Accessory Design Guidelines for Apple Devices

Release R20

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Overview

1. Introduction

Note:

These Accessory Design Guidelines for Apple Devices ('Guidelines') are subject to the terms and conditions set forth on the final page of this document. By downloading, accessing, or otherwise utilizing these Guidelines, you agree to be bound by, and only utilize the Guidelines in accordance with, such terms and conditions.

These guidelines address:

- The physical design of cases, covers, screen overlays, and camera attachments for iOS and iPadOS devices.
- The specifications for hardware accessories using the Bluetooth transport to communicate with iOS devices, iPadOS devices, watchOS devices, tvOS devices, and Mac computers.
- The design of AC power adapters and battery packs for iOS devices, iPadOS devices, and AirPods.
- The design of Qi wireless transmitters for iOS devices and AirPods.
- The physical design of band accessories compatible with Apple Watch.

These guidelines do not address other aspects of accessory communication. Instead, see the Apple MFi Licensing Program (page 21) and the Accessory Interface Specification (page 21).

2. Requirements

The use of the words *shall, shall not, required, prohibited, should, should not, recommended, not recommended, may, optional,* and *deprecated* in a statement have the following meanings:

- *shall*, or *required* means the statement is an absolute requirement.
- shall not or prohibited means the statement is an absolute prohibition.
- should or recommended means the full implications shall be understood before choosing a different course.
- should not or not recommended means the full implications shall be understood before choosing this course.
- may or optional means the statement is truly optional, and its presence or absence cannot be assumed.
- deprecated means the statement is provided for historical purposes only and is equivalent to 'shall not'.

3. Terminology

3.1 Device

Device refers to an iPhone, iPad, or iPod.

iOS device refers to an iPhone or iPod running iOS.

iPadOS device refers to an iPad running iPadOS.

watchOS device refers to an Apple Watch running watchOS.

tvOS device refers to an Apple TV running tvOS.

Where appropriate, specific Apple product and operating system references will also be used.

3.2 Accessory

Accessory refers to any product connecting to a *device* using the interfaces described in this specification.

3.3 Component

A *component* is a functional unit or a constituent part of an accessory. Components inter-connect and function as a part of a greater system. Examples include:

- Integrated circuits, micro-processors, flash memory, microphones, and speakers.
- Data transport interface, such as a Lightning connector, USB connector, or Bluetooth radio.
- Power sources, such as a battery or power supply.
- Human Interface Device (HID) Control Surface (page 20), such as a play/pause button.

A *component* may also refer to a group or collection, such as the keyboard portion of a keyboard/trackpad accessory.

3.4 Control Surface

A *control surface* is a human interface device (HID) component enabling user interaction with an accessory. Examples include:

- Connectors
- Buttons
- Switches
- Rotary knobs
- Joysticks
- Touchscreens or touch-sensitive surfaces
- Microphones
- Motion/presence sensors

References to specific types of control surfaces such as buttons or switches are only applicable to those control surface types. If a requirement calls for a physical button to be implemented, a physical button shall be present.

3.5 Direct User Action

A *direct user action* is defined as user interaction with an accessory using a Control Surface (page 20). Examples include:

- Physical gestures, such as:
 - Attaching an accessory to a device.
 - Pressing a button.
 - Actuating a switch.
 - Turning a knob.
 - Interacting with a touchscreen.
 - Waving a hand.
 - Moving in/out of range (for wireless accessories).
- · Voice input.

Accessories shall not autonomously perform user inputs unless explicitly authorized by the user.

3.6 Built-In Cable

A built-in cable is a cable with one end permanently attached to the accessory enclosure.

3.7 Accessory Interface Specification

The *Accessory Interface Specification* is available to members of the Apple MFi Licensing Program (page 21).

Use of some features requires accessory developers to be a member of the program and to integrate specific MFi hardware into the accessory.

3.8 Apple MFi Licensing Program

The Apple MFi licensing program provides access to specifications, components, connectors, and other resources to create accessories capable of communicating with devices.

See https://developer.apple.com/programs/mfi/ for more information.

Accessories

4. All Accessories

Requirements in this section apply to all accessories regardless of their supported features.

4.1 Scratches and Damage

Accessories shall not scratch or damage any device.

4.2 Compliance Testing

Accessories shall not assume evidence of functionality when attached to a device means the accessory is specification compliant. Such an approach does not account for future devices or software releases, and runs a high risk of dependence on un-documented device behavior which is subject to change at any time.

If available, accessories should validate their design and implementation using the recommended test procedures for all supported features.

4.3 Integrated USB Receptacles

Accessories incorporating a USB receptacle for the purpose of drawing power from an external USB power source shall meet the following requirements:

- USB-B receptacles shall comply with the USB Battery Charging 1.2 specification.
- USB-C receptacles shall comply with the requirements in Drawing Power (page 202).

4.4 User Supplied Cables and AC Power Adapters

Accessories intended for use with user-supplied cables and/or AC power adapters shall be designed to work with any cables, AC Power Adapters (page 66), or Battery Packs (page 69) compliant with this specification, including Apple branded cables and AC power adapters. Such accessories shall not declare compatibility with only Apple branded USB cables or AC power adapters.

This compatibility requirement applies to all aspects of user-supplied cables and power adapters. For example:

- Connector receptacles on accessories shall accommodate all specification-compliant connector overmolds, and any accessory opening surrounding the Lightning receptacle on a device shall provide sufficient clearance for specification-compliant connector overmolds.
- Accessories shall work with all cables compliant with the specification in regards to electrical DCR and SI.

Note:

Such accessories shall be tested with a wide variety of specification-compliant cables (including various lengths of the same cable if applicable) and AC power adapters during accessory development, in addition to Apple branded cables and AC power adapters.

4.5 Attachments

Accessories shall remain compliant with the specification when connected to any attachments designed for the accessory.

Examples of accessory attachments include, but are not limited to:

- Car or desk mounts for a case accessory.
- Wireless charging mats for a Lightning dongle or case accessory.
- Detachable barcode scanners/credit card readers for a Lightning dock accessory.

4.6 Magnetic Interference

Unless otherwise specified, Apple recommends avoiding the use of magnets and metal components in accessories.

Accessories claiming compatibility with a device with a digital compass (magnetometer) shall minimize interference with the digital compass and shall not repeatedly trigger compass recalibration.

Accessories claiming compatibility with a device with autofocus (AF) and/or optical image stabilization (OIS) shall not affect the operation of those features.

The following devices feature optical image stabilization:

- iPhone 14 Pro Max
- iPhone 14 Pro
- iPhone 14 Plus
- iPhone 14

- iPhone SE (3rd generation)
- iPhone 13 Pro Max
- iPhone 13 Pro
- iPhone 13
- iPhone 13 mini
- iPhone 12 Pro Max
- iPhone 12 Pro
- iPhone 12
- iPhone 12 mini
- iPhone SE (2nd generation)
- iPhone 11 Pro Max
- iPhone 11 Pro
- iPhone 11
- iPhone XS Max
- iPhone XS
- iPhone XR
- iPhone X
- iPhone 8 Plus
- iPhone 8
- iPhone 7 Plus
- iPhone 7
- iPhone 6s Plus
- iPhone 6 Plus
- iPad Pro 12.9-inch (2nd generation)
- iPad Pro 10.5-inch

4.7 Radio Frequency (RF) Performance

This section contains RF performance requirements and recommendations for accessories.

4.7.1 Materials and Coatings

Accessories should avoid use of:

- Metals
- Conductive materials or coatings
- Materials with high dielectric (permittivity >5 F/m)

Such materials absorb radio frequency energy and may impair or degrade the performance of antennas for cellular communication, GPS, Wi-Fi, Bluetooth, and NFC.

Examples include, but are not limited to:

- Steel, aluminum, magnesium, titanium, etc.
- · Plastics with any carbon content, glass content, or metallic plating
- Metallic paints
- Black paints with high carbon loading
- White paints with high titanium dioxide loading
- Metallic Physical Vapor Deposition (PVD) coatings

4.7.2 Antenna Keep-Out

Antenna keep-out regions can be found in Device Dimensional Drawings (page 206).

Accessory Materials and Coatings (page 25) which absorb radio frequency energy located in the antenna keep-out region have a higher risk of degrading device's wireless performance.

4.7.3 Over The Air (OTA) Transmission/Reception

Accessories shall not excessively degrade device's RF transmission efficiency. This can be quantified by measuring Total Radiated Power (TRP) across all of the device's operating bands.

Accessories shall not excessively degrade device's RF reception sensitivity. This can be quantified by measuring Effective Isotropic Sensitivity (EIS) across all of the device's operating bands.

Accessories may have a higher risk of excessively degrading device's RF performance if they:

- Contain magnets.
- Intrude on device Antenna Keep-Out (page 26) zones.
- Contain active electronic circuitry, such as:
 - · Bluetooth radios.
 - Switched-mode power supplies.
 - High speed data interfaces.

All accessory configurations shall be taken into account when designing for maximum RF compatibility. Examples include, but are not limited to:

- Accessory on/off.
- Accessory open/closed.
- Attachment present/not present, see Attachments (page 24).

4.7.4 Specific Absorption Rate (SAR)

A list of labs performing SAR testing with devices is available through the Apple MFi Licensing Program (page 21).

4.7.5 Near Field Communication (NFC)

Accessories shall not degrade device's NFC transaction performance.

Accessories may have a higher risk of degrading device's NFC transaction performance if they intrude on device Antenna Keep-Out (page 26) zones.

The following devices are NFC enabled:

- iPhone 14 Pro Max
- iPhone 14 Pro
- iPhone 14 Plus
- iPhone 14
- iPhone SE (3rd generation)
- iPhone 13 Pro Max
- iPhone 13 Pro
- iPhone 13
- iPhone 13 mini
- iPhone 12 Pro Max
- iPhone 12 Pro
- iPhone 12
- iPhone 12 mini
- iPhone SE (2nd generation)
- iPhone 11 Pro Max
- iPhone 11 Pro
- iPhone 11
- iPhone XS Max
- iPhone XS
- iPhone XR
- iPhone X
- iPhone 8 Plus
- iPhone 8
- iPhone 7 Plus
- iPhone 7
- iPhone SE
- · iPhone 6s Plus
- iPhone 6s
- iPhone 6 Plus
- iPhone 6

4.8 Thermal Management

The accessory's supported temperature range shall be greater than or equal to the published temperature ranges of every device it claims compatibility with.

4.9 Tripod Connections

Tripod connections shall comply with ISO 1222:2010. See https://www.iso.org/standard/55918.html.

5. Cases

Cases are accessories substantially enclosing devices.

Accessories substantially enclosing devices shall comply with the requirements stated in this chapter unless the accessory supports other features in this specification whose requirements conflict with the requirements in this chapter.

If the case has multiple user-detachable components substantially enclosing the device, the requirements shall be applied to each component separately.

5.1 Product Design

A well-designed case will securely house a device without interfering with the device's operation. Significant factors in mechanical design include access to the device's sensors, controls, and connectors. Dimensional drawings for devices can be found in Device Dimensional Drawings (page 206).

5.1.1 Device Protection

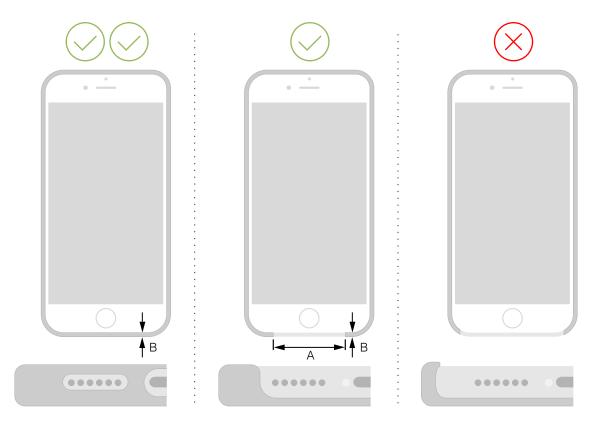
Cases shall protect the device from a 1 m drop onto a hard paved surface in any orientation.

Exposed glass on the device shall not come within 0.85 mm of a flat surface, such as a table or floor, in any orientation when the case is attached. Ideally the glass should not come within 1.00 mm. Device protection should be achieved by creating features around the exposed glass to keep it away from the flat surface.

Care should be given to the design of the bottom of the case to achieve both device protection and provide access to device speakers, microphones, and connectors. For example, the bottom of iPhone X cases should:

- Not have an opening wider than 50 mm, see dimension 'A' in Figure 5-1 (page 30).
- Be made of polycarbonate (PC) at least 1.15 mm thick, see dimension 'B' in Figure 5-1 (page 30).

Figure 5-1 Device Protection



5.1.2 Access to Inputs and Interconnects

Cases shall readily permit user access to inputs and interconnects.

5.1.2.1 Access to Controls

Cases shall readily permit user access and operation of the device's mechanical controls, such as:

- Volume buttons
- Ring/Silent switch
- Side button
- Home/Touch ID sensor
- Home button
- Sleep/Wake button

5.1.2.2 Access to the Headset Jack

Cases shall provide easy access to a device's headset jack (if present).

The headset jack opening (that is, keep-out area):

Shall be at least 6.0 mm in diameter and at most 14.0 mm deep.

 Should be at least 6.5 mm in diameter and at most 10.0 mm deep for the best compatibility with a range of headsets.

Headset jack openings shall be designed with enough margin to compensate for shifting or dimensional changes of the case material.

5.1.2.3 Access to the Lightning Connector

If the case is for a device with the Lightning connector, the opening (that is, keep-out area):

- Shall be at least 12.05 mm by 6.30 mm with full radii rounded edges.
- Should be at least 13.65 mm by 6.85 mm for best compatibility with a range of cables and docks.

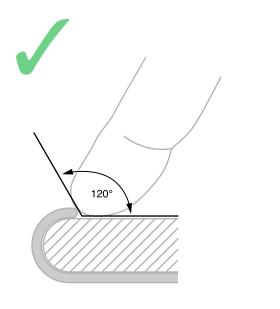
Lightning connector openings shall be designed with enough margin to compensate for shifting or dimensional changes of the case material.

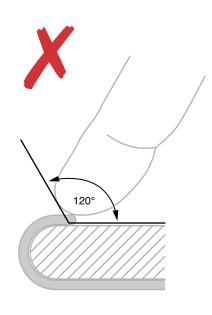
5.1.2.4 Touchscreen

Cases should not have any edges trapping water on the touchscreen when the device is held at a 30° angle relative to the horizon.

Cases shall allow a 120° opening, see Figure 5-2 (page 31), along the edges of a touchscreen's active area to ensure compatibility with touchscreen features. See Device Dimensional Drawings (page 206) for active areas.

Figure 5-2 Touchscreen keep-out angle





5.1.2.5 Edge Swipe Gestures

Users shall be able to easily use edge swipe gestures.

Examples of such gestures include, but are not limited to:

- Swipe in from the top edge for Control Center or Notification Center.
- Swipe in from the bottom edge for Home, App Switcher, or Reachability.
- Swipe in from the left edge in Messages or Mail to go back from a conversation.

The following devices make extensive use of edge swipe gestures in both portrait and landscape orientations:

- iPhone 14 Pro Max
- iPhone 14 Pro
- iPhone 14 Plus
- iPhone 14
- iPhone SE (3rd generation)
- iPhone 13 Pro Max
- iPhone 13 Pro
- iPhone 13
- iPhone 13 mini
- iPhone 12 Pro Max
- iPhone 12 Pro
- iPhone 12
- iPhone 12 mini
- iPhone SE (2nd generation)
- iPhone 11 Pro Max
- iPhone 11 Pro
- iPhone 11
- iPhone XS Max
- iPhone XS
- iPhone XR
- iPhone X
- iPad Pro 12.9-inch (6th generation)
- iPad Pro 11-inch (4th generation)
- iPad (10th generation)
- iPad Air (5th generation)
- iPad mini (6th generation)
- iPad Pro 12.9-inch (5th generation)
- iPad Pro 11-inch (3rd generation)
- iPad Air (4th generation)
- iPad Pro 12.9-inch (4th generation)
- iPad Pro 11-inch (2nd generation)

- iPad Pro 12.9-inch (3rd generation)
- iPad Pro 11-inch (1st generation)

5.1.2.6 Edge Press Gestures

Users shall be able to easily use edge press gestures.

The following devices support edge press gestures:

- iPhone 8 Plus
- iPhone 8
- iPhone 7 Plus
- iPhone 7
- iPhone 6s Plus
- iPhone 6s

An edge press gesture from the left is used to bring up the task switcher in iOS 9.0 and later.

5.1.2.7 Cover Glass Contact

Cases claiming compatibility with the following devices should not contact the cover glass as defined in their dimensional drawings:

- iPhone SE (3rd generation)
- iPhone SE (2nd generation)
- iPhone 11 Pro Max
- iPhone 11 Pro
- iPhone 11
- iPhone XS Max
- iPhone XS
- iPhone XR
- iPhone X
- iPhone 8 Plus
- iPhone 8
- iPhone 7 Plus
- iPhone 7
- iPhone 6s Plus
- iPhone 6s
- iPhone 6 Plus
- iPhone 6

See Device Dimensional Drawings (page 206).

5.1.3 Dock Compatibility

The distance from bottom of the device to the outside of a case should not exceed 1.8 mm. This improves compatibility with Lightning docks such as the Apple iPhone Lightning Dock.

5.1.4 Wireless Power and Rear Pockets

Cases claiming compatibility with MagSafe or Qi wireless power, see Device Power (Inductive) (page 116), shall not have rear pockets or holders for credit cards, RFID cards, or other similar items. Cards may be damaged and/or impact wireless charging performance.

5.2 Acoustics

Cases shall not impair or degrade the acoustic performance of a device.

5.2.1 Call Quality

Cases shall not impair or degrade the user experience making and receiving audio calls over a cellular network or audio/video calls using FaceTime in both handset and speakerphone modes. Cases should not change the frequency response of the speakers or microphones. In addition, the user should not hear any distortion or echo resulting from using the case.

Cases shall not obstruct any microphones during a phone call. Occluding microphones can result in call quality degradation.

5.2.2 Speaker to Microphone Coupling

Cases shall not facilitate the conduction of sound from any speaker to any microphone. Such sound conduction may cause echoing in phone calls.

5.2.3 Speaker/Microphone Openings

Device speaker/microphone port locations vary from model to model, see Device Dimensional Drawings (page 206).

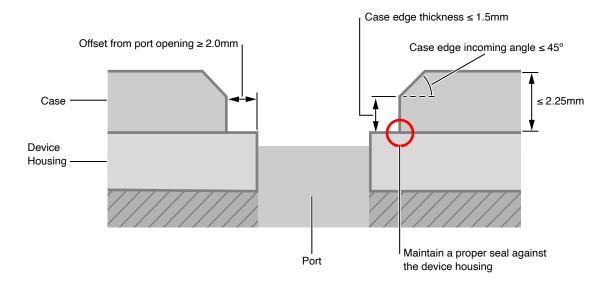
5.2.3.1 Thin Cases (≤2.25 mm)

Microphone/speaker openings in thin cases should:

- Be offset at least 2.0 mm from the edge of any device speaker/microphone port.
- Be at most 1.5 mm thick along their inner diameter.
- Have a maximum 45° incoming angle to their inner diameter.

Maintain a proper seal against the device between speaker/microphone ports.

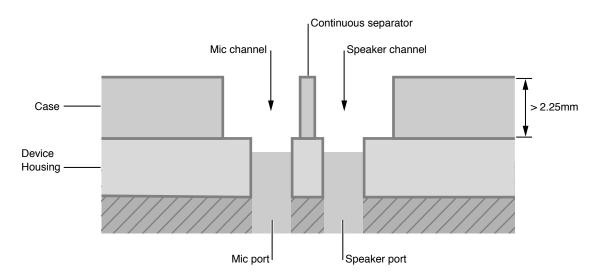
Figure 5-3 Microphone/speaker opening recommendations for thin cases



5.2.3.2 Thick Cases (>2.25 mm)

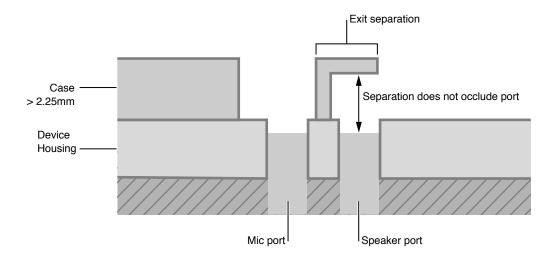
Speaker and microphone openings should be channeled independently and without interruption to/from the outside surface of a thick case.

Figure 5-4 Thick case acoustic channels



Thick cases should maximize exit separation between speaker and microphone channels.

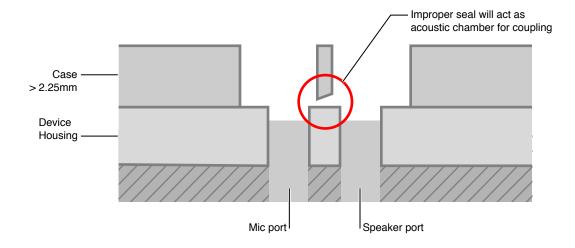
Figure 5-5 Thick case microphone and speaker exit separation



Thick case channels may act as a resonance chamber and detune microphone/speaker frequency response. The resulting frequency response may vary according to channel size/shape.

If a thick case does not maintain a proper seal against the device between microphone/speaker channels, the case itself may become an acoustic chamber.

Figure 5-6 Improper thick case seal



5.3 Ambient Light Sensor and Proximity Sensor

The ambient light sensor and proximity sensor locations for various devices are indicated in the Device Dimensional Drawings (page 206). Some of the dimensional drawings specify a keep-out area around these sensors.

5.4 Taptic Engine

Cases should not cause substantial change in the feel of the device's Taptic Engine.

The following devices contain a Taptic Engine:

- iPhone 14 Pro Max
- iPhone 14 Pro
- iPhone 14 Plus
- iPhone 14
- iPhone SE (3rd generation)
- iPhone 13 Pro Max
- iPhone 13 Pro
- iPhone 13
- iPhone 13 mini
- iPhone 12 Pro Max
- iPhone 12 Pro
- iPhone 12
- iPhone 12 mini
- iPhone SE (2nd generation)
- iPhone 11 Pro Max
- iPhone 11 Pro
- iPhone 11
- iPhone XS Max
- iPhone XS
- iPhone XR
- iPhone X
- iPhone 8 Plus
- iPhone 8
- iPhone 7 Plus
- iPhone 7
- iPhone 6s Plus
- iPhone 6s

5.5 Magnetic Interference

Cases shall not interfere with the device's:

- Magnetic compass.
- Rear camera autofocus.
- Rear camera optical image stabilization (OIS), if present.
- Front camera autofocus, if present.

See Magnetic Interference (page 24) for additional details.

5.6 Touch ID

Accessories shall not inhibit use of the device's Touch ID sensor. Touch ID sensor keep-outs for devices can be found in Device Dimensional Drawings (page 206).

Cases overlaying the sensor may cause users to have difficulty using Touch ID.

5.7 Camera

The camera field of view (FOV) and the illumination provided by the flash are designed for each device camera. It is exceptionally important manufacturers consult Device Dimensional Drawings (page 206) for each device and do not assume parameters are shared between devices.

Images from the camera may be affected by the geometry, color, and surface finish of the case.

Note:

Apple recommends a semi-gloss black material or coating around the camera and flash opening.

5.7.1 Geometry

The camera lens FOV shall not be blocked. Making an opening too small around the camera and flash may block the lens FOV and the illumination from the flash. Blocking the FOV may cause vignetting in the image, where one or more corners of the image are darker than the center. Blocking marginal rays just outside the lens FOV may also reduce the sharpness and contrast of the image. Blocking flash illumination may cause haze in the image, resulting in reduced contrast. See Device Dimensional Drawings (page 206) for the camera keep-out.

Case openings shall not be designed in a manner directing stray light into the camera lens. If the opening is too narrow or too steep, it may reflect light into the camera lens washing out the image or adding a color cast. Adding a chamfer to the openings near the camera may help direct stray light away from the camera lens. When the device includes a flash, a narrow or steep opening may reflect light from the camera and flash opening back into the camera lens. This may cause images to appear washed out or cause artifacts. Designers should also ensure mechanical keep-outs as outlined in the Device Dimensional Drawings (page 206) are maintained with worst-case X-Y placement tolerances to minimize the risk of haze.

5.7.2 Color

Light reflected from a case may carry the color of the case. Black material or black coatings may help avoid color bleeding into the camera lens. The darker the color the less likely light from a flash or external source may be reflected off the case and into the camera lens.

5.7.3 Surface Finish

Semi-gloss materials may help direct reflected light away from the camera lens. Matte or diffusing materials scatter light in all directions increasing the likelihood light from a flash or a strong external light source will be reflected into a camera lens.

5.7.4 Image Degradation Examples

Figure 5-7 Sample image degradation by image blocking in an ambient condition

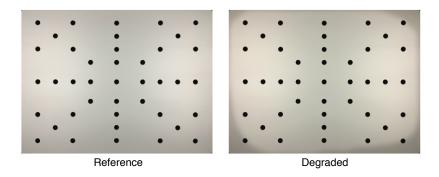


Figure 5-8 Sample image degradation by color shift through accessory with strong color

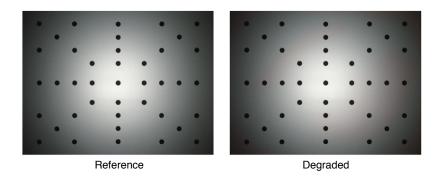
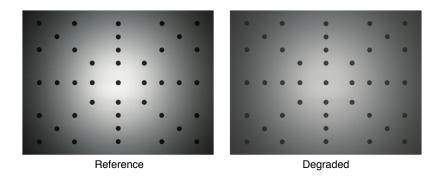


Figure 5-9 Sample image degradation by flash interference



5.8 Reliability

Cases shall be tested to verify they will withstand long-term use under typical use conditions, and will not impair or functionally degrade a device, cause damage to the device or its immediate surroundings, or adversely affect the user.

5.8.1 Device Insertion and Removal

Cases shall hold the device securely while permitting easy insertion and removal. A case shall not cause Scratches and Damage (page 23) to the device by the repeated insertion and removal of the device from the case under conditions representative of long-term use in a variety of environments.

5.8.2 Colorfastness

Dyes, inks, or coatings in or on the case shall not bleed color onto either the device or its user, particularly while the case is in contact with common substances such as water or sunscreen lotions.

5.9 Environmental

Cases shall comply with applicable environmental regulations for the regions in which such accessories are to be sold, as well as applicable substance or material restrictions including:

- Organic tin compounds, PFOS, PFOA, phthalates, azo dyes, polybrominated biphenyls (PBBs) and PAHs, per requirements of the EU REACh regulation EC 1907/2006.
- Nickel leach rate on surfaces in prolonged skin contact, per requirements of the EU REACh regulation EC 1907/2006.
- Cadmium, lead, hexavalent chromium, and nickel, per requirements of EU Directive 2009/48/EC.
- Natural rubber latex, per requirements of EU Directive EC 93/42/EEC.

- Dimethylfumarate (DMFu), per requirements of EU Regulation 412/2012.
- pH and Formaldehyde, per requirements of China GB 18401 for textiles and China GB 20400 for leather.
- Endangered species of flora and fauna in products or packaging (US Lacey Act).
- Polybrominated diphenyl ethers (PBDE).
- Compliance with California proposition 65, as applicable.

5.10 Test Procedures

5.10.1 Device Models

Case testing procedures vary depending on the device they enclose.

5.10.1.1 iPhone 14 Pro Max

Table 5-1 iPhone 14 Pro Max Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone 14 Pro Max	
MagSafe Case Magnet Array (page 137)	iPhone 14 Pro Max	Cases supporting MagSafe only.
Taptic Engine (page 55)	iPhone 14 Pro Max	
Acoustics (page 57)	iPhone 14 Pro Max	

5.10.1.2 iPhone 14 Pro

Table 5-2 iPhone 14 Pro Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone 14 Pro	
MagSafe Case Magnet Array (page 137)	iPhone 14 Pro	Cases supporting MagSafe only.
Taptic Engine (page 55)	iPhone 14 Pro	
Acoustics (page 57)	iPhone 14 Pro	

5.10.1.3 iPhone 14 Plus

Table 5-3 iPhone 14 Plus Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone 14 Plus	
MagSafe Case Magnet Array (page 137)	iPhone 14 Plus	Cases supporting MagSafe only.
Taptic Engine (page 55)	iPhone 14 Plus	
Acoustics (page 57)	iPhone 14 Plus	

5.10.1.4 iPhone 14

Table 5-4 iPhone 14 Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone 14	
MagSafe Case Magnet Array (page 137)	iPhone 14	Cases supporting MagSafe only.
Taptic Engine (page 55)	iPhone 14	
Acoustics (page 57)	iPhone 14	

5.10.1.5 iPhone 13 Pro Max

Table 5-5 iPhone 13 Pro Max Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone 13 Pro Max	
MagSafe Case Magnet Array (page 137)	iPhone 13 Pro Max	Cases supporting MagSafe only.
Taptic Engine (page 55)	iPhone 13 Pro Max	
Acoustics (page 57)	iPhone 13 Pro Max	

5.10.1.6 iPhone 13 Pro

Table 5-6 iPhone 13 Pro Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone 13 Pro	
MagSafe Case Magnet Array (page 137)	iPhone 13 Pro	Cases supporting MagSafe only.
Taptic Engine (page 55)	iPhone 13 Pro	
Acoustics (page 57)	iPhone 13 Pro	

5.10.1.7 iPhone 13

Table 5-7 iPhone 13 Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone 13	
MagSafe Case Magnet Array (page 137)	iPhone 13	Cases supporting MagSafe only.
Taptic Engine (page 55)	iPhone 13	
Acoustics (page 57)	iPhone 13	

5.10.1.8 iPhone 13 mini

Table 5-8 iPhone 13 mini Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone 13 mini	
MagSafe Case Magnet Array (page 137)	iPhone 13 mini	Cases supporting MagSafe only.
Taptic Engine (page 55)	iPhone 13 mini	
Acoustics (page 57)	iPhone 13 mini	

5.10.1.9 iPhone 12 Pro Max

Table 5-9 iPhone 12 Pro Max Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone 12 Pro Max	
MagSafe Case Magnet Array (page 137)	iPhone 12 Pro Max	Cases supporting MagSafe only.
Taptic Engine (page 55)	iPhone 12 Pro Max	
Acoustics (page 57)	iPhone 12 Pro Max	

5.10.1.10 iPhone 12 Pro

Table 5-10 iPhone 12 Pro Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone 12 Pro	
MagSafe Case Magnet Array (page 137)	iPhone 12 Pro	Cases supporting MagSafe only.
Taptic Engine (page 55)	iPhone 12 Pro	
Acoustics (page 57)	iPhone 12 Pro	

5.10.1.11 iPhone 12

Table 5-11 iPhone 12 Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone 12	
MagSafe Case Magnet Array (page 137)	iPhone 12	Cases supporting MagSafe only.
Taptic Engine (page 55)	iPhone 12	
Acoustics (page 57)	iPhone 12	

5.10.1.12 iPhone 12 mini

Table 5-12 iPhone 12 mini Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone 12 mini	
MagSafe Case Magnet Array (page 137)	iPhone 12 mini	Cases supporting MagSafe only.
Taptic Engine (page 55)	iPhone 12 mini	
Acoustics (page 57)	iPhone 12 mini	

5.10.1.13 iPhone 11 Pro Max

Table 5-13 iPhone 11 Pro Max Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone 11 Pro Max	
Taptic Engine (page 55)	iPhone 11 Pro Max	
Acoustics (page 57)	iPhone 11 Pro Max	

5.10.1.14 iPhone 11 Pro

Table 5-14 iPhone 11 Pro Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone 11 Pro	
Taptic Engine (page 55)	iPhone 11 Pro	
Acoustics (page 57)	iPhone 11 Pro	

5.10.1.15 iPhone 11

Table 5-15 iPhone 11 Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone 11	
Taptic Engine (page 55)	iPhone 11	
Acoustics (page 57)	iPhone 11	

5.10.1.16 iPhone XS Max

Table 5-16 iPhone XS Max Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone XS Max	
Taptic Engine (page 55)	iPhone XS Max	
Acoustics (page 57)	iPhone XS Max	

5.10.1.17 iPhone XS

Table 5-17 iPhone XS Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone XS	
Taptic Engine (page 55)	iPhone XS	
Acoustics (page 57)	iPhone XS	

5.10.1.18 iPhone XR

Table 5-18 iPhone XR Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone XR	
Taptic Engine (page 55)	iPhone XR	
Acoustics (page 57)	iPhone XR	

5.10.1.19 iPhone X

Table 5-19 iPhone X Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone X	
Taptic Engine (page 55)	iPhone X	
Acoustics (page 57)	iPhone X	

5.10.1.20 iPhone 8 Plus/iPhone 7 Plus

Table iPhone 8 Plus/iPhone 7 Plus Case Testing Matrix 5-20

Test	Using	Notes
Product Design (page 53)	iPhone 8 Plus and iPhone 7 Plus	
Taptic Engine (page 55)	iPhone 8 Plus and iPhone 7 Plus	
Touch ID Sensor Overlays (page 56)	iPhone 8 Plus and iPhone 7 Plus	
Acoustics (page 57)	iPhone 8 Plus and iPhone 7 Plus	

It is not possible for a case to claim compatibility with only the iPhone 8 Plus or only the iPhone 7 Plus.

