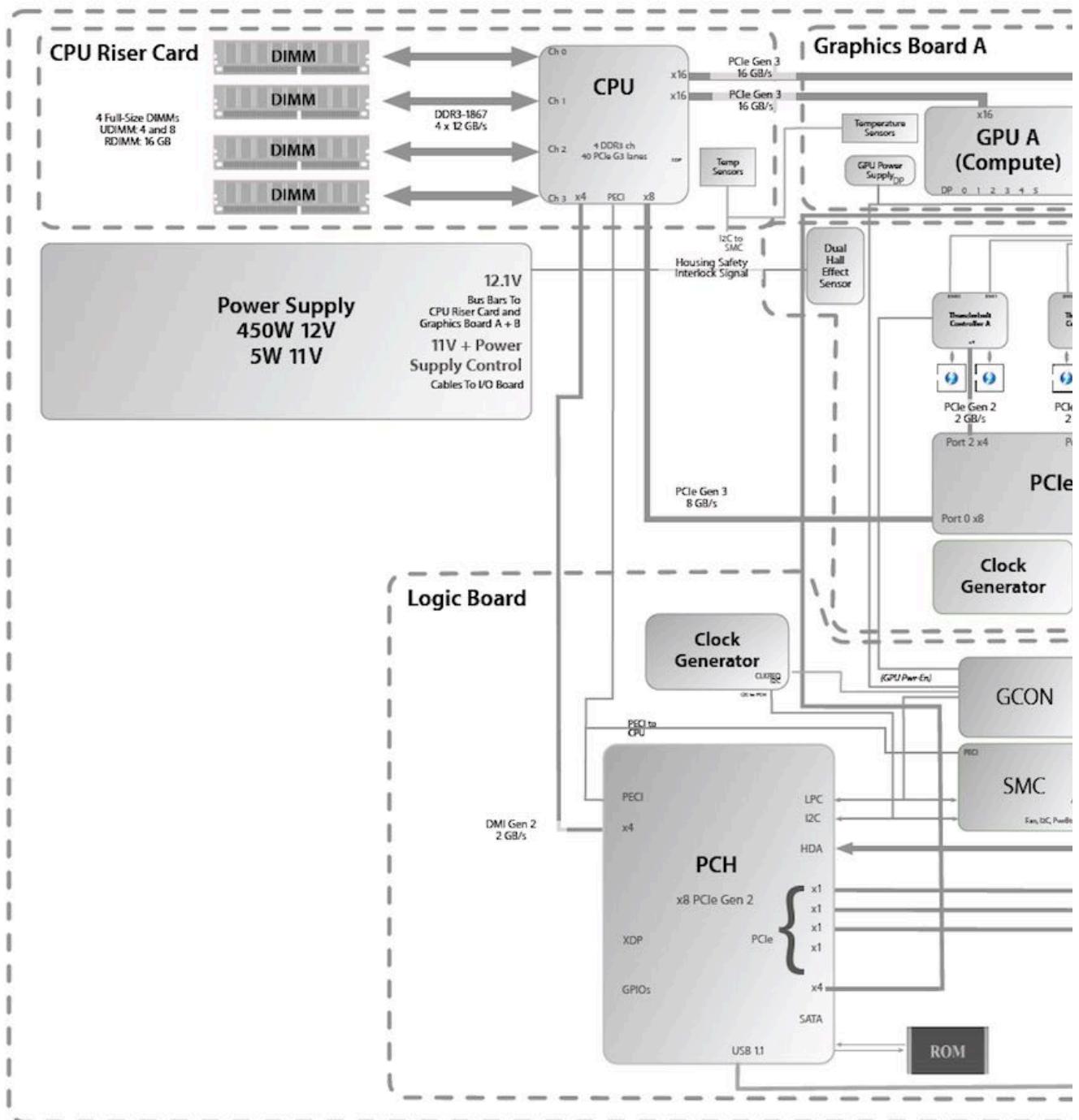
#### Logic Board Error LEDs

- **CPU Check:** This indicates that there is a connection issue between the logic board and the CPU riser card. Verify that the edge connector on the CPU riser card is fully seated into the slot on the logic board.
- **GFXA Check:** This indicates that there is a connection issue between the logic board and Graphics Board A. Check the mezzanine connectors on both the logic board and graphics board to be sure the connections are fully seated.
- **GFXB Check:** This indicates that there is a connection issue between the logic board and Graphics Board B. Check the mezzanine connectors on both the logic board and graphics board to be sure the connections are fully seated.

# Block Diagram

Block Diagram for Mac Pro (Late 2013)

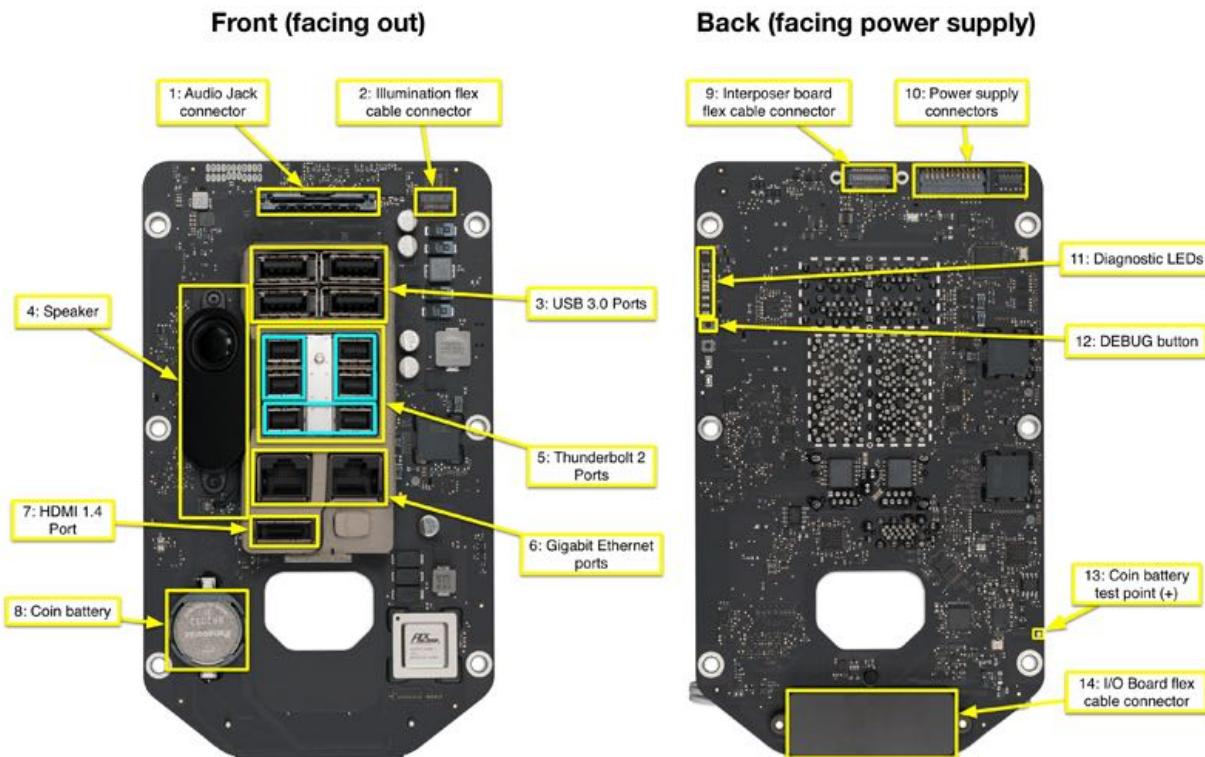
## Mac Pro (Late 2013) System Block Diagram



# Functional Overview

## Functional Overview

### I/O Board



#### 1. Audio jack connector

- No sound from headphones or external speakers
- No headset controls or mic input

#### 2. Illumination flex cable connector

- No lights on I/O Wall

#### 3. USB 3 ports

- USB device not found
- Controller not recognized
- USB power issues

#### 4. Speaker

- No audio / distorted audio from internal speaker

#### 5. Thunderbolt 2 ports

- Thunderbolt device not found
- Thunderbolt power issues
- No video to external display

#### 6. Gigabit Ethernet ports

- No connection to wired ethernet

#### 7. HDMI 1.4 Port

- No video to external display
- No audio to external display

8. Coin battery

- Computer does not keep time when unplugged
- No boot

9. Interposer board flex cable connector

- Fan not functioning
- Cannot enable Wi-Fi or Bluetooth
- Wireless card not seen in System Information

10. Power supply connectors

- No power

11. Diagnostic LEDs

- See [Diagnostic LEDs and Test Points](#)

12. DEBUG button

- Used to activate status LEDs on I/O board.
- See [Diagnostic LEDs and Test Points](#)

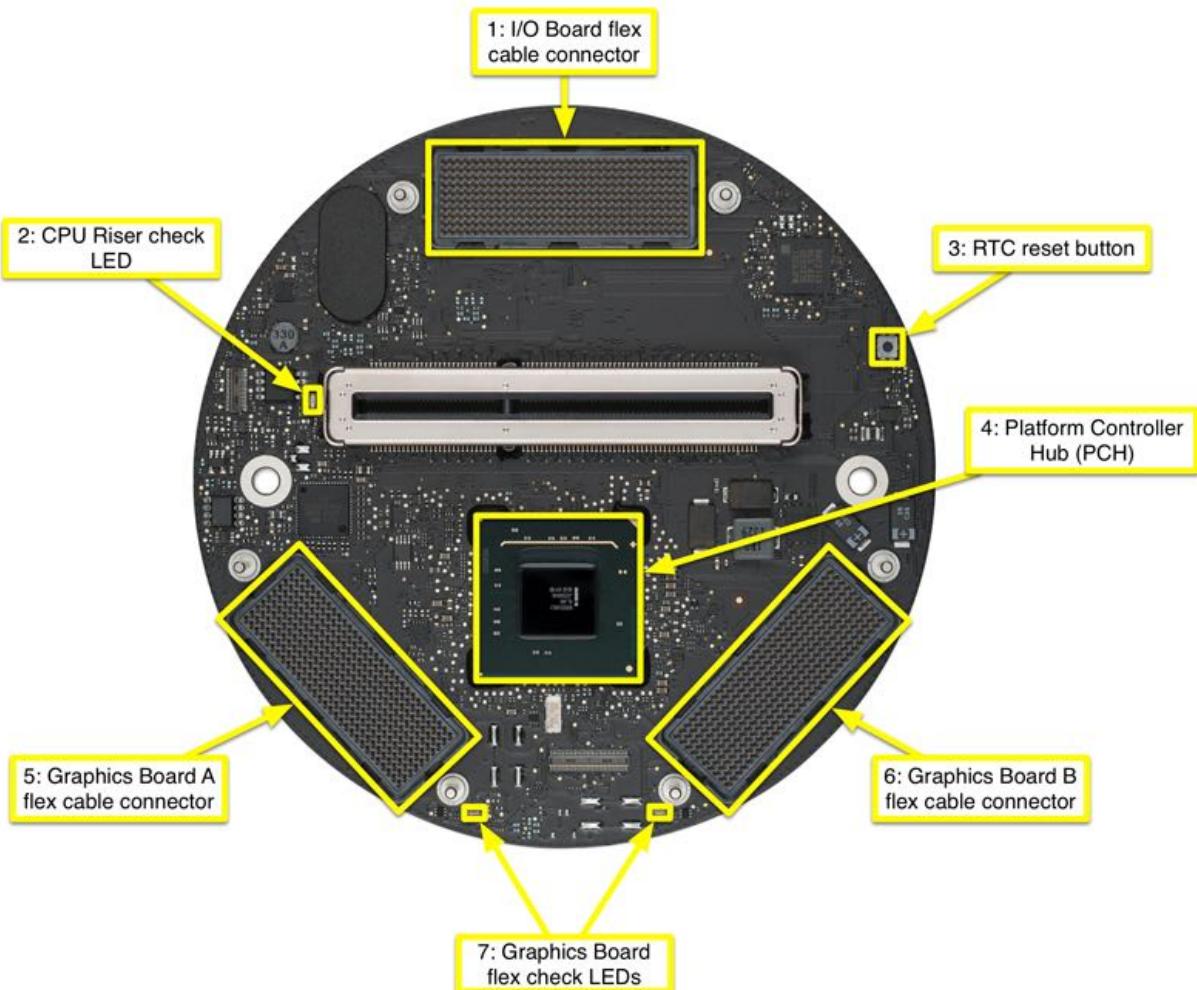
13. Coin battery test point

- Used to check voltage of coin cell battery.
- See [Coin Cell Battery Check](#) in Quick Check Procedures

14. I/O Board flex cable connector

- No power
- No video
- Wi-Fi or Bluetooth issues

## Logic Board



#### 1. I/O Board flex cable connector

- No power
- No video
- Wi-Fi or Bluetooth issues

#### 2. CPU riser check LED

- See [Diagnostic LEDs and Test Points](#)

#### 3. RTC reset button

- See [Real Time Clock \(RTC\) Reset](#) in Quick Check Procedures

#### 4. Platform Controller Hub (PCH)

- No power
- No video
- No Wi-Fi or Bluetooth
- No Ethernet
- See [Block Diagram](#) for more info.

#### 5. Graphics board A flex cable connector

- Only one graphics board shown in System Information

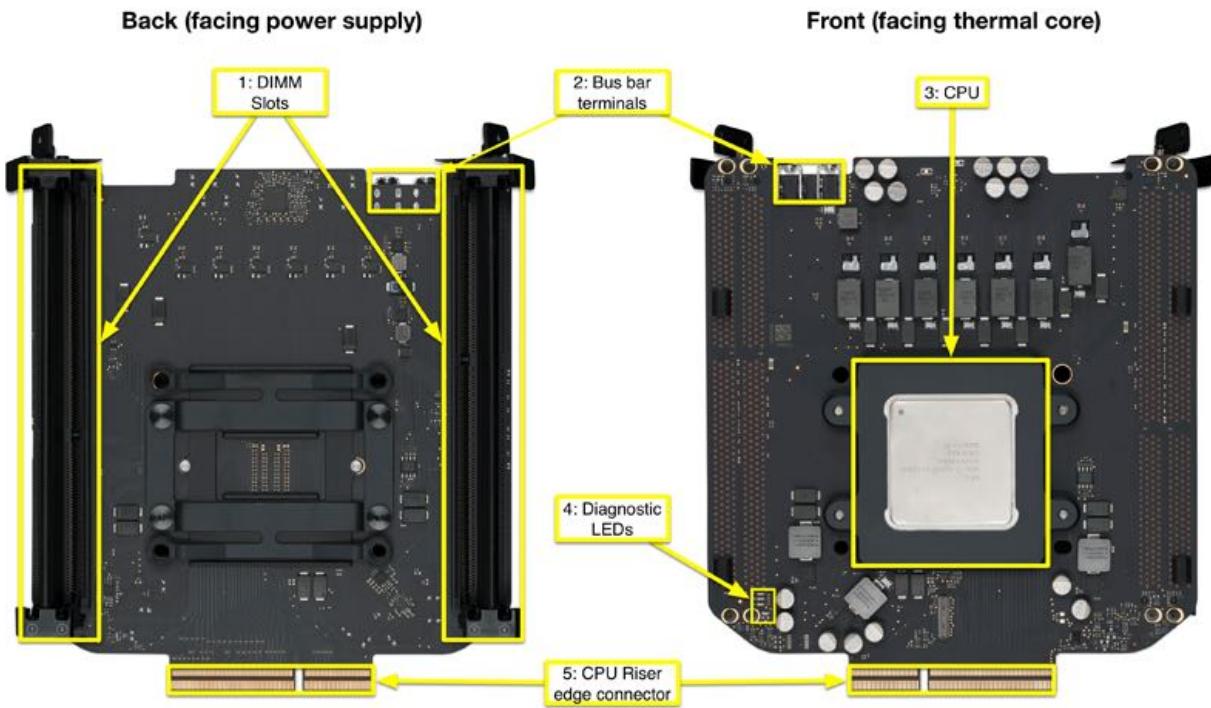
#### 6. Graphics board B flex cable connector

- No video

#### 7. Graphics board flex check LEDs

- See [Diagnostic LEDs and Test Points](#)

## CPU Riser Card



### 1. DIMM slots

- No boot
- Beep tones on startup
- System hangs or kernel panics

### 2. Bus bar terminals

- No power

### 3. CPU

- No power
- No video
- Thunderbolt issues
- Memory not recognized
- System hangs or kernel panics

### 4. Diagnostic LEDs

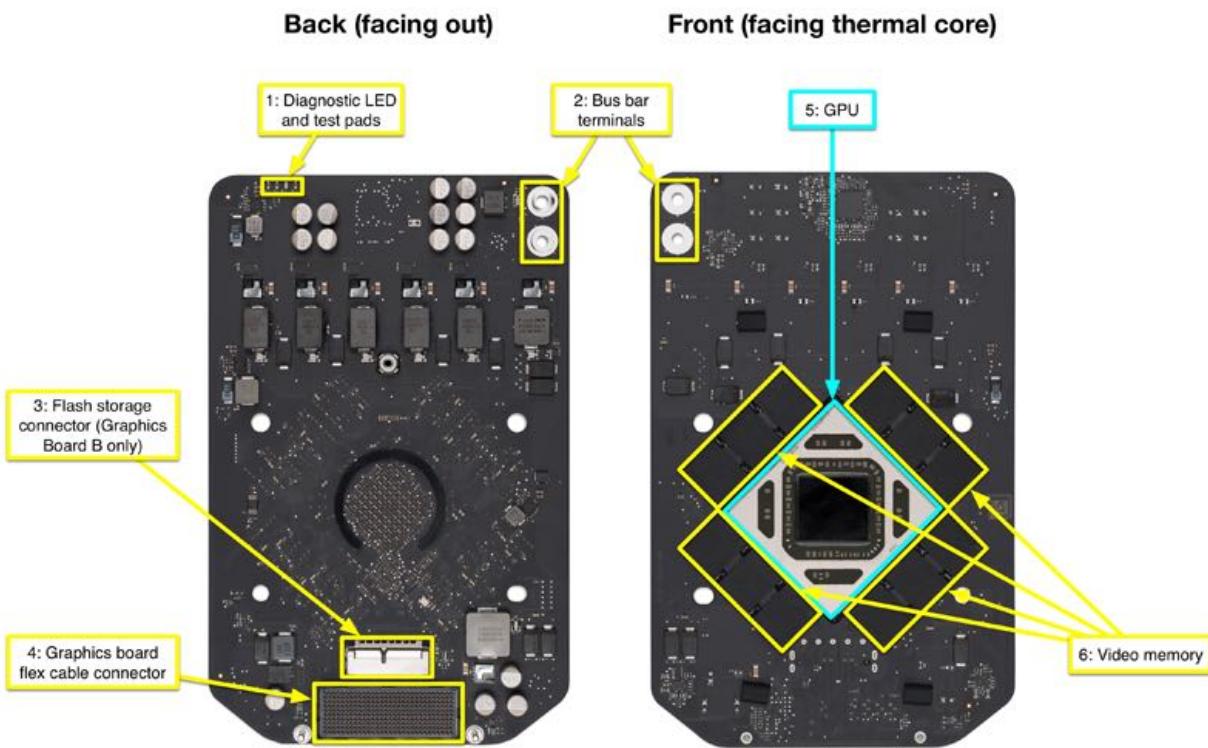
- See [Diagnostic LEDs and Test Points](#)

### 5. CPU riser edge connector

- No power

## Graphics Boards

**Note:** The Mac Pro (Late 2013) has two graphics boards; graphics board A and graphics board B. Graphics board B (back and front) is shown below. Graphics board A looks very similar, but does not have the flash storage connector.



#### 1. Diagnostic LED and test points

- See [Diagnostic LEDs and Test Points](#)

#### 2. Bus bar terminals

- No power
- No video

#### 3. Flash storage connector (graphics board B only)

- Flash storage not recognized
- No boot

#### 4. Graphics board flex cable connector

- Only one graphics card shown in System Information
- No video

#### 5. GPU

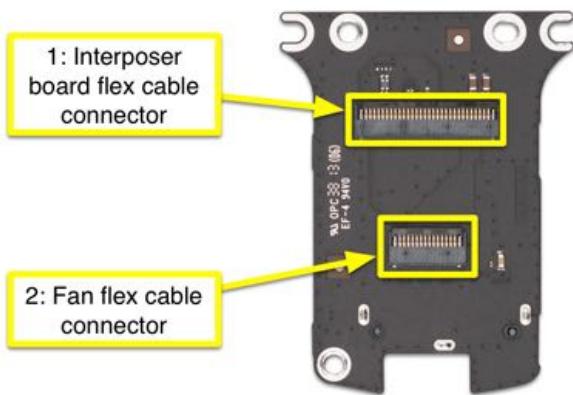
- No video

#### 6. Video memory

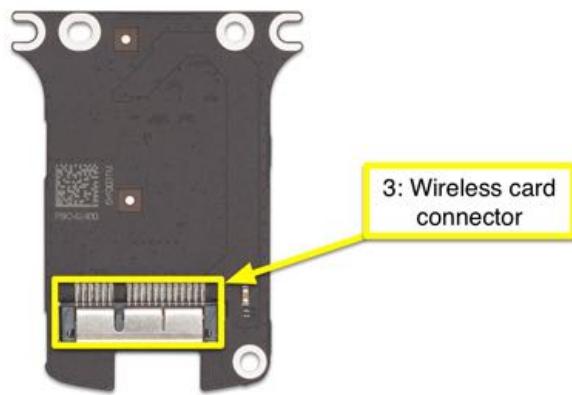
- Distorted / garbled video
- System crashes or kernel panics

## Interposer Board

**Top**



**Bottom**



1. Interposer board flex cable connector

- Fan not spinning Wi-Fi or Bluetooth issues

2. Fan flex cable connector

- Fan not spinning
- System running hot

3. Wireless card connector

- Wi-Fi or Bluetooth issues

## Minimum Configuration

If you encounter unexpected behavior during a troubleshooting step, investigate the last module you reinstalled. Backtrack to the previous step, remove the last installed module, and verify the expected behavior once more.

**Note:** Minimum configuration testing may not be practical for every repair. Refer to other troubleshooting topics in this Service Guide for additional direction.

To test the Mac Pro (Late 2013) with the minimum configuration, remove all parts except:

- Power supply
- One RAM DIMM
- Graphic B card
- I/O board
- AC inlet
- CPU riser card
- Main logic board
- I/O wall

# Bluetooth Device Connection Issues

## Unlikely causes:

AC Inlet, Audio Jack, Bus Bars A and B, Coin Battery, Fan, Flash Storage, Graphics Board A and B, Graphics Board Flex Cables, Memory DIMM, Power Cable, Power Supply, Speaker, Wi-Fi Antenna.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• Bluetooth can be enabled, but computer will not pair with known-good Bluetooth keyboard, mouse, or trackpad.</li><li>• Paired Bluetooth devices intermittently lose their connections.</li><li>• Bluetooth data transfer times out or is too slow.</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. In System Preferences &gt; Bluetooth, verify bluetooth is On.</li><li>2. Disconnect all external USB devices, except for a known-good Apple USB keyboard and mouse. Refer to item 16 in Apple Support article <a href="#">HT201163: Using USB 3 devices on Mac computers FAQ</a>.</li><li>3. Attempt to pair computer with known-good Apple bluetooth keyboard, mouse, or trackpad.</li><li>4. Reset Bluetooth device or delete pairing (if applicable).</li><li>5. Verify integrity of user's Bluetooth device with known-good computer, using Apple Support article <a href="#">HT204621: Troubleshooting wireless mouse and keyboard issues</a>.</li><li>6. Check Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> to make sure system build is correct for this computer model.</li><li>7. Check for and apply latest software and firmware updates.</li><li>8. If Bluetooth pairs normally at your service location, research potential sources of interference in user's environment, such as microwave ovens or cordless phones in 2.4GHz range. See Apple Support article <a href="#">HT1365: Wi-Fi and Bluetooth: Potential sources of wireless interference</a>.</li><li>9. Reset PRAM by holding down Command-Option-P-R keys while rebooting, until you hear the startup sound for the second time. Refer to Apple Support article <a href="#">PH14222: OS X Mavericks: Reset your computer's PRAM</a>.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	Check Mac Resource Inspector (MRI) test results or System Information > Hardware > USB Device Tree to verify Bluetooth interface is recognized.  Is Bluetooth hardware detected?	Yes	Go to step 2.	\${nodeText.yesSymptomCode}	
		No	Go to "Bluetooth Service Not Recognized" troubleshooting flow.	\${nodeText.noSymptomCode}	
2.	Open System Preferences > Bluetooth. Remove all paired devices. Pair computer with known-good Bluetooth device. Run latest version of Bluetooth Service Diagnostic (BSD) while actively paired with known-good device.  Does computer pass BSD tests?	Yes	Computer appears to be performing to specification when paired with known-good Bluetooth device. User's Bluetooth device may be the issue. Go to "External Apple Bluetooth Peripherals" troubleshooting flow.	\${nodeText.yesSymptomCode}	
		No	Go to step 3.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
3.	Start up from the recovery partition or from a known-good up-to-date external volume. Try to connect to known-good Bluetooth device. Compare Bluetooth performance and reliability to known-good computer of similar type and Bluetooth specification.	Yes	Refer to Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> , and restore computer to correct build of OS X. Retest to verify resolution.	\${nodeText.yesSymptomCode}	
	Is Bluetooth performance comparable between user's computer and known-good computer?	No	Go to step 4.		
4.	Follow take apart instructions to remove the exhaust assembly, roof, and interposer board cover.	Yes	Replace Bluetooth antenna. Verify issue resolved.	X03	INTERNAL CABLE
	Verify Bluetooth antenna connection to wireless card (second from right when the interposer flex is pointing away from you). Inspect antenna's cable and connector for any signs of pinched wires or connector damage.	No	Go to step 5.	\${nodeText.noSymptomCode}	
	Do antenna cable or connector show any signs of damage?				
5.	With cable unplugged, inspect antenna cable connector on wireless card for housing or pin damage.	Yes	Replace wireless card. Verify issue resolved.	N17	WIRELESS DEVICE
	Does antenna connector on wireless card show any signs of damage?	No	Go to step 6.	\${nodeText.noSymptomCode}	
6.	With cable unplugged, inspect antenna cable connector on Bluetooth antenna for housing or pin damage.	Yes	Replace Bluetooth antenna. Verify issue resolved.	N17	OTHER ELECTRIC
	Does antenna connector on Bluetooth antenna show any signs of damage?	No	Go to step 7.	\${nodeText.noSymptomCode}	
7.	Reseat antenna cable connection to wireless card. Reassemble. Try to pair with known-good Bluetooth device.	Yes	Issue resolved by reseating Bluetooth antenna. Verify resolution.	\${nodeText.yesSymptomCode}	
	Did computer pair successfully with known-good Bluetooth device?	No	Go to step 8.		
8.	To troubleshoot issue completely, the following known-good parts are required:	Yes	Go to step 9.	\${nodeText.yesSymptomCode}	WIRELESS DEVICE
	<ul style="list-style-type: none"> <li>• Wireless card</li> <li>• Bluetooth antenna cable</li> <li>• Bluetooth antenna</li> </ul> <p>Do you have immediate access to each of these known-good parts?</p>	No	Replace wireless card. Verify issue resolved.	N15	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
9.	Substitute known-good wireless card. Reassemble. Try to pair with known-good Bluetooth device.	Yes	Replace wireless card. Verify issue resolved.	N15	WIRELESS DEVICE
	Did computer pair successfully with known-good Bluetooth device?	No	Go to step 10.	\${nodeText.noSymptomCode}	
10.	Substitute a known-good Bluetooth antenna cable. Try to pair with known-good Bluetooth device.	Yes	Replace Bluetooth antenna cable. Verify issue resolved.	X03	INTERNAL CABLE
	Did computer pair successfully with known-good Bluetooth device?	No	Go to step 11.	\${nodeText.noSymptomCode}	
11.	Substitute a known-good Bluetooth antenna. Try to pair with known-good Bluetooth device.  Did computer pair successfully with known-good Bluetooth device?	Yes	Replace Bluetooth antenna. Verify issue resolved.	N15	OTHER ELECTRIC
		No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TCS for additional support or a multiple-part repair.</p> <p>Click the Help button in the GSX toolbar, then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	N99	
12.	<ul style="list-style-type: none"> <li>Run the latest version of BSD to verify Bluetooth functionality.</li> <li>Pair with a known-good Bluetooth device, and verify that the connection is sustained for several minutes.</li> </ul> Is issue resolved?	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TCS for additional support or a multiple-part repair.</p> <p>Click the Help button in the GSX toolbar, then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	X99	

# Bluetooth Service Not Recognized

## Unlikely causes:

AC Inlet, Audio Jack Assembly, Bluetooth Antenna, Bus Bars A and B, Coin Battery, Fan, Flash Storage, Graphics Card A, Graphics Card B, Graphics Card Flex Cables, Memory, Power Cable, Power Supply, Speaker, Wi-Fi Antenna Assembly.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• Bluetooth cannot be enabled.</li><li>• Bluetooth service not available or recognized.</li><li>• Bluetooth intermittently becomes disabled.</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. In System Preferences, make sure Bluetooth preference pane is available.</li><li>2. Reset NVRAM by holding down Command-Option-P-R keys while rebooting, until you hear startup sound for the second time.</li><li>3. Check Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> to make sure system build is correct for this computer model.</li><li>4. Check for and apply latest software and firmware updates.</li><li>5. Start up from known-good original system media or up-to-date, bootable OS X volume. Verify Bluetooth preference pane is available in System Preferences.</li><li>6. Reset SMC using procedure listed for this computer in Apple Support article <a href="#">HT201295: Intel-based Macs: Resetting the System Management Controller (SMC)</a>.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	To verify Bluetooth is recognized, run Mac Resource Inspector (MRI) or check System Information Hardware > USB for Bluetooth USB Host Controller.	Yes	Refer to Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> and reinstall correct OS X build. Verify resolution.	\${nodeText.yesSymptomCode}	
	Is Bluetooth detected in MRI or System Information?		Go to step 2.		
2.	Follow take-apart instructions to remove the housing, exhaust assembly, and roof.  Reseat the interposer board flex cable on the I/O board side and at the interposer board.  Reassemble, leaving the roof removed. Check MRI or System Information to see if Bluetooth is now recognized.	Yes	Issue resolved by reseating flex cable connection to wireless card. Reinstall roof. Verify issue resolved.	\${nodeText.yesSymptomCode}	
	Is Bluetooth detected in MRI or System Information?		Go to step 3.		

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
3.	To troubleshoot this issue completely, you need the following known-good parts: <ul style="list-style-type: none"><li>• Wireless card</li><li>• Interposer board flex cable</li><li>• Interposer board</li><li>• I/O board</li><li>• I/O board flex cable</li><li>• Logic board</li><li>• CPU riser card</li></ul> Do you have these parts immediately available?	Yes	Go to step 4.	\${nodeText.yesSymptomCode}	
		No	Replace wireless card. Reinstall the user's roof. Verify issue resolved.	N15	WIRELESS DEVICE
4.	Substitute a known-good interposer board flex cable. Reassemble, leaving the roof removed. Check MRI or System Information to see if Bluetooth is now recognized.  Is Bluetooth detected in MRI or System Information?	Yes	Replace interposer board flex cable. Reinstall the user's roof. Verify issue resolved.	X03	INTERNAL CABLE
		No	Go to step 5.	\${nodeText.noSymptomCode}	
5.	Continue using a known good interposer board flex cable. Substitute a known good interposer board. Reassemble, leaving the roof removed. Check MRI or System Information to see if Bluetooth is now recognized.  Is Bluetooth detected in MRI or System Information?	Yes	Replace interposer board. Reinstall user's interposer board flex cable and roof. Verify issue resolved.	X24	OTHER BOARD
		No	Go to step 6.	\${nodeText.noSymptomCode}	
6.	Continue using known-good interposer board flex cable and interposer board. Substitute a known good wireless card. Reassemble, leaving the roof removed. Check MRI or System Information to see if Bluetooth is now recognized.  Is Bluetooth detected in MRI or System Information?	Yes	Replace wireless card. Reinstall user's interposer board flex cable, interposer board, and roof. Verify issue resolved.	M36	WIRELESS DEVICE
		No	Go to step 7.	\${nodeText.noSymptomCode}	
7.	Continue using known-good interposer board flex cable, interposer board, and wireless card. Reseat both ends of the I/O board flex cable. Reassemble, leaving the roof removed. Check MRI or System Information to see if Bluetooth is now recognized.  Is Bluetooth detected in MRI or System Information?	Yes	Issue resolved by reseating I/O board flex cable connection. Reinstall roof. Verify issue resolved.	\${nodeText.yesSymptomCode}	
		No	Go to step 8.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
8.	<p>Reinstall the user's wireless card, interposer flex cable, and interposer board. Substitute a known good I/O board flex cable. Reassemble, leaving the roof removed. Check MRI or System Information to see if Bluetooth is now recognized.</p> <p>Is Bluetooth detected in MRI or System Information?</p>	Yes	Replace I/O board flex cable and reinstall user's roof. Verify issue resolved.	X03	INTERNAL CABLE
		No	Go to step 9.	\${nodeText.noSymptomCode}	
9.	<p>Continue using known good I/O board flex cable. Substitute a known good I/O board. Reassemble, leaving the roof removed. Check MRI or System Information to see if Bluetooth is now recognized.</p> <p>Is Bluetooth detected in MRI or System Information?</p>	Yes	Replace I/O board. Reinstall user's I/O board flex cable and roof. Verify issue resolved.	M36	OTHER BOARD
		No	Go to step 10.	\${nodeText.noSymptomCode}	
10.	<p>Replace the user's I/O board and I/O board flex cable. Remove and reinstall the user's logic board. Reassemble, leaving the roof removed. Check MRI or System Information to see if Bluetooth is now recognized.</p> <p>Is Bluetooth detected in MRI or System Information?</p>	Yes	Issue resolved by reseating CPU riser card. Reinstall roof. Verify issue resolved.	\${nodeText.yesSymptomCode}	
		No	Go to step 11.	\${nodeText.noSymptomCode}	
11.	<p>Replace the user's I/O board and I/O board flex cable. Substitute a known good logic board. Reassemble, leaving the roof removed. Check MRI or System Information to see if Bluetooth is now recognized.</p> <p>Is Bluetooth detected in MRI or System Information?</p>	Yes	Replace logic board and reinstall user's roof. Verify issue resolved.	M36	MLB
		No	Go to step 12.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
12.	<p>Replace the user's logic board. Substitute a known good CPU riser card. Reassemble, leaving the roof removed. Check MRI or System Information to see if Bluetooth is now recognized.</p> <p>Is Bluetooth detected in MRI or System Information?</p>	Yes	Replace CPU riser card. Verify issue resolved.	M36	OTHER BOARD
		No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support or a multiple part repair.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	N99	
13.	<ul style="list-style-type: none"> <li>Run MRI to verify Bluetooth interface is detected.</li> <li>Wirelessly connect known-good Bluetooth device. Run latest version of Bluetooth Service Diagnostic to verify Bluetooth functionality.</li> </ul> <p>Is issue resolved?</p>	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support or a multiple part repair.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	X99	

# Ethernet Issues

## Unlikely causes:

AC Inlet, Audio Jack, Bluetooth Antenna, Bluetooth Antenna Cable, Bus Bars A and B, Coin Battery, Fan, Flash Storage, Graphics Board A and B, Graphics Board Flex Cables, I/O Wall, Memory DIMM, Power Cable, Power Supply, Speaker, Wi-Fi Antenna.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• One or both Ethernet devices not present.</li><li>• Unable to access Ethernet network resources.</li><li>• Ethernet device shows no connection.</li><li>• Ethernet device unable to get an IP address.</li><li>• Slow Ethernet network performance.</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. Check Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> to make sure system build is correct for this computer model.</li><li>2. Verify network setup by accessing it directly via known-good computer's Ethernet port.</li><li>3. With user's computer plugged into known-good network, check System Information &gt; Network for Ethernet as an active service.</li><li>4. With user's computer plugged into known-good network, navigate to System Preferences&gt;Network&gt;Set Service Order and confirm the Ethernet interface(s) is at the top of the list.</li><li>5. Test with known-good network hardware and Ethernet cable (Cat-5 or better is recommended for 100+ Mbps connections).</li><li>6. Check network settings. If a known-good DHCP server is available, set System Preferences &gt; Network &gt; Ethernet to Using DHCP. Verify IP address. (If it begins with 169.x.x.x, system was unable to get valid IP address.) See Apple Support article <a href="#">PH13858: OS X Mavericks: Renew an IP address from the DHCP server</a>.</li><li>7. When started up from user's OS, revert to default network settings by creating new location in System Preferences &gt; Network.</li><li>8. Check for and apply latest software and firmware updates.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	Inspect Ethernet ports for dust, debris, damage, or bent pins. Use compressed air to remove debris. Plug in known-good Ethernet cable and make sure all pins make physical contact with connector.	Yes	Go to step 2.	\${nodeText.yesSymptomCode}	
	Are any Ethernet port pins damaged or making insufficient contact with known-good RJ-45 connector?	No	Go to step 4.	\${nodeText.noSymptomCode}	
2.	Inspect I/O board, Ethernet port, inlet, and housing for dents, scratches, or other indications of impact or abuse.	Yes	Go to step 3.	\${nodeText.yesSymptomCode}	
	Does accidental damage appear to be cause of issue?	No	Replace I/O board. Verify issue resolved.	M24	OTHER BOARD

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
3.	Inform user that computer failures due to accidental damage are not covered.	Yes	Replace I/O board. Verify issue resolved.	M24	OTHER BOARD
	Discuss out-of-warranty repair options.	No	Issue resolved. Return computer to user using correct positioning.	\${nodeText.noSymptomCode}	
	Does user want to proceed with out-of-warranty repair?				
4.	In System Preferences > Network > Ethernet, verify link status is <b>Connected</b> (green dot) and valid IP address is listed. Connect computer to Ethernet network with known-good DHCP server. Make sure static DHCP maps or filtering are not preventing address allocation.	Yes	Go to step 5.	\${nodeText.yesSymptomCode}	
	<b>Note:</b> DHCP allocation may not be instantaneous, depending on network. Retest.  Is Ethernet link status active?	No	Go to step 7.	\${nodeText.noSymptomCode}	
5.	Use simple hub/switch environment. Go to System Preferences > Network > Ethernet and obtain Router IP address. Use Terminal to ping the Router IP address by typing ping -c 10 e.g. \$ ping -c 10 192.168.1.1  Is Terminal able to ping Router IP address?	Yes	No performance or connectivity issues detected. No repair necessary. Problem may be network environment. Refer user to Apple Support article <a href="#">TS1317: Mac OS X: Troubleshooting a cable modem, DSL, or LAN Internet connection</a> .	\${nodeText.yesSymptomCode}	
		No	Go to step 6.	\${nodeText.noSymptomCode}	
6.	Perform network testing from previous step, using same cable and network, but with known-good computer.  Is network performance of user's computer inferior to known-good computer?	Yes	Go to step 7.	\${nodeText.yesSymptomCode}	
		No	No performance or connectivity issues detected. No repair necessary. Problem may be network environment. Refer user to Apple Support article <a href="#">TS1317: Mac OS X: Troubleshooting a cable modem, DSL, or LAN Internet connection</a> .	\${nodeText.noSymptomCode}	
7.	To troubleshoot this issue completely, an I/O board, I/O board flex cable, logic board, and CPU riser card are required.	Yes	Go to step 8.	\${nodeText.yesSymptomCode}	
	Do you have these parts immediately available?	No	Replace I/O board. Verify issue resolved.	M24	OTHER BOARD

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
8.	Remove and carefully inspect the I/O board flex cable for any cable or pin damage. Also inspect the I/O board and logic board connectors for pin damage.  Did you find damage to either the I/O board, I/O board flex cable, or logic board?	Yes	Go to step 9.	\${nodeText.yesSymptomCode}	
		No	Go to step 10.	\${nodeText.noSymptomCode}	
9.	Damage to multiple parts requires an escalation to Apple TSPS for repair approval.  Is the damage limited to the I/O board flex cable?	Yes	Replace I/O board flex cable. Verify issue resolved.	X03	INTERNAL CABLE
		No	<b>ESCALATION REQUIRED.</b> Contact TSPS for additional support or a multiple part repair.  Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	P99	
10.	Reseat the I/O board flex cable on both the logic board and I/O board side and reassemble the system.  In System Preferences > Network > Ethernet, verify link status is <b>Connected</b> (green dot) and valid IP address is listed. Connect computer to Ethernet network with known-good DHCP server. Make sure static DHCP maps or filtering are not preventing address allocation.  <b>Note:</b> DHCP allocation may not be instantaneous, depending on network. Retest.  Is Ethernet link status active?	Yes	Issue resolved by reseating I/O board flex cable. Verify issue resolved.	\${nodeText.yesSymptomCode}	
		No	Go to step 11.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
	Substitute a known-good I/O board flex cable and reassemble the system.	Yes	Replace I/O board flex cable. Verify issue resolved.	X03	INTERNAL CABLE
11.	In System Preferences > Network > Ethernet, verify link status is <b>Connected</b> (green dot) and valid IP address is listed. Connect computer to Ethernet network with known-good DHCP server. Make sure static DHCP maps or filtering are not preventing address allocation.  <b>Note:</b> DHCP allocation may not be instantaneous, depending on network. Retest.  Is Ethernet link status active?	No	Go to step 12.	\${nodeText.noSymptomCode}	
12.	Substitute a known-good I/O board and reassemble the system. Reinstall the user's I/O board flex cable.  In System Preferences > Network > Ethernet, verify link status is <b>Connected</b> (green dot) and valid IP address is listed. Connect computer to Ethernet network with known-good DHCP server. Make sure static DHCP maps or filtering are not preventing address allocation.  <b>Note:</b> DHCP allocation may not be instantaneous, depending on network. Retest.  Is Ethernet link status active?	Yes	Replace I/O board. Verify issue resolved.	M10	OTHER BOARD
		No	Go to step 13.	\${nodeText.noSymptomCode}	
13.	Reinstall the user's I/O board. Remove and reinstall the logic board to reseat the CPU riser card.  In System Preferences > Network > Ethernet, verify link status is <b>Connected</b> (green dot) and valid IP address is listed. Connect computer to Ethernet network with known-good DHCP server. Make sure static DHCP maps or filtering are not preventing address allocation.  <b>Note:</b> DHCP allocation may not be instantaneous, depending on network. Retest.  Is Ethernet link status active?	Yes	Issue resolved by reseating CPU riser card. Verify issue resolved.	\${nodeText.yesSymptomCode}	
		No	Go to step 14.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
14.	Substitute a known-good logic board and reassemble the system.  In System Preferences > Network > Ethernet, verify link status is <b>Connected</b> (green dot) and valid IP address is listed. Connect computer to Ethernet network with known-good DHCP server. Make sure static DHCP maps or filtering are not preventing address allocation.  <b>Note:</b> DHCP allocation may not be instantaneous, depending on network. Retest.  Is Ethernet link status active?	Yes	Replace logic board. Verify issue resolved.	M10	OTHER BOARD
		No	Go to step 15.	\${nodeText.noSymptomCode}	
15.	Reinstall the user's logic board, substitute a known-good CPU riser card, and reassemble the system.  In System Preferences > Network > Ethernet, verify link status is Connected (green dot) and valid IP address is listed. Connect computer to Ethernet network with known-good DHCP server. Make sure static DHCP maps or filtering are not preventing address allocation.  <b>Note:</b> DHCP allocation may not be instantaneous, depending on network. Retest.  Is Ethernet link status active?	Yes	Replace CPU riser card. Verify issue resolved.	M10	MPU
16.		No	<b>ESCALATION REQUIRED.</b>  Contact TSPS for additional support or a multiple part repair.  Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	M99	
	1. Connect Ethernet cable to known-good network with DHCP server. 2. In System Preferences > Network > Ethernet, verify link status is <b>Connected</b> (green dot). 3. Configure TCP/IP settings to <b>Using DHCP</b> and verify valid IP address is obtained from server (not a self-assigned one with 169.x.x.x). 4. Launch web browser. Verify you can access websites and download files.  Is issue resolved?	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	<b>ESCALATION REQUIRED.</b>  Contact TSPS for additional support or a multiple part repair.  Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	M99	



# Wi-Fi Connection Issues

## Unlikely causes:

AC Inlet, Audio Jack, Bluetooth Antenna, Bluetooth Antenna Cable, Bus Bars, Coin Battery, Fan, Flash Storage, Graphics Board A, Graphics Board B, Graphics Board Flex Cables, Memory DIMM, Power Cable, Power Supply, Speaker.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• Unable to find or connect to wireless networks</li><li>• Slow or stalled data transfers</li><li>• Intermittent connection dropouts</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<p><b>On user's computer:</b></p> <ol style="list-style-type: none"><li>1. Check Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> to make sure system build is correct for this computer model.</li><li>2. Using one of the built-in Ethernet ports, connect to Internet. Check for and apply the latest software and firmware updates.</li><li>3. Start up the computer to Recovery Partition or Internet Recovery, or a known-good up-to-date, bootable OS X volume. Attempt to connect to a wireless network.</li><li>4. In System Preferences &gt; Sharing &gt; Internet Sharing, configure a known-good computer to share an Ethernet connection to computers using Wi-Fi. Try to connect the user's computer to the newly created wireless network.</li><li>5. Using known-good OS &amp; base station, compare Wi-Fi throughput to a similar system using Activity Monitor &gt; Network.</li><li>6. Reset NVRAM by holding down the Command-Option-P-R keys while restarting, until you hear the startup sound for the second time.</li><li>7. Reset the SMC using the procedure for this computer in Apple Support article <a href="#">HT201295: Intel-based Macs: Resetting the System Management Controller (SMC)</a>.</li></ol> <p>If the issue cannot be reproduced onsite, prompt the user to check their wireless base station for the following:</p> <ol style="list-style-type: none"><li>1. Check for base station firmware updates. If the user has an Apple Airport base station or Airport Time Capsule, confirm the customer is running the most current firmware for the Airport base station or Time Capsule. If the user has a third-party Wi-Fi router, suggest the customer contact the router manufacturer or their ISP to update router firmware.</li><li>2. If customer is using a USB 3 device, review Apple Support article <a href="#">HT5172: Using USB 3 devices on Mac computers FAQ</a> for possible interference with Wi-Fi and Bluetooth communications.</li><li>3. Check for nearby interference sources in the 2.4/5GHz range, such as microwave ovens and cordless phones. See Apple Support article <a href="#">HT1365: Wi-Fi and Bluetooth: Potential sources of wireless interference</a>.</li><li>4. Make sure the base station is not using MAC address filtering or has not created a hidden network.</li><li>5. Make sure the base station is not set to low-power transmission mode.</li><li>6. Make sure the base station is not using an unsupported connection and encryption protocol.</li><li>7. Check for Wi-Fi channel overlap (a nearby base station using an adjacent channel).</li><li>8. Connect to a known-good test network.</li><li>9. Test in a different environment.</li><li>10. For high performance Wi-Fi networks, speed and range will be less if an 802.11 a/b/g product joins the network.</li></ol>

## Deep Dive

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
1.	Run Mac Resource Inspector (MRI) to check whether the wireless card is recognized.  Is the wireless interface detected in MRI?	Yes	Go to step 2.	\${nodeText.yesSymptomCode}	
		No	Go to “Wi-Fi Service Not Recognized” troubleshooting flow.	\${nodeText.noSymptomCode}	
2.	Start up the computer to Recovery Partition or Internet Recovery, or a known-good up-to-date, bootable OS X volume. Attempt to reproduce the Wi-Fi performance or connection issue.  Does issue persist with known-good OS?	Yes	Go to step 3.	\${nodeText.yesSymptomCode}	
		No	Refer to Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> and install the correct version of OS X. Check for and apply the latest software and firmware updates. Verify issue resolved.	\${nodeText.noSymptomCode}	
3.	Turn off Bluetooth to eliminate potential interference. Check for other interference such as microwave ovens or cordless phones. See Apple Support article <a href="#">HT1365: Wi-Fi and Bluetooth: Potential sources of interference for wireless devices and networks</a> . Change the base station channel.  Does the issue persist?	Yes	Go to step 4.	\${nodeText.yesSymptomCode}	
		No	Issue caused by interference. Remove sources of interference, or use a different AirPort channel or mode (2.4 or 5 GHz). Verify issue resolved.	\${nodeText.noSymptomCode}	
4.	Remove the housing, roof, and interposer board cover. Disconnect the Wi-Fi antennas (positions 1, 2, and 4, with the interposer board flex cable pointing away from you) and inspect each cable and connector for damage.  Are antenna cable and connectors in good condition?	Yes	Go to step 5.	\${nodeText.yesSymptomCode}	
		No	Replace the Wi-Fi antenna. Verify issue resolved.	X03	OTHER ELECTRIC
5.	Locate the Wi-Fi antenna connectors on the wireless card and verify that none of them are damaged, loosened, or unsoldered. Reseat antenna connections to the wireless card. Make sure the connection is secure and correctly aligned and oriented.  Are the wireless card antenna connectors in good condition and can the cables be securely seated?	Yes	Go to step 6.	\${nodeText.yesSymptomCode}	
		No	Replace the wireless card. Verify issue resolved.	N14	WIRELESS DEVICE

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
6.	To verify Wi-Fi performance and reliability, start up computer using an known-good up-to-date, bootable OS X volume (10.8.4 or later) for access to Wireless Diagnostics application. See Apple Support article <a href="#">HT5606: About Wireless Diagnostics</a> to familiarize technician with wireless diagnostic utilities.  Connect to a known-good wireless network and open Wireless Diagnostics > Window > Utilities. Review Utilities > Performance - Quality to evaluate signal quality of wireless connection. Verify signal is good or excellent and transmission rate (Tx Rate) is comparable to another known-good computer of similar type and Wi-Fi specification.	Yes	Wi-Fi performance is within specification. Verify issue resolved.	\${nodeText.yesSymptomCode}	
	Where available, switch between 2.4GHz and 5 GHz networks to verify signal quality comparable to a known good computer. Using a network with a high transmission rate, download a large file from a known-good website or file server.	No	Go to step 7.	\${nodeText.noSymptomCode}	
	Compare network performance to another known-good computer of similar type and Wi-Fi specification. Verify throughput using Activity Monitor > Network.				
	Are performance and throughput comparable between user's computer and a known-good computer?				
7.	To completely troubleshoot this issue, a known-good wireless card and Wi-Fi antenna is required.  Do you have immediate access to both of these parts?	Yes	Go to step 8.	\${nodeText.yesSymptomCode}	
		No	Replace the wireless card. Verify issue resolved.	N14	WIRELESS DEVICE
8.	Substitute known-good wireless card and retest, comparing performance and throughput of user's computer with known-good computer.  Are performance and throughput comparable between user's computer and a known-good computer?	Yes	Replace the wireless card. Verify issue resolved.	N14	WIRELESS DEVICE
		No	Replace the Wi-Fi antenna. Reinstall user's wireless card. Verify issue resolved.	N09	OTHER ELECTRIC

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
		Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
9.	<ul style="list-style-type: none"> <li>• Connect to a known-good wireless network and retest data throughput, checking for adequate transfer speeds.</li> <li>• Verify that the wireless connection is sustained for several minutes.</li> </ul> <p>Is issue resolved?</p>	No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support or a multiple part repair.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	N99	

# Wi-Fi Service Not Recognized

## Unlikely causes:

AC Inlet, Audio Jack, Bluetooth Antenna, Bluetooth Antenna Cable, Bus Bars A and B, Coin Battery, Graphics Board A, Fan, Flash Storage, Graphics Board B, Graphics Board Flex Cables, Memory DIMM, Power Cable, Power Supply, Speaker, Wi-Fi Antenna.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• Wi-Fi Service cannot be enabled.</li><li>• Wi-Fi Service not available or recognized.</li><li>• Wi-Fi Service intermittently becomes disabled.</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. Check Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> to verify system build is correct for this computer model.</li><li>2. Reset NVRAM by holding down Command-Option-P-R keys while rebooting, until you hear startup sound for the second time.</li><li>3. Start up from a known-good up-to-date, bootable OS X volume, and check for Wi-Fi network interface presence in System Information &gt; Network and System Preferences &gt; Network.</li><li>4. Using alternate network interface (like Apple Thunderbolt Ethernet Adapter), connect to Internet. Check for and apply latest software and firmware updates.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	To verify wireless card is recognized, run Mac Resource Inspector (MRI) or check System Information Network > WiFi > Interfaces.	Yes	Refer to Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> and reinstall correct OS X build. Verify resolution.	\${nodeText.yesSymptomCode}	
	Is wireless card detected in MRI or System Information?		No Go to step 2.		
2.	Follow take-apart instructions to remove the housing, exhaust assembly, interposer board cover, and roof.  Reseat the interposer board flex cable on the I/O board side and at the interposer board.  Reassemble, leaving the roof removed. Check MRI or System Information to see if Airport Service is now recognized.	Yes	Issue resolved by reseating flex cable connection to wireless card. Reinstall roof. Verify issue resolved.	\${nodeText.yesSymptomCode}	
	Is wireless card detected in MRI or System Information?		No Go to step 3.		

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
3.	To troubleshoot this issue completely, you need the following known-good parts: <ul style="list-style-type: none"><li>• wireless card</li><li>• interposer board flex cable</li><li>• Interposer board</li><li>• I/O board</li><li>• I/O board flex cable</li><li>• logic board</li><li>• CPU riser card</li></ul> Do you have these parts immediately available?	Yes	Go to step 4.	\${nodeText.yesSymptomCode}	
		No	Replace wireless card. Reinstall the user's roof. Verify issue resolved.	N18	WIRELESS DEVICE
4.	Substitute a known-good interposer board flex cable. Reassemble, leaving the roof removed. Check MRI or System Information to see if wireless card is now recognized.  Is wireless card detected in MRI or System Information?	Yes	Replace interposer board flex cable. Reinstall the user's roof. Verify issue resolved.	X03	INTERNAL CABLE
		No	Go to step 5.	\${nodeText.noSymptomCode}	
5.	Continue using a known good interposer board flex cable. Substitute a known good interposer board. Reassemble, leaving the roof removed. Check MRI or System Information to see if wireless card is now recognized.  Is wireless card detected in MRI or System Information?	Yes	Replace interposer board. Reinstall user's interposer board flex cable and roof. Verify issue resolved.	M35	OTHER BOARD
		No	Go to step 6.	\${nodeText.noSymptomCode}	
6.	Continue using known-good interposer board flex cable and interposer board. Substitute a known good wireless card. Reassemble, leaving the roof removed. Check MRI or System Information to see if wireless card is now recognized.  Is wireless card detected in MRI or System Information?	Yes	Replace wireless card. Reinstall user's interposer board flex cable, interposer board, and roof. Verify issue resolved.	N18	WIRELESS DEVICE
		No	Go to step 7.	\${nodeText.noSymptomCode}	
7.	Continue using known-good interposer board flex cable, interposer board, and wireless card. Reseat both ends of the I/O board flex cable. Reassemble, leaving the roof removed. Check MRI or System Information to see if wireless card is now recognized.  Is wireless card detected in MRI or System Information?	Yes	Issue resolved by reseating I/O board flex cable connection. Reinstall roof. Verify issue resolved.	\${nodeText.yesSymptomCode}	
		No	Go to step 8.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
8.	<p>Reinstall the user's wireless card, interposer board flex cable, and interposer board. Substitute a known good I/O board flex cable. Reassemble, leaving the roof removed. Check MRI or System Information to see if wireless card is now recognized.</p> <p>Is wireless card detected in MRI or System Information?</p>	Yes	Replace I/O board flex cable and reinstall user's roof. Verify issue resolved.	X03	INTERNAL CABLE
		No	Go to step 9.	\${nodeText.noSymptomCode}	
9.	<p>Continue using known good I/O board flex cable. Substitute a known good I/O board. Reassemble, leaving the roof removed. Check MRI or System Information to see if wireless card is now recognized.</p> <p>Is wireless card detected in MRI or System Information?</p>	Yes	Replace I/O board. Reinstall user's I/O board flex cable and roof. Verify issue resolved.	M35	OTHER BOARD
		No	Go to step 10.	\${nodeText.noSymptomCode}	
10.	<p>Replace the user's I/O board and I/O board flex cable. Remove and reinstall the user's logic board. Reassemble, leaving the roof removed. Check MRI or System Information to see if wireless card is now recognized.</p> <p>Is wireless card detected in MRI or System Information?</p>	Yes	Issue resolved by reseating CPU riser card. Reinstall roof. Verify issue resolved.	\${nodeText.yesSymptomCode}	
		No	Go to step 11.	\${nodeText.noSymptomCode}	
11.	<p>Replace the user's I/O board and I/O board flex cable. Substitute a known good logic board. Reassemble, leaving the roof removed. Check MRI or System Information to see if wireless card is now recognized.</p> <p>Is wireless card detected in MRI or System Information?</p>	Yes	Replace logic board and reinstall user's roof. Verify issue resolved.	M35	MLB
		No	Go to step 12.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
12.	<p>Replace the user's logic board. Substitute a known good CPU riser card. Reassemble, leaving the roof removed. Check MRI or System Information to see if wireless card is now recognized.</p> <p>Is wireless card detected in MRI or System Information?</p>	Yes	Replace CPU riser card. Verify issue resolved.	M35	OTHER BOARD
		No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support or a multiple part repair.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	N99	
13.	<ul style="list-style-type: none"> <li>Verify that Wi-Fi network service appears and can be enabled in System Preferences &gt; Network.</li> <li>Connect to a known-good wireless network and retest data throughput, checking for adequate transfer speeds.</li> <li>Verify wireless connection is sustained for several minutes and after sleep/wake.</li> </ul> <p>Is issue resolved?</p>	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support or a multiple part repair.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	X99	

# Distorted Audio from Internal Speaker

## Unlikely causes:

AC Inlet, Bus Bars A and B, CPU Riser Card, DIMM Mechanism, Exhaust Manifold, Fan, Fan Flex Cable, Flash Storage, Graphics Board A, Graphics Board B, Graphics Board Flex Cable, Housing, Housing Lock Switch, Inlet, Interposer Board, Interposer Board Cover, Interposer Board Flex Cable, Memory DIMM, Power Supply, Roof, Wireless Card.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• Audio is distorted, fuzzy, or crackly.</li><li>• Symptom only appears in internal speaker.</li><li>• Symptom also appears in external speakers/headphones.</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. Test with known-good audio file.</li><li>2. Compare same audio file and settings against a known-good similar model computer. Verify audio is distorting.</li><li>3. Reset NVRAM by holding down Command-Option-P-R keys while rebooting, until you hear startup sound for the second time.</li><li>4. If testing with iTunes, make sure equalizer and preamp settings are set to Flat.</li><li>5. Test audio output using more than one application or website.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	Start up computer using known-good up-to-date, bootable OS X volume. Play same known-good audio file. Compare using internal speaker and known-good headphones or external speakers.	Yes	Reinstall OS. Check Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> to make sure system build is correct for this computer model.	\${nodeText.yesSymptomCode}	
	Is internal/external audio now audible, clear and free of distortion?		No Go to step 2.		
2.	Play known-good audio file on internal speaker. Connect known-good headphones or external speakers and compare for distortion.	Yes	Replace I/O board. Verify issue resolved.	M09	OTHER BOARD
	Is audio also distorted through external headphones/speakers?		No Go to step 3.		
3.	Remove I/O board.  Inspect and carefully clean affected speaker cone using soft tissue to remove dust, debris, or foreign material, such as metal fragments that easily adhere to magnetic speaker. Inspect speaker cable connector and corresponding connector on the I/O board. Reseat connection, reassemble and retest.	Yes	Issue resolved by cleaning speaker membrane and reseating speaker cable to logic board. Verify resolution.	\${nodeText.yesSymptomCode}	
	Is audio from internal speaker audible, clear, and free of distortion?		No Go to step 4.		

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
4.	To troubleshoot this issue completely, you need the following known-good parts: <ul style="list-style-type: none"><li>• Speaker</li><li>• I/O board</li></ul> Do you have these parts immediately available?	Yes	Go to step 5.	\${nodeText.yesSymptomCode}	
		No	Replace speaker. Verify issue resolved.	X09	OTHER ELECTRIC
5.	Remove I/O board. Substitute a known-good speaker, reassemble and retest.  Is audio from internal speaker audible, clear and free of distortion?	Yes	Replace speaker. Verify issue resolved.	X09	OTHER ELECTRIC
		No	Go to step 6.	\${nodeText.noSymptomCode}	
6.	Reinstall the user's speaker. Substitute a known-good I/O board, visually inspecting connectors for damage. Retest recording.  Is audio from internal speaker audible, clear and free of distortion?	Yes	Replace I/O board. Verify issue resolved.	M09	OTHER BOARD
		No	<b>ESCALATION REQUIRED.</b>  Contact TSPS for additional support or a multiple part repair.  Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	M99	
7.	Verify audio can be played from both external and internal speakers by connecting and disconnecting external speakers/headphone. Verify computer produces a clear, distortion-free audio.  Is issue resolved?	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	<b>ESCALATION REQUIRED.</b>  Contact TSPS for additional support or a multiple part repair.  Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	X99	

# Distorted/Flickering Video Output

## Unlikely causes:

AC Inlet, DIMM Mechanism, Exhaust Manifold, Fan, Fan Flex Cable, Flash Storage, Housing, Housing Lock Switch, Inlet, Interposer Board, Interposer board flex cable, Interposer Board Cover, Memory DIMM, Power Supply, Roof, Wireless Card.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• Distorted video output, static</li><li>• Vertical or horizontal lines</li><li>• Blocks</li><li>• Pink hue</li><li>• Screen flashing or flickering</li></ul> <p><b>Note:</b> Graphics board A does not directly control video output, except when rendering. Replace graphics board A for these symptoms first; but for other symptoms, graphics board B should be replaced before A.</p> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<p><b>Note:</b> Verify the issue after using the computer for a few minutes to warm it, or by following steps in <a href="#">HT207571: Warm a Mac for testing</a>. Doing this may help identify intermittent issues.</p> <ol style="list-style-type: none"><li>1. Check for and install the latest software updates. The latest versions of macOS have addressed many issues with graphics issues on this model.</li><li>2. Run MRI and Cooling System Diagnostic to verify the thermal system on the system.</li><li>3. Connect known-good, compatible external display to computer's video out port. Review article <a href="#">HT201853: About Apple video adapters and cables</a> to help identify which adapters can be used with this computer model.</li><li>4. Verify that the user is using a supported display configuration. Refer to article <a href="#">HT202801: Use multiple displays with your Mac Pro (Late 2013)</a> to identify compatible display configurations.</li><li>5. Review article <a href="#">HT201177: Get help with video issues on external displays connected to your Mac</a> for common causes of video issues.</li><li>6. If using an Apple Thunderbolt Display, review article <a href="#">HT204154: About Thunderbolt ports and displays</a>.</li><li>7. If using a Mini DisplayPort adapter, review article <a href="#">HT204149: About the Apple Mini DisplayPort adapters</a>.</li><li>8. If the issue is triggered by a particular application, try installing the application on a known good system of the same model (if available).</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
	Start up computer with Option (Alt) key down, using a known-good bootable volume with the latest version of macOS.  <b>Note:</b> Newer versions of macOS include improvements to graphics related software. Recommend that the customer run the latest version of macOS.	Yes	Go to step 2.	\$(nodeText.yesSymptomCode)	
1.	Does graphics issue persist while booted to a known-good volume?	No	Reinstall macOS on the user's computer. Refer to <a href="#">HT201260: How to find the macOS version number on your Mac</a> to check that the system build is correct for this computer model. Check for and apply the latest software and firmware updates. Verify that the issue is resolved.	\$(nodeText.noSymptomCode)	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
2.	Some Mac Pro models with D500 or D700 graphics cards that were manufactured in early 2015 are eligible for graphics board replacements under the Mac Pro Repair Extension Program for Video Issues.  See <a href="#">OP1611: Mac Pro Repair Extension Program for Video Issues</a> or <a href="#">RS192: Mac Pro Repair Extension Program for Video Issues</a> to verify the eligibility of this unit.  Does this unit qualify for the graphics card quality program?	Yes	Replace both graphics board A and graphics board B. Verify issue resolved.	Z77	STANDALONE CARD
		No	Go to step 3.	\$(nodeText.noSymptomCode)	
3.	Determine if distortion occurs in certain applications or across the entire display, or if the distortion is isolated to video files created by the computer.  Does distortion occur only while rendering video files in Final Cut or DaVinci type applications?	Yes	Go to step 4.	\$(nodeText.yesSymptomCode)	
		No	Go to step 5.	\$(nodeText.noSymptomCode)	
4.	Substitute a known-good graphics board A. Reassemble unit and turn on.  Attempt to reproduce the graphics issue.  Does graphics issue persist with known good graphics board A?	Yes	Go to step 5.	\$(nodeText.yesSymptomCode)	
		No	Replace graphics board A. Verify issue resolved.	M04	STANDALONE CARD
5.	Substitute a known-good graphics board B. Reassemble unit and turn on.  Attempt to reproduce the graphics issue.  Does graphics issue persist with known good graphics board B?	Yes	Go to step 6.	\$(nodeText.yesSymptomCode)	
		No	Replace graphics board B. Verify issue resolved.	M04	STANDALONE CARD
6.	Reinstall customer's graphics board B, substituting a known-good logic board. Reassemble unit and turn on.  Attempt to reproduce the graphics issue.  Does graphics issue persist with known good logic board?	Yes	Go to step 7.	\$(nodeText.yesSymptomCode)	
		No	Replace logic board. Verify issue resolved.	M03	MLB
7.	Reinstall customer's logic board, substituting a known-good I/O board. Reassemble unit and turn on.  Attempt to reproduce the graphics issue.  Does graphics issue persist with known good I/O board?	Yes	Go to step 8.	\$(nodeText.yesSymptomCode)	
		No	Replace I/O board. Verify issue resolved.	M04	OTHER BOARD

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
8.	Reinstall customer's I/O board, substituting a known-good CPU riser card. Reassemble unit and turn on.	Yes	Go to step 9.	\${nodeText.yesSymptomCode}	
	Attempt to reproduce the graphics issue.  Does graphics issue persist with known good CPU riser card?	No	Replace CPU riser card. Verify issue resolved.	M04	OTHER BOARD
9.	Reinstall customer's CPU riser card, substituting a known-good graphics board B flex cable. Inspect all connectors for damage. Reassemble unit and turn on.	Yes	Go to step 10.	\${nodeText.yesSymptomCode}	
	Attempt to reproduce the graphics issue.  Does graphics issue persist with known good graphics board flex cable?	No	Replace graphics board flex cable. Verify issue resolved.	X03	INTERNAL CABLE
10.	Reinstall customer's graphics board flex cable, substituting a known-good I/O board flex cable. Inspect all connectors for damage. Reassemble the unit and turn on.	Yes	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	X99	
	Attempt to reproduce the graphics issue.  Does graphics issue persist with known good I/O board flex cable?	No	Replace I/O board flex cable. Verify issue resolved.	X03	INTERNAL CABLE
11.	Connect known-good, compatible display to computer and verify expected video output.  Confirm that the computer display flickering or unstable video issue is resolved.	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
	Run ASD or AST Full System Diagnostic (EFI & OS), if available, to ensure no other issues remain.  Verify that the issue is resolved.  Is issue resolved?	No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	M99	

# External Apple Bluetooth Peripherals

## Unlikely causes:

There are no unlikely causes for this issue.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• Apple Bluetooth wireless keyboard, mouse, or trackpad is not recognized by known-good computer</li><li>• Apple Bluetooth wireless keyboard, mouse, or trackpad will not pair with known-good computer</li><li>• Apple Bluetooth wireless keyboard, mouse, or trackpad intermittently loses its connection</li><li>• Apple wireless keyboard has one or more of the following issues:<ul style="list-style-type: none"><li>◦ No power</li><li>◦ Battery will not charge (for peripherals with embedded batteries)</li><li>◦ Swollen battery (for peripherals with embedded batteries)</li><li>◦ Battery runtime too short</li><li>◦ Will not turn off</li><li>◦ Specific key(s) do not work</li><li>◦ Keys seem to stick, do not respond properly, or respond slowly</li><li>◦ Wrong keyboard language</li><li>◦ Keys missing or falling off keyboard</li><li>◦ Paint is wearing off of one or more keys on the keyboard</li><li>◦ Physical and/or cosmetic issues</li></ul></li><li>• Apple wireless mouse has one or more of the following issues:<ul style="list-style-type: none"><li>◦ No power</li><li>◦ Battery will not charge (for peripherals with embedded batteries)</li><li>◦ Swollen battery (for peripherals with embedded batteries)</li><li>◦ Battery runtime too short</li><li>◦ Will not turn off</li><li>◦ No mouse response</li><li>◦ Mouse click not recognized</li><li>◦ Mouse causes erratic cursor tracking</li><li>◦ Physical and/or cosmetic issues</li></ul></li><li>• Apple wireless trackpad has one or more of the following issues:<ul style="list-style-type: none"><li>◦ No power</li><li>◦ Battery will not charge (for peripherals with embedded batteries)</li><li>◦ Swollen battery (for peripherals with embedded batteries)</li><li>◦ Battery runtime too short</li><li>◦ Will not turn off</li><li>◦ No trackpad response</li><li>◦ Trackpad click not recognized</li><li>◦ Trackpad causes erratic cursor tracking</li><li>◦ Trackpad requires high click force</li><li>◦ Trackpad click overly sensitive</li><li>◦ Force Touch or haptic feedback issue</li><li>◦ Physical and/or cosmetic issues</li></ul></li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<p><b>IMPORTANT:</b> This troubleshooting procedure is intended only for Apple Bluetooth wireless peripheral devices, such as the following Apple products:</p> <ul style="list-style-type: none"><li>• Magic Mouse or Magic Mouse 2</li><li>• Magic Trackpad or Magic Trackpad 2</li><li>• Apple Wireless Keyboard or Magic Keyboard</li></ul> <p>For simplicity, this procedure refers to these products as <b>wireless mouse</b>, <b>wireless trackpad</b>, and <b>wireless keyboard</b> unless otherwise noted.</p> <p>For third-party devices, contact the manufacturer for support, software/firmware updates, or service options.</p> <ol style="list-style-type: none"><li>1. Check for and apply the latest software and firmware updates.</li><li>2. In System Preferences, make sure Bluetooth is on and set to Discoverable.</li><li>3. For Apple Bluetooth peripherals with replaceable batteries, such as the Magic Mouse, Magic Trackpad, or Apple Wireless Keyboard: If the device does not turn on, then install new or freshly charged batteries.</li><li>4. For Apple Bluetooth peripherals with embedded batteries, such as the Magic Mouse 2, Magic Trackpad 2, or Magic Keyboard: If the device does not turn on, then connect a known-good USB Power Adapter and Lightning cable to the device to charge it for at least two minutes. Switching the device power button or switch to the ON position will allow the device to charge more quickly than when OFF.</li><li>5. For Apple Bluetooth peripherals with embedded batteries such as the Magic Mouse 2, Magic Trackpad 2, or Magic Keyboard, verify that the computer being used with the peripheral supports Bluetooth 4.0 or later. Computers with earlier versions of Bluetooth support will not pair with Apple Bluetooth peripherals with embedded batteries.</li><li>6. Reset Bluetooth device or delete pairing (if applicable).</li><li>7. If Bluetooth pairs normally at your service location, then research potential sources of interference in the user's environment, such as microwave ovens or cordless phones in the 2.4/5GHz range. See article <a href="#">HT201542: Potential sources of Wi-Fi and Bluetooth interference</a>.</li><li>8. Magic Mouse 2, Magic Trackpad 2, and Magic Keyboard, can pair with the computer using either Bluetooth or a Lightning cable. If Bluetooth pairing is not possible due to interference or other reasons, then try pairing these products by connecting them to the known-good computer with a known-good Lightning cable.</li><li>9. Follow steps listed in <a href="#">HT204066: Use Bluetooth Diagnostics to help you isolate issues with wireless devices</a>.</li><li>10. For keyboard issues, refer to <a href="#">HT204540: If your Apple keyboard doesn't work</a> for troubleshooting tips.</li></ol>

## Deep Dive

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
1.	Visually inspect the user's wireless mouse, wireless trackpad, or wireless keyboard for any for physical, cosmetic, and/or liquid damage.	Yes	Go to step 2.	\${nodeText.yesSymptomCode}	
	On a wireless mouse or wireless trackpad, verify that the mouse or trackpad button clicks.				
	On keyboards, verify that all keyboard buttons are present and can be depressed normally.	No	Go to step 11.	\${nodeText.noSymptomCode}	
	Does the user's wireless mouse, wireless trackpad, or wireless keyboard show signs of damage?				
2.	Determine whether there is a safety issue, such as fumes, excessive heat, or shock.	Yes	Go to step 3.	\${nodeText.yesSymptomCode}	
	Do not perform procedures that can be a safety risk to you or the user.	No	<b>ESCALATION REQUIRED.</b>	\${nodeText.noSymptomCode}	
	Can you proceed safely?		Contact ACS for additional support regarding safety procedures for this product.		
3.	Isolate damage issue to either user's wireless keyboard, or wireless mouse or trackpad.	Wireless keyboard	Go to step 4.	\${nodeText.yesSymptomCode}	
	Which peripheral is damaged?	Wireless mouse or trackpad	Go to step 8.	\${nodeText.noSymptomCode}	
4.	Closely examine the user's device to determine exact nature of the issue.	Yes	Replace the user's wireless keyboard out of warranty.	K90	KEYBOARD
	Look for any signs of liquid spill, liquid penetration, or liquid damage to device.				
	Is damage to user's device related to liquid spill?	No	Go to step 5.	\${nodeText.noSymptomCode}	
5.	Closely examine the user's device for any signs of physical damage that may affect operation.	Yes	Replace the user's wireless keyboard out of warranty.	K16	KEYBOARD
	Does the user's device exhibit this symptom?	No	Go to step 6.	\${nodeText.noSymptomCode}	
6.	Closely examine the user's device for signs of paint wearing off of one or more keys.	Yes	Replace the user's wireless keyboard out of warranty.	K35	KEYBOARD
	Does the user's device exhibit this symptom?		Go to step 7.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
7.	Closely examine the user's device for any signs of cosmetic damage that does not affect operation.	Yes	Replace the user's wireless keyboard out of warranty.	K21	KEYBOARD
	Does the user's device exhibit this symptom?	No	Issue cannot be duplicated.	\${nodeText.noSymptomCode}	
8.	Closely examine the user's device to determine exact nature of the issue.	Yes	Replace the user's wireless mouse or wireless trackpad out of warranty.	K90	MOUSE
	Look for any signs of liquid spill, liquid penetration, or liquid damage to device.	No	Go to step 9.	\${nodeText.noSymptomCode}	
9.	Is damage to user's device related to liquid spill?	Yes	Replace the user's wireless mouse or wireless trackpad out of warranty.	K16	MOUSE
	Does the user's device exhibit this symptom?	No	Go to step 10.	\${nodeText.noSymptomCode}	
10.	Closely examine the user's device for any signs of cosmetic damage that does not affect operation.	Yes	Replace the user's wireless mouse or wireless trackpad out of warranty.	K21	MOUSE
	Does the user's device exhibit this symptom?	No	Issue cannot be duplicated.	\${nodeText.noSymptomCode}	
11.	Follow steps listed in <a href="#">HT201171: Using a Bluetooth mouse, keyboard, or trackpad with your Mac</a> to pair the user's Bluetooth device with a known-good Mac.  Test the user's wireless mouse, wireless trackpad, or wireless keyboard manually, using built-in applications on a known-good Mac. For example, use the Notes application to check the keys on a wireless keyboard.	Yes	<b>ESCALATION REQUIRED.</b>  The Bluetooth device appears to be performing to specifications. There may be an issue with the user's computer, or wireless interference in user's environment.  If issue persists, then contact ACS for additional support.	\${nodeText.yesSymptomCode}	
	Refer to <a href="#">HT204621: If your Apple wireless mouse, keyboard, or trackpad aren't working as expected</a> for tips to resolve issues.  Does the user's wireless mouse, wireless trackpad, or wireless keyboard pair and function normally?	No	Go to step 12.	\${nodeText.noSymptomCode}	
12.	Isolate failure to either user's wireless keyboard, or wireless mouse or trackpad.	Wireless keyboard	Go to step 13.	\${nodeText.yesSymptomCode}	
	Which peripheral is malfunctioning?	Wireless mouse or trackpad	Go to step 29.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
13.	<p>Look for for any signs of power on the user's wireless keyboard, such as a power LED turning on. <b>Note:</b> Not all devices have a power LED.</p> <p>Verify that the user's wireless keyboard turns ON when the power button or switch is placed in the ON position.</p> <p>Verify that the user's wireless keyboard turns OFF when the power button or switch is placed in the OFF position.</p> <p>Does the user's wireless keyboard exhibit any power-related symptoms?</p>	Yes  No	<p>Go to step 14.</p> <p>Go to step 18.</p>	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
14.	<p>Confirm that the issue with the user's wireless keyboard is:</p> <ul style="list-style-type: none"> <li>User's wireless keyboard is not functioning at all (seems dead, no power, power LED does not turn on)</li> </ul> <p>Does the user's wireless keyboard exhibit this symptom?</p>	Yes  No	<p>Replace the user's wireless keyboard.  Verify that the issue is resolved.</p> <p>Go to step 15.</p>	K09  \${nodeText.noSymptomCode}	KEYBOARD
15.	<p>Verify that the user's wireless keyboard turns ON when the power button or switch is placed in the ON position.</p> <p>Confirm that the issue with the user's wireless keyboard is:</p> <ul style="list-style-type: none"> <li>Power switch or button is defective</li> </ul> <p>Does the user's wireless keyboard exhibit this symptom?</p>	Yes  No	<p>Replace the user's wireless keyboard.  Verify that the issue is resolved.</p> <p>Go to step 16.</p>	K19  \${nodeText.noSymptomCode}	KEYBOARD
16.	<p>Verify that the user's wireless keyboard turns off when the power button or switch is placed in the OFF position.</p> <p>Confirm that the issue with the user's wireless keyboard is:</p> <ul style="list-style-type: none"> <li>User's wireless keyboard remains ON when power button or switch has been placed in the OFF position</li> </ul> <p>Does the user's wireless keyboard exhibit this symptom?</p>	Yes  No	<p>Replace the user's wireless keyboard.  Verify that the issue is resolved.</p> <p>Go to step 17.</p>	K34  \${nodeText.noSymptomCode}	KEYBOARD

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
17.	Verify if the user's wireless keyboard has any other power-related issue that is not related to the power button or switch.  Confirm that the issue with the user's wireless keyboard is: <ul style="list-style-type: none"><li>• Power Issue, not due to power button or switch</li></ul>	Yes	Replace the user's wireless keyboard.  Verify that the issue is resolved.	K20	KEYBOARD
	Does the user's wireless keyboard exhibit this symptom?	No	Go to step 18.	\${nodeText.noSymptomCode}	
18.	If the user's issue involves pairing or connecting to a Magic Keyboard, then you can connect to, pair, and use this device with the computer using either Bluetooth or a Lightning cable.  If Bluetooth pairing is not possible due to interference or other reasons, then try connecting the user's Magic Keyboard to the known-good computer with a known-good Lightning cable.  For other Apple Bluetooth peripherals, select the "Yes" answer to continue.	Yes	Go to step 19.	\${nodeText.yesSymptomCode}	
	Does the user's Magic Keyboard connect and pair using USB?	No	Replace the user's wireless keyboard.  Verify that the issue is resolved.	K30	KEYBOARD
19.	Verify that a known-good computer can recognize the user's wireless keyboard.  Confirm that the issue with the user's wireless keyboard is: <ul style="list-style-type: none"><li>• User's wireless keyboard is not recognized by known-good computer</li></ul>	Yes	Replace the user's wireless keyboard.  Verify that the issue is resolved.	K15	KEYBOARD
	Does the user's wireless keyboard exhibit this symptom?	No	Go to step 20.	\${nodeText.noSymptomCode}	
20.	Verify that a known-good computer can pair with the user's wireless keyboard using Bluetooth.  Confirm that the issue with the user's wireless keyboard is: <ul style="list-style-type: none"><li>• User's wireless keyboard cannot pair with a known-good computer</li></ul>	Yes	Replace the user's wireless keyboard.  Verify that the issue is resolved.	K07	KEYBOARD
	Does the user's wireless keyboard exhibit this symptom?	No	Go to step 21.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
21.	Verify that a known-good computer maintains a Bluetooth connection to the user's wireless keyboard, and does not drop this connection.  Confirm that the issue with the user's wireless keyboard is: <ul style="list-style-type: none"><li>User's wireless keyboard intermittently loses its connection with a known-good computer</li></ul>	Yes	Replace the user's wireless keyboard.  Verify that the issue is resolved.	K08	KEYBOARD
	Does the user's wireless keyboard exhibit this symptom?	No	Go to step 22.	\${nodeText.noSymptomCode}	
22.	Ask the user how often and how long the wireless keyboard is used.  Explain to the user that the battery issue could likely be caused by the user using the wireless keyboard continuously over a long period of time, rather than any fault of the wireless keyboard itself, macOS, or the user's computer.	Yes	Go to step 23.	\${nodeText.yesSymptomCode}	
	Gain agreement from the user that lengthy wireless keyboard usage is likely to be the cause of the battery life issue, and that there is no service issue with the wireless keyboard itself.  Does the user agree that the battery life issue is likely caused by lengthy wireless keyboard usage?	No	Replace the user's wireless keyboard.  Verify that the issue is resolved.	K32	KEYBOARD
23.	Attempt to charge the user's wireless keyboard battery for several more minutes. Verify that the user's wireless keyboard battery charge level that appears on the known-good computer that is paired with this user's wireless keyboard has increased and shows that the user's wireless keyboard is charging.	Yes	Replace the user's wireless keyboard.  Verify that the issue is resolved.	K31	KEYBOARD
	Confirm that the issue with the user's wireless keyboard is: <ul style="list-style-type: none"><li>User's wireless keyboard battery will not charge</li></ul> <b>Note:</b> This symptom does not apply to peripherals with replaceable batteries.  Does the user's wireless keyboard exhibit this symptom?	No	Go to step 24.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
24.	<p>Closely inspect the user's wireless keyboard enclosure for signs of a swollen battery.</p> <p>Confirm that the issue with the user's wireless keyboard is:</p> <ul style="list-style-type: none"> <li>User's wireless keyboard battery appears swollen</li> </ul> <p><b>Note:</b> This symptom does not apply to peripherals with replaceable batteries.</p> <p>Does the user's wireless keyboard exhibit this symptom?</p>	Yes	<p>Replace the user's wireless keyboard.</p> <p>Verify that the issue is resolved.</p>	K33	KEYBOARD
		No	Go to step 25.	\${nodeText.noSymptomCode}	
25.	<p>Verify that each and every wireless keyboard key functions as expected when pressed and released.</p> <p>Confirm that the issue with the user's wireless keyboard is:</p> <ul style="list-style-type: none"> <li>Specific key(s) do not work</li> </ul> <p>Does the user's wireless keyboard exhibit this symptom?</p>	Yes	<p>Replace the user's wireless keyboard.</p> <p>Verify that the issue is resolved.</p>	K01	KEYBOARD
		No	Go to step 26.	\${nodeText.noSymptomCode}	
26.	<p>Verify that each and every wireless keyboard key functions as expected when pressed and released.</p> <p>Confirm that the issue with the user's wireless keyboard is:</p> <ul style="list-style-type: none"> <li>Keys seem to stick, do not respond properly, or respond slowly</li> </ul> <p>Does the user's wireless keyboard exhibit this symptom?</p>	Yes	<p>Replace the user's wireless keyboard.</p> <p>Verify that the issue is resolved.</p>	K05	KEYBOARD
		No	Go to step 27.	\${nodeText.noSymptomCode}	
27.	<p>Verify that each and every wireless keyboard key is intact and not missing.</p> <p>Confirm that the issue with the user's wireless keyboard is:</p> <ul style="list-style-type: none"> <li>Keys missing or falling off keyboard</li> </ul> <p>Does the user's wireless keyboard exhibit this symptom?</p>	Yes	<p>Replace the user's wireless keyboard.</p> <p>Verify that the issue is resolved.</p>	K27	KEYBOARD
		No	Go to step 28.	\${nodeText.noSymptomCode}	
28.	<p>Verify that the wireless keyboard language is as expected.</p> <p>Confirm that the issue with the user's wireless keyboard is:</p> <ul style="list-style-type: none"> <li>Wrong keyboard language version</li> </ul> <p>Does the user's wireless keyboard exhibit this symptom?</p>	Yes	<p>Replace the user's wireless keyboard.</p> <p>Verify that the issue is resolved.</p>	K04	KEYBOARD
		No	Issue cannot be duplicated.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
29.	<p>Look for any signs of power on the user's wireless mouse or trackpad, such as a power LED turning on. <b>Note:</b> Not all devices have a power LED.</p> <p>Verify that the user's wireless mouse or trackpad turns ON when the power button or switch is placed in the ON position.</p> <p>Verify that the user's wireless mouse or trackpad turns OFF when the power button or switch is placed in the OFF position.</p> <p>Does the user's wireless mouse or trackpad exhibit any power-related symptoms?</p>	Yes  No	<p>Go to step 30.</p> <p>Go to step 34.</p>	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
30.	<p>Confirm that the issue with the user's wireless mouse or trackpad is:</p> <ul style="list-style-type: none"> <li>User's wireless mouse or trackpad is not functioning at all (seems dead, no power, power LED does not turn on)</li> </ul> <p>Does the user's wireless mouse or trackpad exhibit this symptom?</p>	Yes  No	<p>Replace the user's wireless mouse or trackpad.  Verify that the issue is resolved.</p> <p>Go to step 31.</p>	K09  \${nodeText.noSymptomCode}	MOUSE
31.	<p>Verify that the user's wireless mouse or trackpad turns ON when the power button or switch is placed in the ON position.</p> <p>Confirm that the issue with the user's wireless mouse or trackpad is:</p> <ul style="list-style-type: none"> <li>Power switch or button is defective</li> </ul> <p>Does the user's wireless mouse or trackpad exhibit this symptom?</p>	Yes  No	<p>Replace the user's wireless mouse or trackpad.  Verify that the issue is resolved.</p> <p>Go to step 32.</p>	K19  \${nodeText.noSymptomCode}	MOUSE
32.	<p>Verify that the user's wireless mouse or trackpad turns off when the power button or switch is placed in the OFF position.</p> <p>Confirm that the issue with the user's wireless mouse or trackpad is:</p> <ul style="list-style-type: none"> <li>User's wireless mouse or trackpad remains ON when power button or switch has been placed in the OFF position</li> </ul> <p>Does the user's wireless mouse or trackpad exhibit this symptom?</p>	Yes  No	<p>Replace the user's wireless mouse or trackpad.  Verify that the issue is resolved.</p> <p>Go to step 33.</p>	K34  \${nodeText.noSymptomCode}	MOUSE

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
33.	<p>Verify if the user's wireless mouse or trackpad has any other power-related issue that is not related to the power button or switch.</p> <p>Confirm that the issue with the user's wireless mouse or trackpad is:</p> <ul style="list-style-type: none"> <li>Power Issue, not due to power button or switch</li> </ul> <p>Does the user's wireless mouse or trackpad exhibit this symptom?</p>	Yes	<p>Replace the user's wireless mouse or trackpad.</p> <p>Verify that the issue is resolved.</p>	K20	MOUSE
		No	Go to step 34.	\${nodeText.noSymptomCode}	
34.	<p>If the user's issue involves pairing or connecting to a Magic Mouse 2 or Magic Trackpad 2, then you can connect to and pair these devices with a computer using either Bluetooth or a Lightning cable.</p> <p>If Bluetooth pairing is not possible due to interference or other reasons, then try connecting the user's Magic Mouse 2 or Magic Trackpad 2 to a known-good computer with a known-good Lightning cable.</p> <p>For other Apple Bluetooth peripherals, select the "Yes" answer to continue.</p> <p>Does the user's Magic Mouse 2 or Magic Trackpad 2 connect and pair using USB?</p>	Yes	Go to step 35.	\${nodeText.yesSymptomCode}	
		No	<p>Replace the user's wireless mouse or trackpad.</p> <p>Verify that the issue is resolved.</p>	K30	MOUSE
35.	<p>Verify that a known-good computer can recognize the user's wireless mouse or trackpad.</p> <p>Confirm that the issue with the user's wireless mouse or trackpad is:</p> <ul style="list-style-type: none"> <li>User's wireless mouse or trackpad is not recognized by known-good computer.</li> </ul> <p>Does the user's wireless mouse or trackpad exhibit this symptom?</p>	Yes	<p>Replace the user's wireless mouse or trackpad.</p> <p>Verify that the issue is resolved.</p>	K15	MOUSE
		No	Go to step 36.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
36.	Verify that a known-good computer can pair with the user's wireless mouse or trackpad.  Confirm that the issue with the user's wireless mouse or trackpad is: <ul style="list-style-type: none"><li>User's wireless mouse or trackpad cannot pair with a known-good computer</li></ul> Does the user's wireless mouse or trackpad exhibit this symptom?	Yes	Replace the user's wireless mouse or trackpad.  Verify that the issue is resolved.	K07	MOUSE
		No	Go to step 37.	\${nodeText.noSymptomCode}	
37.	Verify that a known-good computer maintains a Bluetooth connection to the user's wireless mouse or trackpad, and does not drop this connection.  Confirm that the issue with the user's wireless mouse or trackpad is: <ul style="list-style-type: none"><li>User's wireless mouse or trackpad intermittently loses its connection with a known-good computer</li></ul> Does the user's wireless mouse or trackpad exhibit this symptom?	Yes	Replace the user's wireless mouse or trackpad.  Verify that the issue is resolved.	K08	MOUSE
		No	Go to step 38.	\${nodeText.noSymptomCode}	
38.	Ask the user how often and how long the wireless mouse or trackpad is used.  Gain agreement from the user that lengthy wireless mouse or trackpad usage is likely to be the cause of the battery life issue, and that there is no service issue with the wireless mouse or trackpad itself.  Does the user agree that the battery life issue is likely caused by lengthy wireless device usage?	Yes	Go to step 39.	\${nodeText.yesSymptomCode}	
		No	Replace the user's wireless mouse or trackpad.  Verify that the issue is resolved.	K32	MOUSE

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
39.	Attempt to charge the user's wireless mouse or trackpad battery for several more minutes. Verify that the user's wireless mouse or trackpad battery charge level that appears on the known-good computer that is paired with this user's wireless mouse or trackpad has increased and shows that the user's wireless mouse or trackpad is charging.	Yes	Replace the user's wireless mouse or trackpad.  Verify that the issue is resolved.	K31	MOUSE
	Confirm that the issue with the user's wireless mouse or trackpad is: <ul style="list-style-type: none"><li>User's wireless mouse or trackpad battery will not charge</li></ul> <b>Note:</b> This symptom does not apply to peripherals with replaceable batteries.				
40.	Does the user's wireless mouse or trackpad exhibit this symptom?  Closely inspect the user's wireless mouse or trackpad enclosure for signs of a swollen battery.  Confirm that the issue with the user's wireless mouse or trackpad is: <ul style="list-style-type: none"><li>User's wireless mouse or trackpad battery appears swollen</li></ul> <b>Note:</b> This symptom does not apply to peripherals with replaceable batteries.	No	Go to step 40.	\${nodeText.noSymptomCode}	
41.	Does the user's wireless mouse or trackpad exhibit this symptom?  Isolate failure to either user's wireless mouse or wireless trackpad.  Which peripheral is malfunctioning?	Yes	Replace the user's wireless mouse or trackpad.  Verify that the issue is resolved.	K33	MOUSE
		No	Go to step 41.	\${nodeText.noSymptomCode}	
41.	Which peripheral is malfunctioning?	Wireless mouse	Go to step 42.	\${nodeText.yesSymptomCode}	
		Wireless trackpad	Go to step 45.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
42.	Verify that the overall function of the user's wireless mouse performs as expected when used with the known-good computer.	Yes	Replace the user's wireless mouse.  Verify that the issue is resolved.	K26	MOUSE
	Confirm that the issue with the user's wireless mouse is: <ul style="list-style-type: none"><li>• No mouse response</li></ul>				
	Does the user's wireless mouse exhibit this symptom?	No	Go to step 43.	\${nodeText.noSymptomCode}	
43.	Verify that the clicking function of the user's wireless mouse performs as expected when pressed and released.	Yes	Replace the user's wireless mouse.  Verify that the issue is resolved.	K14	MOUSE
	Confirm that the issue with the user's wireless mouse is: <ul style="list-style-type: none"><li>• Mouse clicking function not working properly</li></ul>				
	Does the user's wireless mouse exhibit this symptom?	No	Go to step 44.	\${nodeText.noSymptomCode}	
44.	Verify that the touch gesture function of the user's wireless mouse performs as expected when the mouse surface is touched.	Yes	Replace the user's wireless mouse.  Verify that the issue is resolved.	K18	MOUSE
	Confirm that the issue with the user's wireless mouse is: <ul style="list-style-type: none"><li>• Touch/Multi-Touch gesture issue</li></ul>				
	Does the user's wireless mouse exhibit this symptom?	No	Issue cannot be duplicated.	\${nodeText.noSymptomCode}	
45.	Verify that the overall function of the user's wireless trackpad performs as expected when used with the known-good computer.	Yes	Replace the user's wireless trackpad.  Verify that the issue is resolved.	K23	MOUSE
	Confirm that the issue with the user's wireless trackpad is: <ul style="list-style-type: none"><li>• Trackpad cursor not responding</li></ul>				
	Does the user's wireless trackpad exhibit this symptom?	No	Go to step 46.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
46.	Verify that the user's wireless trackpad exhibits smooth continuous tracking when used with the known-good computer, and does not skip or behave erratically.	Yes	Replace the user's wireless trackpad.  Verify that the issue is resolved.	K12	MOUSE
	Confirm that the issue with the user's wireless trackpad is: <ul style="list-style-type: none"><li>• Trackpad cursor not tracking properly</li></ul> Does the user's wireless trackpad exhibit this symptom?	No	Go to step 47.	\${nodeText.noSymptomCode}	
47.	Verify that the clicking function of the user's wireless trackpad performs as expected when pressed and released, and that the click is recognized by the known-good computer.	Yes	Replace the user's wireless trackpad.  Verify that the issue is resolved.	K13	MOUSE
	Confirm that the issue with the user's wireless trackpad is: <ul style="list-style-type: none"><li>• Trackpad click not recognized</li></ul> Does the user's wireless trackpad exhibit this symptom?	No	Go to step 48.	\${nodeText.noSymptomCode}	
48.	Verify that the user's wireless trackpad clicking function does not require excessive force when pressed and released.	Yes	Replace the user's wireless trackpad.  Verify that the issue is resolved.	K24	MOUSE
	Confirm that the issue with the user's wireless trackpad is: <ul style="list-style-type: none"><li>• Trackpad requires high click force</li></ul> Does the user's wireless trackpad exhibit this symptom?	No	Go to step 49.	\${nodeText.noSymptomCode}	
49.	Verify that the user's wireless trackpad clicking function is not overly sensitive to clicking when pressed and released.	Yes	Replace the user's wireless trackpad.  Verify that the issue is resolved.	K25	MOUSE
	Confirm that the issue with the user's wireless trackpad is: <ul style="list-style-type: none"><li>• Trackpad click oversensitive</li></ul> Does the user's wireless trackpad exhibit this symptom?	No	Go to step 50.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
50.	Verify that the user's wireless trackpad Force Touch function performs as expected and that haptic feedback is felt in response. <b>Note:</b> This feature does not apply to all models.	Yes	Replace the user's wireless trackpad.  Verify that the issue is resolved.	K29	MOUSE
	Confirm that the issue with the user's wireless trackpad is: <ul style="list-style-type: none"><li>• Trackpad Force Touch or haptic feedback issue</li></ul> Does the user's wireless trackpad exhibit this symptom?	No	Issue cannot be duplicated.	\${nodeText.noSymptomCode}	

# External Apple Wired Keyboard and Mouse

## Unlikely causes:

There are no unlikely causes for this issue.

## Quick Check

Symptoms	Quick Check
<p>Apple wired USB keyboard or mouse does not function with user's computer, or shows one or more of the following symptoms:</p> <ul style="list-style-type: none"><li>• Mouse button(s) does not click</li><li>• Mouse scroll ball does not operate smoothly</li><li>• No mouse response</li><li>• Keyboard keys stick</li><li>• Keyboard keys loose or missing</li><li>• One or more keys do not respond when pressed</li><li>• No keyboard response at all</li><li>• Apple wired mouse causes erratic cursor tracking</li><li>• Apple wired keyboard or mouse is not recognized</li><li>• Apple wired keyboard or mouse has physical damage that affects operation</li><li>• Paint is wearing off of one or more keys on the keyboard</li><li>• Apple wired keyboard or mouse has cosmetic damage that does not affect operation</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. Disconnect all USB devices from the user's computer except for the user's mouse or keyboard. Troubleshoot only one device at a time to help isolate the issue.</li><li>2. Unplug the keyboard or mouse from the USB port, wait a few seconds, and reconnect it.</li><li>3. Connect the keyboard or mouse to another USB port on the user's computer.</li><li>4. Make sure the USB connectors are plugged in completely and correctly.</li><li>5. Visually inspect the USB connectors and ports for damage or debris.</li><li>6. Try operating the user's mouse on another surface. Ask the user about the type of surface usually being used with the mouse. Glossy or transparent surfaces, or those with repetitive patterns, may cause mouse-tracking errors or faulty mouse operation. Explain that solid, non-reflective, opaque surfaces work best. The surface should be clean, but not shiny.</li><li>7. Visually inspect the user's keyboard or mouse for dirt, hair, liquid damage, or other debris. Check to see if the user has pets. Pet hair can lay across the laser and cause intermittent mouse issues. Refer to article <a href="#">HT204172: How to clean your Apple products</a> for information on cleaning the user's keyboard or mouse.</li><li>8. Connect the user's USB keyboard or mouse to an available USB port on a known-good computer to determine if the issue is related to the USB port on the user's computer, or to the user's USB keyboard or mouse. If the user's keyboard or mouse functions when used with a known-good computer, go to the "<b>USB Port Not Recognized</b>" troubleshooting flow.</li><li>9. For keyboard issues, refer to <a href="#">HT204540: If your Apple keyboard doesn't work</a> for troubleshooting tips.</li></ol>

## Deep Dive

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
1.	<p>Visually inspect the user's USB mouse or keyboard to verify that the attached USB cable and/or connector is not damaged or frayed.</p> <p>Check the user's keyboard or mouse for physical and/or liquid damage.</p> <p>On mice, verify that all mouse buttons click and the laser tracking LED illuminates.</p> <p>On keyboards, verify that all keyboard buttons are present and can be depressed normally.</p> <p>Does the user's USB mouse or keyboard, or its attached cable or connector, show signs of damage?</p>	Yes     No	<p>Go to step 2.</p> <p>Go to step 12.</p>	\${nodeText.yesSymptomCode}     \${nodeText.noSymptomCode}	
2.	<p>Isolate the damage issue to either the user's wired USB keyboard or mouse.</p> <p>Which peripheral is damaged?</p>	USB Keyboard  USB Mouse	<p>Go to step 3.</p> <p>Go to step 9.</p>	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
3.	<p>Closely examine the user's keyboard to determine the exact nature of its issue.</p> <p>Look for any signs of liquid spill, liquid penetration, or liquid damage to the keyboard.</p> <p>Is damage to the user's keyboard related to liquid spill?</p>	Yes   No	<p>Replace USB keyboard. Verify issue resolved.</p> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p> <p>Go to step 4.</p>	K90   \${nodeText.noSymptomCode}	KEYBOARD
4.	<p>Click each key to ensure all keys are not sticking in the down or up position.</p> <p>Is damage to the user's keyboard related to sticky keys or slow key response?</p>	Yes   No	<p>Replace USB keyboard. Verify issue resolved.</p> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p> <p>Go to step 5.</p>	K05   \${nodeText.noSymptomCode}	KEYBOARD

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
5.	Look for any loose or missing keycaps.  Is damage to the user's keyboard related to loose or missing keycaps?	Yes	Replace USB keyboard. Verify issue resolved.  <b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.	K27	KEYBOARD
		No	Go to step 6.	\${nodeText.noSymptomCode}	
6.	Closely inspect the keyboard for any signs of physical damage that may affect operation.  Does the user's keyboard exhibit this symptom?	Yes	Replace USB keyboard. Verify issue resolved.  <b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.	K16	KEYBOARD
		No	Go to Step 7.	\${nodeText.noSymptomCode}	
7.	Closely examine the keyboard for signs of paint wearing off of one or more keys.  Does the user's keyboard exhibit this symptom?	Yes	Replace USB keyboard. Verify issue resolved.  <b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.	K35	KEYBOARD
		No	Go to step 8.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
8.	Closely inspect the keyboard for any signs of cosmetic damage that does not affect operation.  Does the user's keyboard exhibit this symptom?	Yes	Replace USB keyboard. Verify issue resolved.  <b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.	K21	KEYBOARD
		No	Issue cannot be duplicated.	\${nodeText.noSymptomCode}	
9.	Closely examine user's mouse to determine exact nature of the issue.  Look for any signs of liquid spill, liquid penetration, or liquid damage to mouse.  Is damage to user's mouse related to liquid spill?	Yes	Replace USB mouse. Verify issue resolved.  <b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.	K90	MOUSE
		No	Go to step 10.	\${nodeText.noSymptomCode}	
10.	Closely inspect the mouse for any signs of physical damage that may affect operation.  Is there physical damage to user's mouse?	Yes	Replace USB mouse. Verify issue resolved.  <b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.	K16	MOUSE
		No	Go to step 11.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
11.	Closely inspect the mouse for any signs of cosmetic damage that does not affect operation.  Is there cosmetic damage to user's mouse?	Yes	Replace USB mouse. Verify issue resolved.  <b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.	K21	MOUSE
		No	Issue cannot be duplicated.	\${nodeText.noSymptomCode}	
12.	Isolate failure issue to either user's wired USB keyboard or mouse.  Which peripheral is malfunctioning?	USB Keyboard	Go to step 17.	\${nodeText.yesSymptomCode}	
		USB Mouse	Go to step 13.	\${nodeText.noSymptomCode}	
13.	Connect user's USB mouse to a free USB port on a known-good computer, and check <b>System Information</b> to determine whether the computer recognizes the mouse.  Is mouse recognized by a known-good computer?	Yes	Go to step 14.	\${nodeText.yesSymptomCode}	
		No	Replace USB mouse. Verify issue resolved.	K15	MOUSE
14.	Move the mouse and verify that the cursor on the known-good computer screen moves smoothly.  Is issue related to mouse function?	Yes	Replace USB mouse. Verify issue resolved.	K26	MOUSE
		No	Go to step 15.	\${nodeText.noSymptomCode}	
15.	Click and roll the mouse's scroll ball to check that it rolls freely in all directions, with no physical resistance.  Is issue related to the scroll ball?	Yes	Replace USB mouse. Verify issue resolved.	K06	MOUSE
		No	Go to step 16.	\${nodeText.noSymptomCode}	
16.	Click the mouse's various buttons to verify they click properly, without sticking, each time they are pressed.  Is issue related to the mouse button(s)?	Yes	Replace USB mouse. Verify issue resolved.	K14	MOUSE
		No	Issue cannot be duplicated.	\${nodeText.noSymptomCode}	
17.	Connect user's USB keyboard to a free USB port on a known-good computer, and check <b>System Information</b> to determine whether the computer recognizes the keyboard.  Is keyboard recognized by a known-good computer?	Yes	Go to step 18.	\${nodeText.yesSymptomCode}	
		No	Replace USB keyboard. Verify issue resolved.	K15	KEYBOARD

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
18.	Verify that each and every keyboard key functions as expected when pressed and released.	Yes	Replace USB keyboard. Verify issue resolved.	K01	KEYBOARD
	Is issue related to specific keys not working?	No	Go to step 19.	\${nodeText.noSymptomCode}	
19.	Verify that the keyboard language is as expected.	Yes	Replace USB keyboard. Verify issue resolved.	K04	KEYBOARD
	Is issue related to keyboard language?	No	Issue cannot be duplicated.	\${nodeText.noSymptomCode}	

# No Audio from Internal Speaker or Headphone Jack

## Unlikely causes:

AC Inlet, Bus Bars A and B, CPU Riser Card, DIMM Mechanism Exhaust Manifold, Fan, Fan Flex Cable, Flash Storage, Graphics Board A, Graphics Board B, Graphics Board Flex Cable, Housing, Housing Lock Switch, Inlet, Interposer Board, Interposer Board Cover, Interposer Board Flex Cable, Memory DIMM, Power Supply, Roof, Wireless Card.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• No Audio Output available in System Preferences</li><li>• No sound from internal speaker</li><li>• No sound from left and/or right speaker channel</li><li>• No sound from headphone jack</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. From System Preferences &gt; Sound &gt; Output, verify "Internal Speaker" output is available and selected. Test with known-good stereo audio file.</li><li>2. Connect headphones or external speakers to audio jack. From System Preferences &gt; Sound &gt; Output, verify Audio Out setting switches to "Headphones." Verify sound can be heard through headphones or external speakers.</li><li>3. Disconnect any device connected to audio jack. From System Preferences &gt; Sound &gt; Output, verify Audio Out setting reverts to "Internal Speaker." Use Volume slider to verify issue is isolated to internal speaker.</li><li>4. Reset NVRAM by holding down Command-Option-P-R keys while rebooting, until you hear the startup sound for the second time.</li><li>5. Check Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> to make sure system build is correct for this computer model.</li><li>6. Check for, and apply, the latest software and firmware updates.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	Start up computer using known-good up-to-date, bootable OS X volume. Play known-good audio file. Verify presence of sound when using internal speaker. Connect known-good headphones or external speakers and retest.  Is sound audible on both internal/external speakers?	Yes	Reinstall OS X. Check Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> to make sure system build is correct for this computer model. Verify resolution.	\${nodeText.yesSymptomCode}	
		No	Go to step 2.	\${nodeText.noSymptomCode}	
2.	Disconnect headphones or external speakers. From System Preferences > Sound > Output, verify "Internal Speaker" Output is available and selected.  Is "Internal Speaker" Output available?	Yes	Go to step 3.	\${nodeText.yesSymptomCode}	
		No	Replace I/O board. Verify issue resolved.	M09	OTHER BOARD
3.	Select "Internal Speaker" Output, then connect known-good headphones or external speakers. Verify presence of sound through external speakers or headphones.  Is sound/channel present through external headphones/speakers?	Yes	Go to step 4.	\${nodeText.yesSymptomCode}	
		No	Go to step 8.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
4.	Remove I/O board. Inspect speaker cable connector and corresponding connector on I/O board. Reseat connection, reassemble and retest.	Yes	Issue resolved by reseating speaker connection. Verify resolution.	\${nodeText.yesSymptomCode}	
	Is internal sound audible on internal speaker?	No	Go to step 5.	\${nodeText.noSymptomCode}	
5.	To troubleshoot this issue completely, you need the following known-good parts: <ul style="list-style-type: none"><li>• Speaker</li><li>• I/O board</li></ul> Do you have these parts immediately available?	Yes	Go to step 6.	\${nodeText.yesSymptomCode}	
		No	Replace speaker. Verify issue resolved.	X08	OTHER ELECTRIC
6.	Remove I/O board. Substitute a known-good speaker. Reassemble and retest.	Yes	Replace speaker. Verify issue resolved.	X08	OTHER ELECTRIC
	Is internal sound audible on internal speaker?	No	Go to step 7.	\${nodeText.noSymptomCode}	
7.	Remove I/O board. Reinstall user's speaker and substitute a known good I/O board. Visually inspect all connectors for damage. Reassemble and retest.  Is internal sound audible on internal speaker?	Yes	Replace I/O board. Verify issue resolved.	M09	OTHER BOARD
		No	<b>ESCALATION REQUIRED.</b>  Contact TSPS for additional support or a multiple part repair.  Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	M99	
8.	To troubleshoot this issue completely, you need the following known-good parts: <ul style="list-style-type: none"><li>• I/O board</li><li>• I/O board flex cable</li><li>• Logic board</li></ul> Do you have these parts immediately available?	Yes	Go to step 9.	\${nodeText.yesSymptomCode}	
		No	Replace I/O board. Verify issue resolved.	M09	OTHER BOARD

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
9.	Substitute a known-good I/O board, visually inspecting connectors for damage. Reassemble and retest.	Yes	Replace I/O board. Verify issue resolved.	M09	OTHER BOARD
	Is internal sound audible on internal speaker?	No	Go to step 10.	\${nodeText.noSymptomCode}	
10.	Reinstall the user's I/O board. Substitute a known-good I/O board flex cable, visually inspecting connectors for damage. Reassemble and retest.	Yes	Replace I/O board flex cable. Verify issue resolved.	X03	INTERNAL CABLE
	Is internal sound audible on internal speaker?	No	Go to step 11.	\${nodeText.noSymptomCode}	
11.	Reinstall the user's I/O board flex cable. Substitute a known-good logic board and retest.  Is internal sound audible on internal speaker?	Yes	Replace logic board. Verify issue resolved.	M09	MLB
			<b>ESCALATION REQUIRED.</b>  Contact TSPS for additional support or a multiple part repair.		
		No	  Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	M99	
12.	Verify audio can be played from both external and internal speakers by connecting and disconnecting external speakers/headphones. Verify computer produces a clear, distortion-free sound.  Is issue resolved?	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
			<b>ESCALATION REQUIRED.</b>  Contact TSPS for additional support or a multiple part repair.		
		No	  Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	X99	

# No Audio to External Display Speakers

## Unlikely causes:

AC Inlet, Audio Jack, Bus Bars A and B, CPU Riser Card, DIMM Mechanism, Exhaust Manifold, Fan, Fan Flex Cable, Flash Storage, Graphics Board A, Graphics Board B, Graphics Board Flex Cable, Housing, Housing Lock Switch, Inlet, Interposer Board, Interposer Board Cover, Interposer Board Flex Cable, Memory DIMM, Power Supply, Roof, Speaker, Wireless Card.

## Quick Check

Symptoms	Quick Check
<p>Sound cannot be enabled and heard on speakers of one or more of the following:</p> <ul style="list-style-type: none"><li>• Thunderbolt display connected to computer's Thunderbolt port</li><li>• Mini DisplayPort display connected to computer's Mini DisplayPort port</li><li>• Compatible HDMI display connected to computer's HDMI port</li><li>• Compatible HDMI display connected to Thunderbolt or Mini DisplayPort port via a compatible Mini DisplayPort-to-HDMI adapter (with audio support)</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. Gather display type, model and connected display port information from user.</li><li>2. From System Preferences &gt; Sound &gt; Output, select "Internal Speakers." Play audio file to verify internal speaker functionality.</li><li>3. Verify computer using known-good Mini DisplayPort or compatible HDMI display equipped with internal speaker(s) and compatible HDMI adapter.</li><li>4. <b>If using Mini DisplayPort display</b>, verify USB cable is also connected to user's computer.</li><li>5. <b>If using Thunderbolt display</b>, verify that computer is Thunderbolt capable.</li><li>6. <b>If using HDMI display</b>, open Input Menu on display and select connected HDMI input.</li><li>7. <b>If using Mini DisplayPort-to-HDMI adapter</b>, verify adapter supports audio over HDMI. Refer to Apple Support article <a href="#">HT4241: About Mini DisplayPort to HDMI adapters</a>.</li><li>8. From System Preferences &gt; Sound &gt; Output, select available "DisplayPort", "HDMI", or "USB" audio output device type (depending on display model and connection).</li><li>9. From System Preferences &gt; Sound &gt; Output, adjust output volume and balance levels.</li><li>10. Reset NVRAM by holding down Command-Option-P-R keys while rebooting, until you hear startup sound for the second time.</li><li>11. Test audio output using more than one application or website.</li><li>12. Check Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> to make sure system build is correct for this computer model.</li><li>13. Check for and apply latest software and firmware updates.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
	According to user's provided display type, model and connection information, connect similar known-good display model. If needed, use known-good cable/adapter.	Yes	Go to step 3.	\${nodeText.yesSymptomCode}	
1.	From System Preferences > Sound > Output, verify availability of "DisplayPort", "HDMI", or "USB" Output device type. Select available device type, adjust output volume level, and play audio file/source.  Can known-good display be enabled and sound heard?	No	Go to step 2.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
2.	Start up user's computer using known-good, original system media or an up-to-date, bootable OS X volume. From System Preferences > Sound > Output, verify availability of "DisplayPort", "HDMI", or "USB" Output device type (according to connected display type). Select available device type, adjust output volume level, and play audio file/source.  Can external display audio be enabled and sound heard when user's computer has known-good OS?	Yes	Reinstall OS X. Check Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> to make sure system build is correct for this computer model. Check for and apply latest software and firmware updates. Verify resolution.	\${nodeText.yesSymptomCode}	
		No	Go to step 7.	\${nodeText.noSymptomCode}	
3.	Substitute user's display and connect it to user's computer. If needed, use known-good cable/adapter.  From System Preferences > Sound > Output, verify availability of "DisplayPort", "HDMI", or "USB" Output device type. Select available device type, adjust output volume level, and play audio file/source.  Can user's display audio be enabled and sound heard with user's computer?	Yes	Go to step 5.	\${nodeText.yesSymptomCode}	
		No	Go to step 4.	\${nodeText.noSymptomCode}	
4.	User's external display appears to be causing issue.  What is product brand?	Apple Display	Issue comes from user's display. Computer is not affected. Return computer to user. Enter Apple display serial number into GSX, locate its service guide, and troubleshoot display using a known-good computer. Verify resolution.	\${nodeText.yesSymptomCode}	
		Third-Party Display	Issue related to user's display. Computer is not affected. Return computer to user and inform user to contact product manufacturer for further compatibility, software requirements information, or service.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
5.	If cable/adapter is needed for display connection, substitute with user's cable/adapter. Check System Preferences > Sound > Output for available "DisplayPort", "HDMI", or "USB" Output device type.	Yes	Issue resolved with correct setup. Verify issue resolved.	\${nodeText.yesSymptomCode}	
	Select available device type, adjust output volume level, and play audio file/source.	No	Go to step 6.	\${nodeText.noSymptomCode}	
6.	Can user's display audio be enabled and sound heard with user's cable/adapter?	Apple	Check for possible accidental damage. Replace Apple cable/adapter. Verify issue resolved.	X03	EXTERNAL CABLE
	User's display cable/adapter appears to be causing issue.  What is product brand?	Third-Party Cable/Adapter	Issue comes from user's cable/adapter. Computer is not affected. Return computer to user and inform user to contact product manufacturer for further compatibility, software requirements information, or service.	\${nodeText.noSymptomCode}	
7.	To troubleshoot this issue completely, you need the following known-good parts: <ul style="list-style-type: none"><li>• I/O board</li><li>• I/O board flex cable</li><li>• logic board</li></ul>	Yes	Go to step 8.	\${nodeText.yesSymptomCode}	
	Do you have these parts immediately available?	No	Replace I/O board. Verify issue resolved.	M09	OTHER BOARD
8.	Substitute a known-good I/O board, visually inspecting connectors for damage. Reassemble and retest.	Yes	Replace I/O board. Verify issue resolved.	M09	OTHER BOARD
	Can user's external display audio be enabled and sound heard?	No	Go to step 9.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
9.	<p>Reinstall the user's I/O board. Substitute a known-good I/O board flex cable, visually inspecting connectors for damage. Reassemble and retest.</p> <p>Can user's external display audio be enabled and sound heard?</p>	Yes	Replace I/O board flex cable. Verify issue resolved.	X03	INTERNAL CABLE
		No	Go to step 10.	\${nodeText.noSymptomCode}	
10.	<p>Reinstall the user's I/O board flex cable. Substitute a known-good logic board and retest.</p> <p>Can user's external display audio be enabled and sound heard?</p>	Yes	Replace logic board. Verify issue resolved.	M09	MLB
		No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support or a multiple part repair.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	M99	
11.	<p>Play known-good audio file/source and verify sound output to all speakers is audible.</p> <p>Is issue resolved?</p>	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support or a multiple part repair.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	X99	

# No Video to External Display

## Unlikely causes:

AC Inlet, DIMM Mechanism, Exhaust Manifold, Fan, Fan Flex Cable, Flash Storage, Graphics Board A, Housing, Housing Lock Switch, Inlet, Interposer Board, Interposer board flex cable, Interposer Board Cover, Memory DIMM, Power Supply, Roof, Wireless Card.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>External display is not detected when connected to computer</li><li>External display does not show any video</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>Connect known-good, compatible external display to computer's video out port. Review article <a href="#">HT201853: About Apple video adapters and cables</a> to help identify which adapters can be used with this computer model.</li><li>Verify that the user is using a supported display configuration. Refer to article <a href="#">HT202801: Use multiple displays with your Mac Pro (Late 2013)</a> to identify compatible display configurations.</li><li>If using an Apple Thunderbolt Display, review article <a href="#">HT204154: Thunderbolt ports and displays: Frequently asked questions (FAQ)</a> to verify computer supports it and has latest Thunderbolt firmware version installed.</li><li>If using an HDMI TV or display, verify the correct HDMI input is selected on the display before starting the computer.</li><li>Review article <a href="#">HT201177: Get help with video issues on external displays connected to your Mac</a> for common causes of video issues.</li><li>Reset PRAM by holding down Command-Option-P-R keys while rebooting, until you hear the startup sound for the second time. Refer to article <a href="#">HT204063: How to Reset NVRAM on your Mac</a>.</li><li>If using with a computer in target display mode, review article <a href="#">HT204592: Use your iMac as a display with Target Display Mode</a>.</li><li>If using a Mini DisplayPort adapter, review article <a href="#">HT204149: Apple Mini DisplayPort adapters: Frequently asked questions (FAQ)</a>.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	Connect a known-good, compatible display to every video port, including HDMI. Use known-good video adapters as necessary.	Yes	Go to step 2.	\${nodeText.yesSymptomCode}	
	Does video output to any port?	No	Go to step 5.	\${nodeText.noSymptomCode}	
2.	Inspect non-functioning video out port for dust, debris, damage, or bent pins that might cause display cable to make insufficient contact. Use compressed air to remove any debris.	Yes	Go to step 3.	\${nodeText.yesSymptomCode}	
	Is video out port damaged?	No	Replace I/O board. Verify issue resolved.	M03	OTHER BOARD

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
3.	Inspect logic board, video out port, and enclosure for dents, scratches, or other indications of impact or abuse.  Does accidental damage appear to be cause of issue?	Yes	Go to step 4.	<code> \${nodeText.yesSymptomCode}</code>	
		No	Replace I/O board. Verify issue resolved.	M24	OTHER BOARD
4.	Inform user that computer failures due to accidental damage are not covered.  Does user want to proceed with out-of-warranty repair?	Yes	Replace I/O board. Verify issue resolved.	M24	OTHER BOARD
		No	Issue resolved. Return computer to customer using correct positioning.	<code> \${nodeText.noSymptomCode}</code>	
5.	Some Mac Pro models with D500 or D700 graphics cards that were manufactured in early 2015 are eligible for graphics board replacements under the Mac Pro Repair Extension Program for Video Issues.  See <a href="#">OP1611: Mac Pro Repair Extension Program for Video Issues</a> or <a href="#">RS192: Mac Pro Repair Extension Program for Video Issues</a> to verify the eligibility of this unit.  Does this unit qualify for the graphics card quality program?	Yes	Replace both graphics board A and graphics board B. Verify issue resolved.	Z77	STANDALONE CARD
		No	Go to step 6.	<code> \${nodeText.noSymptomCode}</code>	
6.	To troubleshoot this issue completely, the following known-good parts are required. <ul style="list-style-type: none"><li>• graphics board B</li><li>• graphics board flex cable</li><li>• I/O board</li><li>• I/O board flex cable</li><li>• logic board</li><li>• CPU riser card</li></ul> Do you have immediate access to each of these known-good parts?	Yes	Go to step 7.	<code> \${nodeText.yesSymptomCode}</code>	
		No	Replace graphics board B. Verify issue resolved.	M03	STANDALONE CARD
7.	Substitute a known-good graphics board B. Reassemble unit and turn on.	Yes	Replace graphics board B. Verify issue resolved.	M03	STANDALONE CARD
	Does video output from any port?	No	Go to step 8.	<code> \${nodeText.noSymptomCode}</code>	
8.	Reinstall customer's graphics board B, substituting a known-good graphics board flex cable between graphics board B and the logic board. Inspect all connectors for damage. Reassemble the unit and turn on.  Does video output from any port?	Yes	Replace graphics board flex cable. Verify issue resolved.	X03	INTERNAL CABLE
		No	Go to step 9.	<code> \${nodeText.noSymptomCode}</code>	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
9.	<p>Reinstall customer's graphics board flex cable. Substitute a known-good I/O board. Reassemble unit and turn on.</p> <p>Does video output from any port?</p>	Yes	Replace I/O board. Verify issue resolved.	M03	OTHER BOARD
		No	Go to step 10.	\$(nodeText.noSymptomCode)	
10.	<p>Reinstall customer's I/O board, substituting a known-good I/O board flex cable. Inspect all connectors for damage. Reassemble the unit and turn on.</p> <p>Does video output from any port?</p>	Yes	Replace I/O board flex cable. Verify issue resolved.	X03	INTERNAL CABLE
		No	Go to step 11.	\$(nodeText.noSymptomCode)	
11.	<p>Reinstall customer's I/O board flex cable. Substitute a known-good logic board. Reassemble unit and turn on.</p> <p>Does video output from any port?</p>	Yes	Replace logic board. Verify issue resolved.	M03	MLB
		No	Go to step 12.	\$(nodeText.noSymptomCode)	
12.	<p>Reinstall customer's logic board. Substitute a known-good CPU riser card. Reassemble unit and turn on.</p> <p>Does video output from any port?</p>	Yes	Replace CPU riser card. Verify issue resolved.	M03	OTHER BOARD
		No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact ACS for additional support or a multiple-part repair.</p> <p>Click the Help button in the GSX toolbar, then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	M99	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
13.	Connect known-good, compatible display to computer and verify following: <ul style="list-style-type: none"><li>• Display is functional at computer startup.</li><li>• Display is functional after computer is put to sleep and awakened.</li><li>• Other display features are functional (depending on display model: USB, audio, Ethernet, and so forth).</li></ul> Test all Thunderbolt and HDMI ports.  Is issue resolved?	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.  Click the Help button in the GSX toolbar, then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	M99	

# Thunderbolt Cable Connectivity Issues

## Unlikely causes:

There are no unlikely causes for this issue.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• Unable to access Thunderbolt peripherals.</li><li>• Thunderbolt shows no connection.</li><li>• Slow Thunderbolt performance.</li></ul> <p><b>Note:</b> These symptoms address issues with the Thunderbolt cable, not the computer's Thunderbolt port. If you suspect an issue with the computer after attempting Quick Check steps that follow, please back up and click on the "Troubleshoot another issue" button to select a functional area and issue that addresses issues with computer's Thunderbolt port instead.</p> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. Check manufacturer's minimum system requirements for connectivity to user's Thunderbolt peripheral. Refer to article <a href="#">HT201164: About Thunderbolt to Thunderbolt cable (2.0 m)</a>.</li><li>2. Check Thunderbolt presence in System Information. Complete following steps:<ul style="list-style-type: none"><li>◦ Connect user's Thunderbolt cable to available Thunderbolt port on user's computer or known-good computer supporting Thunderbolt.</li><li>◦ Connect opposite end of user's Thunderbolt cable to known-good Thunderbolt peripheral, such as:<ul style="list-style-type: none"><li>▪ Known-good computer supporting Thunderbolt target disk mode</li><li>▪ Apple Thunderbolt Display</li><li>▪ Other known-good Thunderbolt peripheral</li></ul></li><li>◦ Power on connected equipment and start up user's computer.</li><li>◦ Launch System Information. Verify computer's Thunderbolt port and cable connection status appear in System Information &gt; Hardware &gt; Thunderbolt. Link status should be: 2 (connected), not 7 (not connected).</li></ul></li><li>3. Reverse Thunderbolt cable. Connect other end of cable to user's computer. Repeat step 2 above to check for Thunderbolt presence.</li><li>4. Disconnect user's Thunderbolt cable and reconnect to another available Thunderbolt port on user's computer (if available). Repeat step 2 to check for Thunderbolt presence.</li><li>5. Substitute known-good Thunderbolt to Thunderbolt cable (2.0 m). Repeat step 2 to check for Thunderbolt presence.</li><li>6. Shut down user's computer, wait a few seconds, then restart it. Repeat step 2 to check for Thunderbolt presence.</li><li>7. Refer to article <a href="#">HT204319: OS X versions and builds included with Mac computers</a> to make sure system build is correct for this computer model.</li><li>8. Reset PRAM by holding down Command-Option-P-R keys while rebooting, until you hear the startup sound for the second time. Repeat step 2 to check for Thunderbolt presence.</li><li>9. Check for and apply the latest software and firmware updates. Repeat step 2 to check for Thunderbolt presence.</li></ol>

## Deep Dive

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
	Inspect both Thunderbolt cable connectors for dust, debris, damage, bent pins, or other indications of accidental damage. Use compressed air to remove debris.	Yes	Go to step 2.	\${nodeText.yesSymptomCode}	
1.	Closely inspect cable for signs of damage, excessive wear, kinks, breaks, bends, knots, being wound too tight, etc.  Did you find any damaged components?	No	Go to step 3.	\${nodeText.noSymptomCode}	
2.	Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.  Refer to article <a href="#">OP18: SERVICE: Flat Rate and Accidental Damage Repair Pricing for Mail-In Mac Products</a> .  Does user want to proceed with out-of-warranty repair?	Yes	Replace Thunderbolt cable. Verify issue resolved.	X26	EXTERNAL CABLE
3.	Inspect user's Thunderbolt cable connectors, and cable itself, for signs of excessive and/or unusual heat dissipation during operation.  Perform this check only after cable has been connected to a powered computer port for at least two minutes.  Did you find any signs of excessive heat in any part of the Thunderbolt cable or connector ends?	No	Issue resolved. Return computer to user using correct positioning.	\${nodeText.noSymptomCode}	
4.	Verify connected Thunderbolt peripheral is recognized by computer when connected by user's Thunderbolt cable.  Is issue resolved?	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	<b>ESCALATION REQUIRED.</b> Contact ACS for additional support or a multiple-part repair.  Click the Help button in the GSX toolbar, then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	X99	

# Thunderbolt FireWire Adapter Connectivity Issues

## Unlikely causes:

There are no unlikely causes for this issue.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• No FireWire port present.</li><li>• Unable to access FireWire resources.</li><li>• FireWire shows no connection.</li><li>• Slow FireWire performance.</li></ul> <p><b>Note:</b> These symptoms address issues with the Thunderbolt FireWire Adapter, not the computer's Thunderbolt port. If you suspect an issue with the computer after attempting Quick Check steps that follow, please back up and click on "Troubleshoot another issue" button to select a functional area and issue that addresses issue with computer's Thunderbolt port instead.</p> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. Open System Information. Verify computer's FireWire port presence in System Information &gt; Hardware &gt; FireWire. Verify Thunderbolt FireWire Adapter presence in System Information &gt; Hardware &gt; Thunderbolt.</li><li>2. Try known-good Thunderbolt FireWire Adapter, FireWire hardware and cable with user's computer.</li><li>3. Using known-good Thunderbolt FireWire Adapter, FireWire hardware and cable, start up computer using OS X Recovery or an up-to-date, bootable OS X volume. Hold down Command-R during startup to restart from the recovery partition. See article <a href="#">HT201314: OS X: About OS X Recovery</a>. Repeat step 1 above to check for Thunderbolt and FireWire presence.</li><li>4. Verify bus-powered FireWire devices are receiving adequate power from computer. Refer to article <a href="#">HT201338: Apple Thunderbolt Adapters: Frequently asked questions (FAQ)</a>.</li><li>5. Check manufacturer's minimum system requirements for device. Refer to article <a href="#">PH19097: If a FireWire device isn't working</a>.</li><li>6. Refer to article <a href="#">HT204319: OS X versions and builds included with Mac computers</a> to make sure system build is correct for this computer model.</li><li>7. Reset PRAM by holding down Command-Option-P-R keys while rebooting, until you hear the startup sound for the second time.</li><li>8. Check for and apply the latest software and firmware updates.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	Inspect Thunderbolt FireWire Adapter connectors, cable, and body for dust, debris, damage, bent pins, or other indications of accidental damage. Use compressed air to remove debris.  Did you find any damaged components?	Yes  No	Go to step 2.  Go to step 3.	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
2.	Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.  Refer to article <a href="#">OP18: SERVICE: Flat Rate and Accidental Damage Repair Pricing for Mail-In Mac Products</a> .  Does user want to proceed with out-of-warranty repair?	Yes  No	Replace Thunderbolt FireWire Adapter. Verify issue resolved.  Issue resolved. Return computer to user using correct positioning.	X03  \${nodeText.noSymptomCode}	EXTERNAL CABLE

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
3.	<p>Connect user's Thunderbolt FireWire Adapter to an available Thunderbolt port on user's computer. Start up computer completely and launch System Information.</p> <p>Verify FireWire port presence in System Information &gt; Hardware &gt; FireWire.</p> <p>Verify Thunderbolt FireWire Adapter presence in System Information &gt; Hardware &gt; Thunderbolt.</p> <p>Does user's Thunderbolt FireWire Adapter appear in both areas of System Information?</p>	Yes  No	<p>Go to step 6.</p> <p>Go to step 4.</p>	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
4.	<p>To troubleshoot this issue completely, a known-good Thunderbolt FireWire Adapter is required.</p> <p>Do you have immediate access to a known-good Thunderbolt FireWire Adapter?</p>	Yes  No	<p>Go to step 5.</p> <p>Replace Thunderbolt FireWire Adapter. Verify issue resolved.</p>	\${nodeText.yesSymptomCode}  X03	EXTERNAL CABLE
5.	<p>Substitute a known-good Thunderbolt FireWire Adapter.</p> <p>Repeat System Information presence checks from previous steps using user's computer.</p> <p>Does known-good Thunderbolt FireWire Adapter now appear in both areas of System Information?</p>	Yes  No	<p>Replace Thunderbolt FireWire Adapter. Verify issue resolved.</p> <p><b>ESCALATION REQUIRED.</b></p> <p>Contact ACS for additional support or a multiple-part repair.</p> <p>Click the Help button in the GSX toolbar, then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	X03  X99	EXTERNAL CABLE

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
6.	To continue troubleshooting this issue, the following known-good parts are required: <ul style="list-style-type: none"><li>• FireWire 400/800 device, for example, hard drive or camera</li><li>• FireWire 800 cable, or FireWire 800-to-400 adapter with FireWire cable</li></ul> Do you have immediate access to each of these known-good parts?	Yes	Go to step 7.	\${nodeText.yesSymptomCode}	
		No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.  Click the Help button in the GSX toolbar, then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	X99	
7.	Connect user's Thunderbolt FireWire Adapter to an available Thunderbolt port on user's computer. Connect adapter's FireWire port to a known-good, bus-powered FireWire device with a known-good FireWire cable or adapter/cable combination.	Yes	Go to step 10.	\${nodeText.yesSymptomCode}	
	Start up computer. Verify FireWire device mounts to desktop or is available in an application that supports the device, for example, iMovie, QuickTime, or Photo Booth.  Does known-good FireWire device/cable combination mount to desktop or appropriate application?	No	Go to step 8.	\${nodeText.noSymptomCode}	
8.	To troubleshoot this issue completely, a known-good Thunderbolt FireWire Adapter is required.  Do you have immediate access to a known-good Thunderbolt FireWire Adapter?	Yes	Go to step 9.	\${nodeText.yesSymptomCode}	
		No	Replace Thunderbolt FireWire Adapter. Verify issue resolved.	X03	EXTERNAL CABLE

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
	Substitute a known-good Thunderbolt FireWire Adapter.	Yes	Replace Thunderbolt FireWire Adapter. Verify issue resolved.	X03	EXTERNAL CABLE
9.	Using same computer, cable, and external FireWire device, start up computer. Verify FireWire device mounts to desktop or is available in an application that supports the device, for example, iMovie, QuickTime, or Photo Booth.	No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.  Click the Help button in the GSX toolbar, then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	X99	
	Does known-good FireWire device/cable combination now mount to desktop or appropriate application?				
10.	Connect user's Thunderbolt FireWire Adapter to an available Thunderbolt port on user's computer. Connect user's FireWire cable or adapter/cable combination to known-good FireWire device and user's Thunderbolt FireWire Adapter.	Yes	Go to step 11.	\${nodeText.yesSymptomCode}	
	Start up computer. Verify FireWire device mounts to desktop or is available in an application that supports the device.	No	Advise user to replace their FireWire adapter and/or FireWire cable set.	\${nodeText.noSymptomCode}	
	Does known-good FireWire device mount to desktop with user's cable?				
11.	Connect user's FireWire device and cable or adapter/cable combination.	Yes	Issue resolved. Verify resolution.	\${nodeText.yesSymptomCode}	
	Start up computer. Verify FireWire device mounts to desktop or is available in an application that supports the device, for example, iMovie, QuickTime, or Photo Booth.	No	Review article <a href="#">PH19097: If a FireWire device isn't working with user</a> . Check manufacturer's minimum system requirements for device. Verify issue resolved.	\${nodeText.noSymptomCode}	
	Does user's FireWire device/cable combination mount to desktop or appropriate application?				

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
12.	<p>Verify connected FireWire device is recognized by computer.</p> <p>Is issue resolved?</p>	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact ACS for additional support or a multiple-part repair.</p> <p>Click the Help button in the GSX toolbar, then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	X99	

# Thunderbolt Port Not Recognized

## Unlikely causes:

AC Inlet, DIMM Mechanism, Exhaust Manifold, Fan, Fan Flex Cable, Flash Storage, Graphics Board A, Graphics Board B, Graphics Board Flex Cable, Housing, Housing Lock Switch, Inlet, Interposer Board, Interposer Board Cover, Interposer Board Flex Cable, Memory DIMM, Power Supply, Roof, Wireless Card.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>Computer does not recognize Thunderbolt devices.</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>Check System Information &gt; Hardware &gt; Thunderbolt to verify all Thunderbolt hardware is recognized. Mac Pro (Late 2013) contains three Thunderbolt controllers.</li><li>Try using a known-good Thunderbolt cable. See Apple Support article <a href="#">HT4614: About Thunderbolt to Thunderbolt cable (2 m)</a>.</li><li>Try using known-good Thunderbolt device or Thunderbolt-capable computer in target disk mode. Refer to <a href="#">PH13842: Transferring files between two computers using target disk mode</a>.</li><li>Refer to Apple Support article <a href="#">HT204154: Thunderbolt ports and displays: Frequently asked questions (FAQ)</a>.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	<p>Check Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> to verify system build is correct for this computer model. Correct build includes Thunderbolt drivers that match logic board Thunderbolt controller.</p> <p>Is proper OS X build installed?</p>	Yes	Go to step 2.	\${nodeText.yesSymptomCode}	
		No	Refer to Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> and reinstall correct OS X build for this computer model. Use Software Update to make sure newest revisions are installed. Verify issue resolved.	\${nodeText.noSymptomCode}	
2.	<p>Apply latest software and firmware updates. Check System Information &gt; Hardware &gt; Thunderbolt. If no device is connected, Thunderbolt controller info should list the following:</p> <ul style="list-style-type: none"><li>Three Thunderbolt controllers each with:<ul style="list-style-type: none"><li>unique user ID (<b>UID</b>)</li><li>firmware version</li><li><b>No devices connected</b> status, unless a Thunderbolt display is being used.</li></ul></li></ul> <p>Does System Information list all Thunderbolt hardware?</p>	Yes	Go to step 3.	\${nodeText.yesSymptomCode}	
		No	Go to step 4.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
3.	Connect a known-good Thunderbolt device using a known-good Thunderbolt cable. Refresh System Information. System Information > Hardware > Thunderbolt should list the following: <ul style="list-style-type: none"><li>• connected Thunderbolt device</li><li>• connected cable</li><li>• port status as <b>connected</b></li></ul> Does System Information list connected Thunderbolt cable and device?	Yes  No	Issue resolved. Verify resolution.  Go to step 5.	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
4.	Reset NVRAM by holding down Command-Option-P-R keys while rebooting, until you hear startup sound for the second time.  Does System Information list all Thunderbolt hardware?	Yes  No	Go to step 3.  Go to step 5.	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
5.	To troubleshoot this issue completely, the following known-good parts are required: <ul style="list-style-type: none"><li>• I/O board</li><li>• I/O board flex cable</li><li>• logic board</li><li>• CPU riser card</li></ul> Do you have immediate access to all of these parts?	Yes  No	Go to step 6.  Replace I/O board. Verify issue resolved.	\${nodeText.yesSymptomCode}  M33	OTHER BOARD
6.	Following take-apart instructions, reseat both sides of the I/O board flex cable. Reset NVRAM again and reboot to desktop. Check System Information to verify Thunderbolt hardware.  Does System Information list Thunderbolt hardware?	Yes  No	Issue resolved by reseating I/O board flex cable. Verify resolution.  Go to step 7.	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
7.	Substitute a known-good I/O board flex cable. Reset NVRAM again and reboot to desktop. Check System Information to verify Thunderbolt hardware.  Does System Information list Thunderbolt hardware?	Yes  No	Replace I/O board flex cable. Verify issue resolved.  Go to step 8.	X03  \${nodeText.noSymptomCode}	INTERNAL CABLE
8.	Replace the user's I/O board flex cable. Substitute a known-good I/O board. Reset NVRAM again and reboot to desktop. Check System Information to verify Thunderbolt hardware.  Does System Information list Thunderbolt hardware?	Yes  No	Replace I/O board. Verify issue resolved.  Go to step 9.	M33  \${nodeText.noSymptomCode}	OTHER BOARD

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
9.	Replace the user's I/O board. Substitute a known-good logic board. Reset NVRAM again and reboot to desktop. Check System Information to verify Thunderbolt hardware.	Yes	Replace logic board. Verify issue resolved.	M33	MLB
	Does System Information list Thunderbolt hardware?	No	Go to step 10.	\${nodeText.noSymptomCode}	
10.	Replace the user's logic board. Substitute a known-good CPU riser card. Reset NVRAM again and reboot to desktop. Check System Information to verify Thunderbolt hardware.	Yes	Replace CPU riser card. Verify issue resolved.	M33	MPU
		No	<b>ESCALATION REQUIRED.</b> Contact TSPS for additional support or a multiple part repair.  Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	M99	
11.	Check System Information to confirm Thunderbolt hardware is recognized and has a unique UID, most recent firmware version, and correct link status.  Is issue resolved?	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	<b>ESCALATION REQUIRED.</b> Contact TSPS for additional support or a multiple part repair.  Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	M99	

# Thunderbolt Target Disk Mode Issues

## Unlikely causes:

AC Inlet, DIMM Mechanism, Exhaust Manifold, Fan, Fan Flex Cable, Flash Storage, Graphics Board A, Graphics Board B, Graphics Board Flex Cable, Housing, Housing Lock Switch, Inlet, Interposer Board, Interposer Board Cover, Interposer Board Flex Cable, Logic Board, Memory DIMM, Power Supply, Roof, Wireless Card.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>Computer does not initiate Thunderbolt target disk mode connection.</li><li>Computer does not show Thunderbolt floating icon after holding down T key during startup.</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>Check for and apply latest software and firmware updates. Check Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> to make sure system build is correct for this computer model. Correct build includes Thunderbolt drivers that match logic board Thunderbolt controller.</li><li>Check System Information &gt; Hardware &gt; Thunderbolt to verify Thunderbolt hardware is recognized.</li><li>Review Apple Support article <a href="#">HT204154: Thunderbolt ports and displays: Frequently asked questions (FAQ)</a> to verify computer has latest Thunderbolt firmware version installed.</li><li>Confirm the system is not protected with a firmware password. See Apple support article <a href="#">TS3554: MacBook Air (Late 2010) and later, MacBook Pro (Early 2011) and later, iMac (Mid 2011) and later, Mac mini (Mid 2011), Mac Pro (Late 2013): Recovering a lost firmware password</a>.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	<p>Check Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> to make sure system build is correct for this computer model. Correct build includes Thunderbolt drivers that match logic board Thunderbolt controller.</p> <p>Is proper OS X build installed?</p>	Yes	Go to step 2.	\${nodeText.yesSymptomCode}	
		No	Refer to Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> and reinstall correct OS X build and USB drivers for this computer model. Use Software Update to make sure newest revisions are installed. Verify issue resolved.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
2.	<p>Check System Information &gt; Hardware &gt; Thunderbolt. If no device is connected, the following information should be listed:</p> <ul style="list-style-type: none"> <li>Three Thunderbolt controllers each with:           <ul style="list-style-type: none"> <li>unique user ID (<b>UID</b>)</li> <li>firmware version</li> <li><b>No devices connected</b> status, unless a Thunderbolt display is being used.</li> </ul> </li> </ul> <p>Does System Information list all Thunderbolt hardware?</p>	Yes  No	<p>Go to step 4.</p> <p>Go to step 3.</p>	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
3.	<p>Reset NVRAM by holding down Command-Option-P-R keys while rebooting, until you hear startup sound for the second time.</p> <p>Does System Information list all Thunderbolt hardware?</p>	Yes  No	<p>Go to step 4.</p> <p>Go to “Thunderbolt Port Not Recognized” troubleshooting flow.</p>	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
4.	<p>Inspect Thunderbolt port(s) on user's computer for physical damage, burnt connectors, or misalignment.</p> <p>Does Thunderbolt port show any damage?</p>	Yes  No	<p>Replace I/O board. Verify issue resolved.</p> <p>Go to step 5.</p>	M24  \${nodeText.noSymptomCode}	OTHER BOARD
5.	<p>To troubleshoot issue completely, the following known-good parts are required:</p> <ul style="list-style-type: none"> <li>Thunderbolt-capable Mac</li> <li>Thunderbolt to Thunderbolt cable (2 m)</li> </ul> <p>Do you have immediate access to each of these known-good parts?</p>	Yes  No	<p>Go to step 6.</p> <p><b>ESCALATION REQUIRED.</b></p> <p>Request TSPS help checking latest updates and information in System Information &gt; Hardware &gt; Thunderbolt.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	\${nodeText.yesSymptomCode}  X99	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
6.	<p>Start up known-good Thunderbolt-capable Mac in target disk mode by holding T key during startup. Connect known-good computer to user's computer using known-good Thunderbolt cable. Start up user's computer. Verify hard drive of known-good computer appears on desktop of user's computer.</p> <p>Verify all Thunderbolt ports on user's computer.</p> <p>Does hard drive on known-good Mac mount to user's computer while using known-good cable?</p>	Yes  No	<p>Go to step 8.</p> <p>Go to step 7.</p>	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
7.	<p>Verify System Information &gt; Hardware &gt; Thunderbolt on user's computer lists Thunderbolt connection and target disk mode information for known-good computer.</p> <p>Does System Information list Thunderbolt target disk mode information?</p>	Yes  No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support. Inform TSPS that user's computer cannot mount hard drive of known-good Mac in Thunderbolt target disk mode. But user's computer does show Thunderbolt connection in System Information.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p> <p>Replace I/O board. Thunderbolt hardware is present, but not fully functioning. Verify issue resolved.</p>	\${nodeText.yesSymptomCode}  M33	OTHER BOARD
8.	<p>Inspect user's Thunderbolt to Thunderbolt (2 m) cable for physical damage, such as contamination or burnt connectors on either end of cable.</p> <p>Is user's Thunderbolt cable damaged?</p>	Yes  No	<p>Create out-of-warranty repair for Thunderbolt to Thunderbolt (2 m) cable. Verify issue resolved.</p> <p>Go to step 9.</p>	X26  \${nodeText.noSymptomCode}	EXTERNAL CABLE

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
9.	Connect user's Thunderbolt to Thunderbolt cable (2 m) to both computers. Start up known-good computer in target disk mode by holding down T key during startup. Reboot user's computer and verify known-good computer's hard drive mounts to desktop of user's computer.  Does known-good computer's drive mount to user's desktop?	Yes	Go to step 10.	\${nodeText.yesSymptomCode}	
		No	Replace Thunderbolt to Thunderbolt cable (2 m). Verify issue resolved.	X26	EXTERNAL CABLE
10.	Continue verification of user's Thunderbolt to Thunderbolt cable (2 m) cable. Start up user's computer in target disk mode by holding down T key during startup. Reboot known-good computer. Verify user's internal hard drive mounts to desktop of known-good computer.  Does user's internal hard drive mount to known-good computer's desktop?	Yes	User's Mac Pro and Thunderbolt cable pass inspections. Thunderbolt target disk mode issue resolved. Verify resolution.	\${nodeText.yesSymptomCode}	
		No	Go to step 11.	\${nodeText.noSymptomCode}	
11.	Substitute known-good Thunderbolt to Thunderbolt cable (2 m) between known-good computer and user's computer. Restart user's computer in target disk mode by holding down T key during startup. Reboot known-good computer and verify user's computer's hard drive mounts to desktop of known-good computer.  Does user's computer's drive mount to known-good computer's desktop?	Yes	Replace Thunderbolt to Thunderbolt cable (2 m). Verify issue resolved.	X26	EXTERNAL CABLE
		No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support. Inform TSPS that user's computer can mount known-good computer's hard drive in Thunderbolt target disk mode, but cannot function as a target disk on other computers.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	M99	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
12.	<p>Check System Information to verify Thunderbolt hardware is recognized and has a unique UID, most recent firmware version, and correct link status.</p> <p>Is issue resolved?</p>	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support or a multiple part repair.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	M99	

# USB Port Not Recognized

## Unlikely causes:

AC Inlet, DIMM Mechanism, Exhaust Manifold, Fan, Fan Flex Cable, Flash Storage, Graphics Board A, Graphics Board B, Graphics Board Flex Cable, Housing, Housing Lock Switch, Inlet, Interposer Board, Interposer Board Cover, Interposer Board Flex Cable, Memory DIMM, Power Supply, Roof, Wireless Card.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>Standard USB devices not recognized or not powered.</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>Disconnect all USB devices.</li><li>Check if user's USB device requires specific driver to function properly.</li><li>Check for and apply latest software and firmware updates.</li><li>Reset NVRAM by holding down Command-Option-P-R keys while rebooting, until you hear the startup sound for the second time. Refer to Apple Support article <a href="#">HT1379: About NVRAM and PRAM</a>.</li><li>Check System Information &gt; Hardware &gt; USB to verify computer recognizes internal USB devices, such as Bluetooth.</li><li>Test each USB port using known-good Apple wired keyboard or mouse.</li><li>If customer is using powered USB hub, verify hub is powered with compatible power supply.</li><li>Refer to Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a> and verify correct version and build of OS X is installed.</li><li>Check Apple Support article <a href="#">HT5172: Using USB 3 devices on Mac computers FAQ</a> for common questions regarding USB 3.0.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	Disconnect all USB devices. Verify whether known-good Apple wired keyboard or mouse functions correctly and is recognized in System Information > Hardware > USB.  Is known-good Apple USB device functional and recognized?	Yes	Go to step 2.	\${nodeText.yesSymptomCode}	
		No	Go to step 4.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
2.	<p>Remove all other high power USB devices. Connect a known-good, high-powered USB device (such as iPad, iPhone, or bus-powered USB hard drive) to one of computer's USB ports.</p> <p>In System Information &gt; Hardware &gt; USB, <b>Current Available (mA)</b> should list 500mA for USB 2.0 devices and earlier and 900mA for USB 3.0 devices. Certain devices (such as iPad) may request up to 1600mA of extra operating current.</p> <p>Repeat the process to check every port USB port.</p> <p>Does Extra Operating Current appear in System Information for each port?</p>	Yes	Go to step 3.	\${nodeText.yesSymptomCode}	
		No	Go to step 4.	\${nodeText.noSymptomCode}	
3.	<p>USB 3.0 devices use different pins for connections than USB 2.0/1.1 devices. If USB 3.0 devices are not recognized, it may indicate an issue with the connectors on the I/O board.</p> <p>Connect a known-good USB 3.0 device to one of the computer's USB ports.</p> <p>In System Information &gt; Hardware &gt; USB, verify that the device appears under the <b>USB 3.0 SuperSpeed Bus</b>, and is functioning as expected.</p> <p>Is a known-good USB 3.0 device recognized and functioning as expected?</p>	Yes	<p>Issue isolated to user's USB device. Advise the user of the following:</p> <ul style="list-style-type: none"> <li>• Contact USB device manufacturer for support.</li> <li>• Verify system requirements and Mac compatibility.</li> <li>• Find out if device requires additional software.</li> </ul>	\${nodeText.yesSymptomCode}	
		No	Go to step 4.	\${nodeText.noSymptomCode}	
4.	<p>Continue to use the same known-good USB device. Start up computer using known-good up-to-date, bootable OS X volume.</p> <p>Verify known-good USB device functions correctly and is recognized in System Information &gt; Hardware &gt; USB.</p> <p>Is known-good Apple USB device functional and recognized?</p>	Yes	Go to step 5.	\${nodeText.yesSymptomCode}	
		No	Go to step 7.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
5.	Use Disk Utility to repair file directory on internal hard drive. Restart. Verify known-good USB device functions correctly and is recognized in System Information > Hardware > USB.	Yes	Issue resolved by directory repair in Disk Utility. Verify resolution.	\${nodeText.yesSymptomCode}	
	Is known-good Apple USB device functional and recognized?	No	Go to step 6.	\${nodeText.noSymptomCode}	
6.	Restore OS X software from Internet. Refer to Apple Support article <a href="#">HT201314: About OS X Recovery</a> for OS X recovery options and requirements.	Yes	Issue resolved by restoring OS X software. Verify resolution.	\${nodeText.yesSymptomCode}	
			<b>ESCALATION REQUIRED.</b>  Contact TSPS for additional support or a multiple part repair.  Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	P99	
7.	Inspect USB ports for lint, debris, or other foreign material. Remove debris with an anti-static brush.	Yes	Issue resolved. Return computer to user, explaining how debris in USB port caused issue and what to do to prevent contamination in future.	\${nodeText.yesSymptomCode}	
	Is known-good Apple USB device functional and recognized?	No	Go to step 8.	\${nodeText.noSymptomCode}	
8.	To troubleshoot this issue completely, you need the following known-good parts: <ul style="list-style-type: none"><li>• I/O board</li><li>• I/O board flex cable</li><li>• logic board</li></ul> Do you have these parts immediately available?	Yes	Go to step 9.	\${nodeText.yesSymptomCode}	
	No	Replace I/O board. Verify issue resolved.	M38	OTHER BOARD	
9.	Disconnect and carefully inspect all pins on the I/O board flex cable as well as the mating connectors on the I/O board and logic board.	Yes	Go to step 10.	\${nodeText.yesSymptomCode}	
	Is there any pin or cable damage?	No	Go to step 11.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
		Yes	Replace I/O board flex cable. Verify issue resolved.	X03	INTERNAL CABLE
10.	Damage to multiple parts requires an escalation to Apple TSPS for repair approval.  Is damage limited to the I/O board flex cable?	No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support or a multiple part repair.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	P99	
11.	Replace the user's I/O board flex cable and try substituting a known-good I/O board.  Is a known-good Apple USB device functional and recognized?	Yes	Replace I/O board. Verify issue resolved.	M38	OTHER BOARD
12.	Try substituting a known-good I/O board flex cable.  Is a known-good Apple USB device functional and recognized?	No	Go to step 12.	\$(nodeText.noSymptomCode)	
13.	Replace the user's I/O board and try substituting a known-good logic board.  Is a known-good Apple USB device functional and recognized?	Yes	Replace logic board. Verify issue resolved.	M38	MLB
		No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support or a multiple part repair.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	M99	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
		Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
14.	<ul style="list-style-type: none"> <li>Verify known-good USB device is functional and recognized.</li> <li>Check System Information for correct power allocation to USB device.</li> </ul> <p>Is issue resolved?</p>	No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support or a multiple part repair.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	M99	

# External USB ODD Noisy

## Unlikely causes:

Not relevant

## Quick Check

Symptoms	Quick Check
<p><b>Note:</b> Be sure you understand what type of optical drive noise you should be concerned about, and what noises you can safely ignore. The following lists help distinguish normal, functional optical drive sounds from noises that may indicate drive malfunction.</p> <p>Typical noises include sounds made during the following activities:</p> <ul style="list-style-type: none"><li>• Waking the computer from sleep</li><li>• Burning a CD or DVD</li><li>• Inserting a disc</li><li>• Ejecting a disc</li><li>• Importing ("ripping") an audio CD in iTunes</li><li>• Playing a DVD</li><li>• Accessing an idle disc</li></ul> <p>Abnormal noises include the following:</p> <ul style="list-style-type: none"><li>• Grinding</li><li>• Loud, repeated clicking</li><li>• Scraping sounds</li><li>• Constantly seeking or cycling the eject mechanism with no disc inserted</li></ul> <p>Listen closely in a quiet environment for the following:</p> <ul style="list-style-type: none"><li>• Noise during start up</li><li>• Noise during operation</li><li>• Noise when drive is copying or saving data</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. Verify that user's issue involves only abnormal sounds, as defined in symptoms.</li><li>2. Make sure the Apple USB SuperDrive is sitting flat on a surface with the silver top facing upward. Do not attempt to operate the SuperDrive on its side or upside-down.</li><li>3. Compare optical drive noise to a known-good equivalent Apple USB SuperDrive. Use sound samples in Apple Support article <a href="#">HT1723: Noises from the optical drive</a> to compare.</li><li>4. Verify that noise issue does not involve waking the computer. When starting up or waking from sleep, the Apple USB SuperDrive may make unfamiliar noises.</li><li>5. Test user's optical disc in a known-good drive to rule out a media issue. Verify that disc size and shape are within specification in Apple Support article <a href="#">HT2801: Apple Computers: Troubleshooting the slot-loading SuperDrive</a>.</li><li>6. Test Apple USB SuperDrive with known-good discs. Verify that media is free to spin without scraping edge or surface of media.</li><li>7. Verify if noise during seek activity is excessive. Seek noise should subside once disc is mounted.</li><li>8. Verify if disc spin noise is excessive. Disc spin should cease 30 seconds after mounting disc in the Finder.</li><li>9. Inspect the Apple USB SuperDrive drive slot for obstructions (stuck disc, etc.)</li><li>10. Inspect the Apple USB SuperDrive USB cable and USB connector for damage.</li><li>11. The Apple USB SuperDrive is designed exclusively for use with MacBook Air, MacBook Pro (Retina, Mid 2012 or later), Mac mini (Early 2009 or later), and Mac Pro (Late 2013). USB ports on other computers may not provide sufficient power to enable proper operation of the drive. Verify that the user's configuration is supported.</li><li>12. The Apple USB SuperDrive must be plugged directly into the computer's USB port, and cannot be used while connected to a USB hub.</li><li>13. Leave the Apple USB SuperDrive connected to the user's computer and restart the computer while pressing the mouse button or keyboard Eject key to cycle the optical drive.</li><li>14. If the user is experiencing an issue using the Apple USB SuperDrive with Microsoft Windows, try starting up the computer with the Apple USB SuperDrive already plugged in.</li><li>15. Reset PRAM by holding down Command-Option-P-R keys while rebooting, until you hear the startup sound for the second time.</li></ol>

## Deep Dive

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
1.	Verify if Apple USB SuperDrive is constantly seeking or cycling the eject mechanism with no optical disc inserted. Optical drive should perform only one reset sequence and then rest idly, ready for media.  Does optical drive spin, seek, and/or reset continuously without an optical disc inserted?	Yes	Replace the Apple USB SuperDrive. Verify issue resolved.	J04	OPTICAL
		No	Go to step 2.	\${nodeText.noSymptomCode}	
2.	Closely inspect the user's Apple USB SuperDrive to determine if a disc or other debris is stuck inside.  Is a disc or other debris stuck in the drive?	Yes	Go to step 3.	\${nodeText.yesSymptomCode}	
		No	Go to step 5.	\${nodeText.noSymptomCode}	
3.	If the user's Apple USB SuperDrive has a rounded USB connector, it can be opened to remove the stuck disc or debris.  If the user's Apple USB SuperDrive has a squared-off USB connector, it cannot be opened.  Which type of USB connector does user's Apple USB SuperDrive have?	Round	Go to step 4.	\${nodeText.yesSymptomCode}	OPTICAL
		Square	Replace the Apple USB SuperDrive. Verify issue resolved.	J05	
4.	Refer to Apple Support article <a href="#">RP451: Apple USB SuperDrive</a> to open the drive enclosure and remove any stuck disc, dust, debris, or other foreign materials.  Retest Apple USB SuperDrive by inserting, mounting and ejecting a known-good optical disc.  Is optical drive function fully restored?	Yes	Issue resolved by removing stuck disc or debris from drive. Verify resolution.	\${nodeText.yesSymptomCode}	OPTICAL
		No	Replace the Apple USB SuperDrive. Verify issue resolved.	J05	
5.	Insert a known-good optical disc, then eject the disc while listening carefully to Apple USB SuperDrive during disc handling. Eject noise should consist of a pop as the disc is released from the motor hub, then a gear sound as the motor pushes the disc out of the slot. Repeat test several times.  Is disc eject noise abnormal and excessive over multiple trials?	Yes	Replace the Apple USB SuperDrive. Verify issue resolved.	J04	OPTICAL
		No	Go to step 6.	\${nodeText.noSymptomCode}	
6.	Disconnect the Apple USB SuperDrive and retest for computer noise.  Has the noise been eliminated?	Yes	Go to step 7.	\${nodeText.yesSymptomCode}	
		No	Go to "Noise / Hum / Vibration" troubleshooting flow.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
7.	To troubleshoot this issue completely, you will need an identical, known-good Apple USB SuperDrive with which to compare optical drive sounds.	Yes	Go to step 8.	\${nodeText.yesSymptomCode}	
	Do you have immediate access to a known-good Apple USB SuperDrive?	No	Replace the Apple USB SuperDrive. Verify issue resolved.	J04	OPTICAL
8.	Substitute a known-good Apple USB SuperDrive and retest.	Yes	Replace the Apple USB SuperDrive. Verify issue resolved.	J04	OPTICAL
	Has the noise been eliminated?	No	Go to “Noise / Hum / Vibration” troubleshooting flow.	\${nodeText.noSymptomCode}	
9.	Verify that the Apple USB SuperDrive does not make any abnormal noises.	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
	Is issue resolved?	No	Go to “Noise / Hum / Vibration” troubleshooting flow.	\${nodeText.noSymptomCode}	

# External USB ODD Not Recognized

## Unlikely causes:

There are no unlikely causes for this issue.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>Discs cannot be inserted.</li><li>Discs can be inserted, but are ejected immediately.</li><li>Discs can be inserted, but are ejected after drive has spun up for some seconds.</li><li>Discs can be inserted and ejected, but do not appear in the Finder.</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>Go to Finder Preferences &gt; General and make sure “CDs, DVDs, and iPods” is checked under “Show these items on the desktop.”</li><li>Make sure the Apple USB SuperDrive is sitting flat on a surface with the silver top facing upward. Do not attempt to operate the SuperDrive on its side or upside-down.</li><li>Inspect the Apple USB SuperDrive slot for obstructions (stuck disc, etc.)</li><li>Inspect the Apple USB SuperDrive USB cable and USB connector for damage.</li><li>The Apple USB SuperDrive must be plugged directly into the computer's USB port, and cannot be used while connected to a USB hub.</li><li>Leave the Apple USB SuperDrive connected to the user's computer and restart the computer while pressing the mouse button or keyboard Eject key to cycle the optical drive.</li><li>If the user is experiencing an issue using the Apple USB SuperDrive with Microsoft Windows, try starting the computer with the Apple USB SuperDrive already plugged in.</li><li>Refer to Apple Support article <a href="#">HT2801: Apple Computers: Troubleshooting the slot load optical disc drive</a>.</li><li>Connect a known-good Apple USB SuperDrive to user's computer. Attempt to use drive to verify computer's functionality separately from user's Apple USB SuperDrive.</li><li>Reset NVRAM by holding down Command-Option-P-R keys while rebooting, until you hear the startup sound for the second time. Refer to Apple Support article <a href="#">HT1379: About NVRAM and PRAM</a>.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	Connect the user's Apple USB SuperDrive to a known-good MacBook Air, MacBook Pro (Retina, Mid 2012 or later), Mac mini (Early 2009 or later), Mac Pro (Late 2013) and attempt to use it, to verify the drive's functionality separately from the user's computer.	Yes	Go to step 2.	\${nodeText.yesSymptomCode}	
	Check System Information > Hardware > USB device tree to verify the presence of the optical drive.  Does drive appear in System Information when connected to a known-good Mac?	No	Replace the Apple USB SuperDrive. Verify issue resolved.	J09	OPTICAL

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
	Connect the Apple USB SuperDrive to an available USB port on user's computer and start up computer. Check System Information > Hardware > USB device tree to verify the presence of the optical drive.	Yes	Go to step 3.	\${nodeText.yesSymptomCode}	
2.	Repeat this process using each USB port on the user's computer to verify all of the computer's USB ports are functioning.  Does drive appear in System Information when connected to every USB port?	No	Go to "USB Port Not Recognized" troubleshooting flow.	\${nodeText.noSymptomCode}	
3.	Attempt to insert a known-good, properly formatted CD or DVD disc into the user's Apple USB SuperDrive. Check if the disc auto-ejects either immediately or within a few seconds after the drive has spun up.  Does disc auto-eject shortly after insertion?	Yes	Replace the Apple USB SuperDrive. Verify issue resolved.	J01	OPTICAL
		No	Go to step 4.	\${nodeText.noSymptomCode}	
4.	After insertion, verify that the disc spins and the disc volume mounts in the Finder.  Does drive mount a known-good disc?	Yes	Go to step 5.	\${nodeText.yesSymptomCode}	
		No	Replace the Apple USB SuperDrive. Verify issue resolved.	J09	OPTICAL
5.	Check to see if the Apple USB SuperDrive properly mounts then reads both known-good CD and DVD media.  If only one type of media is recognized, there may be a laser issue.  Can drive read both media types?	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	Go to "External USB ODD Read-Write or Performance Issues" troubleshooting flow.	\${nodeText.noSymptomCode}	
6.	Insert, mount, and eject both a known-good CD and DVD.  Is issue resolved?	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	<b>ESCALATION REQUIRED.</b> Contact TSPS for additional support or a multiple part repair.  Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	J99	



# External USB ODD Read-Write or Performance Issues

## Unlikely causes:

Not relevant

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• Errors when writing to optical media</li><li>• Errors when reading from optical media</li><li>• Hangs when accessing or writing data</li><li>• Read or write speeds slower than expected</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. Test user's optical media in a known-good Apple USB Superdrive connected to a known-good computer.</li><li>2. Test known-good, compatible optical media in user's Apple USB SuperDrive connected to a known-good computer.</li><li>3. Go to System Information &gt; Hardware &gt; Disc Burning to compare actual disc burning specifications to user's expectations.</li><li>4. See Apple Support articles <a href="#">HT2543: About optical disc drive burning and write speeds</a> and <a href="#">HT2882: Factors that affect writing to or reading from optical media</a> to learn more about disc burning and how performance is affected by write speeds, media types, software and more.</li><li>5. Make sure the Apple USB SuperDrive is sitting flat on a surface with the silver top facing upward. Do not attempt to operate the SuperDrive on its side or upside-down.</li><li>6. Inspect the Apple USB SuperDrive drive slot for obstructions (stuck disc, etc.)</li><li>7. Inspect the Apple USB SuperDrive USB cable and USB connector for damage.</li><li>8. The Apple USB SuperDrive is designed exclusively for use with MacBook Air, MacBook Pro (Retina, Mid 2012 or later), Mac mini (Early 2009 or later), and Mac Pro (Late 2013). USB ports on other computers may not provide sufficient power to enable proper operation of the drive. Verify that the user's configuration is supported.</li><li>9. The Apple USB SuperDrive must be directly plugged into the computer's USB port, and cannot be used while connected to a USB hub.</li><li>10. Leave the Apple USB SuperDrive connected to the user's computer and restart the computer while pressing the mouse button or keyboard Eject key to cycle the optical drive.</li><li>11. If the user is experiencing an issue using the Apple USB SuperDrive with Microsoft Windows, try starting the computer with the Apple USB SuperDrive already plugged in.</li><li>12. Refer to Apple Support article <a href="#">HT2801: Apple Computers: Troubleshooting the slot load optical disc drive</a>.</li><li>13. Reset PRAM by holding down Command-Option-P-R keys while rebooting, until you hear the startup sound for the second time.</li></ol>

## Deep Dive

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
1.	<p>Connect user's Apple USB SuperDrive to an available USB port on the user's computer and start up computer. Insert media into the Apple USB SuperDrive and listen for scraping/scratching noises as the disc spins up. Eject the disc and examine its surface and edges for scrapes or scratches. Verify that the disc can spin without the optical drive scraping the edge or surface of the media.</p> <p>Does media spin freely in the drive?</p>	Yes	Go to step 2.	\${nodeText.yesSymptomCode}	
		No	Replace the Apple USB SuperDrive. Verify issue resolved.	J05	OPTICAL
2.	<p>Closely inspect the user's Apple USB SuperDrive to determine if a disc or other debris is stuck inside.</p> <p>Is a disc or other debris stuck in the drive?</p>	Yes	Go to step 3.	\${nodeText.yesSymptomCode}	
		No	Go to step 5.	\${nodeText.noSymptomCode}	
3.	<p>If the user's Apple USB SuperDrive has a rounded USB connector, it can be opened to remove the stuck disc or debris.</p> <p>If the user's Apple USB SuperDrive has a squared-off USB connector, it cannot be opened.</p> <p>Which type of USB connector does user's Apple USB SuperDrive have?</p>	Round	Go to step 4.	\${nodeText.yesSymptomCode}	
		Square	Replace the Apple USB SuperDrive. Verify issue resolved.	J05	OPTICAL
4.	<p>Refer to Apple Support article <a href="#">RP451: Apple USB SuperDrive</a> to open the drive enclosure and remove any stuck disc, dust, debris, or other foreign materials.</p> <p>Retest Apple USB SuperDrive by inserting, mounting and ejecting a known-good optical disc.</p> <p>Is optical drive function fully restored?</p>	Yes	Issue resolved by removing stuck disc or debris from drive. Verify resolution.	\${nodeText.yesSymptomCode}	
		No	Replace the Apple USB SuperDrive. Verify issue resolved.	J05	OPTICAL
5.	<p>Verify that the optical drive can properly read known-good CDs.</p> <p>Can optical drive read CDs?</p>	Yes	Go to step 7.	\${nodeText.yesSymptomCode}	
		No	Go to step 6.	\${nodeText.noSymptomCode}	
6.	<p>Check System Information &gt; Hardware &gt; USB device tree to verify the presence of the optical drive.</p> <p>Does optical drive appear in System Information?</p>	Yes	Go to step 8.	\${nodeText.yesSymptomCode}	
		No	Go to "External USB ODD Not Recognized" troubleshooting flow.	\${nodeText.noSymptomCode}	
7.	<p>Verify that the optical drive can properly read known-good DVDs.</p> <p>Can optical drive read DVDs?</p>	Yes	Go to step 8.	\${nodeText.yesSymptomCode}	
		No	Go to step 6.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
8.	Burn test data to CD and DVD media compatible with Apple USB SuperDrive. Verify that the burned media is recognized and readable by the drive.  Can optical drive read its own burned media?	Yes	Go to step 9.	\${nodeText.yesSymptomCode}	
		No	Replace the Apple USB SuperDrive. Verify issue resolved.	J03	OPTICAL
9.	To troubleshoot this issue completely, you will need an identical, known-good Apple USB SuperDrive with which to compare optical disc read and burn times.  Do you have immediate access to a known-good Apple USB SuperDrive?	Yes	Go to step 10.	\${nodeText.yesSymptomCode}	
		No	Replace the Apple USB SuperDrive. Verify issue resolved.	J07	OPTICAL
10.	Using the same media type and brand, compare read and burn times of the user's Apple USB SuperDrive connected to a known-good computer, against a known-good Apple USB SuperDrive connected to the user's computer.  Does user's drive have significantly longer read or burn times than the known-good drive?	Yes	Replace the Apple USB SuperDrive. Verify issue resolved.	J07	OPTICAL
		No	Issue resolved.	\${nodeText.noSymptomCode}	
11.	Test all Apple USB SuperDrive functions and drive performance to verify a successful repair.  Is issue resolved?	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	<b>ESCALATION REQUIRED.</b> Contact TSPS for additional support or a multiple part repair.  Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	J99	

# External USB ODD Rejects, Does Not Accept, or Does Not Eject Media

## Unlikely causes:

Not relevant

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• Cannot insert a disc into the drive.</li><li>• Cannot eject a disc from the drive.</li><li>• Drive ejects discs immediately after insertion.</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. Make sure the Apple USB SuperDrive is sitting flat on a surface with the silver top facing upward. Do not attempt to operate the SuperDrive on its side or upside-down.</li><li>2. Inspect the optical drive slot for obstructions (stuck disc, etc.)</li><li>3. Inspect the Apple USB SuperDrive USB cable and USB connector for damage.</li><li>4. The Apple USB SuperDrive is designed exclusively for use with MacBook Air, MacBook Pro (Retina, Mid 2012 or later) Mac mini (Early 2009 or later), or Mac Pro (Late 2013). USB ports on other computers may not provide sufficient power to enable proper operation of the drive. Verify that the user's configuration is supported.</li><li>5. The Apple USB SuperDrive must be directly plugged into the computer's USB port, and cannot be used while connected to a USB hub.</li><li>6. Leave the Apple USB SuperDrive connected to the user's computer and restart the computer while pressing the mouse button or keyboard Eject key to cycle the optical drive.</li><li>7. If the user is experiencing an issue using the Apple USB SuperDrive with Microsoft Windows, try starting the computer with the Apple USB SuperDrive already plugged in.</li><li>8. Refer to Apple Support article <a href="#">HT2801: Apple Computers: Troubleshooting the slot load optical disc drive</a>.</li><li>9. Connect the user's Apple USB SuperDrive to a known-good computer and attempt to use it, to verify the drive's functionality separately from the user's computer.</li><li>10. Connect a known-good Apple USB SuperDrive to the user's computer. Attempt to use the drive, to verify the computer's functionality separately from the user's Apple USB SuperDrive.</li><li>11. Reset NVRAM by holding down Command-Option-P-R keys while rebooting, until you hear the startup sound for the second time.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	Connect user's Apple USB SuperDrive to an available USB port on the user's computer and start up computer. Check System Information > Hardware > USB device tree to verify the presence of the optical drive.	Yes	Go to step 2.	\${nodeText.yesSymptomCode}	
	Does optical drive appear in System Information?	No	Go to "External USB ODD Not Recognized" troubleshooting flow.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
2.	Closely inspect the user's Apple USB SuperDrive to determine if a disc or other debris is stuck inside.  Is a disc or other debris stuck in the drive?	Yes	Go to step 3.	\${nodeText.yesSymptomCode}	
		No	Go to step 5.	\${nodeText.noSymptomCode}	
3.	If the user's Apple USB SuperDrive has a rounded USB connector, it can be opened to remove the stuck disc.  If the user's Apple USB SuperDrive has a squared-off USB connector, it cannot be opened.  Which type of USB connector does user's Apple USB SuperDrive have?	Round	Go to step 4.	\${nodeText.yesSymptomCode}	
		Square	Replace the Apple USB SuperDrive. Verify issue resolved.	J02	OPTICAL
4.	Refer to Apple Support article <a href="#">RP451: Apple USB SuperDrive</a> to open the drive enclosure and remove any stuck disc, dust, debris, or other foreign materials.	Yes	Issue resolved by removing stuck disc or debris from drive. Verify resolution.	\${nodeText.yesSymptomCode}	
	Retest Apple USB SuperDrive by inserting, mounting and ejecting a known-good optical disc.  Is optical drive function fully restored?	No	Replace the Apple USB SuperDrive. Verify issue resolved.	J02	OPTICAL
5.	Inspect the Apple USB SuperDrive enclosure bezel for damage. Check the bezel's slot clearance to verify if a known-good disc can fit through the drive bezel slot.  Is clearance in enclosure bezel slot sufficient for disc insertion?	Yes	Go to step 7.	\${nodeText.yesSymptomCode}	
		No	Go to step 6.	\${nodeText.noSymptomCode}	
6.	Closely inspect the entire Apple USB SuperDrive enclosure for dents, scratches, or other indications of impact or abuse.  Is insufficient clearance due to accidental damage?	Yes	Go to step 9.	\${nodeText.yesSymptomCode}	
		No	Replace the Apple USB SuperDrive. Verify issue resolved.	J01	OPTICAL
7.	Inspect the slot on the optical drive assembly for proper disc clearance.  Is clearance in optical drive slot sufficient for disc insertion?	Yes	Go to step 14.	\${nodeText.yesSymptomCode}	
		No	Go to step 8.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
	When a CD or DVD pops off the spindle inside an optical drive (usually due to impact to the drive) and remains in the drive mechanism, the loose disc prevents the slot from being able to open fully, creating a “closed condition.” Inspect the slot in the optical drive to determine if it is “closed” (not accepting discs).	Yes	Go to step 9.	\${nodeText.yesSymptomCode}	
8.	If the disc slot is closed, inspect the drive mechanism, especially the drive enclosure, for evidence of drop damage.  <b>Note: If the disc slot is closed, but there is no sign of accidental damage, choose "NO" to the question below.</b>  Is disc slot access closed due to accidental damage?	No	Go to step 10.	\${nodeText.noSymptomCode}	
9.	Inform user that computer failures due to accidental damage are not covered.  Discuss out-of-warranty repair options.  Does user want to proceed with out-of-warranty repair?	Yes	Replace the Apple USB SuperDrive. Verify issue resolved.	J05	OPTICAL
10.	Inspect the slot in the Apple USB SuperDrive to determine if it is “closed” (not accepting discs) because of a stuck disc.  Is disc slot access closed?	No	Issue resolved. Using proper positioning, return the computer to the user.	\${nodeText.noSymptomCode}	
11.	Make sure the optical drive assembly is mounted into the enclosure correctly and is properly aligned with the enclosure slot opening.  Is clearance in drive slot sufficient for disc insertion?	Yes	Go to step 14.	\${nodeText.yesSymptomCode}	
12.	If the user's Apple USB SuperDrive has a rounded USB connector, it can be opened to align the drive mechanism.  If the user's Apple USB SuperDrive has a squared-off USB connector, it cannot be opened.  Which type of USB connector does user's Apple USB SuperDrive have?	Round	Go to step 13.	\${nodeText.yesSymptomCode}	
		Square	Replace the Apple USB SuperDrive. Verify issue resolved.	J05	OPTICAL

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
13.	Refer to Apple Support article <a href="#">RP451: Apple USB SuperDrive</a> to open the drive enclosure and align the optical drive assembly with the enclosure's bezel slot.  Retest Apple USB SuperDrive by inserting, mounting and ejecting a known-good optical disc.  Is optical drive function fully restored?	Yes  No	Issue resolved. Apple USB SuperDrive alignment realigned the disc inject function. Verify issue resolved.  Replace the Apple USB SuperDrive. Verify issue resolved.	\${nodeText.yesSymptomCode}  J05	
14.	Attempt to insert a known-good, properly formatted CD or DVD disc into the Apple USB SuperDrive. Check if the disc auto-ejects either immediately or within a few seconds after the drive has spun up.  Does disc immediately auto-eject?	Yes  No	Replace the Apple USB SuperDrive. Verify issue resolved.  Go to step 15.	J01  \${nodeText.noSymptomCode}	OPTICAL
15.	After insertion, verify that the disc spins and the disc volume mounts in the Finder.  Does disc volume mount?	Yes  No	Go to step 16.  Go to “External USB ODD Read-Write or Performance Issues” troubleshooting flow.	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
16.	Eject the disc by dragging the disc icon to Trash or selecting the disc icon and pressing the Eject key or Command-E on the keyboard.  Does disc eject properly?	Yes  No	Issue resolved.  Replace the Apple USB SuperDrive. Verify issue resolved.	\${nodeText.yesSymptomCode}  J02	OPTICAL
17.	Insert, mount, and eject a known-good optical disc.  Is issue resolved?	Yes  No	Issue resolved.  <b>ESCALATION REQUIRED.</b>  Contact TSPS for additional support or a multiple part repair.  Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	\${nodeText.yesSymptomCode}  J99	

# Flash Storage Not Recognized / Not Mounting / Read/Write Issues

## Unlikely causes:

AC Inlet, Audio Jack, Bluetooth Antenna, Bluetooth Antenna Cable, Bus Bars A and B, Coin Battery, Fan, Graphics Board A, Graphics Board A Flex Cable, Memory DIMM, Power Cable, Power Supply, Speaker, Wi-Fi Antenna.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>Boots to gray screen.</li><li>Boots to blue screen.</li><li>Displays flashing folder with question mark or prohibitory sign.</li><li>Cannot save documents.</li><li>Displays read/write error message(s).</li><li>Hangs when accessing or saving data.</li><li>Kernel panic on startup.</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p> <p>System software restore is available to users, though not covered by Apple warranty. Customer may be billed for software troubleshooting or restore.</p>	<p><b>Important:</b> Always ask if user's data has been backed up prior to repair.</p> <p><b>Important:</b> Some Macs that have been updated to macOS High Sierra may not start up to the internal startup volume after logic board replacement. On affected Macs, the <b>Mac BootROM Updater</b> is available to address this issue. This utility updates the EFI BootROM on affected Macs to allow starting up to a volume that has been updated to the APFS file system.</p> <p>If the user's computer does not start up to the internal startup volume after logic board replacement, run the <b>Mac BootROM Updater</b> to ensure the replacement logic board's EFI BootROM firmware is updated to the latest version that supports the APFS file system.</p> <p>For more information and instructions for downloading and using the <b>Mac BootROM Updater</b>, see article <a href="#">OP476: Latest Apple Service Toolkit download links and documentation</a>.</p> <ol style="list-style-type: none"><li>Disconnect all peripherals and attempt to start up the computer.</li><li>To restore the default startup disk, reset the NVRAM using the procedure for this computer in article <a href="#">HT204063: How to Reset NVRAM on your Mac</a>.</li><li>Reset the SMC using the procedure listed for this computer in article <a href="#">HT201295: How to reset the System Management Controller (SMC) on your Mac</a>.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
	Connect a known-good original system media or up-to-date, bootable Mac OS volume. Press Option (alt) keyboard key on startup to select and start from this volume.	Yes	Go to step 2.	\${nodeText.yesSymptomCode}	
1.	Confirm that computer completes the startup process: chime > gray screen > Apple logo > spinning gear > login screen > desktop or installer screen.	No	Go to "Will Not Start Up" troubleshooting flow.	\${nodeText.noSymptomCode}	
	Does computer complete the start up process?				