5.10.1.21 iPhone SE (3rd generation)/iPhone SE (2nd generation)/iPhone 8/iPhone 7

Table 5-21 iPhone SE (3rd generation)/iPhone SE (2nd generation)/iPhone 8/iPhone 7 Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone SE (3rd generation), iPhone SE (2nd generation), iPhone 8, and iPhone 7	
Taptic Engine (page 55)	iPhone SE (3rd generation), iPhone SE (2nd generation), iPhone 8, and iPhone 7	
Touch ID Sensor Overlays (page 56)	iPhone SE (3rd generation), iPhone SE (2nd generation), iPhone 8, and iPhone 7	
Acoustics (page 57)	iPhone SE (3rd generation), iPhone SE (2nd generation), iPhone 8, and iPhone 7	

It is not possible for a case to claim compatibility with only the iPhone SE (3rd generation), only the iPhone SE (2rd generation), only the iPhone 8, or only the iPhone 7.

5.10.1.22 iPhone 6s Plus/iPhone 6 Plus

Table 5-22 iPhone 6s Plus/iPhone 6 Plus Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPhone 6s Plus and iPhone 6 Plus	
Taptic Engine (page 55)	iPhone 6s Plus	

It is not possible for a case to claim compatibility with only the iPhone 6s Plus or only the iPhone 6 Plus.

5.10.1.23 iPhone 6s/iPhone 6

Table iPhone 6s/iPhone 6 Case Testing Matrix 5-23

Test	Using	Notes
Product Design (page 53)	iPhone 6s and iPhone 6	
Taptic Engine (page 55)	iPhone 6s	

It is not possible for a case to claim compatibility with only the iPhone 6s or only the iPhone 6.

5.10.1.24 iPhone 5/iPhone 5s/iPhone SE

Table iPhone 5/iPhone 5s/iPhone SE Case Testing Matrix 5-24

Test	Using	Notes
Product Design (page 53)	iPhone SE	

It is not possible for a case to claim compatibility with only the iPhone 5 or only the iPhone 5s or only the iPhone SE.

5.10.1.25 iPhone 5c

Table iPhone 5c Case Testing Matrix 5-25

Test	Using	Notes
Product Design (page 53)	iPhone 5c	

5.10.1.26 iPad Pro 12.9-inch (6th generation) and iPad Pro 12.9-inch (5th generation)

Table iPad Pro 12.9-inch (6th generation) and iPad Pro 12.9-inch (5th generation) Case Testing

5-26 Matrix

Test	Using	Notes
Product Design (page 53)	iPad Pro 12.9-inch (6th generation)	

It is not possible for a case to claim compatibility with only the iPad Pro 12.9-inch (6th generation) or only the iPad Pro 12.9-inch (5th generation).

5.10.1.27 iPad Pro 11-inch (4th generation) and iPad Pro 11-inch (3rd generation)

Table 5-27 iPad Pro 11-inch (4th generation) and iPad Pro 11-inch (3rd generation) Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPad Pro 11-inch (4th generation)	

It is not possible for a case to claim compatibility with only the iPad Pro 11-inch (4th generation) or only the iPad Pro 11-inch (3rd generation).

5.10.1.28 iPad (10th generation)

Table iPad (10th generation) Case Testing Matrix 5-28

Test	Using	Notes
Product Design (page 53)	iPad (10th generation)	

5.10.1.29 iPad mini (6th generation)

Table iPad mini (6th generation) Case Testing Matrix 5-29

Test	Using	Notes
Product Design (page 53)	iPad mini (6th generation)	

5.10.1.30 iPad (7th generation)/iPad (8th generation)/iPad (9th generation)

Table iPad (7th generation)/iPad (8th generation)/iPad (9th generation) Case Testing Matrix 5-30

Test	Using	Notes
Product Design (page 53)	iPad (7th generation), iPad (8th generation), and iPad (9th generation)	

It is not possible for a case to claim compatibility with only the iPad (7th generation) or only the iPad (8th generation).

5.10.1.31 iPad Air (5th generation)/iPad Air (4th generation)

Table 5-31 iPad Air (5th generation)/iPad Air (4th generation) Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPad Air (5th generation)	

5.10.1.32 iPad Pro 12.9-inch (4th generation)

Table iPad Pro 12.9-inch (4th generation) Case Testing Matrix 5-32

Test	Using	Notes
Product Design (page 53)	iPad Pro 12.9-inch (4th generation)	

5.10.1.33 iPad Pro 11-inch (2nd generation)

Table iPad Pro 11-inch (2nd generation) Case Testing Matrix 5-33

Test	Using	Notes
Product Design (page 53)	iPad Pro 11-inch (2nd generation)	

5.10.1.34 iPad Air (3rd generation)

Table iPad Air (3rd generation) Case Testing Matrix 5-34

Test	Using	Notes
Product Design (page 53)	iPad Air (3rd generation)	

5.10.1.35 iPad mini (5th generation)

Table iPad mini (5th generation) Case Testing Matrix 5-35

Test	Using	Notes
Product Design (page 53)	iPad mini (5th generation)	

5.10.1.36 iPad Pro 12.9-inch (3rd generation)

Table iPad Pro 12.9-inch (3rd generation) Case Testing Matrix 5-36

Test	Using	Notes
Product Design (page 53)	iPad Pro 12.9-inch (3rd generation)	

5.10.1.37 iPad Pro 11-inch (1st generation)

Table 5-37 iPad Pro 11-inch (1st generation) Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPad Pro 11-inch (1st generation)	

5.10.1.38 iPad Pro 10.5-inch

Table iPad Pro 10.5-inch Case Testing Matrix 5-38

Test	Using	Notes
Product Design (page 53)	iPad Pro 10.5-inch	

5.10.1.39 iPad Pro 12.9-inch (2nd generation)

Table iPad Pro 12.9-inch (2nd generation) Case Testing Matrix 5-39

Test	Using	Notes
Product Design (page 53)	iPad Pro 12.9-inch (2nd generation)	

5.10.1.40 iPad (5th and 6th generation)

Table iPad (5th and 6th generation) Case Testing Matrix 5-40

Test	Using	Notes
Product Design (page 53)	iPad (5th generation) or iPad (6th generation)	

5.10.1.41 iPad Pro 9.7-inch

Table 5-41 iPad Pro 9.7-inch Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPad Pro 9.7-inch	

5.10.1.42 iPad Pro 12.9-inch (1st generation)

Table iPad Pro 12.9-inch (1st generation) Case Testing Matrix 5-42

Test	Using	Notes
Product Design (page 53)	iPad Pro 12.9-inch (1st generation)	

5.10.1.43 iPad mini 4

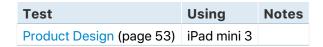
Table iPad mini 4 Case Testing Matrix 5-43

Test	Using	Notes
Product Design (page 53)	iPad mini 4	

5.10.1.44 iPad mini/iPad mini 2/iPad mini 3

Table iPad mini/iPad mini 2/iPad mini 3 Case Testing Matrix

5-44



It is not possible for a case to claim compatibility with only the iPad mini or only the iPad mini 2 or only the iPad mini 3.

5.10.1.45 iPad Air 2

Table iPad Air 2 Case Testing Matrix

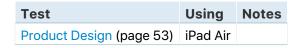
5-45



5.10.1.46 iPad Air

Table iPad Air Case Testing Matrix

5-46



5.10.1.47 iPad (4th generation)

Table 5-47 iPad (4th generation) Case Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPad (4th generation)	

5.10.1.48 iPod touch (5th generation)/iPod touch (6th generation)/iPod touch (7th generation)

Table iPod touch (5th generation)/iPod touch (6th generation)/iPod touch (7th generation) Case

5-48 Testing Matrix

Test	Using	Notes
Product Design (page 53)	iPod touch (7th generation)	

It is not possible for a case to claim compatibility with only the iPod touch (5th generation), iPod touch (6th generation) or the iPod touch (7th generation).

5.10.2 Product Design

5.10.2.1 Equipment

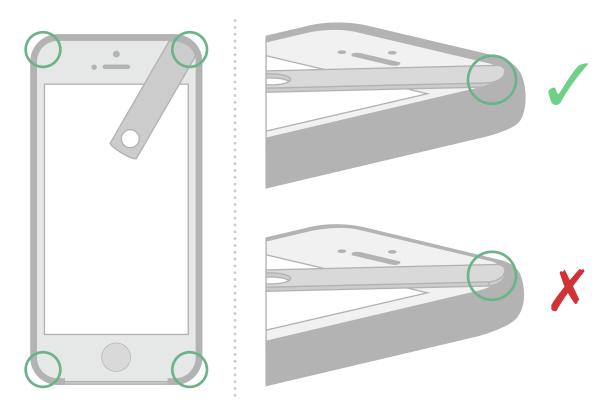
- Device
- Apple Lightning Digital AV Adapter for devices with a Lightning receptacle.
- Apple USB-C Digital AV Multiport Adapter for devices with a USB-C receptacle.
- EarPods with 3.5 mm Headphone Plug for devices with a 3.5 mm headset jack.
- Vernier calipers
- 0.85 mm plastic feeler gauge

5.10.2.2 Procedure

- 1. Insert the device into the case.
- 2. Verify the device completely fits inside the case.
- 3. Verify the device is not loose.
- 4. Verify all buttons are accessible.
- 5. Inspect for button feel. Verify all buttons are not too hard to press or take a lot of effort to press.
- 6. Verify speaker/microphone ports are not occluded.
- 7. If the device has an Apple Lightning receptacle:
 - a. Insert the Apple Lightning Digital AV Adapter into the receptacle and verify it fits.
 - **b.** Using vernier calipers, measure the Lightning connector opening on the case. Verify the opening is measured to be at least 12.05 mm by 6.30 mm.
- **8.** If the device has a USB-C receptacle:
 - a. Insert the Apple USB-C Digital AV Multiport Adapter into the receptacle and verify it fits.
 - **b.** Using vernier calipers, measure the USB-C connector opening on the case. Verify the opening is measured to be at least 10.25 mm by 5.54 mm.
- 9. If the device has a 3.5 mm headset jack:
 - a. Insert EarPods with 3.5 mm Headphone Plug into the headset jack and verify it fits.

- **b.** Using vernier calipers, measure the headset jack opening on the case. Verify the opening is measured to be at least 6 mm in diameter and no more than 14 mm deep.
- **10.** If the device has a Touch ID sensor integrated with the Home button, use vernier calipers to verify the case is at least 2 mm away from the Touch ID sensor.
- 11. If the device has a Touch ID sensor integrated with the Sleep/Wake button, use vernier calipers to verify the case meets the keep-out defined for each device the accessory claims compatibility with. See Device Dimensional Drawings (page 206).
- 12. Verify the case is always proud of the feeler gauge when the gauge is placed at each corner of the device. See Figure 5-10 (page 54).

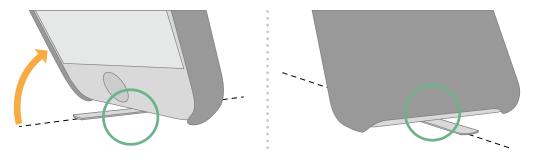
Figure Device proudness test 5-10



- 13. Set the device flat on its face (screen facing down).
- **14.** Roll the device towards any side not enclosed by the case until the gap between the device's exposed glass and flat surface is smallest.

15. Verify the feeler gauge fits into the gap between the device's exposed glass and flat surface.

Figure 5-11 Device gap test



16. If the case has an overlay, verify there are no air gaps introduced between it and the touchscreen.

5.10.3 Taptic Engine

5.10.3.1 Equipment

- Two devices A and B, same model
- Table

5.10.3.2 Procedure

- 1. Attach the case to device B.
- 2. Place device A on top of the table.
- 3. Place device B on top of the table next to device A.
- **4.** Compare the Taptic Engine feedback between device A and device B for each of the following tasks:
 - **a.** Go to: Settings > Sound & Haptics, set Play Haptics in Ring Mode and Play Haptics in Silent Mode to the on position.
 - **b.** Toggle the Ring/Silent switch.
 - **c.** Connect a charger to both devices.
 - **d.** Go to: Settings > Notifications > Phone > Sounds, select Reflection (Default).
 - **e.** Go to: Settings > Notifications > Messages > Sounds, select Note (Default).
 - f. Go to the Home screen.
 - **g.** Trigger a Quick Actions menu by applying pressure to the Settings app. Continue applying pressure.
 - h. Slide your finger across the Quick Actions menu and release when Wi-Fi is selected.
 - i. Go to the Home screen.
 - j. Apply pressure to the Home app.
 - k. Go to: Clock app and select *Timer* on the bottom right.
 - **I.** Scroll through the hours and minutes.

- 5. If the device has a Home button:
 - **a.** Go to: Settings > General > Home Button, tap option 2.
 - **b.** Press the Home button.
- 6. Repeat the above tasks while holding device A in the left hand and device B in the right hand.

5.10.3.3 Pass/Fail Criteria

The case does not cause substantial change in the feel of the device's Taptic Engine.

5.10.4 Touch ID Sensor Overlays

This test procedure applies to accessories overlaying the Touch ID sensor.

5.10.4.1 Equipment

- Nitrile gloves (for example, Ansell TNT Blue)
- Ethyl alcohol hand sanitizer (for example, Purell)
- Scissors

5.10.4.2 Procedure

- 1. Cut off a square of material from the nitrile glove's wrist portion.
- 2. Install the accessory onto the device.
- 3. Press the sleep/wake or side button to place the device into a sleep state (display off).
- **4.** Place the square of nitrile glove material over the Touch ID sensor with the glove's outer side facing away from the device.
- 5. Apply a small amount of hand sanitizer (approximately 2 cm in diameter) to the glove over the Touch ID sensor.
- 6. Repeat the following steps 10 times:
 - a. Press the Touch ID sensor with a thumb.
 - **b.** Verify the device wakes (display on).
 - **c.** Place the device into a sleep state (display off).
- **7.** Repeat the following steps 10 times:
 - a. Press the Touch ID sensor with an index finger.
 - **b.** Verify the device wakes (display on).
 - c. Place the device into a sleep state (display off).

5.10.4.3 Pass/Fail Criteria

Verify the device wakes every time the Touch ID sensor is pressed.

5.10.5 Acoustics

The following test procedures apply to devices with a built in speaker and/or microphone.

5.10.5.1 Speakerphone Call

This procedure evaluates the impact of a case on the speakerphone performance of a device.

5.10.5.1.1 Equipment and Test Setup

This procedure needs two operators in separate quiet rooms.

Room A:

- Operator A
- The device (with cellular service) used to evaluate the case.
 - The device should have at least two out of five bars of cellular reception within the room.

Room B:

- Operator B
- Landline speakerphone
- Digital audio recorder (for example, a device with the Voice Memo app)

5.10.5.1.2 Pass/Fail Criteria

There are two categories of failure for this procedure:

- Echo: If Operator B hears their own voice from the landline.
- Double Talk: If Operator B hears Operator A inconsistently.

The pass/fail threshold for these two categories should be established by performing the test procedure using:

The device (without the case) as a reference.

There should be no perceivable difference between the reference and the test conducted with the case on the device.

5.10.5.1.3 Procedure

- 1. Operator A: Use the device (without a case) in Room A to call the landline phone in Room B.
- 2. Operator A: Place the device in speakerphone mode.
- 3. Operator B: Answer the call with the landline phone in Room B.
- 4. Operator B: Place the landline phone in speakerphone mode.
- 5. Operator A and B: Simultaneously recite the following phrases to evaluate the call quality:
 - a. The birch canoe slid on the smooth planks.
 - **b.** Glue the sheet to the dark blue background.

- c. It's easy to tell the depth of a well.
- d. These days a chicken leg is a rare dish.
- e. Rice is often served in round bowls.
- **f.** The juice of lemons makes fine punch.
- **g.** The box was thrown beside the parked truck.
- **h.** The hogs were fed chopped corn and garbage.
- Four hours of steady work faced us.
- Large size in stockings is hard to sell.
- **6.** Operator B: Evaluate the call. Ensure the call is audible and clear when there is no case on the device.
- 7. Operator A: Place the case on the device.
- 8. Operator B: Start audio recording using a digital audio recorder.
- **9.** Operator A: State the test date and identify the manufacturer name, product name, and a unique identifier (UID) for case (production run name, design version, etc.).
- 10. Operator A and B: Simultaneously recite the same phrases as above.
- 11. Operator B: Stop audio recording.
- 12. Operator B: Evaluate the recording against the Pass/Fail Criteria (page 57).

Note:

The phrases used for this test procedure are from "IEEE Recommended Practice for Speech Quality Measurements," in *IEEE Transactions on Audio and Electroacoustics*, vol. 17, no. 3, pp. 225-246, September 1969.

6. Covers

This chapter is applicable to accessories covering device displays.

6.1 Magnetic Interference

Accessory covers shall not interfere with the device's:

- Magnetic compass.
- Rear camera autofocus.
- Rear camera optical image stabilization (OIS), if present.
- Front camera autofocus, if present.

See Magnetic Interference (page 24) for additional details.

6.2 Smart Covers

Dimensional drawings indicating magnet and Hall effect sensor locations are available for the following devices:

- iPad Pro 12.9-inch (6th generation) 3 of 5 (page 260)
- iPad Pro 11-inch (4th generation) 3 of 5 (page 265)
- iPad (10th generation) 4 of 6 (page 271)
- iPad Air (5th generation) and iPad Air (4th generation) 3 of 5 (page 276)
- iPad mini (6th generation) 3 of 6 (page 281)
- iPad mini (6th generation) 4 of 6 (page 282)
- iPad (9th generation), iPad (8th generation) and iPad (7th generation) 2 of 4 (page 286)
- iPad Pro 12.9-inch (5th generation) 3 of 5 (page 291)
- iPad Pro 11-inch (3rd generation) 3 of 5 (page 296)
- iPad Pro 12.9-inch (4th generation) 3 of 5 (page 301)
- iPad Pro 11-inch (2nd generation) 3 of 5 (page 306)
- iPad Air (3rd generation) with Wi-Fi 2 of 3 (page 310)
- iPad Air (3rd generation) with Wi-Fi + Cellular 2 of 3 (page 313)
- iPad mini (5th generation) with Wi-Fi 2 of 3 (page 316)
- iPad mini (5th generation) with Wi-Fi + Cellular 2 of 3 (page 319)
- iPad Pro 12.9-inch (3rd generation) 2 of 3 (page 322)

- iPad Pro 11-inch (1st generation) 2 of 3 (page 325)
- iPad Pro 12.9-inch (2nd generation) Magnet/Hall Effect Sensors 1 of 2 (page 329)
- iPad Pro 12.9-inch (2nd generation) Magnet/Hall Effect Sensors 2 of 2 (page 330)
- iPad Pro 10.5-inch Magnet/Hall Effect Sensors 1 of 2 (page 333)
- iPad Pro 10.5-inch Magnet/Hall Effect Sensors 2 of 2 (page 334)
- iPad (5th and 6th generation) Magnet/Hall Effect Sensors 1 of 2 (page 336)
- iPad (5th and 6th generation) Magnet/Hall Effect Sensors 2 of 2 (page 337)
- iPad Pro 9.7-inch Magnet/Hall Effect Sensors 1 of 2 (page 340)
- iPad Pro 9.7-inch Magnet/Hall Effect Sensors 2 of 2 (page 341)
- iPad Pro 12.9-inch (1st generation) Magnet/Hall Effect Sensors 1 of 2 (page 344)
- iPad Pro 12.9-inch (1st generation) Magnet/Hall Effect Sensors 2 of 2 (page 345)
- iPad mini 4 Magnet/Hall Effect Sensors (page 348)

7. Screen Overlays

The displays on Apple products have been carefully engineered and tested to deliver exacting visual performance. Many products also feature Multi-Touch technology to support user interactions. Any material overlaying the screen or between the surface and users' fingers (or writing instruments on iPad) may impact the visual, touch, or sensor performance.

7.1 Product Design

A screen overlay shall not:

- Degrade the performance of Multi-Touch, Apple Pencil, or sensors.
- Introduce air gaps between the touchscreen and overlay.
- Be electrically conductive.
- Cause any color tinge to cool white light sources.

A screen overlay should have a relative permittivity (dielectric) of 3.1 to 3.2.

A screen overlay should not:

- Exceed 0.3 mm in thickness.
- Exceed 0.095 mm in thickness to support Apple Pencil.
- Have a water contact angle <110°.

Note:

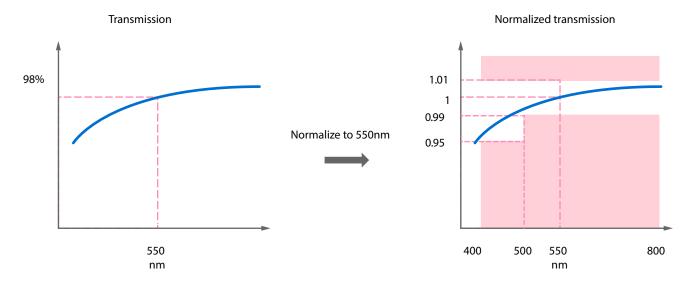
Non-glossy surfaces may accelerate Apple Pencil tip wear.

7.1.1 Optical Transmission

Optical transmission of screen overlays should:

- Be greater than 90% relative to clear glass for any viewing angle across the active display area, see Device Dimensional Drawings (page 206).
- Remain flat as defined in Figure 7-1 (page 62). Upon normalizing the transmission spectrum to the value at 550 nm, the normalized spectrum should fall in the range of [0.99, 1.01] from 500-800 nm and [0.95, 1.01] from 400-500 nm.

Figure 7-1 Transmission Spectrum



7.1.2 Infrared Transmission

Infrared transmission variance shall not exceed 1.5%. The infrared transmission in the 1200 nm - 1500 nm range relative to light source should be greater than:

- 90% for an angle of incidence between 0° and 45°.
- 84% for an angle of incidence between 45° and 60°.

7.1.3 Transmission Haze

Transmission haze is the percentage of visible and infrared light scattered at more than 2.5° from the normal transmission. Transmission haze should:

- Not exceed 0.3% for iPhone 14 Pro Max and iPhone 14 Pro.
- Not exceed 13% for all other devices.
- Be measured with a haze meter, per ASTM D1003.

7.1.4 Dynamic Island

Screen overlays shall not have a punch-out for the Dynamic Island on iPhone 14 Pro Max and iPhone 14 Pro.

7.2 Edge Swipe and Edge Press Gestures

See Edge Swipe Gestures (page 32) and Edge Press Gestures (page 33).

8. Camera Attachments

This chapter is applicable to accessories intentionally altering images captured by device cameras.

8.1 Magnetic Interference

Accessory camera attachments shall not interfere with the device's:

- Magnetic compass.
- Rear camera autofocus.
- Rear camera optical image stabilization (OIS), if present.
- Front camera autofocus, if present.

See Magnetic Interference (page 24) for additional details.

9. Adapters

An adapter accessory is a dongle or a Built-In Cable (page 20) enabling connections between physically incompatible devices and accessories.

Unless otherwise specified, accessories may integrate one or more adapter components as well as other accessory features to create more advanced multi-port adapters. For example, a Lightning or USB-C adapter may support audio, power, external storage, media controls, app communication, and more.

See the Accessory Interface Specification (page 21) for more information.

9.1 Headset Adapters (Lightning to 3.5 mm)

Lightning to 3.5 mm headset adapters are accessories enabling 3.5 mm audio connections.

See the Accessory Interface Specification (page 21) for more information.

9.2 USB-A/USB-C to Lightning Headset Adapters

USB-A to Lightning or USB-C to Lightning headset adapters are accessories integrating a Lightning Receptacle (C37) to support Lightning headsets, speakers, and microphones.

See the Accessory Interface Specification (page 21) for more information.

9.3 Ethernet Adapters (Lightning to RJ45)

A Lightning to Ethernet adapter is an accessory enabling a device to access a wired network. The Apple USB Ethernet Adapter is an example of a similar accessory for a Mac.

See the Accessory Interface Specification (page 21) for more information.

9.4 Lightning to USB Micro-B Adapters

Figure 9-1 Lightning to USB Micro-B Adapter



Lightning to USB Micro-B adapters are Lightning dongle accessories functioning exactly like the Apple Lightning to USB Micro-B Adapter and shall consist of:

- Lightning connector.
- USB Micro-B receptacle.

See the Accessory Interface Specification (page 21) for more information.

10. AC Power Adapters

AC power adapters convert AC "mains" power to DC for the purpose of providing power to a device. They may provide power using one or more of the following:

- USB-C Receptacle (page 202) combined with a USB-C to Lightning cable.
- USB-A Receptacle (page 199) combined with a USB-A to Lightning cable.
- Device Power (Inductive) (page 116).

10.1 Converter Switching Frequencies

Device touchscreen or audio functionality may be degraded if converter switching frequencies do not meet the following requirements:

- Under loads greater than 5 mA, converter switching frequencies shall be above 22 kHz.
- Under loads greater than 20 mA, converter switching frequencies:
 - Shall be above 60 kHz.
 - Should be above 450 kHz.

10.2 YCAP AC Capacitor

AC power adapters should include a YCAP AC capacitor (up to 1000 pF) between the primary and secondary sections of the adapter's transformer to reduce common-mode noise at switching frequencies. These frequencies or their harmonics can interfere with device touchscreen sensors.

10.3 Impedance Stability

AC power adapter series impedance should not change abruptly. Sudden changes in impedance may cause touchscreen sensor output oscillations.

Bridge diodes used in full-wave bridge rectifiers can be a major source of abrupt changes in the series impedance. If the bridge diodes have large inherent reverse capacitance (greater than 100 pF), then the net impedance change due to diode switching may be acceptably small. However, diode reverse capacitance may decrease in more compact IC designs due to decreased chip area.

Impedance of bridge diodes with unacceptably low reverse capacitance can be stabilized using the example circuit shown in Figure 10-1 (page 67) and Table 10-1 (page 67). In this example, capacitors C1, C2, C3, and C4 have been placed in parallel with diodes D1, D2, D3, and D4 to stabilize the bridge impedance. Their values are larger than the inherent reverse capacitances of the diodes.

Resistors R1, R2, R3, and R4 are optional; if included, they can block noise at very high frequencies, which can help with EMI compatibility. The recommended values of R1, R2, R3, and R4 in Table 10-1 (page 67) were chosen to have trivial levels of impedance relative to the impedances of C1, C2, C3, and C4 at power line frequencies.

Figure Typical AC power adapter diode bridge circuit 10-1

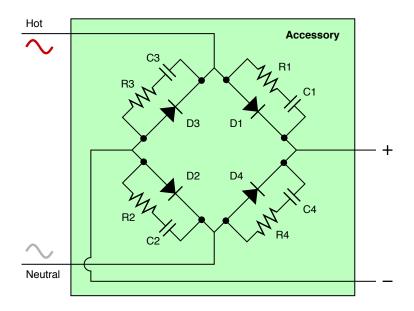


Table 10-1 Typical component values for an AC power adapter diode bridge circuit

Component	Value
C1, C2, C3, C4	47 pF
R1, R2, R3, R4	2 kΩ

10.4 Fuse Protection

A fuse should be present at the input of the AC power adapter to protect it under any fault condition.

10.5 Short Circuit Response

The output of the AC power adapter should drop or fold back without any resulting damage if its output is shorted to the secondary common (less than 10 m Ω).

11. Battery Packs

A battery pack is an accessory designed to provide power to the device.

The battery pack may provide power using one or more of the following:

- Inductive power transmitter, see Device Power (Inductive) (page 116).
- Integrated Lightning connector, see Device Power (Lightning) (page 111).
- USB-C Receptacle (page 202) combined with a USB-C to Lightning cable.
- USB-A Receptacle (page 199) combined with a USB-A to Lightning cable.

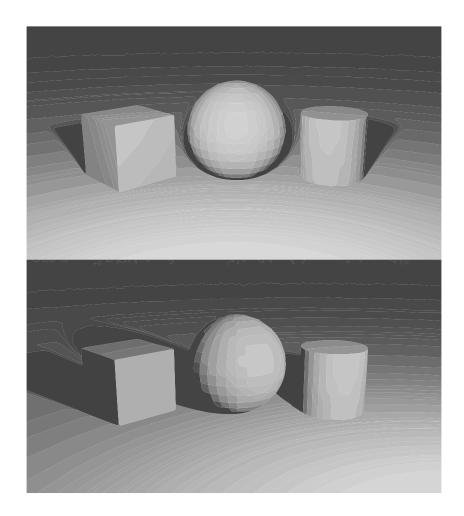
12. Strobes

Strobe accessories replace a device's integrated flash when capturing a still image from either the front or rear-facing cameras. Photographers can use such accessories to control scene lighting for creative purposes.

Strobes are:

- Compatible with all iOS camera applications.
- Synchronized with the iPhone camera using the Lightning connector.

Figure Example of integrated flash (top) vs. accessory strobe (bottom) 12-1



The following devices support strobe accessories:

- iPhone 14 Pro Max
- iPhone 14 Pro
- iPhone 14 Plus
- iPhone 14
- iPhone SE (3rd generation)
- iPhone 13 Pro Max
- iPhone 13 Pro
- iPhone 13
- iPhone 13 mini
- iPhone 12 Pro Max
- iPhone 12 Pro
- iPhone 12
- iPhone 12 mini
- iPhone SE (2nd generation)
- iPhone 11 Pro Max
- iPhone 11 Pro
- iPhone 11

This feature is supported on iOS 14.0 or later.

See the Accessory Interface Specification (page 21) for more information.

13. Keyboards

Devices may accept user input from accessory keyboards in place of the onscreen keyboard.

13.1 Requirements

Keyboards shall support the Human Interface Device (HID) (page 175) protocol and comply with all the requirements listed in Requirements (page 175).

Note:

Keyboards shall not identify themselves as Apple-branded accessories, for example, using the Apple Vendor ID and/or Product IDs.

Keyboard keys exhibiting any of the following behaviors are explicitly prohibited:

- Send anything other than 'key pressed' or 'key released' for key(s) physically pressed/released.
- Emulate combinations or sequences of keys (for example, a Copy button sending %-C or macros generating a timed sequence of events).
- Emulate timed user actions, such as 'press-and-hold'.
- Send different HID usages depending on the state of another control surface.

All HID usages sent from the keyboard shall occur in response to a Direct User Action (page 20).

Keyboards may integrate LEDs to indicate the:

- Caps Lock status of the device.
- Connection status, such as Bluetooth state.
- Battery status of the accessory, if applicable.

Keyboards shall not incorporate any other status LEDs not supported by devices.

Keyboards should be integrated with Trackpads (page 78) when possible to provide an enhanced user experience.

Mechanical key layout shall be based on the ISO/IEC 9995-2, ANSI-INCITS 154-1988, or JIS X 6002-1980 standards. Keyboard HID descriptors shall set the Keyboard Physical Layout usage to the appropriate layout code as defined in Table 13-4 (page 76).

Keyboard HID descriptors shall set the bCountryCode field to the appropriate country code as defined in *Device Class Definition for Human Interface Devices (HID) Version 1.11, section 6.2.1 HID Descriptor.*

Keyboard HID descriptors shall declare support for the HID Keyboard/Keypad Page. HID report descriptors may declare a input usage minimum of 0 and maximum of 255 as shown in Example HID Report Descriptor (page 76) for efficiency. Otherwise, the descriptor shall individually enumerate each HID Keyboard/Keypad page usage the keyboard is capable of sending.

Keyboards shall implement individual keys emitting the following HID Keyboard/Keypad page usages:

Table 13-1 Required HID Keyboard/Keypad Page (0x07) controls for use by keyboards

Usage ID	Usage Name	Apple Function
0x0004	a and A	a and A
0x0005	b and B	b and B
0x0006	c and C	c and C
0x0007	d and D	d and D
0x0008	e and E	e and E
0x0009	f and F	f and F
0x000A	g and G	g and G
0x000B	h and H	h and H
0x000C	i and I	i and I
0x000D	j and J	j and J
0x000E	k and K	k and K
0x000F	I and L	I and L
0x0010	m and M	m and M
0x0011	n and N	n and N
0x0012	o and O	o and O
0x0013	p and P	p and P
0x0014	q and Q	q and Q
0x0015	r and R	r and R
0x0016	s and S	s and S
0x0017	t and T	t and T
0x0018	u and U	u and U
0x0019	v and V	v and V
0x001A	w and W	w and W
0x001B	x and X	x and X
0x001C	y and Y	y and Y
0x001D	z and Z	z and Z
0x001E	1 and !	1 and !
0x001F	2 and @	2 and @

Usage ID	Usage Name	Apple Function	
0x0020	3 and #	3 and #	
0x0021	4 and \$	4 and \$	
0x0022	5 and %	5 and %	
0x0023	6 and ^	6 and ^	
0x0024	7 and &	7 and &	
0x0025	8 and *	8 and *	
0x0026	9 and (9 and (
0x0027	0 and)	0 and)	
0x0028	Return/Enter	Return	
0x002A	Delete/Backspace	Delete	
0x002B	Tab	Tab	
0x002C	Spacebar	Spacebar	
0x002D	- and _	- and _	
0x002E	= and +	= and +	
0x002F	[and {	[and {	
0x0030] and }] and }	
0x0031	\ and	\ and	
0x0033	; and :	; and :	
0x0034	' and "	' and "	
0x0035	Grave Accent and Tilde	` and ~	
0x0036	, and <	, and <	
0x0037	. and >	. and >	
0x0038	/ and ?	/ and ?	
0x0039	CapsLock	Caps Lock	
0x004F	RightArrow	Right Arrow	
0x0050	LeftArrow	Left Arrow	
0x0051	DownArrow	Down Arrow	
0x0052	UpArrow	Up Arrow	
0x00E1	LeftShift	Left Shift	
0x00E2	LeftAlt	Left Option / Alt	
0x00E3	LeftGUI	Left Command / 光	
0x00E5	RightShift	Right Shift	
0x00E6	RightAlt	Right Option / Alt	
0x00E7	RightGUI	Right Command / 光	

Keyboards may implement individual keys emitting the following HID Keyboard/Keypad page usages:

Table 13-2 Optional HID Keyboard/Keypad Page (0x07) controls for use by keyboards

Usage ID	Usage Name	Apple Function
0x0029	Escape	Escape
0x00E0	LeftControl	Left Control
0x00E4	RightControl	Right Control
0x004A	Home	Home
0x004D	End	End
0x0054	Keypad /	Keypad /
0x0055	Keypad *	Keypad *
0x0056	Keypad -	Keypad -
0x0057	Keypad +	Keypad +
0x0058	Keypad Enter	Keypad Enter
0x0059	Keypad 1 and End	Keypad 1
0x005A	Keypad 2 and Down Arrow	Keypad 2
0x005B	Keypad 3 and PageDn	Keypad 3
0x005C	Keypad 4 and Left Arrow	Keypad 4
0x005D	Keypad 5	Keypad 5
0x005E	Keypad 6 and Right Arrow	Keypad 6
0x005F	Keypad 7 and Home	Keypad 7
0x0060	Keypad 8 and Up Arrow	Keypad 8
0x0061	Keypad 9 and PageUp	Keypad 9
0x0062	Keypad 0 and Insert	Keypad 0
0x0063	Keypad . and Delete	Keypad .
0x0067	Keypad =	Keypad =

Keyboards may implement individual keys emitting the following HID Consumer page usages:

Table 13-3 HID Consumer Page (0x0C) controls for use by keyboards

Usage ID	Usage Name	Apple Function
0x0030	Power	Lock
0x0040	Menu	Home Button
0x006F	Display Brightness Increment	Brighter
0x0070	Display Brightness Decrement	Dimmer
0x00B5	Scan Next Track	Transport Right
0x00B6	Scan Previous Track	Transport Left
0x00CD	Play/Pause	Play/Pause
0x00E2	Mute	Mute
0x00E9	Volume Increment	Louder

Usage ID	Usage Name	Apple Function	
0x00EA	Volume Decrement	Softer	
0x01AE	AL Keyboard Layout	Toggle Onscreen Keyboard	
0x029D	AC Keyboard Layout Select	Globe Key	
0x0221	AC Search	Spotlight	
0x025B	Promote	Play More Like This	
0x025C	Demote	Play Less Like This	
0x0262	Add to Cart	Add to Wish List	
0x02C3	Keyboard Physical Layout	Keyboard Physical Layout, see Table 13-4 (page 76).	

Table 13-4 Keyboard Physical Layout Codes

Value	Description
1	101 (for example, US) - ANSI
3	102 (for example, German) - ISO
5	106 (DOS/V Japan) - JIS

JIS keyboards shall also implement additional keys found on the Japanese Apple Magic Keyboard. Non-JIS keyboards shall not implement the Japanese keys.

Table 13-5 Required HID Keyboard/Keypad Page (0x07) controls for use by JIS keyboards

Usage ID	Usage Name	Apple Function
0x0087	Keyboard International1	_
0x0089	Keyboard International3	¥
0x0090	LANG1	Switch to Previous Language
0x0091	LANG2	Switch to Next Language

13.2 Examples

13.2.1 Example HID Report Descriptor

05 01	
09 06	
A1 01	
05 08	
15 00	
25 01	
09 02	
75 01	
	09 06 A1 01 05 08 15 00 25 01 09 02

REPORT COUNT (1)	95 01
OUTPUT (Data, Var, Abs)	91 02
REPORT SIZE (7)	75 07
REPORT COUNT (1)	95 01
OUTPUT (Cnst,Var,Abs)	91 03
USAGE PAGE (Keyboard)	05 07
USAGE MINIMUM (Keyboard Left Control)	19 E0
USAGE MAXIMUM (Keyboard Right GUI)	29 E7
REPORT SIZE (1)	75 01
REPORT COUNT (8)	95 08
INPUT (Data,Var,Abs)	81 02
LOGICAL MINIMUM (0)	15 00
LOGICAL MAXIMUM (255)	26 FF 00
USAGE MINIMUM (0)	19 00
USAGE MAXIMUM (255)	2A FF 00
REPORT SIZE (8)	75 08
REPORT COUNT (5)	95 05
<pre>INPUT (Data,Ary,Abs)</pre>	81 00
USAGE PAGE (Consumer Devices)	05 0C
LOGICAL MINIMUM (0)	15 00
LOGICAL MAXIMUM (1)	25 01
USAGE (Menu)	09 40
USAGE (AC Search)	0A 21 02
USAGE (AL Keyboard Layout)	0A AE 01
USAGE (Scan Previous Track)	09 B6
USAGE (Play/Pause)	09 CD
USAGE (Scan Next Track)	09 B5
USAGE (Mute)	09 E2
USAGE (Volume Down)	09 EA
USAGE (Volume Up)	09 E9
USAGE (Power)	09 30
REPORT SIZE (1)	75 01
REPORT COUNT (10)	95 0A
INPUT (Data,Var,Abs)	81 02
REPORT SIZE (6)	75 06
REPORT COUNT (1)	95 01
INPUT (Cnst,Var,Abs)	81 03
END COLLECTION	C0

14. Trackpads

Devices may accept user input from accessory trackpads.

This feature is supported on iPadOS 14.5 or later.

14.1 Requirements

Accessory trackpads shall support the Human Interface Device (HID) (page 175) protocol and comply with all the requirements listed in Requirements (page 175).

Note:

Accessory trackpads shall not identify themselves as Apple-branded accessories, for example, using the Apple Vendor ID and/or Product IDs.

Accessory trackpads exhibiting any of the following behaviors are explicitly prohibited:

- Emulate combinations of touch gestures.
- Emulate timed user actions, such as 'click and hold', drag, and zoom gestures.
- Send different HID usages depending on the state of another control surface.

All HID reports sent from the accessory trackpad shall occur in response to a Direct User Action (page 20).

Trackpads shall support 2-5 simultaneous contacts on the digitizer surface.

14.1.1 Integration with Keyboards

Accessory trackpads shall be integrated with Keyboards (page 72) and simultaneously support both input methods. The following are examples of interactions involving both keyboard and trackpad input:

- Rapidly transitioning between cursor movement and keyboard entry.
- Pressing and holding modifier keys while performing a drag.
- Pressing #-Tab to see the app switcher, then using the cursor to switch apps.
- Dragging an item using the trackpad, followed by pressing 第-Tab to switch apps.

14.1.2 HID Report Descriptor

HID report descriptors for an accessory trackpad shall declare support for the HID Digitizer Page.

Accessory trackpads shall implement the following HID Digitizer page usages:

Table 14-1 Required HID Digitizer Page (0x0D) controls for use by accessory trackpads

Usage ID	Usage Name	Apple Function	
0x01	Button 1	Primary button state	
0x05	Report ID	Feature Report ID	
0x22	Finger	Number of contact collection points	
0x30	X	X coordinate of contact position	
0x31	Υ	Y coordinate of contact position	
0x38 or 0x51	Transducer Index or Contact ID	Index (from 0-4) uniquely identifying the finger/contact	
0x42	Tip Switch	Contact is on the surface of the digitizer	
0x47	Confidence	Touch is an intended, valid contact	
0x57	Surface Switch	Digitizer surface on/off	

Accessory trackpads may implement the following HID Digitizer page usages. These HID usages are recommended:

Table 14-2 Recommended HID Digitizer Page (0x0D) controls for use by accessory trackpads

Usage ID	Usage Name	Apple Function	
0x02	Button 2	Secondary button state	
0x56	Scan Time	Relative scan time	
0xA1	Report Rate	Report rate (Hz)	

14.1.3 Coexistence

Accessory trackpads shall:

- Not degrade the performance of Multi-Touch or Apple Pencil.
- Not support a drive voltage greater than 6 V_{pp} .
- Not support drive frequencies less than 500 kHz.
- Support 3 or more drive frequencies, separated by at least 50 kHz each.
- Dynamically switch between drive frequencies whenever effective resolution drops below 120 DPI.
 For example, effective resolution may drop in the presence of 50 mV RMS noise from external power sources.

Accessory trackpads should support a sine wave narrow band drive frequency.

14.1.4 Performance

Accessory trackpads shall:

- Behave uniformly across the digitizer surface.
- Uniquely detect contact points as close as 8 mm center to center.
- Detect contact sizes of at least 5 mm.
- Differentiate between multi-finger taps and single-finger drags.
- Maintain an effective input resolution less than 20 µm and immediately report positional updates greater than or equal to the effective input resolution.
- Maintain an effective resolution more than 600 DPI.
- Maintain the highest possible report rate to the device. Apple recommends 60 Hz or higher.
- Maintain a panning latency less than or equal to 23 ms.
- Maintain a touch down latency less than or equal to 35 ms.
- Maintain a positional accuracy less than or equal to 500 μm.
- Maintain a stationary contact jitter less than or equal to 210 μm.
- Not deviate more than 250 µm from an ideal line.

14.1.5 Input Confidence

Accessory trackpads shall:

- Set the Confidence usage when an input transitions from valid to invalid. Contact transitions should be quick, accurate, and stable to achieve the best user experience. Incorrect or fluctuating classification of contacts may result in recognition of unintended gestures, interruption, or cancelation of intended gestures.
- Detect and reject unintended/invalid inputs, such as palms, while continuing to report valid inputs to the device, such as multiple contacts.
- Distinguish between a valid large thumb and an invalid lightly resting palm.
- Reject inputs ≥1 mm from the tracking surface.

14.1.6 Click to Wake

Devices use Report ID usage to indicate to the trackpad whether surface contacts shall be reported or not. Devices will use the Surface Switch usage to tell the accessory to go into Click to Wake mode where only button clicks are accepted. Trackpads may use this opportunity to go into a low power mode where the digitizer surface does not have to be constantly scanned.

This feature report also doubles as an informational report. Devices may query the accessory trackpad at any time after enumeration to obtain the current state of the Surface Switch, and also to get the accessory's Report Rate.

14.2.1 Example HID Report Descriptor

The following descriptor is for a 92.10 mm x 50.60 mm trackpad with two buttons supporting up to five simultaneous contacts.

Additional modifications may be necessary in order to implement this HID report descriptor in the accessory trackpad firmware, specifically:

- Modify physical maximum values for X (0x30) and Y (0x31) positions of each finger to match the physical size of the accessory trackpad. Units are in tenths of a mm (0.1 mm). In the example, X goes from 0x0 to 0x0399 (92.10 mm) and Y goes from 0x0 to 0x01FA (50.60 mm).
- Modify logical maximum values for the X (0x30) and Y (0x31) of each finger positions to match the resolution of the accessory trackpad. In the example, X (0x30) goes from 0 to 0x0451 (for a resolution of $92.10/1105 = \sim 0.083$ mm) and Y (0x31) goes from 0 to 0x025F (for the same resolution of $50.60/607 = \sim 0.083$ mm).

```
USAGE PAGE (Digitizer Device Page)
                                                     95 9D
USAGE (Touch Pad)
                                                     09 05
COLLECTION (Application)
                                                     A1 01
 REPORT_ID (3)
                                                     85 03
                                                     27 FF FF 00 00
 LOGICAL MAXIMUM (65535)
 USAGE (Relative Scan Time (DV=Dynamic Value))
                                                     09 56
 REPORT SIZE (16)
                                                     75 10
 REPORT COUNT (1)
                                                     95 01
 INPUT (Data, Var, Abs)
                                                     81 02
 LOGICAL MAXIMUM (1)
                                                     25 01
 REPORT SIZE (1)
                                                     75 01
                                                     09 57
 USAGE (Surface Switch)
 FEATURE (Data, Var, Abs)
                                                     B1 02
                                                     26 FF 7F
 LOGICAL MAXIMUM (32767)
 REPORT SIZE (15)
                                                     75 0F
 USAGE (Report Rate)
                                                     09 A1
 FEATURE (Data, Var, Abs)
                                                     B1 02
 USAGE PAGE (Button Page)
                                                     05 09
 LOGICAL MAXIMUM (1)
                                                     25 01
 USAGE MINIMUM (Button 1)
                                                     19 01
                                                     29 02
 USAGE MAXIMUM (Button 2)
 REPORT COUNT (2)
                                                     95 92
 REPORT SIZE (1)
                                                     75 01
 INPUT (Data, Var, Abs)
                                                     81 02
                                                     95 06
 REPORT COUNT (6)
 INPUT (Cost, Ary, Abs)
                                                     81 01
 USAGE PAGE (Digitizer Device Page)
                                                     05 0D
                                                     09 22
 USAGE (Finger)
 COLLECTION (Physical)
                                                     A1 00
 USAGE (Tip Switch)
                                                     09 42
 USAGE (Confidence)
                                                     09 47
```

INPUT (Data, Var, Abs) LOGICAL MAXIMUM (5) USAGE (Transducer Index) REPORT SIZE (6) REPORT SIZE (6) REPORT COUNT (1) INPUT (Data, Var, Abs) USAGE PAGE (Generic Desktop Page) PHYSICAL MAXIMUM (921) PHYSICAL MAXIMUM (1105) REPORT SIZE (12) USAGE RAGE (In Continued and in the continued and in t	REPORT COUNT (2)	95 02
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USAGE (Transducer Index) REPORT SIZE (6) REPORT SOUNT (1) SP 06 REPORT COUNT (1) SP 07 REPORT COUNT (1) SP 07 REPORT COUNT (1) RPUT (Data, Var, Abs) USAGE PAGE (Generic Desktop Page) SP 07 REPORT SIZE (12) SP 07 REPORT SIZE (13) SP 07 REPORT SIZE (14) SP 07 REPORT SIZE (15) SP 07 REPORT SIZE (16) SP 07 REPORT SIZE (17 SP 07 REPORT SIZE (17 SP 07 REPORT SIZE (18 SP 08 REPORT SIZE (19 SP 08 REPORT	• •	
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USAGE PAGE (Generic Desktop Page)		
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REPORT SIZE (12) 75 0C UNIT EXPONENT (Unit Value x .01) 55 0E GLOBAL UNIT (Distance in centimeters) 65 11 USAGE (X) 99 30 INPUT (Data, Var, Abs) 81 02 PHYSICAL MAXIMUM (506) 46 FA 03 USAGE (Y) 99 31 INPUT (Data, Var, Abs) 81 02 END COLLECTION (Physical) C0 USAGE PAGE (Digitizer Device Page) 92 COLLECTION (PHYSICAL) A1 00 USAGE (Finger) 99 22 COLLECTION (PHYSICAL) A1 00 USAGE (Tip Switch) 99 47 REPORT SIZE (1) 75 01 REPORT SIZE (1) 75 01 REPORT SIZE (1) 75 01 INPUT (Data, Var, Abs) 81 02 USAGE (Transducer Index) 99 38 LOGICAL MAXIMUM (5) 25 05 REPORT SIZE (6) 75 06 REPORT COUNT (1) 95 01 INPUT (Data, Var, Abs) 81 02 USAGE PAGE (Generic Desktop Page) 95 01 PHYSICAL MAXIMUM (921) 46 99 03 INPUT (Data, Var, Abs) 91 04 USAGE (X) 99 30 INPUT (Data, Var, Abs) 91 05 REPORT SIZE (12) 75 0C USAGE (X) 99 30 INPUT (Data, Var, Abs) 91 05 REPORT SIZE (12) 75 0C USAGE (X) 99 30 INPUT (Data, Var, Abs) 91 05 REPORT SIZE (12) 75 0C USAGE (Y) 99 31 INPUT (Data, Var, Abs) 91 07 USAGE (Y) 99 31 INPUT (Data, Var, Abs) 91 07 USAGE (Y) 99 31 INPUT (Data, Var, Abs) 91 07 USAGE (Y) 99 31 INPUT (Data, Var, Abs) 91 07 USAGE (Y) 99 31 INPUT (Data, Var, Abs) 91 07 USAGE (Y) 99 31 INPUT (Data, Var, Abs) 91 07 USAGE (Y) 99 31 USAGE (Y) 99 32 USAGE (Y) 99 31 USAGE (Y) 99 31 USAGE (Y) 99 31 USAGE (Y) 99 32 USAGE (Y) 99 32 USAGE (Y) 99 31 USAGE (Y) 99 32 USAGE (Y) 99 31 USAGE (Y) 99 32 USAGE (Y) 99 31 USAGE (Tip Switch) 99 42 USAGE (Confidence) 99 47		
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USAGE (X)		
INPUT (Data, Var, Abs) PHYSICAL MAXIMUM (506) LOGICAL MAXIMUM (507) USAGE (Y) USAGE (Y) USAGE (Y) USAGE (P) USAGE (P) USAGE (P) USAGE PAGE (Digitizer Device Page) USAGE (Finger) COLLECTION (PHYSICAL) LOGICAL MAXIMUM (1) USAGE (Tip Switch) USAGE (Tip Switch) USAGE (Confidence) REPORT SIZE (1) REPORT COUNT (2) INPUT (Data, Var, Abs) USAGE (Transducer Index) LOGICAL MAXIMUM (5) REPORT SIZE (6) REPORT SIZE (6) REPORT SIZE (6) REPORT COUNT (1) INPUT (Data, Var, Abs) USAGE PAGE (Generic Desktop Page) USAGE PAGE (Generic Desktop Page) PHYSICAL MAXIMUM (105) REPORT SIZE (12) USAGE (X) INPUT (Data, Var, Abs) REPORT SIZE (12) USAGE (X) INPUT (Data, Var, Abs) REPORT SIZE (12) USAGE (X) INPUT (Data, Var, Abs) REPORT SIZE (12) USAGE (X) INPUT (Data, Var, Abs) REPORT SIZE (12) USAGE (X) INPUT (Data, Var, Abs) REPORT SIZE (12) USAGE (X) INPUT (Data, Var, Abs) REPORT SIZE (12) USAGE (X) INPUT (Data, Var, Abs) REPORT SIZE (12) USAGE (X) INPUT (Data, Var, Abs) REPORT SIZE (12) USAGE (X) INPUT (Data, Var, Abs) REPORT SIZE (12) USAGE (X) INPUT (Data, Var, Abs) REPORT SIZE (12) USAGE (X) INPUT (Data, Var, Abs) REPORT SIZE (12) USAGE (Y) USAGE (Y) USAGE (Y) USAGE (Tip Switch) USAGE (Finger) COLLECTION (Physical) LOGICAL MAXIMUM (1) USAGE (Tip Switch) USAGE (Tip Switch) USAGE (Confidence) USAGE (Confidence)		
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USAGE (Y)		
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USAGE PAGE (Digitizer Device Page)		
USAGE (Finger)	•	
COLLECTION (PHYSICAL) LOGICAL MAXIMUM (1) LOGICAL MAXIMUM (1) USAGE (Tip Switch) USAGE (Confidence) REPORT SIZE (1) REPORT COUNT (2) INPUT (Data,Var,Abs) USAGE (Transducer Index) LOGICAL MAXIMUM (5) REPORT SIZE (6) REPORT SIZE (6) REPORT SIZE (6) REPORT SIZE (6) REPORT COUNT (1) INPUT (Data,Var,Abs) USAGE PAGE (Generic Desktop Page) HYSICAL MAXIMUM (921) LOGICAL MAXIMUM (1105) REPORT SIZE (12) USAGE (X) INPUT (Data,Var,Abs) REPORT SIZE (12) USAGE (Y) INPUT (Data,Var,Abs) REPORT SIZE (12) USAGE (Y) USAGE (Y) USAGE (Y) INPUT (Data,Var,Abs) RED COLLECTION (Physical) USAGE PAGE (Digitizer Device Page) USAGE (Finger) COLLECTION (Physical) LOGICAL MAXIMUM (1) USAGE (Tip Switch) USAGE (Confidence) USAGE (Confidence)		05 0D
LOGICAL MAXIMUM (1)	USAGE (Finger)	09 22
USAGE (Tip Switch)	COLLECTION (PHYSICAL)	A1 00
USAGE (Confidence)	LOGICAL MAXIMUM (1)	25 01
REPORT SIZE (1) 75 01 REPORT COUNT (2) 95 02 INPUT (Data, Var, Abs) 81 02 USAGE (Transducer Index) 09 38 LOGICAL MAXIMUM (5) 25 05 REPORT SIZE (6) 75 06 REPORT COUNT (1) 95 01 INPUT (Data, Var, Abs) 81 02 USAGE PAGE (Generic Desktop Page) 95 01 PHYSICAL MAXIMUM (921) 46 99 03 LOGICAL MAXIMUM (1105) 26 51 06 REPORT SIZE (12) 75 0C USAGE (X) 99 30 INPUT (Data, Var, Abs) 81 02 PHYSICAL MAXIMUM (506) 46 FA 03 LOGICAL MAXIMUM (607) 26 5F 03 USAGE (Y) 99 31 INPUT (Data, Var, Abs) 81 02 END COLLECTION (Physical) 09 31 USAGE (Finger) 09 22 COLLECTION (Physical) A1 00 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 47	USAGE (Tip Switch)	09 42
REPORT COUNT (2) 95 02 INPUT (Data, Var, Abs) 81 02 USAGE (Transducer Index) 99 38 LOGICAL MAXIMUM (5) 25 05 REPORT SIZE (6) 75 06 REPORT COUNT (1) 95 01 INPUT (Data, Var, Abs) 81 02 USAGE PAGE (Generic Desktop Page) 95 01 PHYSICAL MAXIMUM (921) 46 99 03 LOGICAL MAXIMUM (1105) 26 51 03 REPORT SIZE (12) 75 0C USAGE (X) 99 30 INPUT (Data, Var, Abs) 81 02 PHYSICAL MAXIMUM (506) 46 FA 03 LOGICAL MAXIMUM (607) 26 5F 03 USAGE (Y) 99 31 INPUT (Data, Var, Abs) 81 02 END COLLECTION (Physical) 09 22 COLLECTION (Physical) 41 00 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 99 42 USAGE (Confidence) 99 47	USAGE (Confidence)	09 47
INPUT (Data, Var, Abs) USAGE (Transducer Index) LOGICAL MAXIMUM (5) REPORT SIZE (6) REPORT COUNT (1) INPUT (Data, Var, Abs) USAGE PAGE (Generic Desktop Page) PHYSICAL MAXIMUM (921) LOGICAL MAXIMUM (1105) REPORT SIZE (12) USAGE (X) INPUT (Data, Var, Abs) REPORT SIZE (12) USAGE (X) INPUT (Data, Var, Abs) PHYSICAL MAXIMUM (506) LOGICAL MAXIMUM (506) LOGICAL MAXIMUM (607) USAGE (Y) INPUT (Data, Var, Abs) END COLLECTION (Physical) USAGE (Finger) COLLECTION (Physical) LOGICAL MAXIMUM (1) USAGE (Tip Switch) USAGE (Tip Switch) USAGE (Confidence)	REPORT SIZE (1)	75 01
USAGE (Transducer Index) 09 38 LOGICAL MAXIMUM (5) 25 05 REPORT SIZE (6) 75 06 REPORT COUNT (1) 95 01 INPUT (Data, Var, Abs) 81 02 USAGE PAGE (Generic Desktop Page) 05 01 PHYSICAL MAXIMUM (921) 46 99 03 LOGICAL MAXIMUM (1105) 26 51 06 REPORT SIZE (12) 75 0C USAGE (X) 99 30 INPUT (Data, Var, Abs) 81 02 PHYSICAL MAXIMUM (506) 46 FA 03 LOGICAL MAXIMUM (607) 26 5F 03 USAGE (Y) 99 31 INPUT (Data, Var, Abs) 81 02 END COLLECTION (Physical) 09 USAGE (Finger) 09 22 COLLECTION (Physical) 100 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 42 USAGE (Tip Switch) 09 42 USAGE (Confidence) 09 47	REPORT COUNT (2)	95 02
LOGICAL MAXIMUM (5) REPORT SIZE (6) REPORT COUNT (1) INPUT (Data, Var, Abs) USAGE PAGE (Generic Desktop Page) PHYSICAL MAXIMUM (921) LOGICAL MAXIMUM (1105) REPORT SIZE (12) USAGE (X) INPUT (Data, Var, Abs) PHYSICAL MAXIMUM (506) LOGICAL MAXIMUM (506) LOGICAL MAXIMUM (607) USAGE (Y) O9 31 INPUT (Data, Var, Abs) END COLLECTION (Physical) USAGE (Finger) CO USAGE (Finger) CO USAGE (Finger) CO USAGE (Finger) O9 22 COLLECTION (Physical) LOGICAL MAXIMUM (1) USAGE (Tip Switch) USAGE (Confidence)	<pre>INPUT (Data, Var, Abs)</pre>	81 02
REPORT SIZE (6) 75 06 REPORT COUNT (1) 95 01 INPUT (Data, Var, Abs) 81 02 USAGE PAGE (Generic Desktop Page) 05 01 PHYSICAL MAXIMUM (921) 46 99 03 LOGICAL MAXIMUM (1105) 26 51 03 REPORT SIZE (12) 75 0C USAGE (X) 99 30 INPUT (Data, Var, Abs) 81 02 PHYSICAL MAXIMUM (506) 46 FA 03 LOGICAL MAXIMUM (607) 26 5F 03 USAGE (Y) 99 31 INPUT (Data, Var, Abs) 81 02 END COLLECTION (Physical) C0 USAGE (Finger) 09 22 COLLECTION (Physical) A1 00 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 42 USAGE (Tip Switch) 09 47	USAGE (Transducer Index)	09 38
REPORT COUNT (1) 95 01 INPUT (Data, Var, Abs) 81 02 USAGE PAGE (Generic Desktop Page) 05 01 PHYSICAL MAXIMUM (921) 46 99 03 LOGICAL MAXIMUM (1105) 26 51 0 REPORT SIZE (12) 75 0C USAGE (X) 09 30 INPUT (Data, Var, Abs) 81 02 PHYSICAL MAXIMUM (506) 46 FA 03 LOGICAL MAXIMUM (607) 26 5F 03 USAGE (Y) 09 31 INPUT (Data, Var, Abs) 81 02 END COLLECTION (Physical) C0 USAGE PAGE (Digitizer Device Page) 05 0D USAGE (Finger) 09 22 COLLECTION (Physical) A1 00 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 42 USAGE (Confidence) 09 47	LOGICAL MAXIMUM (5)	25 05
INPUT (Data, Var, Abs) USAGE PAGE (Generic Desktop Page) PHYSICAL MAXIMUM (921) LOGICAL MAXIMUM (1105) REPORT SIZE (12) USAGE (X) INPUT (Data, Var, Abs) PHYSICAL MAXIMUM (506) LOGICAL MAXIMUM (607) USAGE (Y) INPUT (Data, Var, Abs) PHYSICAL MAXIMUM (607) USAGE (Y) USAGE (Y) USAGE (Y) USAGE (Y) USAGE (Finger) CO USAGE PAGE (Digitizer Device Page) USAGE (Finger) COLLECTION (Physical) LOGICAL MAXIMUM (1) USAGE (Tip Switch) USAGE (Confidence)	REPORT SIZE (6)	75 06
USAGE PAGE (Generic Desktop Page) 05 01 PHYSICAL MAXIMUM (921) 46 99 03 LOGICAL MAXIMUM (1105) 26 51 04 REPORT SIZE (12) 75 0C USAGE (X) 09 30 INPUT (Data, Var, Abs) 81 02 PHYSICAL MAXIMUM (506) 46 FA 03 LOGICAL MAXIMUM (607) 26 5F 03 USAGE (Y) 09 31 INPUT (Data, Var, Abs) 81 02 END COLLECTION (Physical) C0 USAGE PAGE (Digitizer Device Page) 05 0D USAGE (Finger) 09 22 COLLECTION (Physical) A1 00 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 42 USAGE (Confidence) 09 47	REPORT COUNT (1)	95 01
PHYSICAL MAXIMUM (921) 46 99 03 LOGICAL MAXIMUM (1105) 26 51 04 REPORT SIZE (12) 75 0C USAGE (X) 09 30 INPUT (Data, Var, Abs) 81 02 PHYSICAL MAXIMUM (506) 46 FA 03 LOGICAL MAXIMUM (607) 26 5F 03 USAGE (Y) 09 31 INPUT (Data, Var, Abs) 81 02 END COLLECTION (Physical) C0 USAGE PAGE (Digitizer Device Page) 05 0D USAGE (Finger) 09 22 COLLECTION (Physical) A1 00 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 42 USAGE (Confidence) 09 47	<pre>INPUT (Data, Var, Abs)</pre>	81 02
LOGICAL MAXIMUM (1105) 26 51 0 REPORT SIZE (12) 75 0C USAGE (X) 09 30 INPUT (Data, Var, Abs) 81 02 PHYSICAL MAXIMUM (506) 46 FA 0 LOGICAL MAXIMUM (607) 26 5F 0 USAGE (Y) 09 31 INPUT (Data, Var, Abs) 81 02 END COLLECTION (Physical) C0 USAGE PAGE (Digitizer Device Page) 05 0D USAGE (Finger) 09 22 COLLECTION (Physical) A1 00 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 42 USAGE (Confidence) 09 47	USAGE PAGE (Generic Desktop Page)	05 01
LOGICAL MAXIMUM (1105) 26 51 0 REPORT SIZE (12) 75 0C USAGE (X) 09 30 INPUT (Data, Var, Abs) 81 02 PHYSICAL MAXIMUM (506) 46 FA 0 LOGICAL MAXIMUM (607) 26 5F 0 USAGE (Y) 09 31 INPUT (Data, Var, Abs) 81 02 END COLLECTION (Physical) C0 USAGE PAGE (Digitizer Device Page) 05 0D USAGE (Finger) 09 22 COLLECTION (Physical) A1 00 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 42 USAGE (Confidence) 09 47	PHYSICAL MAXIMUM (921)	46 99 0
REPORT SIZE (12) 75 0C USAGE (X) 09 30 INPUT (Data, Var, Abs) 81 02 PHYSICAL MAXIMUM (506) 46 FA 03 LOGICAL MAXIMUM (607) 26 5F 03 USAGE (Y) 09 31 INPUT (Data, Var, Abs) 81 02 END COLLECTION (Physical) C0 USAGE PAGE (Digitizer Device Page) 05 0D USAGE (Finger) 09 22 COLLECTION (Physical) A1 00 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 42 USAGE (Confidence) 09 47		26 51 0
INPUT (Data, Var, Abs) 81 02 PHYSICAL MAXIMUM (506) 46 FA 03 LOGICAL MAXIMUM (607) 26 5F 03 USAGE (Y) 09 31 INPUT (Data, Var, Abs) 81 02 END COLLECTION (Physical) C0 USAGE PAGE (Digitizer Device Page) 05 0D USAGE (Finger) 09 22 COLLECTION (Physical) A1 00 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 42 USAGE (Confidence) 09 47	REPORT SIZE (12)	
PHYSICAL MAXIMUM (506) 46 FA 05 LOGICAL MAXIMUM (607) 26 5F 05 USAGE (Y) 09 31 INPUT (Data, Var, Abs) 81 02 END COLLECTION (Physical) C0 USAGE PAGE (Digitizer Device Page) 05 0D USAGE (Finger) 09 22 COLLECTION (Physical) A1 00 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 42 USAGE (Confidence) 09 47	USAGE (X)	09 30
LOGICAL MAXIMUM (607) 26 5F 07 USAGE (Y) 09 31 INPUT (Data, Var, Abs) 81 02 END COLLECTION (Physical) C0 USAGE PAGE (Digitizer Device Page) 05 0D USAGE (Finger) 09 22 COLLECTION (Physical) A1 00 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 42 USAGE (Confidence) 09 47	INPUT (Data, Var, Abs)	81 02
LOGICAL MAXIMUM (607) 26 5F 07 USAGE (Y) 09 31 INPUT (Data, Var, Abs) 81 02 END COLLECTION (Physical) C0 USAGE PAGE (Digitizer Device Page) 05 0D USAGE (Finger) 09 22 COLLECTION (Physical) A1 00 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 42 USAGE (Confidence) 09 47	PHYSICAL MAXIMUM (506)	46 FA 0:
USAGE (Y) 09 31 INPUT (Data, Var, Abs) 81 02 END COLLECTION (Physical) C0 USAGE PAGE (Digitizer Device Page) 05 0D USAGE (Finger) 09 22 COLLECTION (Physical) A1 00 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 42 USAGE (Confidence) 09 47		26 5F 0
INPUT (Data, Var, Abs) END COLLECTION (Physical) USAGE PAGE (Digitizer Device Page) USAGE (Finger) COLLECTION (Physical) LOGICAL MAXIMUM (1) USAGE (Tip Switch) USAGE (Confidence) 81 02 C0 C0 USAGE PAGE (Digitizer Device Page) 05 0D 07 22 09 22 COLLECTION (Physical) A1 00 LOGICAL MAXIMUM (1) USAGE (Tip Switch) 09 42	USAGE (Y)	09 31
END COLLECTION (Physical) USAGE PAGE (Digitizer Device Page) USAGE (Finger) COLLECTION (Physical) LOGICAL MAXIMUM (1) USAGE (Tip Switch) USAGE (Confidence) CO CO D5 0D A1 00 LOG LOG LOG LOG LOG LOG LOG L	INPUT (Data.Var.Abs)	
USAGE PAGE (Digitizer Device Page) 05 0D USAGE (Finger) 09 22 COLLECTION (Physical) A1 00 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 42 USAGE (Confidence) 09 47		
USAGE (Finger) 09 22 COLLECTION (Physical) A1 00 LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 42 USAGE (Confidence) 09 47	•	
COLLECTION (Physical) LOGICAL MAXIMUM (1) USAGE (Tip Switch) USAGE (Confidence) A1 00 25 01 USAGE (Tip Switch) 09 42 USAGE (Confidence)		
LOGICAL MAXIMUM (1) 25 01 USAGE (Tip Switch) 09 42 USAGE (Confidence) 09 47	•	
USAGE (Tip Switch) 09 42 USAGE (Confidence) 09 47		
USAGE (Confidence) 09 47		
KEPUKI 31ZE (1) /5 ØI		
	MEFUNI SIZE (I)	/2 QT