	Check	Result	Action	Code	Commodity
2.	Run AST Storage Diagnostic on the user's computer and examine the results of the test.  Does internal drive pass test in Storage Diagnostic?	Yes	<b>ESCALATION REQUIRED.</b>  If you suspect a problem even though AST Storage Diagnostic gives a passing result, contact ACS for additional support.	H99	
		No	Go to step 3.	\${nodeText.noSymptomCode}	
3.	Examine Storage Diagnostic results for presence of an internal drive.  Did drive presence test PASS or FAIL?	Pass	Go to step 4.	\${nodeText.yesSymptomCode}	
		Fail	Go to step 16.	\${nodeText.noSymptomCode}	
4.	Examine Storage Diagnostic results for SMART status.  Did SMART test PASS or FAIL?	Pass	Go to step 5.	\${nodeText.yesSymptomCode}	
		Fail	Replace the user's flash storage. Verify issue resolved.	H05	SSD
5.	Examine Storage Diagnostic results for Short Random Multi-Block Read Test.  Did Short Random Multi-Block Read Test PASS or FAIL?	Pass	Go to step 6.	\${nodeText.yesSymptomCode}	
		Fail	Go to step 16.	\${nodeText.noSymptomCode}	
6.	Examine Storage Diagnostic results for File System Check.  Did File System Check PASS or FAIL?	Pass	Go to step 7.	\${nodeText.yesSymptomCode}	
		Fail	Go to step 9.	\${nodeText.noSymptomCode}	
7.	Examine Storage Diagnostic results for Bootable Volume Presence Check.  Did Bootable Volume Check PASS or FAIL?	Pass	Go to step 8.	\${nodeText.yesSymptomCode}	
		Fail	Go to step 13.	\${nodeText.noSymptomCode}	
8.	Examine Storage Diagnostic results for Last OS Reinstall Check.  Did Last OS Reinstall Check PASS or FAIL?	Pass	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	H99	
		Fail	Go to step 9.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
9.	<p>In Mac Resource Inspector (MRI), check for presence of correct version and build of macOS on internal flash storage.</p> <p>Is correct OS version and build installed?</p>	Yes	Go to step 10.	\${nodeText.yesSymptomCode}	
		No	Go to step 13.	\${nodeText.noSymptomCode}	
10.	<p>Restart while holding down the Command-R keys to start up from the recovery partition.</p> <p>Does computer start up from recovery tools partition?</p>	Yes	Go to step 12.	\${nodeText.yesSymptomCode}	
		No	Go to step 11.	\${nodeText.noSymptomCode}	
11.	<p>If macOS is present but not able to restart from the recovery partition, or the partition is missing, refer to article <a href="#">HT202294: About Recovery Disk Assistant</a> to restore the partition.</p> <p>Restart from the new recovery partition, holding down Command-R during restart.</p> <p>Does computer start up from newly created recovery tools partition?</p>	Yes	Go to step 12.	\${nodeText.yesSymptomCode}	
		No	Go to step 16.	\${nodeText.noSymptomCode}	
12.	<p>In Disk Utility, select the Partition tab, then click the Option button to verify that the partition table is correctly set to GUID. Try to repair the partition using Disk Utility.</p> <p>Does Disk Utility successfully repair the partition?</p>	Yes	Go to step 15.	\${nodeText.yesSymptomCode}	
		No	Go to step 13.	\${nodeText.noSymptomCode}	
13.	<p>Start up the computer to Internet Recovery or a known-good bootable macOS volume. Run Disk Utility and select the internal flash storage drive, then choose the Partition tab.</p> <p>Follow all steps listed in <a href="#">HT204743: Partition a problematic drive two times before recommending service or replacement</a>.</p> <p>This will force a rewrite of the partitions table.</p> <p>Does Disk Utility successfully partition the drive without any errors?</p>	Yes	Go to step 14.	\${nodeText.yesSymptomCode}	
		No	Go to step 16.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
14.	<p>Reinstall macOS on the user's computer. Refer to <a href="#">HT201260: How to find the macOS version number on your Mac</a> to check that the system build is correct for this computer model. Check for and apply the latest software and firmware updates.</p> <p>Does computer complete the start up process?</p>	Yes	Go to step 15.	\${nodeText.yesSymptomCode}	
		No	<b>ESCALATION REQUIRED.</b> Contact ACS for additional support or a multiple-part repair.	H99	
15.	<p>Run AST Storage Diagnostic on the user's computer again. Examine the results of the test.</p> <p>Do all internal drive tests pass in Storage Diagnostic?</p>	Yes	Issue resolved. Verify resolution.	\${nodeText.yesSymptomCode}	
		No	<b>ESCALATION REQUIRED.</b> Contact ACS for additional support or a multiple-part repair.	H99	
16.	<p>Remove and inspect flash storage connector.</p> <p>Check for damaged or corroded connector and missing or bent pins on Graphics Board B flash storage connector.</p> <p>Did you find damage to flash storage or Graphics Board B connectors?</p>	Yes	Go to step 26.	\${nodeText.yesSymptomCode}	
		No	Go to step 17.	\${nodeText.noSymptomCode}	
17.	<p>Reconnect flash storage to the logic board.</p> <p>Run AST Storage Diagnostic on the user's computer again. Examine the results of the test.</p> <p>Do all internal drive tests pass in Storage Diagnostic?</p>	Yes	Issue resolved by reseating flash storage. Verify issue resolved.	\${nodeText.yesSymptomCode}	
		No	Go to step 18.	\${nodeText.noSymptomCode}	
18.	<p>To troubleshoot this issue completely, a known-good flash storage, Graphics Board B, graphics board flex cable, logic board, and CPU riser card are required.</p> <p>Do you have these part immediately available?</p>	Yes	Go to step 19.	\${nodeText.yesSymptomCode}	
		No	Replace the user's flash storage. Verify issue resolved.	H01	SSD

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
19.	Substitute known-good flash storage and perform Internet Recovery to install the correct version of macOS.	Yes	Replace the user's flash storage. Verify issue resolved.	H01	SSD
	Run AST Storage Diagnostic on the user's computer again. Examine the results of the test.  Does internal flash storage test pass in Storage Diagnostic?	No	Go to step 20.	\${nodeText.noSymptomCode}	
20.	Replace the user's original flash storage card. Remove and inspect the Graphics Board B flex cable for damage, as well as the Graphics Board B and logic board connectors.	Yes	Go to step 21.	\${nodeText.yesSymptomCode}	
	Did you find damage on the Graphics Board B, flex cable, or the logic board?	No	Go to step 22.	\${nodeText.noSymptomCode}	
21.	Damage to multiple parts requires an escalation to ACS for repair approval.	Yes	Replace graphics flex cable. Verify issue resolved.	X03	INTERNAL CABLE
	Is damage limited to the Graphics Board B flex cable?	No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	H99	
22.	Reseat the Graphics Board B flex cable on the logic board and Graphics Board B side.	Yes	Issue resolved by reseating flash storage. Verify issue resolved.	\${nodeText.yesSymptomCode}	
	Run AST Storage Diagnostic on the user's computer again. Examine the results of the test.  Does internal flash storage test pass in Storage Diagnostic?	No	Go to step 23.	\${nodeText.noSymptomCode}	
23.	Install a known-good Graphics Board B flex cable.	Yes	Replace Graphics Board B flex cable. Verify issue resolved.	X03	INTERNAL CABLE
	Run AST Storage Diagnostic on the user's computer again. Examine the results of the test.  Does internal flash storage test pass in Storage Diagnostic?	No	Go to step 24.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
24.	Replace the user's original graphics board flex. Install a known-good logic board.	Yes	Replace logic board. Verify issue resolved.	M19	MLB
	Run AST Storage Diagnostic on the user's computer again. Examine the results of the test.	No	Go to step 25.	\${nodeText.noSymptomCode}	
	Does internal flash storage test pass in Storage Diagnostic?				
25.	Replace the user's original logic board. Install a known-good CPU riser card.	Yes	Replace CPU riser card. Verify issue resolved.	M19	MPU
	Run AST Storage Diagnostic on the user's computer again. Examine the results of the test.	No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	H99	
	Does internal flash storage test pass in Storage Diagnostic?				
26.	Damage to multiple parts requires an escalation to ACS for repair approval.	Yes	Replace flash storage. Verify issue resolved.	H01	SSD
	Is damage limited to flash storage card connector?	No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	P99	
27.	Confirm that the computer can successfully start up from the internal flash storage.	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
	Is issue resolved?	No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	H99	

# Burnt Smell / Odor

## Unlikely causes:

DIMM Mechanism, Housing, Inlet.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>Computer emits a burnt, smoky, or other unusual odor.</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>Disconnect all third-party devices to eliminate external devices as source of odor.</li><li>Verify computer is source of odor.</li><li>Clean enclosure to eliminate odors resulting from external contamination. Refer to Apple Support article <a href="#">HT3226: How to clean Apple products</a>. Explain cause to user.</li><li>Inspect air intake vents and outlets for any obstructions. Verify air can flow freely into and out of enclosure.</li><li>Inspect enclosure and components for obvious signs of burning or smoky residue. Check rear vents, slots, ports, and power cord. Refer to Apple Support article <a href="#">TS4039: Smoke emitted may be from failed component</a>.</li><li>Verify functionality of computer. If computer is nonfunctional, troubleshoot that first as a separate issue.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	Closely inspect computer for possible safety issue. Refer to Apple Support article <a href="#">TS4039: Smoke emitted may be from failed component</a> .	Yes	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for safety-related issues. Refer to Apple Support article <a href="#">OP44: SERVICE: Handling Potential Product Safety Issues</a>.</p>	T99	
	Have you identified any safety issues?		Click the Help button in the GSX toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.		
2.	Odor can be related to external contamination. Inspect computer exterior for contamination or lack of cleanliness.	Yes	Go to step 3.	<a href="#">\${nodeText.yesSymptomCode}</a>	
	Can you determine odor is caused by external contamination?		Go to step 4.		

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
3.	<p>Thoroughly clean entire enclosure and all external surfaces. Refer to Apple Support article <a href="#">HT3226: How to clean Apple products</a>.</p> <p>Explain cause to user.</p> <p>Does user agree that odor is due to external contamination?</p>	Yes	Issue resolved. Verify resolution.	\$nodeText.yesSymptomCode}	
		No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support or a multiple part repair.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>		
4.	<p>Odors can be related to how long new product has been powered on. Refer to Apple Support article <a href="#">HT4921: New equipment: Odors may be present short-term</a>.</p> <p>Can you determine odor is due to newness?</p>	Yes	Go to step 5.	\$nodeText.yesSymptomCode}	
		No	Go to step 6.		
5.	<p>Explain to user that new computers sometimes emit odor similar to odors generated from new carpeting or a new car. In most cases, odor dissipates after a brief period. Refer user to Apple Support article <a href="#">HT4921: New equipment: Odors may be present short-term</a>.</p> <p>Does user agree odor is related to computer's newness?</p>	Yes	Issue resolved. Verify resolution.	\$nodeText.yesSymptomCode}	
		No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support or a multiple part repair.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>		
6.	<p>Follow take-apart instructions to remove access cover. Closely inspect internal components and enclosure for indications of physical damage or internal contamination.</p> <p>Can you identify signs of internal damage or contamination?</p>	Yes	Go to step 7.	\$nodeText.yesSymptomCode}	
		No	Go to step 8.		

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
7.	Inform user that computer failures due to accidental damage are not covered.  Discuss out-of-warranty repair options.	Yes	Proceed with resolution or repair using proper positioning. Inform user that computer failures due to accidental damage are not covered by Apple's one-year limited warranty or AppleCare Protection Plan. Refer to <a href="http://www.apple.com/legal/warranty">www.apple.com/legal/warranty</a> .	X99	
	Does user want to proceed with out-of-warranty repair?	No	Return computer to customer using correct positioning.	\${nodeText.noSymptomCode}	
8.	Follow take-apart instructions to remove all parts and modules. Inspect each module and its associated cables for signs of burnt or damaged components, smoke residue or other traces of burning, and melted or damaged wiring.	Yes	<b>ESCALATION REQUIRED.</b>  Contact TSPS for additional support or a multiple part repair.	M99	
	Have you identified a component failure as source of odor?		Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.		
		No	Issue resolved. Verify resolution.	\${nodeText.noSymptomCode}	
9.	Reassemble computer. Run computer for several hours and check for issue/odor. Test with Apple Service Diagnostic (ASD), both ASD EFI and ASD OS. If no functional failure is detected, use correct positioning to explain to user that odor is most likely related to external contamination or newness of computer.	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
	Is issue resolved?	No	<b>ESCALATION REQUIRED.</b>  Contact TSPS for additional support or a multiple part repair.	M99	
			Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.		

# Computer Runs Hot

## Unlikely causes:

AC Inlet, Audio Jack, Bluetooth Antenna, Speaker, Wi-Fi Antenna.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• Computer feels unusually warm.</li><li>• Fan not operation.</li><li>• Fan not functioning at full capacity.</li><li>• Fan runs constantly at high speeds.</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. Check for and apply the latest software and firmware updates.</li><li>2. Ensure the fan spins during operation. Verify inlet and exhaust are not blocked. Remove any debris and blow out with compressed air if necessary.</li><li>3. Compare computer's operation temperature to a known-good, similarly configured computer.</li><li>4. CPU and graphics intensive applications and processes may cause computer to feel warm and fan to run at high speed. Use Activity Monitor to help identify these processes and explain this behavior to the user.</li><li>5. Reset the SMC using procedure listed for this computer in article <a href="#">HT201295: Intel-based Macs: Resetting the System Management Controller (SMC)</a>.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	Run MRI to check fan operation and status of thermal sensors. MRI will report a failure if fan is not rotating or a sensor is undetected or exceeding thermal values.  Does computer pass all MRI checks?	Yes  No	Go to step 2.	\$(nodeText.yesSymptomCode)	
			Go to step 4.	\$(nodeText.noSymptomCode)	
2.	Boot computer to Apple Service Toolkit (AST) and run CSD. This test will run for approximately 10 minutes running checks on the entire thermal system of the computer.  Does the computer pass CSD?	Yes  No	Go to step 3.	\$(nodeText.yesSymptomCode)	
			Go to step 4.	\$(nodeText.noSymptomCode)	
3.	<ul style="list-style-type: none"><li>• Restart computer from ASD OS bootable drive. Loop tests one hour to enable system to heat.</li><li>• Select "View stand-alone tests" item of popup menu (to only run tests that don't require any user interaction).</li><li>• Start testing.</li></ul> Does the computer pass ASD?	Yes	Computer passed all testing. Verify operation and refer customer to article <a href="#">HT202179: About fans and fan noise in your Mac</a>	\$(nodeText.yesSymptomCode)	
			Go to step 4.	\$(nodeText.noSymptomCode)	
4.	A disconnected or improperly functioning fan will prevent proper cooling and cause thermal sensors to exceed expected values.  Does the test report a fan failure?	Yes  No	Go to step 6.	\$(nodeText.yesSymptomCode)	
			Go to step 5.	\$(nodeText.noSymptomCode)	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
5.	<p>Any under/heated, clogged, disconnected, shorted, or failing sensor will lead computer to preventively operate fan at higher speed.</p> <p>Does the test report a thermal sensor (Txxx) failure?</p>	Yes	Go to step 22.	\${nodeText.yesSymptomCode}	
		No	<b>ESCALATION REQUIRED.</b> Contact ACS for additional support or a multiple-part repair.	X99	
6.	<p>Remove housing and exhaust assembly. Verify that the fan spins freely in assembly.</p> <p>Remove the fan and inspect the fan, fan flex cable, interposer board flex cable, and their corresponding connectors for damage.</p> <p>Are any components damaged?</p>	Yes	Go to step 9.	\${nodeText.yesSymptomCode}	
		No	Go to step 7.	\${nodeText.noSymptomCode}	
7.	<p>Clean fan and exhaust assembly. Use an ESD-safe vacuum and compressed air to remove dust and debris. Clean fan blades using a soft brush.</p> <p>Reset all connections and reassemble computer.</p> <p>Run fan tests to verify operation.</p> <p>Does computer pass fan test?</p>	Yes	Issue resolved by cleaning and reseating connectors. Verify resolution.	\${nodeText.yesSymptomCode}	
		No	Go to step 8.	\${nodeText.noSymptomCode}	
8.	<p>To troubleshoot issue completely, the following known-good parts are required:</p> <ul style="list-style-type: none"> <li>• fan</li> <li>• fan flex cable</li> <li>• logic board</li> <li>• interposer board</li> <li>• interposer board flex cable</li> <li>• I/O board</li> <li>• I/O board flex cable</li> </ul> <p>Do you have immediate access to these known-good parts?</p>	Yes	Go to step 15.	\${nodeText.yesSymptomCode}	
		No	Replace fan. Verify issue resolved.	X22	OTHER ELECTRIC
9.	<p>Inspect I/O board, interposer board, fan, and corresponding cables for damage.</p> <p>If several components are damaged, it might indicate that an unauthorized repair has taken place.</p> <p>Are multiple components damaged?</p>	Yes	<b>ESCALATION REQUIRED.</b> Contact ACS for additional support or a multiple-part repair.	X99	
		No	Go to step 10.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
10.	Inspect fan and connector for damage. Make sure the fan can spin freely.	Yes	Replace fan. Verify issue resolved.	X22	OTHER ELECTRIC
	Is fan damaged or not spinning?	No	Go to step 11.	\${nodeText.noSymptomCode}	
11.	Inspect fan flex cable for damage.	Yes	Replace fan flex cable. Verify issue resolved.	X03	INTERNAL CABLE
	Is the cable damaged?	No	Go to step 12.	\${nodeText.noSymptomCode}	
12.	Inspect interposer board for damage to connectors for fan flex cable and interposer flex cable.	Yes	Replace interposer board. Verify issue resolved.	M24	OTHER BOARD
	Is interposer board damaged?	No	Go to step 13.	\${nodeText.noSymptomCode}	
13.	Inspect interposer board flex cable for damage.	Yes	Replace interposer board flex cable. Verify issue resolved.	X03	INTERNAL CABLE
	Is the cable damaged?	No	Go to step 14.	\${nodeText.noSymptomCode}	
14.	Inspect I/O board for damage to connector for interposer flex cable.	Yes	Replace I/O board. Verify issue resolved.	M24	OTHER BOARD
	Is I/O board damaged?	No	<b>ESCALATION REQUIRED.</b> Contact ACS for additional support or a multiple-part repair.	X99	
15.	Substitute a known-good fan.	Yes	Replace fan. Verify issue resolved.	X22	OTHER ELECTRIC
	Run fan tests to verify.	No	Go to step 16.	\${nodeText.noSymptomCode}	
16.	Does computer pass fan test?				
	Reinstall the user's fan, substituting a known-good fan flex cable.	Yes	Replace fan flex cable. Verify issue resolved.	X03	INTERNAL CABLE
17.	Run fan tests to verify.	No	Go to step 17.	\${nodeText.noSymptomCode}	
	Does computer pass fan test?				
17.	Reinstall the user's fan flex cable.	Yes	Replace logic board. Verify issue resolved.	M18	MLB
	Substitute a known-good logic board.	No	Go to step 18.	\${nodeText.noSymptomCode}	
17.	Run fan tests to verify.				
	Does computer pass fan test?				

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>	
18.	Reinstall the user's logic board.	Yes	Replace interposer board. Verify issue resolved.	M24	OTHER BOARD	
	Substitute a known-good interposer board.					
	Run fan tests to verify.	No	Go to step 19.	\${nodeText.noSymptomCode}		
	Does computer pass fan test?					
19.	Reinstall the user's interposer board, substituting a known-good interposer board flex cable.	Yes	Replace interposer board flex cable. Verify issue resolved.	X03	INTERNAL CABLE	
	Run fan tests to verify.					
	Does computer pass fan test?	No	Go to step 20.	\${nodeText.noSymptomCode}		
20.	Reinstall the user's interposer board flex cable.	Yes	Replace I/O board flex cable. Verify issue resolved.	X03	INTERNAL CABLE	
	Substituting a known-good I/O board flex cable.					
	Run fan tests to verify.	No	Go to step 21.	\${nodeText.noSymptomCode}		
	Does computer pass fan test?					
21.	Substitute a known-good I/O board, reinstalling the user's I/O board flex cable.  Run fan tests to verify.  Does computer pass fan test?	Yes	Replace I/O board. Verify issue resolved.	M18	OTHER BOARD	
		No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	X99		
22.	Disassemble and clean computer. Be sure to check the fan, inlet, exhaust manifold, and thermal core. Use an ESD-safe vacuum and compressed air to remove any dust and debris.	Yes	Issue resolved by cleaning and reseating connectors. Verify resolution.	\${nodeText.yesSymptomCode}		
	Reassemble computer, carefully reseating all connectors.					
	Run sensor tests to verify operation.	No	Go to step 23.	\${nodeText.noSymptomCode}		
	Does computer pass sensor tests?					
23.	Identify if the failing sensor is one of the following:  <b>TA0p, Tm0p, TA2p, TA1p</b>	Yes	Replace logic board. Verify issue resolved.	M23	MLB	
	Is the failing sensor on this list?	No	Go to step 24.			

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
24.	Identify if the failing sensor is one of the following: <b>TC0p, TC1p, TCXr, TM0p, TM0r, TM1p, TM1r</b>  Is the failing sensor on this list?	Yes	Replace CPU Riser Card. Verify issue resolved.	M23	OTHER BOARD
		No	Go to step 25.	\${nodeText.noSymptomCode}	
25.	Identify if the failing sensor is one of the following: <b>TG0d, TG0p, TG0r</b>  Is the failing sensor on this list?	Yes	Replace Graphics Board A. Verify issue resolved.	M23	STANDALONE CARD
		No	Go to step 26.	\${nodeText.noSymptomCode}	
26.	Identify if the failing sensor is one of the following: <b>TG1d, TG1p, TG1r</b>  Is the failing sensor on this list?	Yes	Replace Graphics Board B. Verify issue resolved.	M23	STANDALONE CARD
		No	Go to step 27.	\${nodeText.noSymptomCode}	
27.	Identify if the failing sensor is one of the following: <b>TI1p, TI0t, Te0t, TI0p</b>  Is the failing sensor on this list?	Yes	Replace I/O board. Verify issue resolved.	M23	OTHER BOARD
		No	Go to step 28.	\${nodeText.noSymptomCode}	
28.	Identify if the failing sensor is one of the following: <b>TH0a, TH0b, TH0c</b>  Is the failing sensor on this list?	Yes	Replace SSD. Verify issue resolved.	H05	SSD
		No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	X99	
29.	Verify that the thermal issue has been resolved.  Run CSD, or run loop ASD OS to assist in verification.  Is the issue resolved?	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	X99	

# Mechanical/Physical/Cosmetic Damage

## Unlikely causes:

Not relevant

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• Stripped screw/head</li><li>• Stripped screw boss/threads</li><li>• Dented or scratched enclosure</li><li>• Broken memory/cable connector</li><li>• Liquid Damage</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	Inspect computer and discuss nature of issue with user. Determine whether user wants to proceed with repair (despite possible accidental damage) or pursue other service options. Click <b>No</b> to proceed with further troubleshooting.

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	Determine cause of damage or defects: User/technician, environment, accidental damage, or abuse.  Is an Apple agent responsible for damage or defect on computer?	Yes	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for assistance with Apple-related accidental damage.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	X99	
		No	<p>Proceed with resolution or repair using proper positioning. Inform user that computer failures due to accidental damage are not covered by Apple's one-year limited warranty or AppleCare Protection Plan. Refer to <a href="http://www.apple.com/legal/warranty">www.apple.com/legal/warranty</a>.</p>	X99	

# Noise / Hum / Vibration

## Unlikely causes:

Bus Bars A and B, Bluetooth Antenna, DIMM Mechanism, Flash Storage, Graphics Board A, Graphics Board B, Graphics Board Flex Cable, Housing, Interposer Board, Interposer Board Cover, Interposer Board Flex Cable, I/O Board, I/O Board Flex Cable, I/O Wall, Memory DIMM, Root, Logic Board, Wi-Fi Antenna, Wireless Card.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• Buzzing noise</li><li>• Rattling noise</li><li>• Ticking noise</li><li>• Squeaking noise</li><li>• Humming noise</li><li>• High frequency noise</li><li>• Mechanical vibration</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<p><b>Note:</b> Verify the issue after using the computer for a few minutes to warm it, or by following steps in <a href="#">HT207571: Warm a Mac for testing</a>. Doing this may help identify intermittent issues.</p> <ol style="list-style-type: none"><li>1. Work with user to reproduce the noise. If the user has third party peripherals, connect and disconnect them as necessary. Be sure the sound is coming from the computer, and not from an external device. If the sound only occurs when an external device is connected, it may be caused by a ground loop.</li><li>2. Determine if the sound is normal or abnormal.</li><li>3. Verify inlet is free from dust and debris that might inhibit proper airflow through computer.</li><li>4. If fan runs at full speed after power on, reset the SMC using the procedure listed for this computer in article <a href="#">HT201295: How to reset the System Management Controller (SMC) on your Mac</a>.</li><li>5. Launch Applications &gt; Utilities &gt; Activity Monitor. Determine if an application or process is consuming a high percentage of CPU bandwidth. Intensive tasks can cause fans to run at high speed to maintain proper temperature. If needed, quit process or restart computer to resolve issue.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	Remove housing, check for and remove any debris around fan and exhaust assembly.	Yes	Issue resolved by removing debris from exhaust assembly. Verify issue resolved.	\${nodeText.yesSymptomCode}	
	Reinstall housing and retest for noise.  Has noise been eliminated?		Go to step 2.		
2.	Remove housing. Inspect computer for any loose components or missing screws.	Yes	Issue resolved by securing internal components. Verify issue resolved.	\${nodeText.yesSymptomCode}	
	Replace any missing screws, and properly secure components as necessary.		Go to step 3.		
	Reassemble and retest for noise.  Has noise been eliminated?	No	Go to step 3.	\${nodeText.noSymptomCode}	
3.	Connect computer to AC power and listen carefully, close to internal power supply.	Yes	Replace power supply. Verify issue resolved.	P04	POWER SUPPLY
	Is noise coming from power supply?	No	Go to step 4.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
4.	An unreadable thermal sensor can cause fan to run excessively. Run MRI to check thermal sensors.	Yes	Go to "Computer Runs Hot" troubleshooting flow.	\${nodeText.yesSymptomCode}	
	Does MRI report any thermal sensors failures?	No	Go to step 5.	\${nodeText.noSymptomCode}	
5.	Some sounds may be caused by issues with the fan, or obstructions inside the fan assembly.	Yes	Go to step 8.	\${nodeText.yesSymptomCode}	
	Run Cooling System Diagnostic (CSD) or the fan test in Apple System Diagnostic (ASD) to verify proper functionality of the fan.	No	Go to step 6.	\${nodeText.noSymptomCode}	
	While test is running, listen for changes to the noise. Changes in the noise would indicate problems with the fan.				
	Is the noise being caused by the fan?				
6.	Disconnect any external speakers.	Yes	Go to "Distorted Audio from Internal Speaker" troubleshooting flow.	\${nodeText.yesSymptomCode}	
	Remove I/O board and temporarily disconnect internal speaker.	No	Go to step 7.	\${nodeText.noSymptomCode}	
	Reinstall I/O board and retest.				
	Has noise been eliminated?				
7.	Noise may be from interference of other electrical devices nearby or plugged into same power circuit as computer. Check for noise when computer runs in a different location, on a different circuit.	Yes	Issue resolved. Verify resolution.	\${nodeText.yesSymptomCode}	
		No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	X99	
8.	Remove exhaust assembly and inspect thoroughly for any obstructions that may be touching fan blades and causing noise.	Yes	Issue resolved by removing obstructions from fan/exhaust assembly. Verify issue resolved.	\${nodeText.yesSymptomCode}	
	Remove fan from assembly and verify that it spins freely without interference from housing or exhaust assembly.	No	Replace fan. Verify issue resolved.	X23	OTHER ELECTRIC
	Reassemble system and check for noise.				
	Has noise been eliminated?				

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
9.	<p>Reassemble computer as necessary and run for several minutes, listening for abnormal noise, hum, or vibration.</p> <p>Is issue resolved?</p>	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	<b>ESCALATION REQUIRED.</b> Contact ACS for additional support or a multiple-part repair.	X99	

# Intermittent Shutdown

## Unlikely causes:

Audio Jack, Bluetooth Antenna, Roof, Speaker, Wi-Fi Antenna

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• Shuts down during startup</li><li>• Shuts down unexpectedly during use</li><li>• Restarts spontaneously</li><li>• Powers off when waking from sleep</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. Collect the following information from customer:<ul style="list-style-type: none"><li>◦ When shutdown occurs. (For example, after running for a while.)</li><li>◦ Frequency of shutdowns.</li><li>◦ Which applications are running when shutdowns occur.</li></ul></li><li>2. Verify power cord is securely attached to back of power supply, and not getting caught (such as on a desk) and pulled loose.</li><li>3. Verify power supply DC cable is securely attached to back of computer.</li><li>4. Plug computer power supply directly into an AC outlet to isolate issues with a surge protector or UPS.</li><li>5. Open System Preferences &gt; Energy Saver &gt; Schedule and make sure that a “Shut Down” event is not scheduled.</li><li>6. Start up computer using known-good original system media or an up-to-date, bootable OS X volume.</li><li>7. Hold Shift key during startup to put computer into Safe Mode. See Apple Support article <a href="#">HT201262: Mac OS X: What is Safe Boot, Safe Mode?</a></li><li>8. Reset SMC using procedure listed for this computer in Apple Support article <a href="#">HT201295: Intel-based Macs: Resetting the System Management Controller (SMC)</a>.</li><li>9. Reset NVRAM by holding down Command-Option-P-R keys while restarting, until you hear startup sound for the second time.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	Run Mac Resource Inspector (MRI) or Apple Service Diagnostics (ASD) to check for fan (motor) or sensor failures.	Yes	Go to step 4.	\${nodeText.yesSymptomCode}	
	Sensors that signal abnormal operating range or an inoperative fan can cause intermittent shutdowns.  Did ASD/MRI report any fan or sensor failures?	No	Go to step 2.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
2.	<p>Startup from the internal drive and attempt to reproduce shutdown symptoms.</p> <p>Can you reproduce shutdown event?</p>	Yes	Go to step 3.	\${nodeText.yesSymptomCode}	
		No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support or a multiple part repair.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	X99	
3.	<p>Start up computer with Option (Alt) key down, using a known-good bootable OS X volume. See <a href="#">HT204319: Mac OS X versions (builds) for computers</a> to determine the correct minimum build for this computer.</p> <p>Does shutdown issue persist while booted to a known-good volume?</p>	Yes	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact TSPS for additional support or a multiple part repair.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	X99	
		No	<p>Repair disk using Disk Utility. If issue persists after repair, reinstall OS X. Refer to Apple Support article <a href="#">HT204319: Mac OS X versions (builds) for computers</a>. Check for and apply the latest software and firmware updates. Verify issue resolved.</p>	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
4.	Failures in the thermal / cooling system can cause intermittent shutdowns.	Yes	Go to "Computer Runs Hot" troubleshooting flow.	\${nodeText.yesSymptomCode}	
	Check test results for failures related to fan or thermal sensors ( <b>Txxx</b> ).	No	Go to step 5.	\${nodeText.noSymptomCode}	
	Are failures related to fan or thermal sensors?				
5.	Identify if the failing sensor is <b>VD2R</b> . This sensor is specific to the AC/DC power supply.	Yes	Replace power supply. Verify issue resolved.	P02	POWER SUPPLY
	Is the failed sensor VD2R?	No	Go to step 6.	\${nodeText.noSymptomCode}	
6.	Identify if the failing sensor is one of the following:	Yes	Go to step 7.	\${nodeText.yesSymptomCode}	
	<b>VC0C, VCTR, VC0S, IC0C, ICTR, IC0S</b>	No	Go to step 8.	\${nodeText.noSymptomCode}	
	Is the failing sensor on this list?				
7.	Substitute a known-good CPU riser card and run testing again.	Yes	Replace CPU riser card. Verify issue resolved.	M08	MPU
	Do the sensor tests pass?	No	Go to step 16.	\${nodeText.noSymptomCode}	
8.	Identify if the failing sensor is one of the following:	Yes	Go to step 9.	\${nodeText.yesSymptomCode}	
	<b>VG0R, VG0C, VG0S, IG0R, IG0C, IG0S</b>	No	Go to step 10.	\${nodeText.noSymptomCode}	
	Is the failing sensor on this list?				
9.	Substitute a known-good graphics board A and run testing again.	Yes	Replace graphics board A. Verify issue resolved.	M08	STANDALONE CARD
	Do the sensor tests pass?	No	Go to step 16.	\${nodeText.noSymptomCode}	
10.	Identify if the failing sensor is one of the following:	Yes	Go to step 11.	\${nodeText.yesSymptomCode}	
	<b>VG1R, VG1C, VG1S, IG1R, IG1C, IG1S</b>	No	Go to step 12.	\${nodeText.noSymptomCode}	
	Is the failing sensor on this list?				
11.	Substitute a known-good graphics board B and run testing again.	Yes	Replace graphics board B. Verify issue resolved.	M08	STANDALONE CARD
	Do the sensor tests pass?	No	Go to step 16.	\${nodeText.noSymptomCode}	
12.	Identify if the failing sensor is one of the following:	Yes	Go to step 13.	\${nodeText.yesSymptomCode}	
	<b>VI1R, II0R</b>	No	Go to step 14.	\${nodeText.noSymptomCode}	
Is the failing sensor on this list?					

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
13.	Substitute a known-good I/O board and run testing again.	Yes	Replace I/O board. Verify issue resolved.	M08	OTHER BOARD
	Do the sensor tests pass?	No	Go to step 16.	\${nodeText.noSymptomCode}	
14.	Identify if the failing sensor is one of the following:  <b>VH0R, IH0R</b>  Is the failing sensor on this list?	Yes	Go to step 15.	\${nodeText.yesSymptomCode}	
		No	<b>ESCALATION REQUIRED.</b>  Contact TSPS for additional support or a multiple part repair.  Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	X99	
15.	Substitute a known-good SSD and run testing again. Do the sensor tests pass?	Yes	Replace SSD. Verify issue resolved.	H99	SSD
		No	Go to step 16.	\${nodeText.noSymptomCode}	
16.	Reinstall the user's original parts, substituting a known-good power supply.  Reassemble and run testing again.  Do the sensor tests pass?	Yes	Replace power supply. Verify issue resolved.	P02	POWER SUPPLY
		No	<b>ESCALATION REQUIRED.</b>  Contact TSPS for additional support or a multiple part repair.  Click the Help button in the GSX Toolbar then choose Troubleshooting > Technical Help with a Repair > Contact Apple.	X99	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
		Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
17.	Run ASD in OS loop mode for 8-10 hours to verify that computer does not unexpectedly shut down. Is issue resolved?	No	<p style="color: red; font-weight: bold;">ESCALATION REQUIRED.</p> <p>Contact TSPS for additional support or a multiple part repair.</p> <p>Click the Help button in the GSX Toolbar then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	X99	

# Kernel Panic / System Crashes

## Unlikely causes:

AC Inlet, Audio Jack, Bluetooth Antenna, Fan, Fan Flex Cable, I/O Wall, Speaker, Wi-Fi Antenna

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>Computer displays a kernel panic alert message. See article <a href="#">HT200553: OS X: When your computer spontaneously restarts or displays “Your computer restarted because of a problem.”</a></li><li>Computer freezes during use.</li><li>Computer freezes upon wake from sleep.</li><li>Computer freezes when Wi-Fi is enabled or activated.</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>Check for and apply latest software and firmware updates.</li><li>Remove suspected external devices.</li><li>Verify memory configuration matches installed physical memory.</li><li>Hold Shift key during startup to put computer into safe mode. See article <a href="#">HT201262: Try safe mode if your Mac doesn't finish starting up</a>.</li><li>Try the troubleshooting steps listed in article <a href="#">HT200553: OS X: When your computer spontaneously restarts or displays “Your computer restarted because of a problem.”</a></li><li>Check kernel panic log file to look for crash cause. See article <a href="#">HT201753: Mac OS X: How to log a kernel panic</a>.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	A voltage, current, or thermal sensor failure or an inoperative fan can cause kernel panics or system crashes. Run MRI or consult MRI results to check for any sensor or fan failures.	Yes	Go to “Intermittent Shutdown” troubleshooting flow.	<code> \${nodeText.yesSymptomCode}</code>	
	Does MRI report any sensor or fan failures?	No	Go to step 2.	<code> \${nodeText.noSymptomCode}</code>	
2.	Reset SMC using procedure for this computer in article <a href="#">HT201295: Intel-based Macs: Resetting the System Management Controller (SMC)</a> .	Yes	Go to step 3.	<code> \${nodeText.yesSymptomCode}</code>	
	Then reset NVRAM by holding down Command-Option-P-R keys while rebooting, until you hear startup sound for the second time.	No	Issue resolved by resetting SMC and NVRAM. Verify resolution.	<code> \${nodeText.noSymptomCode}</code>	
3.	Ask user what external USB or Thunderbolt devices may be connected to the computer when crashes or kernel panics occur.	Yes	Go to step 4.	<code> \${nodeText.yesSymptomCode}</code>	
	Does user have USB or Thunderbolt devices that may be causing crashes or kernel panics?	No	Go to step 5.	<code> \${nodeText.noSymptomCode}</code>	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
4.	Disconnect all external devices and only connect a known-good Apple USB wired keyboard and mouse to a USB port on the computer.	Yes	Go to step 5.	\${nodeText.yesSymptomCode}	
	Connect a known-good Apple Thunderbolt Display to a Thunderbolt port on the computer.	No	Issue isolated to user's external device(s). If user has multiple devices, attempt to isolate to the specific device causing the crash.		
	Attempt to reproduce the issue. If necessary, test by stressing the computer in OS X or by running Apple Service Diagnostic (ASD).	No	Check for software/driver updates from the device manufacturer and refer the customer to that manufacturer for further support.	\${nodeText.noSymptomCode}	
	Does computer still experience crashes or kernel panics?				
5.	Start up computer from a known-good up-to-date external volume with compatible OS X version build. Check article <a href="#">HT204319: OS X versions and builds included with Mac computers</a> to make sure system build is correct for this computer model.	Yes	Go to step 9.	\${nodeText.yesSymptomCode}	
	Does computer still experience crashes or kernel panics?	No	Go to step 6.	\${nodeText.noSymptomCode}	
6.	Boot computer to Apple Service Toolkit (AST) and run Storage Diagnostic to verify functionality of the flash storage.	Yes	Go to step 7.	\${nodeText.yesSymptomCode}	
	Is the flash storage detected and passing storage diagnostic?	No	Go to "Flash Storage Not Recognized / Not Mounting / Read-Write Issues" troubleshooting flow.	\${nodeText.noSymptomCode}	
7.	Check article <a href="#">HT204319: OS X versions and builds included with Mac computers</a> and use System Information or MRI to determine if user's flash storage has the correct minimum system build for this computer model.	Yes	Go to step 8.	\${nodeText.yesSymptomCode}	
	Is correct build of OS X installed on user's flash storage?	No	Restore correct version of OS X using internet recovery. See article <a href="#">HT201314: OS X: About OS X Recovery</a> for more information about Internet Recovery.  Verify issue resolved.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
8.	Run Disk Utility from an external volume to repair user's internal volume.  Start up from user's drive and attempt to reproduce the issue.	Yes	Restore correct version of OS X using internet recovery. See article <a href="#">HT201314: About OS X Recovery</a> for more information about Internet Recovery.  Verify issue resolved.	\${nodeText.yesSymptomCode}	
	Does computer still experience crashes or kernel panics?	No	Issue resolved by repairing the volume in Disk Utility.  Verify resolution.	\${nodeText.noSymptomCode}	
9.	Hold Shift key during startup to put computer into safe mode. See article <a href="#">HT201262: Try safe mode if your Mac doesn't finish starting up.</a>	Yes	Go to step 16.	\${nodeText.yesSymptomCode}	
	Does computer still experience crashes or kernel panics?	No	Go to step 10.	\${nodeText.noSymptomCode}	
10.	Some Mac Pro models with D500 or D700 graphics cards that were manufactured in early 2015 are eligible for graphics board replacements under the Mac Pro Repair Extension Program for Video Issues.  See <a href="#">OP1611: Mac Pro Repair Extension Program for Video Issues</a> or <a href="#">RS192: Mac Pro Repair Extension Program for Video Issues</a> to verify the eligibility of this unit.	Yes	Replace both graphics board A and graphics board B. Verify issue resolved.	Z77	STANDALONE CARD
	Does this unit qualify for the graphics card quality program?	No	Go to step 11.	\${nodeText.noSymptomCode}	
11.	To troubleshoot this issue completely, you need the following known-good parts: <ul style="list-style-type: none"><li>• graphics board A</li><li>• graphics board B</li><li>• graphics board flex cable</li></ul> Do you have immediate access to these known-good parts?	Yes	Go to step 12.	\${nodeText.yesSymptomCode}	
		No	Replace graphics board B. Verify issue resolved.	M06	STANDALONE CARD

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
12.	Safe boot disables some graphics card features. If the issue does not occur in safe boot, this may indicate an issue with one of the graphics cards.  Substitute a known-good graphics board A.  Reassemble and start up computer. Attempt to reproduce the issue.  Does the computer still experience crashes or kernel panics?	Yes	Go to step 13.	\${nodeText.yesSymptomCode}	
		No	Replace graphics board B. Verify issue resolved.	M06	STANDALONE CARD
13.	Safe boot disables some graphics card features. If the issue does not occur in safe boot, this may indicate an issue with one of the graphics cards.  Reinstall customer's graphics board A, substituting a known-good graphics board B.  Reassemble and start up computer. Attempt to reproduce the issue.  Does the computer still experience crashes or kernel panics?	Yes	Go to step 14.	\${nodeText.yesSymptomCode}	
		No	Replace graphics board B. Verify issue resolved.	M06	STANDALONE CARD
14.	Reinstall customer's graphics board B, substituting a known-good graphics board flex cable to connect graphics board A.  Reassemble and start up computer. Attempt to reproduce the issue.  Does the computer still experience crashes or kernel panics?	Yes	Go to step 15.	\${nodeText.yesSymptomCode}	
		No	Replace graphics board flex cable. Verify issue resolved.	X03	INTERNAL CABLE

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
15.	Reinstall customer's graphics board A flex cable, substituting a known-good graphics board flex cable to connect graphics board B.  Reassemble and start up computer. Attempt to reproduce the issue.  Does the computer still experience crashes or kernel panics?	Yes	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact ACS for additional support or a multiple-part repair.</p>	X99	INTERNAL CABLE
		No	<p>Click the Help button in the GSX toolbar, then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p> <p>Replace graphics board flex cable. Verify issue resolved.</p>	X03	
16.	Use ASD EFI to run full memory testing on computer to check for possible memory errors.	Yes	Go to step 17.	\${nodeText.yesSymptomCode}	
	Does ASD EFI report any memory failures?	No	Go to step 21.	\${nodeText.noSymptomCode}	
17.	Remove and reseat all memory modules to verify proper insertion.	Yes	Go to step 18.	\${nodeText.yesSymptomCode}	
	Run ASD EFI memory testing to verify.  Does ASD EFI report any memory failures?	No	<p>Issue resolved by reseating memory. Verify resolution.</p>	\${nodeText.noSymptomCode}	
18.	Verify each memory module individually by removing all modules, then inserting only one module at a time into first DIMM slot.  Run ASD EFI memory testing on each module to verify.	Yes	<p>Replace failed DIMM. Verify issue resolved.</p> <p><b>Note:</b> Only replace the defective memory module. There is no need to replace memory in pairs.</p>	X01	MEMORY
	Does memory fail testing?	No	Go to step 19.	\${nodeText.noSymptomCode}	
19.	Using a known-good DIMM, move to slot 2 and perform testing again.  Repeat testing on slots 3 and 4 until a failure has been found, or all slots pass.  Does ASD EFI report any memory failures?	Yes	Replace CPU riser card. Verify issue resolved.	M07	MPU
		No	Go to step 20.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
20.	If all modules and DIMM slots have passed individually, there may have been an issue with installation.  Reseat all modules, being careful to verify proper installation after the DIMM mechanism has been closed.  Run ASD EFI memory tests again with all modules installed.  Does ASD EFI report any memory failures?	Yes  No	Replace CPU riser card. Verify issue resolved.  Issue resolved by reseating memory. Verify resolution.	M07  \${nodeText.noSymptomCode}	OTHER BOARD
21.	Disassemble and clean computer. Be sure to check the fan, inlet, exhaust manifold, and thermal core. Use an ESD-safe vacuum and compressed air to remove any dust and debris.  Reassemble computer, carefully reseating all connectors.  Run ASD fan and sensor tests to verify operation, then attempt to reproduce the issue.  Does the computer still experience crashes or kernel panics?	Yes  No	Go to step 22.  Issue resolved by cleaning and reseating connectors. Verify resolution.	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
22.	Disconnect antennas and remove wireless card.  Reassemble computer and attempt to reproduce the issue.  Does the computer still experience crashes or kernel panics?	Yes  No	Go to step 23.  Go to “Wi-Fi Service Not Recognized” troubleshooting flow.	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
23.	Remove user's flash storage.  Reassemble computer and start up from a known-good up-to-date external volume with compatible OS X version build.  Attempt to reproduce the issue.  Does the computer still experience crashes or kernel panics?	Yes  No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.  Click the Help button in the GSX toolbar, then choose Troubleshooting > Technical Help with a Repair > Contact Apple.  Replace flash storage. Verify issue resolved.	X99  H99	SSD

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
		Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
24.	<p>Run full ASD EFI and loop ASD OS for 8-10 hours to verify computer does not encounter a crash or kernel panic.</p> <p>Is issue resolved?</p>	No	<p><b>ESCALATION REQUIRED.</b></p> <p>Contact ACS for additional support or a multiple-part repair.</p> <p>Click the Help button in the GSX toolbar, then choose Troubleshooting &gt; Technical Help with a Repair &gt; Contact Apple.</p>	X99	

# No Power

## Unlikely causes:

Audio Jack, Bluetooth Antenna, DIMM Mechanism, Fan, Fan Flex Cable, Flash Storage, Graphics Board A, Graphics Board B, Interposer Board, Inlet, Interposer Board Flex Cable, Roof, Wi-Fi Antenna, Wireless Card

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• Computer does not turn on</li><li>• No image on external displays</li><li>• No startup sound</li><li>• No sounds from fan or hard drive (if hard drive present)</li><li>• No Caps Lock LED when key is pressed on wired keyboard</li><li>• Non-operational</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. Verify AC power source.</li><li>2. Disconnect all peripherals.</li><li>3. Determine if computer is powered on. Check the following:<ul style="list-style-type: none"><li>◦ System Indicator Light (in power button)</li><li>◦ Caps Lock LED on wired keyboard</li><li>◦ Fan spinning sound</li><li>◦ External display signal</li><li>◦ Thunderbolt target disk mode operation (Hold T key on wired keyboard at startup)</li><li>◦ Attempt to reset NVRAM and listen for startup sound.</li></ul></li><li>4. Verify that the housing is properly installed and locked in place.</li><li>5. Reset SMC using procedure listed for this computer in article <a href="#">HT201295: Intel-based Macs: Reset the System Management Controller (SMC) on your Mac</a> to ensure computer is powered off. Then try to turn on.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	The Mac Pro (Late 2013) contains a Hall Effect sensor that will prevent operation of the computer with the housing removed. The housing has an embedded magnet to activate this switch.  The magnet looks like a small silver dot on the inside of the housing, to the left of the port opening. Inspect the housing to verify that the magnet is in place.  Is the housing magnet in place?	Yes	Go to step 2.	\${nodeText.yesSymptomCode}	
		No	Replace housing. Verify issue resolved.	X12	ENCLOSURE
2.	Inspect user's power cable for wire or connector damage. Also inspect the AC inlet on the computer for signs of arcing or damaged pins that affect power cable connection.  Are any components damaged?	Yes	Go to step 3.	\${nodeText.yesSymptomCode}	
		No	Go to step 5.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
3.	Determine if damage only affects the user's AC Power cable.  Does damage only affect power cable?	Yes	Inform customer that damage is not covered by warranty.  Replace power cable out of warranty. Verify issue resolved.	X03	EXTERNAL CABLE
		No	Go to step 4.	\${nodeText.noSymptomCode}	
4.	Determine AC inlet has damaged or missing pins.  If there are signs of arcing or other damage, multiple parts may be required.  Does damage only affect AC inlet?	Yes	Inform customer that damage is not covered by warranty.  Replace AC inlet out of warranty. Verify issue resolved.	P16	PIECE PART
		No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	X99	
5.	Substitute a known-good power cable and attempt to turn on the computer.	Yes	Replace power cable. Verify issue resolved.	X03	EXTERNAL CABLE
	Does the computer turn on?	No	Go to step 6.	\${nodeText.noSymptomCode}	
6.	Remove housing and connect computer to AC Power.  The diagnostic LEDs are located on the rear of the I/O board, across from DIMM Slots 3 and 4.  Using a black stick, activate the diagnostic LED button and check results. LED #2 (11V_STBY) indicates trickle power, and should be illuminated when AC power is connected.  See <a href="#">TP1087: Using Diagnostic LEDs For Troubleshooting</a> for the proper procedure for using the diagnostic LEDs.  Is LED #2 illuminated?	Yes	Go to step 14.	\${nodeText.yesSymptomCode}	
		No	Go to step 7.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
7.	<p>Following the procedures in the Service Guide, remove the exhaust assembly and I/O and power supply assembly.</p> <p>Check and reseat AC inlet cable, and power supply cables connected to I/O board.</p> <p>Reassemble computer as per Service Guide, verifying that the bus bar connections are properly connected and screwed in at correct torque.</p> <p>Leave housing removed to check diagnostic LEDs.</p> <p>Is LED #2 illuminated?</p>	Yes  No	<p>Go to step 13.</p> <p>Go to step 8.</p>	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
8.	<p>To troubleshoot this issue completely, the following known-good parts are required.</p> <ul style="list-style-type: none"> <li>• Power supply</li> <li>• AC inlet</li> </ul> <p>Do you have immediate access to each of these known-good parts?</p>	Yes  No	<p>Go to step 9.</p> <p>Replace power supply. Verify issue resolved.</p>	\${nodeText.yesSymptomCode}  P01	POWER SUPPLY
9.	<p>Substitute a known-good power supply.</p> <p>Reassemble computer, leaving housing, removed, to check diagnostic LEDs.</p> <p>Is LED #2 illuminated?</p>	Yes  No	<p>Go to step 10.</p> <p>Go to step 11.</p>	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
10.	<p>Fully reassemble computer and attempt to turn on.</p> <p>Does computer turn on?</p>	Yes  No	<p>Replace power supply. Verify issue resolved.</p> <p><b>ESCALATION REQUIRED.</b> Contact ACS for additional support or a multiple-part repair.</p>	P01  X99	POWER SUPPLY
11.	<p>Reinstall customer's power supply, substituting a known-good AC inlet.</p> <p>Reassemble computer, leaving housing removed, to check diagnostic LEDs.</p> <p>Is LED #2 illuminated?</p>	Yes  No	<p>Go to step 12.</p> <p><b>ESCALATION REQUIRED.</b> Contact ACS for additional support or a multiple-part repair.</p>	\${nodeText.yesSymptomCode}  X99	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
	Fully reassemble computer and attempt to turn on.	Yes	Replace AC inlet. Verify issue resolved.	P01	POWER SUPPLY
12.	Does computer turn on?	No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	\${nodeText.noSymptomCode}	
13.	Fully reassemble computer and attempt to turn on.	Yes	Issue resolved by reseating power connections. Verify resolution.	\${nodeText.yesSymptomCode}	
	Does computer turn on?	No	Go to step 14.	\${nodeText.noSymptomCode}	
14.	With the housing still removed and AC power connected:  Hold a magnetic source approximately 1 inch to the right of the power button, immediately to the right of the vertical EMI gasket of the I/O wall.  Press the power button and observe the behavior of the LEDs.  <b>Note:</b> Operating the computer with the housing removed for purposes other than viewing diagnostic LEDs is not recommended. Removing the magnet will immediately power off the computer.  Is there any change to the LEDs when the power button is pressed?	Yes	Go to step 26.	\${nodeText.yesSymptomCode}	
		No	Go to step 15.	\${nodeText.noSymptomCode}	
15.	To troubleshoot this issue completely, the following known-good parts are required. <ul style="list-style-type: none"><li>• I/O wall</li><li>• Power supply</li><li>• I/O board</li><li>• I/O board flex cable</li><li>• Logic board</li></ul> Do you have immediate access to each of these known-good parts?	Yes	Go to step 16.	\${nodeText.yesSymptomCode}	
		No	Replace I/O wall. Verify issue resolved.	X14	OTHER ELECTRIC

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
16.	Substitute a known-good I/O wall.  Reassemble the computer, leaving the housing removed. Attempt to turn on using previous procedure.  Is there any change to the LEDs when the power button is pressed?	Yes	Go to step 17.	\${nodeText.yesSymptomCode}	
	No	Go to step 18.	\${nodeText.noSymptomCode}		
17.	Fully reassemble computer and attempt to turn on.  Does computer turn on?	Yes	Replace I/O wall. Verify issue resolved.	X14	OTHER ELECTRIC
	No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	X99		
18.	Reinstall customer's I/O wall, substituting a known-good power supply.  Reassemble the computer, leaving the housing removed. Attempt to turn on using previous procedure.  Is there any change to the LEDs when the power button is pressed?	Yes	Go to step 19.	\${nodeText.yesSymptomCode}	
	No	Go to step 20.	\${nodeText.noSymptomCode}		
19.	Fully reassemble computer and attempt to turn on.  Does computer turn on?	Yes	Replace power supply. Verify issue resolved.	P01	POWER SUPPLY
	No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	X99		
20.	Reinstall customer's power supply, substituting a known-good I/O board.  Reassemble the computer, leaving the housing removed. Attempt to turn on using previous procedure.  Is there any change to the LEDs when the power button is pressed?	Yes	Go to step 21.	\${nodeText.yesSymptomCode}	ADAPTER
	No	Go to step 22.	\${nodeText.noSymptomCode}		

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
	Fully reassemble computer and attempt to turn on.	Yes	Replace I/O board. Verify issue resolved.	M01	OTHER BOARD
21.	Does computer turn on?	No	<b>ESCALATION REQUIRED.</b> Contact ACS for additional support or a multiple-part repair.	X99	
	Reinstall customer's I/O board, substituting a known-good I/O board flex cable.	Yes	Go to step 23.	\${nodeText.yesSymptomCode}	
22.	Reassemble the computer, leaving the housing removed. Attempt to turn on using previous procedure.  Is there any change to the LEDs when the power button is pressed?	No	Go to step 24.	\${nodeText.noSymptomCode}	
	Fully reassemble computer and attempt to turn on.	Yes	Replace I/O board flex cable. Verify issue resolved.	X03	INTERNAL CABLE
23.	Does computer turn on?	No	<b>ESCALATION REQUIRED.</b> Contact ACS for additional support or a multiple-part repair.	X99	
	Reinstall customer's I/O board flex cable.	Yes	Go to step 25.	\${nodeText.yesSymptomCode}	
24.	Substitute a known-good logic board.  Reassemble the computer, leaving the housing removed. Attempt to turn on using previous procedure.  Is there any change to the LEDs when the power button is pressed?	No	<b>ESCALATION REQUIRED.</b> Contact ACS for additional support or a multiple-part repair.	X99	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
	Fully reassemble computer and attempt to turn on.	Yes	Replace logic board. Verify issue resolved.	M01	MLB
25.	Does computer turn on?	No	<b>ESCALATION REQUIRED.</b> Contact ACS for additional support or a multiple-part repair.	X99	
26.	Verify diagnostic LED #3 (12V_MAIN) turns on, and stays on, soon after the power button is pressed.  Does LED #3 stay illuminated?	Yes	Go to step 27.	\${nodeText.yesSymptomCode}	
		No	Replace power supply. Verify issue resolved.	P01	POWER SUPPLY
27.	The computer contains a Hall effect switch that prevents the computer from starting up with the housing removed.  With the magnet in place, attempt to turn on and startup the computer.  Does the computer startup with the housing removed?	Yes	Replace housing. Verify issue resolved.	X12	ENCLOSURE
		No	Go to "Will Not Start Up" troubleshooting flow.	\${nodeText.noSymptomCode}	
28.	Verify that computer can now power and complete startup process over multiple trials.  Is issue resolved?	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
		No	<b>ESCALATION REQUIRED.</b> Contact ACS for additional support or a multiple-part repair.	X99	

# Will Not Start Up

## Unlikely causes:

AC Inlet, Audio Jack, Bluetooth Antenna, Fan, Fan Flex Cable, Graphics Board A, I/O Wall, Speaker, Wi-Fi Antenna.

## Quick Check

Symptoms	Quick Check
<ul style="list-style-type: none"><li>• No startup sound or Power-On Self-Test (POST)</li><li>• Gray screen only appears during startup</li><li>• Some video activity, Apple logo, spinning gear</li><li>• Prohibitory sign or folder with a flashing question mark</li><li>• Error beep tones on startup</li><li>• Audible fan, hard drive spin sounds</li><li>• System Indicator light is on, blinking, or went out</li><li>• Caps Lock LED on wired keyboard toggles on and off when pressed</li></ul> <p><b>Note:</b> Inform user that computer failures due to accidental damage are not covered. If applicable, discuss out-of-warranty repair options.</p>	<ol style="list-style-type: none"><li>1. The Mac Pro cannot be started up without the housing installed. Remove and reseat the housing to confirm proper installation.</li><li>2. Verify startup process passes initial memory checks and POST. If computer beeps, there may be a memory issue. See article <a href="#">HT201702: Intel-based Mac Power-On Self-Test RAM error codes</a>.</li><li>3. Disconnect all external peripherals and cables.</li><li>4. Reset SMC using procedure listed for this computer in article <a href="#">HT201295: Resetting the System Management Controller (SMC) on your Mac</a> to put computer to known powered-off state. Then try to power on.</li><li>5. Reset NVRAM by holding down Command-Option-P-R keys while restarting, until you hear the startup sound for the second time.</li><li>6. Start up computer using an up-to-date, bootable OS X volume.</li><li>7. Run Disk Utility or check Mac Resource Inspector (MRI) results to verify presence and SMART status of user's SSD.</li><li>8. Check article <a href="#">HT204319: OS X versions and builds included with Mac computers</a> to make sure system build is correct for this computer model.</li><li>9. Hold Shift key during startup to put computer into safe mode. See article <a href="#">HT201262: Try safe mode if your Mac doesn't finish starting up</a>.</li><li>10. To isolate issue, Identify when computer hangs in startup process. See article <a href="#">HT204156: About the screens you see when your Mac starts up</a>.</li></ol>

## Deep Dive

	Check	Result	Action	Code	Commodity
1.	Reset NVRAM by holding down Command-Option-P-R keys while rebooting, until you hear the startup sound for the second time.  Does computer produce the standard startup sound?	Yes	Go to step 15.	\${nodeText.yesSymptomCode}	
		No	Go to step 2.	\${nodeText.noSymptomCode}	
2.	Power on computer and listen for error beep tones.  Memory errors are indicated by a sequence of one to three tones.  Refer to article <a href="#">HT202768: Mac computers: About startup tones</a> for more information.  Does computer make error beep tones at startup?	Yes	Go to step 3.	\${nodeText.yesSymptomCode}	
		No	Go to step 9.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
3.	Remove housing and reseat all memory modules securely in their slots.	Yes	Go to step 4.	\${nodeText.yesSymptomCode}	
	Reinstall the housing and power on the computer.		Issue resolved by reseating memory. Verify resolution.		
	Does computer make error beep tones at startup?	No		\${nodeText.noSymptomCode}	
4.	Remove all user memory modules.	Yes	Go to step 5.	\${nodeText.yesSymptomCode}	
	Substitute known-good memory into first DIMM slot and power on computer.	No	Go to step 6.		
	Does computer startup with only known-good memory installed?			\${nodeText.noSymptomCode}	
5.	Move known-good memory to DIMM slot two and power on computer. Listen for error beeps at startup.	Yes	Issue isolated to user's memory. Test each module individually to isolate defective module(s).	X02	MEMORY
	If memory errors do not occur, repeat the procedure for remaining DIMM slots, verifying functionality on all slots.		Replace defective memory. Verify issue resolved.		
	Does computer startup with known-good memory installed in any DIMM slot?	No	Go to step 7.	\${nodeText.noSymptomCode}	
6.	Substitute a known-good graphics board A.	Yes	Replace graphics board A. Verify issue resolved.	M05	STANDALONE CARD
	Reassemble computer and attempt to start up.		Go to step 7.		
	Does computer start up successfully?	No		\${nodeText.noSymptomCode}	
7.	To completely troubleshoot this issue, a known-good CPU riser card is required.	Yes	Go to step 8.	\${nodeText.yesSymptomCode}	
	Do you have immediate access to a known-good CPU riser card?	No	Replace CPU riser card. Verify issue resolved.		MPU
8.	Substitute a known-good CPU riser card.	Yes	Replace CPU riser card. Verify issue resolved.	M07	MPU
	Reassemble computer and start up.				
	Does computer start up?	No	<b>ESCALATION REQUIRED.</b> Contact ACS for additional support or a multiple-part repair.	X99	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
9.	Verify that computer is powering on by checking System Indicator Light (SIL), located in the power button.  If the computer is powering on, the SIL will illuminate shortly after the power button is pressed.  Does the SIL illuminate after pressing the power button?	Yes  No	Go to step 10.  Go to “No Power” troubleshooting flow.	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
10.	Remove all user memory modules from the computer.  Power on the computer with no memory installed and listen for error beeps.  The computer should produce one beep to indicate no memory is installed. (Error beep tones repeat every five seconds.)  Does computer make one error beep tone?	Yes  No	Go to step 4.  Go to step 11.	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
11.	Disconnect AC power and remove housing. Press the Real Time Clock (RTC) Reset button on the logic board.  The button can be accessed by removing the DIMMs from the left two slots, then using a black stick to press the button.  Substitute known-good memory into the first DIMM slot.  Reassemble the computer and start up.  Does computer start up?	Yes  No	Issue resolved by resetting the logic board. Verify resolution.  Go to step 12.	\${nodeText.yesSymptomCode}  \${nodeText.noSymptomCode}	
12.	To troubleshoot this issue completely, the following known-good parts are required:  • CPU riser card • logic board  Do you have immediate access to each of these known-good parts?	Yes  No	Go to step 13.  Replace logic board. Verify issue resolved.	\${nodeText.yesSymptomCode}  M02	MLB
13.	Substitute a known-good logic board.  Reassemble computer and start up.  Does computer start up?	Yes  No	Replace logic board. Verify issue resolved.  Go to step 14.	M02  \${nodeText.noSymptomCode}	MLB

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
	Reinstall the customer's logic board, substituting a known-good CPU riser card.	Yes	Replace CPU riser card. Verify issue resolved.	M02	MPU
14.	Reassemble computer and start up.  Does computer start up?	No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	X99	
15.	Observe startup process to verify computer at least gets to initial gray screen after startup sound.  Does computer reach a gray screen during startup process?	Yes	Go to step 16.	\${nodeText.yesSymptomCode}	
		No	Go to "No Video to External Display" troubleshooting flow.	\${nodeText.noSymptomCode}	
16.	Determine if a kernel panic is occurring at startup.  For more info, refer to article <a href="#">HT200553: OS X: When your computer spontaneously restarts or displays "Your computer restarted because of a problem."</a>  Does computer display kernel panic during startup?	Yes	Go to "Kernel Panic / System Crashes" troubleshooting flow.	\${nodeText.yesSymptomCode}	
		No	Go to step 17.	\${nodeText.noSymptomCode}	
17.	Start up computer with Option (Alt) key down, using a known-good, bootable OS X volume. See <a href="#">HT204319: OS X versions and builds included with Mac computers</a> to determine the correct minimum build for this computer.  During startup, allow up to four minutes for a defective flash storage to time out, after which computer will start up from known-good external device.  Does computer start up from a known-good volume?	Yes	Go to step 18.	\${nodeText.yesSymptomCode}	
		No	Go to step 21.	\${nodeText.noSymptomCode}	
18.	Boot computer to Apple Service Toolkit (AST) and run Storage Diagnostic to verify functionality of the flash storage.  Is the flash storage detected and passing Storage Diagnostic?	Yes	Go to step 19.	\${nodeText.yesSymptomCode}	
		No	Go to "Flash Storage Not Recognized / Not Mounting / Read/Write Issues" troubleshooting flow.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
19.	<p>Check article <a href="#">HT204319: OS X versions and builds included with Mac computers</a> and use Disk Utility or MRI to determine if user's flash storage has the correct minimum system build for this computer model.</p> <p>Is correct build of OS X installed on user's flash storage?</p>	Yes	Go to step 20.	\${nodeText.yesSymptomCode}	
		No	<p>Restore correct version of OS X using internet recovery. See article <a href="#">HT201314: OS X: About OS X Recovery</a> for more information about Internet Recovery.</p> <p>Verify issue resolved.</p>	\${nodeText.noSymptomCode}	
20.	<p>Run Disk Utility from an external volume to repair user's flash storage.</p> <p>Attempt to start up from user's flash storage.</p> <p>Does computer start up successfully from user's flash storage?</p>	Yes	<p>Issue resolved by repairing the volume in Disk Utility.</p> <p>Verify resolution.</p>	\${nodeText.yesSymptomCode}	
		No	<p>Restore correct version of OS X using internet recovery. See article <a href="#">HT201314: OS X: About OS X Recovery</a> for more information about Internet Recovery.</p> <p>Verify issue resolved.</p>	\${nodeText.noSymptomCode}	
21.	<p>Try to perform a safe boot by holding down the Shift key at startup.</p> <p>See article <a href="#">HT201262: Try safe mode if your Mac doesn't finish starting up</a> for more information about safe mode.</p> <p>Does computer start up in safe mode?</p>	Yes	Go to step 22.	\${nodeText.yesSymptomCode}	
		No	Go to step 24.	\${nodeText.noSymptomCode}	
22.	<p>Substitute a known-good graphics board A.</p> <p>Reassemble computer and attempt to start up.</p> <p>Does computer start up successfully?</p>	Yes	Replace graphics board A. Verify issue resolved.	M05	STANDALONE CARD
		No	Go to step 23.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
	Reinstall the customer's graphics board A and substitute a known-good graphics board B.	Yes	Replace graphics board B. Verify issue resolved.	M05	STANDALONE CARD
23.	Reassemble computer and attempt to start up.  Does computer start up successfully?	No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	X99	
24.	Disconnect antennas and remove wireless card.  Reassemble computer and attempt to start up from a known-good volume.  Does computer start up successfully?	Yes	Go to "Wi-Fi Service Not Recognized" troubleshooting flow.	\${nodeText.yesSymptomCode}	
		No	Go to step 25.	\${nodeText.noSymptomCode}	
25.	Disassemble computer, disconnecting the I/O board, CPU riser board, and graphics boards.  Carefully inspect all the connectors for any damage.  Reassemble computer, securely reseating all connections. Attempt to start up from a known-good volume.  Does computer start up successfully?	Yes	Issue resolved by reseating internal connections. Verify resolution.	\${nodeText.yesSymptomCode}	
		No	Go to step 26.	\${nodeText.noSymptomCode}	
26.	To troubleshoot this issue completely, the following known-good parts are required: <ul style="list-style-type: none"><li>• Logic board</li><li>• CPU riser card</li><li>• I/O board</li><li>• I/O board flex cable</li></ul> Do you have immediate access to each of these known-good parts?	Yes	Go to step 27.	\${nodeText.yesSymptomCode}	
		No	Replace logic board. Verify issue resolved.	M05	MLB
27.	Substitute a known-good logic board.  Reassemble computer and attempt to start up from a known-good volume.  Does computer start up successfully?	Yes	Replace logic board. Verify issue resolved.	M05	MLB
		No	Go to step 28.	\${nodeText.noSymptomCode}	

	<b>Check</b>	<b>Result</b>	<b>Action</b>	<b>Code</b>	<b>Commodity</b>
	Reinstall the user's logic board, substituting a known-good CPU riser card.	Yes	Replace CPU riser card. Verify issue resolved.	M05	MPU
28.	Reassemble computer and attempt to start up from a known-good volume.  Does computer start up successfully?	No	Go to step 29.	\${nodeText.noSymptomCode}	
	Reinstall the user's CPU riser card, substituting a known-good I/O board flex cable.	Yes	Replace I/O board flex cable. Verify issue resolved.	X03	INTERNAL CABLE
29.	Reassemble computer and attempt to start up from a known-good volume.  Does computer start up successfully?	No	Go to step 30.	\${nodeText.noSymptomCode}	
	Reinstall the user's I/O board flex cable, substituting a known-good I/O board.	Yes	Replace I/O board. Verify issue resolved.	M05	OTHER BOARD
30.	Reassemble computer and attempt to start up from a known-good volume.  Does computer start up successfully?	No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	X99	
	Fully reassemble computer and verify computer can now complete startup process over multiple trials.  Is issue resolved?	Yes	Issue resolved.	\${nodeText.yesSymptomCode}	
31.		No	<b>ESCALATION REQUIRED.</b>  Contact ACS for additional support or a multiple-part repair.	X99	

# Safety

## Mac Pro (Late 2013) Safety

### Electrical Safety Precautions

Before working on a computer with exposed, potentially energized parts:

1. **Remove rings, watches, necklaces, metal-rimmed eyewear, and other metallic articles** which increase your risk of electric shock.
2. **Do not wear a cell phone or other signaling device**, as these may cause a dangerous startle reflex during energized work.
3. **If the computer needs to be plugged in for LED checks or similar troubleshooting, do NOT wear an ESD wrist strap.** Wearing an ESD grounding system increases your risk of electric shock in this situation.
4. **Remain alert**, focused on the work being performed, and aware of the proximity of grounded objects to your body.
5. **Use the plastic black stick or other nonmetal extension tool as needed** to connect or disconnect cables, to keep fingers away from potentially energized parts.

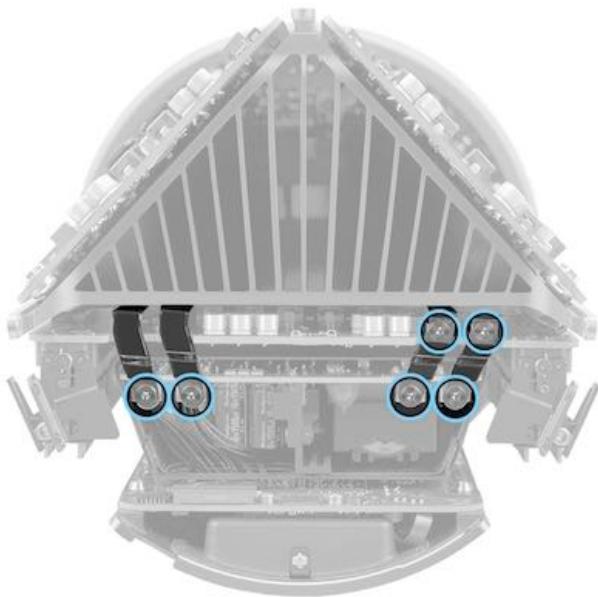


Technicians servicing the Mac Pro (Late 2013) should be aware of the following potential hazards and understand how to avoid injury from those hazards:

**Hazardous energy** (>240 VA) exists on each of the bus bars and throughout each of the logic boards when the power supply 12 Vdc output is energized. To avoid injury, avoid contact with the bus bars and the logic boards.

A safety interlock circuit on the I/O board de-energizes the power supply output immediately when the housing is removed. However, overriding the safety interlock circuit (the area shown by the blue circle) with a magnet, as instructed in step 6 of article [TP1087: Mac Pro \(Late 2013\): Diagnostic LEDs and Test Points](#), energizes the power supply output. Overriding the safety interlock should only be done for the purpose of observing the status of the LEDs. **Do not disassemble the system, other than removing the outer housing, with the safety interlock defeated.** Additionally, the technician should not be physically touching the system while the power supply output is energized. Hazardous energy can cause burns if opposite polarity sources are bridged by metal objects (such as a ring, other jewelry, or metal tools).

Avoid contact with I/O board bus bars and bus bar screws:



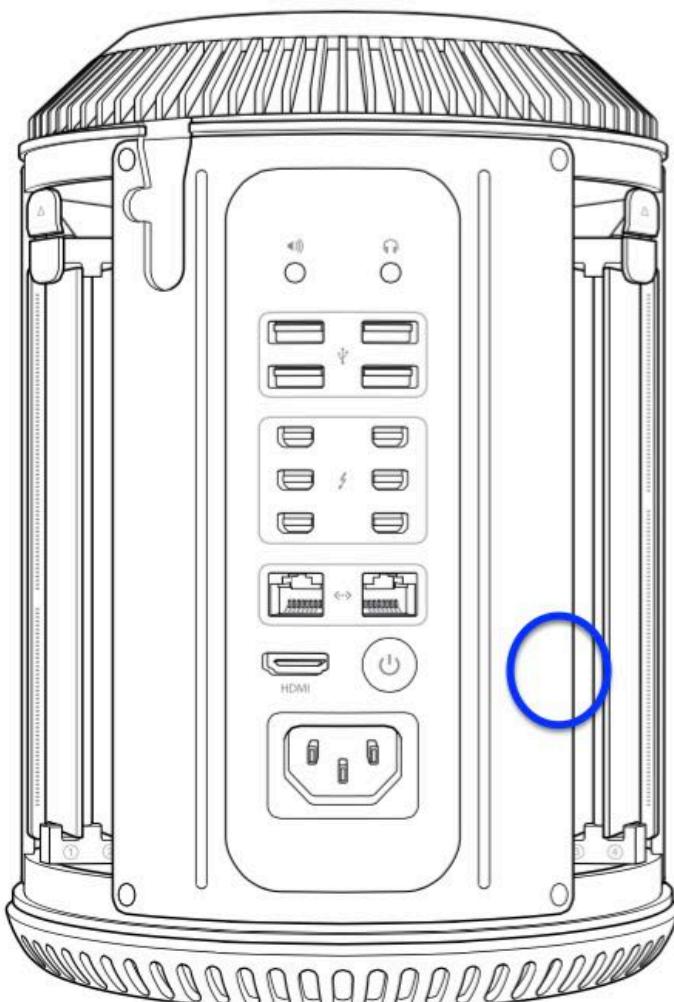
Avoid contact with Graphics board A bus bar screws:



Avoid contact with Graphics board B bus bar screws:



The safety interlock sensor location is behind the metal I/O panel, on the I/O board:



**Shock hazards:** Any voltage source exceeding 60 Vdc or 42.4 Vp has the potential to create an electrical shock. There are no shock hazards accessible to a technician servicing the Mac Pro (Late 2013) with the housing on or with the housing removed, even if the power cord is plugged in. As long as the Mac Pro is not disassembled with the power cord plugged in, the technician is safe from a shock hazard. Overriding the safety interlock for the purpose of observing the status of the LEDs does not expose the technician to a shock hazard, only a hazardous energy hazard (see previous topic). Hazardous energy can cause burns if opposite polarity sources are bridged by metal objects (ie: a ring, other jewelry, or metal tools).