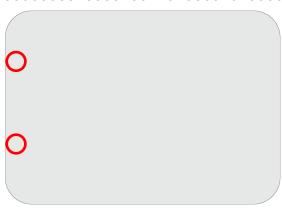
REPORT COUNT (2)	95	02	
INPUT (Data, Var, Abs)	81	02	
USAGE (Transducer Index)	09	38	
LOGICAL MAXIMUM (5)	25	05	
REPORT SIZE (6)	75	06	
REPORT COUNT (1)	95	01	
INPUT (Data, Var, Abs)	81	02	
USAGE PAGE (Generic Desktop Page)	05	01	
PHYSICAL MAXIMUM (921)	46	99	03
LOGICAL MAXIMUM (1105)	26	51	04
REPORT SIZE (12)	75	0C	
USAGE (X)	09	30	
INPUT (Data, Var, Abs)	81	02	
PHYSICAL MAXIMUM (506)	46	FA	01
LOGICAL MAXIMUM (607)	26	5F	02
USAGE (Y)	09	31	
INPUT (Data,Var,Abs)	81	02	
END COLLECTION (PHYSICAL)	C0		
USAGE PAGE (Digitizer Device Page)	05	0D	
USAGE (Finger)	09	22	
COLLECTION (PHYSICAL)	Α1	00	
LOGICAL MAXIMUM (1)	25	01	
USAGE (Tip Switch)	09	42	
USAGE (Confidence)	09	47	
REPORT SIZE (1)	75	01	
REPORT COUNT (2)	95	02	
INPUT (Data,Var,Abs)	81		
USAGE (Transducer Index)	09	38	
LOGICAL MAXIMUM (5)	25	05	
REPORT SIZE (6)	75	06	
REPORT COUNT (1)	95	01	
INPUT (Data, Var, Abs)	81	02	
USAGE PAGE (Generic Desktop Page)	05	01	
PHYSICAL MAXIMUM (921)	46	99	03
LOGICAL MAXIMUM (1105)	26	51	04
REPORT SIZE (12)	75		
USAGE (X)	09	30	
INPUT (Data,Var,Abs)		02	
PHYSICAL MAXIMUM (506)	46	FA	01
LOGICAL MAXIMUM (607)		5F	02
USAGE (Y)	09	31	
INPUT (Data, Var, Abs)	81	02	
END COLLECTION (Physical)	C0		
USAGE PAGE (Digitizer Device Page)	05	0D	
USAGE (Finger)	09	22	
COLLECTION (PHYSICAL)		00	
LOGICAL MAXIMUM (1)		01	
USAGE (Tip Switch)		42	
USAGE (Confidence)		47	
REPORT SIZE (1)		01	
REPORT COUNT (2)		02	
INPUT (Data, Var, Abs)		02	
USAGE (Transducer Index)	09	38	

```
LOGICAL MAXIMUM (5)
                                                     25 05
 REPORT SIZE (6)
                                                     75 06
 REPORT COUNT (1)
                                                     95 01
 INPUT (Data, Var, Abs)
                                                     81 02
 USAGE PAGE (Generic Desktop Page)
                                                     05 01
 PHYSICAL MAXIMUM (921)
                                                    46 99 03
 LOGICAL MAXIMUM (1105)
                                                     26 51 04
 REPORT SIZE (12)
                                                     75 0C
 USAGE (X)
                                                     09 30
 INPUT (Data, Var, Abs)
                                                     81 02
 PHYSICAL MAXIMUM (506)
                                                     46 FA 01
                                                     26 5F 02
 LOGICAL MAXIMUM (607)
 USAGE (Y)
                                                     09 31
 INPUT (Data, Var, Abs)
                                                     81 02
 END COLLECTION (Physical)
                                                     C0
END COLLECTION (Application)
                                                     C0
```

14.2.2 Example Trackpad

The following HID reports are for a 60 Hz accessory trackpad using the Example HID Report Descriptor (page 81):

1. Two contacts are made on the surface of the accessory trackpad. 03000000 0300100F 0700C016 00000000 00000000 00000000



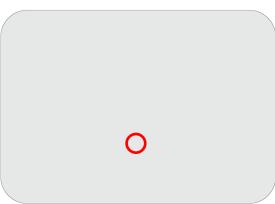
Two contacts move simultaneously along the X axis.
 03A70000 0314110F 0714C116 00000000 00000000 00000000



3. Two contacts continue moving until they reach the center of the digitizer surface. 034E0100 0328120F 0728C216 00000000 00000000 00000000

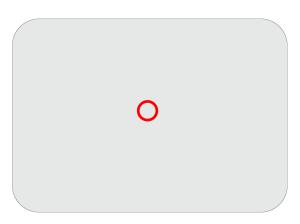


4. One contact is removed. Confidence for removed contact is still 1 and its coordinates are unchanged. 03F50100 0328120F 0628C216 00000000 00000000 00000000



5. Remaining contact moves to the exact center of the digitizer surface. Confidence and coordinates of the removed contact are now 0.

039C0200 0328F212 00000000 00000000 00000000 00000000



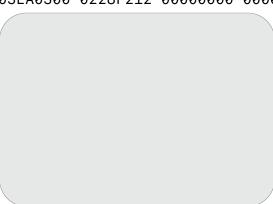
6. Button 1 is clicked.

03430301 0328F212 00000000 00000000 00000000 00000000



7. Button 1 is un-clicked and contact is removed. Confidence for removed contact is still 1 and its coordinates are unchanged.

03EA0300 0228F212 00000000 00000000 00000000 00000000



15. AirPods Accessories

Accessories shall not interfere with AirPods operation. Keep-out regions can be found in the device dimensional drawings, see:

- AirPods Pro (2nd generation) (page 393).
- AirPods (3rd generation) (page 395).
- AirPods Pro (1st generation) (page 397).
- AirPods (1st generation) and AirPods (2nd generation) (page 399).

15.1 Charging Case Covers

Charging case covers shall:

- Not interfere with AirPods charging case operation.
- Have a uniform thickness across the metal keep-out region.
- Not exceed 2.5 mm in thickness. Apple recommends 1.0 mm for maximum compatibility with inductive transmitters.

Keep-out regions can be found in the device dimensional drawings, see:

- MagSafe Charging Case for AirPods Pro (2nd generation) 1 of 3 (page 390).
- MagSafe Charging Case for AirPods (3rd generation) (page 394).
- Wireless Charging Case for AirPods Pro (1st generation) (page 396).
- Wireless Charging Case for AirPods (page 398).

Case covers for MagSafe Charging Case for AirPods Pro (2nd generation) claiming compatibility with Apple Watch chargers shall not obstruct the Apple Watch charger keep-out region, see MagSafe Charging Case for AirPods Pro (2nd generation) 2 of 3 (page 391).

15.2 Chargers

Charging accessories shall be physically compatible with all charging cases.

Charging accessories with integrated:

- Lightning connectors shall meet the requirements for iPhone/iPod in Device Power (Lightning) (page 111).
- Inductive transmitters shall meet the requirements in Device Power (Inductive) (page 116).

15.3 Test Procedures

Test procedures for AirPods accessories.

15.3.1 Power

Power test procedures for AirPods charging case covers.

15.3.1.1 Equipment

Equipment needed to perform the power test procedure:

- AirPods.
- AirPods charging case.
- AirPods charging case cover.
- Apple MagSafe Charger.
- Device running iOS 16.0 or later.

15.3.1.2 Test Environment and Setup

- 1. Insert AirPods into charging case.
- 2. Unlock the device and open the charging case lid.
- 3. Pair AirPods with the device, if necessary.
- 4. Using the device, verify the state of charge for:
 - a. Charging case is less than 80%.
 - **b.** AirPods is less than 50%.
- 5. Close the charging case lid.
- **6.** Verify the MagSafe charger is plugged into a functional power source.
- 7. Place the charging case onto the MagSafe charger on a flat surface.
- 8. Verify the charging case LED turns on momentarily.
- 9. Monitor the charging case LED for 30 seconds and verify the LED turns off.
- 10. Tap the charging case and verify the LED turns on momentarily.

15.3.1.3 MagSafe Charging

- 1. Attach the accessory to the AirPods charging case.
- 2. Place the charging case and attached accessory onto a MagSafe charger on a flat surface.
- 3. Verify the charging case LED turns on momentarily.
- 4. Monitor the charging case LED for 30 seconds and verify the LED turns off.
- 5. Tap the charging case and verify the LED turns on momentarily.

16. Watch Bands

A well-designed watch band will securely attach to Apple Watch without interfering with Apple Watch operation. See <u>Device Dimensional Drawings</u> (page 206) for Apple Watch dimensional drawings with defined keep-out zones.

16.1 Requirements

Watch bands for Apple Watch shall integrate two lugs to mate with the Apple Watch Band Interface (page 91). Apple Watch uses a high precision interface profile, see https://developer.apple.com/accessories/apple-watch-lug-profile.zip for a sample 2D lug profile. Lugs should lock into the watch band mating slot with a 'lug latch' feature to prevent accidental removal of the watch band.

Exposed edges of watch bands and lugs shall pass UL 1439 tests for sharpness of edges on equipment and BS EN 71-1:2014, *Safety of Toys - Mechanical and physical properties*.

The lug latch shall never become jammed in the extended position.

Watch bands shall not integrate magnetic chargers.

Watch bands and lugs should:

- Pass a 72 hour salt mist test as specified in ASTM B117 with no visible corrosion.
- Resist a 5-20 kgf lateral slide-out force when installed in Apple Watch.
- Resist a 20 kgf or greater pull force as specified in ISO-6245:1996, *Specifications for Diver's Watches*, section 7.3.
- Detach easily from Apple Watch when the watch band release buttons are pressed.
- Take into account the weight of Apple Watch.

Watch bands shall enable the user to maintain direct skin contact with the Apple Watch heart sensors and the back of Apple Watch, and shall incorporate sufficient margin to compensate for shifting or dimensional changes of the watch band material. Failure to do so may interfere with Apple Watch wrist detect and Apple Pay features. Watch bands should:

- Have length sizing adjustment pitch of less than 7 mm (center to center).
- Provide sufficient adjustability for the user to achieve a snug, yet comfortable fit preventing movement of Apple Watch relative to the wearer's skin.

Watch bands intended for use during exercise should maintain a snug fit through a full range of motion to maintain compatibility with Apple Watch heart sensors.

Apple recommends the following materials for lug bodies:

- 75 Shore A silicone.
- 50-55% glass-filled nylon.
- 240-270HV 316L / EN 1.4435 stainless steel.

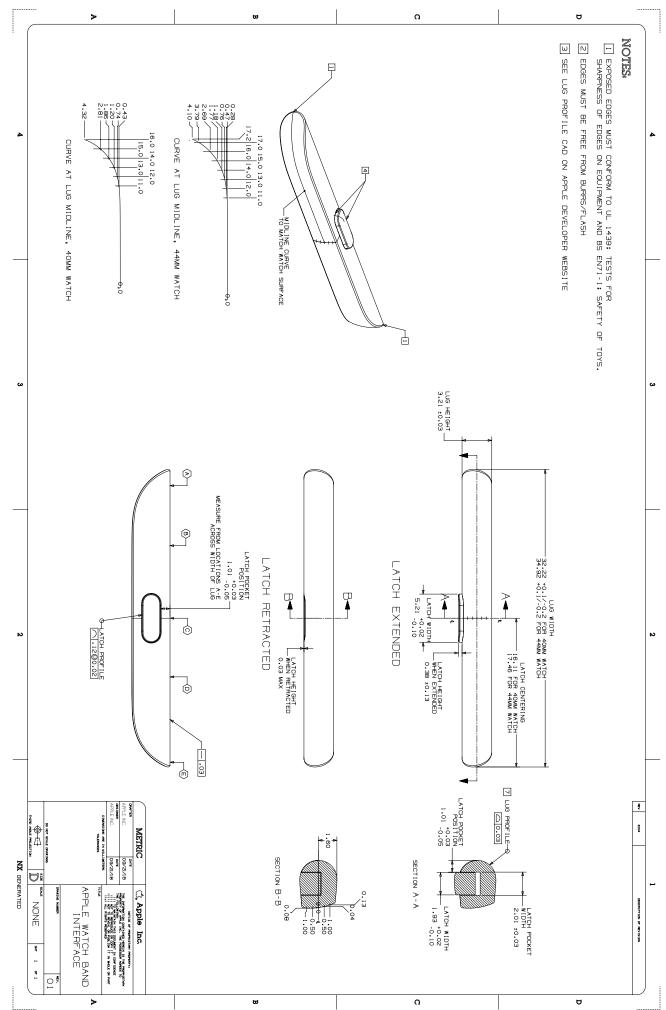
Apple recommends the following materials for lug latches:

- 50-55% glass-filled nylon.
- 240-270HV 316L / EN 1.4435 stainless steel.

Watch bands for Apple Watch shall comply with applicable environmental regulations for the regions in which the watch bands are to be sold, and any applicable substance or material restrictions, including applicable restrictions on:

- Organic tin compounds, PFOS, PFOA, phthalates, azo dyes, polybrominated biphenyls (PBBs) and PAHs, per requirements of the EU REACh regulation EC 1907/2006.
- Nickel leach rate on surfaces in prolonged skin contact, per requirements of the EU REACh regulation EC 1907/2006.
- Cadmium, lead, hexavalent chromium, and nickel, per requirements of EU Directive 2009/48/EC.
- Natural rubber latex, per requirements of EU Directive EC 93/42/EEC.
- Dimethylfumarate (DMFu), per requirements of EU Regulation 412/2012.
- pH and Formaldehyde, per requirements of China GB 18401 for textiles and China GB 20400 for leather.
- Endangered species of flora and fauna in products or packaging (US Lacey Act).
- Polybrominated diphenyl ethers (PBDE).

16.2 Apple Watch Band Interface



16.3 Example Apple Watch Lug Assembly

Assembly instructions are based on Example Apple Watch Lug (page 94) and an assembly fixture with a clamping mechanism.

Proper assembly of the lug is critical to ensure the watch band securely attaches to the Apple Watch. Improper assembly may result in damage to the Apple Watch and/or the watch band.

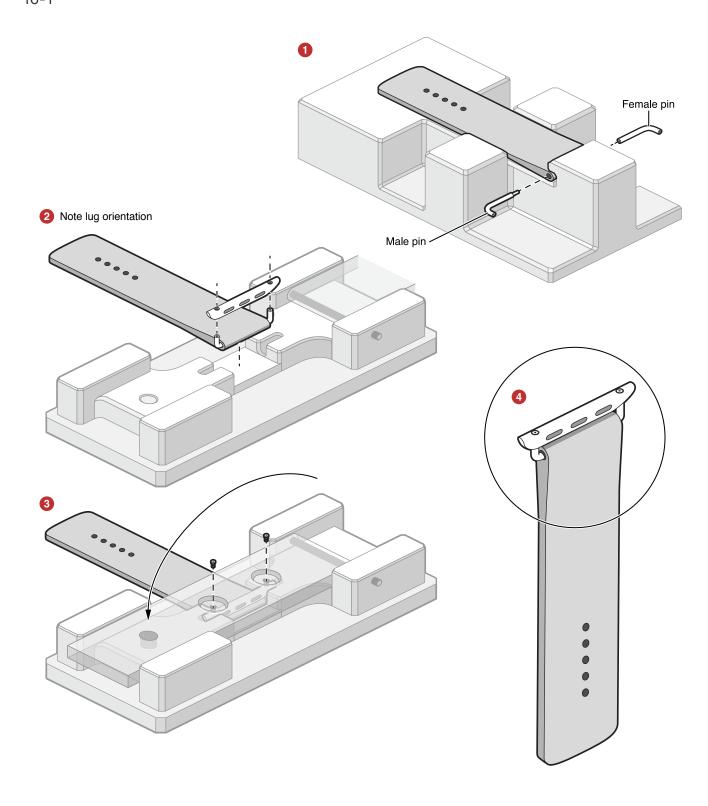
Screw threads should be secured with Loctite 435. Previously installed/used screws should not be reused.

The assembly fixture should hold the lug assembly in place and a clamping mechanism should compress the lug during screw insertion.

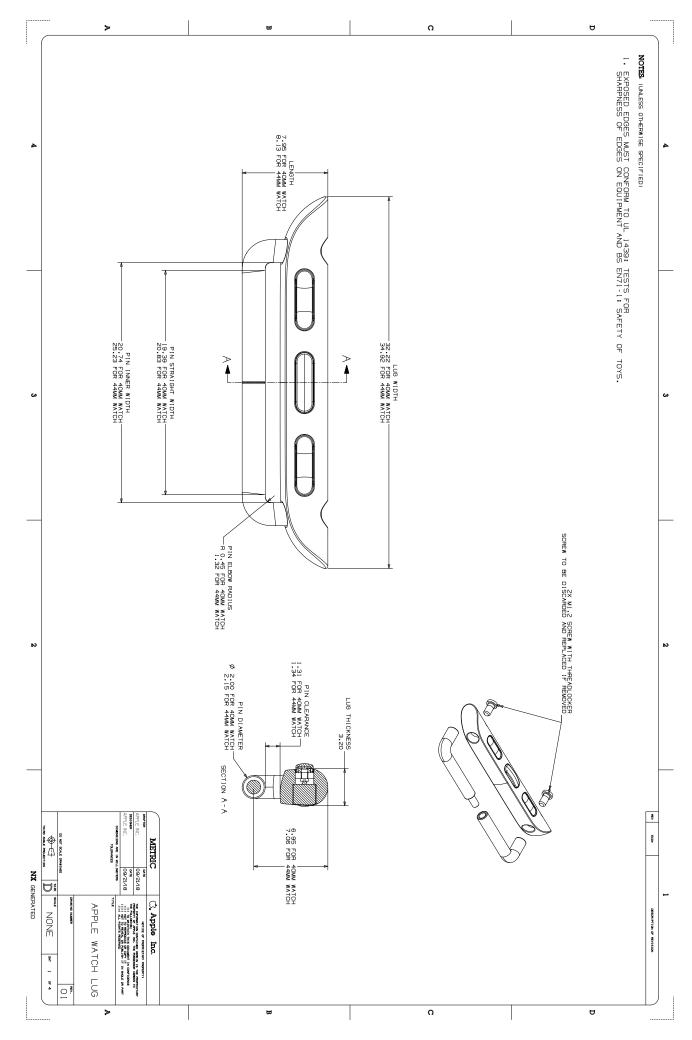
Assemble the watch band and lug as follows, see Figure 16-1 (page 93).

- 1. Lightly insert the long end of the female pin in the watch band until hard stop. Ensure there is no warping or damage in the watch band.
- 2. Lightly insert the long end of the male pin in the other side of the band until it interlocks with the female pin and both pins are seated together. Ensure there is no warping or damage in the watch band.
- 3. Align the holes on the bottom of the lug with the exposed ends of the female and male pins. Note lug latch top/bottom orientation relative to the watch band. Latch shall be on the side of the watch band against the wrist.
- 4. Apply Loctite 435 to screw threads.
- **5.** Install both screws using the following specification:
 - Torque: 1.1 kgf-cm ±10%
 - RPM: 120 ±10%
- 6. Visually inspect at 1200-1400 lux for screw proudness and cross-threading.
- 7. Ensure screws are just sub-flush to the lowest part of the counterbore and appear parallel to the long axis of the lug.
- 8. Ensure screws are undamaged, flat, and concentric with the counterbore.

Figure Apple Watch Lug Assembly Fixture 16-1



16.4 Example Apple Watch Lug

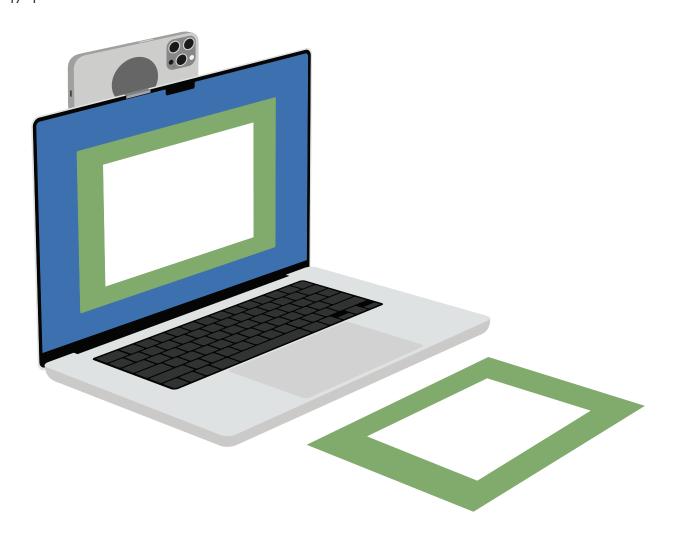


17. Continuity Camera Mounts

Continuity Camera enables iPhone cameras to be used with a Mac and enables Portrait, Studio Light, Center Stage, and Desk View video effects. This feature is supported on iOS 16.0 or later and macOS 13.0 Ventura or later.

Continuity Camera Mounts securely hold an iPhone at the optimal height and angle near or on a Mac, external display or tripod.

Figure Continuity Camera MacBook Desk View example 17-1



Center Stage and Desk View are supported on the following devices:

- iPhone 14 Pro Max
- iPhone 14 Pro
- iPhone 14 Plus
- iPhone 14
- iPhone 13 Pro Max
- iPhone 13 Pro
- iPhone 13
- iPhone 13 mini
- iPhone 12 Pro Max
- iPhone 12 Pro
- iPhone 12
- iPhone 12 mini
- iPhone 11 Pro Max
- iPhone 11 Pro
- iPhone 11

Studio Light is supported on iPhone 12 or later including iPhone SE (3rd generation).

iPhone as a webcam and Portrait mode are supported on iPhone XR or later.

17.1 Product Design

All Continuity Camera Mounts:

- Shall support devices in portrait and landscape orientations.
- Shall enable use of a Lightning to USB charge/sync cable.
- Shall not touch the device cover glass, block any device camera field of view, or obstruct any ambient light sensors, see Device Dimensional Drawings (page 206).
- Shall not cause Scratches and Damage (page 23).
- Should prevent free rotation of the iPhone.
- Should enable an iPhone camera lens height of at least 228 mm to support Desk View.
- Should not obstruct Access to Controls (page 30).
- Should implement the MagSafe Accessory Magnet Array (page 129).
- Should support Tripod Connections (page 28).

Apple recommends using a Lightning to USB charge/sync cable during Continuity Camera use.

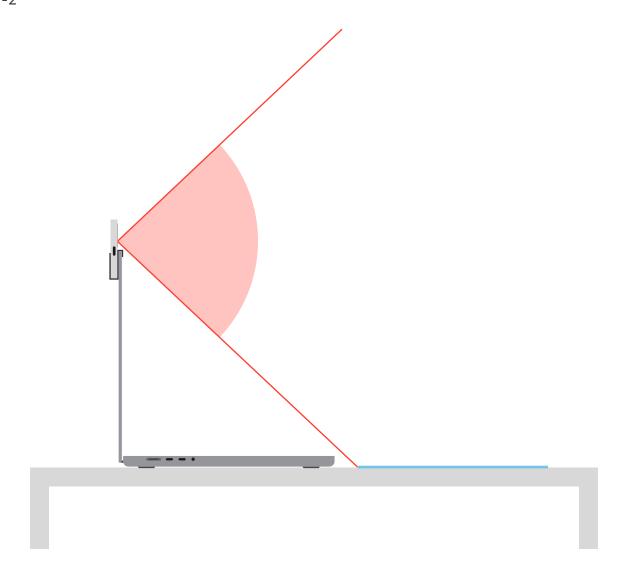
Additional requirements apply to Continuity Camera Mounts used in the following scenerios:

- MacBook Mount (page 97)
- iMac or Display Mount (page 98)

17.2 MacBook Mount

Figure MacBook mount example

17-2



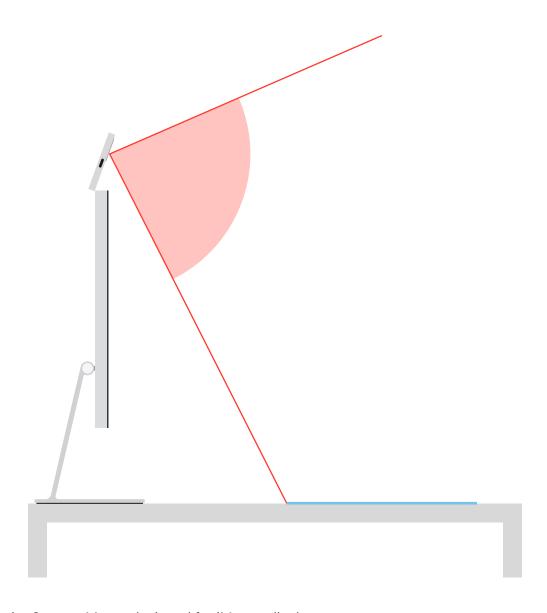
A Continuity Camera Mount designed for MacBook, MacBook Air, and MacBook Pro:

- Shall not scratch or damage the MacBook.
- Shall not touch the MacBook display glass (active and non-active areas).
- Shall not interfere with or prevent fully closing the MacBook.
- Shall not sandwich or squeeze the MacBook and the iPhone together.
- Should not cover or touch any portion of the MacBook display glass, camera, or other sensors.
- Should enable a downward tilt in portrait orientation from 0° to 12° to support Desk View.
- Should minimize the mass to maintain stability of the display.

17.3 iMac or Display Mount

Figure Display mount example

17-3



A Continuity Camera Mount designed for iMac or displays:

- Shall not scratch or damage the iMac or display.
- Shall not touch the display glass (active and non-active areas).
- Shall not sandwich or squeeze the iMac or display and the iPhone together.
- Should not cover or touch any portion of the display glass, camera, microphones, or other sensors.
- Should enable a downward tilt from 0° to 30° to support Desk View.

17.4 Test Procedures

17.4.1 Equipment

The following equipment is needed to perform the tests in this procedure:

- Continuity Camera Mount to be tested.
- Supported devices running iOS 16.0 or later.
- A Mac computer running macOS 13.0 Ventura or later.
 - A MacBook, MacBook Air, and MacBook Pro if the mount is designed for MacBook.
 - An iMac if the mount is designed for iMac.
- An Apple ID used on all Mac computers and devices with two-factor authentication enabled.
- A variety of displays if the mount is designed for external displays.
- A tripod if the mount is designed for tripod connections.
- A Lightning to USB charge/sync cable.

17.4.2 Enable Continuity Camera

To configure a Mac and device to enable Continuity Camera:

- 1. Connect the device to the Mac using a Lightning to USB charge/sync cable.
- 2. If the Mac is not a trusted computer, select *Trust* on the 'Trust This Computer' alert on the device.
- 3. To use Continuity Camera wirelessly, remove the Lightning to USB charge/sync cable.
- 4. Open FaceTime on the Mac.
- 5. If the 'Use your iPhone as a Camera for your Mac' alert appears, select *Continue*.
- 6. Select the Continuity Camera option from the Video menu.
- 7. The Continuity Camera view will display in FaceTime.

To reconnect after the Mac and/or device are in sleep mode:

- 1. Wake the device and the Mac.
- 2. Connect the device to the Mac using a Lightning to USB charge/sync cable for a wired connection or disconnect the cable for a wireless connection.
- 3. Open FaceTime on the Mac and select Continuity Camera from the Video menu.
- 4. The Continuity Camera view will display in FaceTime.

17.4.3 Product Design

Verify the Continuity Camera Mount:

- 1. Supports portrait and landscape orientations.
- 2. Does not touch the device cover glass or block any device camera field of view.
- 3. Enables use of Lightning to USB charge/sync cables.
- 4. Does not scratch or damage the device.

If the mount is designed for MacBook, iMac or displays, verify the mount:

- 1. Does not touch the display glass.
- 2. Does not block any MacBook, iMac or display camera field of view.
- 3. Does not sandwich or squeeze the device, MacBook, iMac, or display together.
- 4. Does not scratch or damage the device, MacBook, iMac, or display.

17.4.4 Center Stage

Center Stage is a video effect available in the Mac Control Center. Selecting Video Effects and enabling Center Stage will cause the video to follow people as they move within the Continuity Camera field of view. The video will zoom (in and out) and pan (left to right, right to left, up and down), to keep people in the frame.

- 1. Ensure the device is awake, and logged into the same Apple ID account as the Mac.
- 2. Place the device in the mount and on the MacBook, iMac, display, tripod or free-standing support.
- 3. Perform mount testing using the Photo Booth app with and without Center Stage enabled.
 - a. Open the Photo Booth app on the Mac, use the Camera menu to select Continuity Camera.
 - **b.** Use the still photo mode.
- 4. Use the Mac Control Center menu to select Video Effects, and enable Center Stage.
- 5. Capture photos from different positions using Center Stage face tracking, in portrait and landscape orientation, waiting 5 seconds between each photo.
- 6. Use the Mac Control Center menu to select Video Effects, and disable Center Stage.
- 7. Capture photos in portrait and landscape orientation, waiting 5 seconds between each photo.
- 8. Using the Photo Booth film strip feature, verify all photos taken during the test:
 - a. Are saved to the computer.
 - **b.** Are clearly displayed when viewed.
 - c. Have no visible anomalies caused by the mount in either portrait and landscape orientation.

17.4.5 Desk View

Desk View is a video effect available in the Mac Control Center. Selecting Video Effects and enabling Desk View causes a confirmation dialog box to appear, then a separate Desk View window opens. The tilt angle of the Continuity Camera Mount and its mount position determines the Desk View field of view. Adjust the tilt angle as necessary to display the desktop subject matter. Remote viewers will see the subject matter from the presenters perspective. Closing the Desk View window disables Desk View.

- 1. Ensure the device is awake, and logged into the same Apple ID account as the Mac.
- 2. Place the device in the mount and on the MacBook, iMac, display, tripod or free-standing support.
- 3. Perform mount testing using the FaceTime app with the Desk View video effect enabled.
 - a. Open the FaceTime app on the Mac, and use the Video menu to select the Continuity Camera.
 - b. Use the Mac Control Center menu to select Video Effects, and enable Desk View.

- c. Verify the Desk View window is displayed.
- **4.** In both landscape and portrait orientation:
 - **a.** Adjust the tilt angle of the Continuity Camera Mount to display the desktop subject matter in the Desk View window.
 - **b.** Verify the desktop subject matter is visible in the Desk View window, and clearly displayed.
 - **c.** Verify there are no visible anomalies caused by the mount in the Desk View window.
 - **d.** Verify the user's face is still visible in FaceTime while Desk View is showing the desktop subject matter.

Features

18. Bluetooth Accessory Identification

This chapter describes Apple-specific Bluetooth commands extending accessory capabilities beyond those supported by standard Bluetooth profiles.

To enable Apple-specific features, the accessory shall support HFP Command AT+XAPL (page 103), which provides accurate information about the accessory's supported features. The device will use the information sent by this command to enable and disable custom commands.

The accessory shall send the following AT+XAPL command after making a successful HFP Service Level Connection (SLC) to the device. The accessory should send an AT+XAPL command first, before sending any additional Apple-specific commands. See Siri (page 145) and Bluetooth Headset Battery Level Indication (page 110).

18.1 HFP Command AT+XAPL

Description: Enables custom AT commands from an accessory.

Initiator: Bluetooth accessory

Format: AT+XAPL=vendorlD-productlD-version,features

Parameters:

- *vendorID*: A string representation of the hex value of the vendor ID from the manufacturer, without the 0x prefix.
- productID: A string representation of the hex value of the product ID from the manufacturer, without the 0x prefix.
- version: The software version.
- features: A base-10 representation of a bit field. Available features are:
 - Bit 0 = reserved
 - Bit 1 = The accessory supports battery reporting (reserved only for battery operated accessories).
 - Bit 2 = The accessory is docked or powered (reserved only for battery operated accessories).
 - Bit 3 = The accessory supports Siri status reporting.
 - Bit 4 = the accessory supports noise reduction (NR) status reporting.
 - All other values are reserved.

Example: AT+XAPL=ABCD-1234-0100,10 (Supports battery reporting and Siri status)

Response: +XAPL=iPhone, *features*

19. Accessory Power (Lightning)

Accessories may draw a limited amount of power from a device and avoid the need to integrate a battery or connect to an external power source. This feature may eliminate the need for users to manage an additional accessory battery and permits the accessory to function as long as the device has power.

Accessories temporarily connecting to the device are good candidates for this feature. Additionally, the accessory should integrate the Lightning Receptacle (C37) and implement Lightning Receptacle (C37) Passthrough USB Charge/Sync so users can charge the device from an external power source while the accessory is attached.

See the Accessory Interface Specification (page 21) for more information.

20. App Discovery

The App Discovery feature enables accessories to retrieve a list of installed apps on the device capab	le
of communicating with the accessory. See App Launch (page 107) to make use of the list.	

See the Accessory Interface Specification (page 21) for more information.

21. App Launch

Accessories supporting the App Launch feature can request a device launch an app on its behalf.

Figure App Launch Alert 21-1



See the Accessory Interface Specification (page 21) for more information.

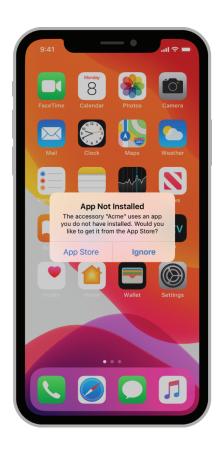
22. App Match

The App Match feature enables accessories supporting the External Accessory Protocol feature to match with compatible apps on the App Store.

When connected for the first time, the device asks the user if they would like to visit the App Store and view compatible apps. Subsequently, this action may be repeated by the user using Settings > General > About > 'Accessory Name' > 'Find App for this Accessory'.

Matched apps are listed in alphabetical order with one exception. If the accessory works with apps from multiple development teams/companies, the accessory may provide a preferred Team ID to place apps from the preferred team at the top of the list.

Figure App Match Alert 22-1



See the Accessory Interface Specification (page 21) for more information.						

23. Bluetooth Headset Battery Level Indication

Any Hands-Free Bluetooth headset accessory may display its battery level to the user as an indicator icon in the device status bar. This feature is supported on all devices supporting the Hands-Free Profile, including iPhone, iPod touch, and iPad.

Headset battery indication is implemented by two Apple-specific Bluetooth HFP AT commands, HFP Command AT+XAPL (page 103) and HFP Command AT+IPHONEACCEV (page 110)

23.1 HFP Command AT+IPHONEACCEV

Description: Reports a headset state change.

Initiator: Headset accessory

Format: AT+IPHONEACCEV=Number of key/value pairs, key1, val1, key2, val2, ...

Parameters:

• Number of key/value pairs: The number of parameters coming next.

- *key*: the type of change being reported:
 - 1 = Battery Level
 - 2 = Dock State
- val: the value of the change:
 - Battery Level: string value between '0' and '9'
 - Dock State: 0 = undocked, 1 = docked

Example: AT+IPHONEACCEV=1,1,3

24. Device Power (Lightning)

The Device Power feature enables accessories to report their power characteristics and provide power to a device.

Apple strongly recommends providing power to the device whenever possible for the best user experience.

Accessories providing power to a device shall connect to the device either through an integrated Lightning connector or a USB to Lightning cable. To incorporate an integrated Lightning connector, the accessory developer shall be a member of the Apple MFi Licensing Program (page 21).

Accessories providing power to a device shall either:

- Provide direct power, see <u>Direct Power Source</u> (page 111).
- Manage power from external sources, see External Power Source (page 111).

Accessories without the potential for data communication with the device shall provide direct power to the device, see Direct Power Source (page 111).

24.1 Direct Power Source

Accessories providing power directly shall provide power at all times unless a direct user action is taken turning the accessory 'off'. Failure to provide power at all times may result in the accessory being unable to charge a device whose battery level is too low to boot.

All accessory power source testing shall be performed with programmable loads, not devices. Device power draw varies with environmental factors.

24.2 External Power Source

Accessories drawing power from external power sources and providing all or a portion of their power to the device shall identify the power source's capability and report accordingly to the device.

Note:

Accessories shall not manipulate a device into drawing more power from the external power source than the device would normally draw when directly connected to the external power source.

Accessories shall not manipulate a device into drawing less than the minimum power required by the accessory compatibility claims if it is available from the external source, see Providing Power using USB Connectors (page 112).

Accessories drawing power from external power sources may inform the device when power is not available or only available at a reduced level (for example, from an internal battery) or when the user unplugs the accessory from the external power source (for example, an AC power adapter or AC "mains" power outlet). Power to the device shall be restored and the updated power providing capability change shall be communicated to the device when the user re-connects the external power source.

See AC Power Adapters (page 66), Integrated USB Receptacles (page 23), and User Supplied Cables and AC Power Adapters (page 23) for additional requirements specific to external USB power supplies/cables.

24.3 Declaring Capability

If the accessory provides power using a:

- USB-A receptacle, it shall use one of the following to declare its power providing capability:
 - USB Power Capability Vendor Request (page 164).
 - USB D+/D- Resistor Networks (page 165).
- USB-C receptacle, then:
 - It shall use one of the following to declare its power providing capability:
 - USB-C Current (page 169).
 - USB Power Delivery (page 168).
 - If the accessory does not have the potential for data communication with the device, it shall also support the *USB Battery Charging 1.2* specification.

24.4 Providing Power using USB Connectors

If the accessory connects using a USB-A receptacle, see USB-A Receptacle (page 199).

If the accessory connects using a USB-C receptacle, see USB-C Receptacle (page 202).

24.5 Labeling Multiple Connectors

If the accessory has multiple connectors with different device compatibilities, the iPad-compatible connectors shall be labeled with the text 'iPad' unless it is physically impossible to connect an iPad to the iPhone/iPod compatible connectors.

24.6 Fast Charge for iPhone (20 W)

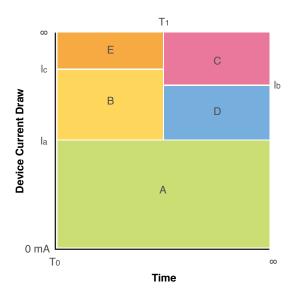
Accessories advertising "fast charge" for iPhone (https://support.apple.com/en-us/HT208137) shall:

- Support USB Power Delivery (page 168).
- Supply at least 20 W (2.22 A at 9 V) using USB-PD.
- Claim compatibility with at least one of the following iPhone models:
 - iPhone 14 Pro Max
 - iPhone 14 Pro
 - iPhone 14 Plus
 - iPhone 14
 - iPhone SE (3rd generation)
 - iPhone 13 Pro Max
 - iPhone 13 Pro
 - iPhone 13
 - iPhone 13 mini
 - iPhone 12 Pro Max
 - iPhone 12 Pro
 - iPhone 12
 - iPhone 12 mini
 - iPhone SE (2nd generation)
 - iPhone 11 Pro Max
 - iPhone 11 Pro
 - iPhone 11
 - iPhone XS Max
 - iPhone XS
 - iPhone XR
 - iPhone X
 - iPhone 8 Plus
 - iPhone 8

Accessories such as charging cables should be capable of supporting up to 60 W (3 A at 20 V) to provide compatibility with a variety of sources and devices.

24.7 Overcurrent and Short Circuit Protection

Figure Overcurrent and Short Circuit Protection 24-1



Power-providing accessories shall implement overcurrent and short circuit protection for each region in Figure 24-1 (page 114) according to Table 24-1 (page 114), Table 24-2 (page 114), and Table 24-3 (page 115).

Table 24-1 Overcurrent/Short Circuit Protection Current Thresholds

Threshold	Definition
l a	Nominal accessory output current (for example, 1000 mA, 2100 mA, 2400 mA, 3000 mA).
I _b	I _a + 60%.
I _c	Lowest device current draw causing accessory output voltage (measured at Lightning Device Power) to drop below 2 V.

Table Overcurrent/Short Circuit Protection Time Thresholds 24-2

Threshold	Definition
T ₀	Start of any device current draw transient.
T ₁	Accessory overcurrent/short circuit deglitch/debounce time, shall $\geq T_0 + 1$ ms.

Table Overcurrent/Short Circuit Protection Behaviors

24-3

Region	Name	Accessory Behavior
Α	Normal Operation	Accessory shall not limit or shutdown output current.
В	Overcurrent Transient	Accessory shall not shutdown output current. Accessory may limit output current to ${\bf I_a}$ or higher.
С	Overcurrent	Accessory shall shutdown output current.
D	Potential Overcurrent	Accessory may shutdown output current.
Е	Potential Short Circuit	If Lightning Device Power voltage drops below 2 V, the accessory may trigger short circuit protection. Accessories shall not trigger short circuit protection on device current draw.

24.8 Overcurrent and Short Circuit Protection Resets

Accessory overcurrent and short circuit protection shall reset without mechanical intervention.

24.9 Power State Changes

Accessories shall not change the amount of power provided to a device unless:

- Direct user action is taken to turn the accessory on or off.
- An external power source (for example, mains electricity or battery) is connected to or disconnected from the accessory.
- The accessory's internal power source (for example, a battery) is depleted or loaded to the point where it is no longer capable of supplying its declared power providing capability or is now capable of supplying more power than previously declared.

25. Device Power (Inductive)

Accessories may provide power to devices using inductive power transmitters, specifically:

- Qi Wireless Power (page 116)
- MagSafe (page 117)

25.1 Qi Wireless Power

The following devices support Qi Wireless Power (page 116):

- iPhone 14 Pro Max
- iPhone 14 Pro
- iPhone 14 Plus
- iPhone 14
- iPhone SE (3rd generation)
- iPhone 13 Pro Max
- iPhone 13 Pro
- iPhone 13
- iPhone 13 mini
- iPhone 12 Pro Max
- iPhone 12 Pro
- iPhone 12
- iPhone 12 mini
- iPhone SE (2nd generation)
- iPhone 11 Pro Max
- iPhone 11 Pro
- iPhone 11
- iPhone XS Max
- iPhone XS
- iPhone XR
- iPhone X
- iPhone 8 Plus
- iPhone 8
- MagSafe Charging Case for AirPods Pro (2nd generation)
- MagSafe Charging Case for AirPods (3rd generation)
- Wireless Charging Case for AirPods

Accessories incorporating a Qi transmitter shall use an embedded Qi Certified subsystem or shall be Qi Certified according to *The Qi Wireless Power Transfer System, Power Class O Specification*, version 1.2.4, see https://www.wirelesspowerconsortium.com.

25.2 MagSafe

The following devices support MagSafe:

- iPhone 14 Pro Max
- iPhone 14 Pro
- iPhone 14 Plus
- iPhone 14
- iPhone 13 Pro Max
- iPhone 13 Pro
- iPhone 13
- iPhone 13 mini
- iPhone 12 Pro Max
- iPhone 12 Pro
- iPhone 12
- iPhone 12 mini
- MagSafe Charging Case for AirPods Pro (2nd generation)
- MagSafe Charging Case for AirPods (3rd generation)

See the Accessory Interface Specification (page 21) for information on MagSafe.

25.3 Electromagnetic Compatibility (EMC)

Accessories providing inductive device power should be designed for electromagnetic compatibility.

Apple recommends shielding the magnetic field from the charging coil and maintaining a low impedance shield termination for cables to comply with regulatory EMC requirements for the completed product. Implementation, final compliance testing, report preparation, and labeling are the responsibilities of the company marketing and producing the product.

Cable termination is critical for reduced emissions. Cable termination and connectors should be kept away from the charging soil and cables should be routed away from the charging surface.

If emissions are present, adding clamp-on ferrites/absorbers to the cable can help reduce emissions. Selected ferrite/absorber materials should be rated for the failing frequencies.

Depending on the accessory's supported use cases, testing should be performed with the following power supplies:

- Apple USB-C Power Adapters:
 - Apple 140W USB-C Power Adapter
 - Apple 96W USB-C Power Adapter
 - Apple 67W USB-C Power Adapter
 - Apple 30W USB-C Power Adapter
 - Apple 20W USB-C Power Adapter
 - Apple 35W Dual USB-C Port Compact Power Adapter
 - Apple 35W Dual USB-C Port Power Adapter
- Apple USB-A Power Adapters:
 - Apple 12W USB Power Adapter
 - Apple 5W USB Power Adapter
 - Model A1385 (US)
 - Model A1400 (Int.)
 - Model A1552 (UK)
 - Model A1443 (China)
 - Model A1444 (Australia)
 - Model A1486 (Brazil)
 - Model A1487 (Korea)
 - Model A1501 (Argentina)
- Apple Mac computers:
 - Apple MacBook Pro
 - Apple MacBook Air

If power sources are used differing from those listed above, emission testing should be performed while the power sources are on.

In addition to the use cases above, charging devices should be tested in idle mode for emissions.

Emissions tests should be conducted in accordance with standards referenced in the following:

- FCC CFR 47, Part 15
- ICES-003, Issue 5, CAN/CSA-CEI/IEC CISPR 22-10
- CISPR 22: 2008
- EN 55022: 2010
- AS/NZS CISPR 22:2009, TCVN 7189:2009
- VCCI V-3/2013.04
- GB 9254-2008, GB 17625.1-2012, GB 17625.2-2007, CNS 13438-2006
- CISPR 24: 2010
- EN 55024: 2010

26. Location Information

Location features enable accessories to provide Global Navigation Satellite System (GNSS) and sensor data (for example, speed) to devices in the form of National Marine Electronics Association (NMEA) sentences. Devices can use the additional information to augment built-in location services. For example, some external accessories provide more accurate or more frequent position updates. Additionally, devices can conserve power by using location information from a self-powered external accessory.

27. MagSafe Attach

The following devices support MagSafe Attach:

- iPhone 14 Pro Max
- iPhone 14 Pro
- iPhone 14 Plus
- iPhone 14
- iPhone 13 Pro Max
- iPhone 13 Pro
- iPhone 13
- iPhone 13 mini
- iPhone 12 Pro Max
- iPhone 12 Pro
- iPhone 12
- iPhone 12 mini

MagSafe Cases (page 29) shall:

- Claim compatibility with a MagSafe-capable device.
- Integrate a MagSafe Case Magnet Array (page 122).

Other MagSafe accessories shall:

- Claim compatibility with a MagSafe-capable device.
- Integrate a MagSafe Accessory Magnet Array (page 129).

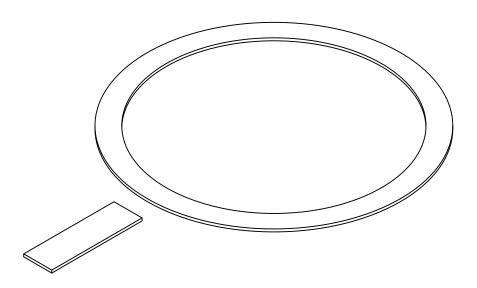
Apple recommends the following magnet array vendors:

- Ningbo Sanhuan Magsound Industry & Trade Co., Ltd. (http://magsound.com)
- Phone In Mag Electronics Co., Ltd. (http://www.phonein.com.tw)
- Quadrant Solutions, Inc. (https://www.quadrant.us)

27.1 MagSafe Case Magnet Array

Figure MagSafe Case Magnet Array

27-1



27.1.1 Product Design

All cases integrating a MagSafe case magnet array shall:

- Enclose the device.
- Have a uniform thickness no greater than 2.1 mm; Apple recommends 2.0 mm.
- Firmly attach to the device without relying on the magnets.
- Not integrate magnets on the back of the case other than the MagSafe magnets.
- Comply with requirements for Cases (page 29).
- Work with:
 - Apple MagSafe Charger.
 - Apple MagSafe Battery Pack.
 - iPhone Leather Wallet with MagSafe.

27.1.2 Mechanical

All magnets that are part of the MagSafe case magnet array shall be positioned in the same plane.

The case and MagSafe case magnet array shall enable MagSafe accessories to magnetically self align within a 1.55 mm radial maximum.

27.1.2.1 Magnets

All MagSafe case magnets shall be N45SH NdFeB with a 7 μ m - 13 μ m NiCuNi plating finish (or similar) and shall meet the requirements in Table 27-1 (page 123).

Table 27-1 Magnet Properties

Property	Minimum	Maximum
Br	13.2 kGs	13.6 kGs
Hcb	12.75 kOe	
Hcj	20.50 kOe	
BHmax	43 MGOe	46 MGOe

27.1.2.2 Magnet Array

The magnets shall be positioned in the case following the dimensions and polarity shown in Figure 27-2 (page 124), Figure 27-3 (page 125) and Figure 27-4 (page 125).

Figure MagSafe Magnet Array Dimensions 27-2

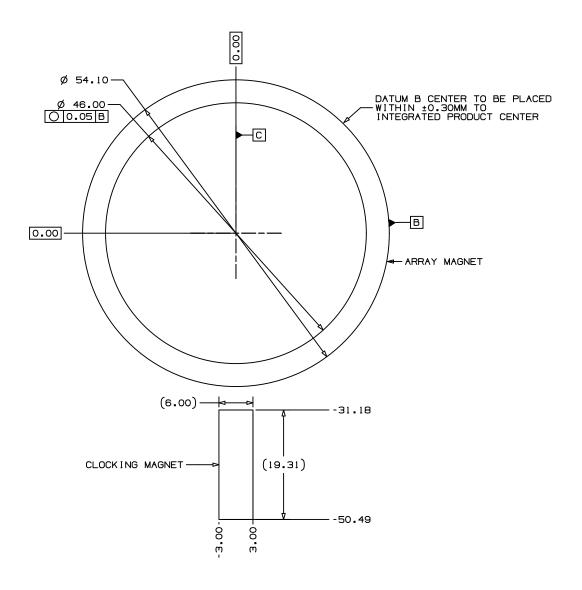


Figure MagSafe Magnet Ring Dimensions and Polarity 27-3

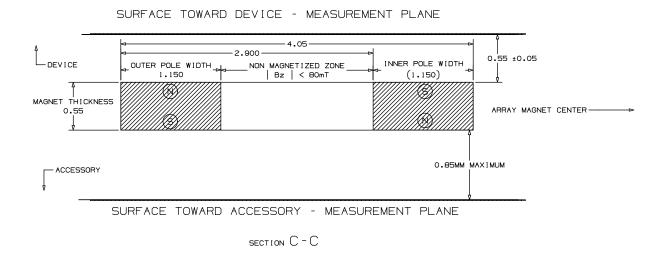
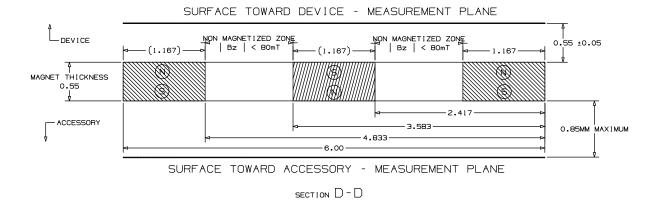


Figure MagSafe Orientation Magnet Dimensions and Polarity 27-4



The flux density of a MagSafe case magnet ring shall comply with Table 27-2 (page 126) and Table 27-3 (page 127) across the 8 lines (S1 - S8) in Figure 27-5 (page 126).