High voltage is **inside** the power supply, an area that should **never** be touched by the repair technician. Shock hazards exist between the AC inlet and the power supply and could become accessible if the I/O panel or power supply shroud is removed with the unit connected to a 100 – 240 Vac power source. **No service should ever be performed in this condition.**

Power supply metal shroud:



**Specific Reassembly Procedures:** There are certain procedures that must be followed as specified in the Mac Pro (Late 2013) Service Guide to avoid introducing a hazardous condition within the product.

1. AC inlet cable: When reattaching the AC inlet cable to the power supply connector, make sure that the cable is captured by the U-shaped clip on the power supply assembly. Failure to do so may result in the AC inlet cable being pinched by the edge the power supply shroud. This could damage the cable insulation and create a shock or fire hazard.



2. I/O flex cable: The I/O flex cable, routed from the I/O board to the bottom logic board, must be routed under the I/O board rather than under the power supply. The I/O flex cable does not have insulation suitable for the voltages and temperatures of the power supply components. Routing the flex cable outward, or under the I/O board, prevents contact with the power supply.



3. Coin cell battery: When replacing the coin cell battery, observe the proper polarity. Slide the battery into the socket with the engraved markings (+ side) facing up. If the battery is installed incorrectly or replaced with an incorrect type of battery, there is a risk of explosion.



# General Take-Apart Information

## Tools for Mac Pro (Late 2013)

- Torx T5 screwdriver
- Torx T8 screwdriver
- Torx T10 screwdriver
- Torx T15, a standard torx bit: Used with adjustable torque driver below
- Adjustable torque driver: Special tool, 923-0735 (0.3-1.2 Nm)
- Nut setter bit, 1/4 in. Hex bit: Special tool, 923-00320
- Torx T10 1/4 in. Hex, 50 mm bit: Special tool, 923-0740
- Torx T8 security bit: Special tool for bus bars, 923-0734
- Torx T10 ball-end bit: Special tool for PSU, 923-0733
- Mezzanine connector removal tool: Special tool, 076-1458
- Mac Pro (Late 2013) service fixture starter kit: 076-1455 (includes: I/O wall stand, roof alignment fixture, core cradle, foam block, CPU riser cover, mezzanine connector removal tool, and core end caps)
- Mac Pro (Late 2013) service fixture foam kit: 076-1456 (includes: I/O wall stand, roof alignment fixture, core cradle, and foam block)
- CPU riser spring press fixture: 076-1459
- CPU grease stencil, pack of 5: 076-1460
- GPU grease stencil, pack of 5: 076-1461
- Suction cup: 922-8252
- Access card tool: 922-7172
- Thermal syringe (**Note:** The thermal compound that ships with the cpu riser card and graphics board is the same as thermal compound 922-7144.)
- Thermal pads
- Isopropyl alcohol (IPA) wipes

**Note:** The Torx T8 security bit must be used when removing or installing bus bars. The Torx T10 ball-end bit must be used when removing or installing the PSU. Either a basic Torx T8 screwdriver or the Torx T8 security bit may be used for other T8 screws. Either a basic Torx T10 screwdriver or the Torx T10 ball-end bit may be used for other T10 screws.

For more information about tools, refer to article [OP101: Apple notebooks and desktops: Hand tools for repairs](#).

## Electrostatic Discharge (ESD) Precautions

Proper ESD precautions must always be used when servicing this product. Make sure you are working on a properly grounded ESD-safe mat and are wearing a properly connected ESD-safe wrist strap.

For more information about ESD, refer to:

- [OP100: Electrostatic Discharge Precautions and Myths](#)
- [ATLAS: ESD Precautions](#)

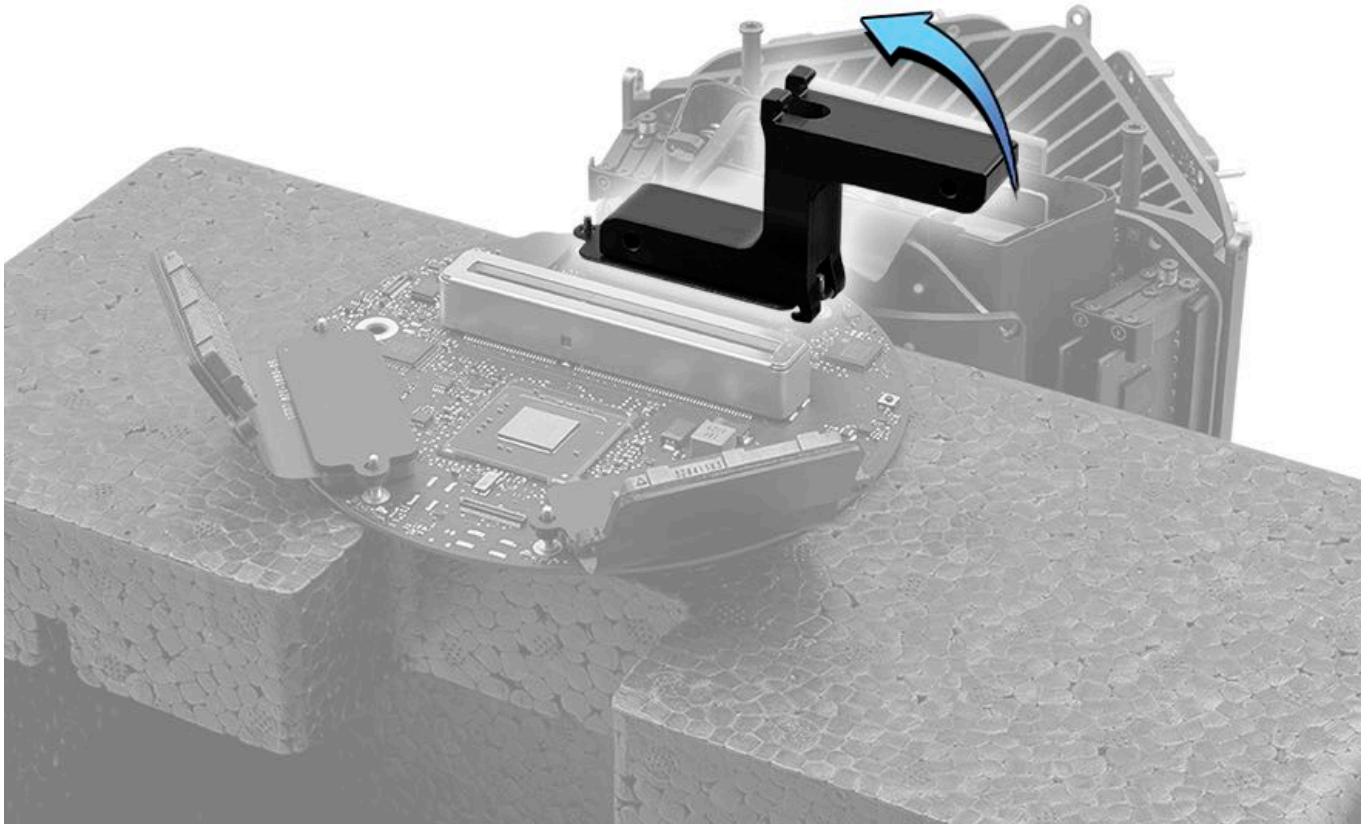
## Screws

When replacing a part, you must use the screws shipped with the replacement part, both for the new part installation and for reinstalling parts included in the procedure's First Steps. Discard the original screws, as they are not reusable.

**Note:** Replacement screws are labeled with 452-xxxx numbers; use the [Mac Pro \(Late 2013\): Screw Chart](#) to match screws to their parts.

## Mezzanine Connectors

Mac Pro (Late 2013) includes mezzanine connectors on the graphics board cables and I/O board cable. The connectors require the following special handling:



- Use the mezzanine connector removal tool for disconnecting the connectors. Position the tool's small hook under the stiffener on the graphics board cable connectors, and position the large hook under the stiffener on the I/O board cable connectors. Rocking the tool back like a bottle opener, release first one end and then the other end of the connector, then lift the cable connector straight off the board.
- Before reconnecting mezzanine connectors, always check for bent pins. Hold an LED flashlight at a 45-degree angle to the pins on both the cable and board connectors, and look for abnormal light reflection indicating bent or broken pins. If a cable connector exhibits damaged pins, replace the cable. If pins look damaged on a board connector, reassemble the computer and follow the Service Guide's troubleshooting flows to check for symptoms related to a failed connector. (Note that not all pins on board connectors are live and therefore, if damaged, may not affect the connection.)

### Reassembly Steps

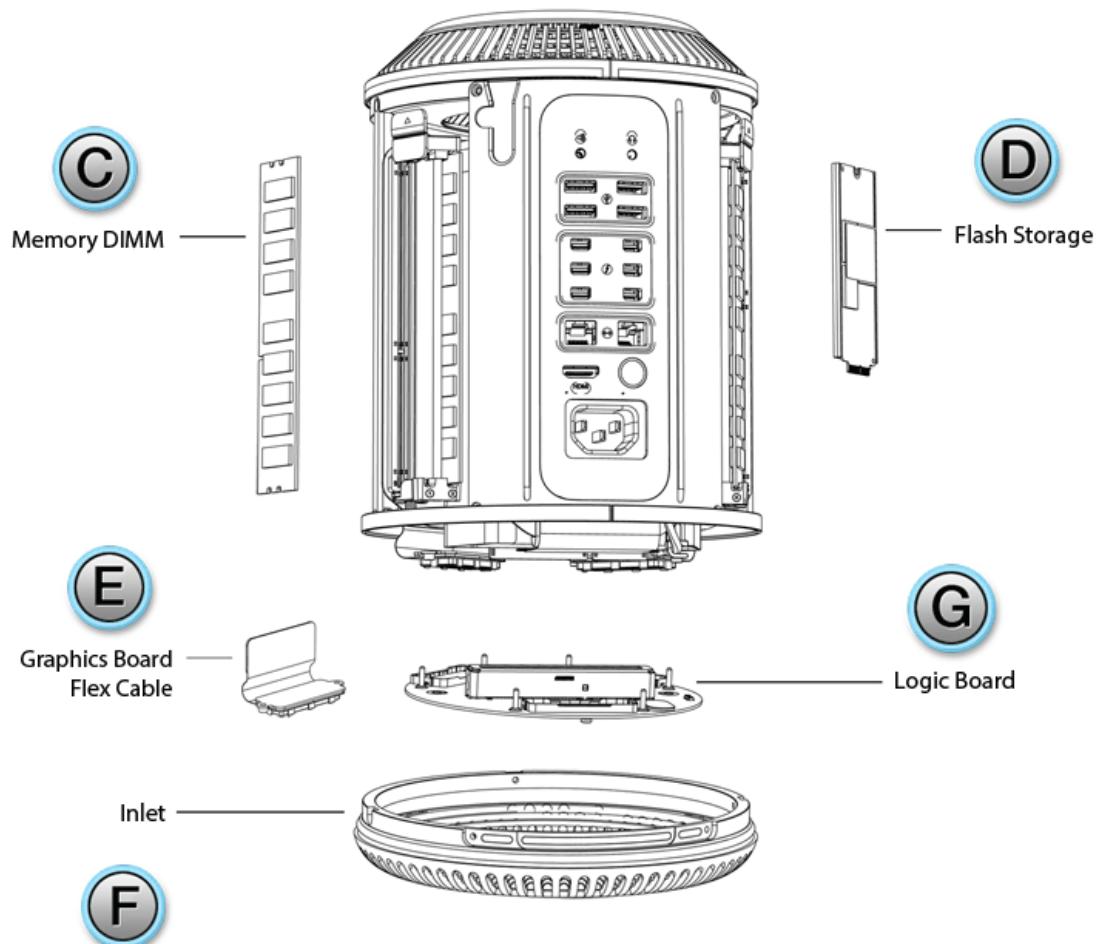
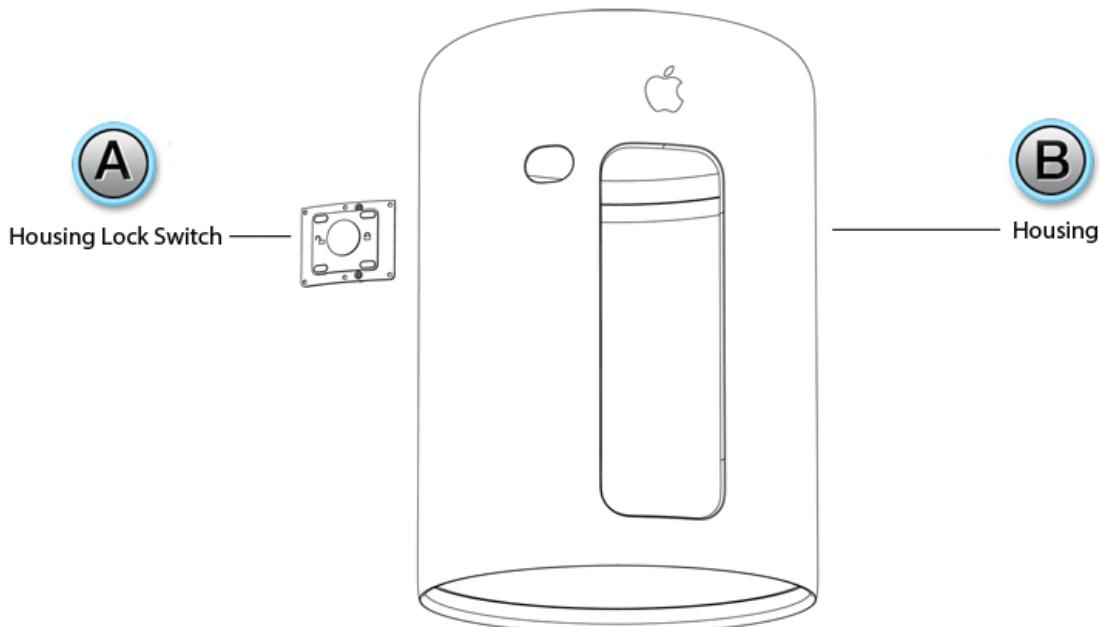
When no replacement steps are listed, replace parts in exact reverse order of Removal procedure.

### Note About Images in This Guide

Because preproduction units were used for the illustrations, you may notice small differences between the images provided and the computer you are servicing.

# Housing/Memory/Storage/Logic Board Overview

## Housing/Memory/Storage/Logic Board



A = [Housing Lock Switch](#)

B = [Housing](#)

C = [Memory Dimm](#)

D = [Flash Storage](#)

E = [Graphics Board Flex Cable](#)

F = [Inlet](#)

G = [Logic Board](#)

# Housing

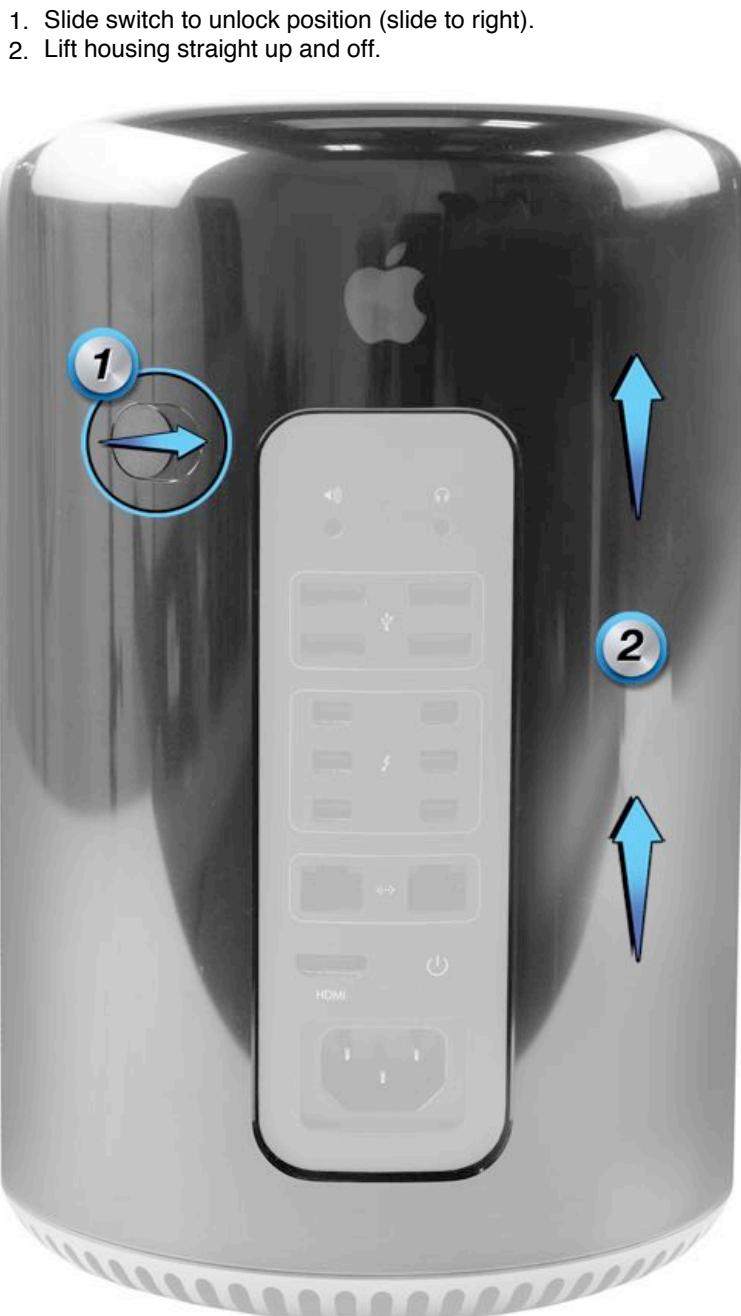
## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

## Tools

- ESD wrist strap

## Steps For Removal



## Steps For Reassembly

Reassemble in reverse order of removal steps.

# Inlet

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)



## Tools

- ESD wrist strap
- Torx T10 screwdriver (magnetized)
- Roof alignment fixture (**Note:** The roof alignment fixture is necessary when only servicing the inlet. When inlet removal is part of a service process, it is not always necessary to use the fixture.)

## Steps For Removal

1. Position exhaust in roof alignment fixture and invert computer so that inlet is on top.



2. Remove three (3) T10 inlet-to-core screws (923-0713) in the order shown.



**Reassembly note:** Replace screws in the same order.



3. Remove two (2) T10 inlet-to-I/O screws (923-0713).



4. Lift inlet straight up off computer.



## Steps For Reassembly

1. **Note:** If replacing the inlet, make sure to match the color of the gasket on the inlet to the gasket on the I/O wall. The replacement inlet (923-00466) includes a new I/O wall with a matching gasket.



2. When replacing an inlet, retain the user's original inlet until the repair is complete. Before installing a replacement inlet, use a fine-tipped permanent marker to write the original system serial number on the inside matte surface of the inlet.



2. Reassemble in reverse order of removal steps.

# Housing Lock Switch

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)



## Tools

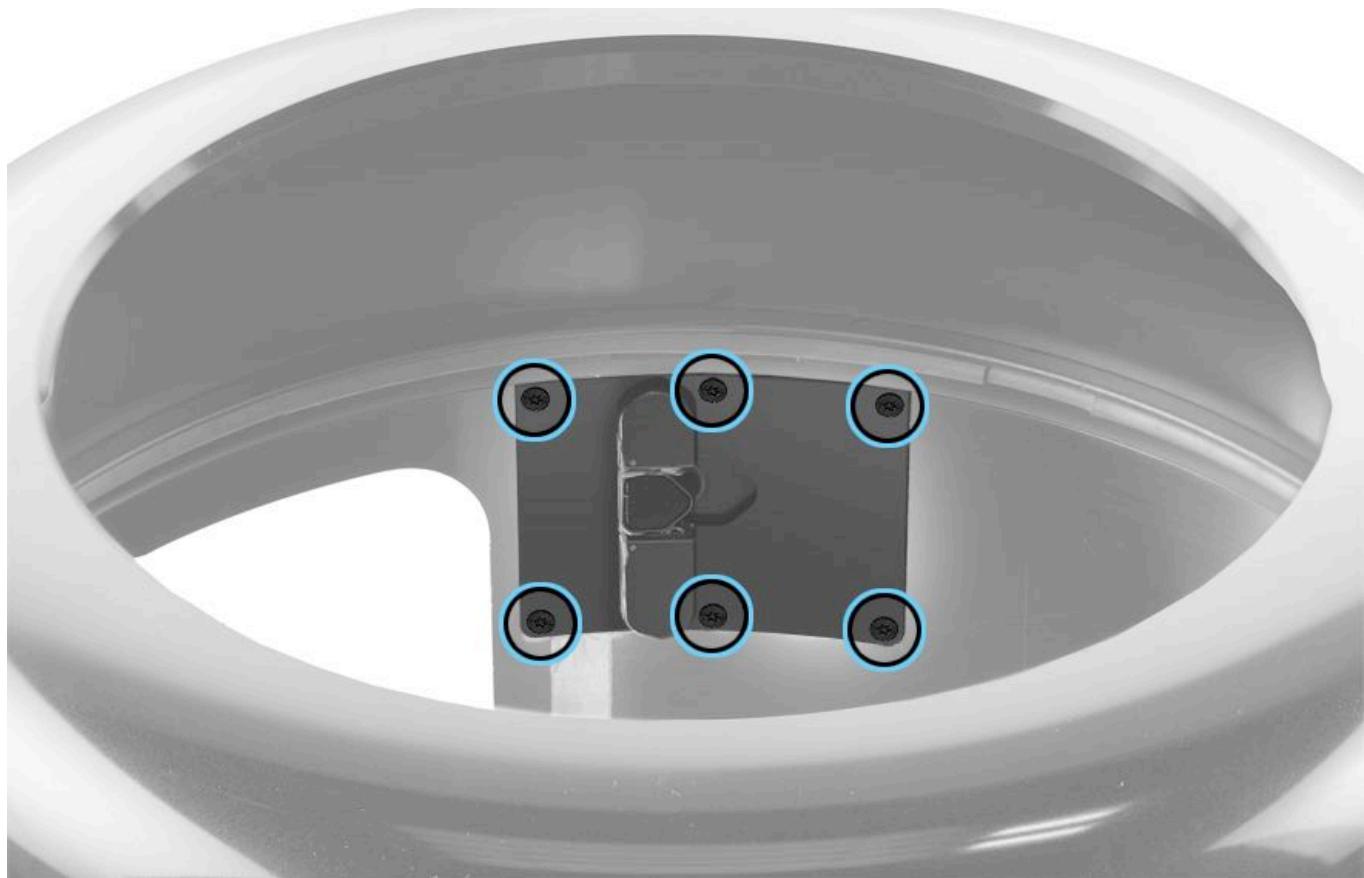
- ESD wrist strap
- Torx T5 short-handled screwdriver

## Steps For Removal

1. Remove six (6) T5 housing lock switch screws (923-0710).



2. Remove lock switch from housing.



### Steps For Reassembly

Reassemble in reverse order of removal steps.

# Memory DIMM

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:



## Tools

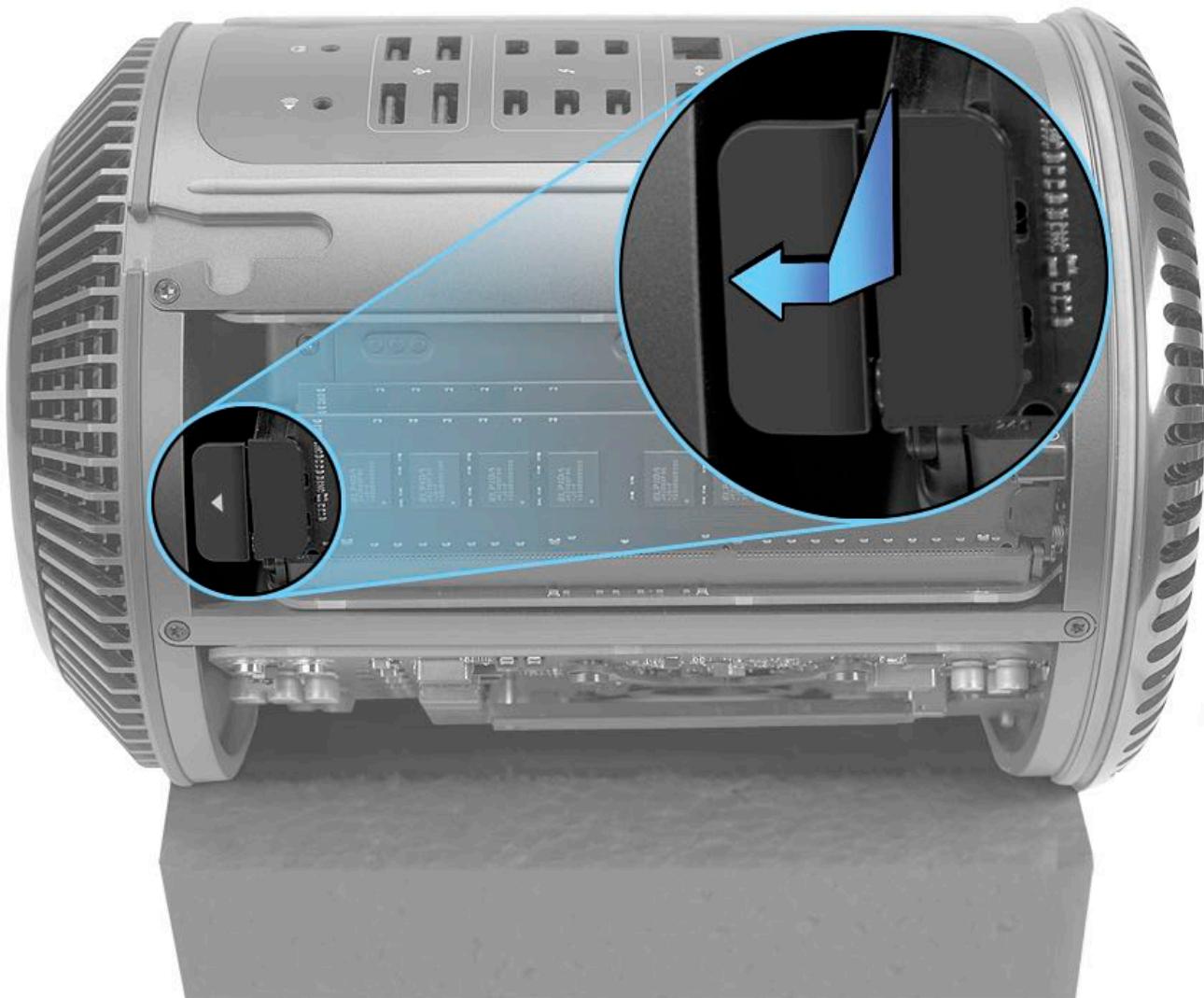
- ESD wrist strap
- Compressed air (recommended)
- I/O wall stand (recommended)

## Steps For Removal

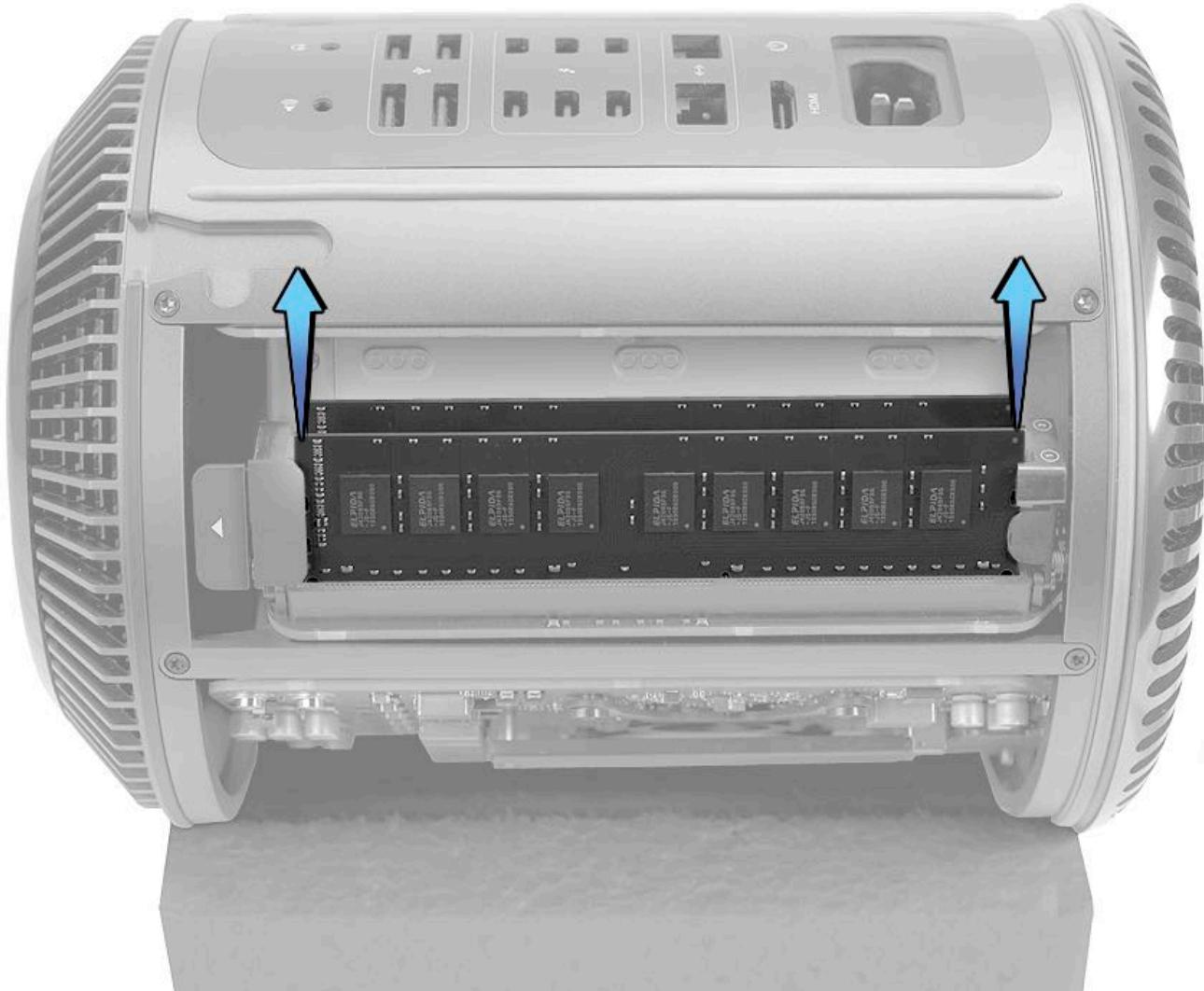
### General notes:

- Apple recommends laying computer on its side for DIMM removal and insertion. Placing computer in I/O wall stand will keep it from rocking.
- Always hold DIMM by edges. Do not touch gold pins on DIMM.

1. Depress DIMM mechanism tab to unlatch mechanism and release DIMM.



2. Holding DIMM by the edges, pull it straight out from DIMM slot. Do not rock or wiggle DIMM out of slot.



## Steps For Reassembly

### General notes:

- Apple recommends cleaning DIMM and DIMM slot with compressed air before installing DIMM. Keep compressed air can upright to prevent supercooled liquid from ejecting onto computer. Liquid may leave residue that is difficult to remove.
- Mechanism must be fully open during DIMM installation. Do not try inserting DIMM while mechanism is in locked position.
- If you are installing more than one DIMM on a side, install DIMM in inner slot first, then in outer slot.

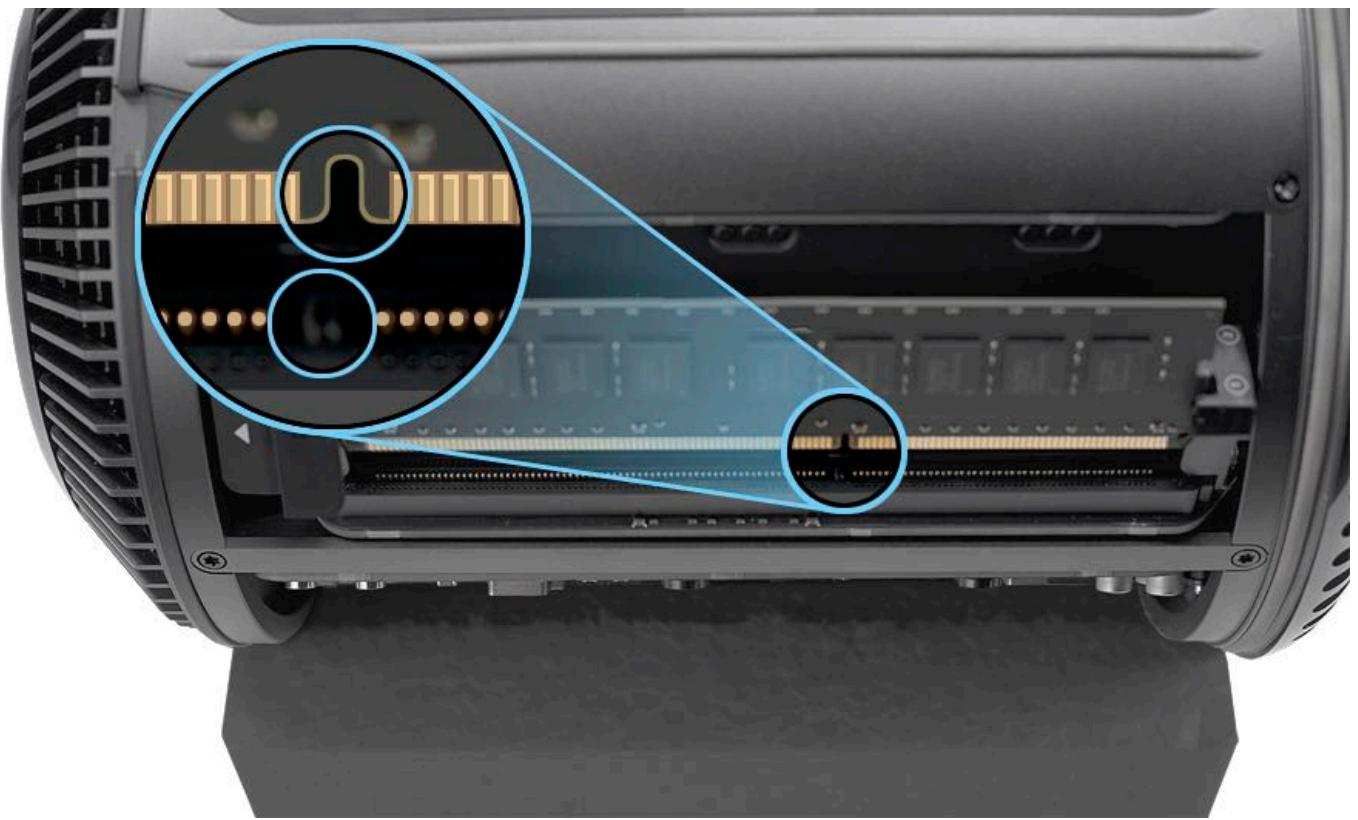
### Note on DIMM slots and DIMM placement:

DIMM slots are numbered 1 through 4. To optimize system cooling, Apple recommends installing DIMMs as shown.

No. of DIMMs	Slots Filled			
	1	2	3	4
1		X		
2		X	X	
3	X	X	X	
4	X	X	X	X



1. Position DIMM so that keys in DIMM and DIMM slot align.
2. Gently insert DIMM into slot until DIMM pins are touching DIMM slot contacts.

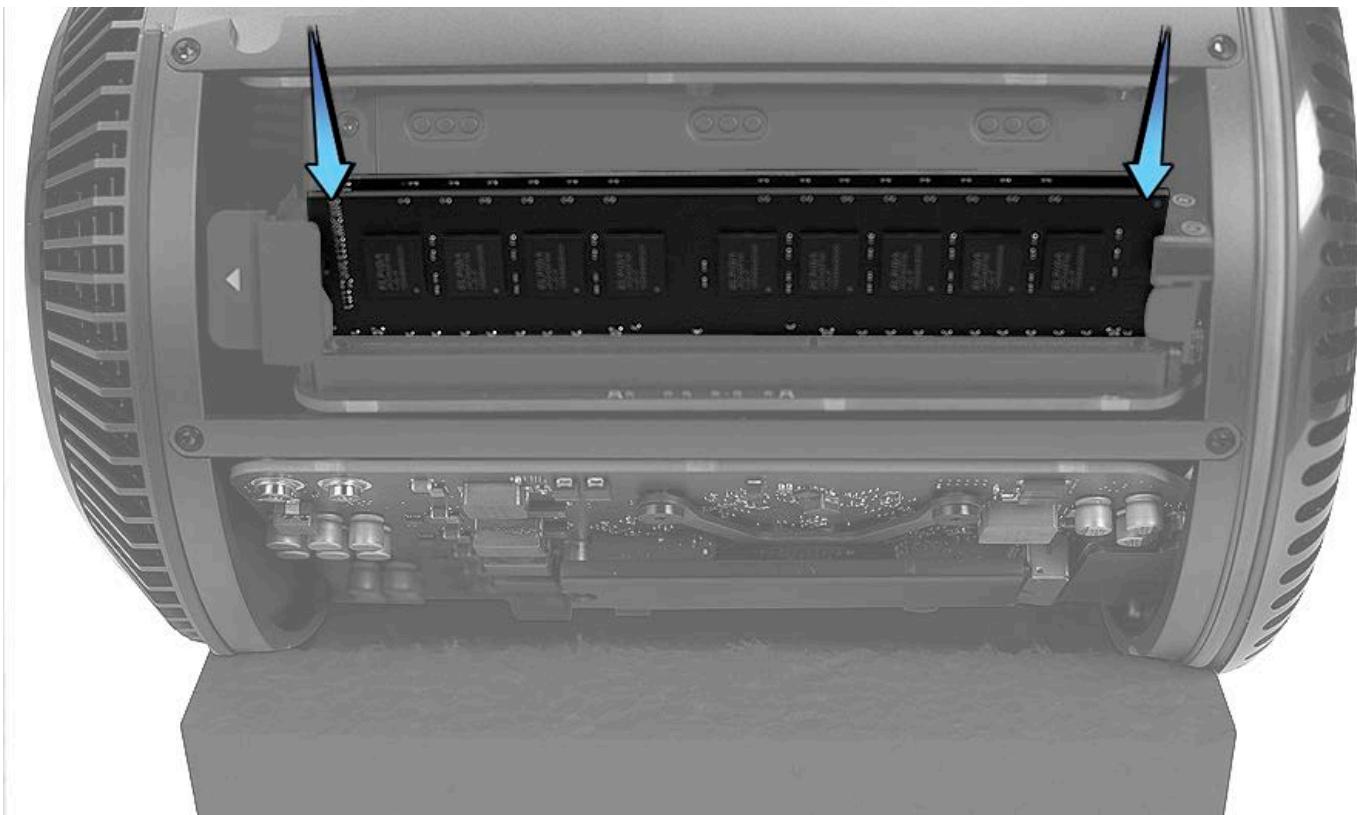


3. Pressing with thumbs on ends of DIMM, insert DIMM into slot until fully seated.

**Notes:**

- To avoid bending DIMM during insertion, apply force evenly on both ends. Do not apply force in middle of DIMM. Do not rock DIMM into slot.
- Unlike DIMMs on previous Mac Pro models, Mac Pro (Late 2013) DIMMs may not click or give audible feedback when fully inserted. A sign of incorrect or partial insertion is that DIMM mechanism binds against DIMM and does not move easily to locked position.

4. Rotate DIMM mechanism back so that the latch engages and mechanism is in locked position.



5. Before completing repair, double-check that DIMM mechanism is in locked position.

# Flash Storage

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)



## Tools

- ESD wrist strap
- Torx T8 screwdriver, magnetized

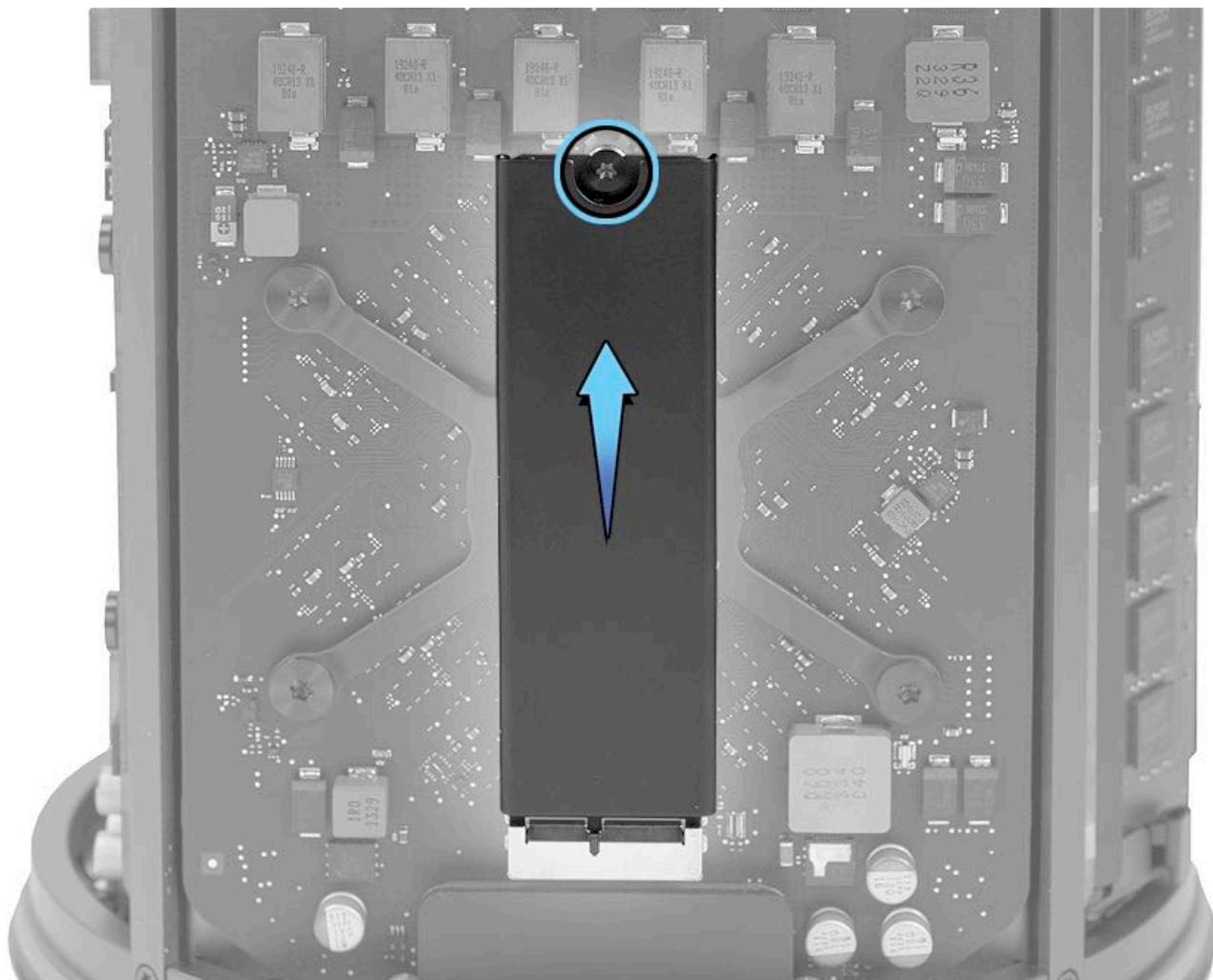
## Steps For Removal

1. Remove one (1) T8 flash storage mounting screw (923-0715).



2. Disconnect flash storage straight up from connector on graphics card B.

**Note:** Avoid removing or inserting flash storage into connector at too great an angle.



## Steps For Reassembly

Reassemble in reverse order of removal steps.

# Reinstalling Software That Came with the Computer

## Reinstalling Software That Came with the Computer

This procedure requires an Internet connection.

**Note:** In some situations, a user may have set a firmware password. The user must know the firmware password in order to reinstall OS X or macOS. If the user cannot remember the password, then refer to the technician instructions in article [HT204455: How to set a firmware password on your Mac](#).

**Important:** Apple recommends that users back up their data before any software restore procedure. Back up essential files before installing OS X or macOS. Apple is not responsible for any loss of data. For instructions on using Time Machine, refer to article [HT201250: How to use Time Machine to back up or restore your Mac](#).

For instructions on reinstalling the OS, follow the steps in article [HT204904: How to reinstall macOS](#).

For more information about recovery mode, refer to article [HT201314: About macOS Recovery](#).

# Logic Board

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Inlet](#)



## Tools

- ESD wrist strap
- Torx T8 screwdriver
- Torx T15 bit, a standard torx bit (use with adjustable torque driver below)
- Adjustable torque driver 923-0735 (0.3-1.2 Nm)
- Mezzanine connector removal tool
- Roof alignment tool

## Steps For Removal

1. Position computer in roof alignment fixture so that logic board is on top.

**Note:** The roof alignment fixture (shown below) is necessary when servicing the logic board, inlet, and the roof.



2. Using mezzanine connector removal tool, disconnect graphics card flex cables from graphics cards A and B.

### Mezzanine Connector Removal Tool



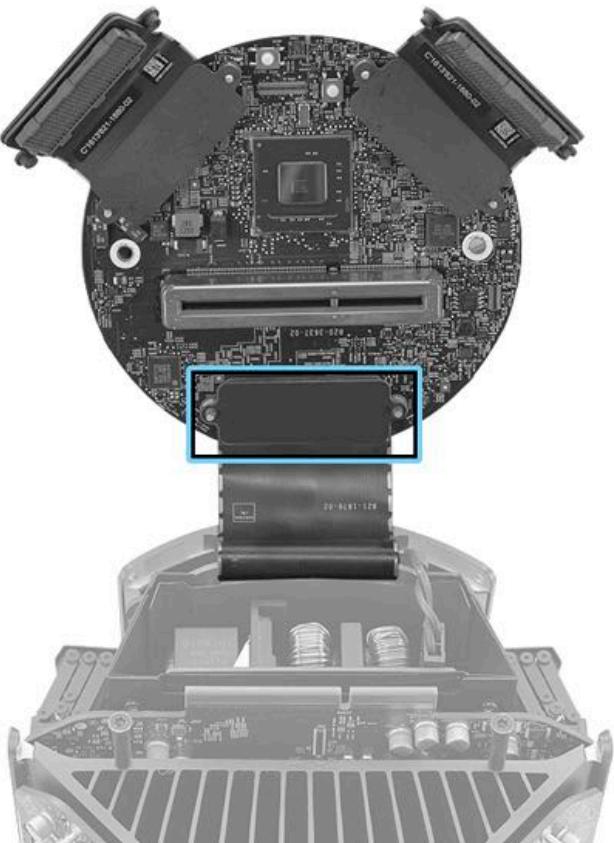
3. Remove two (2) T8 logic-board-to-core screws (923-0711).



**Note:** In next step, the logic board is connected to the computer underneath the board by the CPU riser connector and by the I/O flex cable. Do not try to remove board from computer without first disconnecting both.

4. Disconnect logic board (with graphics board flex cables attached) straight up from core assembly and rotate back from the computer.

5. Using mezzanine connector removal tool, disconnect I/O board flex cable from logic board.



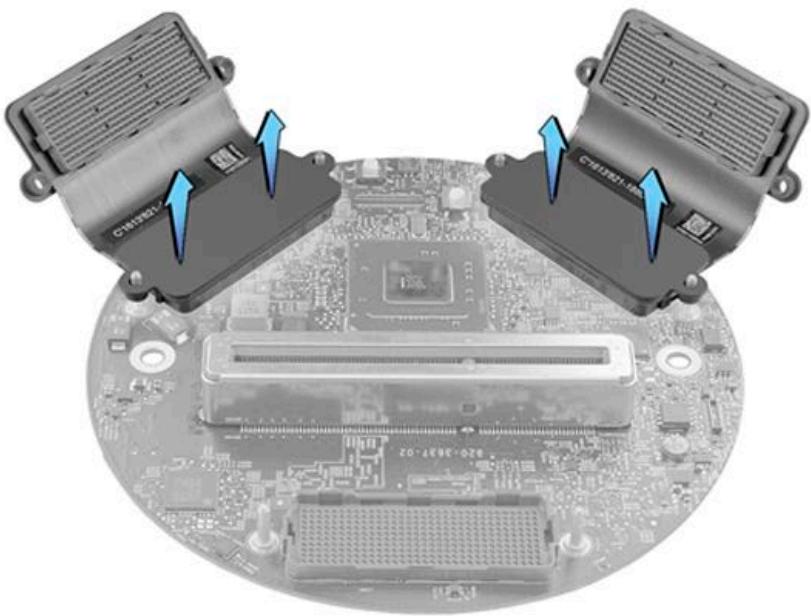
## Steps For Reassembly

**Reassembly Note 1:** Before installing logic board, check that core standoffs below logic board are secure. If you need to replace standoffs (Apple part 923-0693), use a standard Torx T15 bit with the adjustable torque driver 923-0735, and tighten them to torque value of 3.0 in.-lbs. (0.35 Nm).

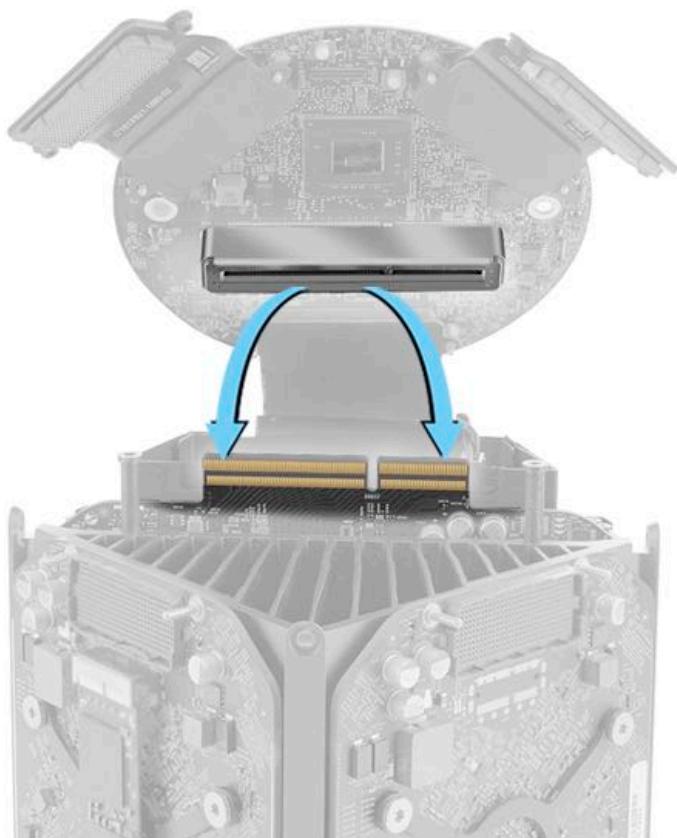
The indicated torque value must be used to avoid damaging the unit or causing the unit to malfunction.



**Reassembly Note 2:** If a replacement logic board will be installed, use mezzanine connector removal tool to disconnect graphics board flex cables, then transfer to replacement logic board.

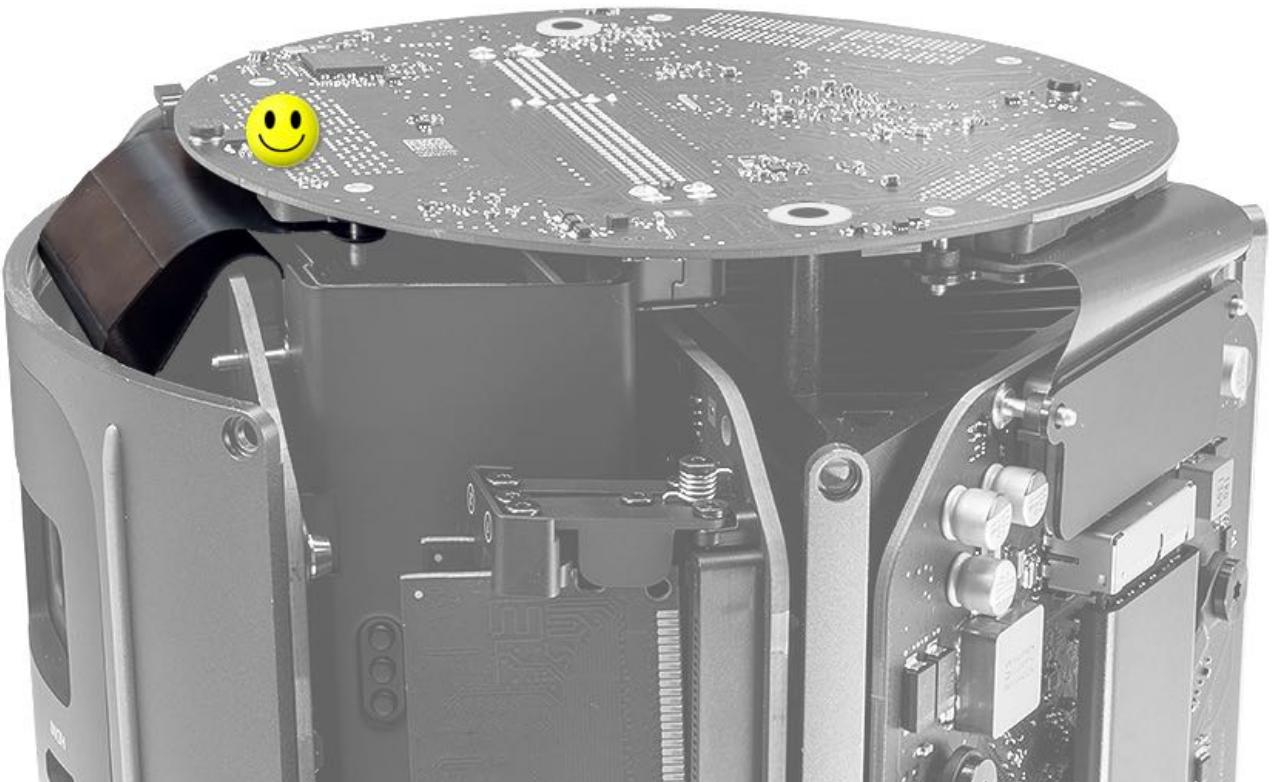


**Reassembly Note 3:** Carefully align logic board connector with CPU riser connector (as shown) before pressing logic board onto connector.

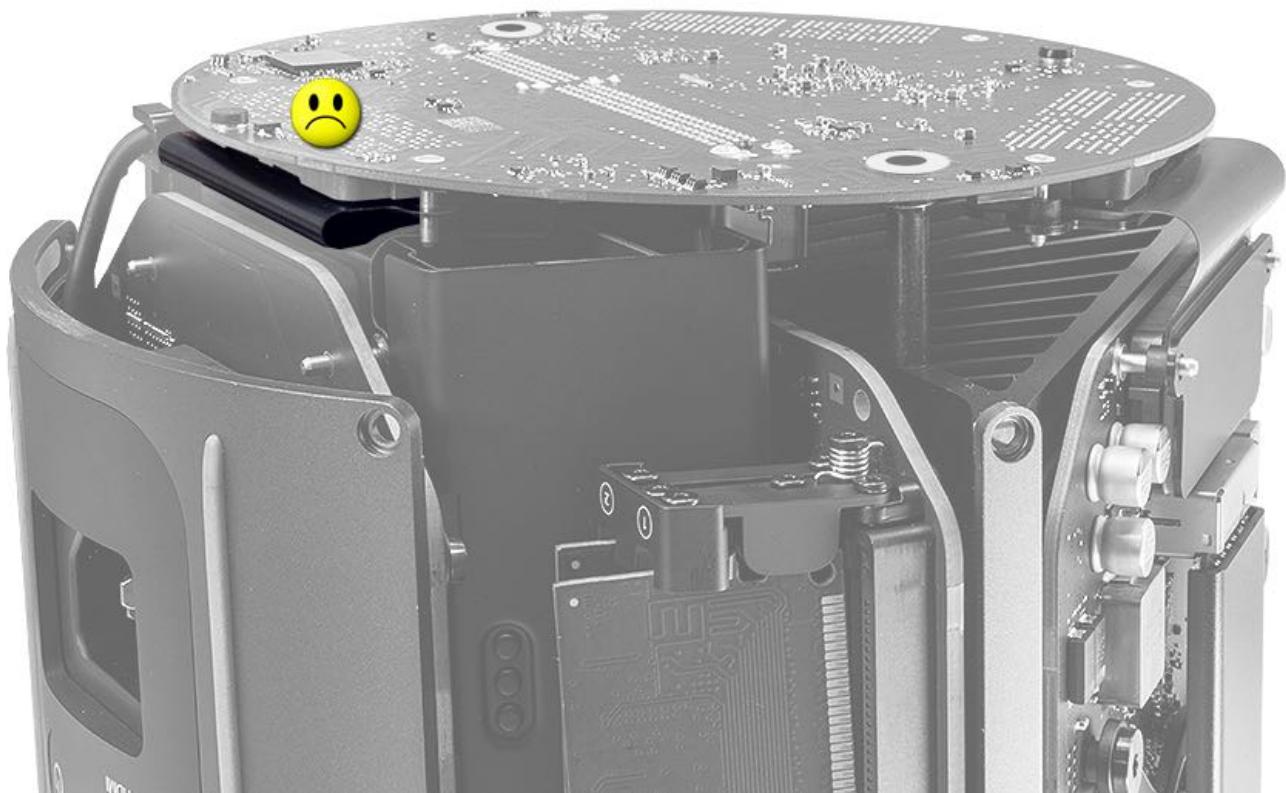


**Reassembly Note 4:** Check that the I/O flex cable is folded outward and not folded under the logic board.

**Correct fold/position of I/O cable**



**Incorrect fold/position of I/O cable**



**Reassembly Note 5:** When installing two logic board screws, hand-tighten each one full turn and then tighten to torque value of 3.0 in.-lbs. (0.5 Nm). Do not overtighten screws.

The indicated torque value must be used to avoid damaging the unit or causing the unit to malfunction.



**If installing a new replacement logic board:**

1. Run Blank Board Serializer (BBS) to set the computer's serial number to the new logic board. BBS can be run from AST 1 or AST 2, or as a stand-alone, USB-based version found in article [SD63: Blank Board Serializer](#).

**Note:** When using Blank Board Serializer in AST 1 or AST 2, ensure that the unit under test (UUT) and the AST server are connected to the same network, and that the AST server has the latest software version installed.

2. Run the Mac BootROM Updater to ensure the replacement logic board's EFI BootROM firmware is updated to the latest version that supports the APFS file system.

**Caution:** Some Macs that have been updated to macOS High Sierra may not start up to the internal startup volume after a logic board replacement. On affected Macs, the Mac BootROM Updater is available to address this issue. This utility updates the EFI BootROM on affected Macs to allow starting up to a volume that has been updated to the APFS file system.

For more information about AST and AST 2, supported Mac models, and instructions for downloading and using these utilities, see article [OP476: Latest Apple Service Toolkit download links and documentation](#).

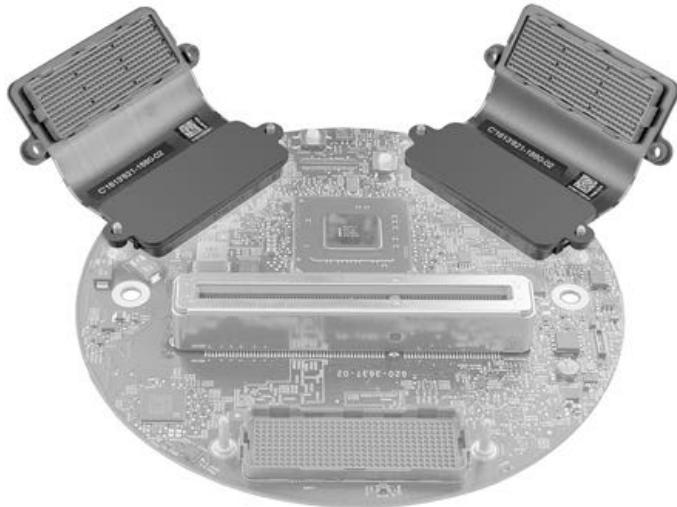
# Graphics Board Flex Cable

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Inlet](#)
- [Logic Board](#)

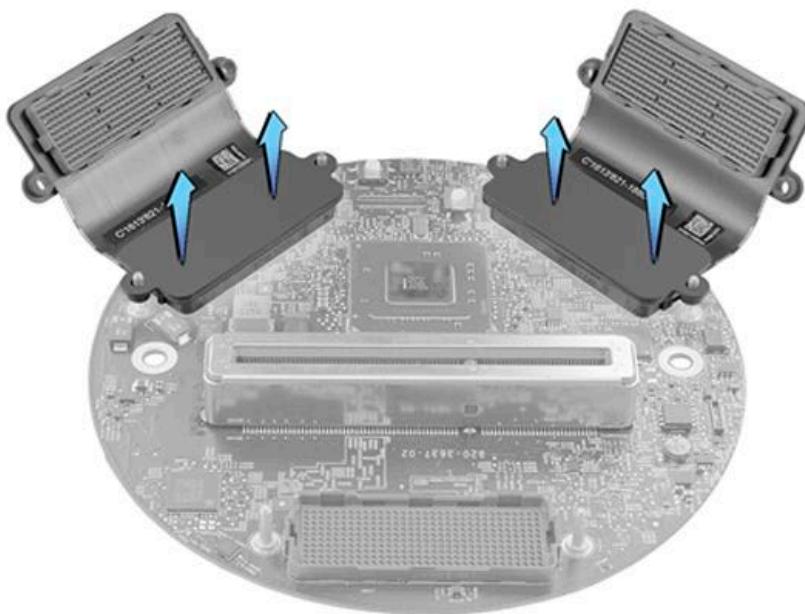


## Tools

- ESD wrist strap
- Mezzanine connector removal tool

## Steps For Removal

Using mezzanine connector removal tool, disconnect graphics board flex cables straight off logic board connectors.

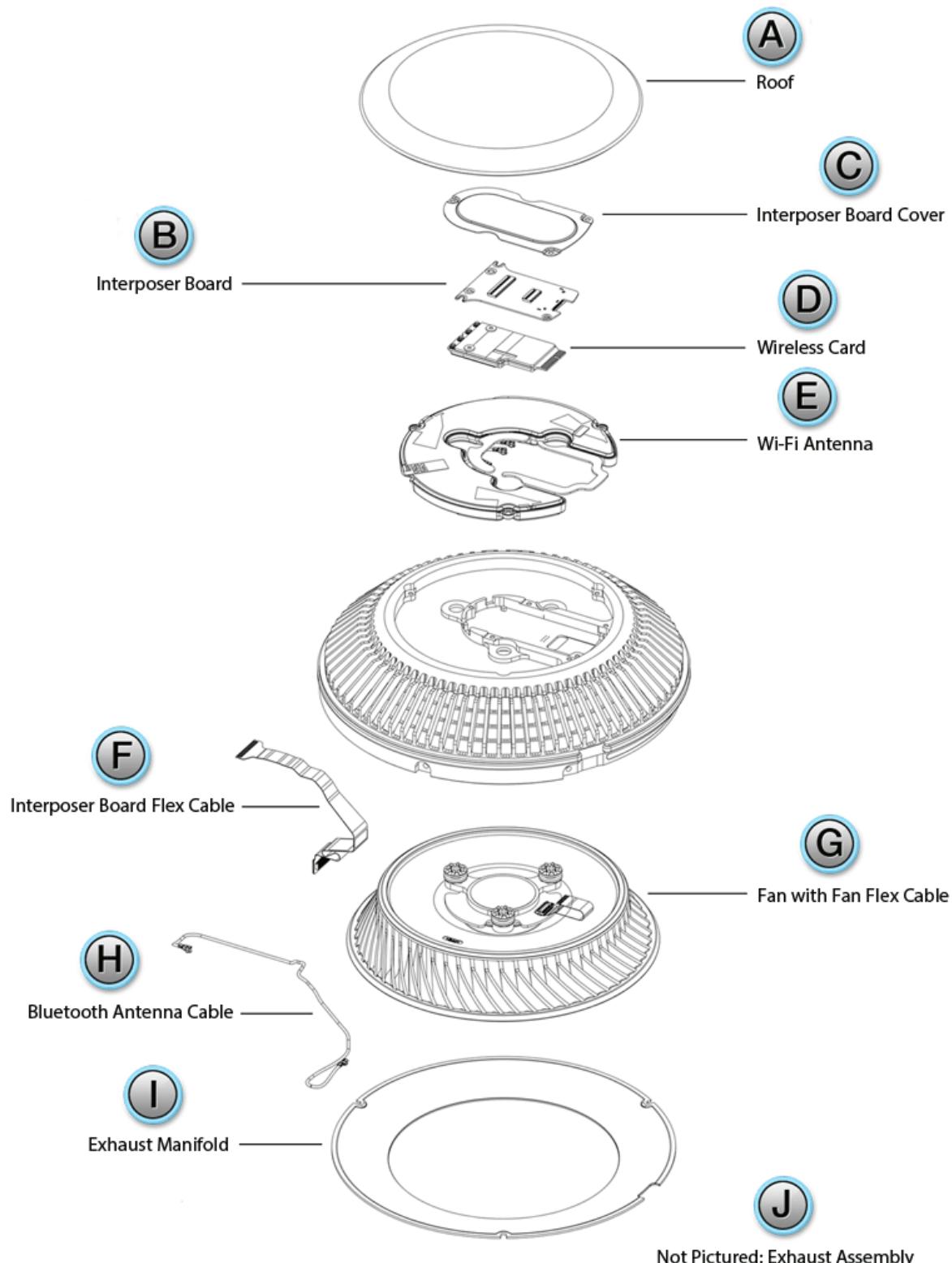


## Steps For Reassembly

Reassemble in reverse order of removal steps.

# Exhaust Assembly Overview

## Exhaust Assembly



A = [Roof](#)

B = [Interposer Board](#)

C = [Interposer Board Cover](#)

D = [Wireless Card](#)

E = [Wi-Fi Antenna](#)

F = [Interposer Board Flex Cable](#)

G = [Fan with Fan Flex Cable](#)

H = [Bluetooth Antenna Cable](#)

I = [Exhaust Manifold](#)

J = [Exhaust Assembly](#)

# Exhaust Assembly

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)



## Tools

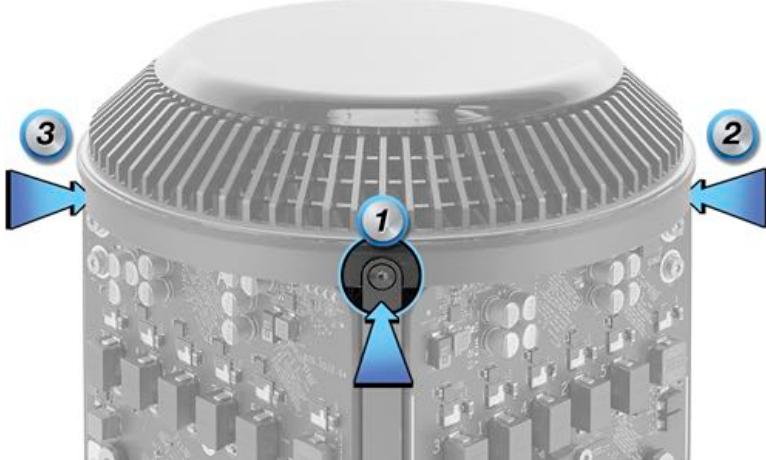
- ESD wrist strap
- Torx T8 screwdriver (magnetized)
- Torx T10 screwdriver (magnetized)

## Steps For Removal

1. Remove three (3) T10 exhaust-to-core screws (923-0713) in the order shown.



**Reassembly note:** Replace screws in the same order.

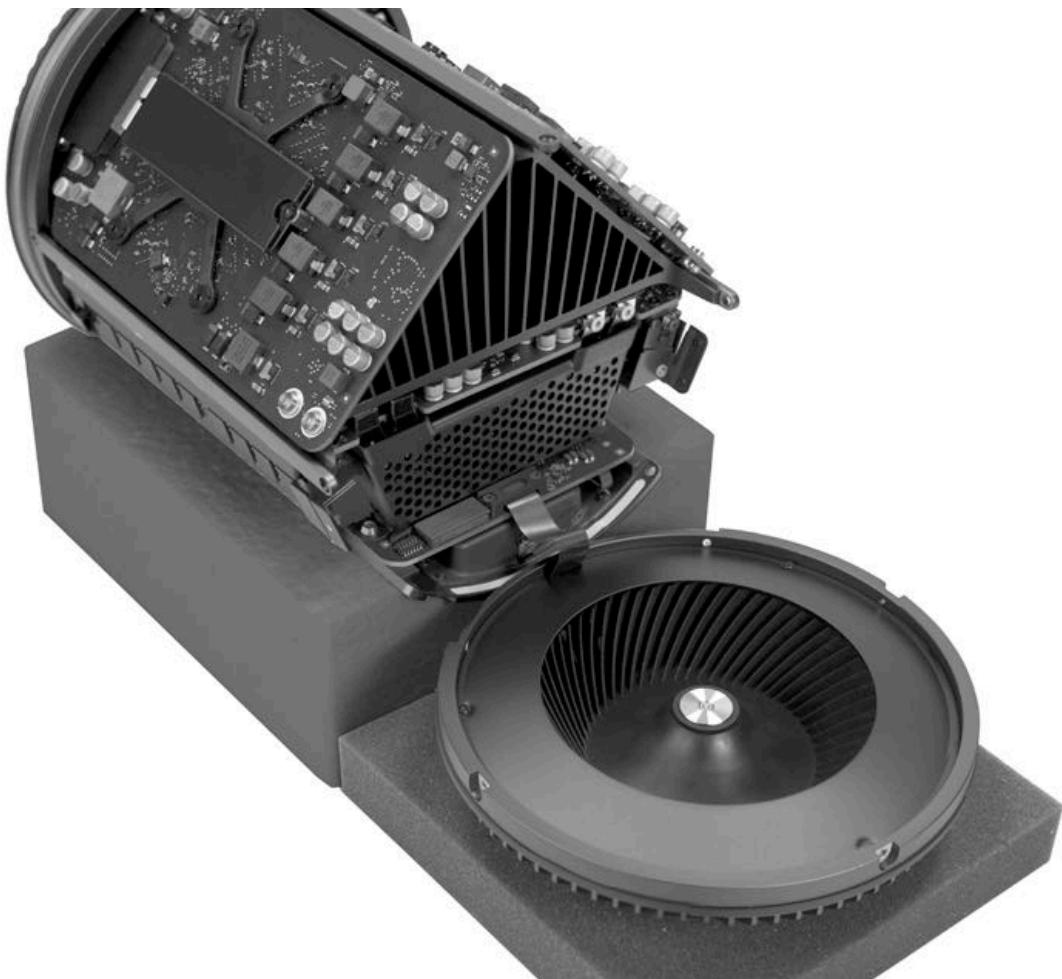


2. Remove two (2) T10 exhaust-assembly-to-I/O screws (923-0713).

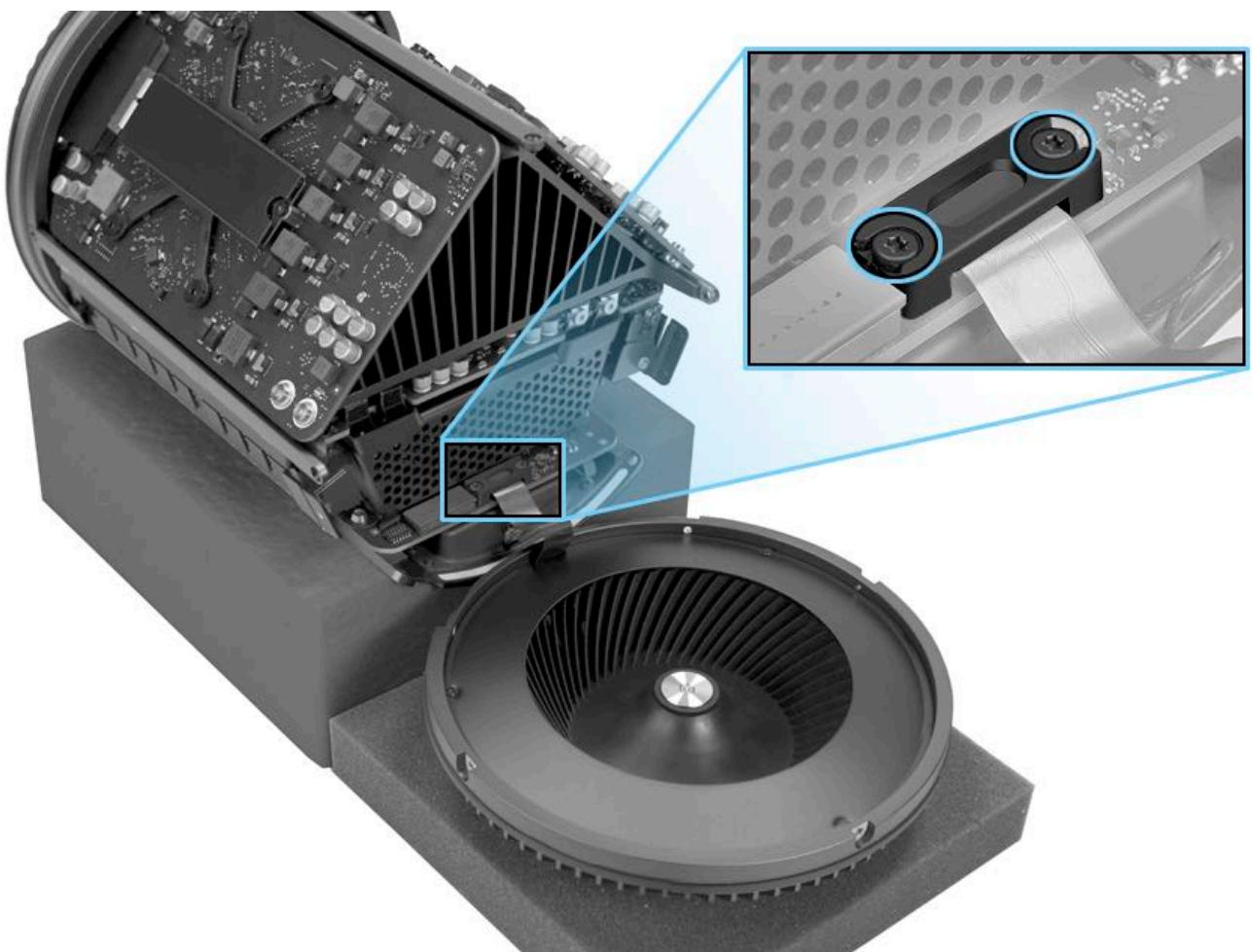


**Note:** Below the exhaust assembly on the I/O wall side, the Bluetooth antenna cable and interposer board flex cable attach the assembly to the computer. To facilitate disconnecting these cables, lay the computer in the I/O wall stand as shown, with the apex of the graphics boards pointing up. Position the foam block next to the exhaust.

3. Starting at the apex side of the exhaust assembly, lift the assembly slightly and tilt it back onto the foam block.



4. Loosen the two T8 captive screws that secure the retaining bracket on interposer board flex cable and remove bracket.  
**Note:** The retaining bracket service part (923-0692) includes two captive screws.



5. Disconnect interposer board flex cable from I/O board.

6. Disconnect Bluetooth antenna cable from I/O wall.

7. Lift exhaust assembly off computer.



### **Steps For Reassembly**

Reassemble in reverse order of removal steps.

# Roof

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)



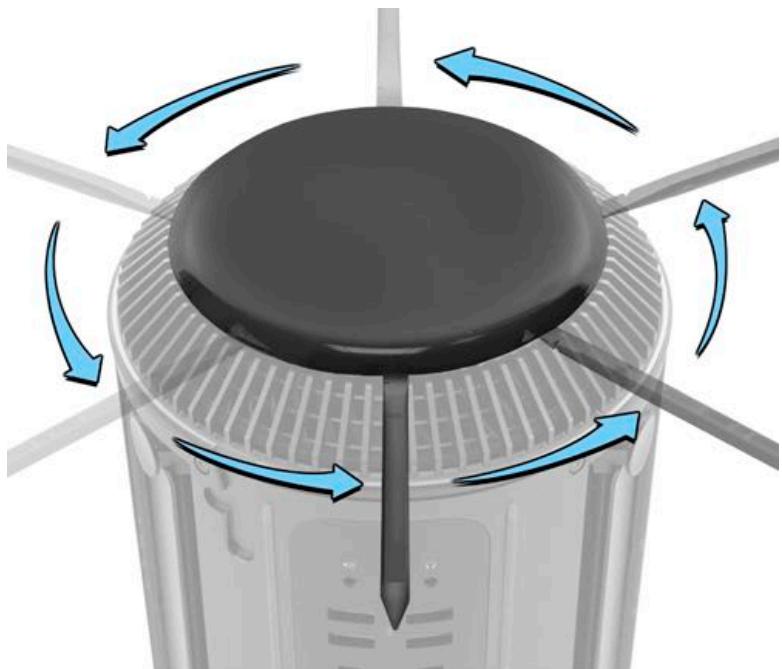
## Tools

- ESD wrist strap
- Black stick
- Roof alignment fixture
- Suction cup

## Steps For Removal

**Note:** Roof is held to exhaust assembly by VHB adhesive.

1. Using the flat end of a black stick, carefully pry up roof in several places, working around roof as shown.
2. Lift roof off assembly.



## Steps For Reassembly

**Reassembly Note:** Be sure to clean off all adhesive residue from original roof before installing replacement roof.

When replacing a part that requires roof removal, a new roof must be installed. The replacement roof comes with the service part.

To position roof correctly on exhaust assembly, place roof alignment fixture over assembly before installing roof. Use a suction cup to lower roof into fixture; then center roof within fixture and press down.



# Interposer Board Cover

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Roof](#)



## Tools

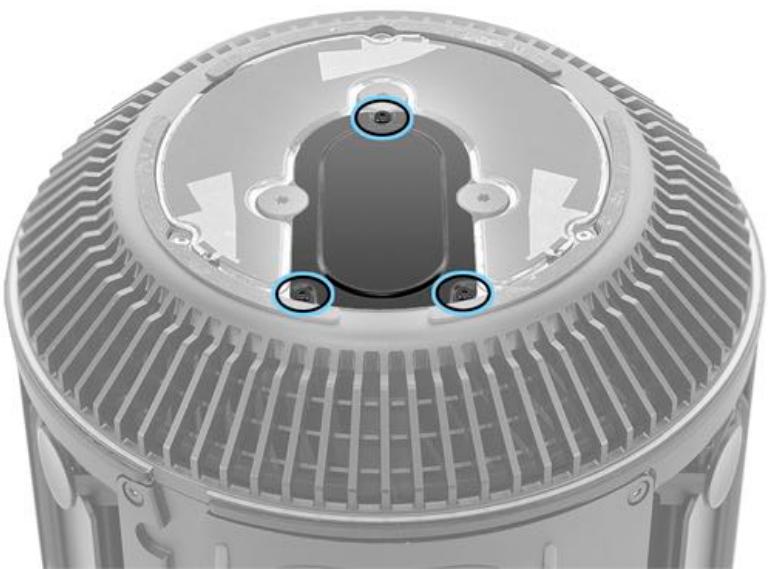
- ESD wrist strap
- Torx T5 screwdriver (magnetized)

## Steps For Removal

1. Remove three (3) T5 screws (923-0709).



2. Remove interposer board cover.



### Steps For Reassembly

Reassemble in reverse order of removal steps.

# Wireless Card

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

For video instruction, refer to Apple Support article [SV228: Wireless Card Replacement Video](#).

Remove:

- [Housing](#)
- [Roof](#)
- [Interposer Board Cover](#)



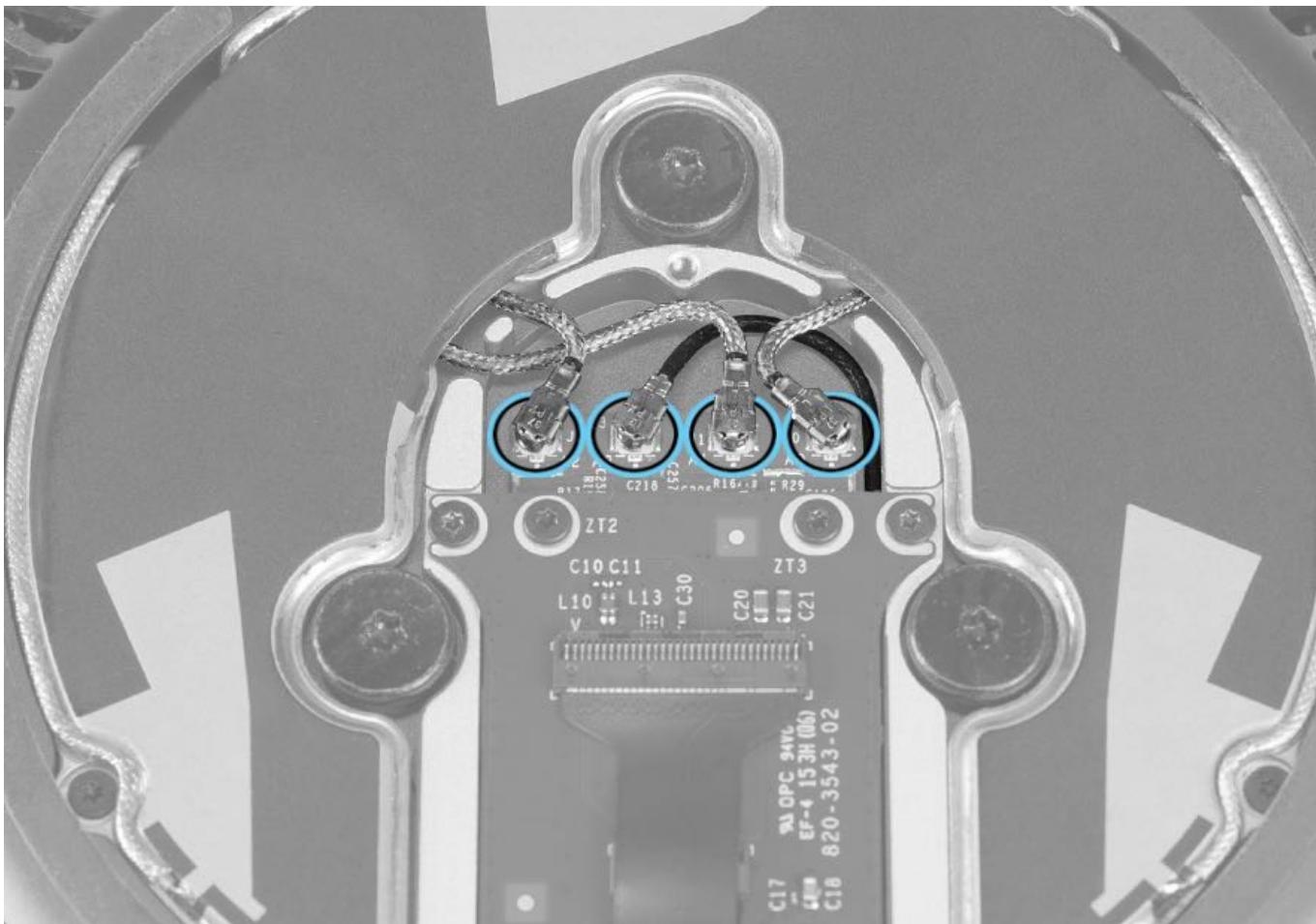
## Tools

- ESD wrist strap
- Torx T5 screwdriver, magnetized
- Black stick

## Steps For Removal

**Note:** Wireless card is attached to interposer board.

1. Use pointed end of black stick to disconnect the following cables: Three (3) silver Wi-Fi antenna cables and one (1) black Bluetooth cable.



2. Flip open locking lever (1) and disconnect interposer board flex cable (2).



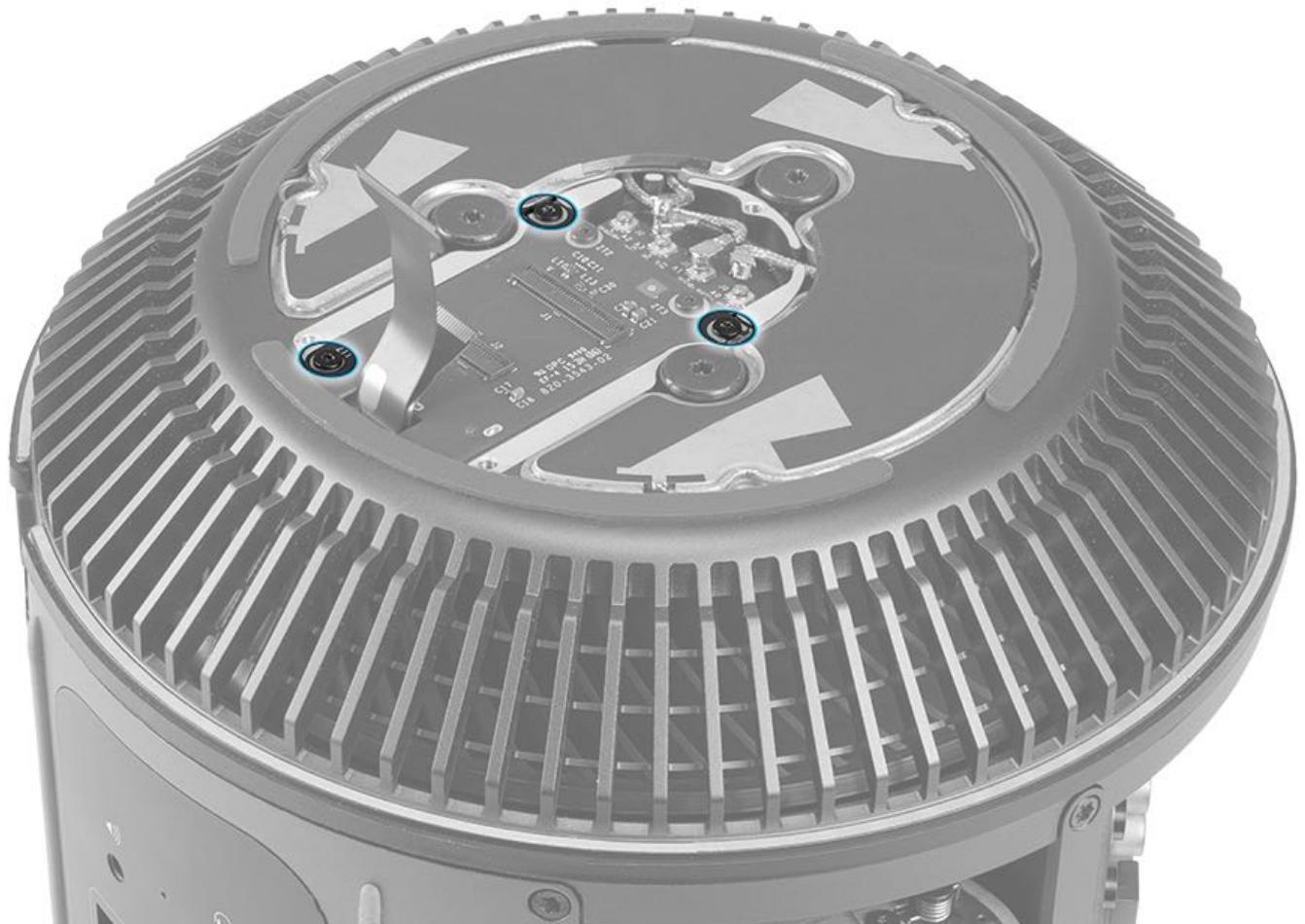
3. Carefully bend back interposer board flex cable to reveal fan flex cable connector.

4. Flip open locking lever (1) and disconnect fan flex cable (2) from interposer board.

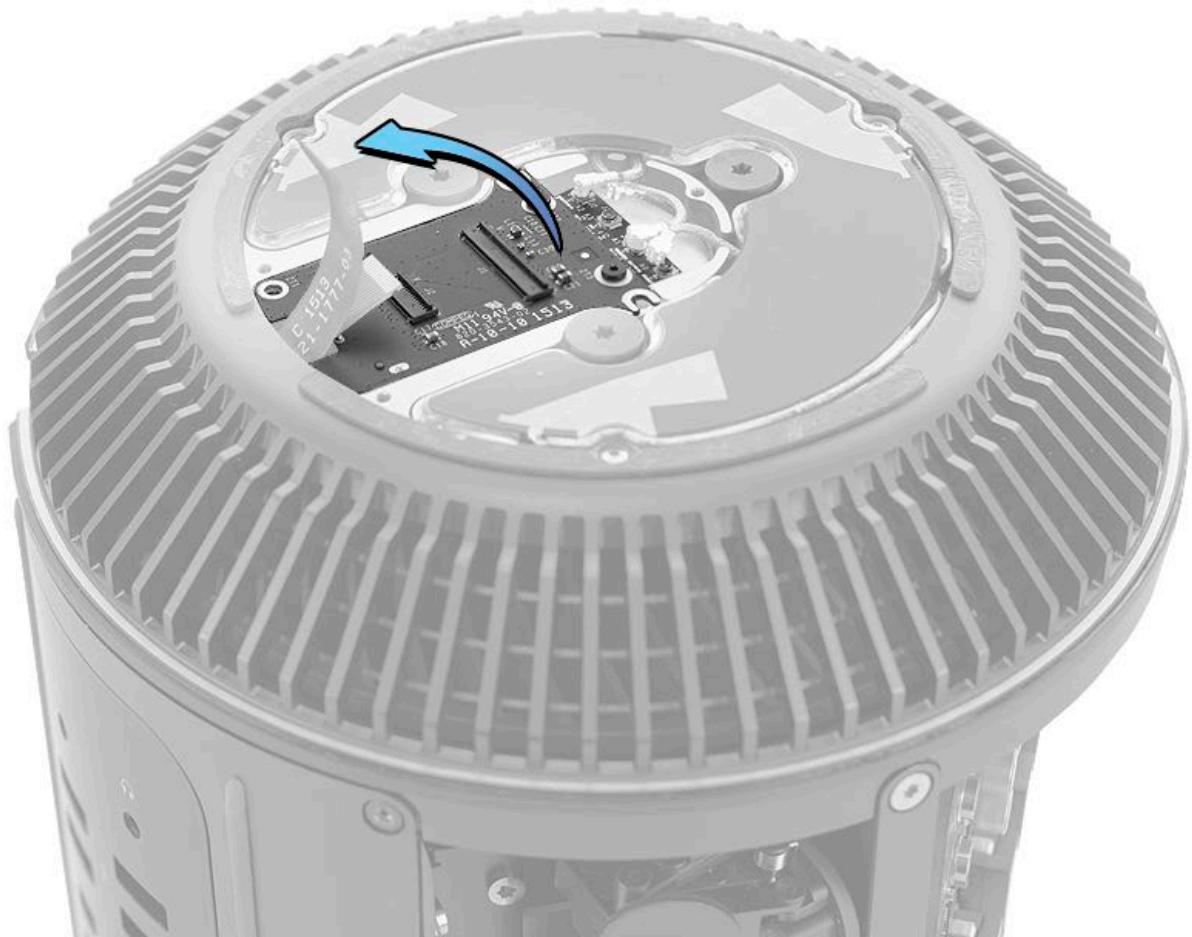


5. Remove three (3) T5 screws (923-0709).



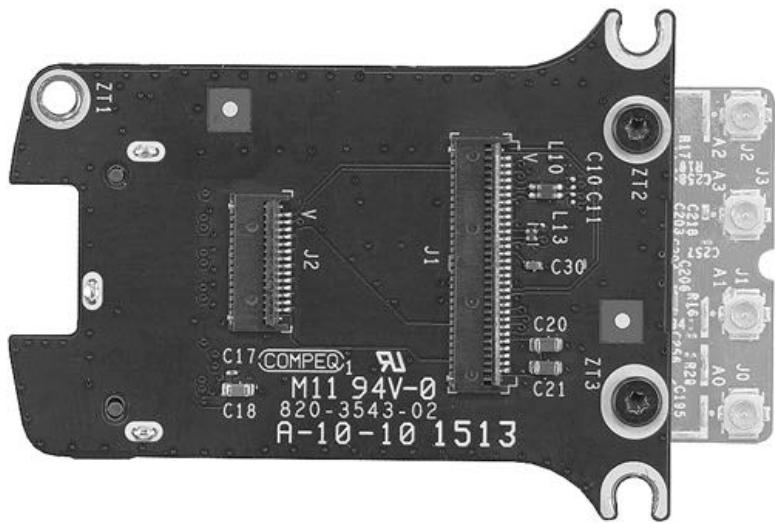


6. Remove wireless card and attached interposer board from exhaust assembly.



7. Remove two (2) T5 screws (923-0725) that mount card to interposer board.

**Note:** When placing interposer board connector-side down on mat, make sure locking bars on both connectors are closed.

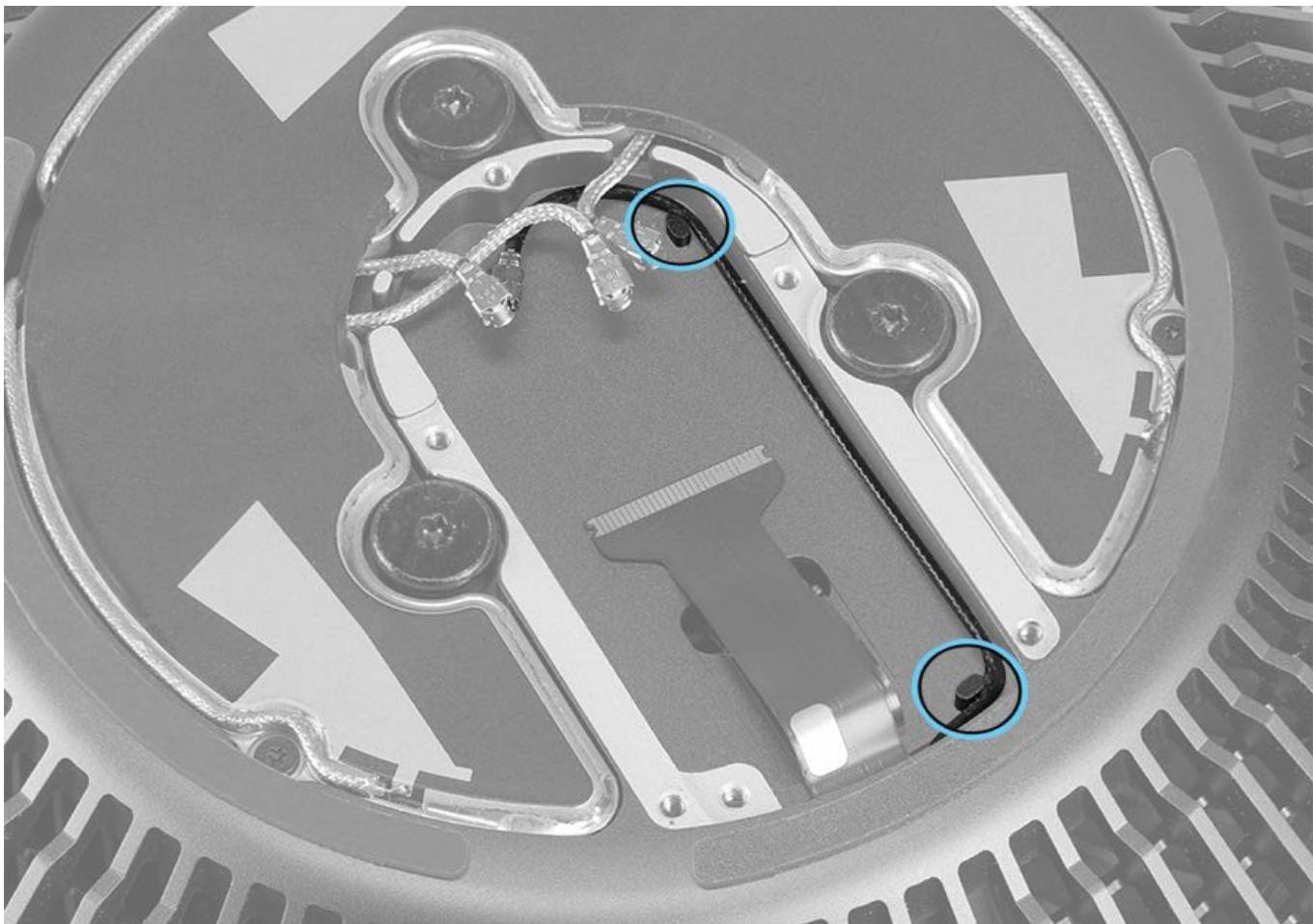


8. Wiggle and pull wireless card to disconnect it from interposer board.



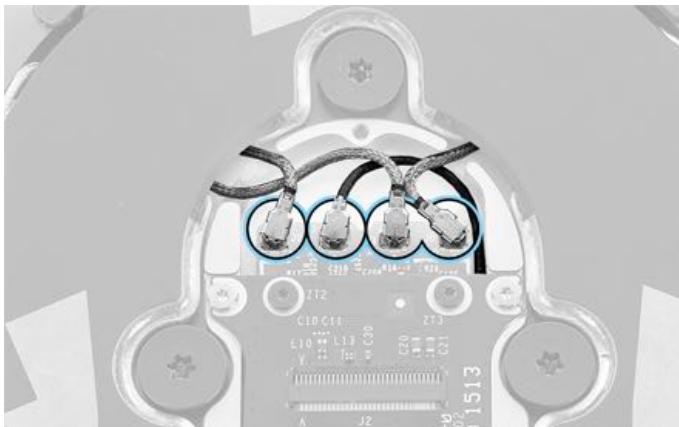
## Steps For Reassembly

**Note:** Ensure that Bluetooth cable is routed through two (2) guides in wireless card bay.



**Notes:**

- Bluetooth cable connects to second connector from the left.
- Route Bluetooth antenna below interposer board, as shown.
- Route Wi-Fi antennas as shown.
- Connect Bluetooth and Wi-Fi connectors as shown.



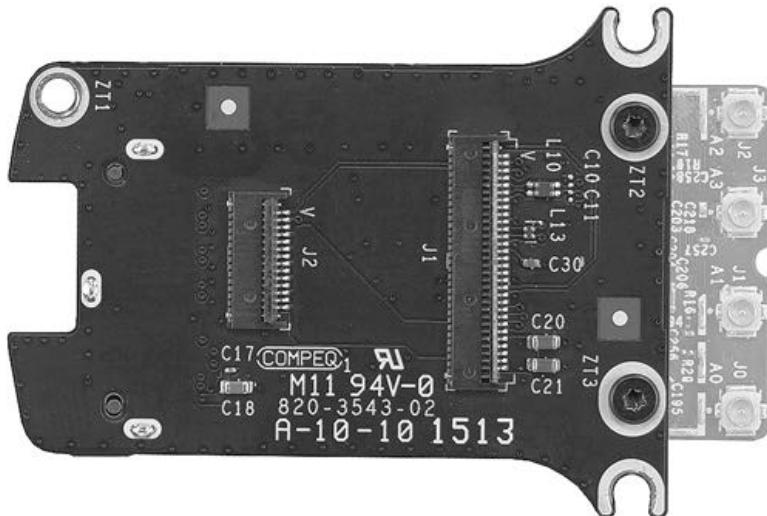
# Interposer Board

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Roof](#)
- [Interposer Board Cover](#)
- [Wireless Card with Interposer Board](#)



## Tools

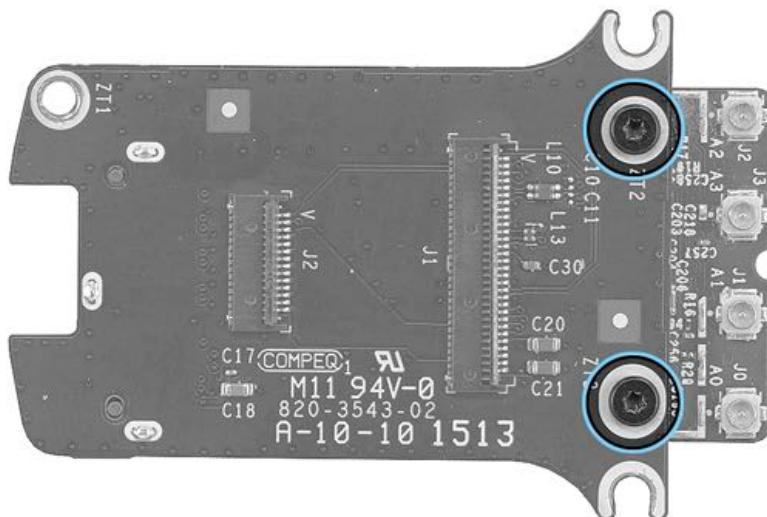
- ESD wrist strap
- Torx T5 screwdriver (magnetized)

## Steps For Removal

1. Remove two (2) T5 screws (923-0725).



2. Remove wireless card from interposer board.



## Steps For Reassembly

Reassemble in reverse order of removal steps.



# Wi-Fi Antenna

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Roof](#)
- [Interposer Board Cover](#)



## Tools

- ESD wrist strap
- Torx T5 screwdriver (magnetized)
- Black stick

## Steps For Removal

1. Use a black stick to disconnect three (3) silver Wi-Fi antenna cables from wireless card. (Bluetooth cable is the fourth black cable connected to the wireless card.)
2. Remove three (3) T5 screws (923-0709).
3. Using a black stick, pry up Wi-Fi antenna assembly and lift it off exhaust assembly.





## Steps For Reassembly

Reassemble in reverse order of removal steps.

# Interposer Board Flex Cable

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Roof](#)
- [Interposer Board Cover](#)
- [Exhaust Assembly](#)
- [Exhaust Manifold](#)
- [Fan](#)



## Tools

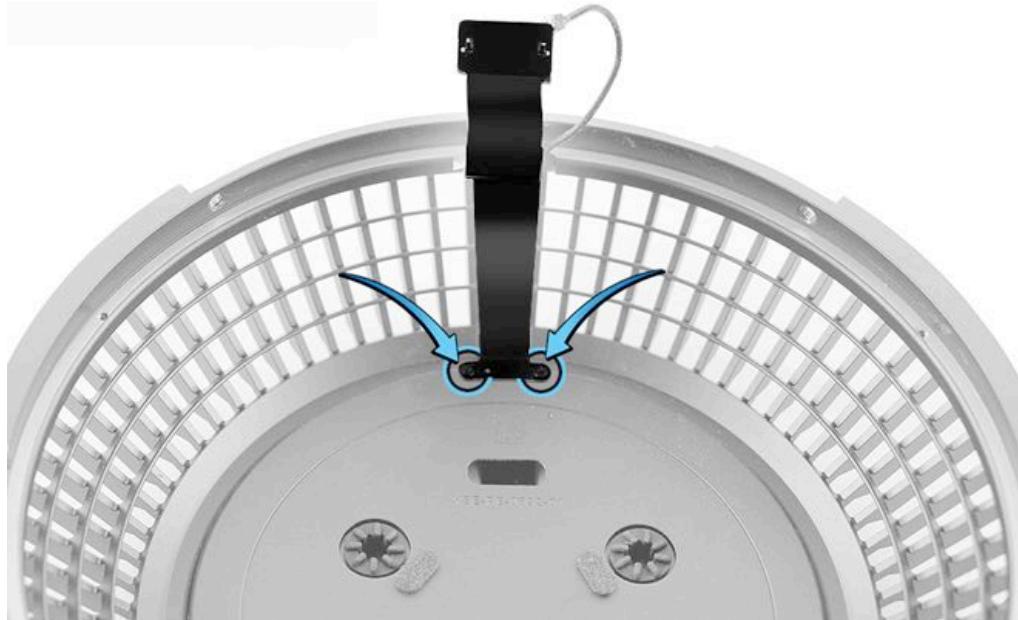
- ESD wrist strap
- Torx T5 screwdriver (magnetized)

## Steps For Removal

1. Remove two (2) T5 screws (923-0728) securing interposer board flex cable to exhaust housing.



2. Carefully thread cable out of opening in housing.



## **Steps For Reassembly**

Reassemble in reverse order of removal steps.

# Exhaust Manifold

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Exhaust Assembly](#)



## Tools

- ESD wrist strap
- Torx T5 screwdriver (magnetized)

## Steps For Removal

1. Remove three (3) T5 screws (923-0709).



2. Release adhesive on interposer board flex cable from exhaust manifold.
3. Remove manifold from exhaust assembly.



### Steps For Reassembly

**Reassembly Note:** Position manifold in exhaust housing so that screw holes align and the interposer board cable and Bluetooth antenna cable route through opening in manifold.

Reassemble in reverse order of removal steps.

# Fan

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Roof](#)
- [Interposer Board Cover](#)
- [Exhaust Assembly](#)
- [Exhaust Manifold](#)

**Note:** The fan assembly includes the fan cable; the cable is not available separately.



## Tools

- ESD wrist strap
- Torx T5 screwdriver, magnetized
- Torx T10 screwdriver, magnetized
- Two black sticks

## Steps For Removal

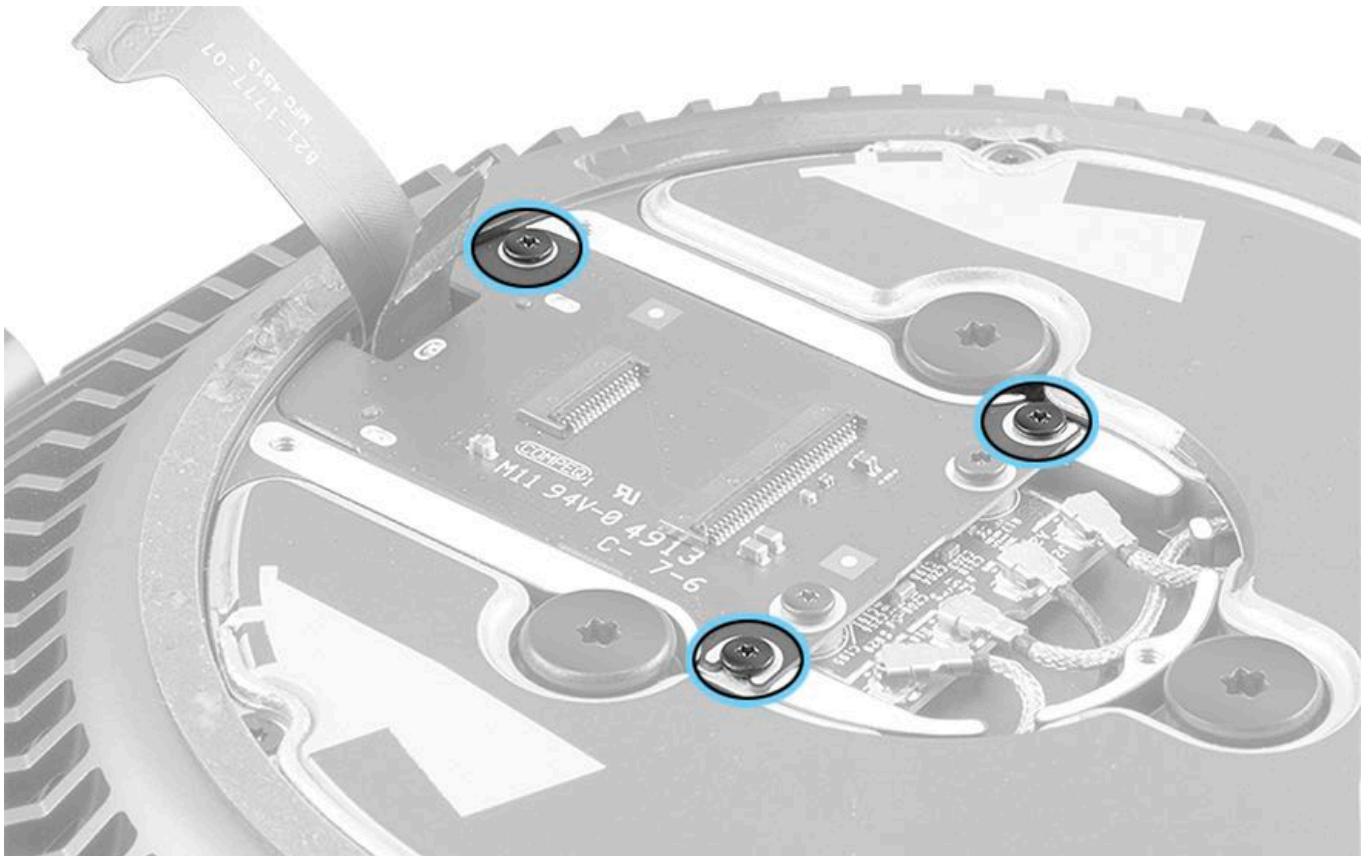
1. Orient the fan assembly so the interposer board is face up. Flip up the locking lever and disconnect the interposer board flex cable from the interposer board.



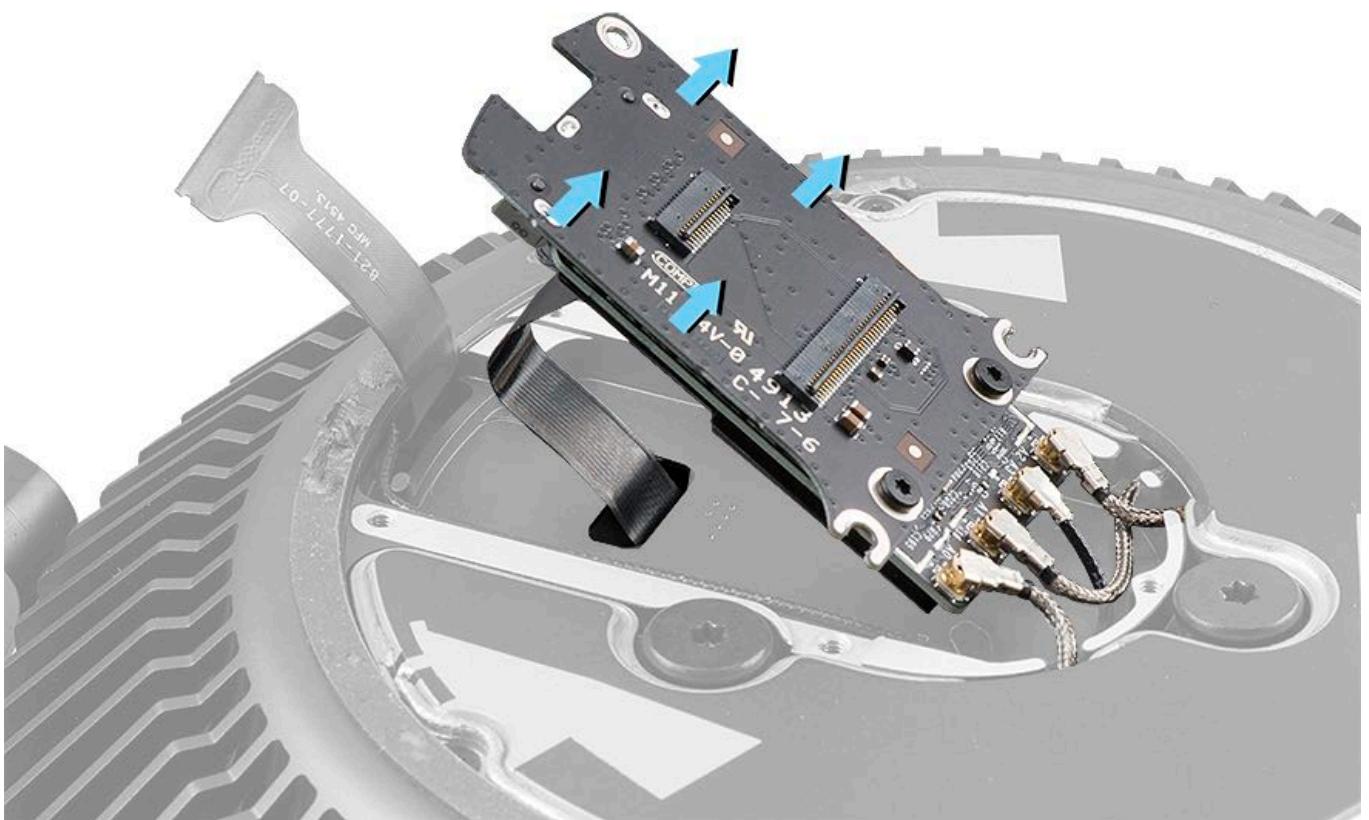
2. Flip up the locking lever and disconnect the fan flex cable from the interposer board.



3. Remove three T5 screws (923-0709) on the interposer board.

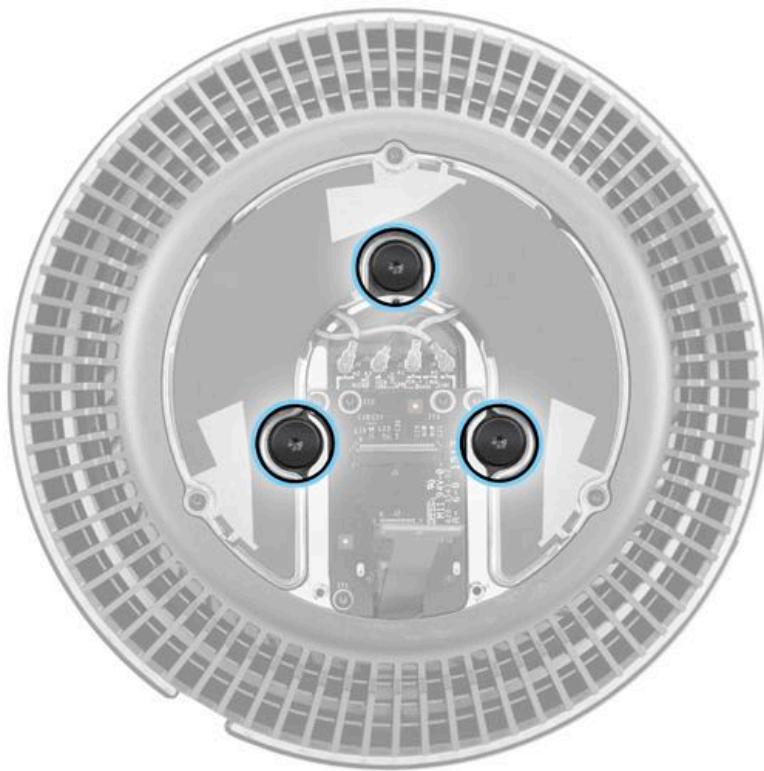


4. Gently lift the interposer board to observe that the fan cable routes through the opening in the middle of the exhaust assembly.

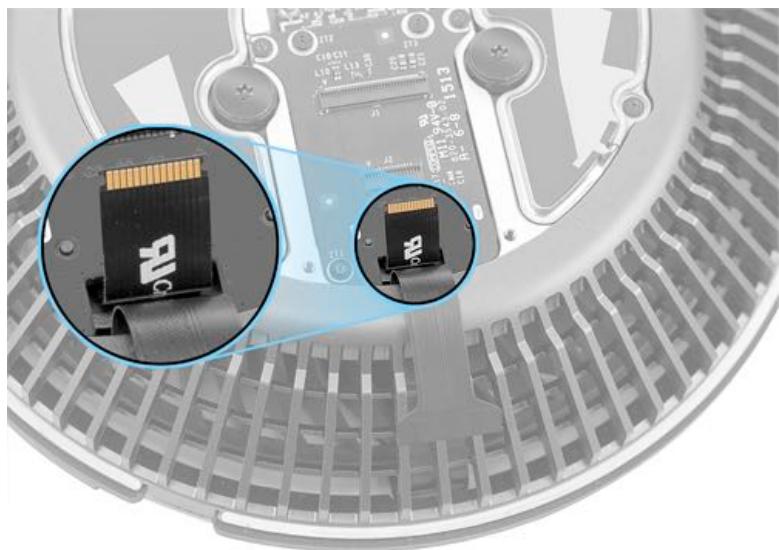


5. Hold exhaust assembly in your hand so that the roof side faces up and your fingers support the fan below.

6. Remove three T10 fan screws (923-0724).



7. Carefully separate the fan assembly from the exhaust assembly, routing the fan cable down through the opening in exhaust assembly.



8. The fan assembly is shown below. **Note:** The fan assembly includes the fan cable; the cable is not available separately.

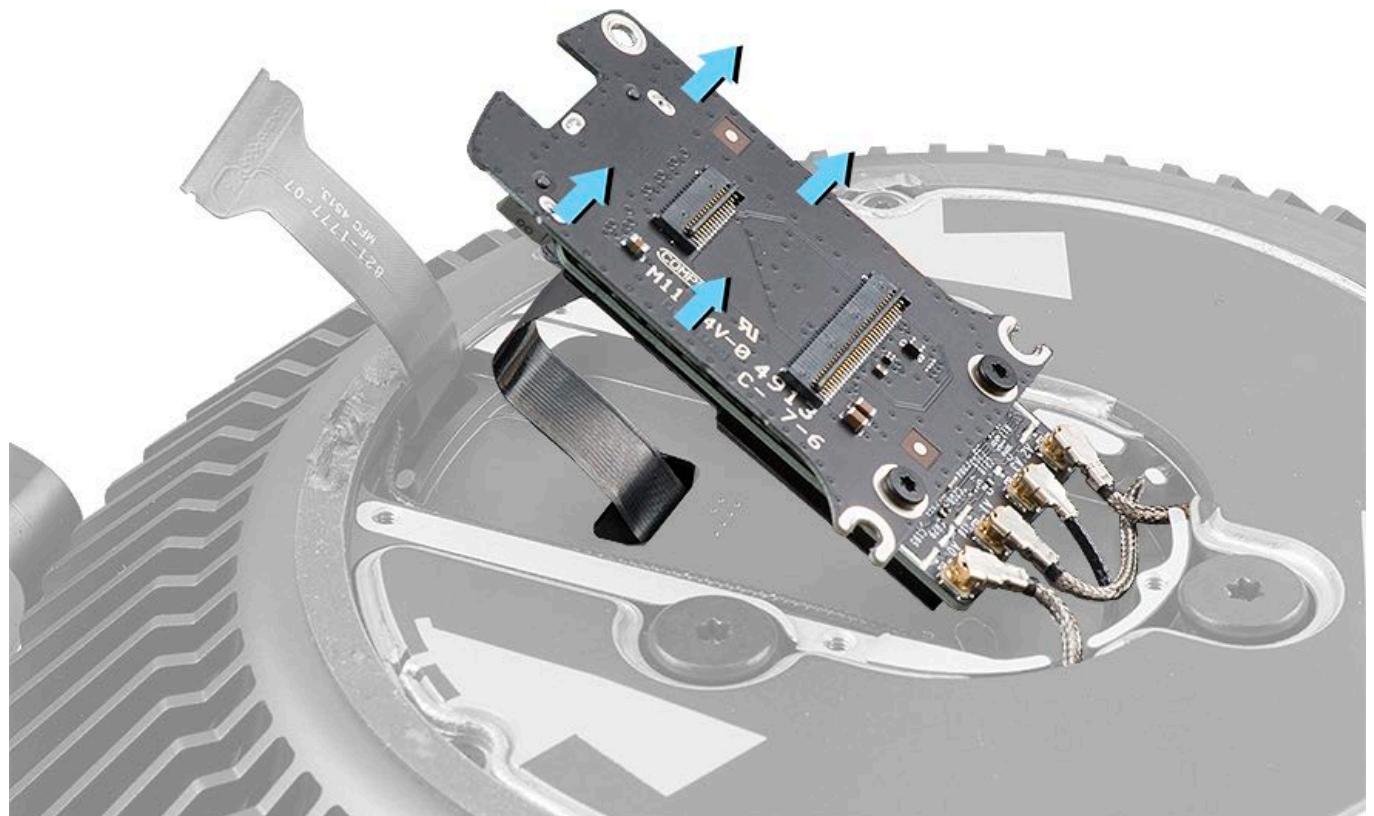


### Steps For Reassembly

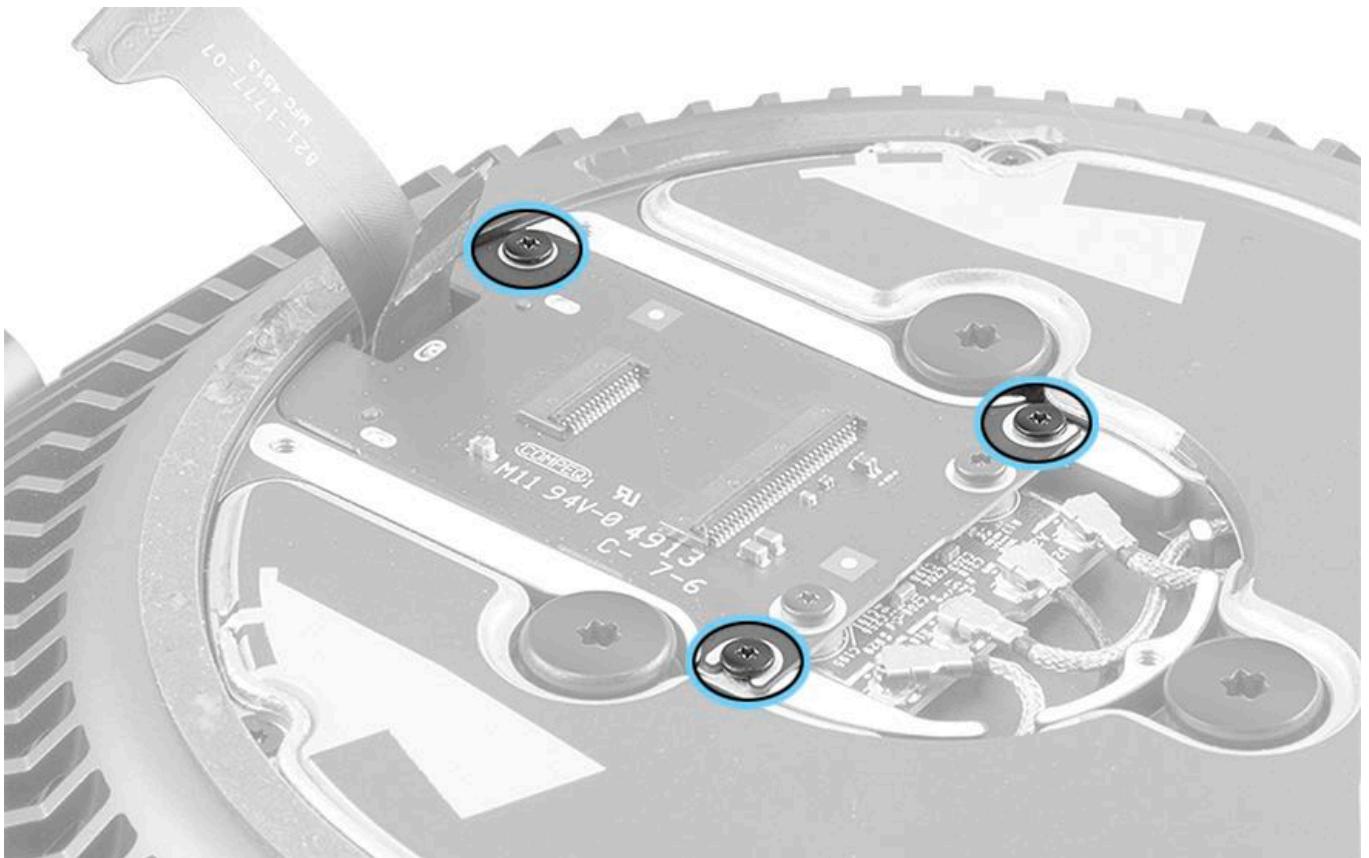
1. Holding the fan assembly, route the fan cable through the opening in the exhaust housing.



2. Position the exhaust assembly so the interposer board is face up. Lift the interposer board and carefully pull the fan cable through the opening.



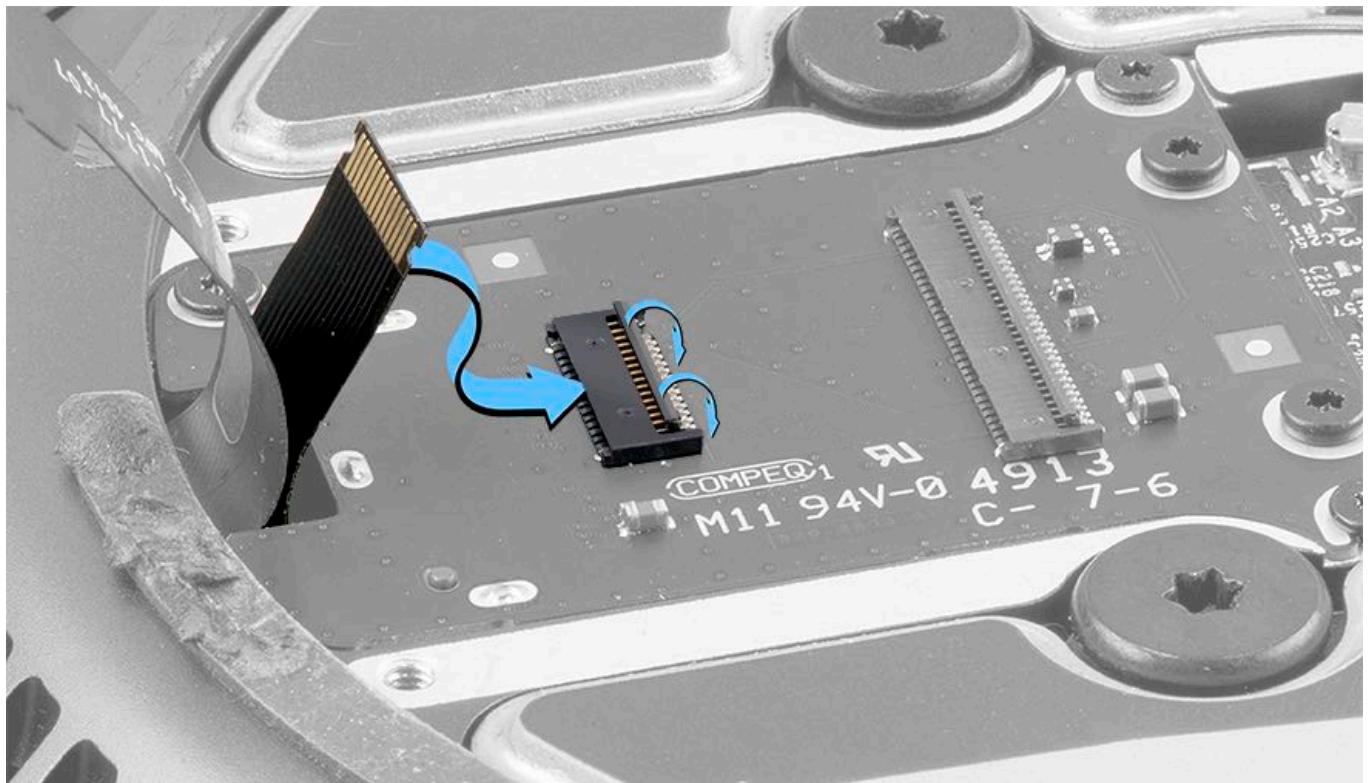
3. Route the fan cable through the same opening as the interposer flex cable, then replace three T5 interposer screws.



4. Using pointed end of black stick, align one screw hole in exhaust housing with one screw hole in fan below. Insert point of black stick into holes to secure.
5. Insert pointed end of second black stick into second screw hole to align and secure housing and fan screw holes.
6. Install a fan screw (923-0724) in third screw hole.
7. Remove second and first black sticks and install the two remaining fan screws (923-0724).
8. Tighten screws finger-tight and then use T10 screwdriver to secure screws.



9. Connect the fan cable to the interposer board. Use the flat end of a black stick to flip down the locking lever on the connector.



10. Connect interposer board flex cable to interposer board. Use the flat end of a black stick to flip down the locking lever on the connector.



11. Replace the [Interposer Board Cover](#).

12. Replace the [Roof](#).

13. Replace the [Housing](#).

# Fan Flex Cable

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Roof](#)
- [Interposer Board Cover](#)
- [Exhaust Assembly](#)
- [Exhaust Manifold](#)
- [Fan](#)



## Tools

- ESD wrist strap

## Steps For Removal

Use the flat end of a black stick to pry the flex cable from the vertical blind mate connector.



## Steps For Reassembly

Reassemble in reverse order of removal steps.

# Bluetooth Antenna Cable

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Roof](#)
- [Interposer Board Cover](#)
- [Exhaust Assembly](#)
- [Exhaust Manifold](#)
- [Fan](#)
- [Interposer Board Flex Cable](#)



## Tools

- ESD wrist strap
- Black stick

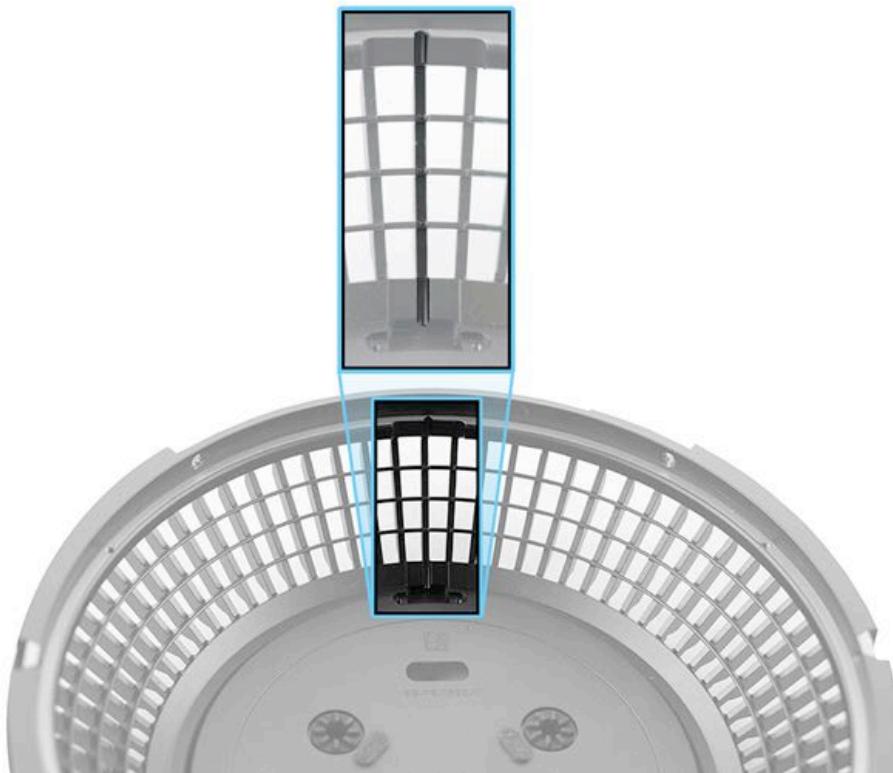
## Steps For Removal

1. Release Bluetooth antenna cable from adhesive and lift cable from exhaust housing.



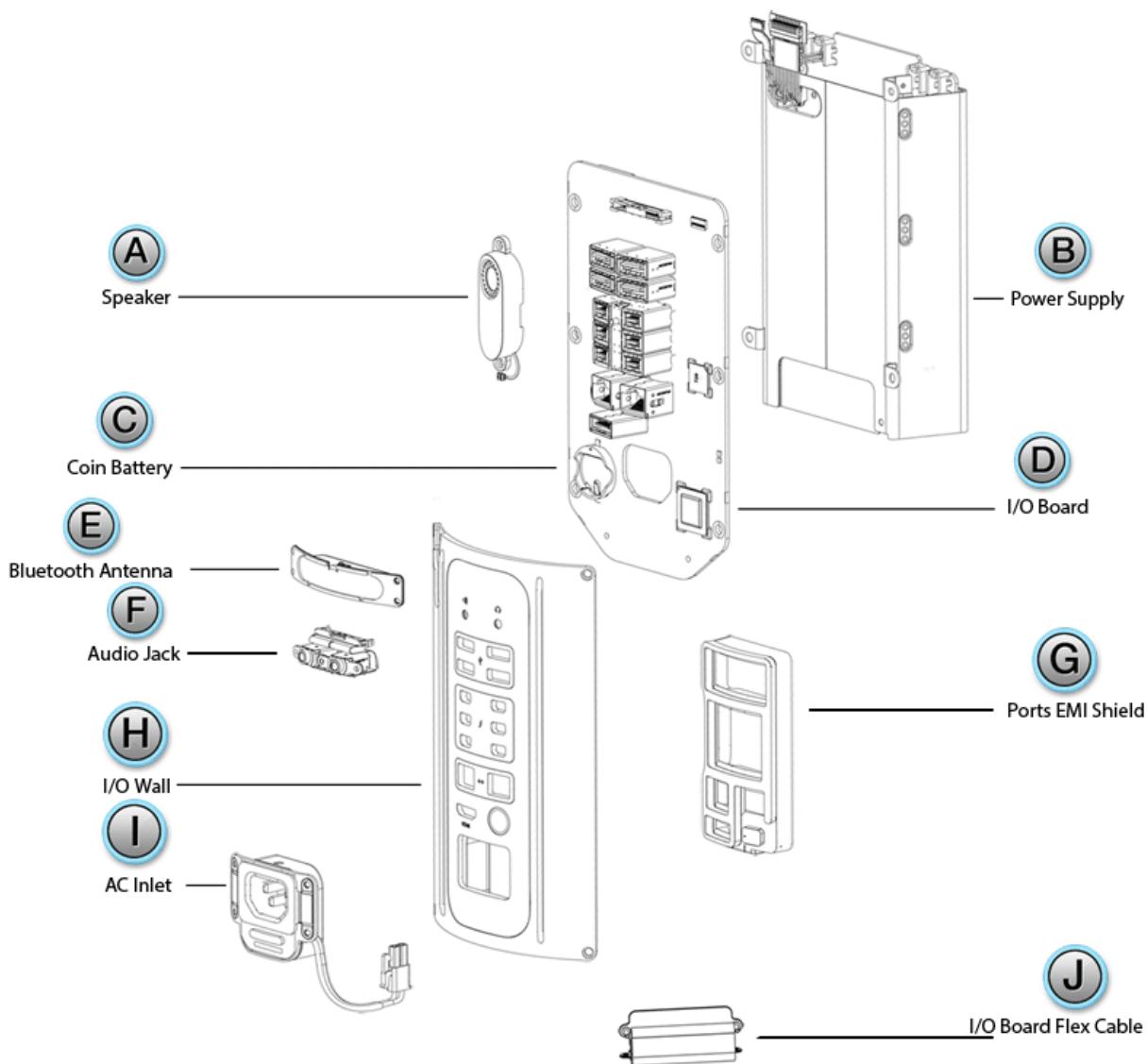
## Steps For Reassembly

**Reassembly Note:** When installing cable, make sure it routes into notches in exhaust housing.



# I/O Wall and Power Supply Assembly Overview

## I/O Wall and Power Supply Assembly



A = [Speaker](#)

B = [Power Supply](#)

C = [Coin Battery](#)

D = [I/O Board](#)

E = [Bluetooth Antenna](#)

F = [Audio Jack](#)

G = [Ports EMI Shield](#)

H = [I/O Wall](#)

I = [AC Inlet](#)

J = [I/O Board Flex Cable](#)

# I/O and Power Supply Assembly

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT205332: About AppleCare service certifications](#).

For video instruction, refer to article [SV227: I/O and Power Supply Assembly Replacement Video](#).

Remove:

- [Housing](#)
- [Exhaust Assembly](#)



## Tools

- ESD wrist strap
- Black stick
- T5 screwdriver (magnetized)
- T10 ball-end bit
- T8 security bit
- Torque driver
- Foam block
- I/O wall stand
- Mezzanine connector removal tool

- CPU riser cover

**Note:** New tools are required for this procedure. Refer to [General Take-Apart Information](#).

## Steps For Removal

**Note:** The I/O and power supply assembly is a module that cannot be ordered for replacement. However, removing it is a required step for other repair procedures.

1. Remove two (2) T10 screws (923-0713) that connect I/O wall to inlet.



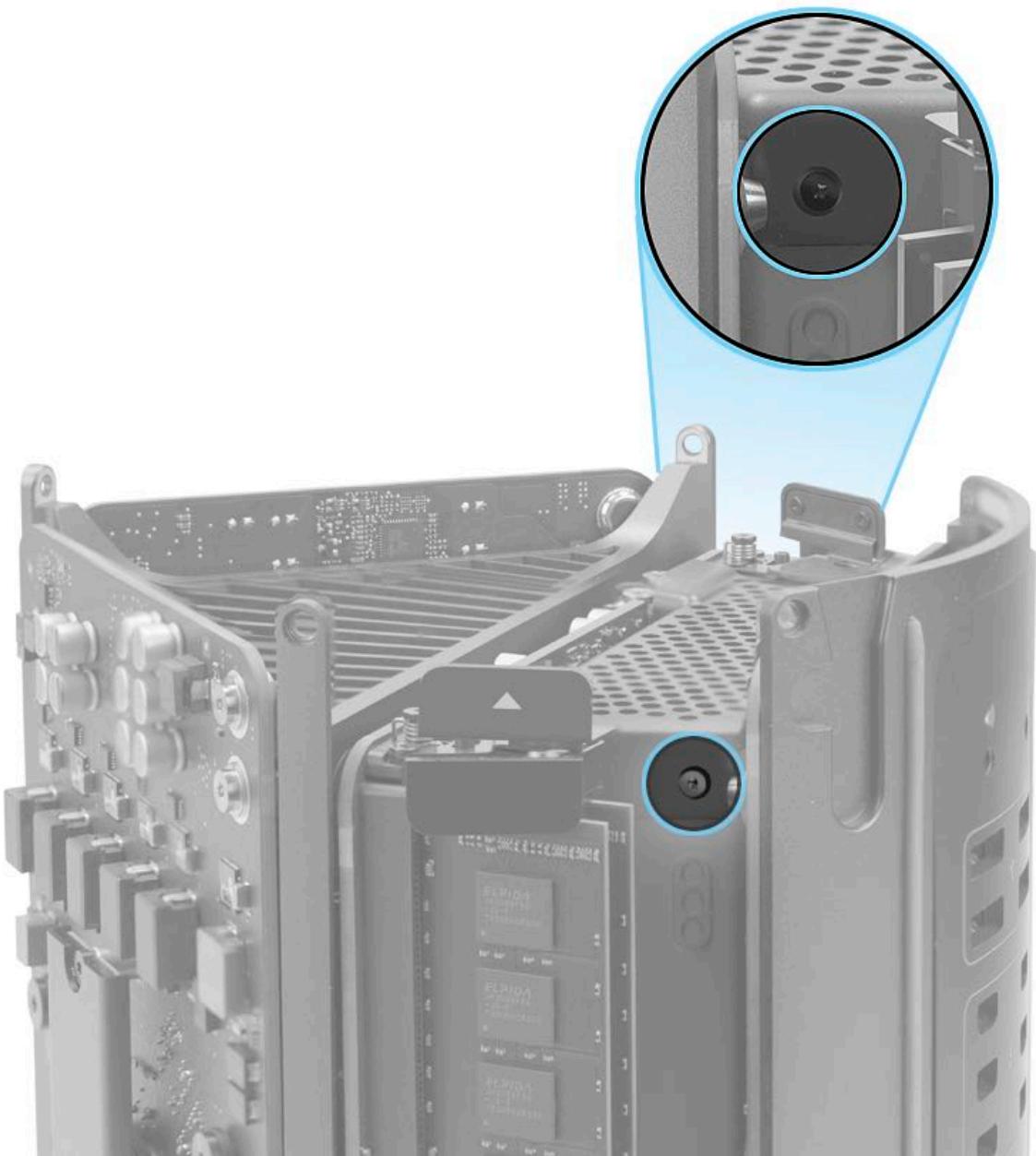


2. Open DIMM mechanisms, but do not remove DIMMs.



3. Remove two (2) T5 screws (923-0714) from power supply cover.



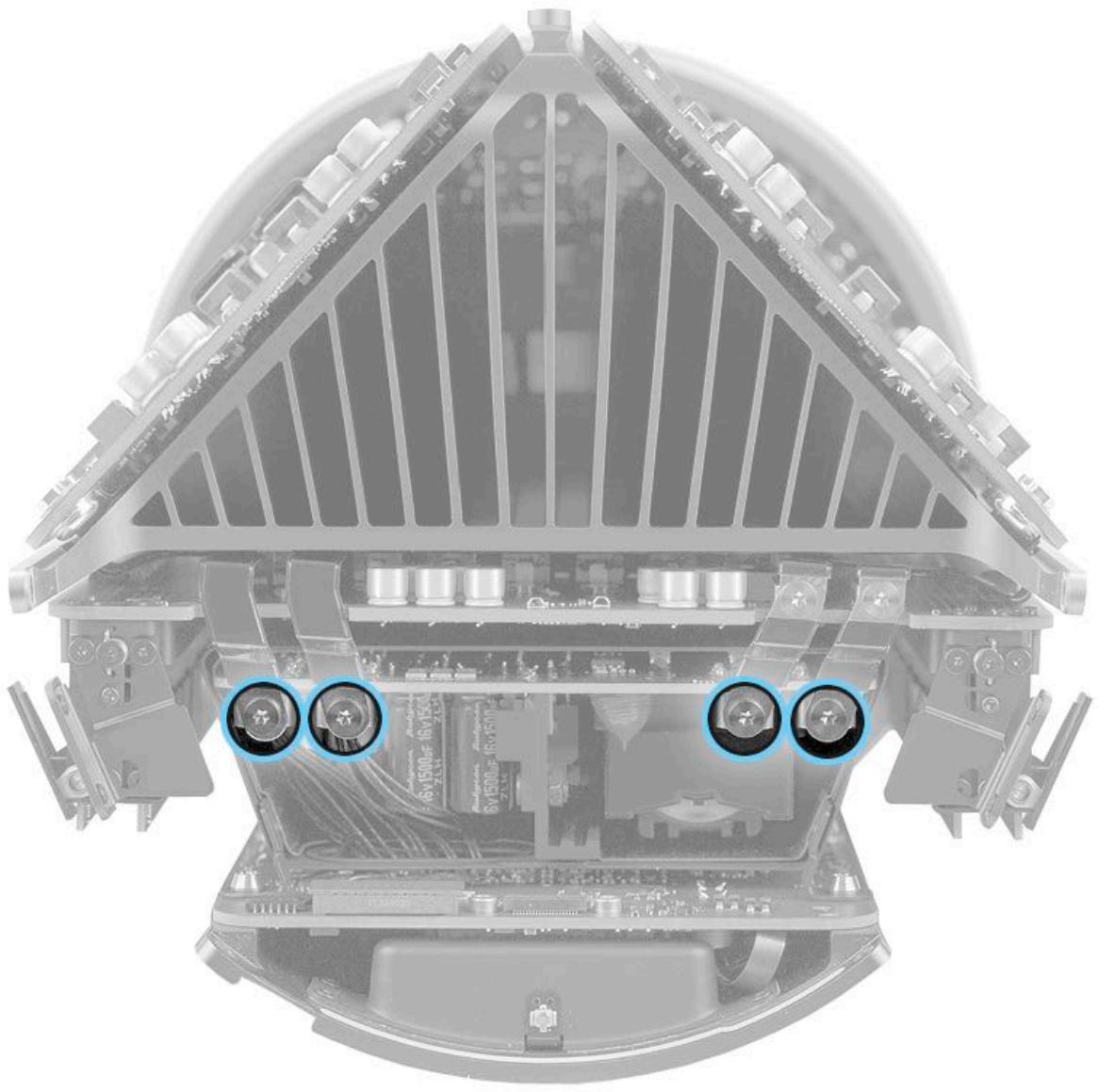


4. Lift power supply cover (923-0718) off of assembly.



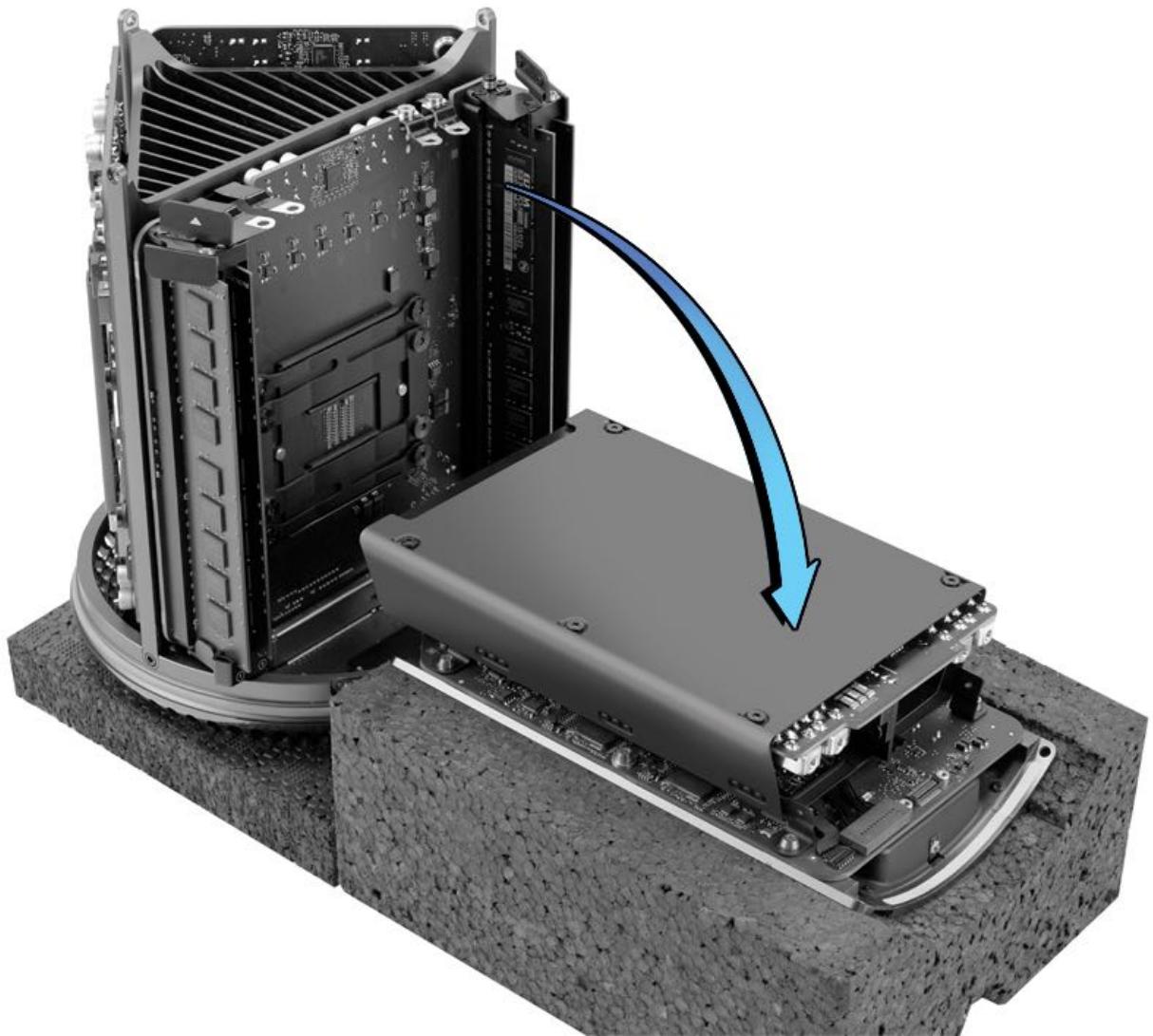
5. Using the torque driver with the T8 security bit, remove four (4) T8 bus bar screws (923-0712).





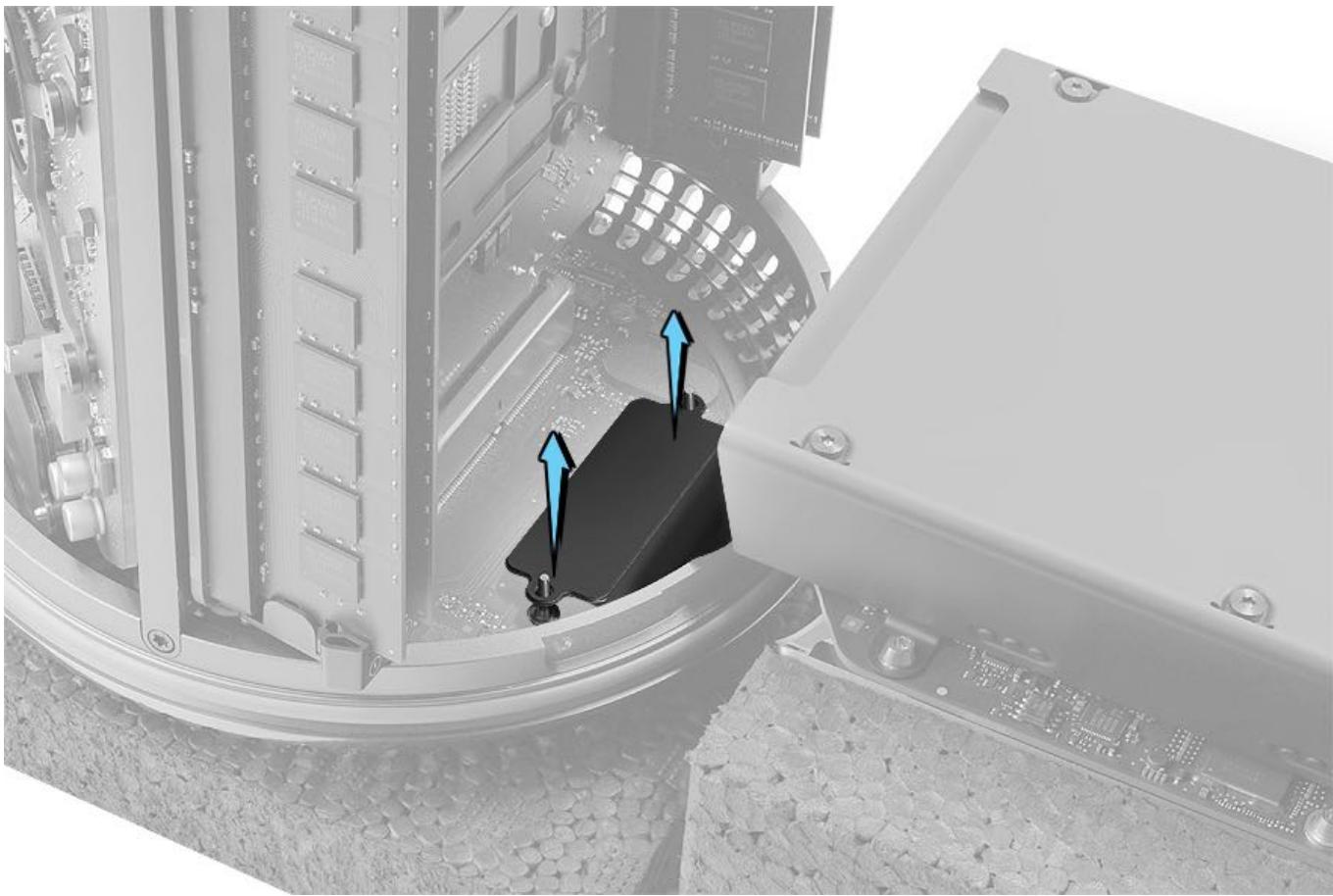
6. Place core assembly onto foam block.

7. Without straining attached cable, lay I/O and power supply assembly onto I/O wall stand.



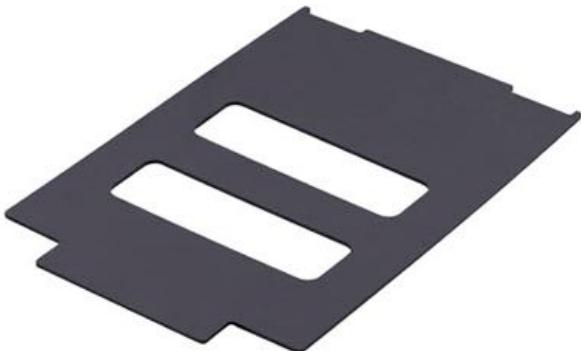
8. Use the mezzanine connector removal tool to disconnect I/O board flex cable from logic board.

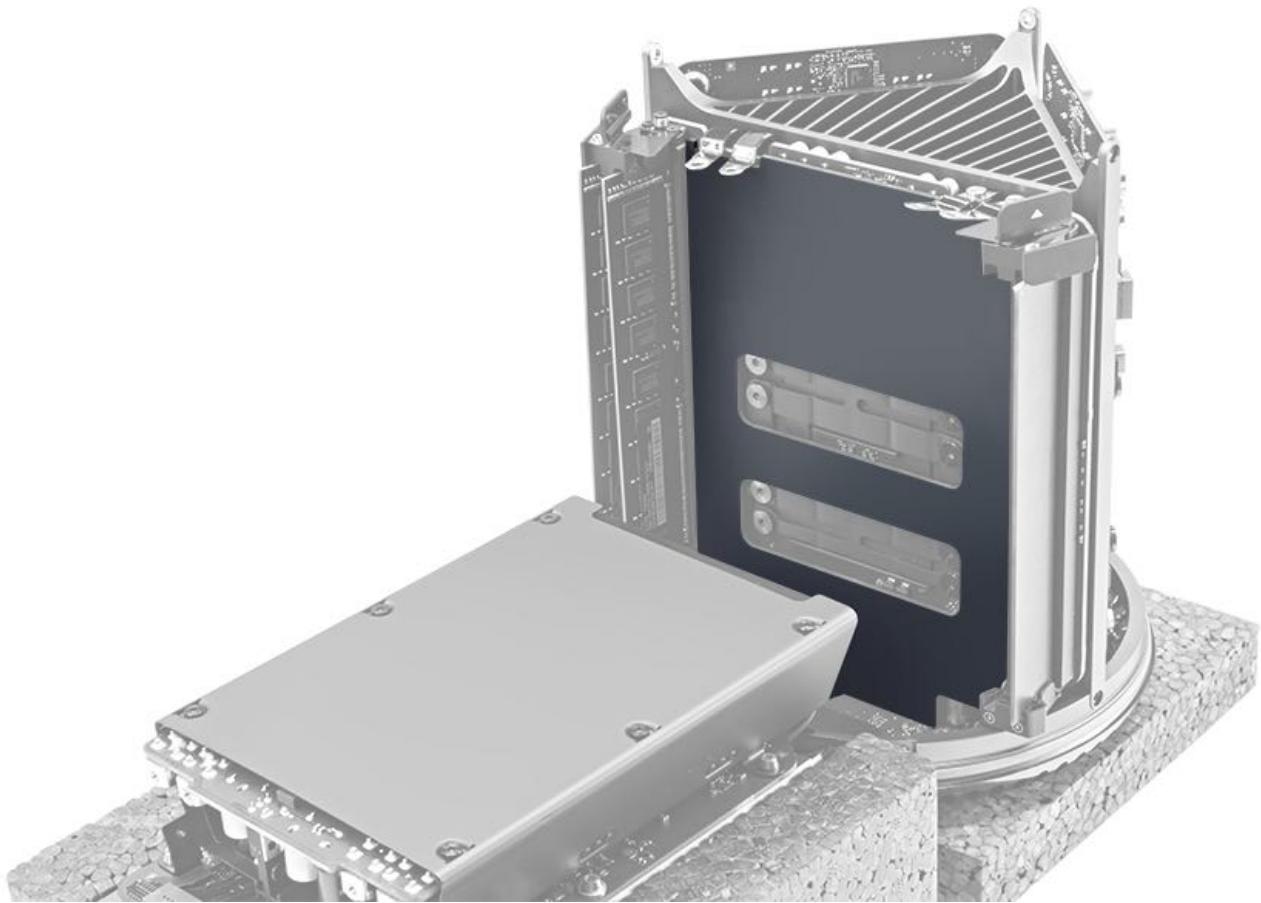




### Steps For Reassembly

1. Connect I/O board flex cable to logic board.
2. Install the CPU riser card cover to protect the CPU riser card components as you reinstall the I/O and power supply assembly.



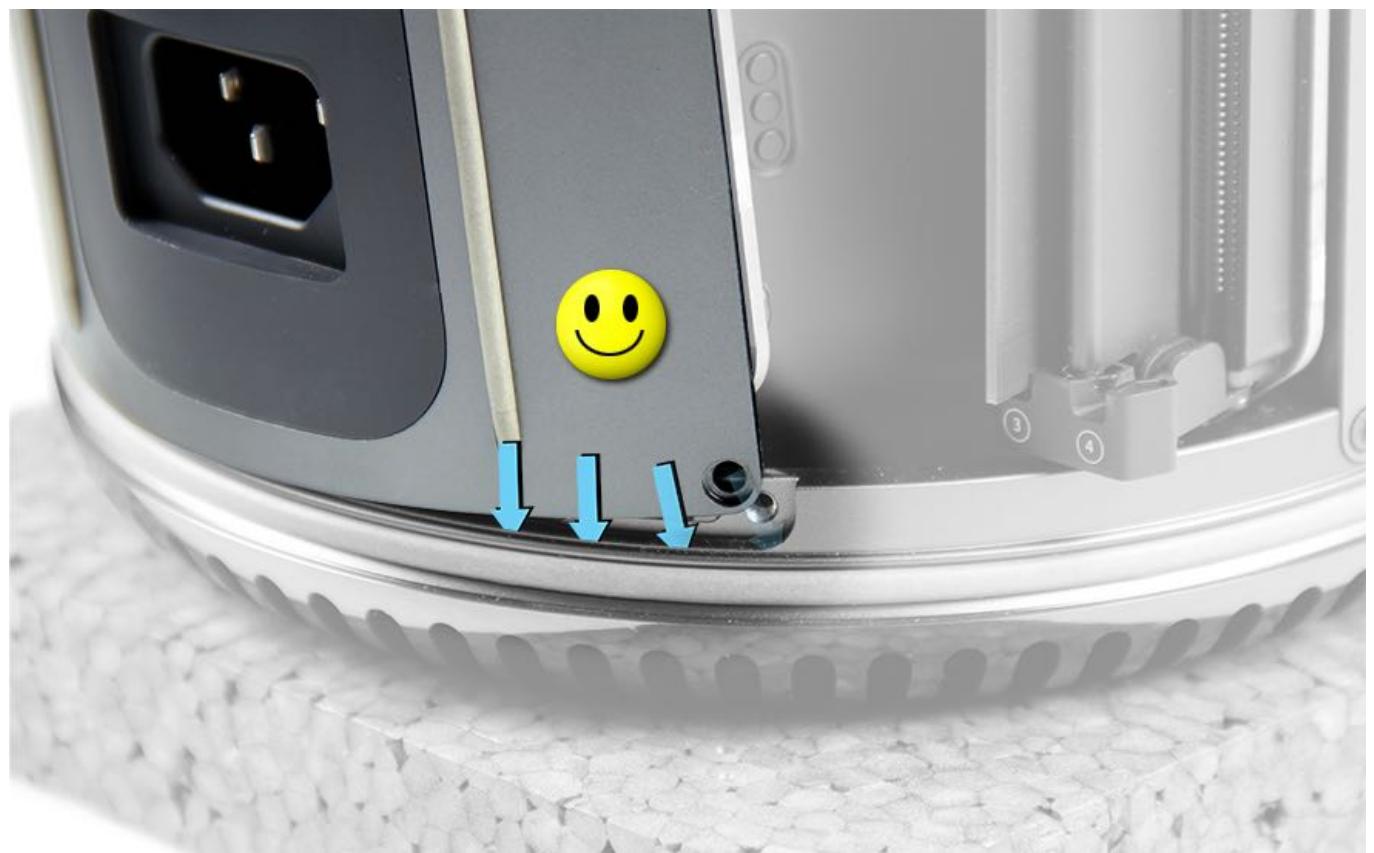


3. Use a black stick to assist in folding the I/O flex cable as you install the I/O and power supply. **Note:** The flex cable should fold outward as shown.

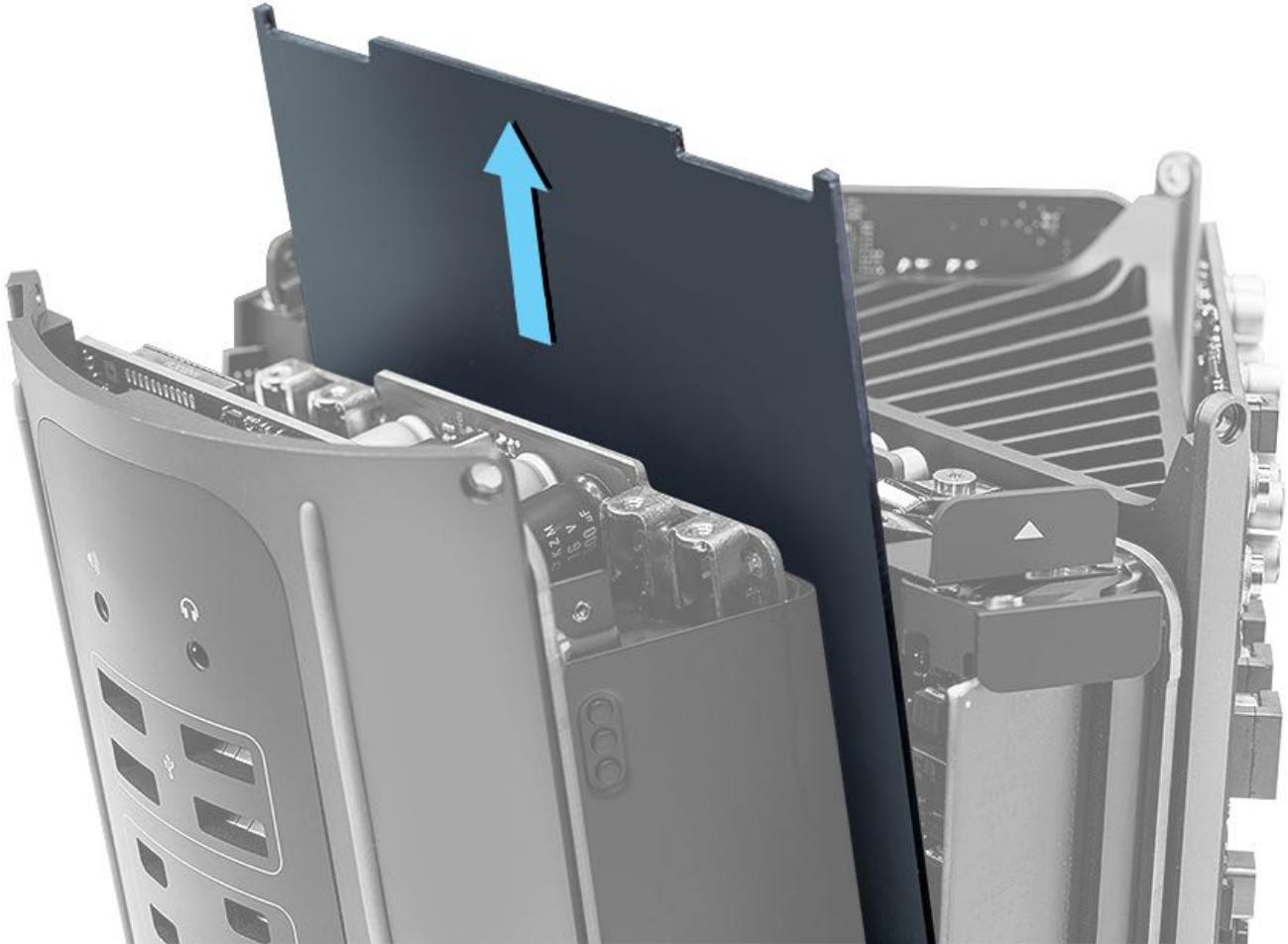




4. Align the I/O and power supply assembly to the outside edge of the inlet, making sure to align the two screw holes.



5. Before installing the I/O and power supply assembly flush against the system, gently remove the CPU riser cover, being careful not to damage the bus bars.



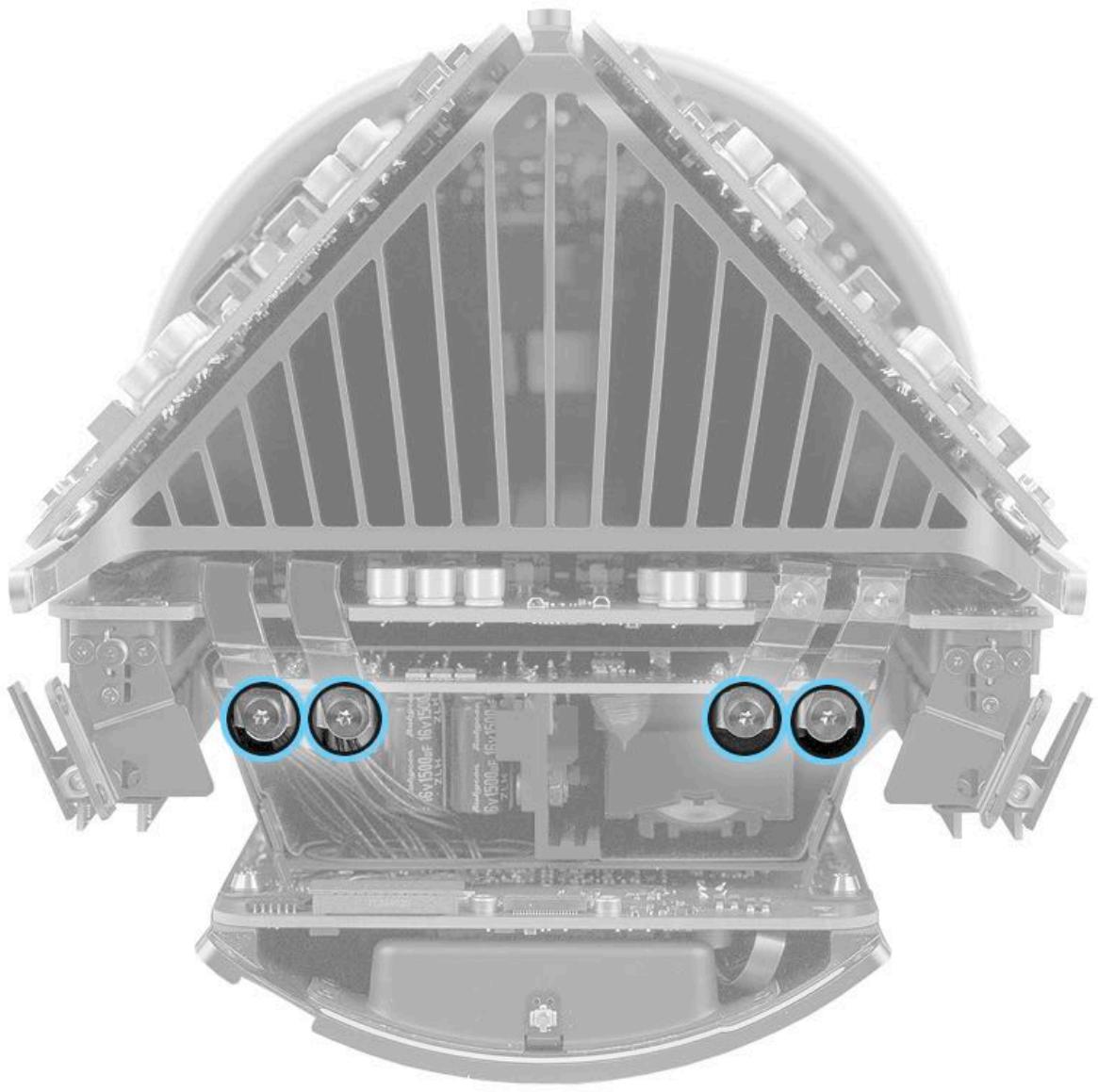
6. Make sure the bus bars are on top of the screw holes. **Tip:** If necessary, use a black stick to lift the bus bars and slide the I/O and power supply assembly under the bus bars.



7. Install the two T10 I/O wall-to-inlet screws (923-0713) in order shown. This sequence improves alignment of the bus bar screws.



8. Tighten the four (4) T8 bus bar screws (923-0712) to 7.5 inch pounds (in.-lbs.) or 0.85 Newton metres (Nm) using the torque driver with the T8 security bit. The indicated torque value must be used to avoid damaging the unit or causing the unit to malfunction.



9. Replace the power supply cover (923-0718) and two T5 screws.
10. Ensure that the memory DIMMs are seated before closing the DIMM mechanisms.

# Power Supply

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

For video instruction, refer to Apple Support article [SV226: Power Supply Replacement Video](#).