Figure MagSafe Flux Density Measurement Plane 27-5

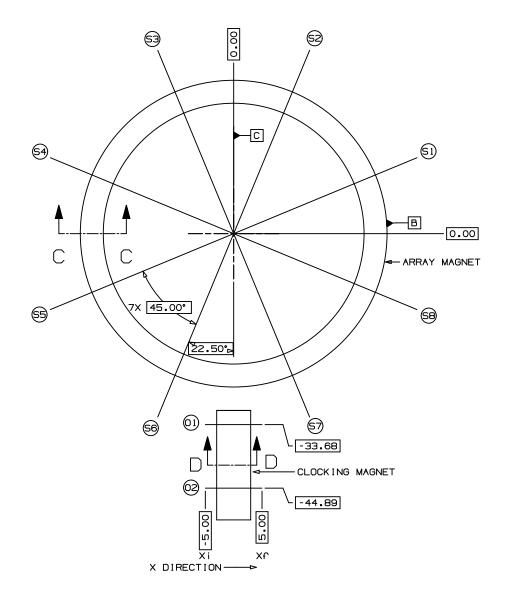


Table 27-2 Device side flux density at 0.55 mm from magnet ring surface

Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
r	r	Bz	Bz	Вху	Вху
	19.5 mm	-0.020 T	0.020 T		0.025 T
19.5 mm	23 mm				0.075 T
23 mm	24 mm	-0.170 T	-0.125 T		
24 mm	26 mm			0.095 T	0.1325 T
26 mm	27 mm	0.125 T	0.170 T		

Minimum r	Maximum r	Minimum Bz	Maximum Bz	Minimum Bxy	Maximum Bxy
27 mm	30 mm				0.075 T
30 mm		-0.020 T	0.000 T		0.025 T

Table 27-3 Accessory side flux density at 0.80 mm from magnet ring surface

Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
r	r	Bz	Bz	Вху	Вху
	19.5 mm	-0.020 T	0.020 T		0.025 T
19.5 mm	23 mm				0.065 T
23 mm	24 mm	-0.120 T	-0.085 T		
24 mm	26 mm			0.070 T	0.100 T
26 mm	27 mm	0.85 T	0.120 T		
27 mm	30 mm				0.065 T
30 mm		-0.020 T	0.000 T		0.025 T

The flux density of a MagSafe case orientation magnet shall comply with Table 27-4 (page 127) and Table 27-5 (page 127) across the 2 lines (O1 and O2) in Figure 27-5 (page 126).

Table 27-4 Device side flux density at 0.55 mm from orientation magnet surface

Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
X	X	Bz	Bz	Вху	Вху
	-5.0 mm	-0.020 T	0.020 T		0.025 T
-5.0 mm	-4.5 mm	-0.020 T	0.020 T		
-4.5 mm	-2.75 mm			0.080 T	0.110 T
-2.75 mm	-2.0 mm	0.125 T	0.175 T		
-2.0 mm	-0.5 mm			0.110 T	0.155 T
-0.5 mm	0.5 mm	-0.1925 T	-0.140 T		
0.5 mm	2.0 mm			0.110 T	0.155 T
2.0 mm	2.75 mm	0.125 T	0.175 T		
2.75 mm	4.0 mm			0.080 T	0.110 T
4.0 mm	5.0 mm	-0.020 T	0.020 T		
5.0 mm		-0.020 T	0.020 T		0.025 T

Table 27-5 Accessory side flux density at 0.80 mm from orientation magnet surface

Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
x	x	Bz	Bz	Bxy	Bxy
	-5.0 mm	-0.020 T	0.020 T		0.025 T

Minimum x	Maximum x	Minimum Bz	Maximum Bz	Minimum Bxy	Maximum Bxy
-5.0 mm	-4.5 mm	-0.020 T	0.020 T		
-4.5 mm	-2.75 mm			0.050 T	0.070 T
-2.75 mm	-2.0 mm	0.085 T	0.120 T		
-2.0 mm	-0.5 mm			0.0825 T	0.115 T
-0.5 mm	0.5 mm	-0.140 T	-0.0975 T		
0.5 mm	2.0 mm			0.0825 T	0.115 T
2.0 mm	2.75 mm	0.085 T	0.120 T		
2.75 mm	4.0 mm			0.050 T	0.070 T
4.0 mm	5.0 mm	-0.020 T	0.020 T		
5.0 mm		-0.020 T	0.020 T		0.025 T

27.1.2.3 Magnetic Force

The force normal to the back of the case needed to dislodge a MagSafe accessory, such as the Apple MagSafe Charger, shall meet the requirements in Table 27-6 (page 128).

Table 27-6 Magnetic force

Scenario	Minimum	Maximum
Case attached to device	800 gf	1100 gf
Case only	600 gf	900 gf

27.1.3 Magnetic Interference

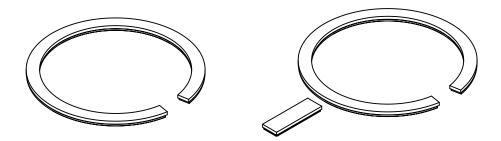
All cases with an integrated MagSafe magnet array shall not interfere with:

- Inductive charging.
- Magnetic stripe cards in an attached iPhone Leather Wallet with MagSafe.

27.2 MagSafe Accessory Magnet Array

Figure MagSafe Accessory Magnet Array Options

27-6



The MagSafe accessory magnet array shall be implemented as a Magnet Ring (page 130). The magnet ring enables the device and accessory to be attached in any orientation. To support a specific orientation, the accessory may include an Orientation Magnet (page 132) as part of the array.

27.2.1 Product Design

Accessories integrating the MagSafe accessory magnet array shall not enclose the device.

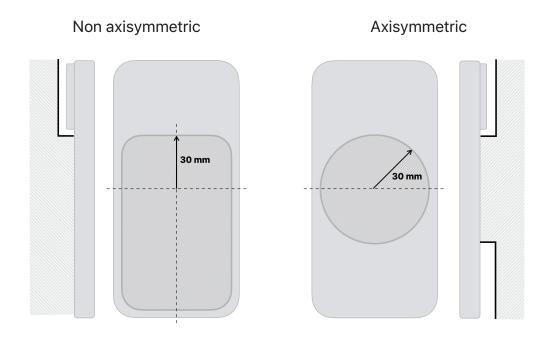
27.2.2 Mechanical

The accessory shall not interfere with or cause Scratches and Damage (page 23) to the device.

To avoid interference with devices, accessories shall:

- Not exceed 30 mm from the center of the magnet ring surface towards the top edge of the device for all supported device orientations. If the device can be attached in any orientation, the accessory shall not exceed 30 mm in radius around the center of the magnet ring surface.
- Maintain a clearance of 5 mm from the back of the device (mating surface) for any part of the accessory past the 30 mm keep-in constraint.
- Stay within the MagSafe Accessory Enclosure Geometry (page 136).

Figure MagSafe Accessory Clearance 27-7



All magnets that are part of the MagSafe accessory magnet array shall be positioned in the same plane.

The MagSafe accessory's Magnet Ring (page 130) shall magnetically self align to the device's magnet ring within a 1.55 mm radial maximum.

27.2.2.1 Magnets

All MagSafe accessory magnets shall be N48H NdFeB with a 7 μ m - 13 μ m NiCuNi plating finish (or similar) and shall meet the requirements in Table 27-7 (page 130).

Table 27-7 Magnet Properties

Property	Minimum	Maximum
Br	13.7 kGs	14.1 kGs
Hcb	13.25 kOe	
Hcj	17 kOe	
BHmax	45 MGOe	48 MGOe

27.2.2.2 Magnet Ring

The magnet ring shall be positioned in the accessory in compliance with the dimensions and polarity requirements in Figure 27-8 (page 131) and Figure 27-9 (page 132).

Figure MagSafe Magnet Ring Dimensions 27-8

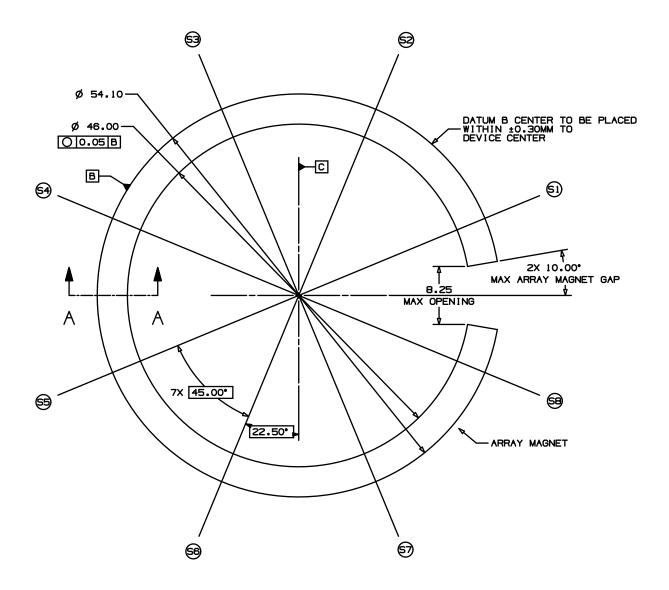
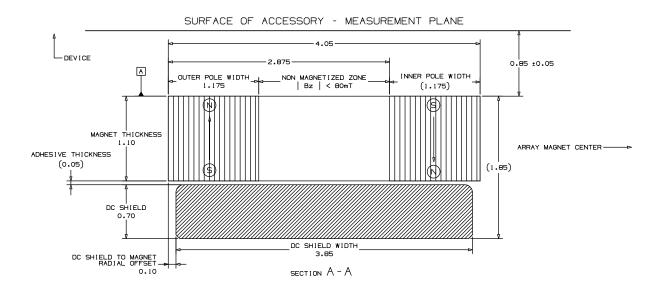


Figure MagSafe Magnet Ring Dimensions and Polarity 27-9



See DC Shield (page 135) for additional requirements of the DC shield specified in Figure 27-9 (page 132).

The flux density of a MagSafe accessory magnet ring shall comply with Table 27-8 (page 132) across the 8 lines (S1 - S8) in Figure 27-8 (page 131).

Table 27-8 Flux density at 0.85 mm from magnet ring surface

Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
r	r	Bz	Bz	Вху	Вху
0 mm	19.5 mm	-0.025 T	0.025 T		0.025 T
19.5 mm	23 mm				0.075 T
23 mm	24.5 mm	-0.215 T	-0.155 T		
24.5 mm	25.5 mm			0.170 T	0.215 T
25.5 mm	27 mm	0.155 T	0.215 T		
27 mm	30 mm				0.075 T
30 mm		-0.025 T	0.025 T		0.025 T

27.2.2.3 Orientation Magnet

If orientation magnets are included, they shall be positioned according to Figure 27-10 (page 133) and Figure 27-11 (page 134).

Figure MagSafe Orientation Magnet Dimensions 27-10

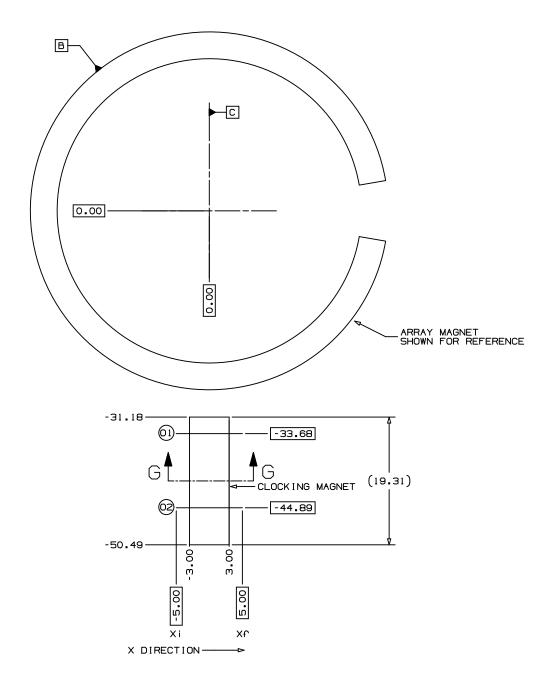
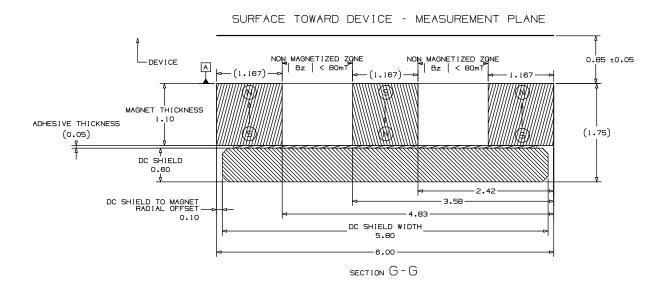


Figure MagSafe Orientation Magnet Dimensions and Polarity 27-11



See DC Shield (page 135) for additional requirements of the DC shield specified in Figure 27-11 (page 134).

The flux density of a MagSafe accessory orientation magnet shall comply with Table 27-9 (page 134) across the 2 lines (O1 and O2) in Figure 27-10 (page 133).

Table 27-9 Flux density at 0.85 mm from orientation magnet surface

Minimum x	Maximum x	Minimum Bz	Maximum Bz	Minimum Bxy	Maximum Bxv
^	^			БХУ	
	-5.0 mm	-0.025 T	0.025 T		0.025 T
-5.0 mm	-4.5 mm	-0.025 T	0.025 T		
-4.5 mm	-3.0 mm			0.0625 T	0.0875 T
-3.0 mm	-2.0 mm	0.145 T	0.195 T		
-2.0 mm	-0.5 mm			0.165 T	0.215 T
-0.5 mm	0.5 mm	-0.250 T	-0.185 T		
0.5 mm	2.0 mm			0.165 T	0.215 T
2.0 mm	3.0 mm	0.145 T	0.195 T		
3.0 mm	4.0 mm			0.0625 T	0.0875 T
4.0 mm	5.0 mm	-0.025 T	0.025 T		
5.0 mm		-0.025 T	0.025 T		0.025 T

27.2.2.4 Magnetic Force

The force normal to the back of the device needed to dislodge the MagSafe accessory shall meet the requirements in Table 27-10 (page 135).

Table Magnetic force 27-10

Scenario	Minimum	Maximum
Accessory attached to device	650 gf	900 gf

27.2.2.5 DC Shield

The DC shield shall be low carbon steel (1010, DT4 or similar), per ASTM848, with a 5 μ m - 10 μ m Ni plating finish or similar.

The DC shield shall have a saturation flux density (B $_{\rm sat}$) of at least 2.0 T.

27.4 Test Procedures

27.4.1 MagSafe Case Magnet Array

27.4.1.1 Case Thickness

27.4.1.1.1 Equipment

Digital thickness gauge, such as the Mitutoyo 547-520S.

27.4.1.1.2 Procedure

- 1. Using the digital thickness gauge, verify the thickness is less than or equal to 2.1 mm at:
 - Four points along the magnet ring.
 - Two points along the orientation magnet.

27.4.1.2 Accessory Clearance

27.4.1.2.1 Equipment

- MagSafe-capable device.
- Apple MagSafe Battery Pack.

27.4.1.2.2 Procedure

- 1. Attach the case to the device.
- 2. Attach the Apple MagSafe Battery Pack to the back of the case.
- 3. Verify the case does not interfere with the Apple MagSafe Battery Pack and only the mating surface is in contact.

27.4.1.3 Magnetic Force

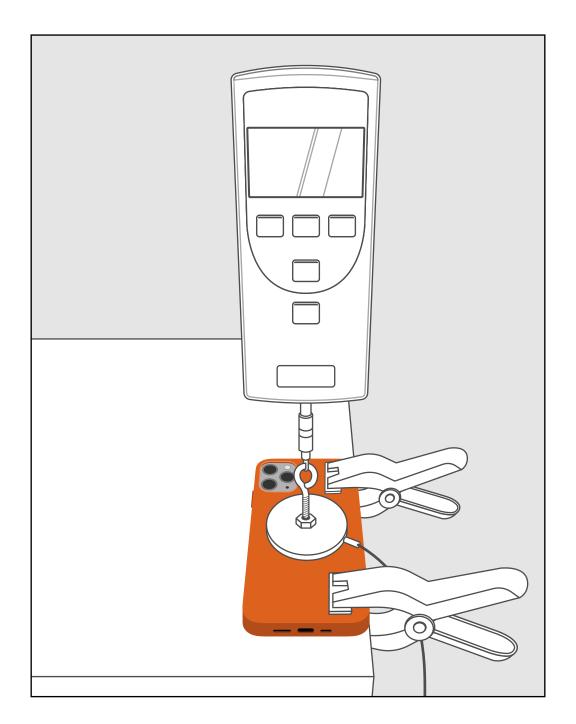
27.4.1.3.1 Equipment

- MagSafe-capable device.
- Apple MagSafe Charger with a non-magnetic eyelet screw glued firmly to its back. Pulling on the eyelet should exert a force on the center of the charger.
- Digital force gauge capable of capturing peak values, such as the Chatillon DFX II.
- Hook attachment for digital force gauge.
- Clamps.

27.4.1.3.2 Procedure

- 1. Attach the case to the device.
- 2. Place the device on a flat level surface with the display facing down and clamp it firmly in place. See Figure 27-12 (page 139).
- **3.** Repeat the following steps 5 times:
 - **a.** Attach the modified Apple MagSafe Charger to the back of the case, allowing the Apple MagSafe Charger to magnetically align.
 - **b.** Connect the force gauge hook to the eyelet. See Figure 27-12 (page 139).
 - c. Reset the force gauge's peak force value.
 - **d.** Pull the force gauge vertically until the Apple MagSafe Charger and eyelet assembly dislodge from the case.
 - e. Note the peak force value displayed on the force gauge.
- 4. Calculate the average of the 5 peak force measurements.
- 5. Verify the average force is within the range of 800 gf to 1100 gf.

Figure Magnetic Force Test Setup 27-12



27.4.1.4 iPhone Leather Wallet with MagSafe Detection

27.4.1.4.1 Equipment

• MagSafe-capable device.

• iPhone Leather Wallet with MagSafe.

27.4.1.4.2 Procedure

- 1. Attach the case to the device.
- 2. Attach the wallet to the back of the case.
- **3.** Verify the device displays the wallet animation.

27.4.1.5 Magnetic Stripe Cards in iPhone Leather Wallet with MagSafe

27.4.1.5.1 Equipment

- MagSafe-capable device.
- iPhone Leather Wallet with MagSafe.
- Low Coercivity Magnetic stripe (LoCo) cards, such as cards from the following vendors:
 - American Card Service.
 - Allsafe.
 - Cl Solutions.
 - PSA.
- LoCo card reader/writer, such as:
 - Q-card Mag3x.
 - Magtek InSpec 9000.
 - Misiri X6BT.
 - Deftun MSR605X.

27.4.1.5.2 Procedure

- 1. Attach the accessory to the device.
- 2. Repeat this procedure for three different brands of LoCo cards:
 - a. Write to the LoCo card and confirm readability.
 - **b.** Insert the LoCo card into the wallet with the magnetic stripe facing the magnets.
 - **c.** Place additional cards into the wallet to ensure a LoCo card is in contact with the magnet side of the wallet.
 - **d.** Attach the wallet to the accessory (attached to the device).
 - e. Wait 10 seconds.
 - **f.** Remove the wallet from the accessory.
 - g. Remove the LoCo card from the wallet.
 - **h.** Verify the LoCo card can be read and it displays the correct information.

27.4.2 MagSafe Accessory Magnet Array

27.4.2.1 Orientation Magnet

If the accessory includes an orientation magnet:

- 1. Use a straight edge to verify the device contact surfaces of the magnet ring and orientation magnet are coplanar (aligned in the same plane).
- 2. Attach a MagSafe-capable device to the accessory and align it with the orientation magnet. Verify there are no gaps between the:
 - MagSafe magnet ring and device.
 - MagSafe orientation magnet and device.

28. Media Library Access

The Media Library feature allows accessories to download the metadata contents of a device's media libraries (not the media items themselves) and request playback of media items. The feature is divided into the following sub-features:

- Media Library Information informs the accessory about media libraries available on the device.
- Media Library Updates provide an accessory with an updated view of the contents of a particular media library.
- Media Library Playback allows the accessory to request playback of one or more items from a media library.

29. Now Playing Updates

The Now Playing feature enables an accessory to display information about the current "Now Playing" media source and media item on a device. Media sources include both the built-in Apple Music and Apple Video apps on devices and certain third-party iOS apps supporting the generation of Now Playing metadata, see *MPNowPlayingInfoCenter* in the iOS SDK documentation. Accessories shall be prepared for the Now Playing media source and media item to change at any time, whether the accessory requested the change or not.

30. Out-of-Band Bluetooth Pairing

Accessories with the ability to connect to a device using Bluetooth and a wired transport should use the Out-of-Band Bluetooth Pairing feature to simplify Bluetooth connection setup.

For example, Lightning to USB charge/sync cables or Lightning to USB accessory cables can be used to exchange Bluetooth pairing information upon initial connection. This may reduce or eliminate the need for instruction manuals to describe how to:

- Put the accessory into a discoverable and pairable mode.
- Initiate Bluetooth pairing on the device using the Settings app.
- Download the accessory's companion app and initiate pairing from the app.

31. Siri

Siri enables a user to have rich interactions with a device by primarily using their voice.

Accessories supporting Siri shall not use an icon resembling the Siri microphone icon.

The rest of this chapter is applicable to accessories supporting Siri over Bluetooth using HFP commands.

To support Siri using other transports and protocols, the accessory developer shall be a member of the Apple MFi Licensing Program (page 21).

31.1 Enabling Custom Siri Commands

Every accessory supporting Siri over Bluetooth using HFP commands shall support HFP Command AT+XAPL (page 103). The device will use the information sent by this command to enable and disable custom commands related to Siri.

To receive Siri status events, the accessory shall send the AT+XAPL command after making a successful HFP Service Level Connection (SLC) to the device. The accessory should send an AT+XAPL command first, before sending any of the additional Siri-specific commands described below.

31.2 Obtaining Siri Availability Information

After establishing an HFP profile connection, an accessory can determine if Siri is available and enabled on a device. It can also receive notifications of changes in Siri status. If Siri is disabled, Voice Control will be activated instead.

31.2.1 Obtaining Status Information at Connection

The accessory should send the following command after making a successful HFP profile (SLC) connection and sending an AT+XAPL command.

31.2.1.1 HFP Command AT+API SIRI?

Description: AT command to retrieve Siri status information.

Initiator: Accessory

Format: AT+APLSIRI?

Response: +APLSIRI: value

Defined Values:

- 0 = Siri is not available on this platform.
- 1 = Siri is available and enabled.
- 2 = Siri is available but not enabled.

Example: +APLSIRI:1 (Siri is available and enabled)

31.2.2 Receiving Siri Availability Updates from the Device

After initialization has been completed, the device will send the accessory the following notification if there is a change in Siri status. This notification will be provided only if the accessory has requested Siri status (by sending AT+APLSIRI?) at least once after connection and if the device has reported Siri is available and enabled.

31.2.2.1 HFP Command +APLSIRI

Description: Unsolicited event indicating a change in Siri status.

Initiator: Device

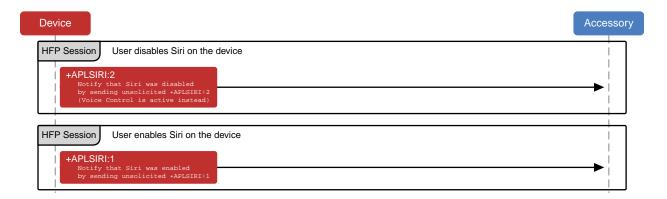
Format: +APLSIRI: value

Defined Values:

- 1 = Siri is available and enabled.
- 2 = Siri is available but not enabled.

Example: +APLSIRI: 2 (Siri is available but not enabled)

Figure Siri is Disabled/Enabled from the Device's Settings 31-1



31.3 Initiating a Siri Session

Once support for Siri is established on both the accessory and the device, a Siri session can be started from either one.

31.3.1 Initiating a Session from the Accessory

The accessory should only initiate a Siri session as a result of a direct user action.

The accessory shall use the voice recognition command AT+BVRA defined in the Bluetooth *Hands-Free Profile* specification (*Hands-Free Profile* 1.6 profile specification, section 4.25) to initiate a Siri session.

The HFP profile shall be connected and SLC shall exist.

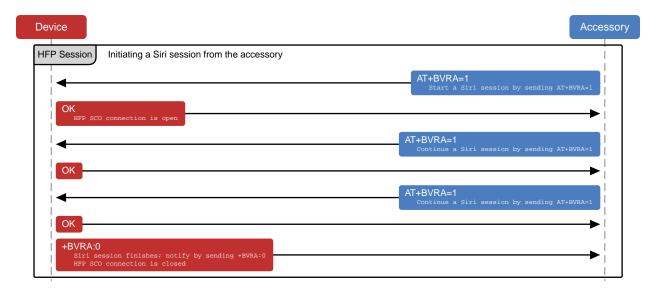
The accessory should use the following command sequence:

- The accessory sends an AT+BVRA=1 command to the device.
- The device sends an OK response.
- The device activates a Siri session and creates a Synchronous Connection (SCO) for the audio.
- If the Siri session is not finished, the accessory shall send AT+BVRA=1 to continue the conversation. This may need to happen multiple times.
- When the Siri session is finished, the device sends a +BVRA: 0 result code to the accessory.
- The device disconnects the SCO connection.

While a Siri session is active, the accessory shall let the user continue the conversation and ask follow up questions within the current context. In order to do so, the accessory shall be able to send an AT+BVRA=1 command to the device even after Siri has been already activated and before +BVRA:0

is received. Figure 31-2 (page 148) shows an overview of the interaction when Siri is triggered from the accessory, the running session was continued twice and once Siri was finished, the device dismissed the session.

Figure Initiating a Siri Session from the Accessory 31-2



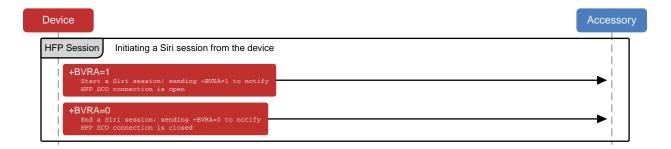
31.3.2 Initiating a Session from the Device

If the accessory supports voice recognition commands, the device sends a +BVRA event to indicate the start of a Siri session. The accessory shall enable support for voice recognition and indicate it in its feature response as described in the Bluetooth *Hands-Free Profile* 1.6 specification, section 4.34.1, "Bluetooth Defined AT Capabilities." Specifically, the HFP profile shall be connected, SLC shall exist, and voice recognition activation (bit 3) shall be enabled in the AT+BRSF command. The device will not use virtual call functionality for the Siri session if voice recognition activation is supported by the accessory.

The accessory should expect the following command sequence:

- The device sends a +BVRA:1 event to the accessory.
- The device activates a Siri session and creates a SCO connection for the audio.
- When the Siri session is finished, the device sends a +BVRA: 0 result code to the accessory.
- The device disconnects the SCO connection.

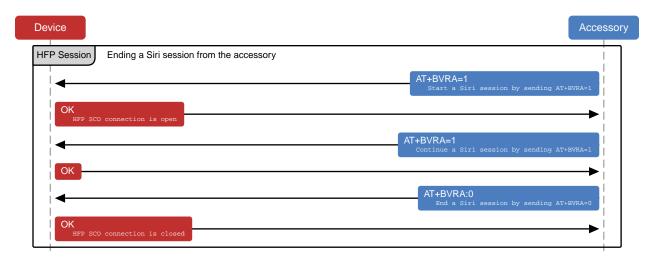
Figure Initiating a Siri Session from the Device 31-3



31.3.3 Ending a Session from the Accessory

Once a Siri session is running the accessory shall be capable of ending the session by sending an AT+BVRA=0 command to the device. Figure 31-4 (page 149) shows an example of ending a running Siri session from the accessory. The accessory should only end an active session as a result of a direct user action.

Figure Ending a Siri Session from the Accessory 31-4



31.4 Siri Eyes Free Mode

Siri Eyes Free mode is a feature to control Siri responses including display information and can be enabled or disabled as needed. In Siri Eyes Free mode, the user experience is tailored towards a driving scenario and interactions with Siri are done primarily using voice to minimize the need for the user to

look at a screen. Siri Eyes Free mode is supported only for Bluetooth-enabled vehicle entertainment systems and should not be used by any other accessories. Siri Eyes Free should not be triggered using a voice command.

The device will listen for the HFP AT command AT+APLEFM to enable or disable Siri Eyes Free mode.

This command is used by the device to modify Siri responses containing visual information or requiring user interaction. Suitable audio feedback and voice commands will be available to the user based on the initiated Siri use case.

Siri Eyes Free mode is disabled by default. Once the accessory has enabled Siri Eyes Free mode, it remains enabled for all subsequent Siri sessions initiated from the accessory until the accessory disables it or the Bluetooth connection is disconnected.

31.4.1 HFP Command AT+APLEFM

Description: An accessory sends this command to notify a device of the preferred state of Siri Eyes Free mode.

Initiator: Accessory

Format: AT+APLEFM=value

Response: OK

Defined Values:

- 0x00 = Disable Siri Eyes Free mode.
- 0x01 = Enable Siri Eyes Free mode.
- 0x02-0xFF = reserved

Example: AT+APLEFM=1

31.5 Improving Voice Recognition

The microphone audio an accessory sends to the device during a Siri session should be suitable for voice recognition. Audio requirements for optimal voice recognition may differ from requirements for optimal human perception (for example, during a cellular phone call).

Filtering of the audio signal to remove echoes or feedback noise is acceptable.

To provide the best possible audio quality as Siri input, the accessory shall observe the following recommendations:

- Echo cancellation and noise suppression (EC/NR): Directional microphones and linear beamforming with microphone arrays giving improved SNR are recommended. Linear echo cancellation for reducing unwanted audio sources (such as audio output from the system) without having any other effect on the speech signal are also recommended. However, single channel noise reduction methods (such as spectrum subtraction) shall not be applied, as they will be detrimental to the speech recognition accuracy. Similarly, automatic gain control, residual echo suppression and attempts to blank out non-speech periods in the waveform shall not be applied.
- **Signal gain**: When adjusting signal levels, the accessory shall avoid artifacts, dropouts, and clipping in all circumstances. Automatic Gain Control is not recommended. If the accessory adjusts signal gain, the gain should be held constant across each spoken utterance. The nominal level measured at the uplink output of the accessory should be A-weighted -30 dB ±2 dB root-mean-square (RMS), expressed in units relative to full-scale (dBFS(A)). Alternatively, the nominal level may be 13 dB ±2 dB SLR if using the ITU measurement procedure.
- Signal-to-noise ratio (SNR): The average SNR should be greater than 20 dB. Below 20 dB, recognition rates will be impacted.
- Reverberation: An RT60 time less than 200 ms should be maintained.

31.5.1 Wide Band Speech Support

An accessory using Siri should support 16 kHz wide band speech audio for better audio quality and voice recognition performance. See the Bluetooth *Hands-Free Profile* 1.6 specification for details about wide band speech audio. Narrow band audio signal (8 kHz) is supported but not recommended.

31.6 Optimizing the Siri Experience

The start of a Siri session should not be accompanied by local beeps or verbal indications (such as an announcement of "...voice dialing...") from the accessory. When a Siri session becomes active, the device sends two beeps indicating that Siri is ready to receive instructions. Adding extra audible notifications only inserts delays in the system.