Remove:

- [Housing](#)
- [Exhaust Assembly](#)
- [I/O and Power Supply Assembly](#)



## Tools

- ESD wrist strap
- T10 ball-end bit
- Torque driver
- Black stick
- I/O wall stand

## Steps For Removal

1. Disconnect the following cables by lifting them straight up:

- Small power supply unit (PSU) signal cable (use black stick under cable)
- Large PSU power cable



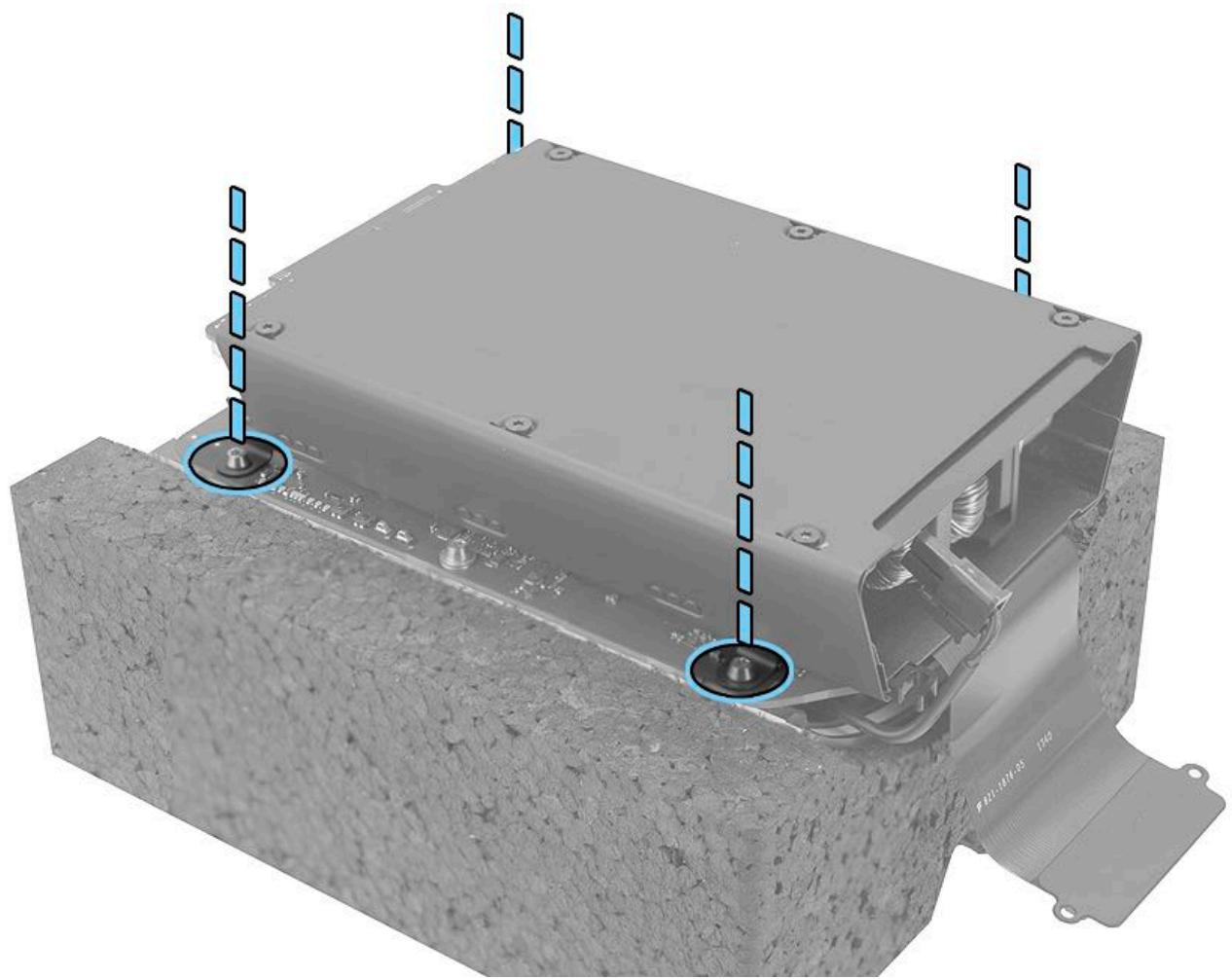
2. Press latch (1) on AC inlet cable connector, then pull connector (2) to disconnect it.
3. Release cable from U-shaped clip.



4. Hold the torque driver with the ball-end T10 bit at a slight angle. Remove four (4) T10 screws (923-0717) that attach power supply to I/O board.

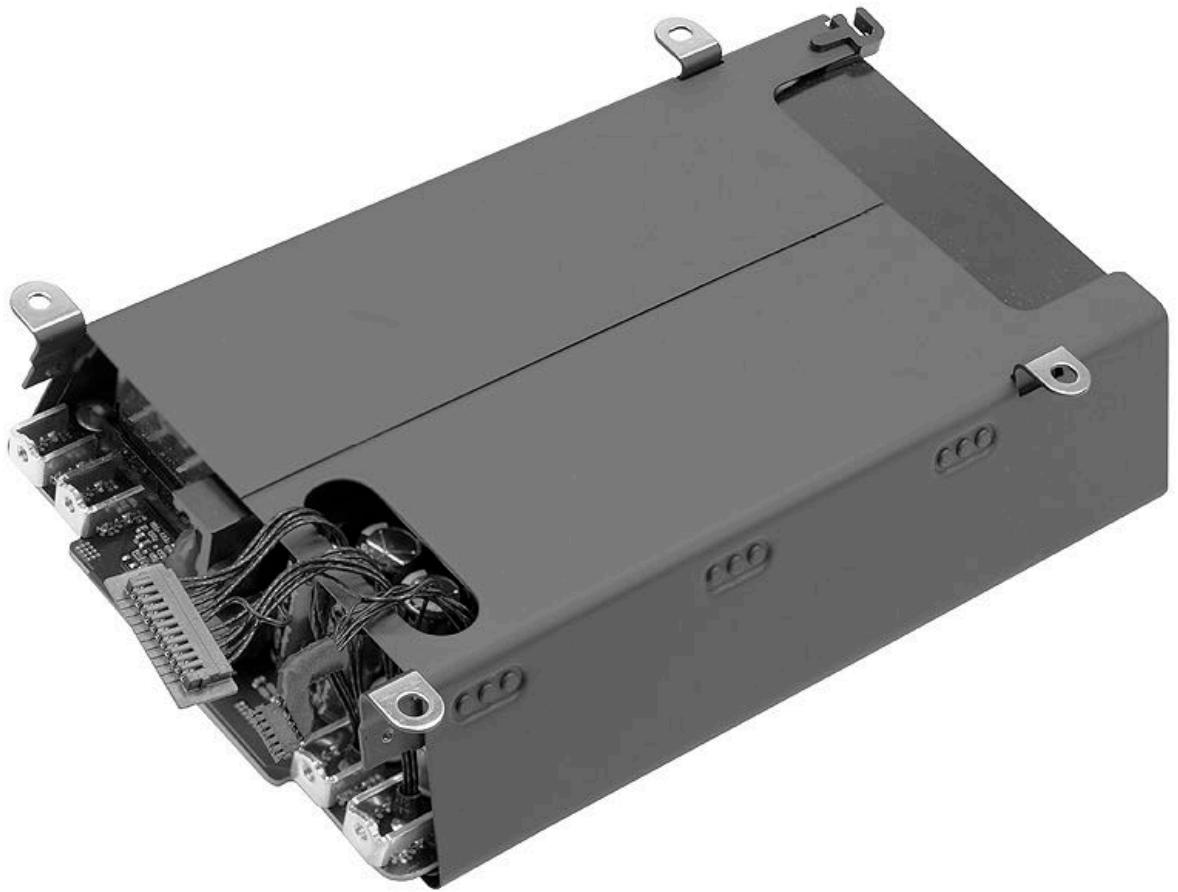


5. Lift power supply off of I/O board.



## Steps For Reassembly

- 1. Reassembly Note:** Ensure that cables lay flat and are not pinched when installing power supply onto I/O board. To protect the components on the I/O board, ensure that all four tabs of power supply touch only the flat areas of I/O board.



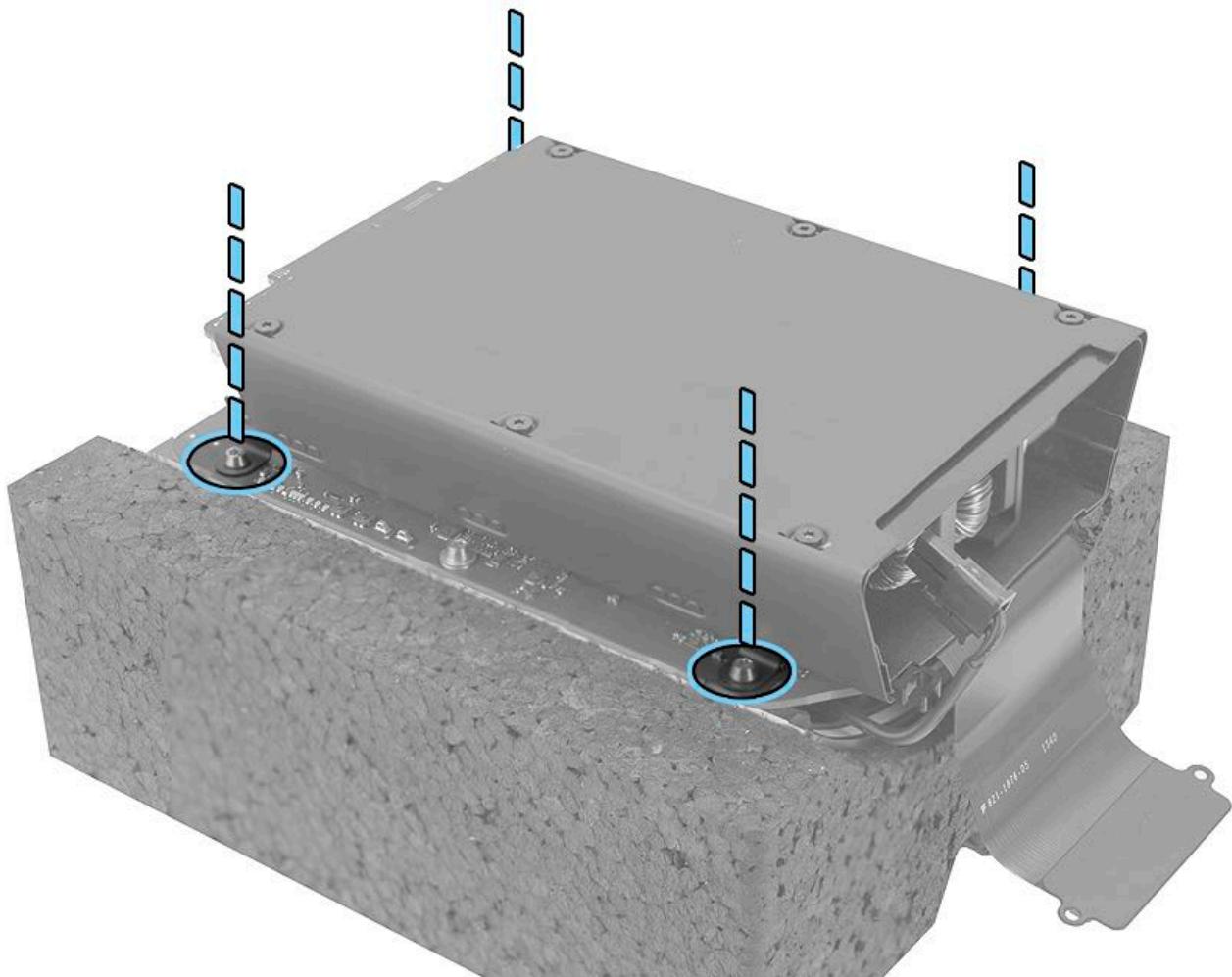
**2. Reassembly Note:** Ensure that AC inlet cable is routed into U-shaped clip when connecting cable to power supply.

**Warning:** When reattaching the AC inlet cable to the power supply connector, make sure that the cable is captured by the U-shaped clip on the power supply assembly. Failure to do so may result in the AC inlet cable being pinched by the edge of the power supply shroud. This could damage the cable insulation and create a shock or fire hazard.



**3.** Using the torque driver with T10 ball-end bit, install four (4) screws (923-0717) to 10.5 inch pounds (in.-lbs.) or 1.2 Newton metres (Nm).

**Note:** When reinstalling the I/O and Power Supply Assembly board into the chassis, make sure to route the I/O flex cable outwards or under the I/O board and not under the power supply. The I/O flex cable does not have insulation suitable for the voltages and temperatures of the power supply components. Routing the flex cable under the I/O board prevents contact with the power supply.



# I/O Board and I/O Wall

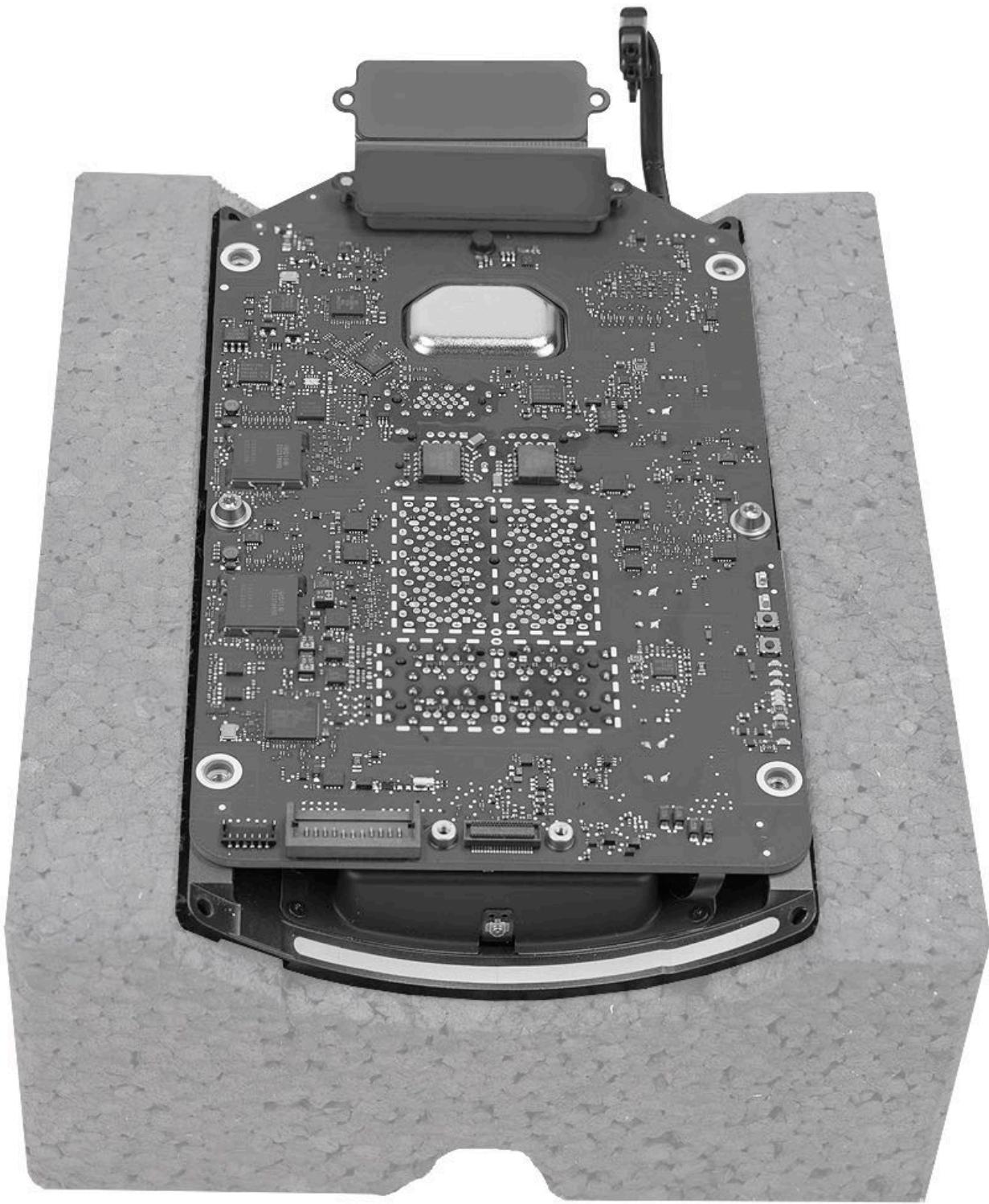
## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

For video instruction, refer to Apple Support article [SV225: I/O Board and I/O Wall Removal Video](#).

Remove:

- [Housing](#)
- [Exhaust Assembly](#)
- [I/O and Power Supply Assembly](#)
- [Power Supply](#)



## Tools

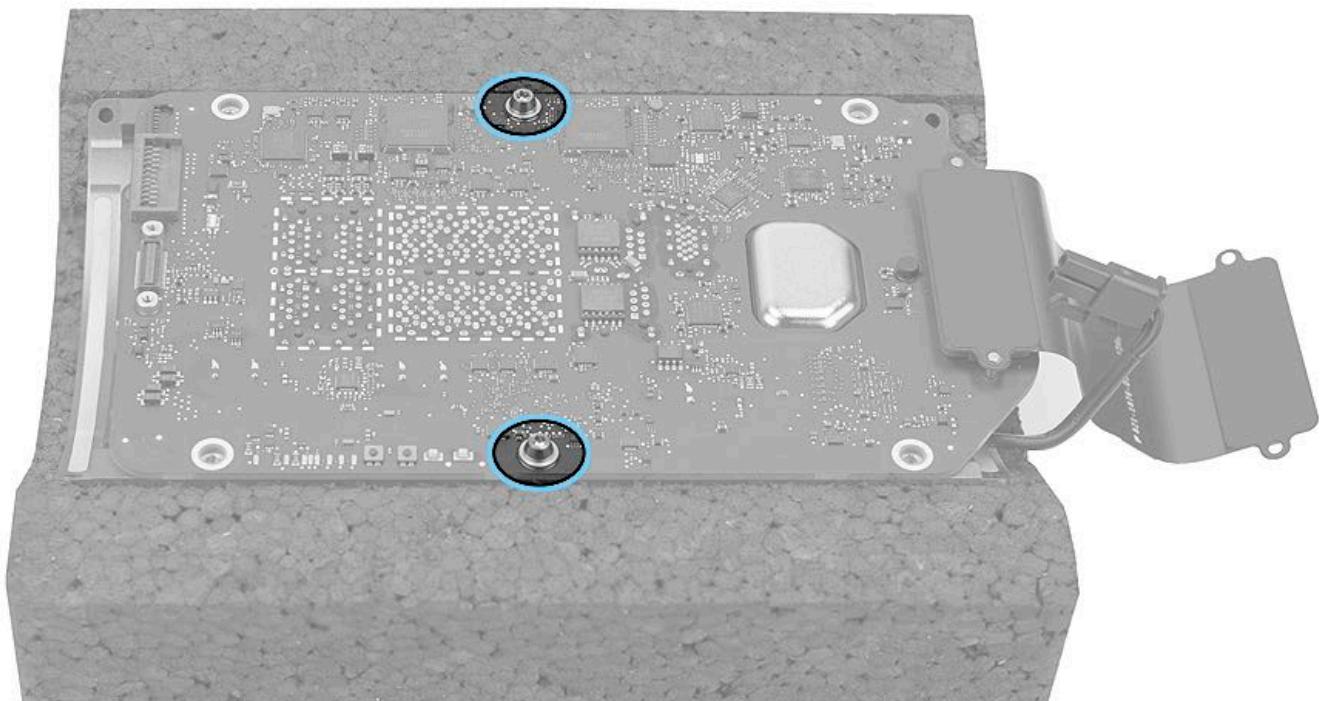
- ESD wrist strap
- Torx T10 screwdriver, magnetized
- Black stick
- I/O wall stand
- Apple HDMI cable (for reassembly)
- Apple USB cable (for reassembly)

## Steps For Removal

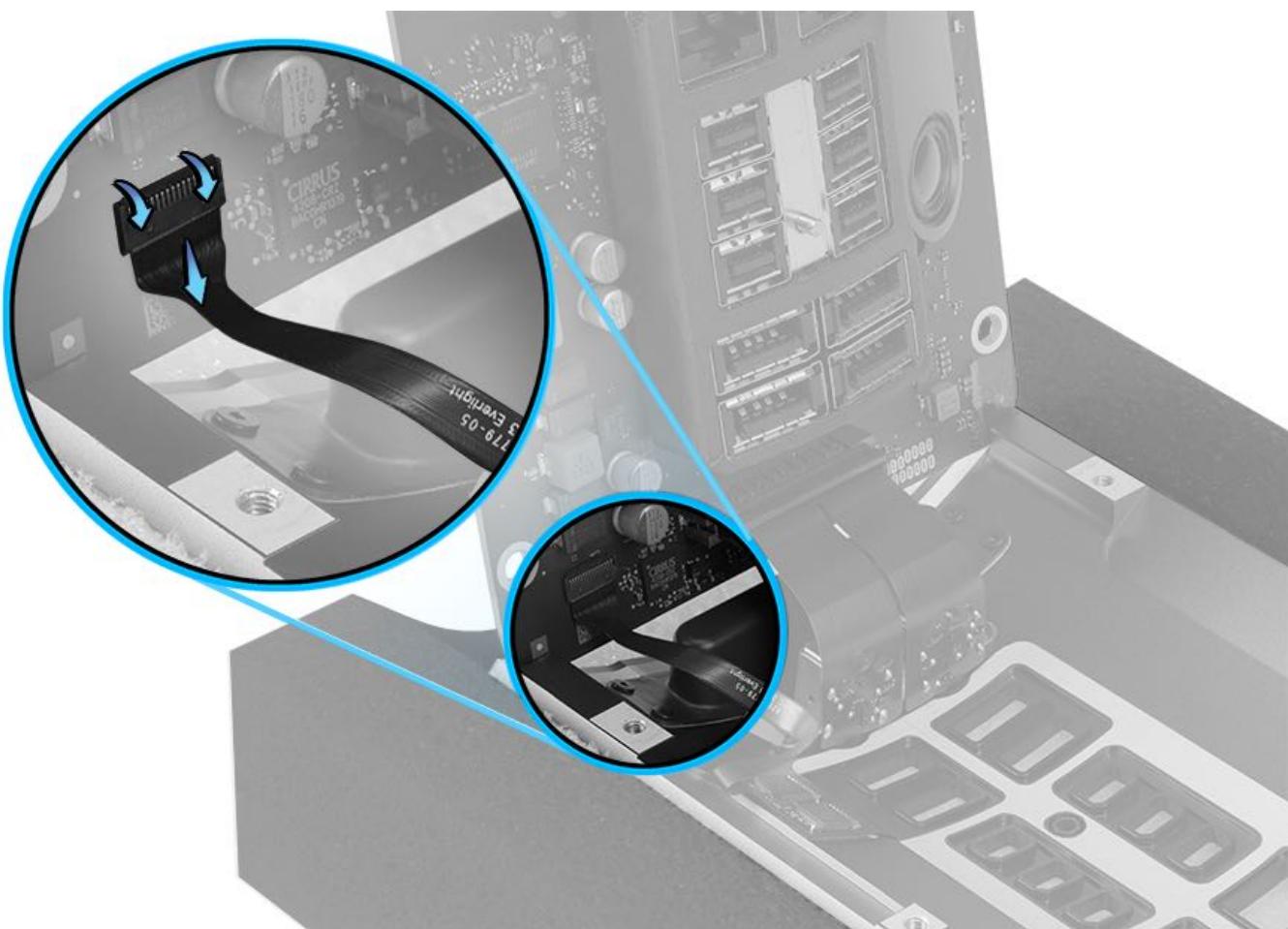
1. Remove two (2) T10 screws (923-0717) from I/O board.



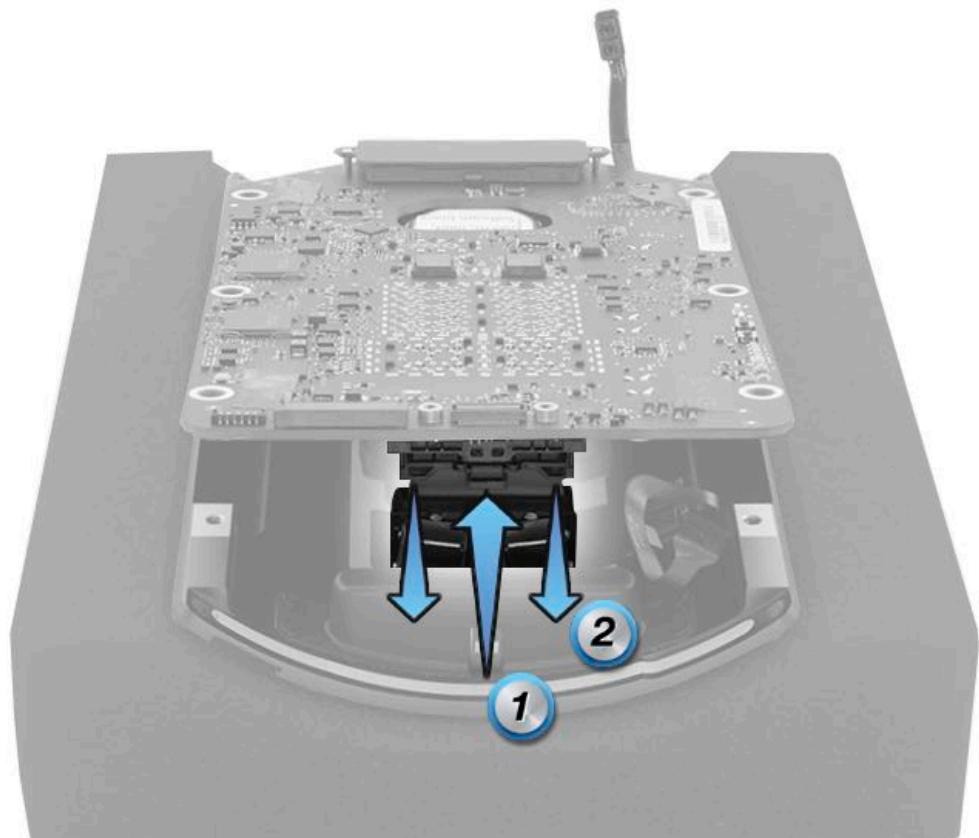
**Important:** In the next step, I/O board is connected to I/O wall by two cables. Do not attempt to separate I/O board until cables are disconnected.



2. Carefully tilt I/O board at a 90-degree angle to I/O wall.
3. Flip up locking lever of illumination flex cable connector. Disconnect cable from I/O board.



4. Lower I/O board onto I/O wall. Rotate I/O stand so large audio cable is in front.
5. Press locking latch (1) on audio cable connector and disconnect cable (2) from I/O board.
6. Remove I/O board from I/O wall.

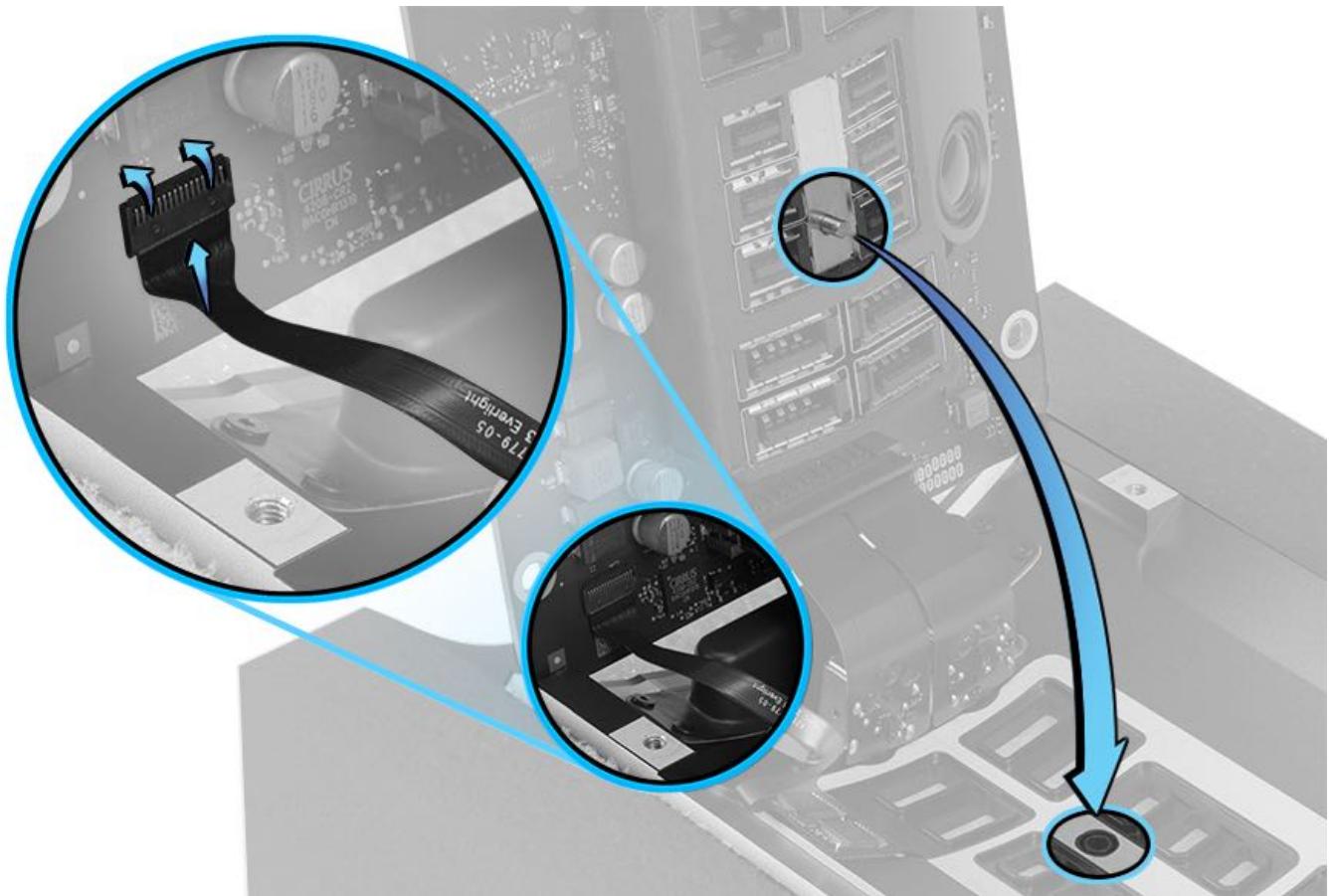


### Steps For Reassembly

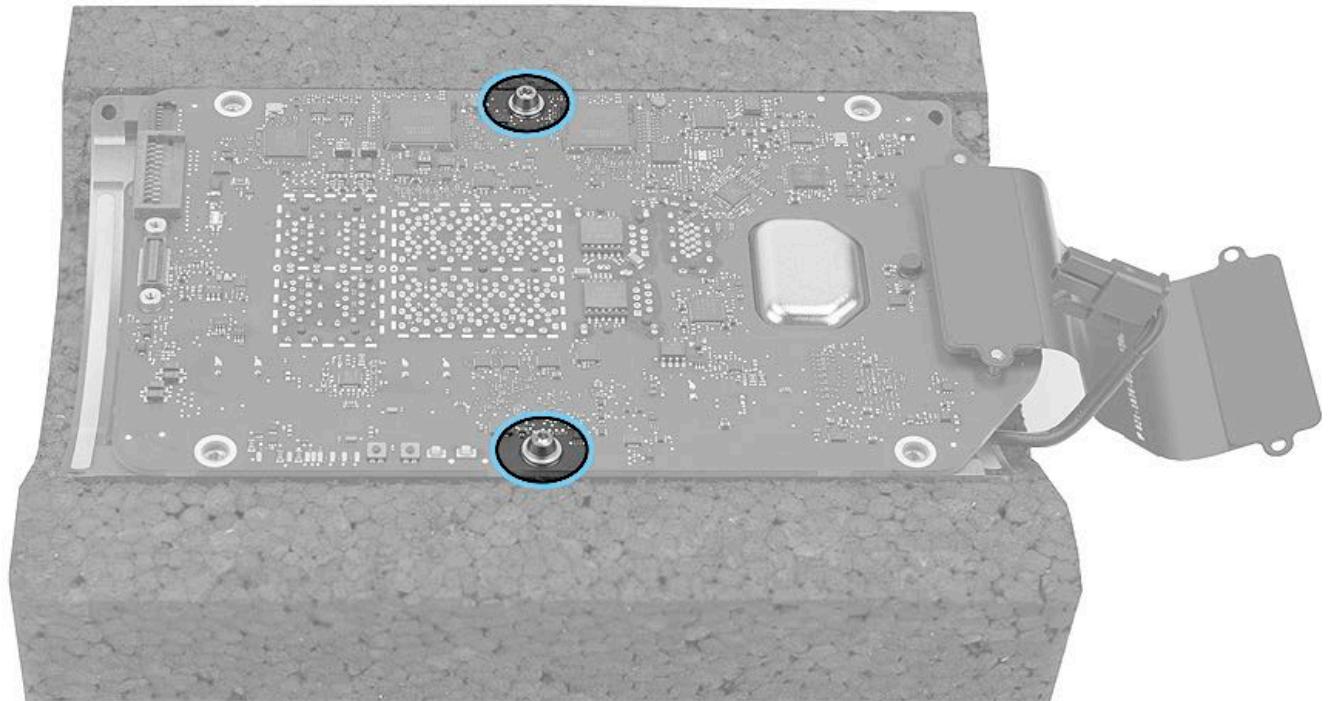
1. **Note:** If replacing the I/O wall, make sure to match the color of the I/O wall gasket to the gasket on the inlet. The replacement I/O wall (923-00466) includes a new inlet with a matching gasket.



2. Connect audio cable.
3. Using black stick, connect illumination flex cable and flip locking lever closed.
4. Ensure that the I/O board seats correctly by aligning the pin on the I/O board with the hole in the I/O wall.



5. Loosely install two (2) T10 screws (923-0717) while maintaining pin alignment.



5. To maintain alignment with I/O board, connect these cables:

- Apple USB connector to upper right port
- Apple HDMI connector

6. With ports aligned, finish installing two (2) T10 screws (923-0717).

7. Disconnect the Apple USB and Apple HDMI cables.



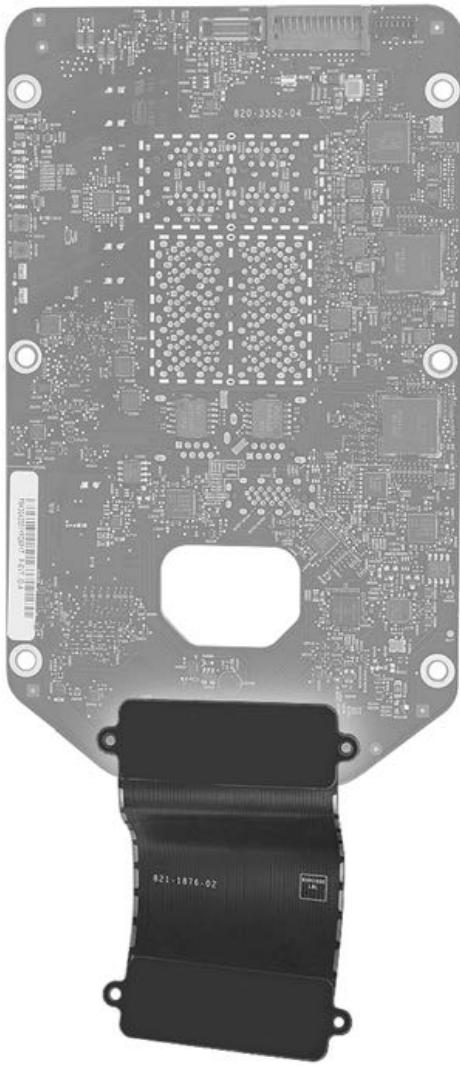
# I/O Board Flex Cable

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Exhaust Assembly](#)
- [I/O and Power Supply Assembly](#)
- [Power Supply](#)
- [I/O Board and I/O Wall](#)

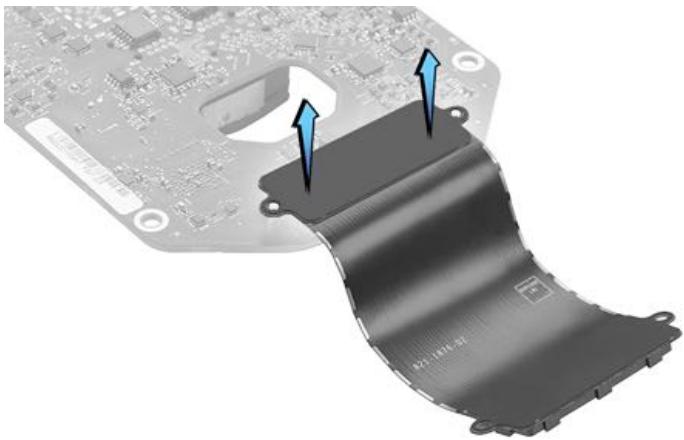


## Tools

- ESD wrist strap
- Mezzanine connector removal tool

## Steps For Removal

Using the mezzanine connector removal tool, disconnect the I/O flex cable straight off of the I/O board connector.



## Steps For Reassembly

Reassemble in reverse order of removal steps.

**Note:** When reinstalling the I/O and Power Supply Assembly board into the chassis, make sure to route the I/O flex cable outwards or under the I/O board and not under the power supply. The I/O flex cable does not have insulation suitable for the voltages and temperatures of the power supply components. Routing the flex cable under the I/O board prevents contact with the power supply.

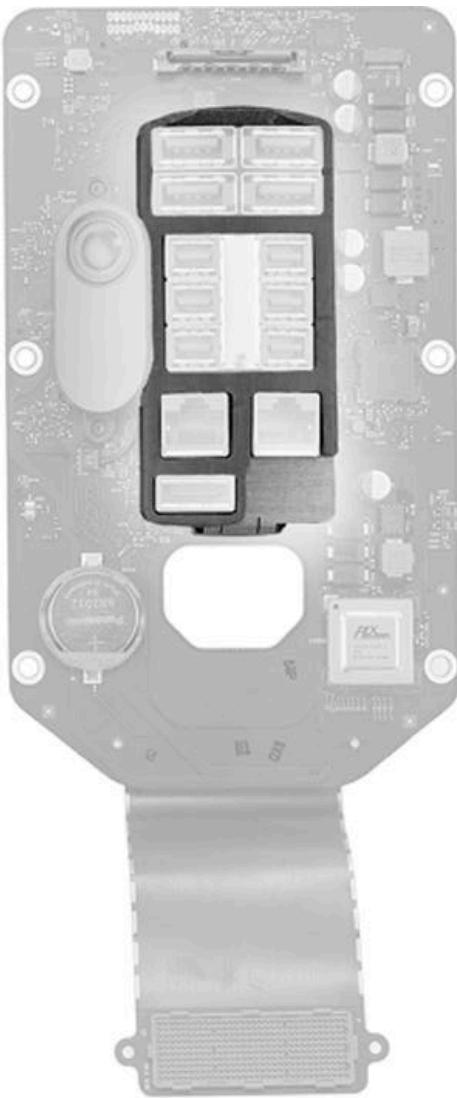
# Ports EMI Shield

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Exhaust Assembly](#)
- [I/O and Power Supply Assembly](#)
- [Power Supply](#)
- [I/O Board](#)

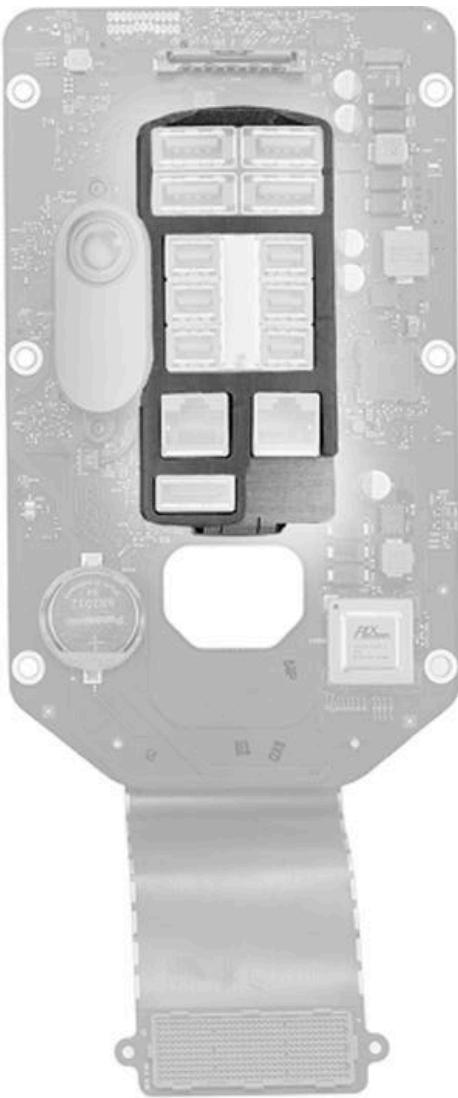


## Tools

- ESD wrist strap

## Steps For Removal

Carefully pull EMI shield straight up off ports.



## Steps For Reassembly

**Reassembly Note:** Before installing shield, carefully position it over ports. Make sure not to pinch speaker cable under edge of shield.

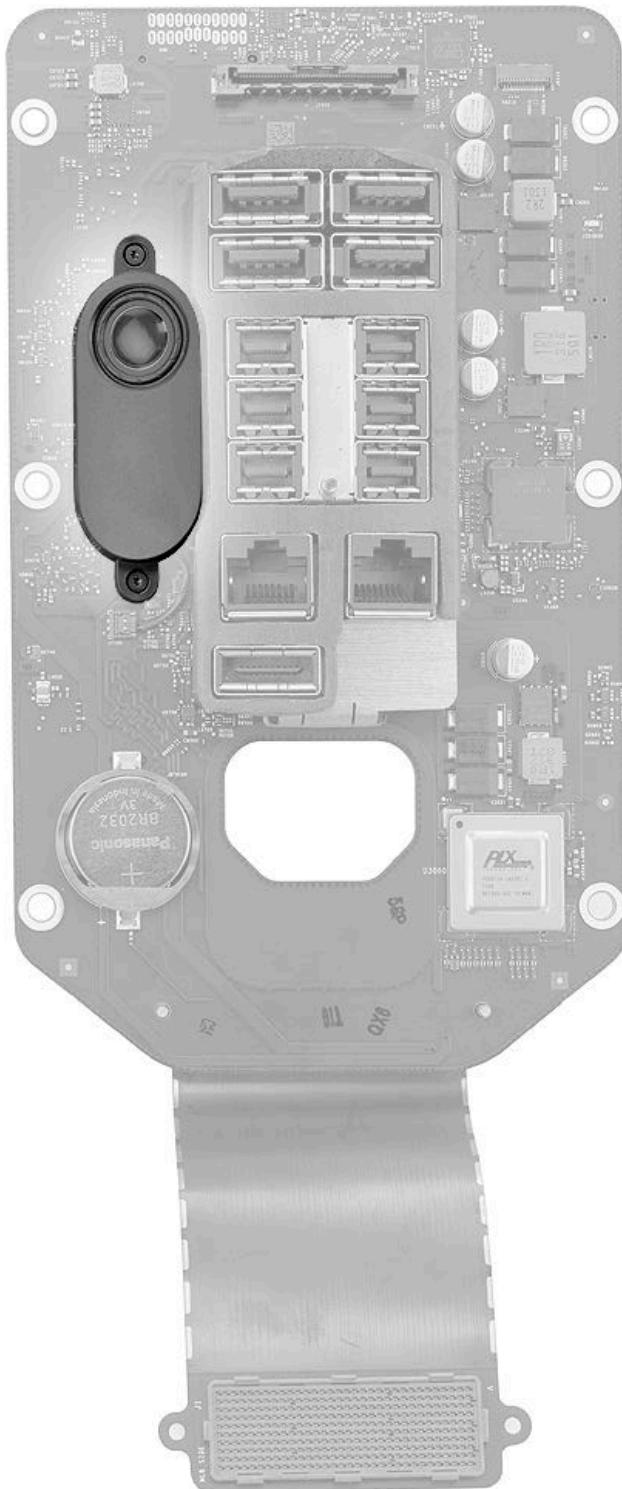
# Speaker

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Exhaust Assembly](#)
- [I/O and Power Supply Assembly](#)
- [Power Supply](#)
- [I/O Board](#)



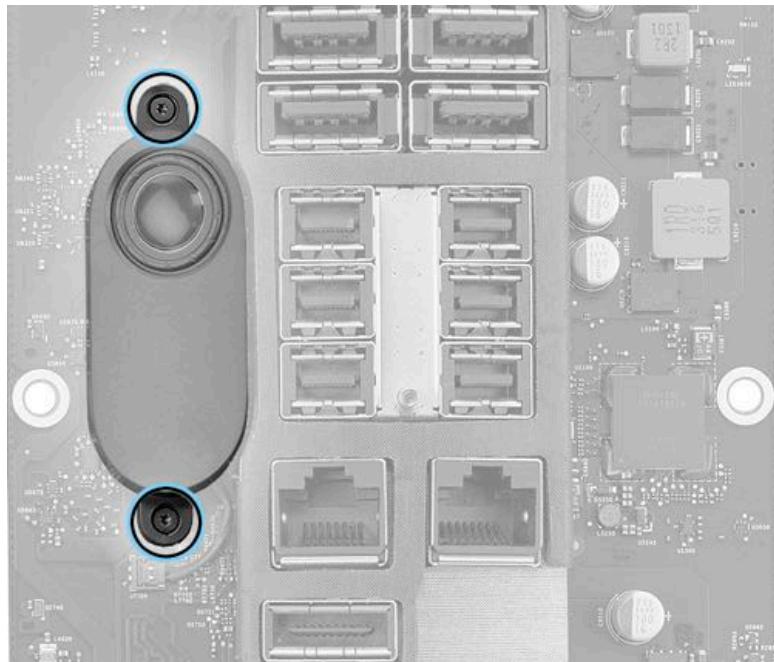
## Tools

- ESD wrist strap

- T5 Torx screwdriver (magnetized)
- Black stick

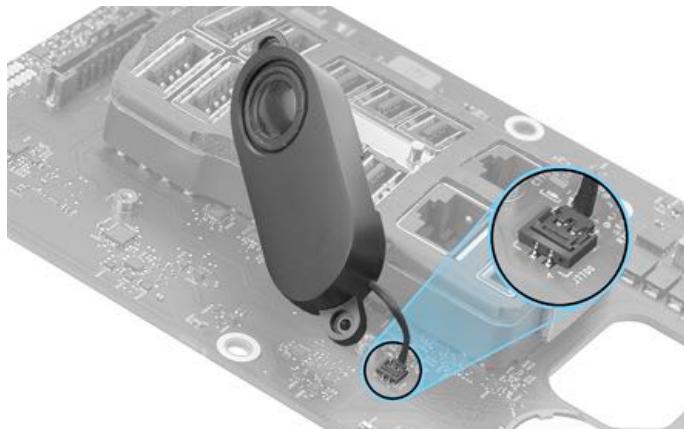
## Steps For Removal

1. Remove two (2) T5 screws (923-0726).



2. Carefully rotate speaker away from I/O ports and use a black stick to disconnect speaker cable from I/O board. (Cable connector lifts straight up.)

3. Remove speaker from I/O board.



## Steps For Reassembly

Reassemble in reverse order of removal steps.

# Coin Battery

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Exhaust Assembly](#)
- [I/O and Power Supply Assembly](#)
- [Power Supply](#)
- [I/O Board](#)



## Tools

- ESD wrist strap
- Black stick

## Steps For Removal

Pry up the coin battery and remove it from the I/O board.



## Steps For Reassembly

**Warning:** If the battery is installed incorrectly or replaced with an incorrect type of battery, there is a risk of explosion. Dispose of used batteries according to local environmental laws and guidelines.

**Note:** Effective immediately, some coin cell batteries used on Mac systems are now available only from electronics parts distributors (for example, MCM). The coin battery noted below is no longer available to order via GSX. When the Mac repair process indicates the noted coin battery needs to be replaced, please order it from an electronics parts distributor. **Note:** BR2032 and CR2032 batteries have the same form factor and nominal voltage. However, BR2032 batteries have a lower self-discharge rate and broader operating temperature range than CR2032 batteries for longer shelf and service life.

Slide the battery (922-8892) into the socket with the engraved markings (+ side) facing up.

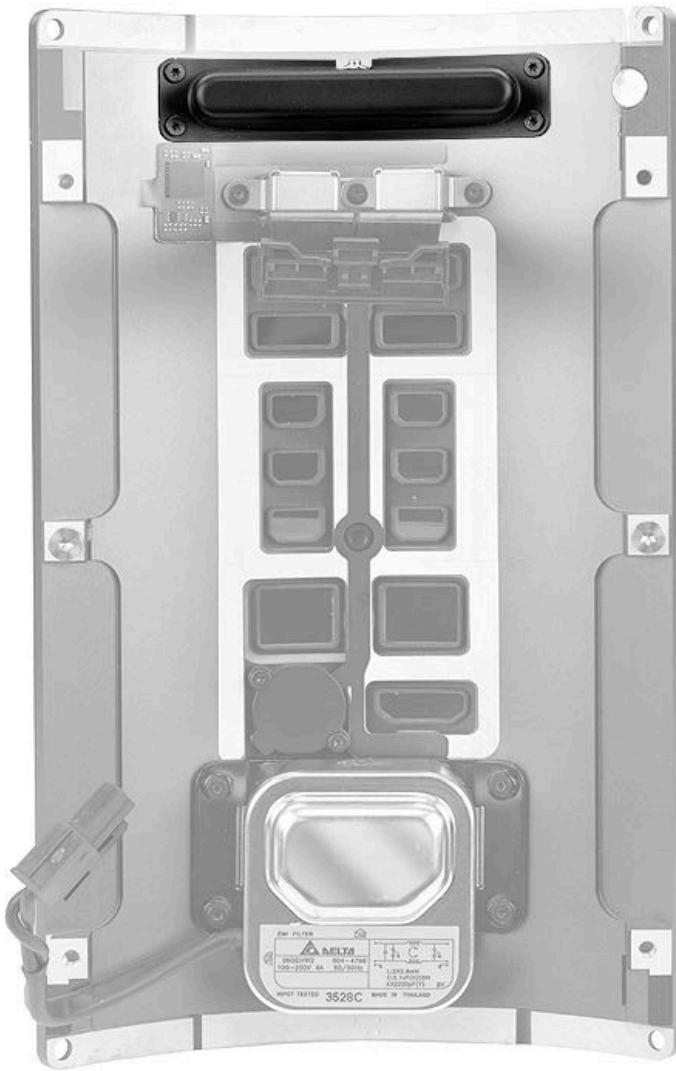
# Bluetooth Antenna

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Exhaust Assembly](#)
- [I/O and Power Supply Assembly](#)
- [Power Supply](#)
- [I/O Board and I/O Wall](#)



## Tools

- ESD wrist strap
- Torx T5 screwdriver (magnetized)
- I/O wall stand

## Steps For Removal

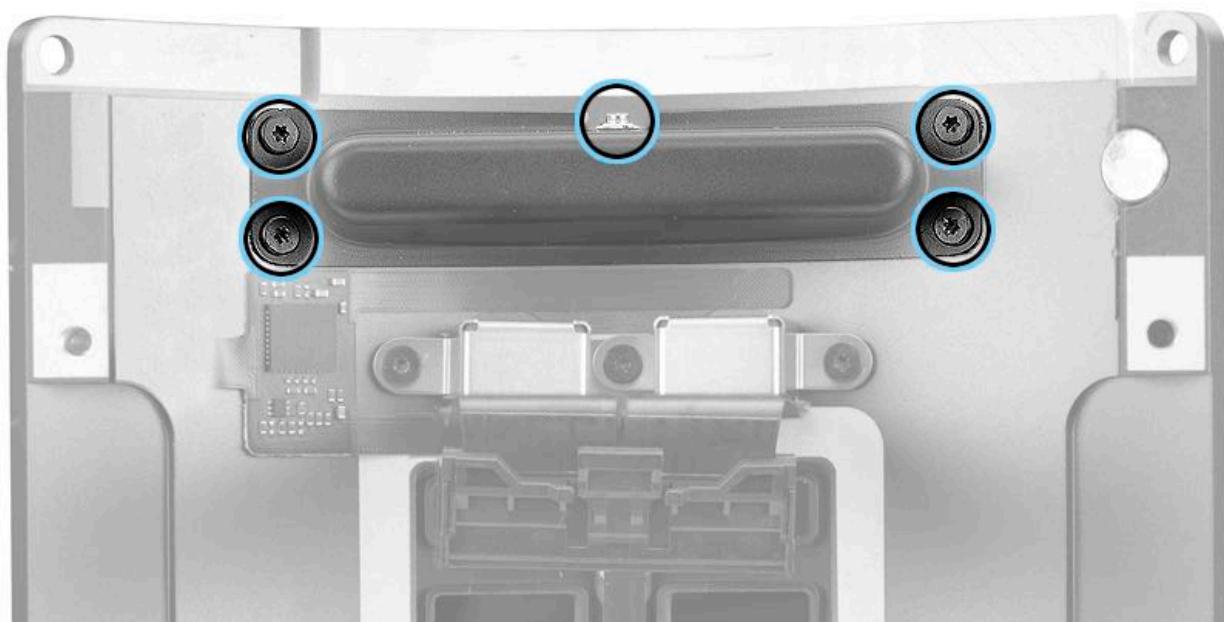
**Note:** Before beginning this procedure, place the I/O wall in the I/O wall stand.



1. Remove four (4) T5 screws (923-0726).

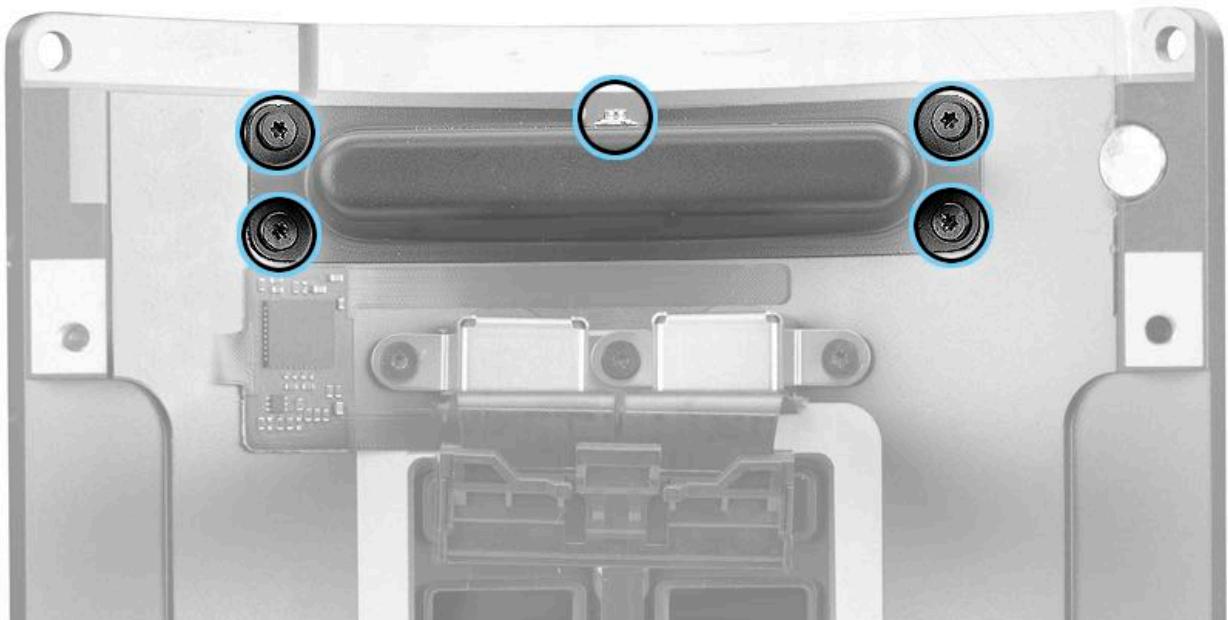


2. Remove Bluetooth antenna from I/O wall.



## Steps For Reassembly

**Reassembly Note:** Make sure antenna connector faces up when installing Bluetooth antenna on I/O wall.



# Audio Jack Assembly

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Exhaust Assembly](#)
- [I/O and Power Supply Assembly](#)
- [Power Supply](#)
- [I/O Board and I/O Wall](#)



## Tools

- ESD wrist strap
- Torx T5 screwdriver (magnetized)
- I/O wall stand

## Steps For Removal

**Note:** Before beginning this procedure, place the I/O wall in the I/O wall stand.



1. Remove three (3) T5 screws (923-0709).

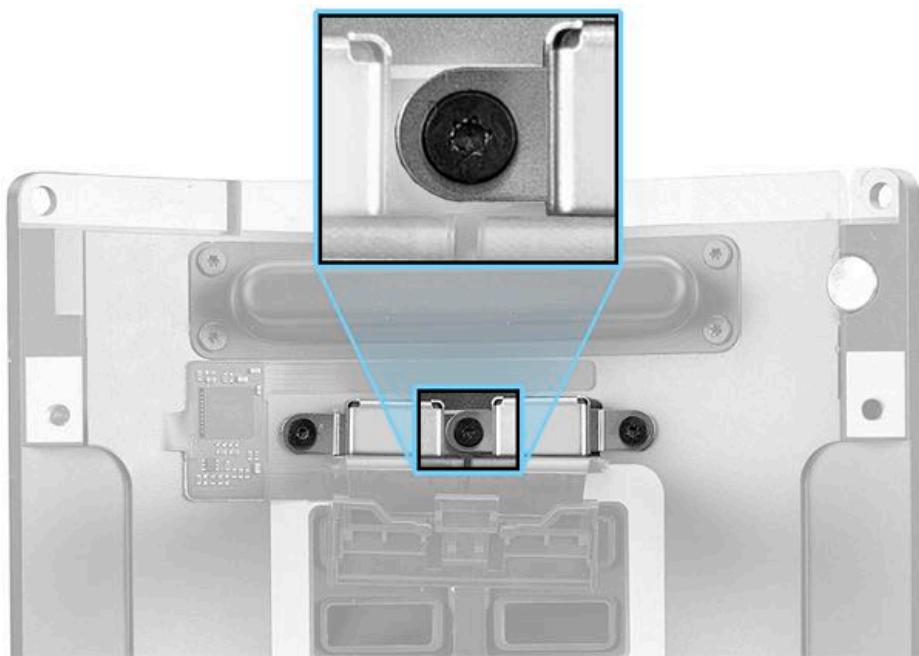


2. Remove audio jack assembly from I/O wall.



### Steps For Reassembly

**Reassembly Note:** Position audio jack with housing facing up and screw tabs overlapped as shown.



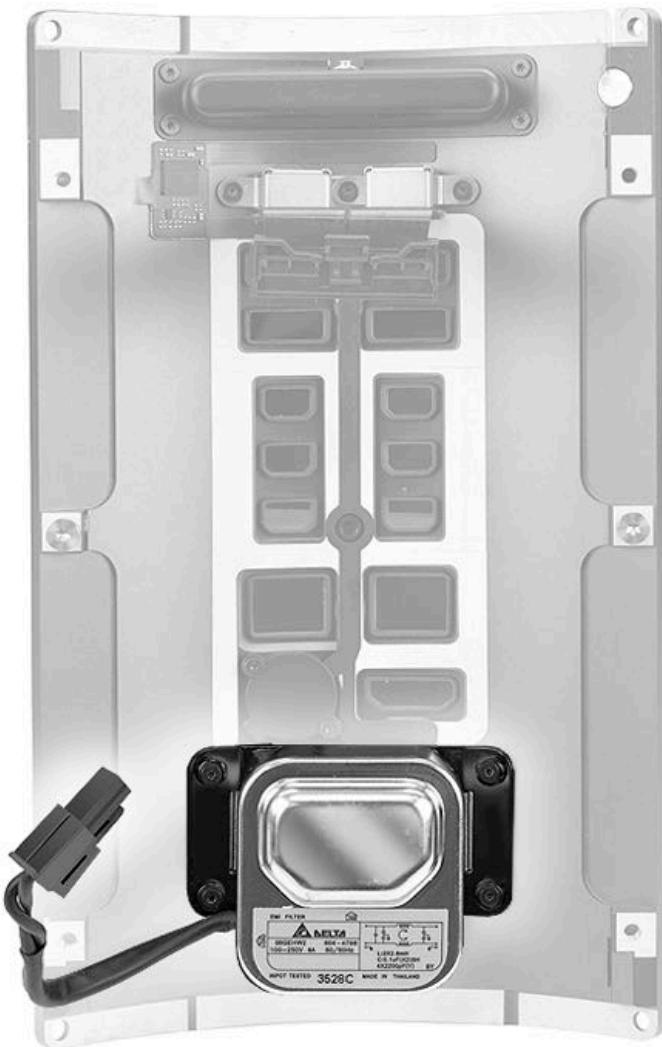
# AC Inlet

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Exhaust Assembly](#)
- [I/O and Power Supply Assembly](#)
- [Power Supply](#)
- [I/O Board and I/O Wall](#)

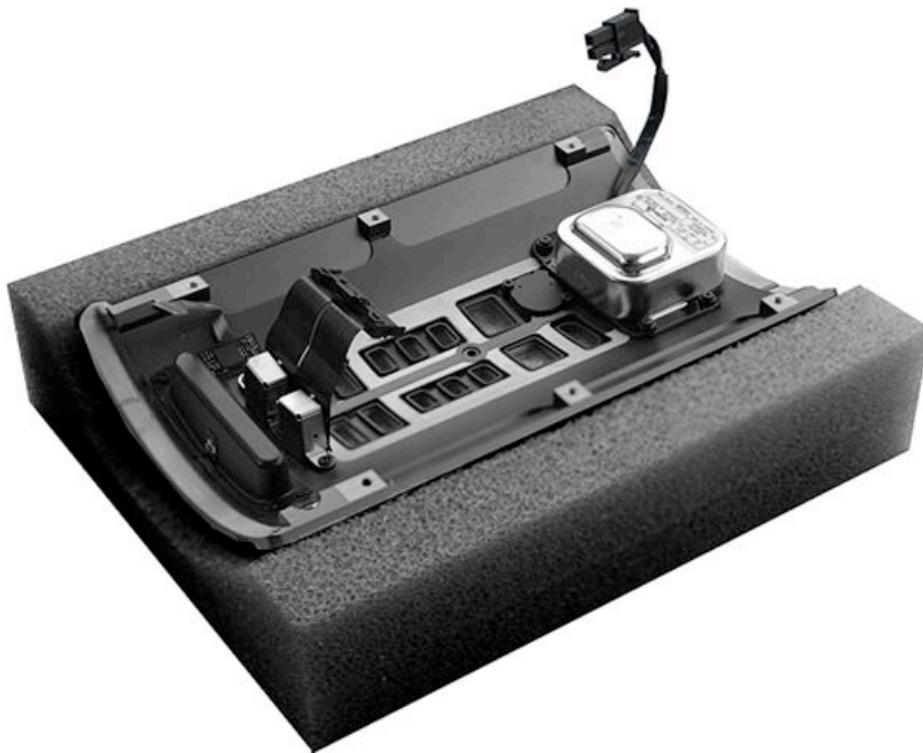


## Tools

- ESD wrist strap
- Torx T5 screwdriver (magnetized)
- I/O wall stand

## Steps For Removal

**Note:** Before beginning this procedure, place the I/O wall in the I/O wall stand.



1. Remove four (4) T5 screws (923-0727).



2. Remove the AC inlet from the I/O wall.



## Steps For Reassembly

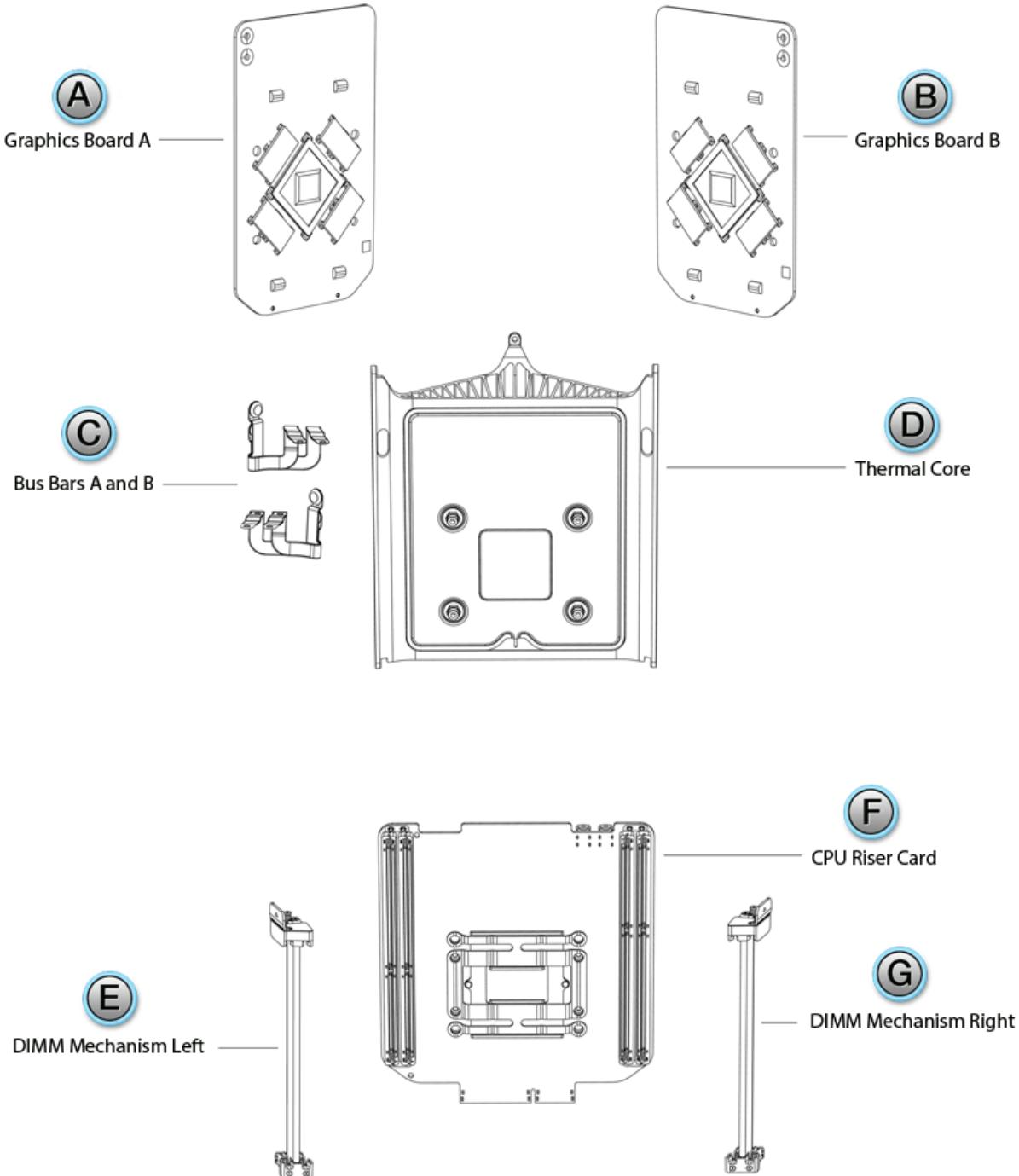
Reassemble in reverse order of removal steps.

**Warning:** When reattaching the AC inlet cable to the power supply connector, make sure that the AC inlet cable is captured by the U-shaped clip on the power supply assembly. Failure to do so may result in the AC inlet cable becoming pinched by the edge of the power supply shroud. This could damage the cable insulation and create a shock or fire hazard.



# Core Assembly Overview

## Core Assembly



A = [Graphics Board A](#)

B = [Graphics Board B](#)

C = [Bus Bars A and B](#)

D = [Thermal Core](#)

E = [DIMM Mechanism Left](#)

F = [CPU Riser Card](#)

G = [DIMM Mechanism Right](#)



# Graphics Boards

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams and courses that you need to service Mac products](#).



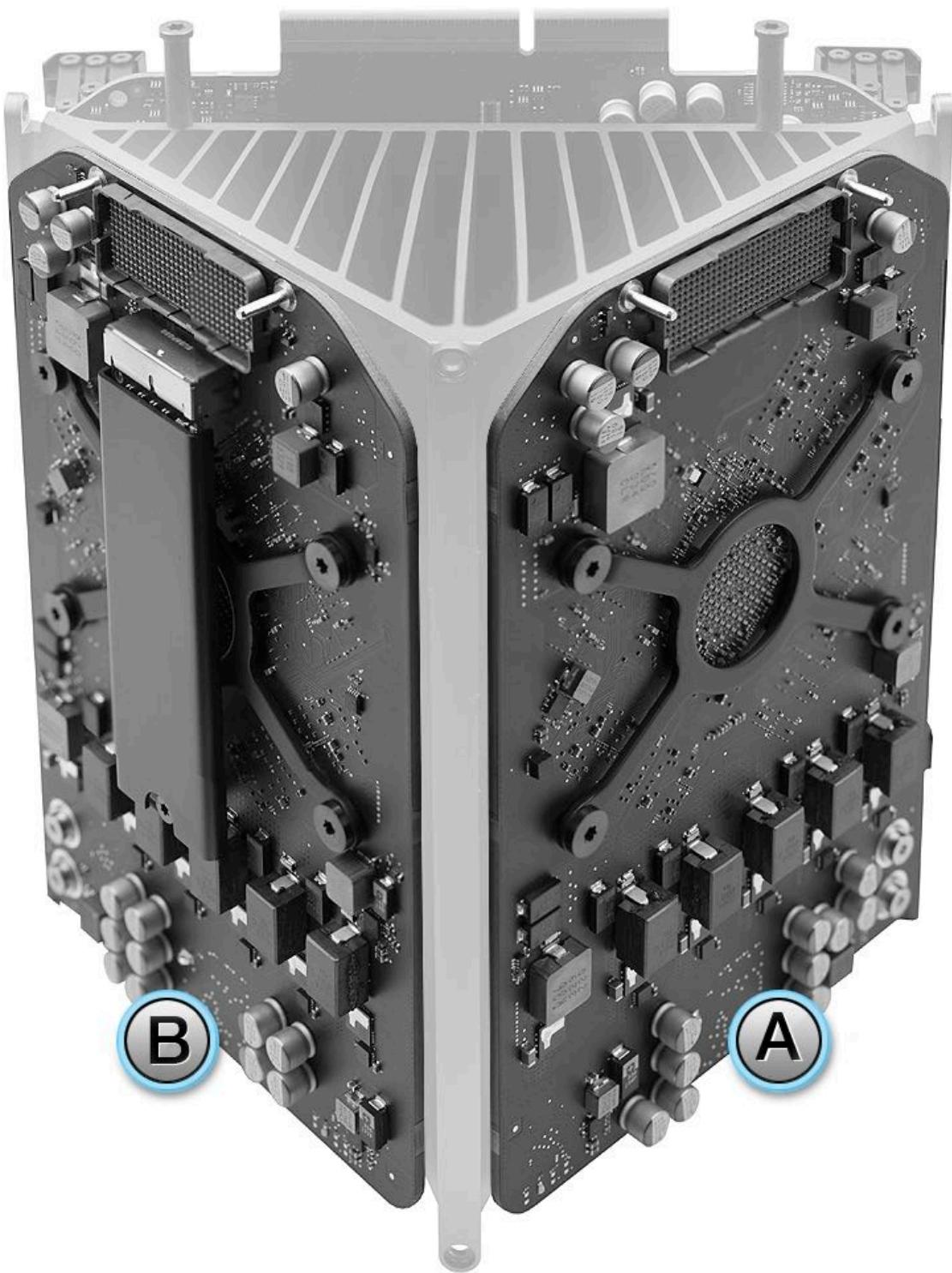
**Important:** Before repairing any graphics board issue, update the computer to OS X version 10.10.3 or later and verify if that resolves the issue.

For video instruction, refer to article [SV224: Graphics Boards Replacement Video](#).

Remove:

- [Housing](#)
- [Exhaust Assembly](#)
- [I/O and Power Supply Assembly](#)
- [Inlet](#)
- [Logic Board](#)
- [Flash Storage](#) (only if replacing graphics board B)

**Note:** The two graphics boards are nearly identical, but graphics board B has a slot for flash storage.

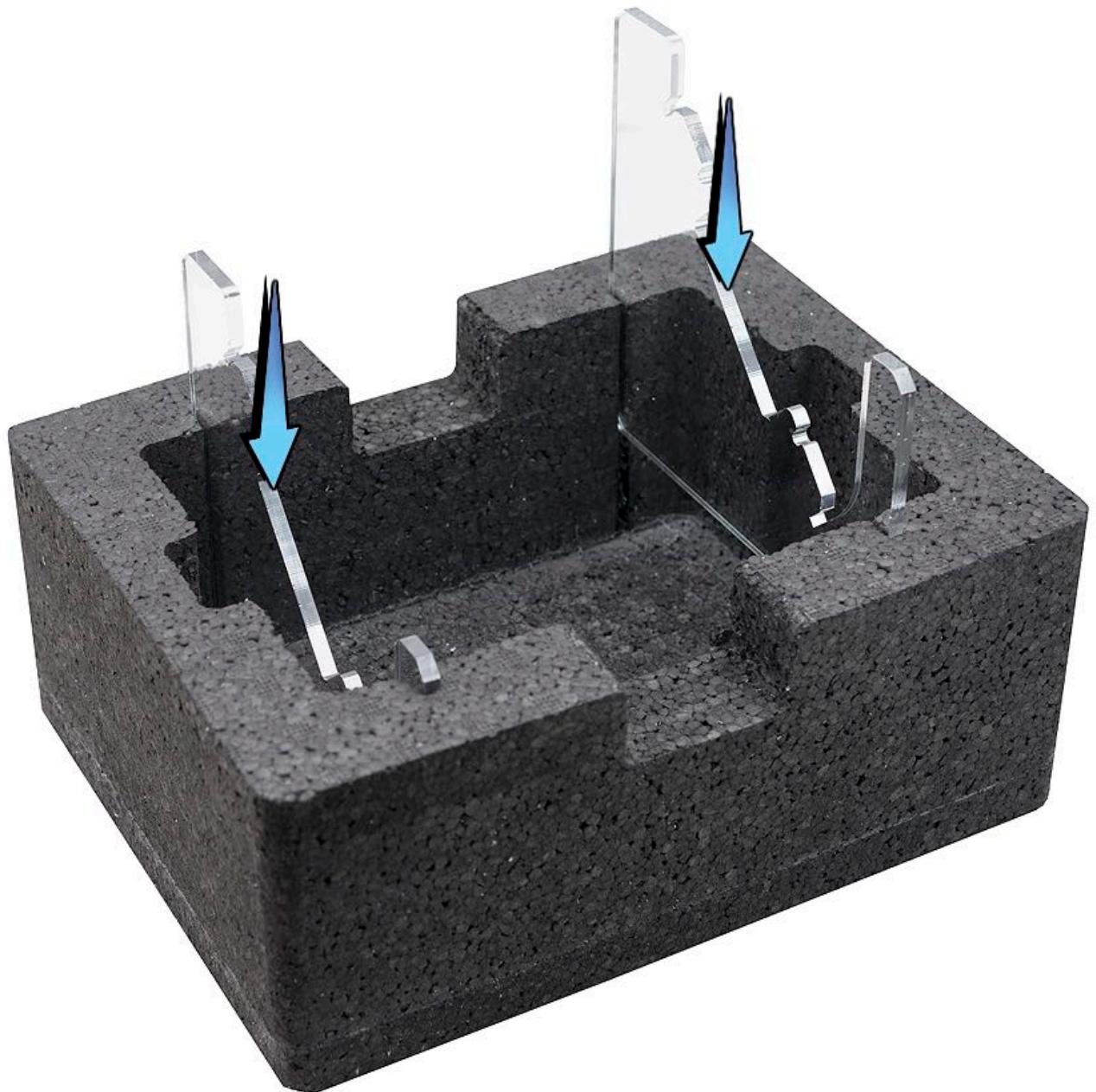


## Tools

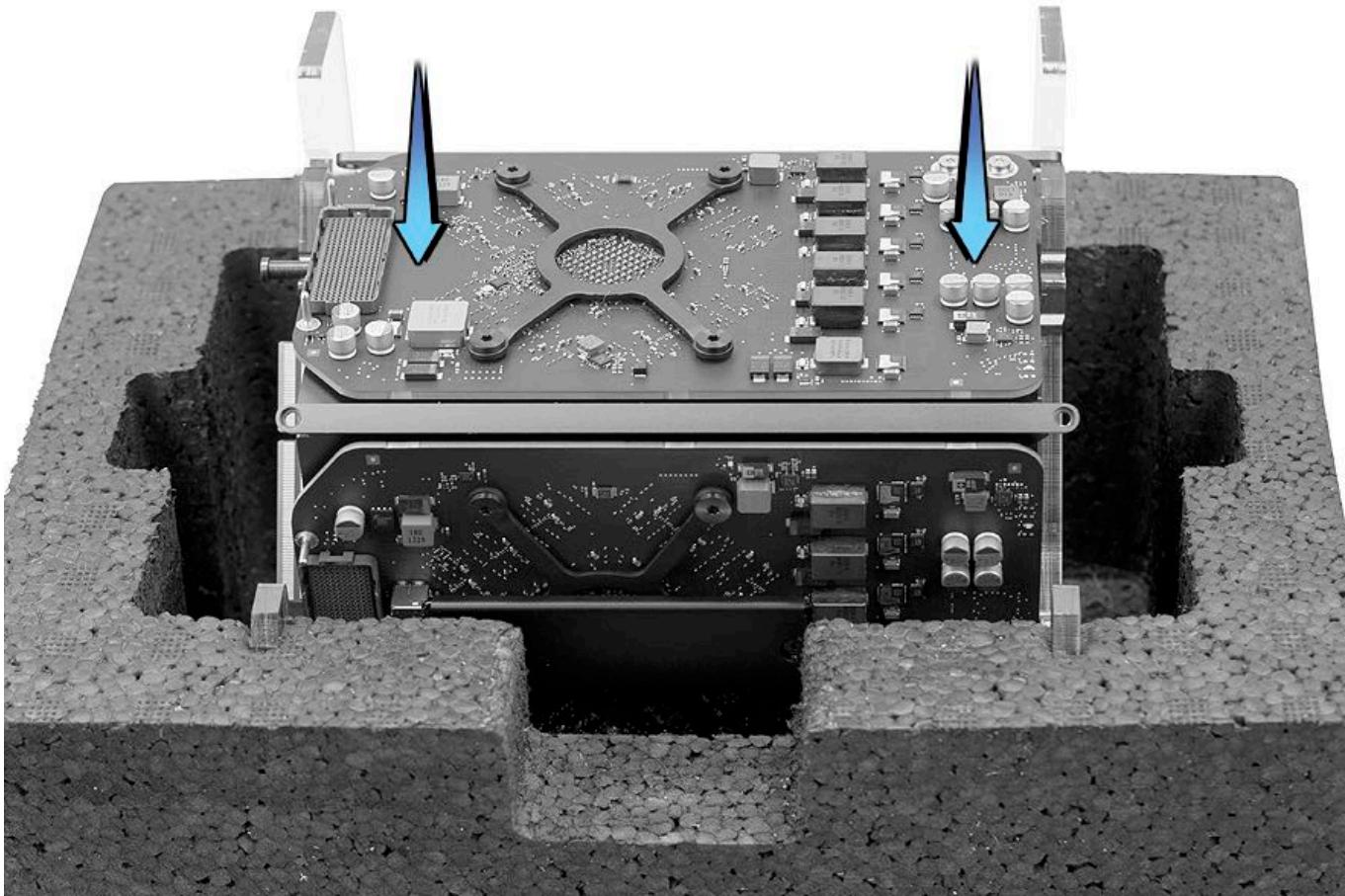
- ESD wrist strap
- Torque driver, adjustable, 923-0735
- Torx T8 security bit, 923-0734
- Torx T10 (50 mm) bit, 923-0740
- Core cradle
- Core end caps
- GPU grease stencil
- Thermal grease (**Note:** The thermal compound that ships with the graphics board is the same as thermal compound 922-7144.)
- Isopropyl alcohol (IPA) wipes
- Access card tool
- Nut setter bit, 923-00320

## Steps For Removal

1. Insert two core end caps into core cradle.



2. Place core assembly into core cradle so graphics board faces up.



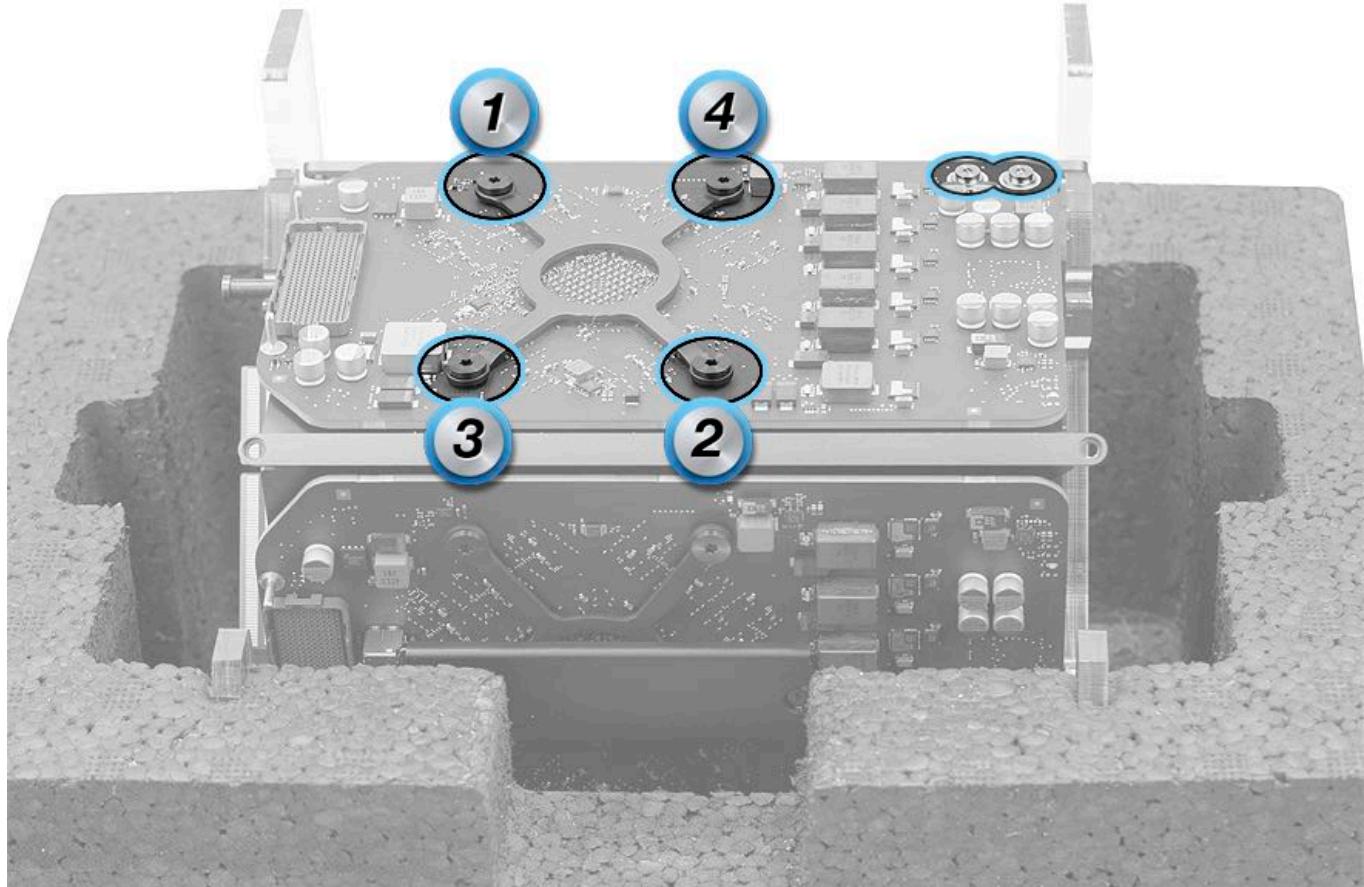
3. Using torque driver with T8 security bit, remove two T8 bus bar screws (923-0716) from graphics board.



4. Using torque driver with T10 bit, remove four T10 screws (923-0708) in the order shown. Remove the leaf spring and set it aside.



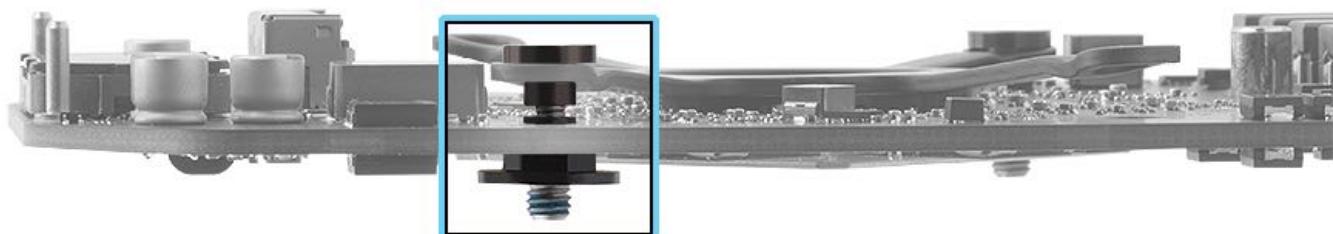
**Important:** If one or more screws spin freely and can't be removed, try removing another screw until all four screws are loose. Then, carefully remove the graphics board. Check for standoff(s) attached to the screws on the underside of the board. If standoff(s) are present, the standoff(s) pulled away from the core, and the graphics board must be repaired by Apple. Do not attempt to remove the standoff(s). Refer to the graphics board return instructions in step 9.



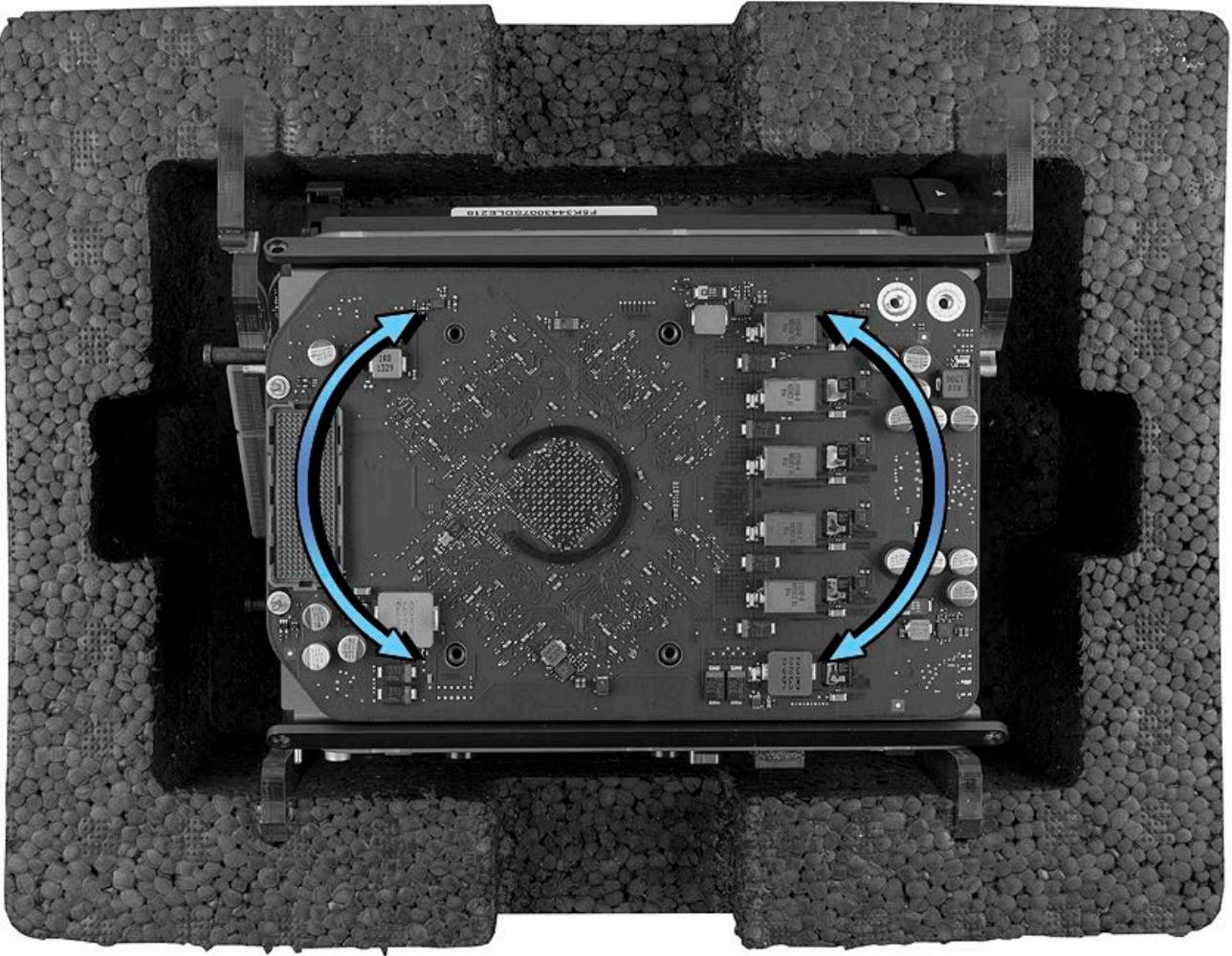
Graphics board standoff



Refer to step 9 if a standoff is attached to the underside of the board as shown.



5. Gently shift graphics board back and forth a short distance to loosen thermal grease and thermal pads.

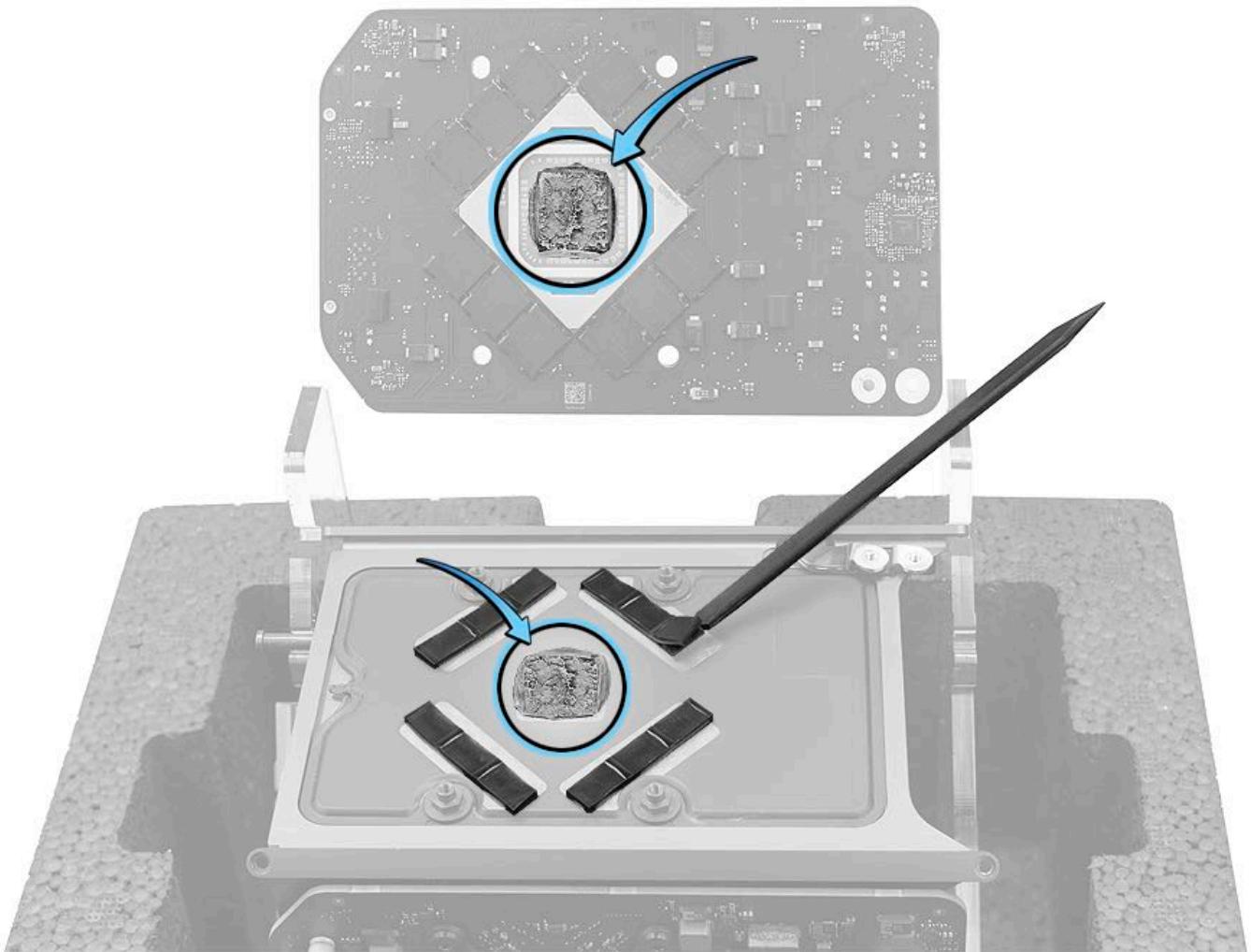


6. Remove graphics board from core assembly.

7. Lift away and discard thermal pads from graphics board and core platform.

**Note:** Graphics boards have four thermal pads covering the four sets of video RAM (VRAM). When a graphics board is removed, pads will stick to either graphics board or core platform. All four thermal pads must be removed and replaced with new ones.

8. Use IPA wipes to clean both the graphics board and the core.



**9. Graphics board return instructions:** If a standoff pulls away from the core, do not attempt to remove the standoff from the underside of the graphics board. Removing the standoff could damage other components on the board. Keep the board and screws intact. Use IPA wipes to clean the graphics board, package the board in an ESD bag, and return the part to Apple. The graphics board must be repaired by Apple.



## Steps For Reassembly

**Note:** If a standoff did not pull away from the core, follow steps 2–14.

1. If a standoff pulls away from the core during a graphics board removal, install a new standoff (923-0690) on the core. Use the torque driver (923-0735) with the nut setter (923-00320) to tighten the standoff to 11.5 inch pounds (in.-lbs.) or 1.2 Newton metres (Nm). The indicated torque value must be used to avoid damaging the unit or causing the unit to malfunction.  
**Note:** If the standoff spins and can not be tightened, the core's thread could be damaged, and the core will need to be replaced.

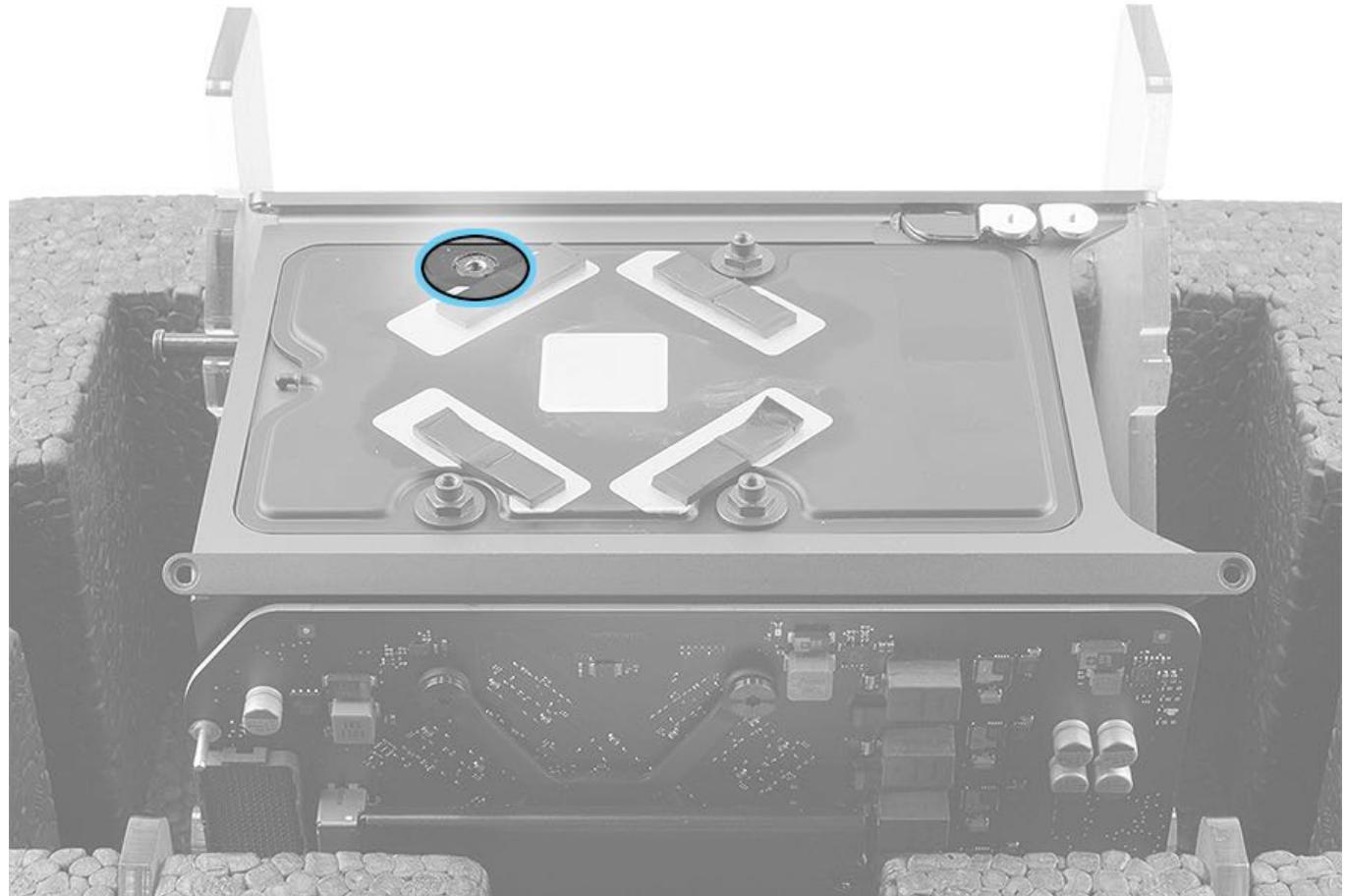
Torque driver and nut setter



Graphics core standoff

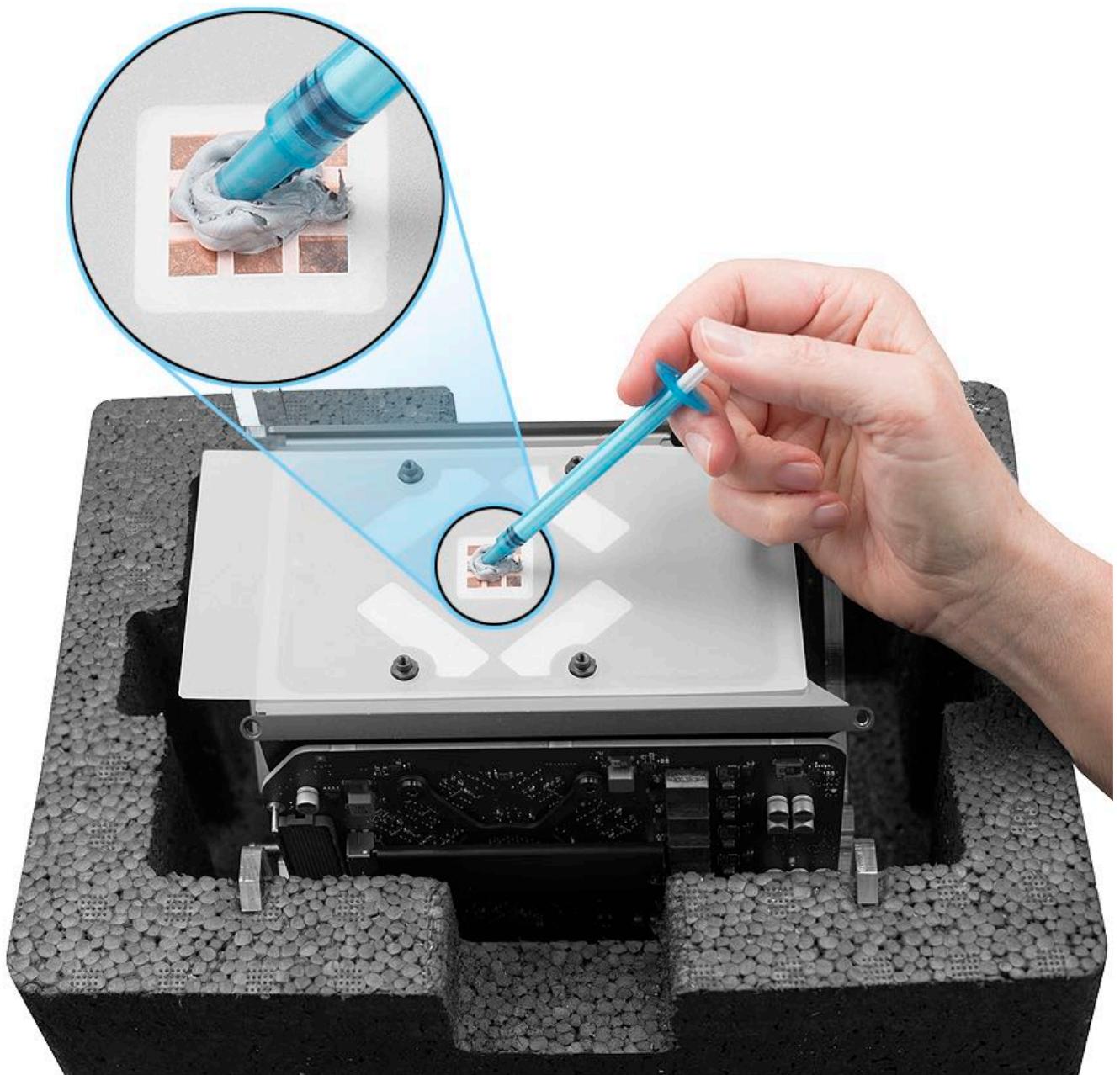


Core with missing standoff

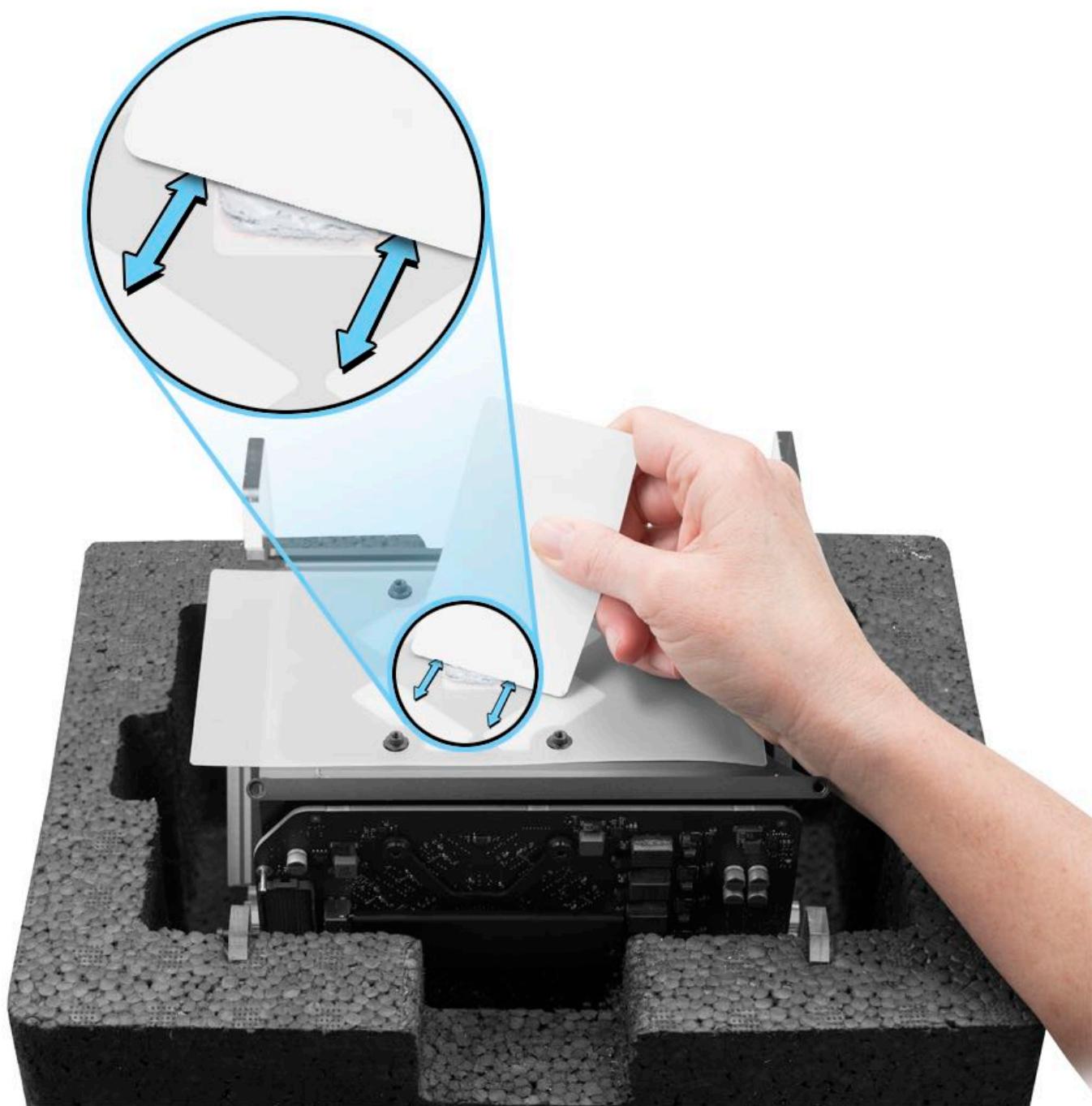


**Note:** If other repairs were performed, check that two bus bars are present.

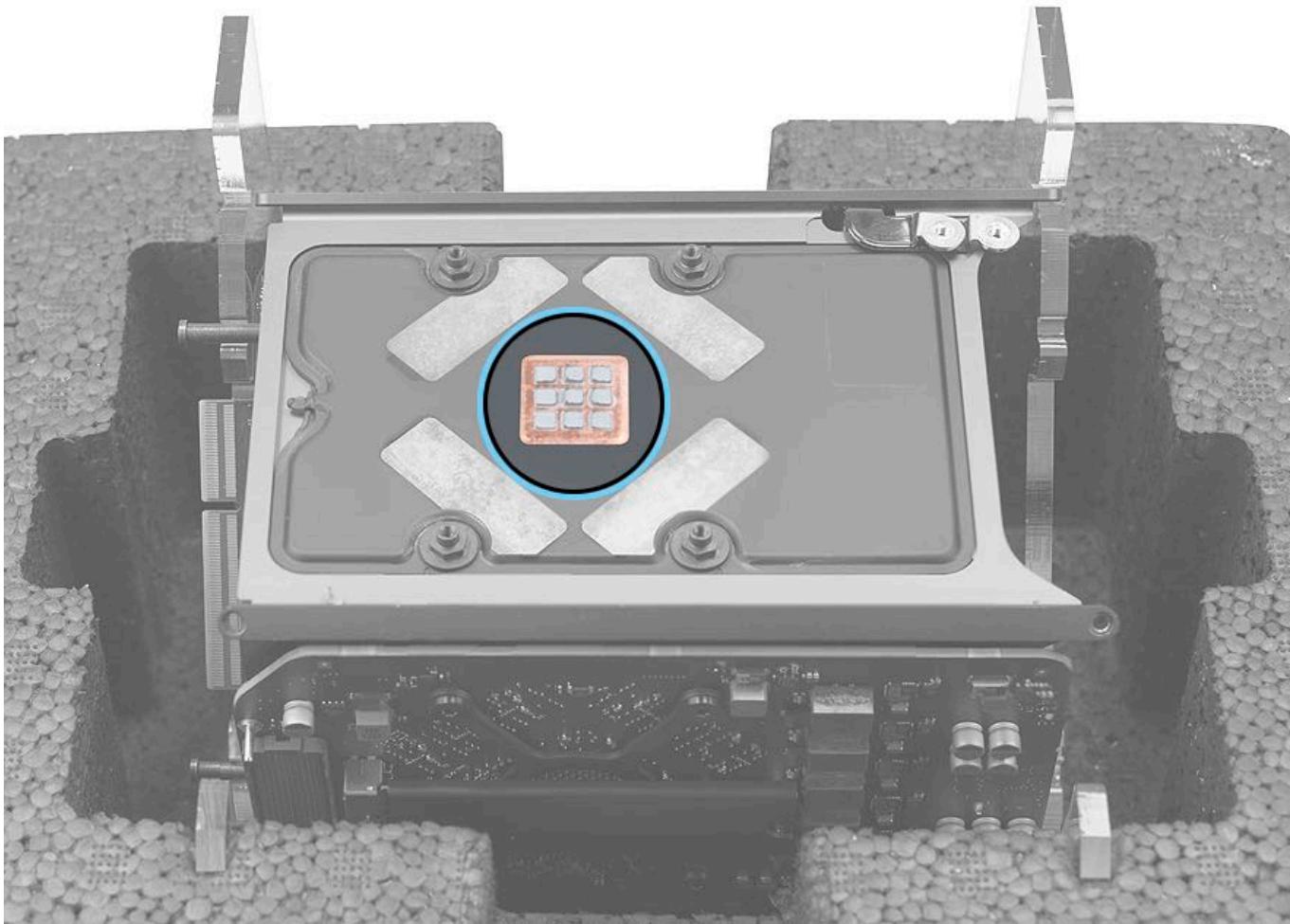
2. Place GPU grease stencil over cleaned core platform and under bus bars.
3. Apply a full syringe of thermal grease to center of GPU grease stencil. (**Note:** The thermal compound that ships with the graphics board is the same as thermal compound 922-7144.)



4. Use flat end of access card tool to evenly spread thermal grease until all stencil squares are covered.



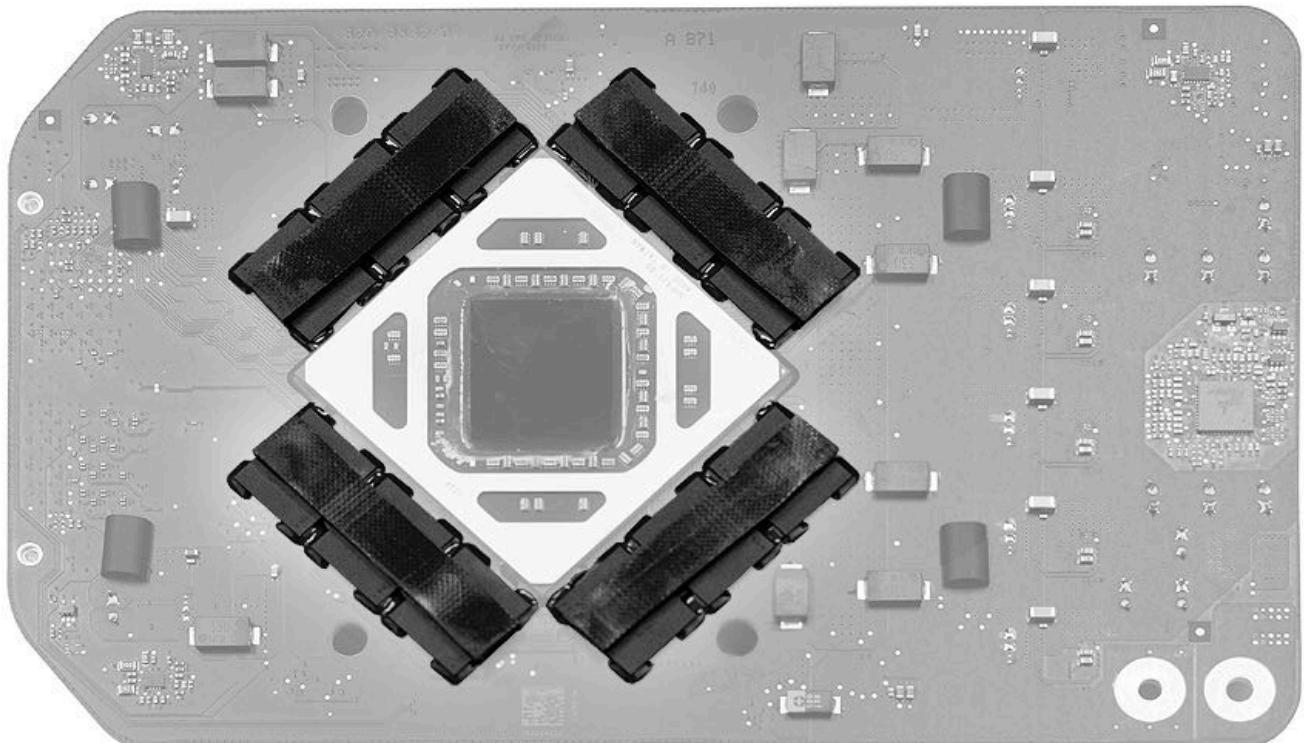
5. Remove GPU grease stencil.



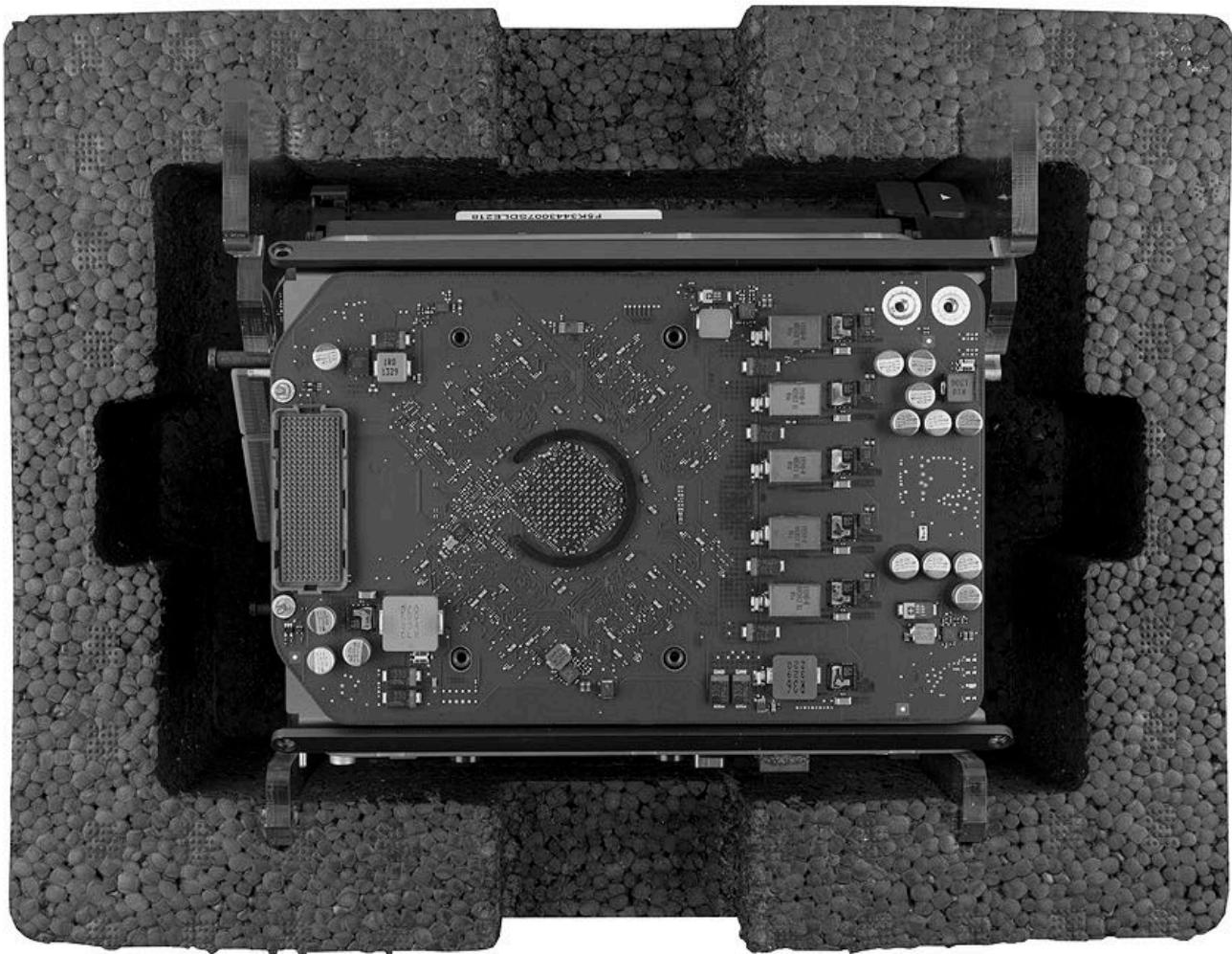
6. Adhere smooth side of four new thermal pads over VRAM on graphics board. Ensure that pads are centered on chips and adhere completely.

**Note:** Thermal pads are included with the new graphics boards and offered separately. Each set of thermal pads is matched to the appropriate graphics board (one set for FirePro D300 and another set for FirePro D500 and D700).

- 923-00323 Pads, Thermal, FirePro, D300, pack of 4
- 923-00324 Pads, Thermal, FirePro, D500/D700, pack of 4



7. Keep graphics board level while carefully aligning it over four screw standoffs.

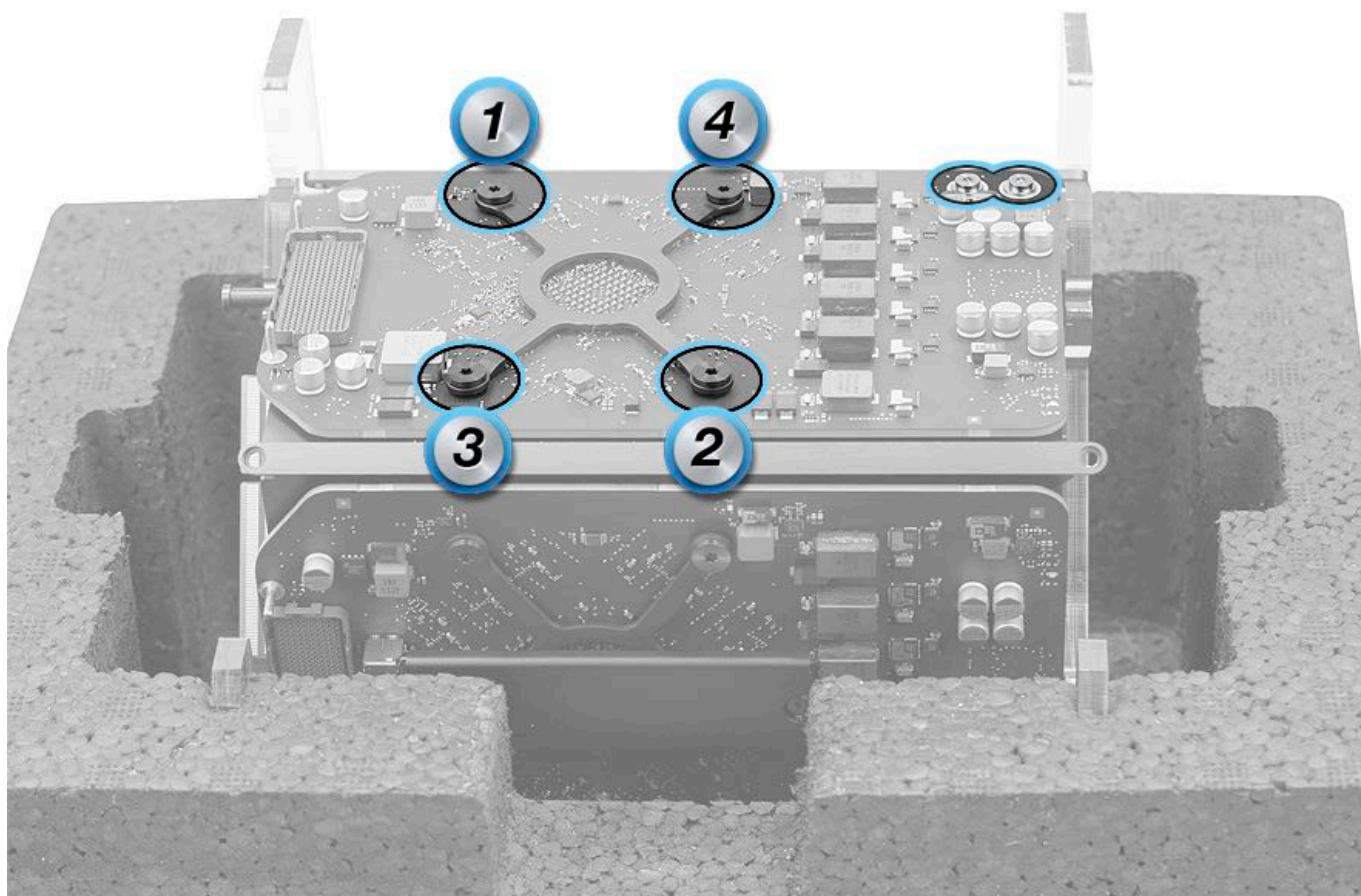


8. Notice shape of leaf spring.

9. Place leaf spring on graphics board with corners angled up.



10. Using torque driver with T10 bit, install four T10 screws (923-0708) in the order shown, with three turns per screw, before moving to next screw. Repeat the pattern until all screws are tightened to 10.5 inch pounds (in.-lbs.) or 1.2 Newton metres (Nm). **Note:** The indicated torque value must be used to avoid damaging the unit or causing the unit to malfunction.



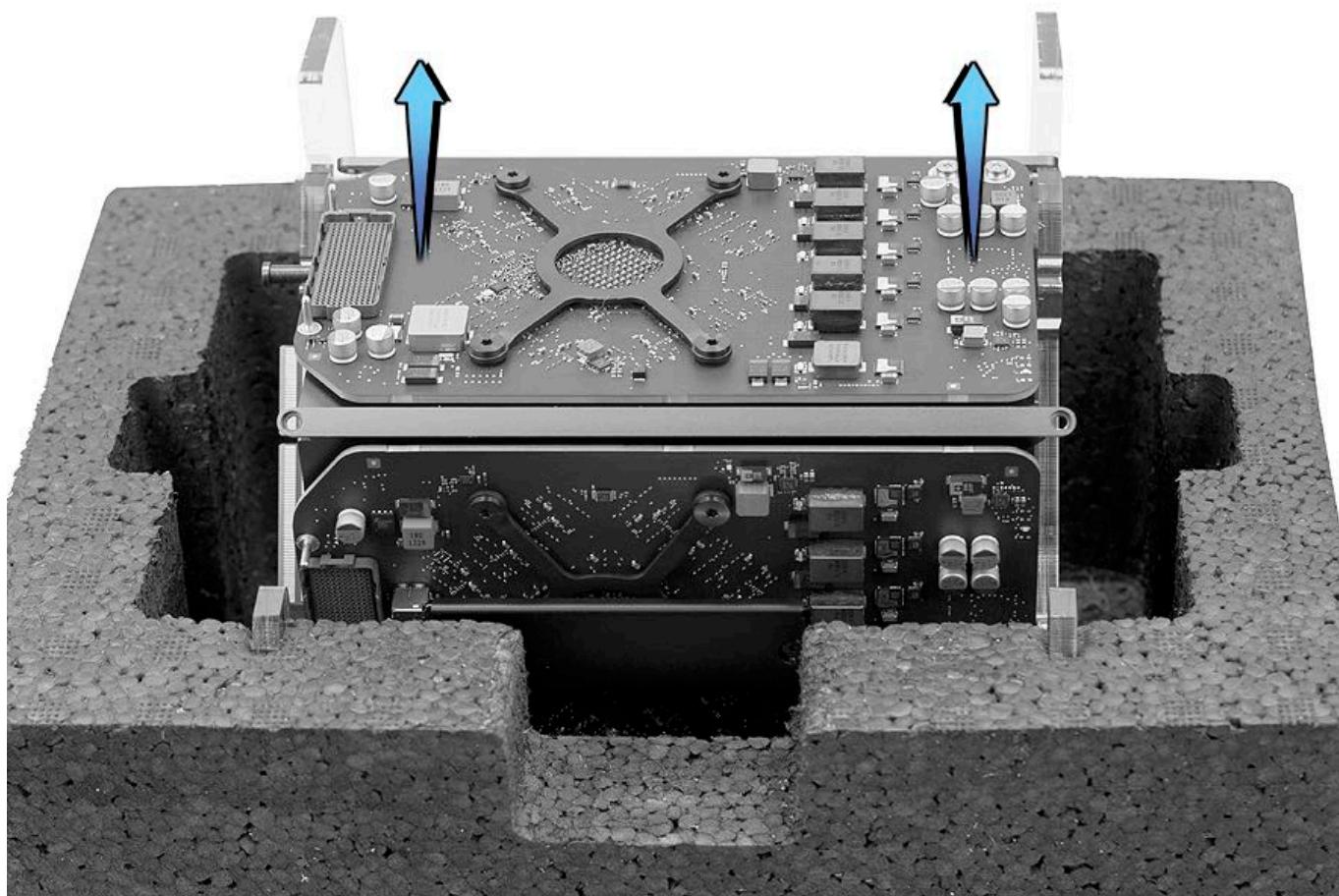
11. Place flat end of a black stick under bus bars to steady them.

12. Using torque driver with T8 security bit, install two T8 bus bar screws (923-0716). Tighten bus bar screws to torque value of 10.5 inch pounds (in.-lbs.) or 1.2 Newton metres (Nm).

**Note:** The indicated torque value must be used to avoid damaging the unit or causing the unit to malfunction.



13. Remove core assembly from core cradle.



14. After reassembling computer, run Cooling System Diagnostic (CSD). For more information, refer to article [TP578: AST Reference Guide: Cooling System Diagnostic \(Standard and Extended\)](#).

15. The EFI version may need to be updated after the repair is complete.

The graphics cards listed below require EFI version MP61.0116.B11 or later.

- 661-7531: Board, Graphics A, 3GB VRAM (EEEE GN03)
- 661-7548: Board, Graphics B, 3GB VRAM (EEEE GN04)

The graphics cards listed below require EFI version MP61.0116.B21 or later:

- 661-7531: Board, Graphics A, 3GB VRAM (EEEE HQDH)
- 661-7532: Board, Graphics A, 6GB VRAM (EEEE HQDK)
- 661-7533: Board, Graphics A, 2GB VRAM (EEEE HQDM)
- 661-7547: Board, Graphics B, 6GB VRAM (EEEE HQDL)
- 661-7548: Board, Graphics B, 3GB VRAM (EEEE HQDJ)
- 661-7549: Board, Graphics B, 2GB VRAM (EEEE HQDN)

Update the macOS to the required EFI level through AST1.

# Bus Bars A and B

## First Steps

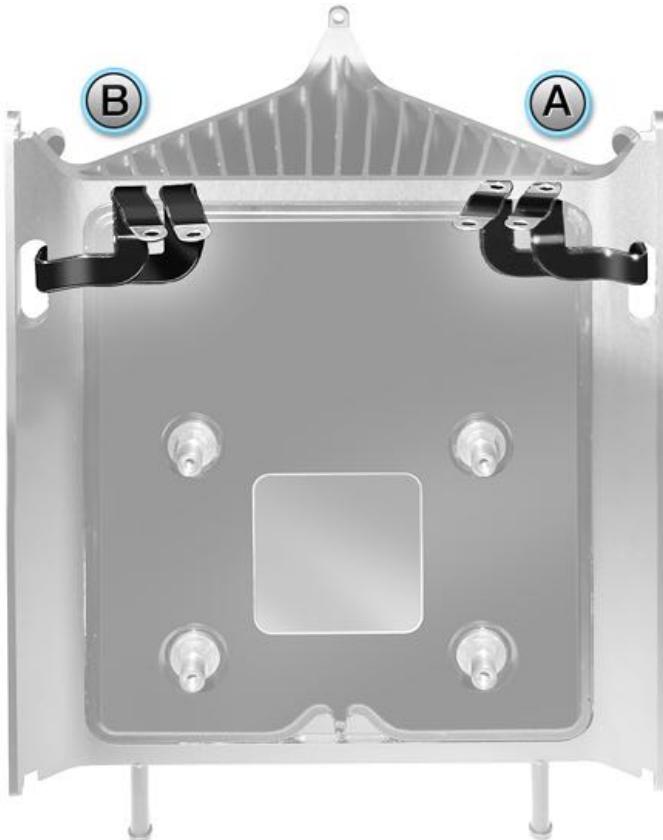
**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Memory DIMM](#)
- [Exhaust Assembly](#)
- [I/O and Power Supply Assembly](#)
- [Inlet](#)
- [Logic Board](#)
- [Graphics Boards](#)
- [CPU Riser Card](#)

**Warning:** Hazardous energy exists if the safety interlock circuit is defeated. To prevent injury, avoid contact with the bus bars (shown below) when the computer is plugged in, powered on, and the safety interlock is defeated with a magnet. The bus bars, located at the top of the main boards, have enough energy to cause a burn if they are bridged with metal (ring, jewelry, etc.).

For more information on the safety interlock circuit, refer to the topic, "Using Diagnostic LEDs for Troubleshooting" in article [TP1087: Diagnostics LEDs and Test Points](#).



## Tools

- ESD wrist strap

## Steps For Removal

Rotate the bus bar as shown and maneuver it out of the slot in the thermal core.



### Steps For Reassembly

**Reassembly Note:** Make sure bus bars are positioned as shown.



# CPU Riser Card

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

For video instruction, refer to Apple Support article [SV223: CPU Riser Card Replacement Video](#).

Remove:

- [Housing](#)
- [Memory DIMMs](#)
- [Exhaust Assembly](#)
- [I/O and Power Supply Assembly](#)
- [Inlet](#)
- [Logic Board](#)

**Note:** Replacement CPU riser cards include attached DIMM mechanisms.



## Tools



- ESD wrist strap
- Torque driver (923-0735)
- Torx T8 security bit (923-0734)
- Torx T10 (50 mm) bit (923-0740)
- Core cradle
- CPU riser spring press
- CPU riser cover
- CPU grease stencil
- Access card tool
- Thermal grease (**Note:** The thermal compound that ships with the cpu riser card is the same as thermal compound 922-7144.)
- Isopropyl alcohol (IPA) wipes
- Nut setter bit (923-00320) (not pictured)

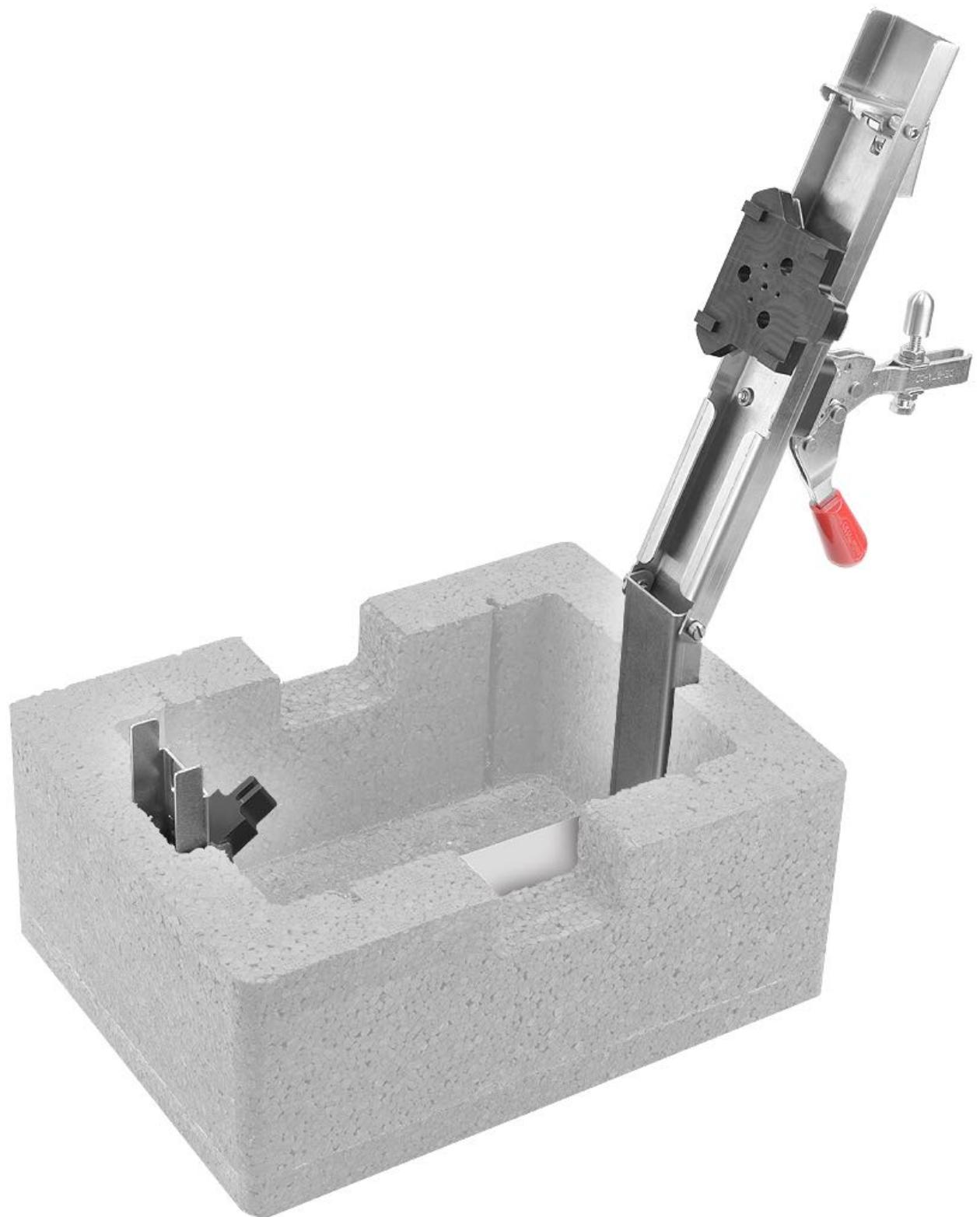
## Steps For Removal

1. Using torque driver with T8 security bit (923-0734), remove two T8 bus bar screws (923-0712) from lower corner of CPU riser card.

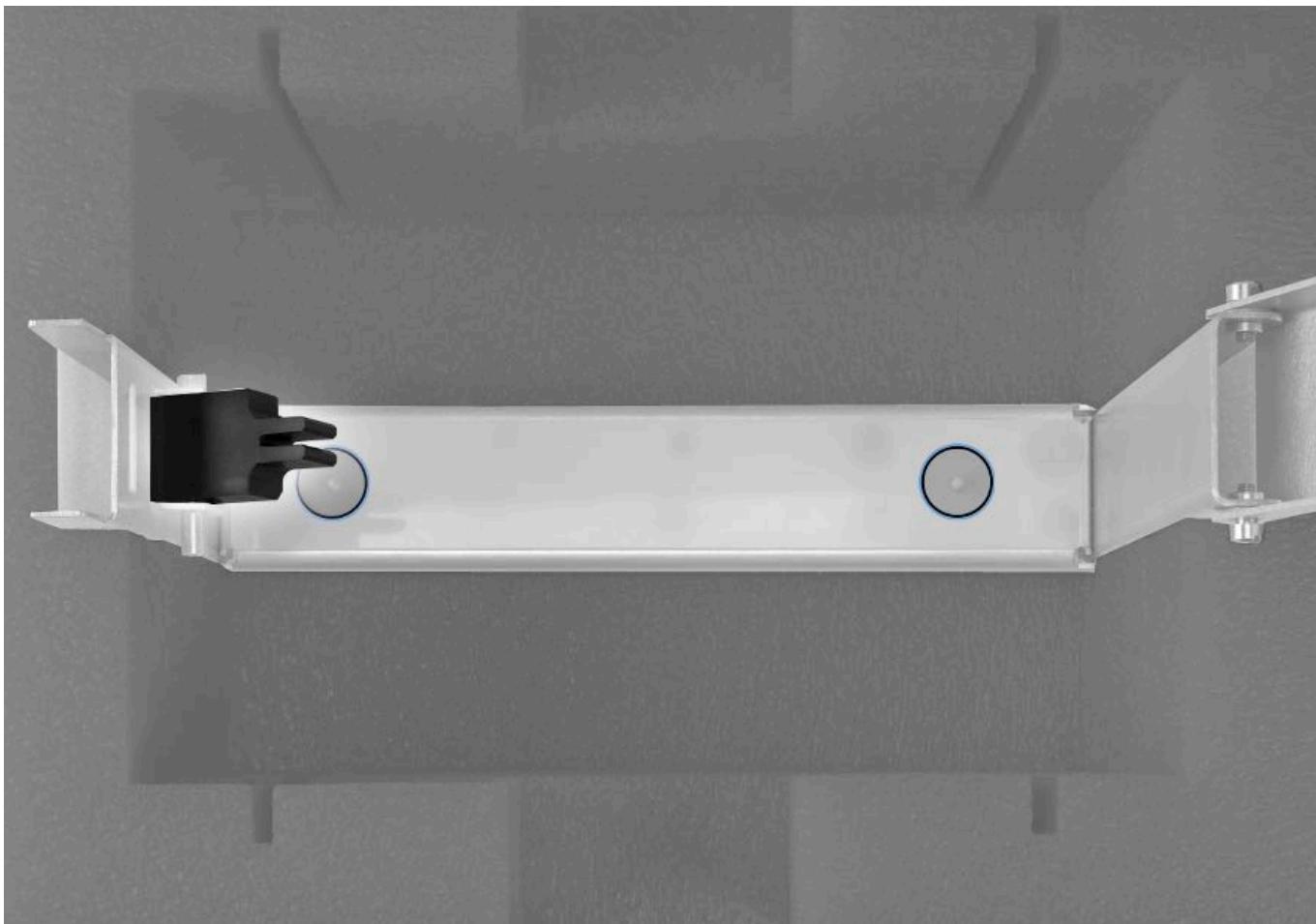




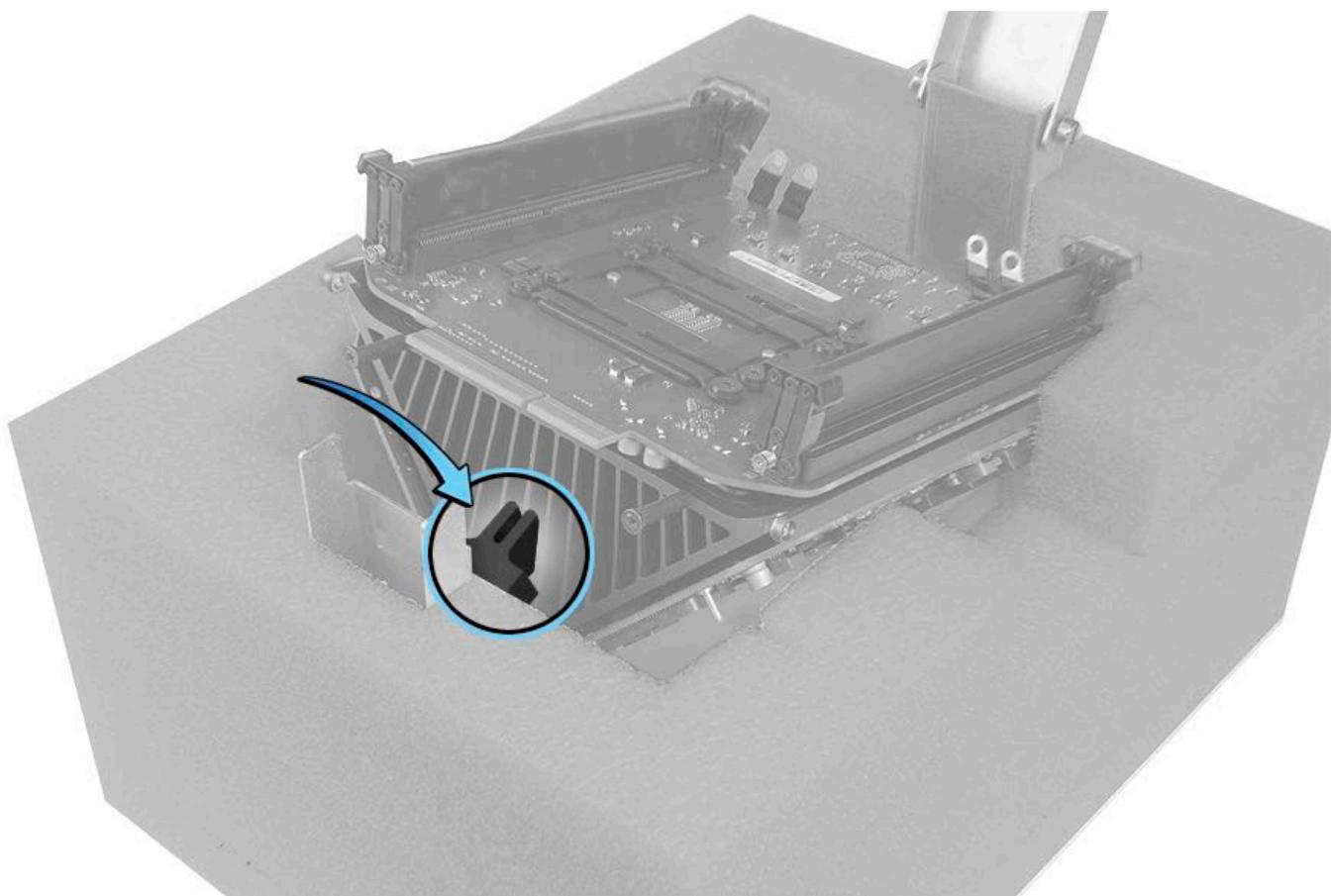
2. Place CPU riser spring press into core cradle.



3. Note two pins inside base of core cradle. Refer to next step for how to use pins.

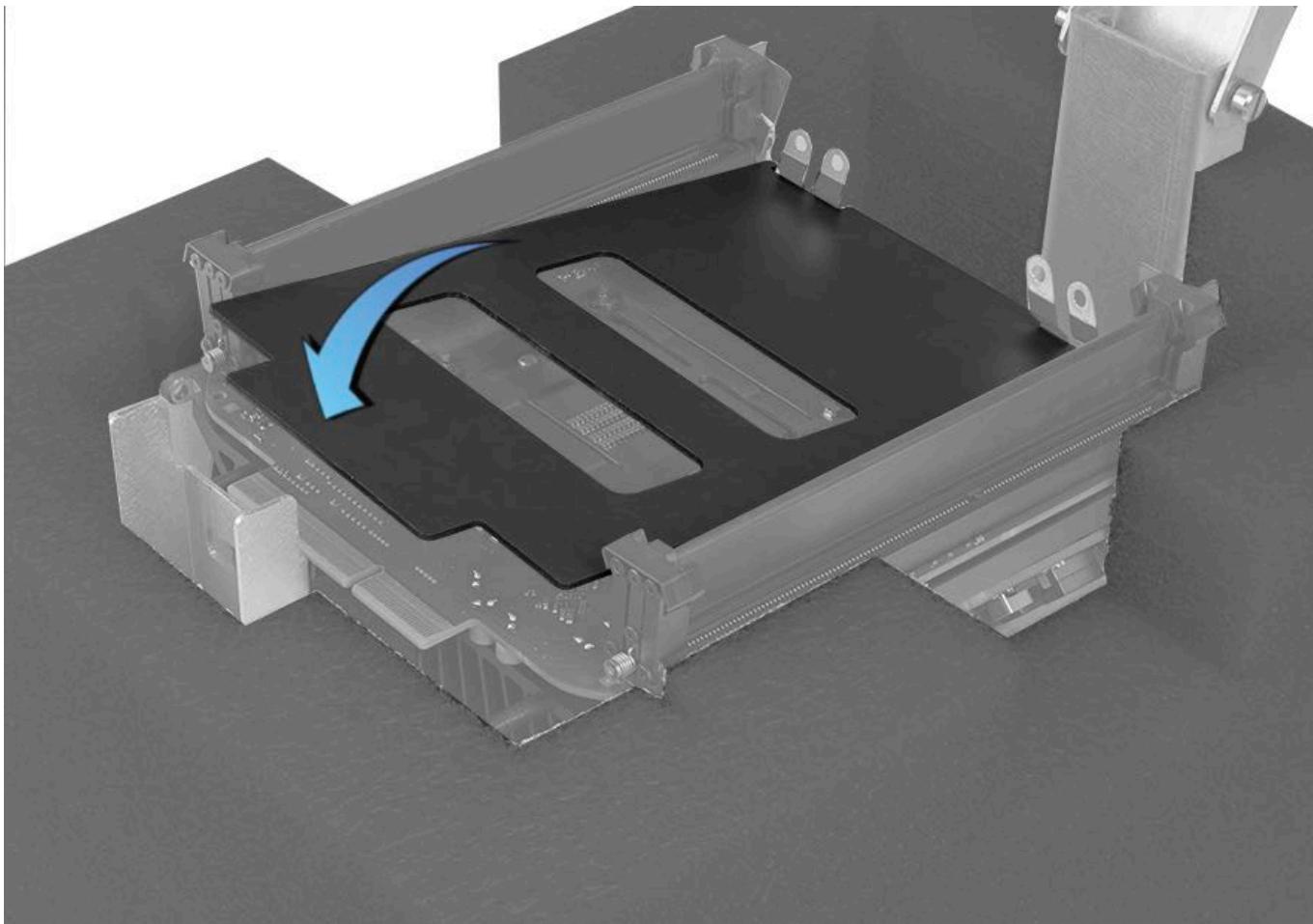


4. Place core assembly into core cradle so that core support wedge catches center fin of core. Then lower core assembly to ensure that holes at pointed end of core assembly fit over two pins in core cradle.

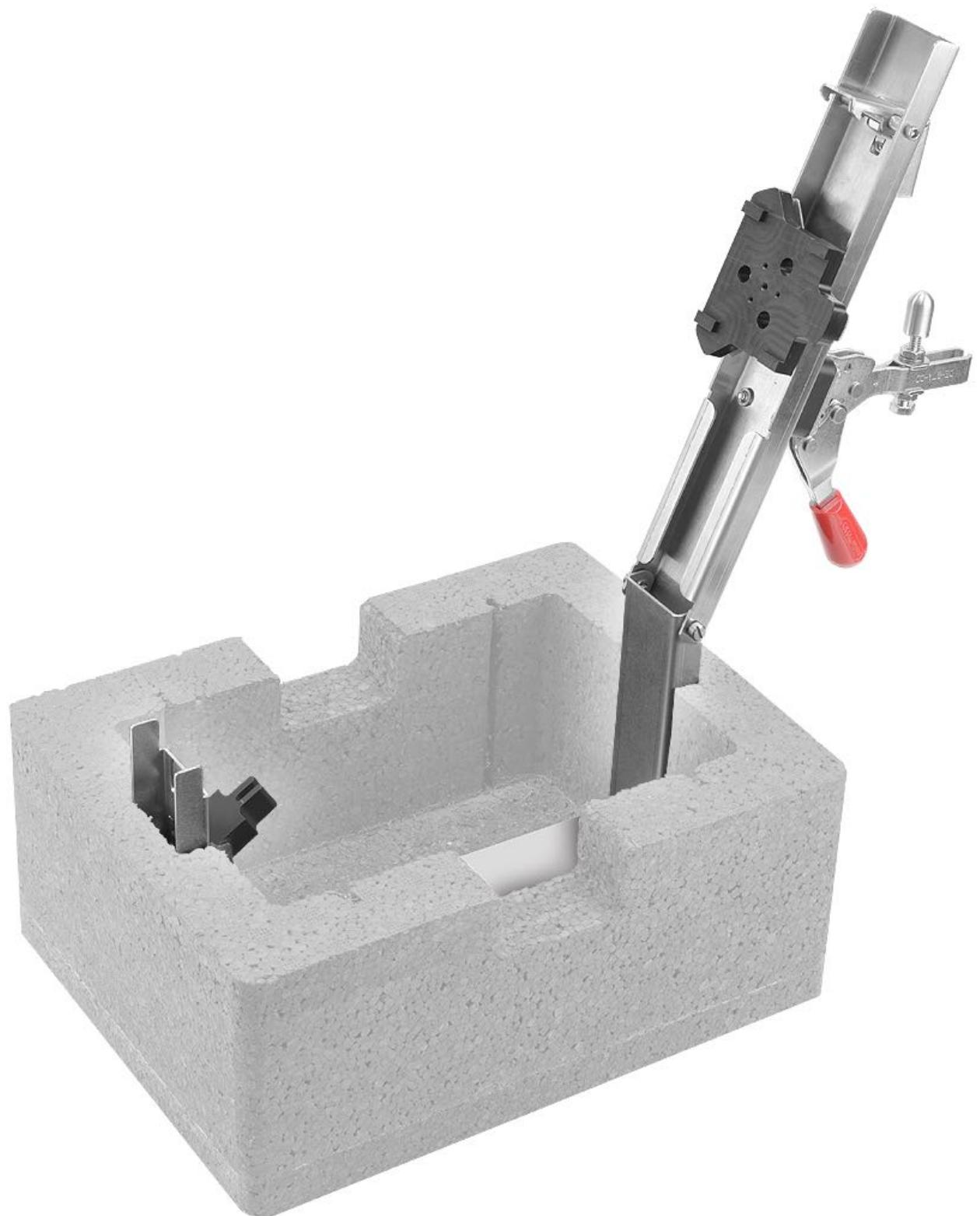


5. Ensure that DIMM mechanisms are in the open position.

6. Place CPU riser cover against bus bars and lower it onto CPU riser card.

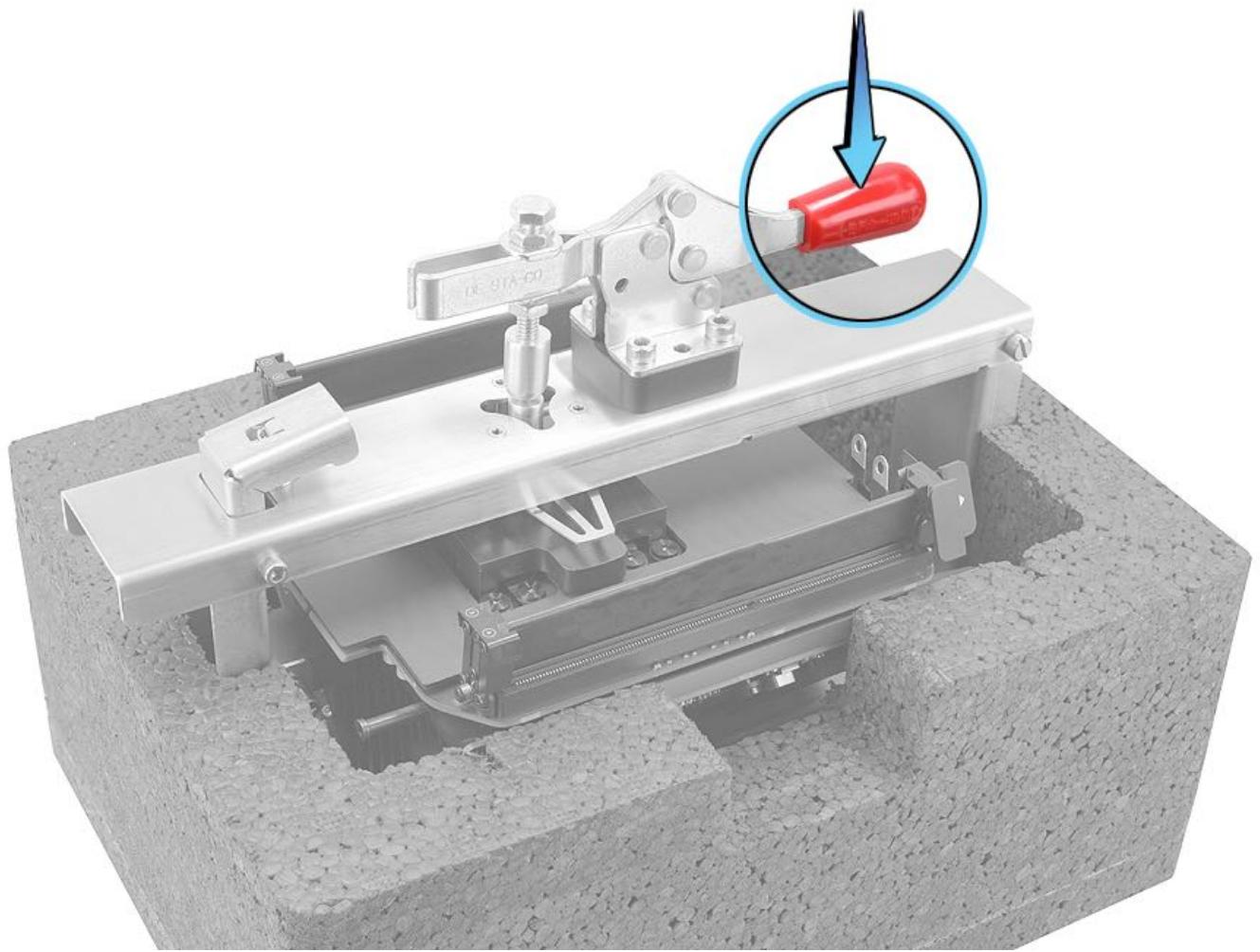


7. Ensure that the red spring press handle is the release position as shown.



8. Lower the metal bar and spring press handle onto the CPU riser card. Press down on the metal bar to lock the spring press fixture.

9. Press down on the red handle to compress the spring plate on the CPU riser card. Press down on the handle until it's completely depressed.

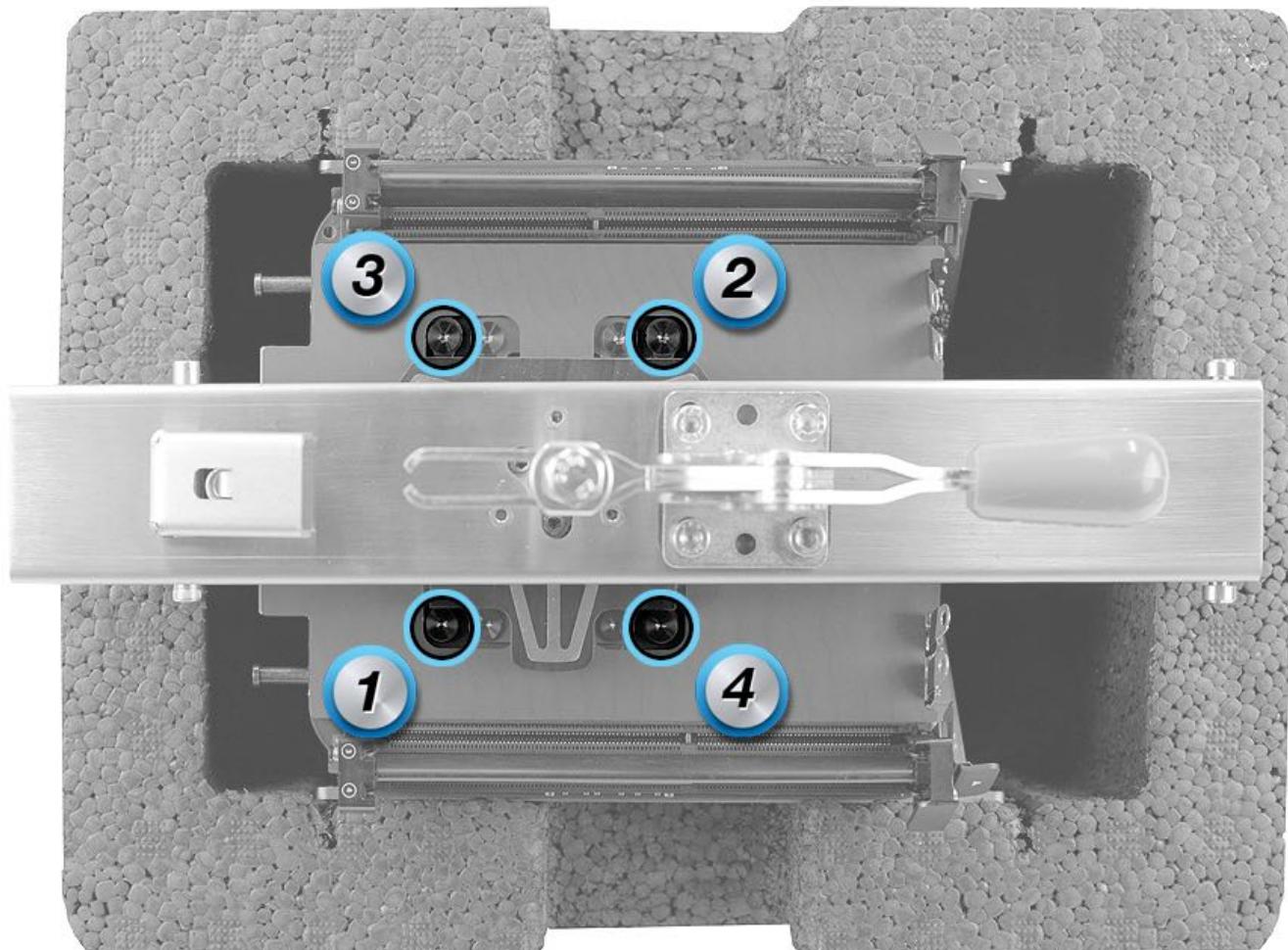


10. Using torque driver with T10 bit (923-0740), remove four T10 CPU leaf spring screws (923-0707) in the order shown.

CPU leaf spring screw



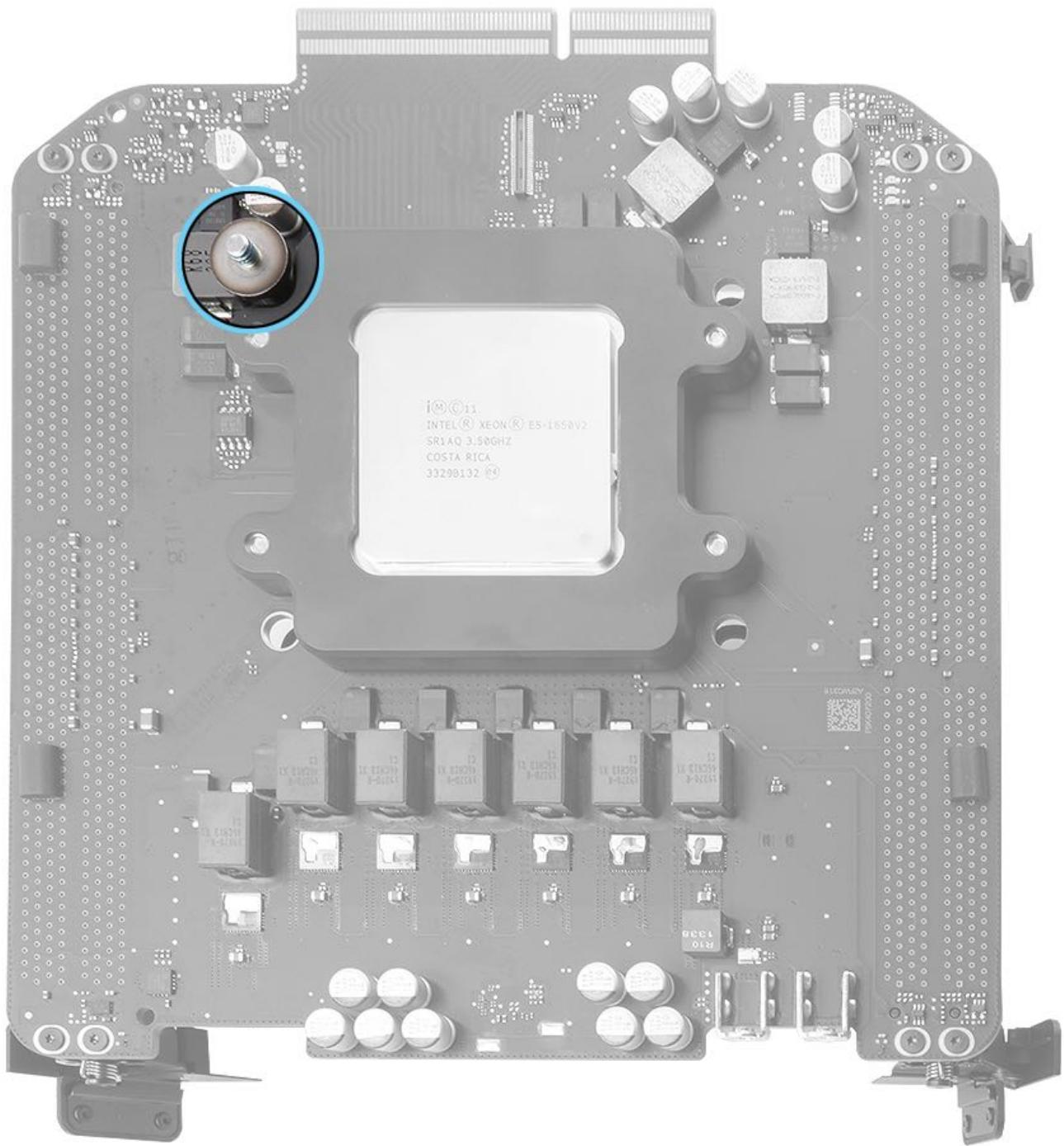
**Important:** If one or more CPU leaf spring screws spin freely and can not be removed, try removing another screw until all four screws are loose. Carefully remove the CPU riser card from the core cradle. Check for standoff(s) attached to the underside of the board. If standoff(s) are present, the standoff(s) pulled away from the core and the CPU riser card must be repaired by Apple. Do not attempt to remove the standoff(s). Refer to the return instructions in step 14.



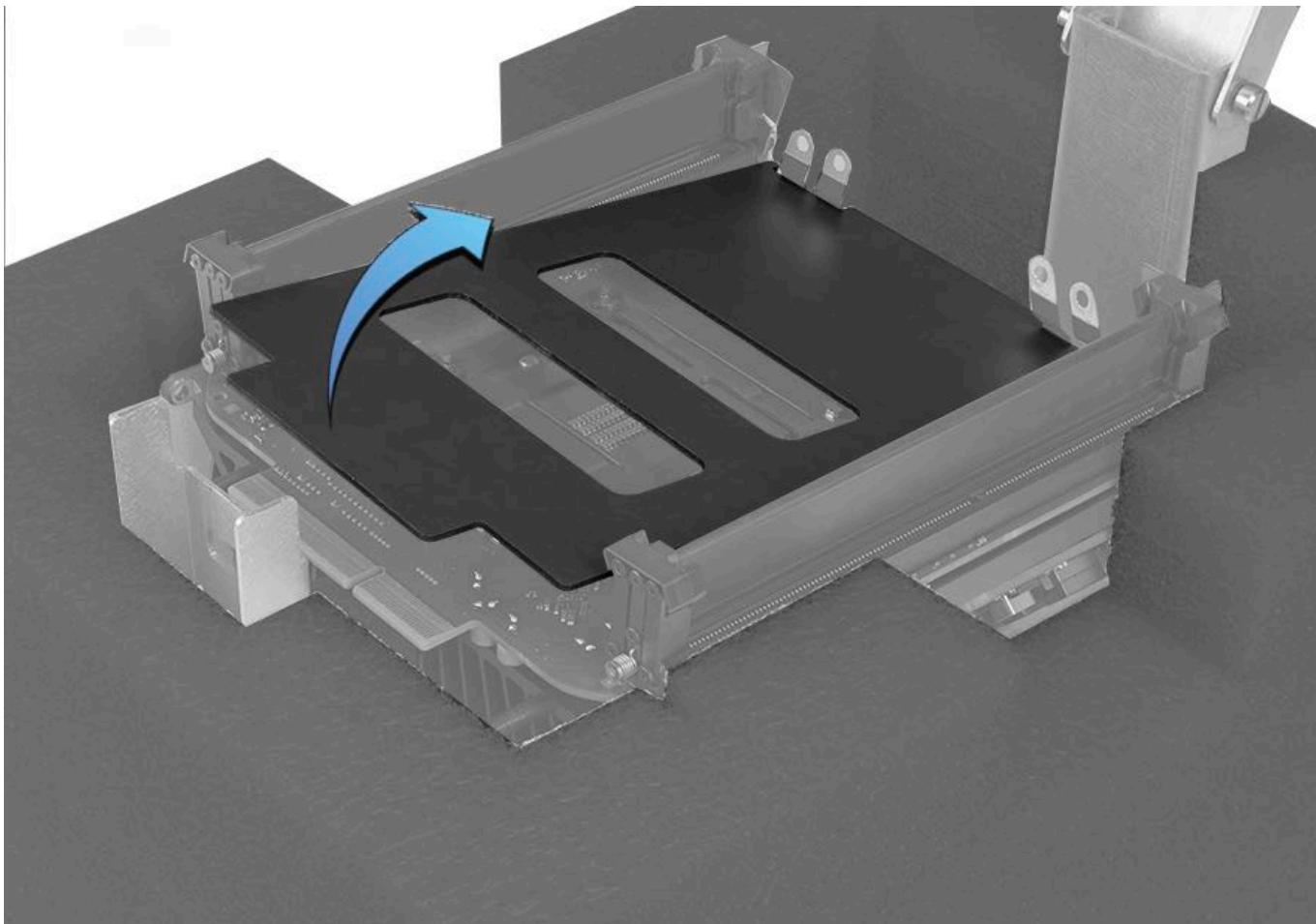
CPU standoff (923-0689)



Refer to step 14 if a standoff is attached to the underside of the board as shown.



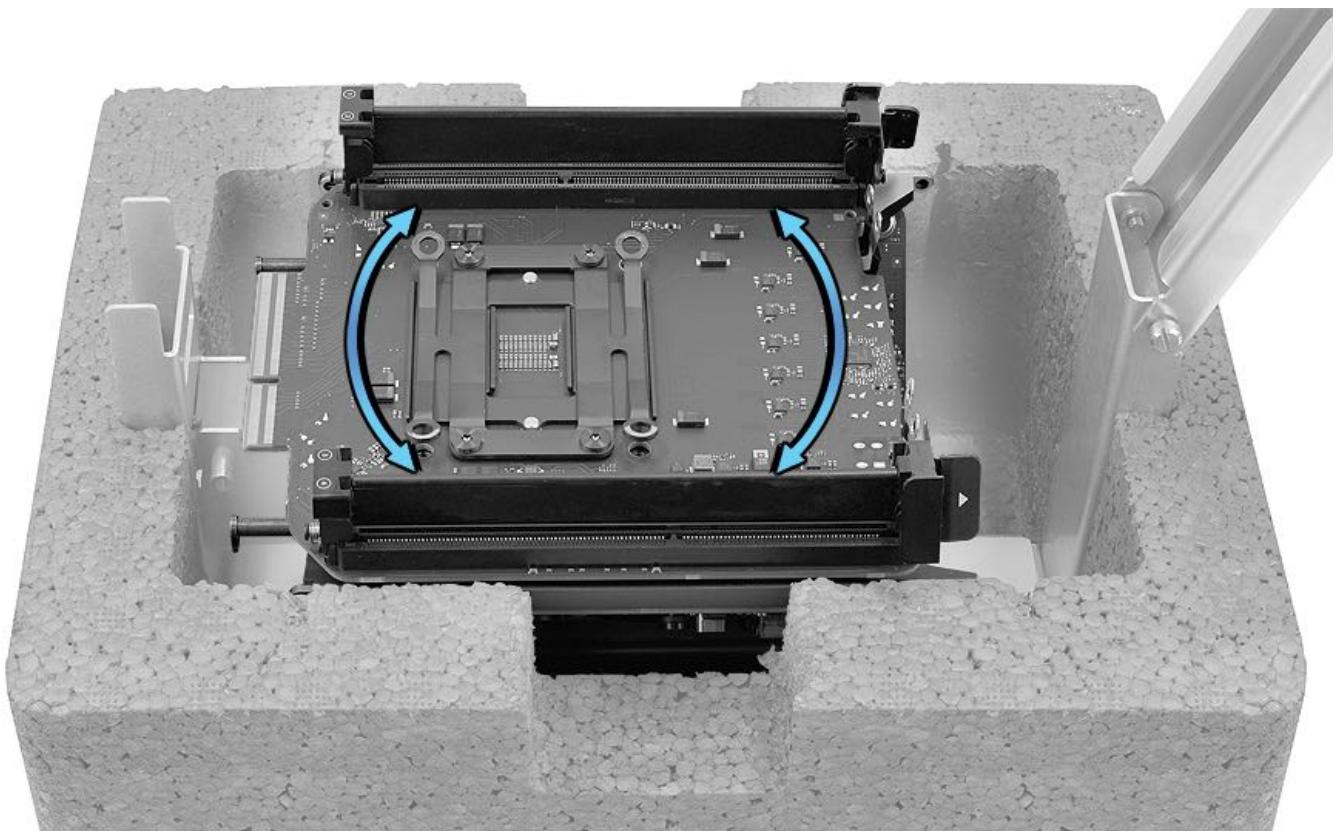
11. Raise the red clamp handle to release the spring press. Remove CPU riser cover.



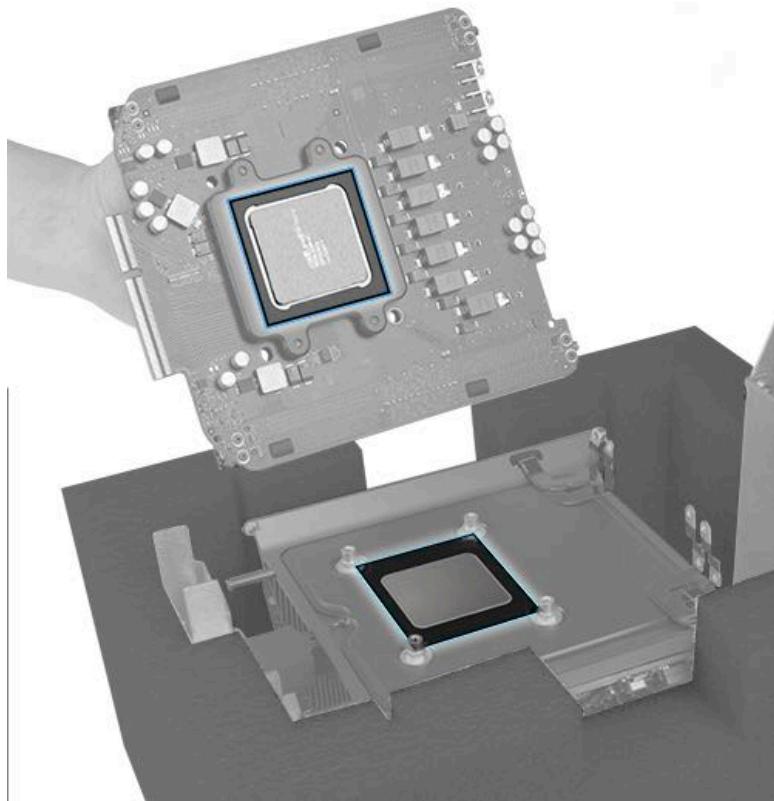
12. Gently shift CPU riser card back and forth a short distance to loosen thermal grease. Then carefully lift card away from core assembly.