The accessory should wait for the device to end each Siri session.

The accessory should not send an AT+BVRA=0 command unless it is prompted to do so by user interaction.

The accessory should be capable of rendering audio within 200 ms of SCO connection activation to ensure that the user always hears the Siri introductory beeps.

31.7 Common Siri Applications

Siri can send messages, find points of interests, place phone calls, and much more. As Siri capabilities are constantly growing, additional use cases may become available after the initial integration. In Siri Eyes Free mode, some of these use cases may not be accessible as the user experience is tailored towards a driving scenario.

31.7.1 Initialization Procedure After Connection is Established

Figure 31-5 (page 152) outlines the sequence the accessory has to trigger to be able to use Siri on a device. After establishing an HFP profile connection, the accessory shall first enable the custom Siri commands by sending AT+XAPL and provide the features it supports. After a confirmation is received from the device, the accessory should determine Siri's availability with AT+APLSIRI?.

Vehicles with Bluetooth-enabled infotainment systems can also enable Siri Eyes Free Mode during initialization. This is detailed in Figure 31-6 (page 153).

Figure Siri Initialization Procedure 31-5

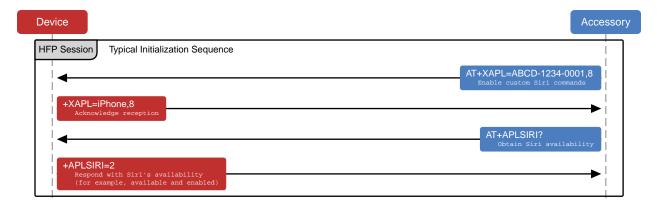


Figure Siri Initialization Procedure with Siri Eyes Free 31-6



31.7.2 Phone Dialing Using Siri

Upon user request, Siri can initiate an outgoing phone call. The device will initiate HFP call signaling to establish a phone call as described in Bluetooth (page 179). The accessory shall be able to transition to Hands-Free dialing at any time during or after a Siri session when signaled by the device.

31.7.3 Audio Routing and Media Playback Using Siri

Siri can control the media playback on a device, and if Siri determines the user wants to play or pause music, Siri will either start, pause or resume media playback. The device will send a notification to the accessory indicating a change in playback state and any associated track information. The accessory shall respond to the notifications, start or stop the music playback as requested, as well as update the correct playback state (for example, shuffle, repeat).

The accessory shall not force a change in the playback state after a Siri session is ended. If music was playing before Siri was started, it shall continue playing, if it was paused, it shall remain paused.

After Siri starts music playback the accessory shall set its current audio route to match the audio source, depending on how audio is being received from the device (using Bluetooth or by a wired connection).

The available media playback notifications depend on the audio route being used:

- Bluetooth audio routes shall use the approach described in Notifications (page 186) and Audio Data Received using A2DP Profile (page 189).
- Wired audio routes shall use iAP2.

31.7.4 Turn-By-Turn Directions Using Siri

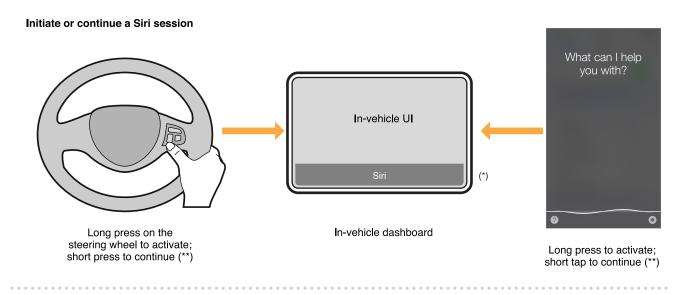
Siri can initiate active route guidance to provide turn-by-turn directions. In case the device is the active source and is already playing music, turn-by-turn directions will be mixed in as part of the audio stream. In case the device is not playing music, the accessory should be able to mix in turn-by-turn directions with the active audio source.

The device will notify the accessory to play turn-by-turn directions only over Bluetooth. Detailed information on how to distinguish between music playback and turn-by-turn notifications is available in Notifications (page 186).

31.8 User Interaction with Siri Eyes Free in a Vehicle

A vehicle using Siri Eyes Free mode shall integrate the Siri experience with the existing in-vehicle entertainment system and controls. The vehicle should provide a convenient interface to initiate, continue, and end a Siri session. Once a Siri session is running, the vehicle shall display a visual cue indicating voice recognition is in use. Figure 31-7 (page 155) outlines how a Siri interaction should be designed.

Figure Siri Eyes Free User Interaction 31-7



End a Siri session In-vehicle UI Long press to end (**) In-vehicle dashboard Short press to end

As shown in Figure 31-7 (page 155):

- (*) If the accessory wishes to indicate Siri is active, it shall do one of the following:
 - Display the word 'Siri' (as capitalized) with no additional text or icon.
 - Use generic text or icon not resembling the Siri microphone icon.
- (**) If the vehicle is equipped with steering wheel controls, the steering wheel shall have a dedicated button or a long-press action on a button to start, continue and end a Siri session. The button long-press shall be 600 ms or less. If no steering wheel controls are available, a soft button shall be available within the in-vehicle user interface to start, continue or end a Siri session.

When a vehicle enables Siri Eyes Free mode, the device will not display any onscreen Siri content. If the device was locked at the time the Siri session was activated from the vehicle, it will remain locked and the screen will not turn on. If the user unlocks or manually activates the device while in an Eyes Free Session there will be a notification the device is in an active Siri session but there will be no visual Siri content displayed.

31.9 Enabling/Disabling Siri from the Device

The user has the ability to disable or enable Siri from the Settings menu on the device. When Siri is disabled, Voice Control becomes the recognition engine on the device and will be triggered by default. The accessory may choose to either:

- Activate Voice Control (in the same way Siri is activated) as in Figure 31-8 (page 156).
- Display a warning message and not send an activation command to the device as in Figure 31-9 (page 157).

Figure Siri is Disabled - Activating Voice Control 31-8

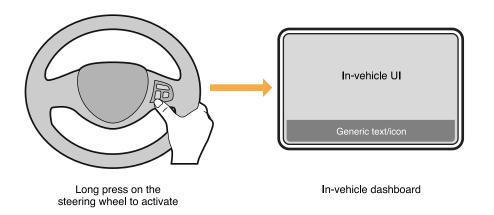
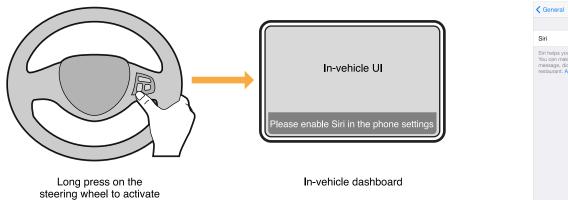




Figure Siri is Disabled - Displaying a Warning Message 31-9





31.10 Test Procedures

31.10.1 Siri Eyes Free

The following test procedures are applicable to accessories interacting with Siri Eyes Free.

The speaker should be a native speaker of North American English. If the tester's native language is not North American English, set Siri to the speaker's native language and translate the provided phrases to that language.

31.10.1.1 General

- 1. Pair and establish a Bluetooth Hands-Free Profile (HFP) connection between the iPhone and the head unit. Activate Siri from the vehicle steering wheel button (for example, by pressing and holding):
 - **a.** Observe the iPhone screen remains inactive after a Siri session has started (a visual indicator will be visible on the device if the screen is activated manually).
 - **b.** Ensure Siri's opening chime is heard completely through the vehicle speakers.
 - c. Observe a visual notification in the in-car User Interface (UI) indicating a Siri session is active (for example, text notification, on-screen UI).
- 2. Activate Siri from the vehicle steering wheel button and say "Send a message to Peter. How are you?". While still saying the message, press the vehicle steering wheel button to cancel Siri:
 - **a.** Ensure the iPhone screen remains inactive (if manually activated, the visual indicator on the phone will disappear).
 - **b.** Verify the in-car Siri UI interaction is dismissed and the head unit returns to its prior state before the Siri interaction.

- 3. Activate Siri from the vehicle steering wheel button and say "How is the weather in San Francisco?". Wait for Siri to respond with the weather forecast. Once the weather forecast is complete, resume Siri from the vehicle steering wheel button and say "What about New York?":
 - a. Confirm the visual indicator is still active on the phone.
 - **b.** Listen for the Siri opening chime.
 - c. The vehicle UI should indicate a Siri session is active.
 - **d.** Verify Siri responds with the weather forecast for New York.
- 4. In case the vehicle UI offers on-screen controls to activate/cancel/resume Siri, repeat steps (1) to (3) for all on-screen controls.
- **5.** Activate Siri from the steering wheel button and say "What's the time". Listen to the current time and do not interact with Siri or the iPhone. After 5 seconds have expired:
 - a. Observe the visual Siri session indicator on the phone is no longer visible.
 - **b.** The in-car UI for Siri interaction should be dismissed.
 - **c.** The head unit should return to its prior state before the Siri interaction.
- **6.** Listen to FM radio from the car speakers (for example, no A2DP streaming active). Press and hold the phone's Home button to activate Siri from the phone:
 - **a.** Observe a visual notification in the in-car UI indicating a Siri session is active (textual notification, on-screen UI, etc.).
 - **b.** Observe Siri's interaction on the phone's screen and ask "What's the time?"
 - **c.** After Siri has responded, lock the phone again to dismiss the Siri session by pressing the phone's sleep/wake or side button.
- 7. On the phone go to Settings and turn Siri off. Activate Siri from the head unit. Observe one of the following depending on the actual implementation (a) Voice Control starts instead of Siri (b) The head unit displays a warning indicating Siri Eyes Free is not available.
- **8.** On the phone go to Settings and turn Siri back on. Verify Siri can be activated/cancelled from the head unit and from the Home button on the phone.
- 9. Turn Bluetooth off using Settings on the phone. Verify Siri cannot be started.
- **10.** Turn Bluetooth back on using Settings on the phone. Verify Bluetooth HFP profile reconnects and Siri can be activated/cancelled from the head unit and from the phone's Home button.
- **11.** Confirm there is no accessory battery status level indicator icon displayed on the phone's status bar.

31.10.1.2 Siri Dialog

1. Activate Siri from the vehicle's steering wheel button and say "Send a text message to insert contact name". When Siri prompts for "what would you like it to say", dictate a short message. After Siri has read back the dictated message, say "Review it". After Siri has read back the message again, say "Review it" again. Repeat this cycle ~5 times to ensure the head unit is able to handle a long interaction with Siri. At the end say "Send it" and verify the message is sent. Verify the opening

- chime is audible and the message is sent. After the Siri session is closed, the audio playback should go back to the state it was in before Siri was activated (that is, if audio was paused it remains paused, if it was playing it resumes playing).
- 2. Start Siri from the vehicle's steering wheel button and ask for directions. Follow up through the dialog until the navigation is started. Verify the Siri session is closed and the audio playback goes back to the state it was in before Siri was activated (that is, if audio was paused it remains paused, if it was playing it resumes playing).
- 3. Start Siri from the vehicle's steering wheel button and say "Search the web for polar bears". Verify Siri Eyes Free mode is on and this use case is blocked by Siri. Note: In some implementations the vehicle has to be in motion before Siri Eyes Free is activated by the car kit.
- 4. Start Siri from the vehicle's steering wheel button and say "What is the current time in Munich?". After Siri answers but before ~5 seconds have elapsed, resume Siri (for example, using a short press on the steering wheel button) and verify Siri is activated again. Say "What about San Francisco?". Repeat (with a different city) and verify this can continue indefinitely as long as there is a short press on the steering wheel button within 5 seconds of the last response.

31.10.1.3 Bluetooth HFP A2DP Music

- 1. Establish a Bluetooth A2DP connection and switch to Bluetooth audio source on the head unit. Activate Siri and say "Next track". Verify the track advances and audio is played through the vehicle speakers. Verify the Siri in-car UI is dismissed and the head unit returns to its initial state.
- 2. Activate Siri and say "Pause the music". Verify audio remains paused after Siri has been dismissed. Verify the Siri in-car UI is dismissed and the head unit goes back to its initial state.
- 3. Pause music playback on the head unit (using AVRCP command). Activate Siri and ask "What time is it?". Verify the music playback remains paused after the Siri session has been dismissed. Verify the Siri in-car UI is dismissed and the head unit goes back to its initial state.
- 4. Switch to FM radio on the head unit. Activate Siri and say "Play me a song". Verify the head unit is able to automatically switch to Bluetooth audio and iPhone music starts playing. Verify the beginning of the selected track is heard (for example, there is no skipping of audio packets). Verify the Siri in-car UI is dismissed and the head unit returns to its initial state.
- 5. Activate Siri and say "Shuffle all songs". Verify the head unit correctly updates the NowPlaying track information. Verify the Siri in-car UI is dismissed and the head unit returns to its initial state.
- 6. Activate Siri and ask to play a specific artist or title. Verify the Siri session is dismissed after the music starts. Confirm the correct metadata is displayed on the screen. Verify the Siri in-car UI is dismissed and the head unit returns to its initial state.

31.10.1.4 Call

1. Activate Siri and call a contact with more than one phone number (for example, home and mobile). Wait for Siri's response asking which phone number to call. Answer with "home". Verify call transition is handled correctly by the head unit and any Siri UI displayed on the vehicle screen is dismissed.

- 2. While iPhone music is playing, activate Siri and say "Call (insert contact to call)". Verify call transition is handled correctly by the head unit. Verify iPhone music playback resumes after the call has been answered and terminated on the far end. Verify the Siri in-car UI is dismissed and the head unit returns to its initial state.
- 3. While iPhone music is playing, start Siri and say "Call (insert contact to call)". Verify call transition is handled correctly by the head unit. Verify iPhone music playback resumes after the call has been answered and terminated on the near end (that is, on the head unit). Verify the Siri in-car UI is dismissed and the head unit returns to its initial state.
- **4.** While in a Siri session, receive an incoming call on the head unit. Verify the head unit handles call-signaling correctly and transitions to the phone UI once the call has been accepted. Verify the Siri in-car UI is dismissed and the head unit returns to its initial state.

31.10.1.5 Bluetooth + Wired iAP2

- 1. Connect the device to the head unit using a Lightning connector (iPhone 5). Switch to iPod music and verify audio is playing. Activate Siri and say "Next track". Verify the track advances and the head unit displays the track metadata correctly. Verify the Siri in-car UI is dismissed and the head unit returns to its initial state.
- 2. From the head unit UI, select a playlist with a single song and start playing it. Start Siri from the vehicle steering wheel and say "Play make sure to select a song to play that is (a) not in the same album as the single-track playlist and (b) not song track index 0 of its album". Verify the new song starts playing and the head unit correctly displays the track metadata for the new song. Verify the Siri in-car UI is dismissed and the head unit returns to its initial state.
- 3. Turn Shuffle off on the head unit UI. Then start Siri and say "Shuffle all songs". Verify the shuffle indicator on the head unit UI is updated and the correct track metadata for the new now playing song is displayed correctly. Verify the Siri in-car UI is dismissed and the head unit returns to its initial state.
- 4. Switch to FM radio on the head unit. Activate Siri and say "Play me a song". Verify the head unit is able to automatically switch to iPOD audio source and iPOD audio starts playing through the speakers. Verify there is no skipping of audio at the beginning of the selected track. Verify the Siri in-car UI is dismissed and the head unit returns to its initial state.
- **5.** Pause music playback on the head unit (using iAP2 commands). Activate Siri and ask "What time is it?". Verify music playback remains paused after the Siri session has been dismissed. Verify the Siri in-car UI is dismissed and the head unit returns to its initial state.
- **6.** While iPhone music is playing, start Siri and say "Call (insert contact to call)". Verify call transition is handled correctly by the head unit. Verify iPhone music playback resumes after the call has been answered and terminated on the far end. Verify the Siri in-car UI is dismissed and the head unit returns to its initial state.

- 7. While iPhone music is playing, start Siri and say "Call (insert contact to call)". Verify call transition is handled correctly by the head unit. Verify iPhone music playback resumes after the call has been answered and terminated on the near end (for example, on the head unit). Verify the Siri in-car UI is dismissed and the head unit returns to its initial state.
- **8.** Pause music playback on the head unit (using iAP2 commands). Start Siri and say "Call *insert contact name to call*". Verify call transition is handled correctly by the head unit. Verify iPhone music playback remains paused after the call has been answered and terminated on the far end. Verify the Siri in-car UI is dismissed and the head unit returns to its initial state.

32. Wi-Fi Information Sharing

Wi-Fi configuration information can be exchanged between devices and accessories.

Devices can share Wi-Fi configuration information with an accessory. The accessory can initiate this process, but the user shall grant permission for the device to share this information. The device can only share information about the currently connected Wi-Fi network, and this feature will not account for other router-configured access control mechanisms, such as RADIUS or MAC address filtering.

Figure Wi-Fi Information Sharing Alert 32-1



See the Accessory Interface Specification (page 21) for more information.

Protocols

33. USB Power Capability Vendor Request

If the accessory is a USB host, and it does not implement iAP2 (page 174), then it may send an Apple-specific USB vendor request communicating how much power is available to the device. In this case, the accessory shall enumerate and identify the presence of a device, then send the vendor request. The vendor request shall be sent every time the device is enumerated by the accessory.

Table 33-1 USB Vendor Request for non-iAP2 accessory USB Embedded Host

Field	Value	Comments	
bmRequestType	0x40	Device-to-host request, vendor-defined type, device is recipient.	
bRequest	0x40	Vendor-defined USB get enabled capabilities request.	
wValue	See comments.		
wIndex	See comments.	Shall be the same as wValue.	
wLength	0	0 bytes expected.	

34. USB D+/D- Resistor Networks

Accessories not implementing any of the following may use USB resistor networks to identify their current capability:

- iAP2 (page 174).
- USB Power Capability Vendor Request (page 164).
- USB-C Current (page 169).
- USB Power Delivery (page 168).

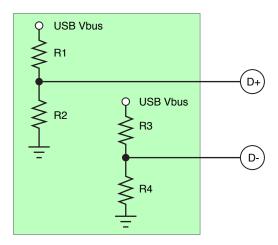
Note:

Device power draw varies with environmental factors. All accessory power source testing shall be performed with programmable loads, not devices.

34.1 Declaring Power Source Capability

Accessories shall connect the USB D+ and USB D- pins to resistor networks as shown in Figure 34-1 (page 165).

Figure USB D+/D- resistor networks 34-1



Note:

Every iOS device-compatible connector on an accessory using a USB resistor network shall have its own set of resistors. The accessory shall be capable of supplying the total current required when all connectors are in use, regardless of whether the connectors are compatible with devices or not.

The resistor network shall be connected at all times unless the accessory uses one of the following methods to enable charging or detect the presence of a device. In these cases, it shall immediately present the resistor network. The accessory:

- Uses a direct user action to enable charging.
- Senses the attachment of the device using electromechanical means such as a contact switch.

The accessory shall not monitor the USB D+ and USB D- pins to detect the presence of a device.

Note:

All resistors used to implement the networks specified in Figure 34-1 (page 165) shall have a tolerance of 1% or better. The resistor network shall not be emulated by driving the voltage of the USB D+/D- pins using some other means.

Table 34-1 USB D+/D- resistor values

Max Current	R1	R2	R3	R4
3000 mA	43.2 kΩ	49.9 kΩ	24.9 kΩ	49.9 kΩ
2400 mA	43.2 kΩ	49.9 kΩ	43.2 kΩ	49.9 kΩ
2100 mA	43.2 kΩ	49.9 kΩ	75.0 kΩ	49.9 kΩ
1000 mA	75.0 kΩ	49.9 kΩ	43.2 kΩ	49.9 kΩ

34.2 Identifying Power Source Current Limit

Accessories shall take into account the variation of USB VBUS voltage and resistor tolerances.

The resistor network values and corresponding current source limits should be identified using the following procedures:

- 1. Read the VBUS voltage using an ADC. If value is less than 4.5 V, return no resistors detected.
- 2. Pull-down the D+ and D- lines and read the voltage using an ADC. If either voltage value is less than 1 V, return no resistors detected.
- 3. Disable the D+ and D- pull-downs and allow the voltage to return to normal.
- 4. Read the D+ and D- voltages using an ADC (to determine the value for R1 and R3 respectively):
 - If voltage is >2.995 V (based on 1 M Ω load impedance), assume a resistor value of 24.9 k Ω .

- If voltage is between 2.320 V and 2.995 V (based on 1 M Ω load impedance), assume a resistor value of 43.2 k Ω .
- If voltage is < 2.320 V (based on 1 M Ω load impedance), assume a resistor value of 75.0 k Ω .
- 5. Determine the max current based on Table 34-2 (page 167).
- **6.** If resistor values could not be identified, proceed to identify the power available based on the *USB Battery Charging 1.2* specification.

Table USB D+/D- resistor values 34-2

Max Current	R1	R2	R3	R4
1000 mA	24.9 kΩ	49.9 kΩ	24.9 kΩ	49.9 kΩ
1000 mA	24.9 kΩ	49.9 kΩ	43.2 kΩ	49.9 kΩ
1000 mA	24.9 kΩ	49.9 kΩ	75.0 kΩ	49.9 kΩ
3000 mA	43.2 kΩ	49.9 kΩ	24.9 kΩ	49.9 kΩ
2400 mA	43.2 kΩ	49.9 kΩ	43.2 kΩ	49.9 kΩ
2100 mA	43.2 kΩ	49.9 kΩ	75.0 kΩ	49.9 kΩ
1000 mA	75.0 kΩ	49.9 kΩ	24.9 kΩ	49.9 kΩ
1000 mA	75.0 kΩ	49.9 kΩ	43.2 kΩ	49.9 kΩ
500 mA	75.0 kΩ	49.9 kΩ	75.0 kΩ	49.9 kΩ

35. USB Power Delivery

Accessories providing USB Power Delivery (USB-PD) or drawing power from USB-PD sources shall comply with the *USB Power Delivery Specification, Revision 3.1*, version 1.3.

Accessories implementing USB-PD shall incorporate a USB-IF certified PD controller with a *Silicon* Test ID from the USB-IF.

Accessories drawing power from USB-PD sources shall correctly identify all sources as defined in the USB Power Delivery Specification.

Apple recommends the GRL-USB-PD-C2 (see https://www.graniteriverlabs.com/en-us/test-solutions/protocol-power-test-solutions/usb-pd-c2) for USB-PD testing and compliance verification.

36. USB-C Current

Accessories providing direct power using USB-C Current or drawing power from USB-C Current sources
shall comply with the USB Type-C Cable and Connector Specification Release 1.3, section 4.6.2.

Apple recommends the GRL-USB-PD-C2 (see https://www.graniteriverlabs.com/en-us/test-solutions/protocol-power-test-solutions/usb-pd-c2) for USB-C Current testing and compliance verification.

37. Advanced Audio Distribution Profile (A2DP)

Accessories may implement the Advanced Audio Distribution Profile (A2DP) over Bluetooth (page 179) to receive audio from iOS devices and Mac computers.

The audio content from the device can be broadly classified into two categories:

- Audio content from music, video, or gaming applications.
- System-generated sounds for alerts and notifications.

A2DP is often implemented in speakers and headsets.

Accessories implementing A2DP shall satisfy all requirements stated in Bluetooth (page 179).

37.1 Bluetooth A2DP Specification

Every accessory implementing the Advanced Audio Distribution Profile shall meet the requirements of the Bluetooth *Advanced Audio Distribution Profile* specification, Version 1.2.

37.1.1 AVDTP Transactions

Accessories shall respond to Audio/Video Distribution Transport Protocol (AVDTP) signaling transactions before the device's 5 second RTX_SIG_TIMER expires or the device will terminate the signaling channel. See Section 6.2 "Transaction Model" and section 6.4 "Signal Command Set" of the Bluetooth *Audio/Video Distribution Transport Protocol*, Version 1.3.

37.2 SubBand Codec (SBC)

The SBC Codec Specific Information Elements, defined in Section 4.3.2 of the A2DP specification, applicable to iOS devices and Mac computers are listed in Table 37-1 (page 170).

Table 37-1 SubBand Codec Information Elements for iOS devices and Mac computers

Element	Value
Sampling Frequency	44,100 Hz
Channel Mode	Stereo

Element	Value
Block Length	16
Subbands	8
Allocation Method	Loudness
Bitpool range	2 to 53. Accessories for iOS devices and Mac computers should support 53.

37.3 MPEG 2/4 AAC Codecs

Devices support the non-mandatory codec MPEG-2/4 AAC, as defined in Section 4.5 of the *Advanced Audio Distribution Profile* specification, Version 1.2. Accessories should use the AAC codec in addition to SBC, because AAC provides higher audio quality for a given bit rate.

Note:

The following specifications provide details of Apple's implementation of the MPEG-2/4 AAC codec. In case of conflicts, the A2DP specification governs.

The MPEG 2/4 AAC Codec Specific Information Elements, defined in Section 4.5 of the A2DP specification, applicable to devices are listed in Table 37-2 (page 171).

Table 37-2 MPEG-2/4 AAC Codec Information Elements for devices

Element	Value	
Object Type	MPEG-2 AAC LC	
Sampling Frequency	44,100 Hz	
Channels	2	
Bit rate	264,630 bps	
VBR	0	

AAC audio stream packets in devices have the structure shown in Table 37-3 (page 171).

Table 37-3 AAC audio packet for devices

L2CAP	AVDTP	MPEG-4 LATM	MPEG-4 AAC
Header	Header	AudioMuxElement	Audio Payload

The AAC Media Payload Format, as defined in Section 4.5.4 of the A2DP specification, is formatted using LATM, as defined in Section 4 of *IETF RFC 3016*. The following notes apply to the packet fields shown in Table 37-3 (page 171).

• The recommended L2CAP MTU value for each device's AAC streaming channel is 885 bytes.

- The AVDTP Header is shown as the RTP header in Figure 4 of RFC 3016, and is the header defined in Section 7.2.1 of the Bluetooth *Audio/Video Distribution Transport Protocol*, Version 1.2.
- The AudioMuxElement is the same as the RTP payload in RFC 3016. It is defined in Section 1.7.3, Table 1.41 in ISO/IEC 14496-3:2009, subpart 1. The muxConfigPresent argument to the AudioMuxElement is set to 1 (in-band mode), as recommended in Section 4.1 of RFC 3016. As recommended in Section 4.3 of RFC 3016, only one AudioMuxElement is put into each AVDTP packet.
- The audio payload is encoded using MPEG-4, as recommended in Section 4.5.4 of the A2DP specification.
- The accessory should support AAC-LC VBR and handle bit rate changes without audio gaps. Devices will vary AAC bit rate depending on the content.

37.4 Test Procedures

37.4.1 Audio Quality

Verify there are no audio quality issues in each of the following scenarios:

- 1. Stream music from the Apple Music app.
- 2. Stream music from a radio station within the Apple Music app.
- 3. Stream audio using the Apple Podcasts app.

37.4.2 Audio Switching

- 1. During A2DP streaming, switch audio back to device and switch back to accessory.
- 2. Audio should be routed to the intended source. Audio quality should be good switching back to Bluetooth.

37.4.3 HFP Interaction

- 1. Make incoming / outgoing call during A2DP.
- 2. Audio should be suspended during the call and resume after the call.

37.4.4 Siri

- 1. Trigger Siri during A2DP.
- 2. Audio should resume after the Siri session.

37.4.5 Video Playback

- 1. Stream A2DP while watching a video.
- 2. Audio / video synchronization and quality should be good.

38. iAP2

Accessories may use the iAP2 protocol to access advanced device features. One such feature is the ability to communicate securely with third-party iOS applications using the iOS External Accessory Framework (https://developer.apple.com/library/archive/featuredarticles/ExternalAccessoryPT/Introduction/Introduction.html).

See the Accessory Interface Specification (page 21) for more information.

39. Human Interface Device (HID)

Devices can accept input from and send output to Human Interface Device (HID) accessories, such as external keyboards, trackpads, mice, and game controllers. This capability is made available system-wide for all apps on the device as well as to support features built into iOS, iPadOS, and tvOS. If an accessory is designed to provide human input events to a specific third-party app, the accessory should use the External Accessory Protocol feature instead; see the Accessory Interface Specification (page 21) for more information.

The HID protocol can be implemented over:

- USB
- Bluetooth

39.1 Requirements

Accessories supporting the HID protocol shall comply with the following requirements:

- Accessories shall only send HID reports for changes in physical or virtual control surfaces declared in the corresponding HID descriptor.
- Accessories shall not send a HID report if there has not been any change in the state of the corresponding physical or virtual control surface. For example, the accessory shall never generate a "Play/Pause" event without the user pressing a dedicated "Play/Pause" button.
- Each HID report shall contain the correct number of bytes as described in its corresponding HID descriptor.
- The accessory shall not anticipate or assume corresponding state changes in the device after sending HID reports.
- Unless otherwise specified:
 - The accessory shall be capable of generating and receiving all HID usages declared in its HID descriptor.
 - The accessory's declared HID usages shall map directly to physical or virtual control surfaces on a 1:1 basis. For example, a button labeled "Play/Pause" shall send a Play/Pause HID usage and not "Play" or "Pause" usages. Compound controls such as knobs, joysticks, and directional pads may be considered multiple control surfaces. For example, clockwise and counterclockwise rotation may map to separate HID usages.

- Physical or virtual control surfaces generating HID reports shall be labeled with appropriate iconography or text corresponding to the resulting device behavior. For example, a Play/Pause button shall be labeled with the text 'Play/Pause' or a Play/Pause icon.
- The accessory shall send one HID report in response to each direct user action on the corresponding physical or virtual control surface. For example:
 - When the user presses a button, one 'button pressed' HID report shall be sent to the device.
 - When the user releases the button, one 'button released' HID report shall be sent to the device.

39.1.1 Report Descriptor

When padding packets to align within a byte boundary, each Main item tag (Input, Output, or Feature) shall be marked constant. Padding bits should be set to 0.

When defining Variable type Input/Output fields, either:

- Report Count number shall correspond to the number of Usages specified.
- Report Size shall be 8 and the Report Count shall correspond to the size of a multi-byte blob.

39.1.2 USB

If implementing HID over USB, the accessory shall comply with the *Device Class Definition for Human Interface Devices 1.11*, see https://www.usb.org/hid.

39.2 Test Procedures

39.2.1 General

- Verify the accessory generates and receives all HID usages declared in the component's HID descriptor.
- 2. Verify the accessory does not send a HID report if there has not been any change in the state of the control surfaces (that is, no polling of HID reports).
- 3. Verify if any accessory has physical or virtual control surfaces generating accessory HID usages, the controls are labeled with appropriate iconography or text corresponding to the resulting device behavior (for example, a Play/Pause button is labeled with the text "Play/Pause" or a Play/Pause icon).
- **4.** Verify HID usages map to physical or virtual controls on a 1:1 basis (for example, Play button only sends Play usages, not Play/Pause).