**Caution:** Avoid flexing card and do not touch gold connectors on card.



13. Use IPA wipes to clean both the CPU riser card and the core.



14. **Standoff instructions:** If a standoff pulls away from the core, do not attempt to remove the standoff from the underside of the CPU riser card. Removing the standoff could damage other components on the board. Keep the board and screws intact. Use IPA wipes to clean the CPU riser card, package the board in an ESD bag, and return the part to Apple. The CPU riser card must be repaired by Apple.



## Steps For Reassembly

**Note:** If a standoff did not pull away from the core, follow steps 2–14.

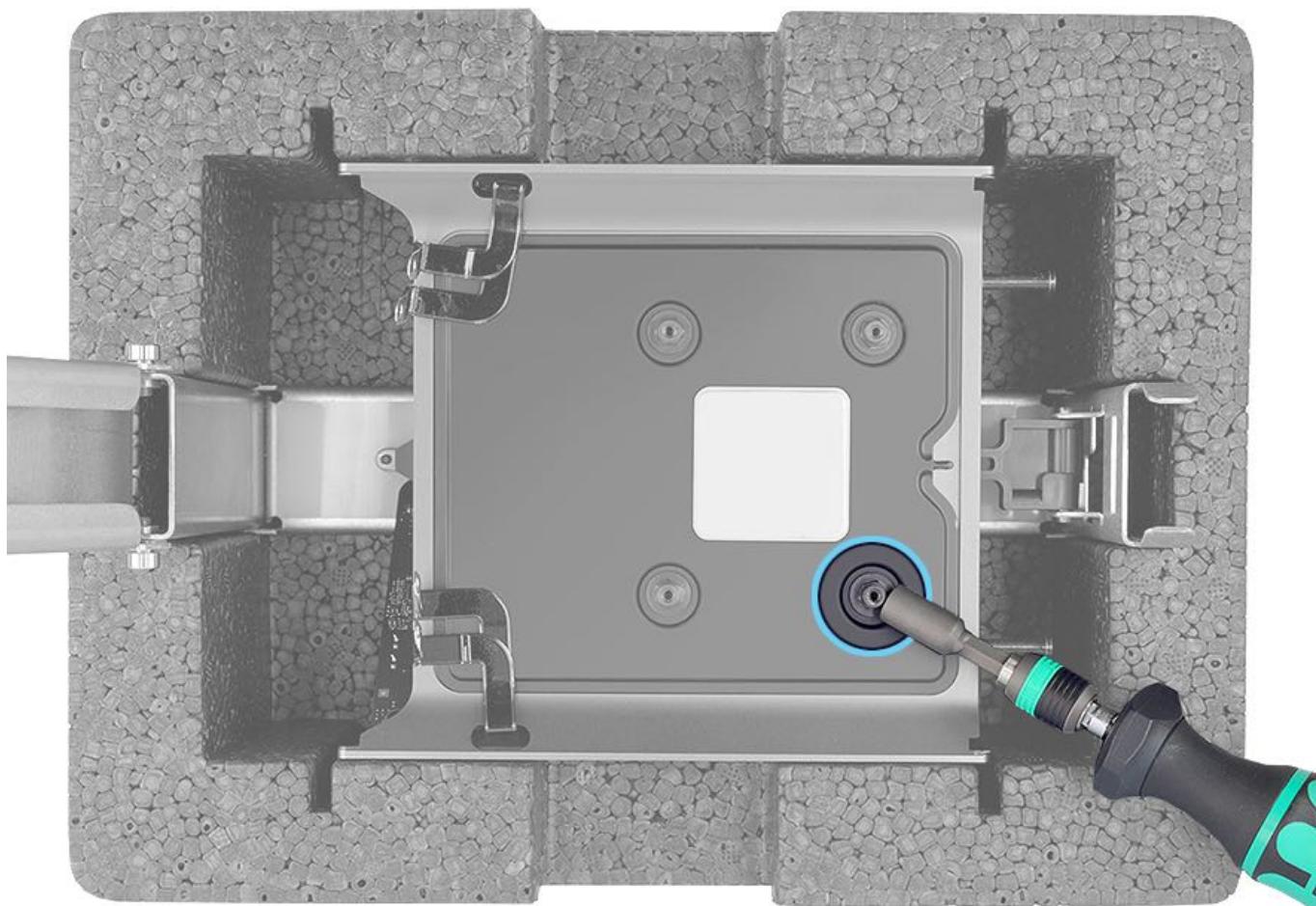
1. If a standoff pulls away from the core during CPU riser card removal, install a new standoff (923-0689) on the core. Use the torque driver (923-0735) with the nut setter (923-00320) to tighten the standoff to 11.5 inch pounds (in.-lbs.) or 1.2 Newton metres (Nm). The indicated torque value must be used to avoid damaging the unit or causing the unit to malfunction.

**Note:** If the standoff can't be tightened, the core's thread could be damaged, and the core will need to be replaced.

Torque driver and nut setter



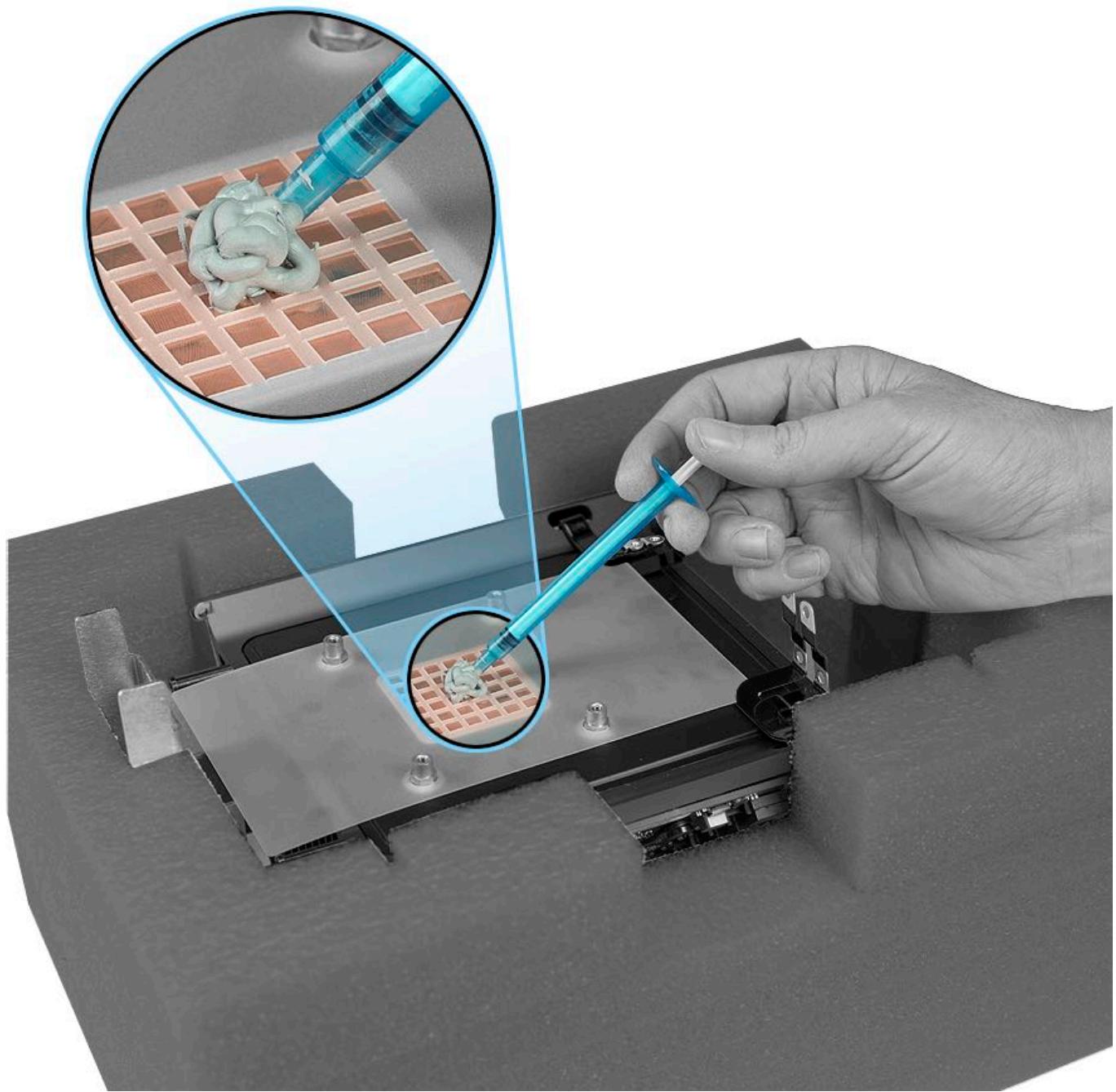
CPU core standoff



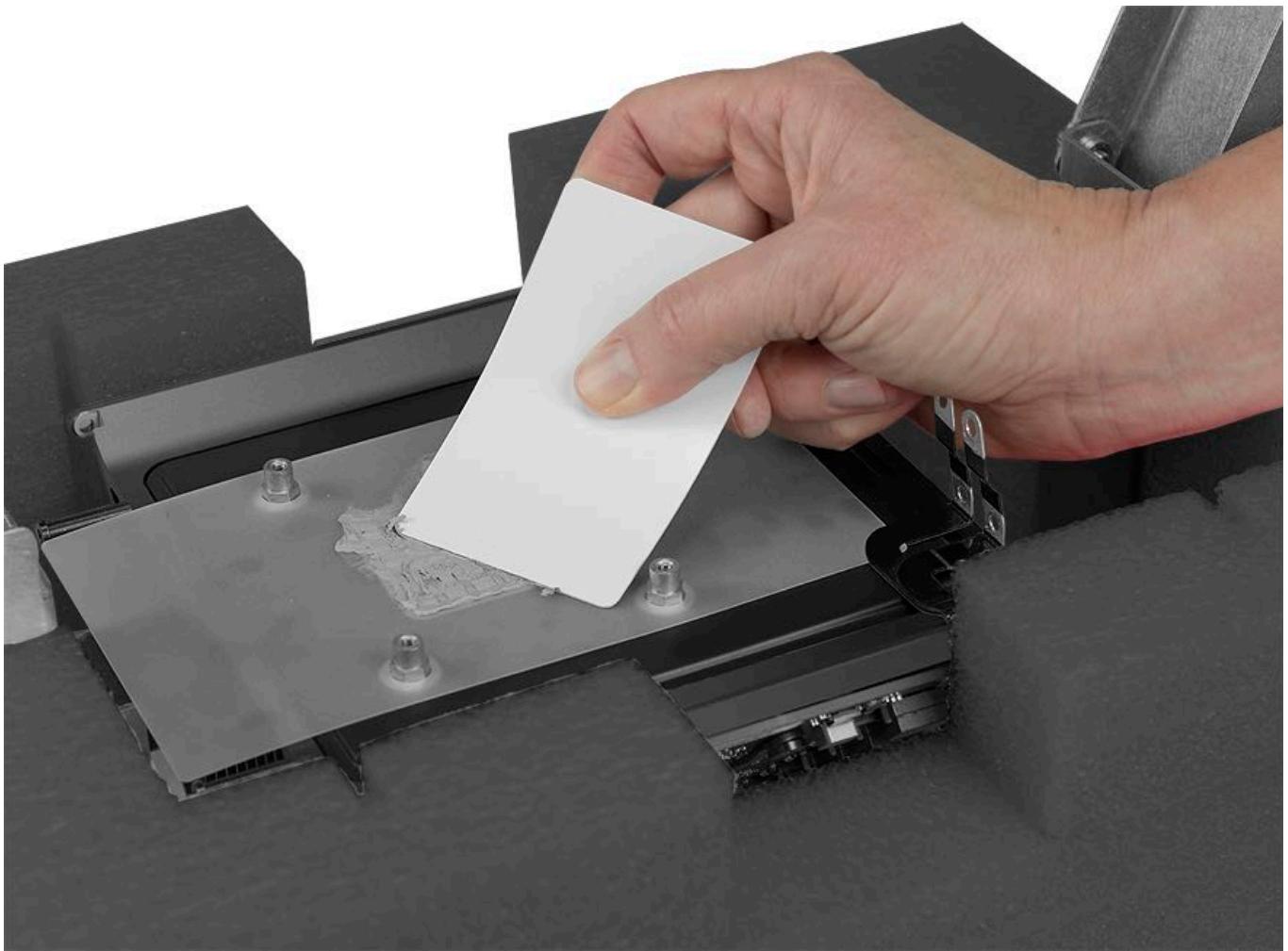
**2. Note:** If other repairs were performed, ensure that these parts are installed first:

- Four bus bars on core
- DIMM mechanisms on CPU riser card

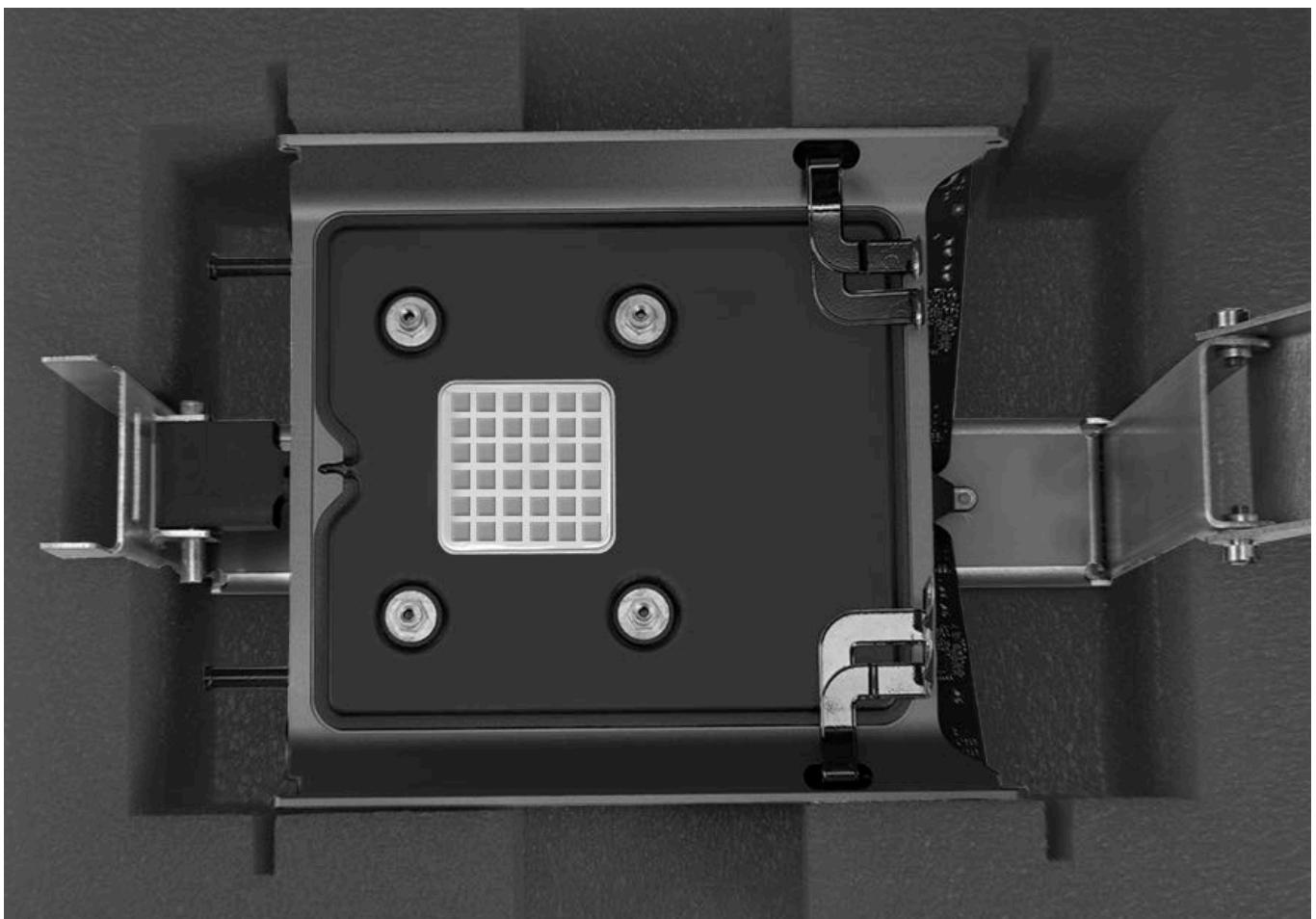
3. Place CPU grease stencil onto cleaned core platform and under bus bars.
4. Apply three syringes of thermal grease onto center of CPU grease stencil. (**Note:** The thermal compound that ships with the cpu riser card is the same as thermal compound 922-7144.)



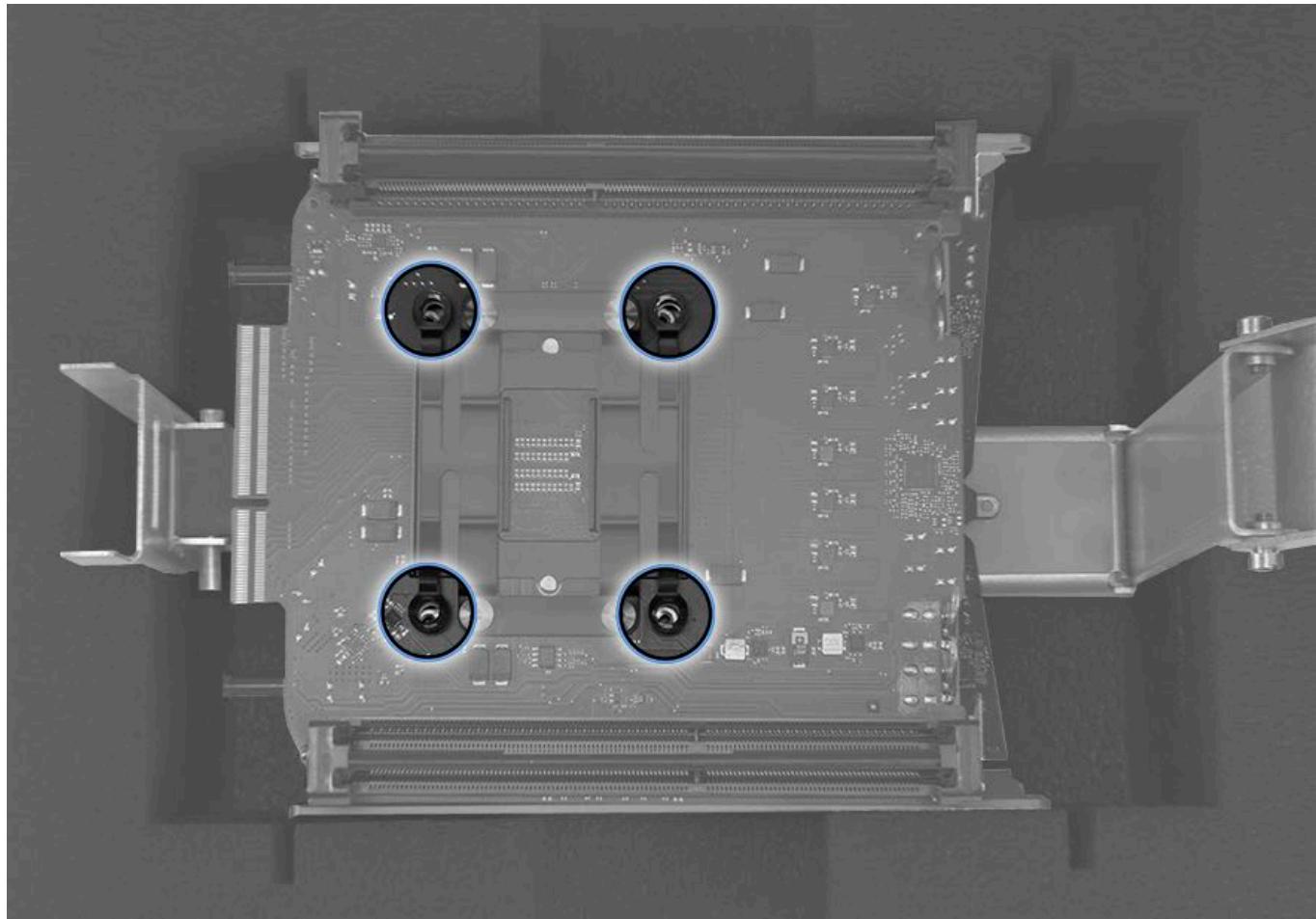
5. Use flat end of access card tool in a back-and-forth motion to spread thermal grease evenly over the center of the stencil until all squares are covered.



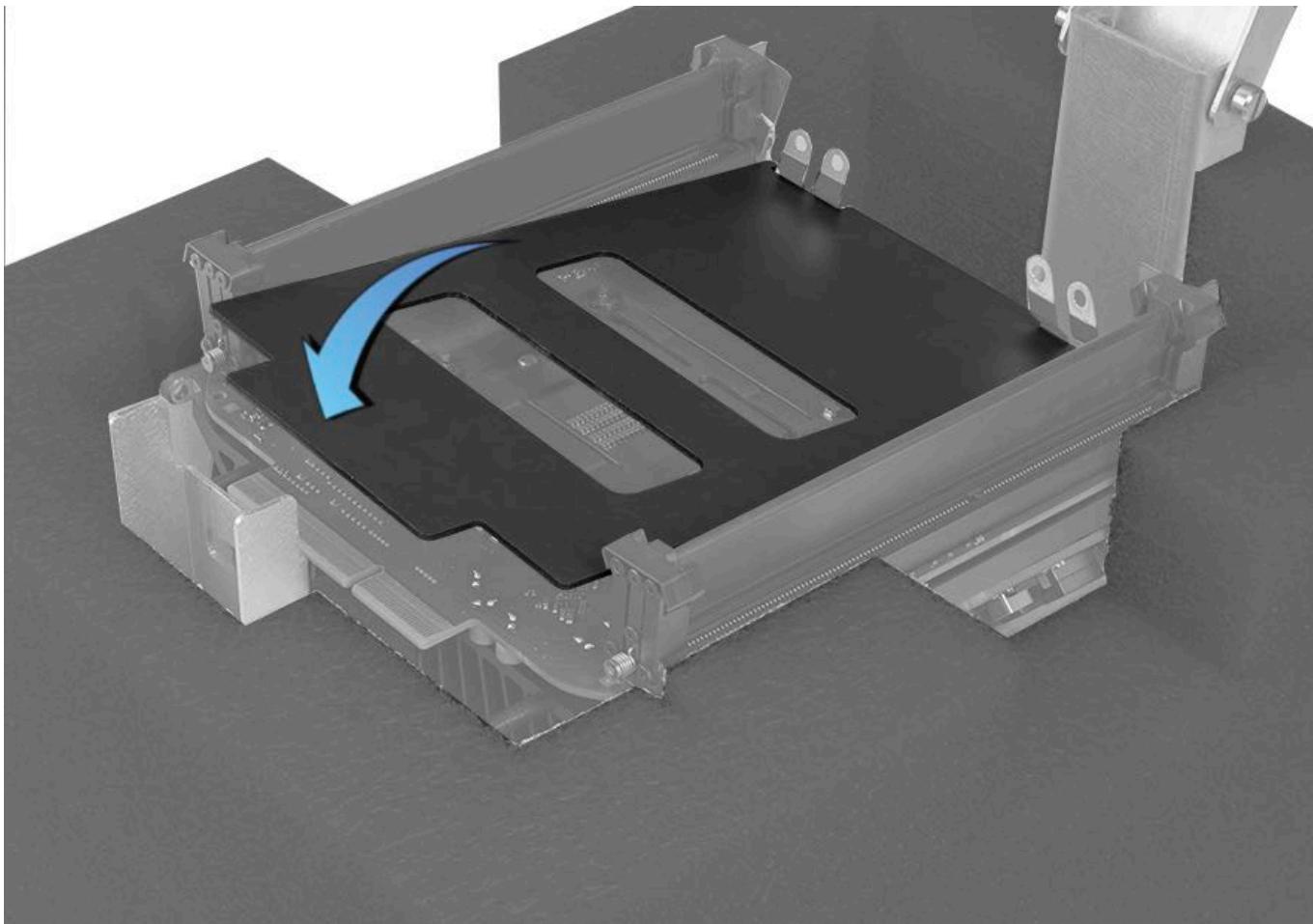
6. Remove stencil.



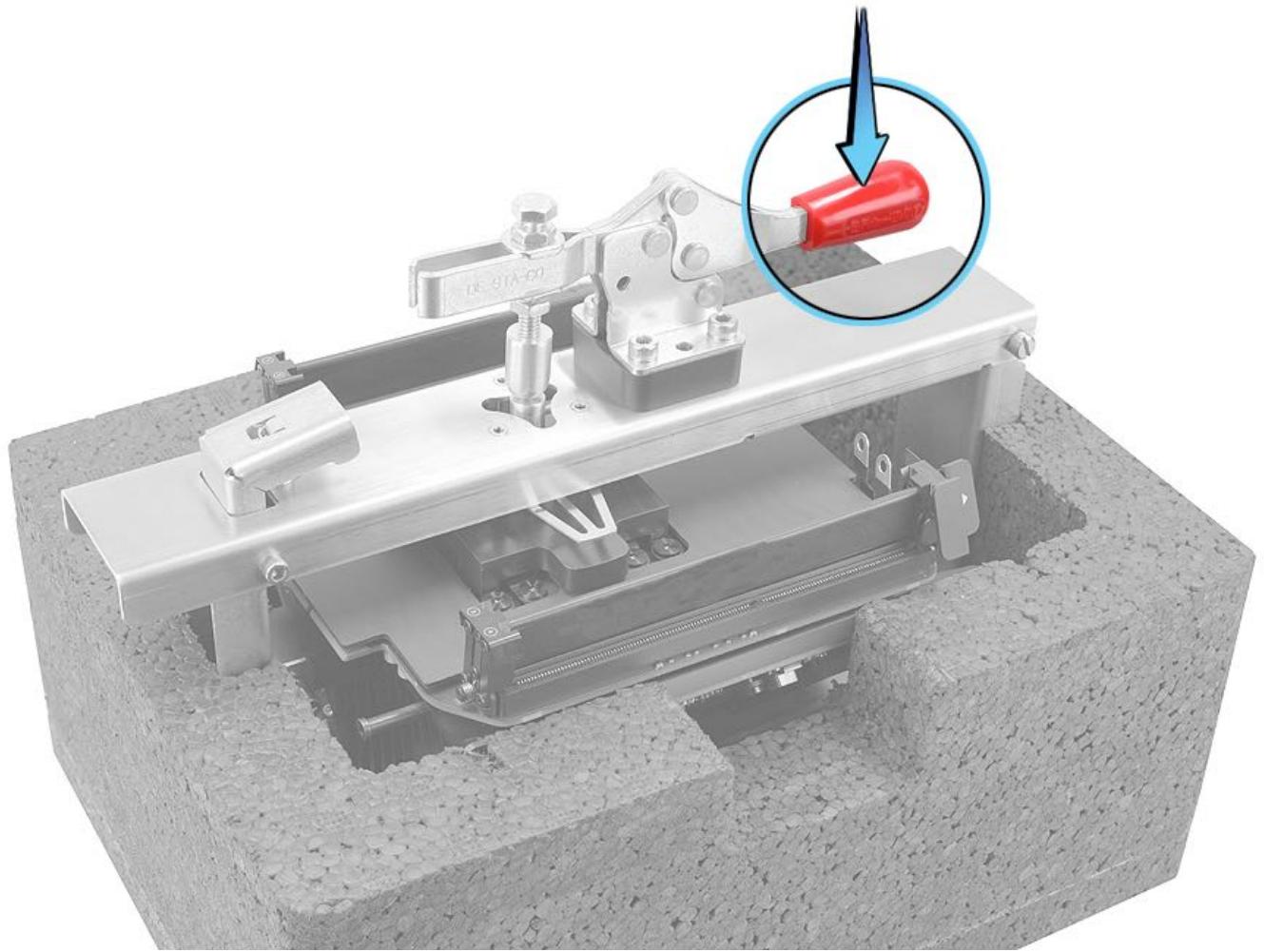
7. Keep CPU riser card level while aligning it over four screw standoffs. Be careful that screw standoffs do not touch components on card.



8. Place CPU riser cover over card.

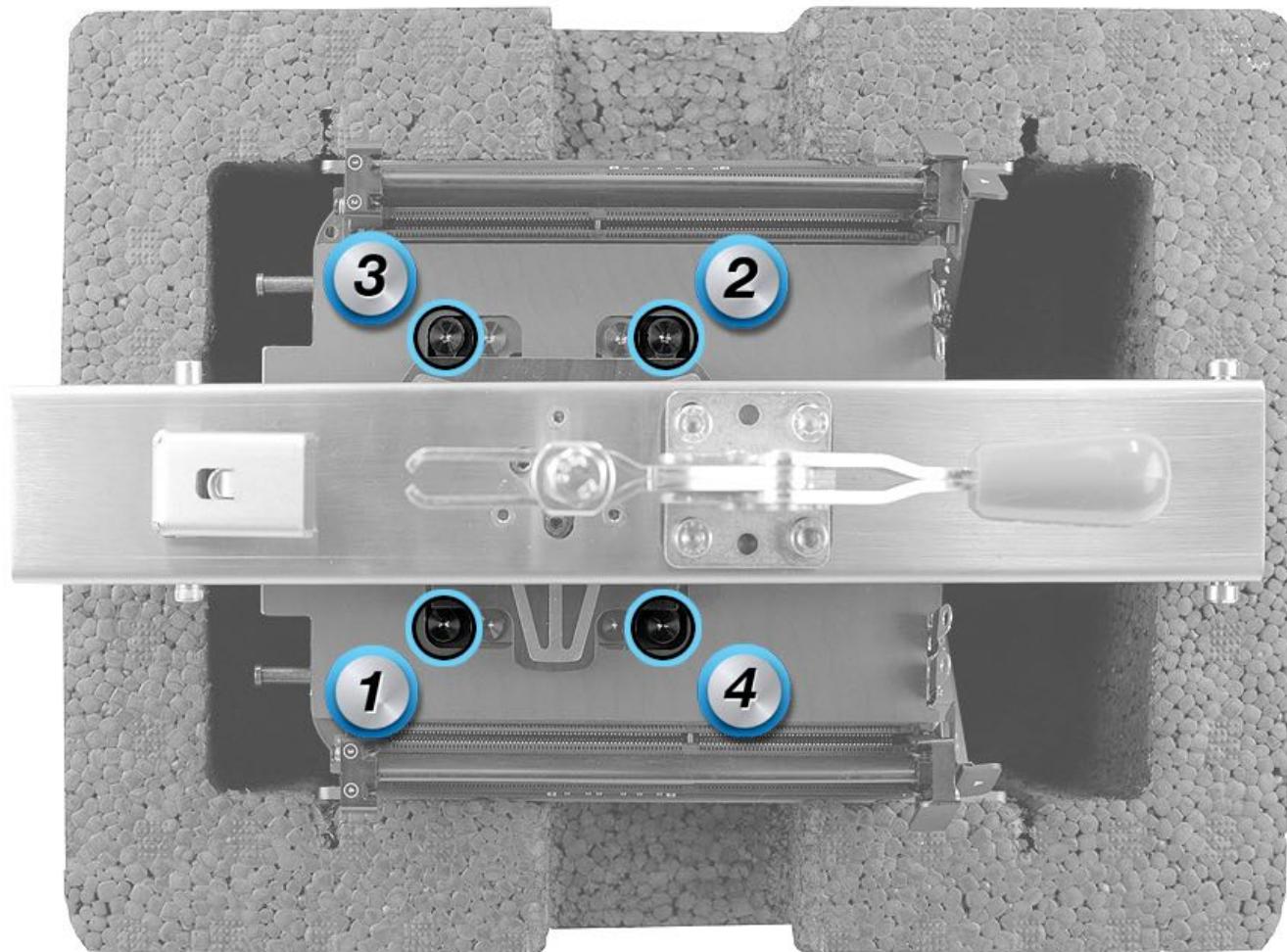


9. Lower arm of CPU riser press and lock it. Clamp down handle.



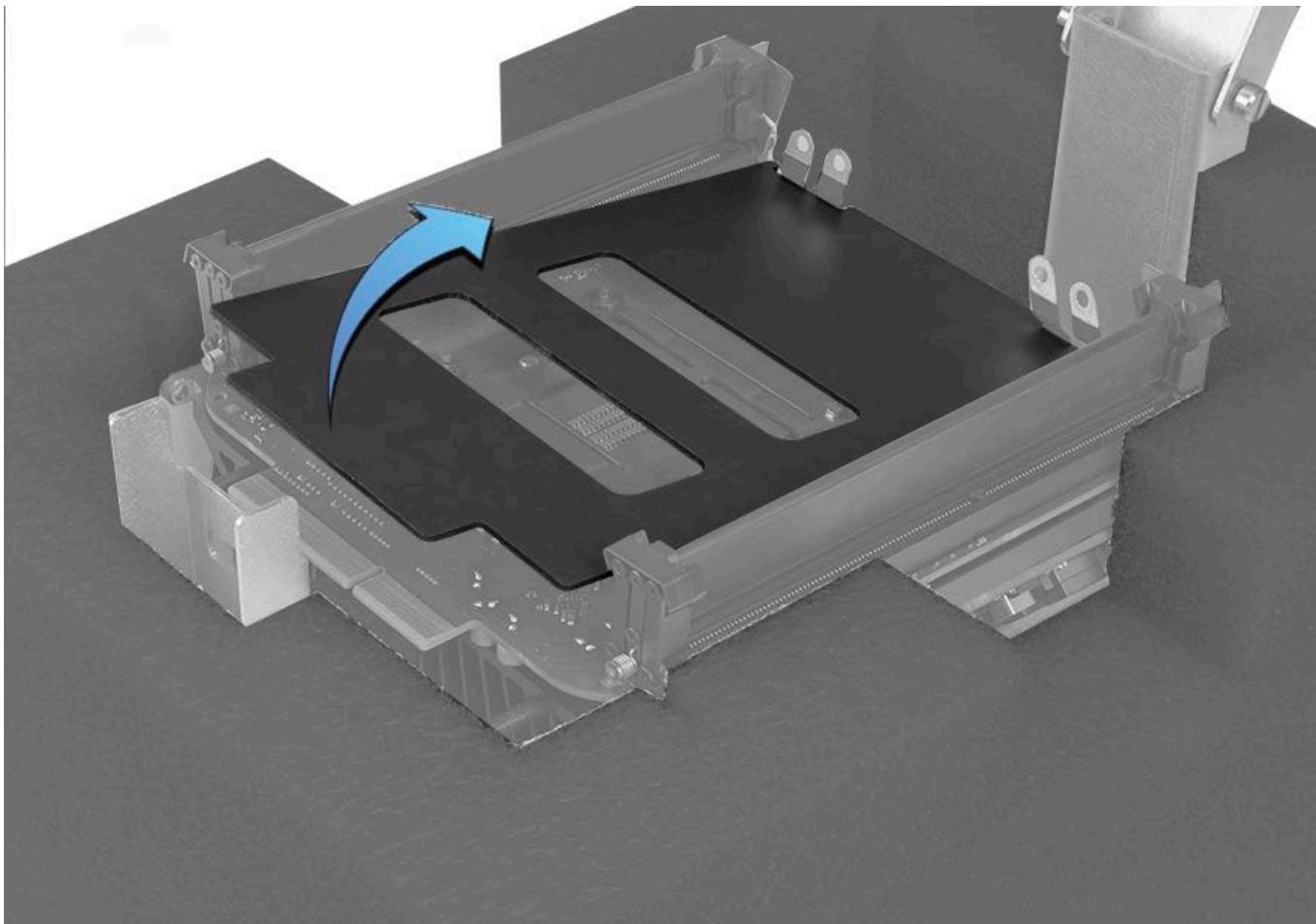
10. Using the torque driver with a regular T10 bit, install four T10 screws (923-0707) in sequence shown until all screws are tightened to 10.5 inch pounds (in.-lbs.) or 1.2 Newton metres (Nm).

**Note:** The indicated torque value must be used to avoid damaging the unit or causing the unit to malfunction.



11. Unlock CPU riser press and raise the arm.

12. Remove CPU riser cover.



13. Remove core assembly from cradle.

14. Using torque driver with T8 security bit, install two T8 bus bar screws (923-0712) and tighten them to 7.5 inch pounds (in.-lbs.) or 0.85 Newton metres (Nm).

**Note:** The indicated torque value must be used to avoid damaging the unit or causing the unit to malfunction.

15. After reassembling computer, run Cooling System Diagnostic (CSD). For more information, refer to Apple Support article [TP578: AST Reference Guide: Cooling System Diagnostic \(Standard and Extended\)](#).



# DIMM Mechanism

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT205332: About AppleCare service certifications](#).

Remove:

- [Housing](#)
- [Memory DIMMs](#)
- [Exhaust Assembly](#)
- [I/O and Power Supply Assembly](#)
- [Inlet](#)
- [Logic Board](#)
- [CPU Riser Card](#)



## Tools

- ESD wrist strap
- Torx T5 screwdriver (magnetized)

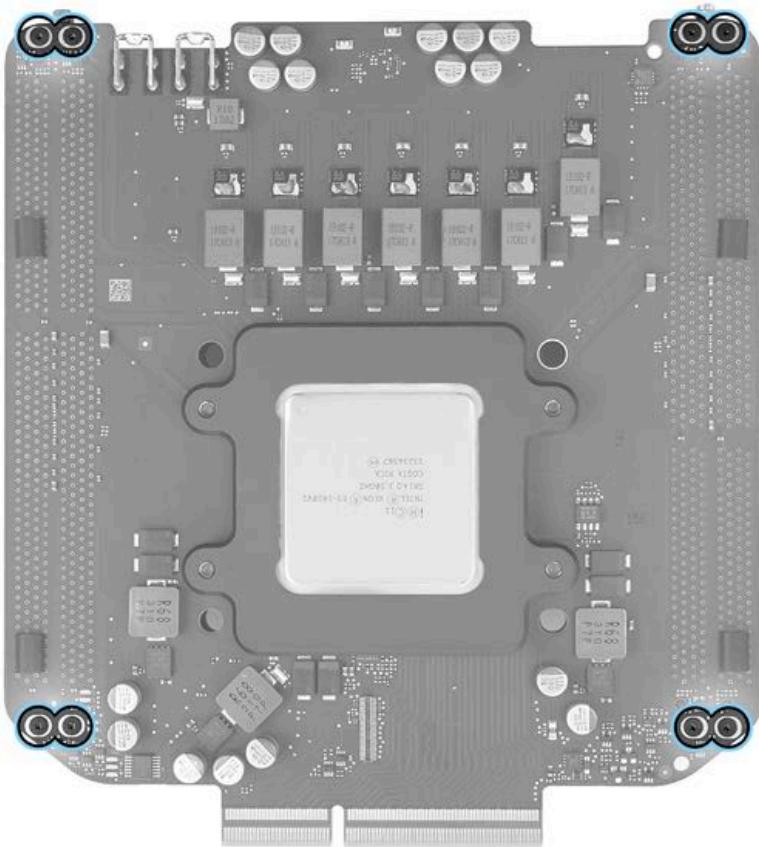
## Steps For Removal

**Note:** Before removing DIMM mechanism from CPU riser card, be sure to clean thermal grease off of CPU.

1. Remove four (4) T5 screws (923-01314) from the DIMM mechanism. **Note:** There are a total of eight (8) screws shown in image below because there are two (2) DIMM mechanisms.



2. Lift DIMM mechanism off CPU riser card.



## Steps For Reassembly

Reassemble in reverse order of removal steps.

# Thermal Core

## First Steps

**Important:** This procedure should only be performed by Apple-certified technicians. For more information, refer to article [HT202594: Exams for Service Technicians](#).

Remove:

- [Housing](#)
- [Memory DIMMs](#)
- [Exhaust Assembly](#)
- [I/O and Power Supply Assembly](#)
- [Inlet](#)
- [Logic Board](#)
- [Graphics Card Flex Cable](#)
- [Graphics Boards](#)
- [CPU Riser Card](#)



## Tools

- ESD wrist strap

## Steps For Removal

After removing all parts listed in First Steps, the thermal core is what remains.

## Steps For Reassembly

Reassemble in reverse order of removal steps.

# Apple USB SuperDrive

## First Steps

**Important:** The following procedure is intended only for removing a stuck disc from an Apple USB SuperDrive at the user's request. Do not take apart an Apple USB SuperDrive for repair. The repair strategy for this product is Whole Unit Replacement.

This procedure requires placing SuperDrive upside down on its top case. Always use a clean, debris-free static mat to avoid scratches and other cosmetic damage to the housing.



## Tools

- ESD wrist strap and mat
- Black stick (922-5065)
- #000 Phillips screwdriver
- T10 Torx screwdriver (later models)
- Suction cup (922-8252)



## Steps For Removal

Because this is a handheld procedure, perform these steps over a workbench or elevated repair surface to minimize height from which a component might fall.

1. Hold SuperDrive securely in one hand by edges of silver top case, with black bottom case facing up and USB cable leading away from you.



2. With other hand, place suction cup on center of bottom case. Press down firmly to flatten and secure suction cup.

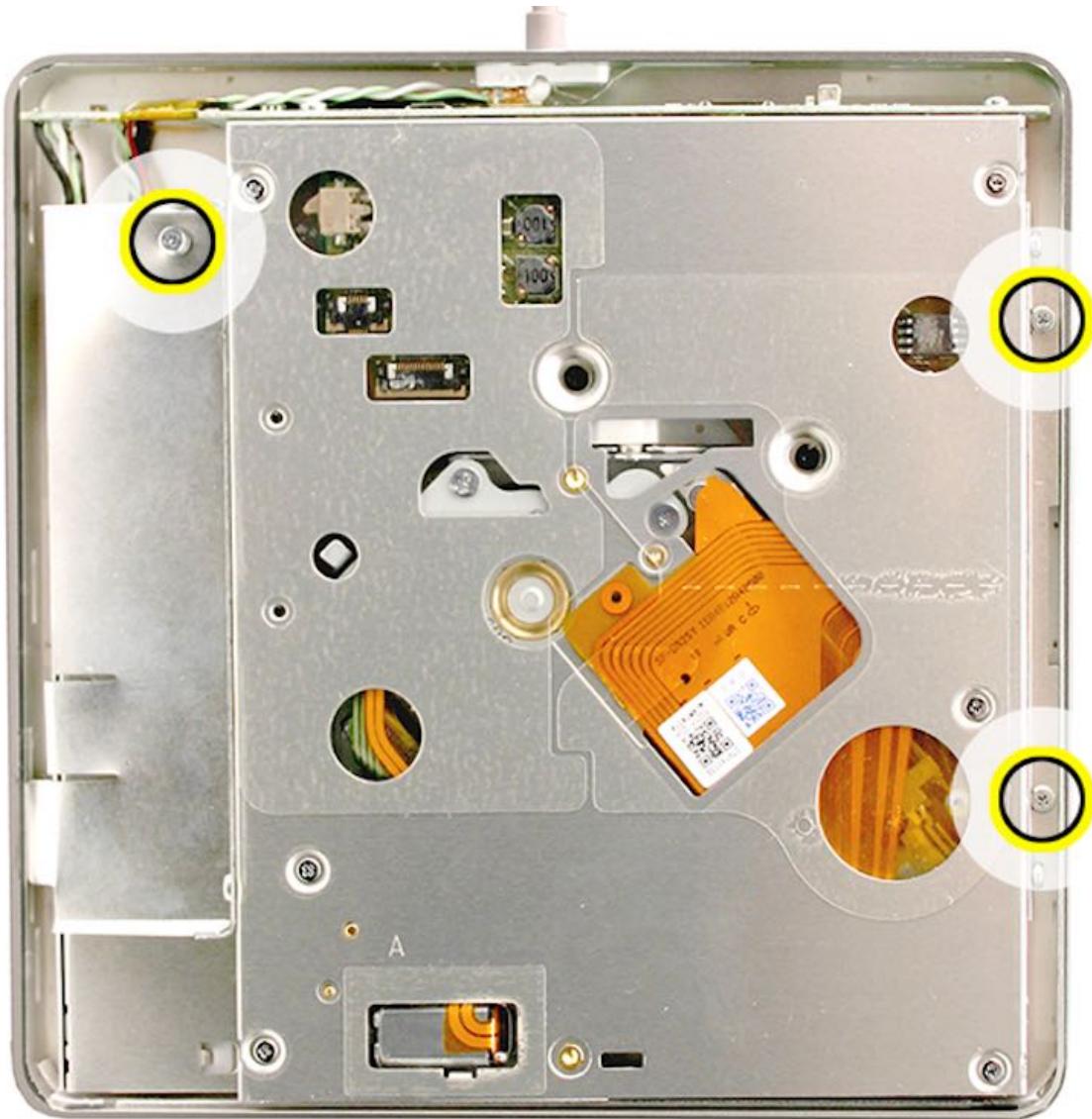


3. Once suction cup is fully adhered, lift straight up. Pull bottom case directly out of top case in one smooth motion. Secure fit might give a lot of resistance.

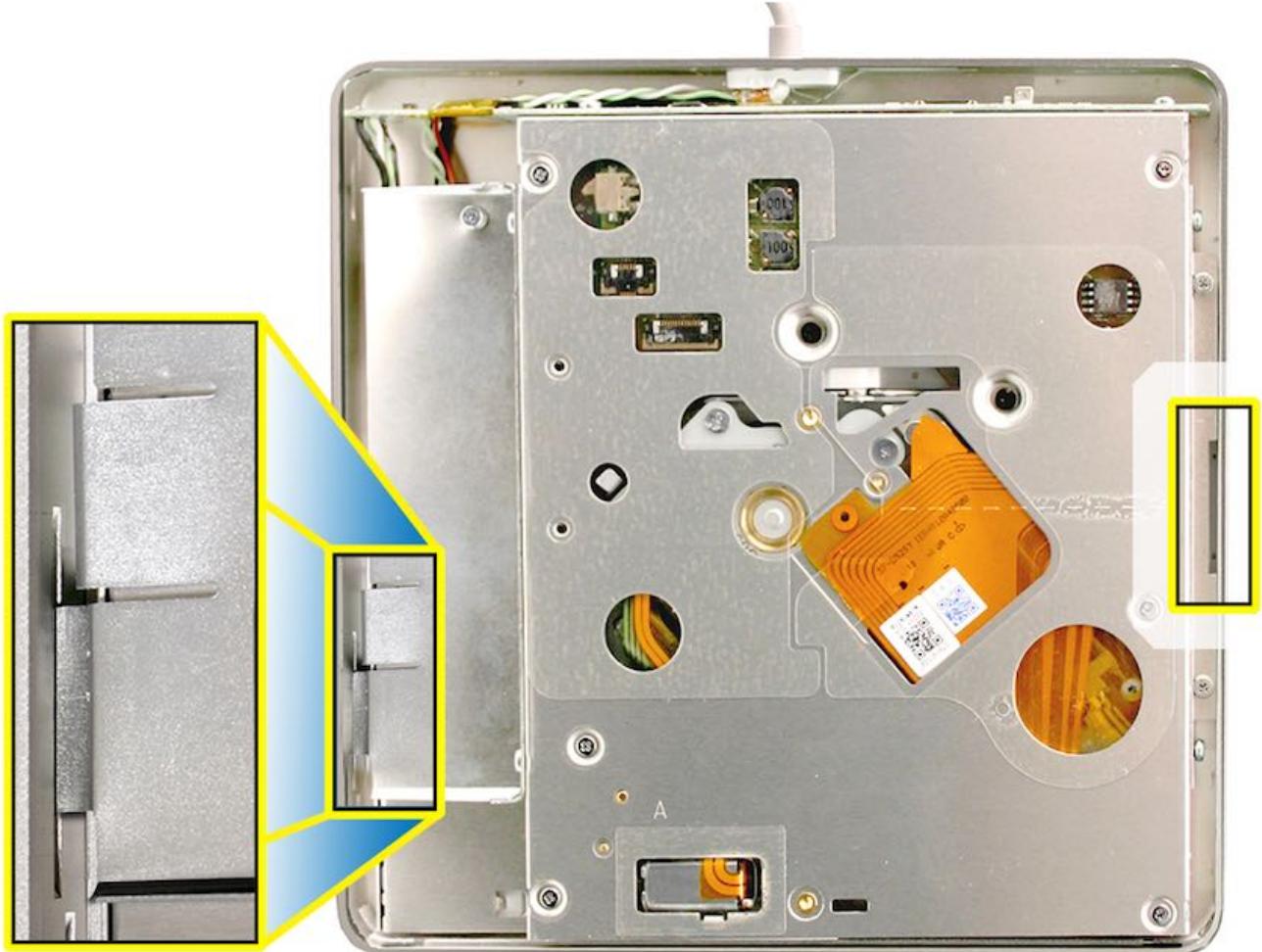
**Important:** Adhesion of suction cup is short-lived. To avoid damage from dropping, immediately set bottom case on a clean surface. Be mindful of tabs.



4. Set drive top-down on a soft, clean surface, with inside facing up and USB cable leading away from you. Remove three #000 Phillips screws (shown below).



5. Note tab on lower left of drive fits into recessed slit on inside edge of top case (see below left). On opposite side of drive, note gap in center of right edge of drive (see below right).



6. Insert flat edge of black stick into gap on right edge of drive. Carefully pivot edge upward slightly, just enough to slide drive a few millimeters right. Ease left tab out of top case.



7. Note internal cable leading to external USB cable. In earlier model you will see a controller board connected to cable (see inset below).

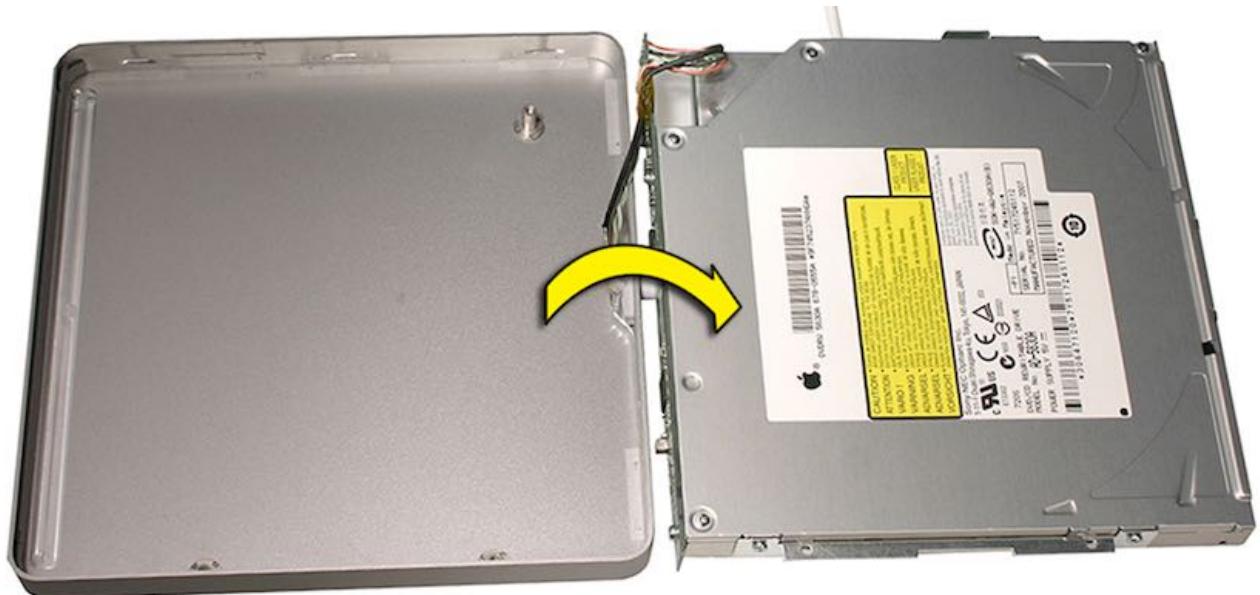
**Caution:** Since cable remains connected during this procedure, be careful not to pull or stress cable connections. To avoid

damaging cable, always keep drive within an inch or so of outer case.

8. Grip drive by edges. Avoid touching components. Lift drive up and out of top case a few millimeters — enough to pivot and flip drive over.



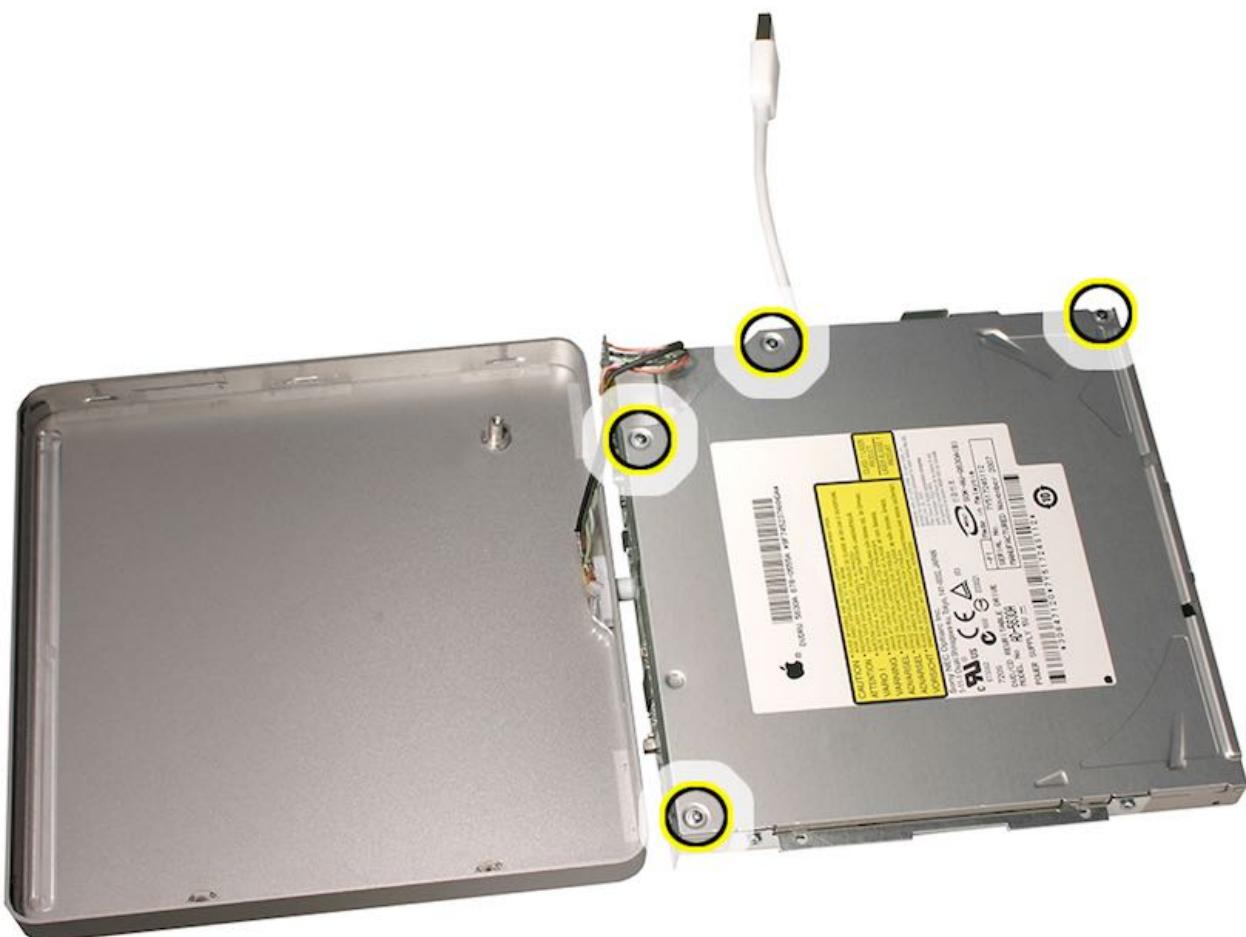
9. As if opening a book, flip drive up and over. Gently lay it down, keeping edges as close together as possible to avoid straining cable connections.



10. Immobilize drive while removing screws or components, holding drive by bracket or edges only.



11. Remove four #000 Phillips screws from top of drive (shown below).



12. Remove two T10 screws or two Phillips screws (depending on model) holding bracket to drive.

**Earlier model:**



**Later models:**



13. Lift top lid of drive, pivoting right edge up. Then shift lid left and downward to remove left edge.



14. Remove stuck disc. Reassemble SuperDrive in reverse order of previous steps 4-13. Proceed to step 15 to correctly reinstall bottom case.



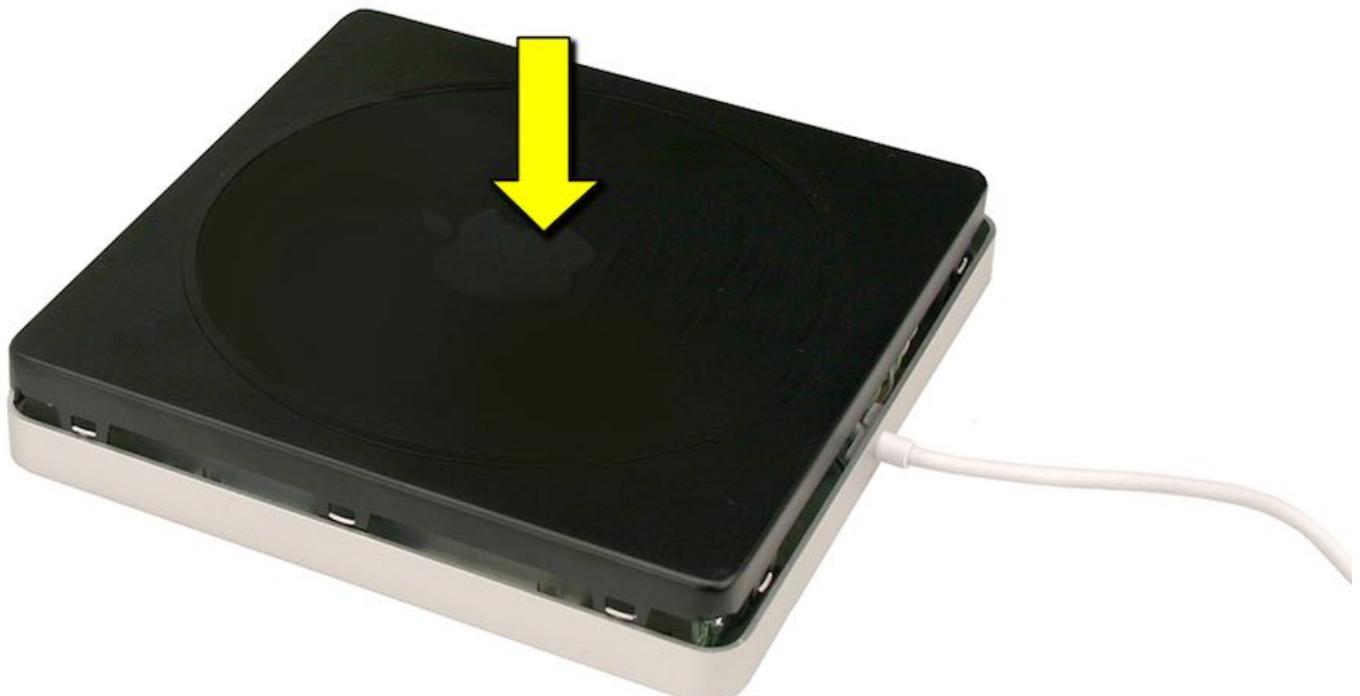
15. Orient bottom case to top case, as pictured below. Note three tabs per side on left and right sides of drive and two corner tabs in back. There are no tabs in front (where disc slot is located).



16. Set bottom case evenly on top case with tabs just inside perimeter of top case edge. Align all tabs with top case.

**Note:** If case is oriented correctly, Apple logo will be right-side up when USB cable is pointed toward you.

17. With firm, even pressure, snap bottom case into top case to seat tabs. Verify all tabs are fully seated and SuperDrive sits flat.



## Steps For Reassembly

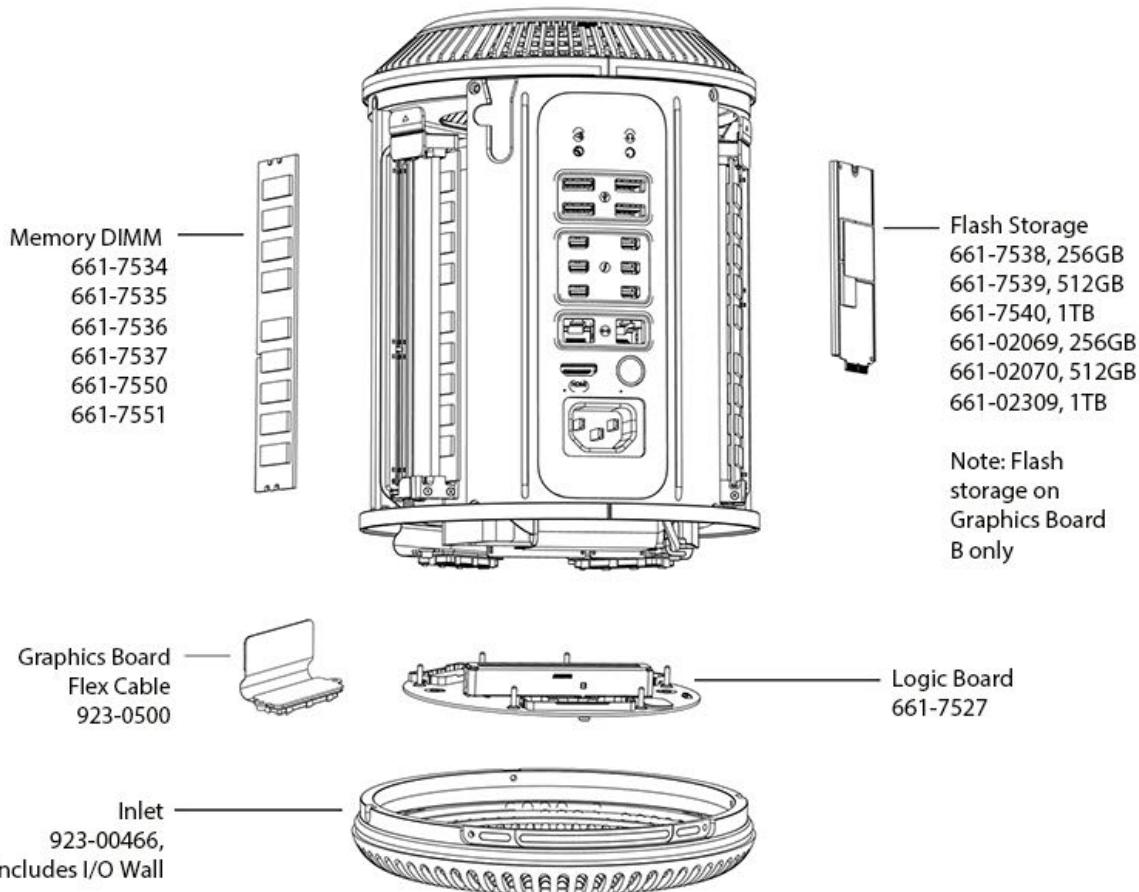
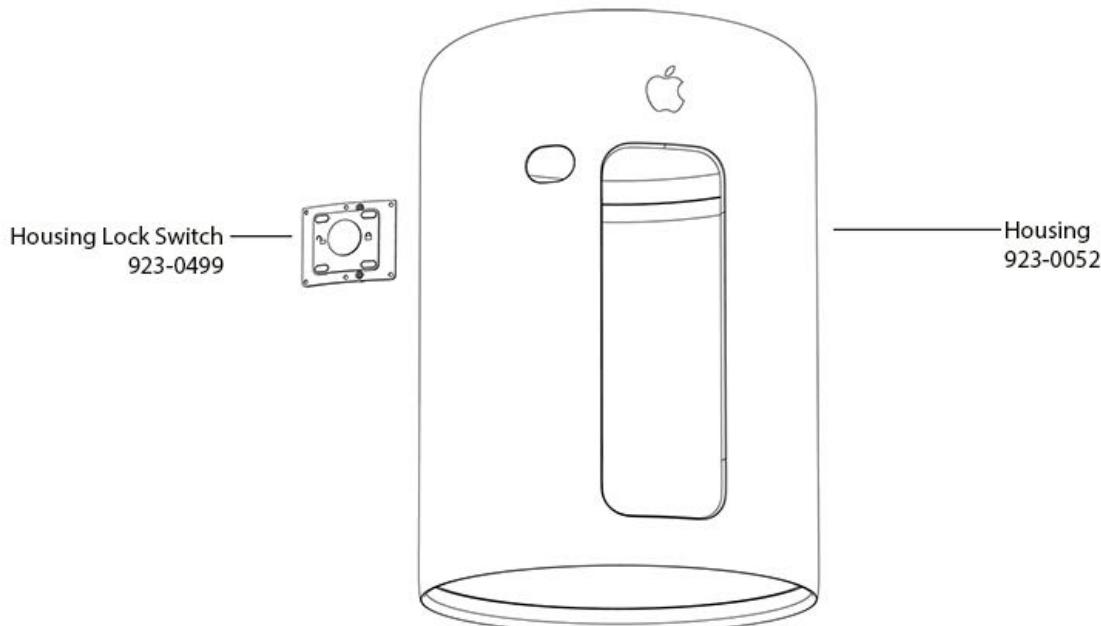
Reassemble in reverse order of removal steps.

### **Quick Test**

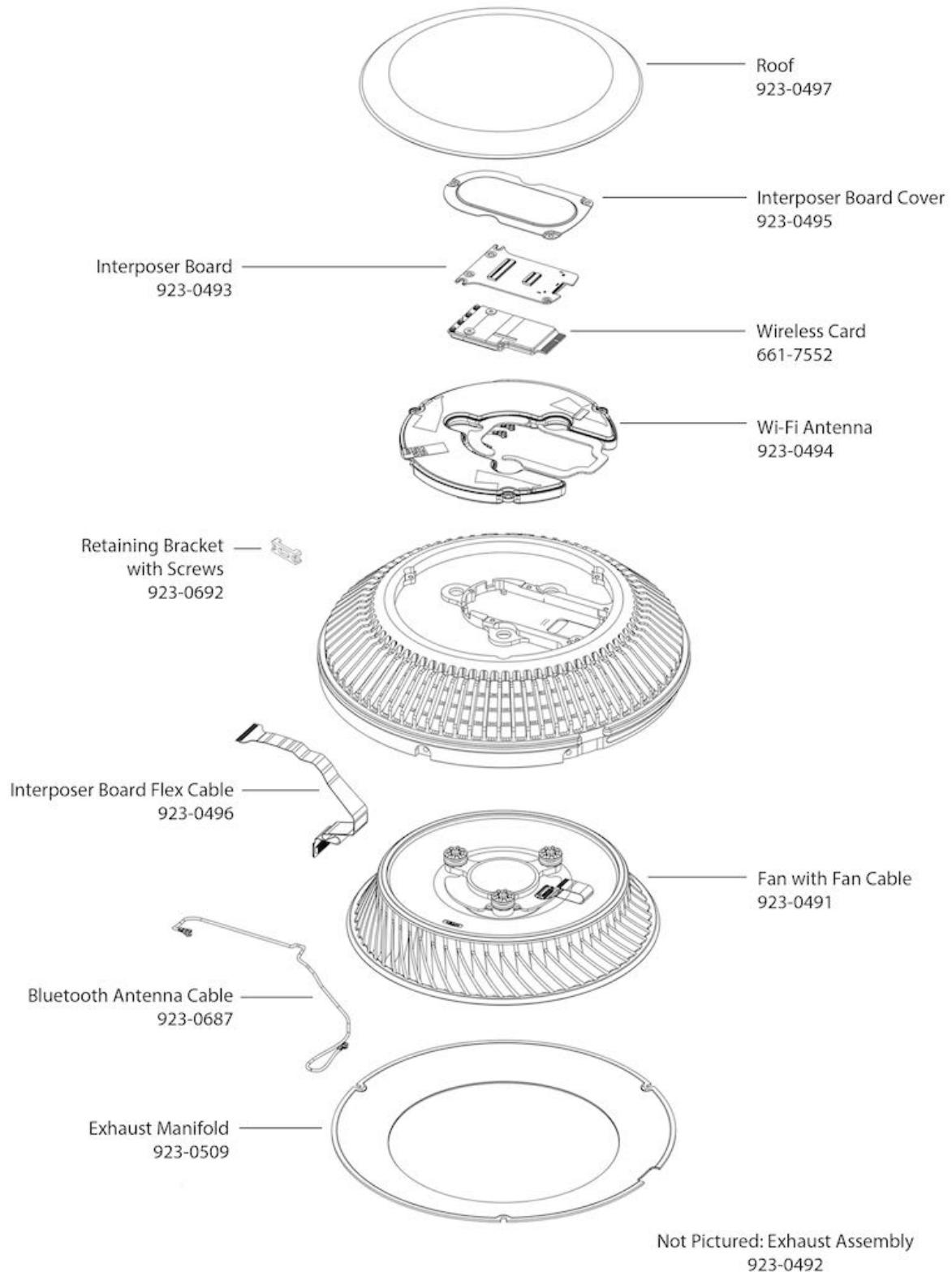
Plug Apple USB SuperDrive into known-good computer to check functionality. Check drive for disc insertion, mounting, and ejection of a variety of optical media.

# Exploded View

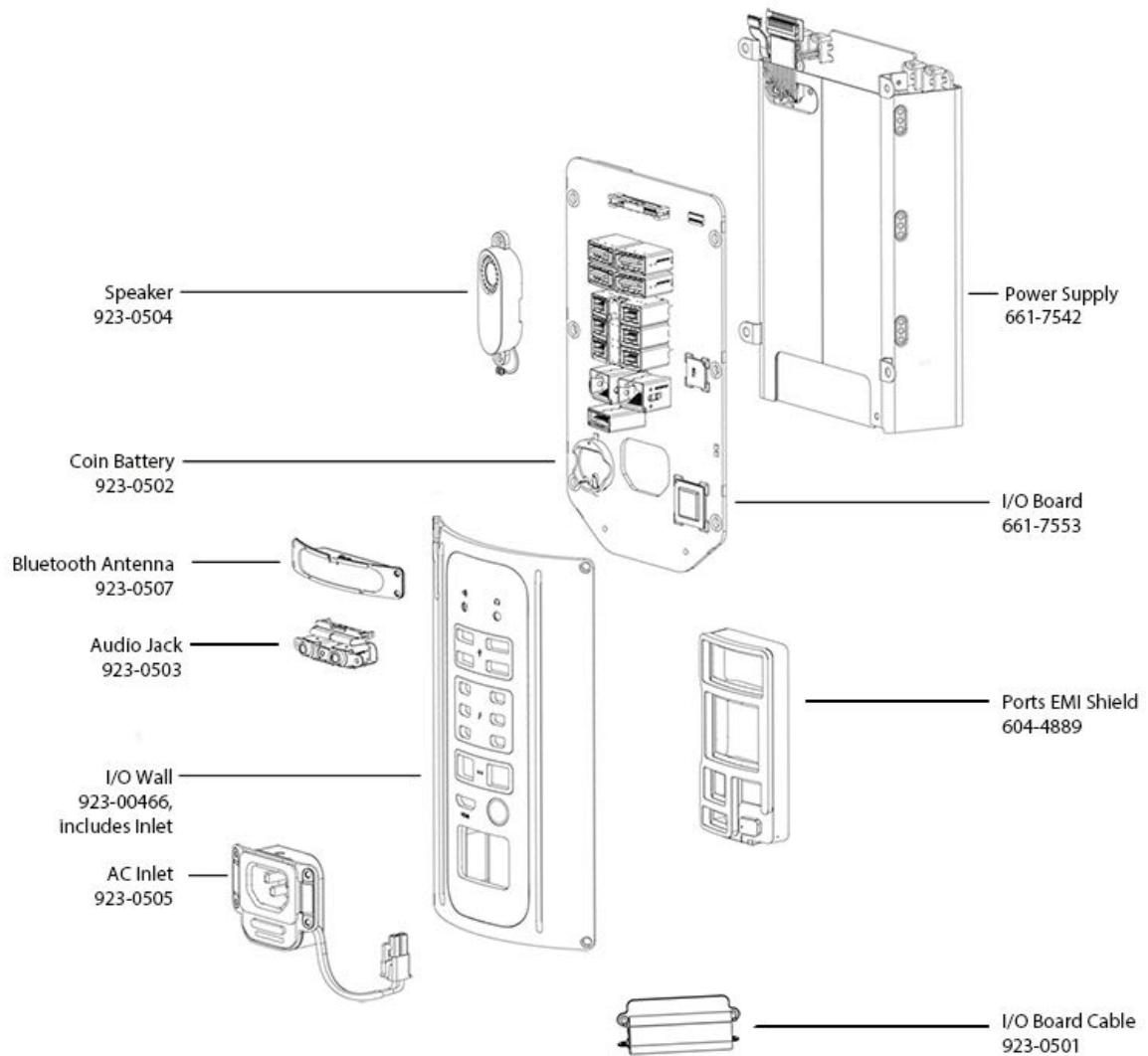
## Housing / Memory / Storage / Logic Board



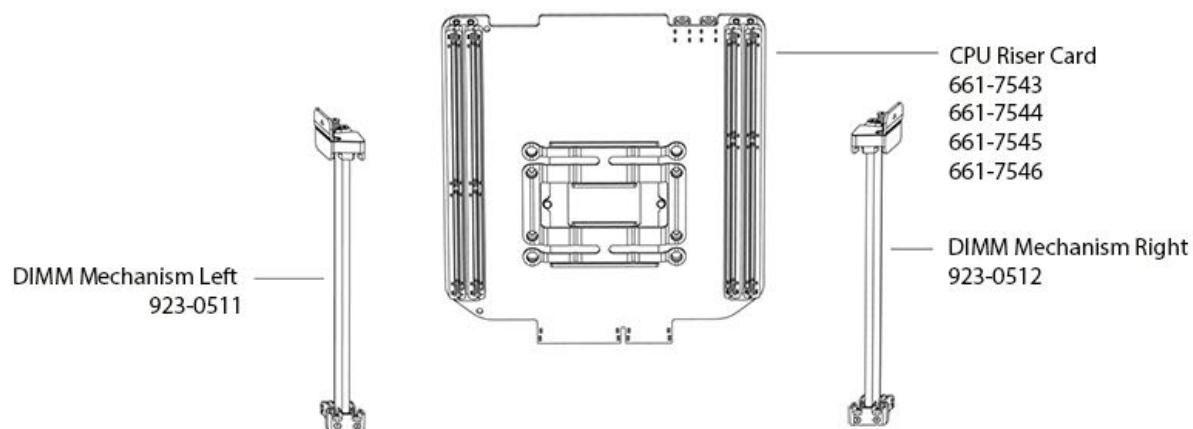
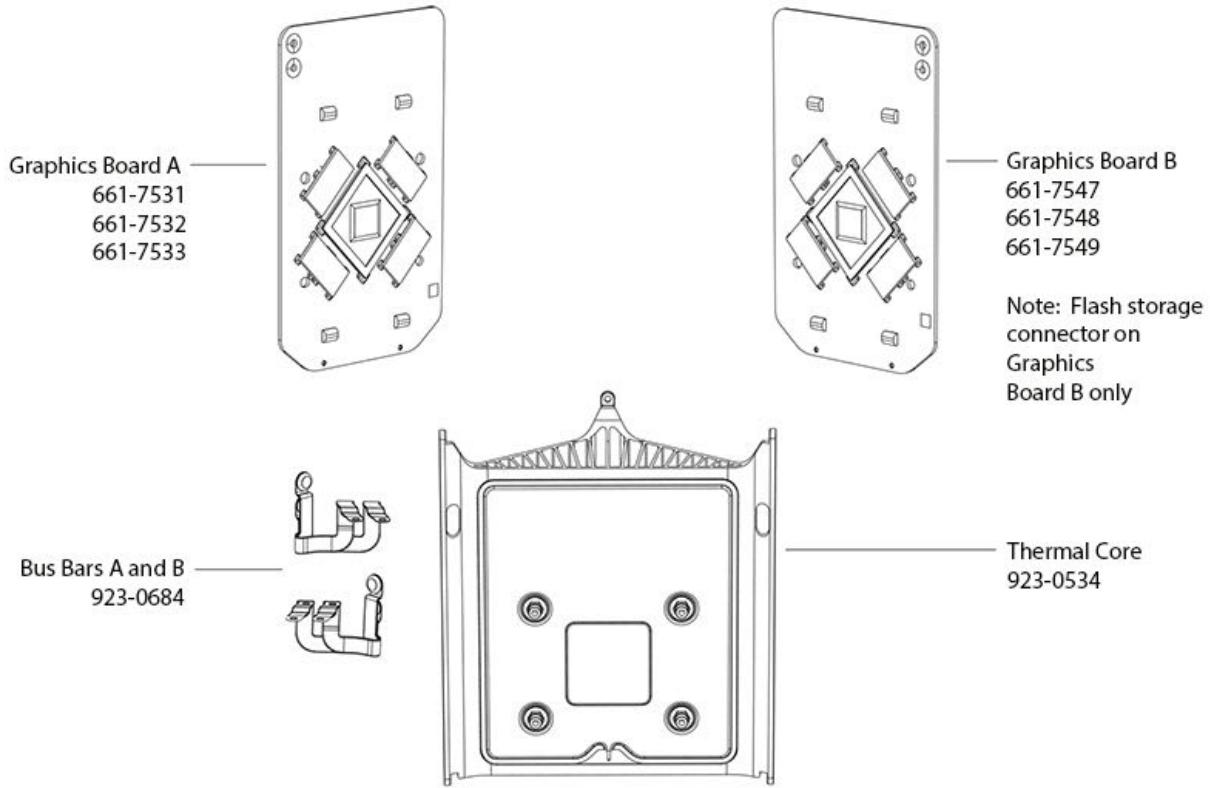
## Exhaust Assembly



#### I/O Wall / Power Supply Assembly



## Core Assembly



**Note:** Effective immediately, some coin cell batteries used on Mac systems are now available only from electronics parts distributors (for example, MCM). The coin battery is no longer available to order via GSX. When the Mac repair process indicates the coin battery needs to be replaced, please order it from an electronics parts distributor. **Note:** BR2032 and CR2032 batteries have the same form factor and nominal voltage. However, BR2032 batteries have a lower self-discharge rate and broader operating temperature range than CR2032 batteries for longer shelf and service life.

## External Views

### Front View



### Ports View



A = Housing lock

B = Combined optical/digital audio output/analog line out

C = HDMI 1.4 UltraHD

D = Headphone

E = USB 3 (4 ports)

F = Thunderbolt 2 (6 ports)

G = Dual Gigabit Ethernet (2 ports)

H = Power button

I = AC inlet

## Screw Chart

### Mandatory torque values:

Item and step	No. of screws	Part number	Upper level part number	Driver	Factory setting	WERA 2.5-11.5 in-lbs adjustable driver	WERA 0.3-1.2 Nm adjustable driver
Graphics Board A to Core	4	452-2922	923-0708	Torx 10	10.4 in.-lbs. or 1.17 Nm	10.5 in-lbs	1.2 Nm
Graphics Board B to Core	4	452-2922	923-0708	Torx 10	10.4 in.-lbs. or 1.17 Nm	10.5 in-lbs	1.2 Nm
CPU Riser Card to Core	4	452-2921	923-0707	Torx 10	10.4 in.-lbs. or 1.17 Nm	10.5 in-lbs	1.2 Nm
Logic Board to Core	2	452-2941	923-0711	Torx 8	3.1 in.-lbs. or 0.35 Nm	3.0 in-lbs	0.35 Nm
Bus Bars to CPU Riser Card	2	452-2981	923-0712	Torx 8	7.3 in.-lbs. or 0.82 Nm	7.5 in-lbs	0.85 Nm
Bus Bars to Power Supply	4	452-2981	923-0712	Torx 8	7.3 in.-lbs. or 0.82 Nm	7.5 in-lbs	0.85 Nm
Bus Bar A to Graphics Board A	2	452-5371	923-0716	Torx 8	10.4 in.-lbs. or 1.17 Nm	10.5 in-lbs	1.2 Nm
Bus Bar B to Graphics Board B	2	452-5371	923-0716	Torx 8	10.4 in.-lbs. or 1.17 Nm	10.5 in-lbs	1.2 Nm
Logic Board Stand-offs to Core	2	860-2488	923-0693	Torx 15	3.1 in.-lbs. or 0.35 Nm	3.0 in-lbs	0.35 Nm

### Suggested torque values:

<b>Item and step</b>	<b>No. of screws</b>	<b>Part number</b>	<b>Upper level part number</b>	<b>Driver</b>	<b>Factory setting</b>	<b>WERA 2.5-11.5 in-lbs adjustable driver</b>	<b>WERA 0.3-1.2 Nm adjustable driver</b>
Flash Storage	1	452-4213	923-0715	Torx 8	3.5 in.-lbs. or 0.40 Nm	3.5 in-lbs	0.40 Nm
Fan to Exhaust	3	452-2926	923-0724	Torx 10	10.4 in.-lbs. or 1.17 Nm	10.5 in-lbs	1.2 Nm
Wireless Card to Interposer Board	2	452-2927	923-0725	Torx 5	1.6 in.-lbs. or 0.18 Nm	Light hand tightening with manual driver	
Interposer Board to Exhaust	3	452-2925	923-0709	Torx 5	3.1 in.-lbs. or 0.35 Nm	3.0 in-lbs	0.35 Nm
Interposer Board Cover to Exhaust	3	452-2925	923-0709	Torx 5	3.1 in.-lbs. or 0.35 Nm	3.0 in-lbs	0.35 Nm
Interposer Board Cable Bracket to I/O Board	2	452-4505	923-0692	Torx 8	3.1 in.-lbs. or 0.35 Nm	3.0 in-lbs	0.35 Nm
Interposer Board Cable to Exhaust	2	452-2968	923-0728	Torx 5	1.3 in.-lbs. or 0.15 Nm	Light hand tightening with manual driver	
Exhaust Manifold to Exhaust	3	452-2925	923-0709	Torx 5	3.1 in.-lbs. or 0.35 Nm	3.0 in-lbs	0.35 Nm
Wi-Fi Antenna to Exhaust	3	452-2925	923-0709	Torx 5	1.6 in.-lbs. or 0.18 Nm	Light hand tightening with manual driver	
Spring to CPU Riser Card	4	452-2921	923-0707	Torx 10	10.4 in.-lbs. or 1.17 Nm	10.5 in-lbs	1.2 Nm
Inlet to Core	3	452-3267	923-0713	Torx 10	10.4 in.-lbs. or 1.17 Nm	10.5 in-lbs	1.2 Nm
Inlet to I/O/PSU Assembly	2	452-3267	923-0713	Torx 10	10.4 in.-lbs. or 1.17 Nm	10.5 in-lbs	1.2 Nm
Audio Jack to I/O Wall	3	452-2925	923-0709	Torx 5	1.6 in.-lbs. or 0.18 Nm	Light hand tightening with manual driver	
Bluetooth Antenna to I/O Wall	4	452-2940	923-0726	Torx 5	1.6 in.-lbs. or 0.18 Nm	Light hand tightening with manual driver	
AC Inlet to I/O Wall	4	452-2965	923-0727	Torx 5	1.6 in.-lbs. or 0.18 Nm	Light hand tightening with manual driver	
Speaker to I/O Board	2	452-2940	923-0726	Torx 5	2.2 in.-lbs. or 0.25 Nm	2.5 in-lbs	0.3 Nm
I/O Board to I/O Wall	2	452-7035	923-0717	Torx 10	10.4 in.-lbs. or 1.17 Nm	10.5 in-lbs	1.2 Nm
Power Supply to Cover	2	452-3646	923-0714	Torx 5	3.1 in.-lbs. or 0.35 Nm	3.0 in-lbs	0.35 Nm
Power Supply to I/O Board	4	452-7035	923-0717	T10 Ball End	10.4 in.-lbs. or 1.17 Nm	10.5 in-lbs	1.2 Nm
Housing Lock Switch	6	452-2929	923-0710	Torx 5	0.79 in.-lbs. or 0.09 Nm	Light hand tightening with manual driver	
Exhaust Assembly to Core	3	452-3267	923-0713	Torx 10	10.4 in.-lbs. or 1.17 Nm	10.5 in-lbs	1.2 Nm
Exhaust Assembly to I/O / PSU Assembly	2	452-3267	923-0713	Torx 10	10.4 in.-lbs. or 1.17 Nm	10.5 in-lbs	1.2 Nm
DIMM Mech. to CPU Riser Card	4	452-7442	923-01314	Torx 5	3.1 in.-lbs. or 0.35 Nm	3.0 in-lbs	0.35 Nm

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