5. Verify one accessory HID usage report is sent in response to each direct user action on the corresponding physical or virtual control surface. For example, when the user presses a button, one 'button pressed' usage report is sent, and a separate 'button released' usage report is sent when the user releases the button.

Transports

40. Bluetooth

Accessories integrating Bluetooth technology shall comply with the requirements stated in this chapter.

Accessories shall support the Bluetooth Core Specification Version 2.1 + EDR or later.

40.1 Enhanced Data Rate

The Enhanced Data Rate (EDR) feature introduced in the *Bluetooth 2.0* specification enables accessories to communicate more efficiently. Every accessory shall use EDR for the following reasons:

- EDR provides higher data rates compared to Basic Data Rate (BDR).
- EDR communicates more efficiently, transferring more data bits in less time.
- EDR reduces power consumption per bit transferred.
- EDR improves coexistence with Wi-Fi and other Bluetooth accessories by using less airtime.
- EDR improves performance in multipoint configurations.

40.2 Adaptive Frequency Hopping

Adaptive Frequency Hopping (AFH) introduced in the *Bluetooth 1.2* specification improves coexistence with Wi-Fi and other connected Bluetooth accessories. Every accessory shall use AFH.

40.3 Sniff Mode for Low Power Consumption

Minimizing power consumption is critical for all mobile devices, therefore accessories:

- Shall support and should request Bluetooth sniff mode.
- Shall accept sniff mode requests and support valid parameters from the Bluetooth specification.
- Shall support a sniff interval of 15 ms.
- Shall support sniff subrating.
- Shall not renegotiate sniff mode after it is established.
- Should use sniff mode values of:
 - Max Interval: 15 msMin Interval: 15 ms
 - Sniff Attempt: 1

Sniff Timeout: 0

Accessories compatible with iOS devices and Mac computers should use sniff mode as often as possible, especially when there is little or no data being transmitted over the Bluetooth link. Sniff mode enables better antenna sharing with Wi-Fi, in addition to the power consumption advantages.

Sniff mode parameters are specific to the usage model and Bluetooth profile. Accessories should request sniff mode with appropriate parameters for specific usage models. If the accessory does not send a sniff mode request, the device may send a sniff mode request. When the device sends a sniff mode request, the accessory shall accept the request and parameters without negotiation.

If the accessory requests sniff mode, the accessory shall set the sniff interval to less than a third of the Bluetooth baseband Link Supervision Timeout (page 182), to make the Bluetooth link less susceptible to interference. To improve link robustness, the accessory should use a shorter sniff interval instead of multiple sniff attempts.

Links with a sniff interval of 1 second or more require a large correlation window, which has to be taken into account when calculating the number of sniff attempts. With sniff intervals shorter than 1 second, multiple sniff attempts can improve link robustness, but will increase power consumption.

40.4 Role and Topology Management

Accessories shall:

- Accept device Role Switch requests.
- Continue with the connection when the device rejects a request for Role Switch.

In a Bluetooth connection, there are two entities:

- The Central entity establishes a common clock and frequency hopping synchronization reference.
- The Peripheral entity synchronizes with the Central entity.

The Central entity can be synchronized with multiple Peripheral entities, thus forming a piconet. The Central entity can also be a Peripheral entity to another Central entity, creating a scatternet.

Accessories simultaneously connecting to multiple iOS devices or Mac computers shall support creating a scatternet.

Scatternets create complications since the device has to alternate between piconets, wasting valuable bandwidth. Efficiently managing network topology is important to maximize performance. The device may request a Role Switch, depending on its current topology, and the accessory shall accept the request. The device may also reject a Role Switch request due to topology concerns, as suboptimal topologies may degrade audio quality and the user experience.

Accessories should avoid requesting to be the Central entity, as in more frequently occurring scenarios the device needs to be the Central entity. Accessories insisting on being the Central entity may negatively impact the overall user experience.

40.5 Extended Inquiry Response

Accessories shall provide the following information in their Extended Inquiry Response packet:

- Local Name of the accessory (Complete or Shortened).
- TX Power Level.

During Bluetooth discovery, devices display accessories Friendly Names when available. Extended Inquiry Response enables accessories to proactively send their Local Name, and other information, as part of an Inquiry Response to increase the speed and efficiency of the discovery process.

Accessory Local Name should match the accessory's labeling and packaging without colons ':' or semi-colons ';'. Accessories may append up to six differentiating characters to their Local Name, such as the last few digits of a serial number or MAC address, if users are likely to encounter multiple accessories at the same time using the same name. If the accessory allows a user to customize the Local Name parameter, the accessory should provide a means to restore the factory default name.

40.6 Secure Simple Pairing

Accessories shall:

- Use Secure Simple Pairing.
- Use the Numerical Comparison method, if it has a display and input device supporting it.

Secure Simple Pairing greatly increases security, and is a mandatory security feature in the Bluetooth 2.1 specification. To protect against a 'man-in-the-middle' attack, the Numerical Comparison association model should be used whenever feasible. See Volume 1, Section 5.4 in the *Bluetooth Core Specification*, Version 2.1 + EDR.

40.7 Pairing Button

If the accessory has a labeled dedicated pairing control, it should use official Bluetooth branding. See https://www.bluetooth.com/develop-with-bluetooth/marketing-branding/.

40.8 Class of Device (CoD)

iOS devices and Mac computers use the accessory's Class of Device for UI purposes or to configure specific features. Accessories shall accurately set their Class of Device using the Bluetooth SIG defined Major Device Class and Minor Device Class. See Volume 3, Part C, Section 3.2.4 in the *Bluetooth Core Specification*, Version 5.0. For example, an audio/video accessory intended to operate in a vehicle should set Major Device Class to 'audio/video' and Minor Device Class to 'car-audio'.

40.9 Link Supervision Timeout

Link supervision timeout is used to detect link loss between an accessory and a device. An accessory shall set the link supervision timeout to 2 seconds or greater when it is the Central entity, to account for the unpredictable nature of RF signals, as well as the device's need to service other concurrent wireless systems.

40.10 Delay Reporting

As of iOS 8.2, devices support Delay Reporting commands as specified in the Bluetooth *Audio/Video Distribution Transport Protocol*, Version 1.3. Accessories should provide this information to improve audio/video synchronization for video playback. Accessories should not report a delay of more than 1000 ms, and should not update the delay more than 1 time per second.

40.11 Profiles

The Apple Bluetooth profiles knowledge base article https://support.apple.com/kb/ht3647 provides a complete list of the profiles supported by devices. Bluetooth specifications are the starting point for designing accessories compatible with these devices. The following sections provide additional information and requirements for common profiles to help accessory developers achieve superior results.

40.11.1 Device ID Profile (DID)

Accessories shall:

Support Bluetooth Device ID Profile, Version 1.3 or later.

- Use their Company Identifier from the Assigned Numbers specification assigned by the Bluetooth SIG as the Vendor ID value (VID), see https://www.bluetooth.com/specifications/assigned-numbers/.
 Bluetooth HID Profile accessories may use a VID assigned by the USB Implementers Forum (USB-IF), see https://www.usb.org/getting-vendor-id, if the manufacturer does not have a Bluetooth SIG Company Identifier.
- Use its VID value for the end product manufacturer.
- Not use the Company ID assigned to Apple by the Bluetooth SIG, or the Vendor ID assigned to Apple by the USB Implementers Forum.
- Use the Vendor ID Source field to identify which organization assigned the value used in the Vendor ID field. See Section 5.6 of the *Bluetooth Device ID Profile Specification*.
- Use a ProductID value uniquely identifying the product.
- Use a Version value uniquely identifying the software version.

The Device ID record enables devices to identify the implementation of the remote accessory, which is used to bridge alternate interpretations of the Bluetooth specification when communicating with a remote accessory. It is important the information in the Device ID record uniquely identify the implementation in use.

In the case of Bluetooth car kit devices, the same car kit may be present in different car models. Ideally, the two car kits should have different ProductIDs. However, it is acceptable for them to have the same ProductID as long as they have identical hardware, software, and features. If the implementations differ at all, they should have different ProductIDs. The accessory can also use a secondary Device ID record to uniquely identify the product ID, or model number.

40.11.2 Service Discovery Protocol (SDP)

To facilitate caching Service Discovery Protocol service records, accessories shall:

- Support the ServiceDiscoveryServer Service Class.
- Support the ServiceDatabaseState attribute.
 - Attribute's value shall change whenever any SDP service record or attributes within a record are added, removed, or modified.
 - Attribute's value shall not change based on RFCOMM channel protocol parameters. Devices query these values separately at connection time.

40.11.3 Hands-Free Profile (HFP)

Accessories supporting Hands-Free Profile should meet the requirements of the *Bluetooth Hands-Free Profile Specification*, Version 1.5 or later. Additional Apple requirements are specified in this section.

Remote accessories can use the Bluetooth *Hands-Free Profile* for phone communications. To achieve the best user experience, the remote accessory should support the following features, which are optional in the Bluetooth specification.

40.11.3.1 Remote Audio Volume Control

Accessories supporting HFP should:

- Support Remote Audio Volume Control, so speaker volume on the hands-free accessory can be controlled from the device as described in Section 4.28 in the *Bluetooth Hands-Free Profile* Specification, Version 1.5.
- Set the Remote volume control bit in the Supported Features bitmap sent with the AT+BRSF= command.

In some situations it is easier for the user to control the output volume through the device, instead of directly on the remote accessory. For example, a car passenger (or if the car is parked, the driver) could use the volume slider on the phone to control audio volume. Volume control synchronization is outlined in Section 4.48.2 in the *Bluetooth Hands-Free Profile Specification*, Version 1.5.

40.11.3.2 Indicator Event Reporting

Accessories supporting HFP should use Indicator Event Reporting, and not perform repetitive status polling.

iOS devices and Mac computers support all mandatory and optional indicators specified in HFP version 1.5 (service, call, callsetup, callheld, signal, roam, battchg). To minimize unnecessary status polling using the AT+CIND? command, the remote accessory should enable Indicator Event Reporting by sending an AT+CMER command. The device will then send a +CIEV event when there is a status change. The remote accessory should request initial status using the AT+CIND=? and AT+CIND? commands, according to the HFP specification.

40.11.3.3 Voice Recognition Activation

Accessories supporting HFP shall:

- Support Voice Recognition Activation, both AG and HF, initiated as described in Section 4.25 in the *Bluetooth Hands-Free Profile Specification*, Version 1.5.
- Set the Voice Recognition Activation bit in the "SupportedFeatures" bitmap sent with the AT+BRSF= command.

iOS devices and Mac computers support voice recognition initiated by remote (Hands-Free) accessories, and iOS (Audio Gateway) accessories.

40.11.3.4 Echo Cancellation and Noise Reduction

When echo cancellation and noise reduction are performed locally on a hands-free accessory, the accessory should turn off echo cancellation and noise reduction on the device by sending an AT+NREC command, as described in Section 4.24 in the *Bluetooth Hands-Free Profile Specification*, Version 1.5.

iOS devices and Mac computers support echo cancellation and noise reduction by default. If a hands-free accessory performs echo cancellation and noise reduction, the accessory needs to turn these features off on the device (the Audio Gateway), to avoid unnecessary audio quality degradation due to duplicate audio processing.

40.11.3.5 In-Band Ringing

Accessories supporting HFP should also support In-Band Ringing as specified in Section 4.13.1 in the *Bluetooth Hands-Free Profile Specification*, Version 1.5. If the user sets a ring tone on the device, the same ring tone should sound on the hands-free accessory.

40.11.3.6 Synchronous Connection

Accessories supporting HFP shall:

- Support eSCO parameter set S2 and S3 and accept requests for these settings. See Section 5.6
 of the Bluetooth Hands-Free Profile Specification version 1.5.
- Request eSCO parameter set S2 or S3 when setting up a Synchronous Connection. eSCO parameter set S1 should not be requested.
- Render audio within 40 ms after the SCO/eSCO connection has been set up.

eSCO packet types offer packet retransmission, whereas traditional SCO packets are not retransmitted. This improves audio quality and the user experience. eSCO packet types 2-EV3 and 3-EV3 offer a greater time interval between packets, which can improve Wi-Fi performance and allow time for other concurrent Bluetooth connections to send data.

Apple strongly recommends the use of 2-EV3 and 3-EV3 packets for SCO connections. Using HV3 packets is highly discouraged. HV3 packets require more link time and do not allow audio packet retransmission, which impacts audio performance in the presence of RF interference.

40.11.3.7 Wide Band Speech

Accessories supporting HFP should support Wide Band Speech, as described in Section 5.7.4 of the Bluetooth *Hands-Free Profile Specification*, Version 1.6. If Wide Band Speech is supported, the accessory should support the T2 link parameter settings.

Devices running iOS 5 or later support Wide Band Speech. If both the device and the accessory support Wide Band Speech, the device will use it for eSCO connection scenarios such as cellular calls, FaceTime, and Siri.

40.11.4 Message Access Profile (MAP)

Accessories supporting Message Access Profile:

- Shall support Message Notification, as described in Section 4.1 of the *Bluetooth Message Access Profile Specification*, Version 1.1.
- Shall register for notifications immediately after the connection is established, as described in Section 4.5 in the *Message Access Profile Specification*, Version 1.1.

Devices running iOS 13.0 or later support MAP 1.1.

40.11.5 Audio/Video Remote Control Profile (AVRCP)

Accessories supporting Audio/Video Remote Control Profile should meet the requirements of the *Bluetooth Audio/Video Remote Control Profile Specification*, Version 1.4. Additional Apple requirements are specified in this section.

40.11.5.1 Supported Operations

iOS devices and Mac computers support the following operation_IDs in passthrough commands:

- Play
- Stop
- Pause
- Fast Forward
- Rewind
- Forward
- Backward

40.11.5.2 Repeat and Shuffle Modes

Every device in the role of an AVRCP target supports Repeat and Shuffle modes. An AVRCP controller may use SetPlayerApplicationSettingValue to set a value on the device and GetPlayerApplicationSettingValue to read a value, as described in Sections 6.5.4 and 6.4.3 of the Bluetooth Audio/Video Remote Control Profile Specification, Version 1.4.

40.11.5.3 Notifications

Accessories supporting AVRCP:

- Shall register for notifications.
- Shall not perform repetitive device status polling.

Every device in the role of an AVRCP Target supports registering for notifications, as described in Section 6.7 of the *Bluetooth Audio/Video Remote Control Profile Specification*, Version 1.4. The commands RegisterNotification and GetPlayStatus are supported for these notifications:

- EVENT_PLAYBACK_STATUS_CHANGED
- EVENT_TRACK_CHANGED

- EVENT_NOW_PLAYING_CONTENT_CHANGED
- EVENT_AVAILABLE_PLAYERS_CHANGED
- EVENT_ADDRESSED_PLAYER_CHANGED
- EVENT_VOLUME_CHANGED

40.11.5.4 Play/Pause Button

Accessories supporting AVRCP implementing a Play/Pause control surface shall confirm the playback status of the device using AVRCP Notifications (page 186), before sending a Play or Pause command. See Supported Operations (page 186). Specifically:

- If a device notifies the accessory it is paused, pressing the accessory's Play/Pause control surface should send a Play command.
- If a device notifies the accessory it is playing, pressing the accessory's Play/Pause control surface should send a Pause command.
- The accessory should not infer device playback status based on the number of times the Play/Pause control surface has been pressed.

40.11.5.5 Volume Handling

Accessories supporting AVRCP should support Absolute Volume, as described in Section 6.13 of the *Bluetooth Audio/Video Remote Control Profile Specification*, Version 1.4.

Every device in the role of AVRCP Controller supports volume handling.

40.11.5.6 Browsing

Accessories supporting Browsing (in controller role) as part of AVRCP:

- Shall not try to index or cache the entire library upon connection. The device may contain tens of thousands of media items, and each may be present multiple times in the hierarchy.
- Shall not fetch all items when browsing a folder; only fetch items displayed to the user. The accessory may prefetch a few items to improve the responsiveness of the user interface.
- Shall not reorder items (for example, alphabetically).
- Shall not assume UIDs to be statically defined, especially in the root folder. The ordering and UIDs
 of folders and items may change at any point in future releases.
- Shall send the SetBrowsedPlayer command after receiving an EVENT_UIDS_CHANGED notification.
- Shall not assume the UID passed to the PlayItem command will result in the media player playing the UID.

Currently only the built-in Music app supports browsing. When switching between players, an EVENT_AVAILABLE_PLAYERS_CHANGED notification, and an EVENT_ADDRESSED_PLAYER_CHANGED notification will be generated. The UI needs to look at the feature bit mask of the listed player to determine whether browsing is currently available.

All devices running iOS 6.0 or later support AVRCP Browsing.

40.11.5.7 iOS App-Provided Metadata

An audio app running on a device may use the iOS Media Player Framework to provide metadata about the current audio stream to the accessory using AVRCP. Requirements and usage for these messages may be found in the MPNowPlayingInfoCenter class in Apple Media Player Framework documentation.

40.11.6 Advanced Audio Distribution Profile (A2DP)

See Advanced Audio Distribution Profile (A2DP) (page 170).

40.12 Audio Routing

Accessories can differentiate between various audio content provided by a device, and determine playback behavior.

An accessory can receive audio data from the device using either of two Bluetooth profiles:

- HFP using eSCO channel.
- A2DP using ACL channel.

The device determines which channel to use, depending on how the audio content is used. An audio path created for two-way communication (for example, phone calls or FaceTime) always uses the HFP (eSCO) route for sending audio data. Music and similar content uses the A2DP channel route. In the absence of a defined route, audio playback defaults to the device.

40.12.1 Audio Data Received using HFP Profile

Most of the audio content sent using HFP (eSCO) route requires two-way communication. Scenarios where HFP (eSCO) is used include, but are not limited to: cellular calls, FaceTime, and voice mail.

The accessory speaker and microphone should be dedicated to the HFP (eSCO) route, and not mixed/muxed with any other audio sources.

40.12.2 Audio Data Received using A2DP Profile

Audio content transferred using A2DP profiles can be broadly classified into two categories:

- Audio content from music, video, or game-like applications.
- System-generated sounds used for alerts and notifications.

40.12.2.1 Differentiating Audio Content from System Sounds

Music-like content can be differentiated from system sounds by adding support for Audio/Video Remote Control Profile (AVRCP) version 1.3 or later. The AVRCP profile allows an accessory to be aware of the audio playback device state, using notifications. See Audio/Video Remote Control Profile (AVRCP) (page 186).

When a device initiates audio playback over an A2DP channel for playing music content, an AVRCP notification EVENT_PLAYBACK_STATUS_CHANGED is sent to indicate playback status has changed to the play state. See Section 6.7.2 of the *Audio/Video Remote Control Profile Specification*, Version 1.4. This indicates audio data using the A2DP profile contains music. When a device initiates audio playback over an A2DP channel for playing system sounds, no AVRCP notifications are sent.

Figure 40-1 (page 189) and Figure 40-2 (page 190) show the difference between notifications for music playback, and system sounds.

Figure Initiate Audio Playback (for example, music) 40-1

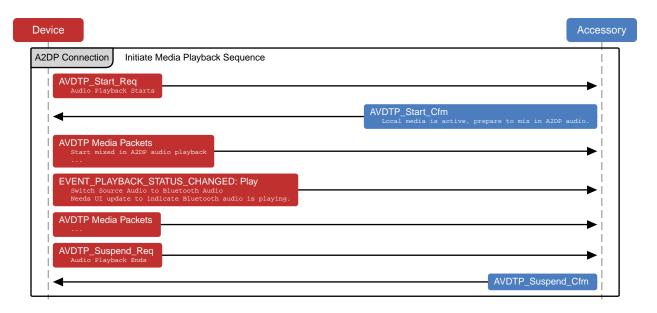
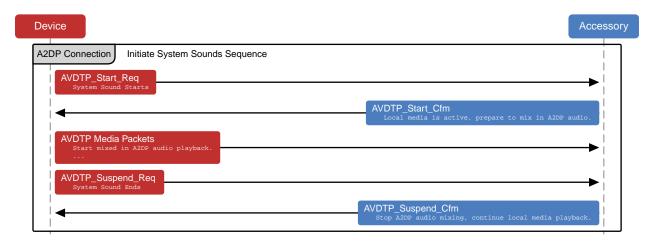


Figure Initiate System Sound (for example, turn-by-turn directions) 40-2



40.12.2.2 Expected Audio Routing Behavior for A2DP

The accessory should tune its audio routing behavior based on audio content over the A2DP channel.

If audio data contains music, accessory speakers are expected to be dedicated to audio data using the Bluetooth link, and any other audio playback is paused. If audio data contains system sounds, it is expected the accessory can render audio as desired. If the accessory is playing audio from a different source, it is not necessary to pause existing audio playback on the device, and system sound data can be mixed with the existing track for playback.

40.13 HID

When implementing HID over Bluetooth, the accessory:

- Should support Bluetooth HID Profile 1.1.
- Should support Sniff Mode for Low Power Consumption (page 179).
- Should use the following parameters in SDP for sniff subrating:
 - HIDSSRHostMaxLatency 450 ms (720 slots)
 - HIDSSRHostMinTimeout 45 ms (72 slots)
- Should use a typical report packet of 22 bytes or less. This is small enough to fit into a DH1 packet with L2CAP and HID header.

41. Bluetooth Low Energy (BLE)

The *Bluetooth 4.0* specification introduces Bluetooth Low Energy (BLE), a wireless technology targeted for accessories with limited battery resources. If Bluetooth Low Energy is supported, the accessory should follow the guidelines in this section.

41.1 Role

The accessory should implement either the Peripheral role as defined in the *Bluetooth 4.0* specification, Volume 3, Part C, Section 2.2.2.3 or the Broadcaster role, as defined in Section 2.2.2.1.

41.2 Advertising Channels

The accessory should advertise on all three advertising channels (37, 38, and 39) at each advertising event. See the *Bluetooth 4.0* specification, Volume 6, Part B, Section 4.4.2.1.

41.3 Advertising PDU

The accessory should use one of the following advertising PDUs:

- ADV_IND
- ADV_NOCONN_IND
- ADV_SCAN_IND

ADV_DIRECT_IND should not be used. See the *Bluetooth 4.0* specification, Volume 6, Part B, Section 2.3.1.

41.4 Advertising Data

The advertising data sent by the accessory should contain at least the following information as described in the *Bluetooth Core Specification Supplement*, Part A:

- Flags
- TX Power Level

- Local Name
- Services

The Local Name should match the accessory's markings and packaging and not contain a colon ':' or semi-colon ';'.

The accessory may put the Local Name and the TX Power Level data in the SCAN_RSP PDU if, for example, it needs to reduce power consumption or not all of the advertising data fit into the advertising PDU. Depending on its state, the device may not always perform active scanning.

The primary services should always be advertised in the advertising PDU. Secondary services should not be advertised. Services not significant to the primary use case of the accessory may be omitted if space is limited in the Advertising PDU.

The advertising data and the scan response data in the SCAN_RSP PDU should comply with the formatting guidelines in the *Bluetooth 4.0* specification, Volume 3, Part C, Section 18: it starts with a length field, followed by AD Type and AD Data.

41.5 Advertising Interval

The accessory should first use the recommended advertising interval of 20 ms for at least 30 seconds.

If it is not discovered within the initial 30 seconds, Apple recommends using one of the following longer intervals to increase chances of discovery by the device:

- 152.5 ms
- 211.25 ms
- 318.75 ms
- 417.5 ms
- 546.25 ms
- 760 ms
- 852.5 ms
- 1022.5 ms
- 1285 ms

Note:

Longer advertising intervals usually result in longer discovery and connect times, but may lower accessory power consumption.

41.6 Connection Parameters

The accessory is responsible for the connection parameters used for the Low Energy connection. The accessory should request connection parameters appropriate for its use case by sending an L2CAP Connection Parameter Update Request at the appropriate time. See the *Bluetooth 4.0* specification, Volume 3, Part A, Section 4.20 for details.

The connection parameter request may be rejected if it does not meet the following guidelines:

- Peripheral Latency of up to 30 connection intervals.
- Supervision Timeout from 2 seconds to 6 seconds.
- Interval Min of at least 15 ms.
- Interval Min is a multiple of 15 ms.
- One of the following:
 - Interval Max at least 15 ms greater than Interval Min.
 - Interval Max and Interval Min both set to 15 ms.
- Interval Max * (Peripheral Latency + 1) of 2 seconds or less.
- Supervision Timeout greater than Interval Max * (Peripheral Latency + 1) * 3.

Note:

If an accessory requests both an Interval Min and Interval Max of 15 ms, some devices will scale the interval to 30 ms to balance power and performance constraints.

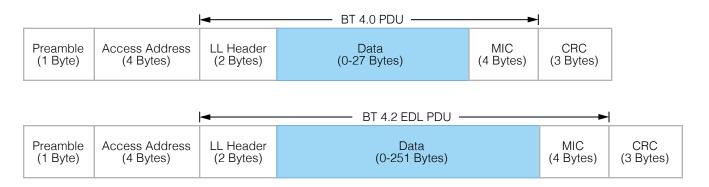
If Bluetooth Low Energy HID is one of the connected services of an accessory, a connection interval down to 11.25 ms may be accepted by the device.

The device will not read or use the parameters in the Peripheral Preferred Connection Parameters characteristic. See the *Bluetooth 4.0* specification, Volume 3, Part C, Section 12.5.

41.7 Data Packet Length Extension

Data Packet Length Extension is an enhancement introduced in the *Bluetooth 4.2* specification which increases the maximum data length from 27 to 251. Using a longer per-packet data length improves radio efficiency, greatly increases application data rates, and boosts battery life. See the *Bluetooth 5.0* specification, Volume 6, Part B, Section 4.6.6 for details.

Figure Data Packet Length Extension 41-1



Accessories should support Data Packet Length Extension for best performance with devices.

iOS devices and Mac computers operating as the Central will negotiate optimal data packet lengths based on various factors, such as connection event length, system topology, and protocol.

41.8 Privacy

The accessory should be able to resolve a Resolvable Private Address in all situations. Due to privacy concerns, the device will use a Random Device Address as defined in the *Bluetooth 4.0* specification, Volume 3, Part C, Section 10.8.

41.9 Permissions

The accessory should not require special permissions, such as pairing, authentication, or encryption to discover services and characteristics. It may require special permissions only for access to a characteristic value or a descriptor value. See the *Bluetooth 4.0* specification, Volume 3, Part G, Section 8.1, fifth paragraph.

41.10 Pairing

The accessory should not request pairing until an ATT request is rejected using the Insufficient Authentication error code. See the *Bluetooth 4.0* specification, Volume 3, Part F, Section 4 for details.

If, for security reasons, the accessory requires a bonded relationship with the Central, the Peripheral should reject the ATT request using the Insufficient Authentication error code, as appropriate. As a result, the device may proceed with the necessary security procedures.

Similarly, if the device acts as a Central and a GATT server, it may reject an ATT request using the Insufficient Authentication error code. The accessory should initiate the security procedure for pairing in response.

Pairing may require user authorization depending on device. Once an accessory is paired with a device, the accessory shall retain the distributed keys of both central and peripheral for future use. If the pairing is no longer required, the accessory shall delete both sets of keys.

41.11 MTU Size

An accessory supporting packet length extension shall perform the packet length update procedure before performing the Exchange MTU Request handshake, see Data Packet Length Extension (page 193).

Devices will support and request an MTU size larger than the default during the Exchange MTU Request handshake. See the *Bluetooth 4.0* specification, Volume 3, Part F, Section 3.2.8.

When operating as ATT client, the device will request the optimal MTU size based on factors such as the Bluetooth topology, connection event length, maximum data length, and protocol (GATT or connection-oriented L2CAP).

An accessory operating as ATT server should select an MTU equal to or greater than the device's MTU request.

41.12 Services

41.12.1 Generic Access Profile Service

The accessory should implement the Device Name characteristic per the *Bluetooth 4.0* specification, Volume 3, Part C, Section 12.1. The Device Name characteristic should be writeable.

41.12.2 Generic Attribute Profile Service

The accessory shall implement the Service Changed characteristic only if the accessory has the ability to change its services during its lifetime.

The device may use the Service Changed characteristic to determine if it can rely on previously read (cached) information from the device. See the *Bluetooth 4.0* specification, Volume 3, Part G, Section 7.1.

41.12.3 Device Information Service

The accessory shall implement the Device Information Service. The service UUID for this service should not be advertised in the Advertising Data. The following characteristics should be supported:

- Manufacturer Name String (26 characters maximum).
- Model Number String (26 characters maximum).
- Firmware Revision String
- Software Revision String

41.12.4 Available Services

With iOS 7.0, any device makes Battery Service, Current Time Service and Apple Notification Center Service (ANCS) available to an accessory. The Current Time Service supports the current time and local time information characteristics. The service does not provide an "Adjust Reason" when the current time changes. ANCS uses 7905F431–B5CE–4E99–A40F–4B1E122D00D0 as its UUID.

These services are not guaranteed to be available immediately after connection and the accessory shall support Characteristic Value Indication of the Service Changed characteristic (see *Bluetooth 4.0* specification, Volume 3, Part G, Section 7.1) to be notified when the services become available. The device will maintain a connection to an accessory as long as it is paired and uses one of the available services.

41.13 GATT Server

With iOS 6.0, applications may contribute services and characteristics to the GATT server the device makes available to the accessory. The recommendations in this section apply to the accessory in this case.

The following services are implemented internally by iOS and shall not be published by third-party iOS applications:

- Generic Attribute Profile Service
- Generic Access Profile Service
- Bluetooth Low Energy HID Service
- Battery Service
- Current Time Service
- Apple Notification Center Service

The device implements the GAP Service Changed characteristic, because the database contents can change at any time. The accessory should therefore support the Characteristic Value Indication of this characteristic and, upon receiving indications, invalidate its database cache accordingly. See the *Bluetooth 4.0* specification, Volume 3, Part G, Section 7.1.

The accessory should minimize the use of ATT/GATT requests and commands and only send what is necessary. For example, do not use GATT Discover All Services when the accessory is looking for specific services. Use Discover Primary Service By Service UUID instead. Less airtime equals less power consumption and better performance for both the accessory and the device.

When third-party iOS applications discover services on the accessory, the following services are used internally by iOS and are filtered out from the list of discovered services:

- Generic Attribute Profile Service
- Generic Access Profile Service
- Bluetooth Low Energy HID Service
- Apple Notification Center Service

The accessory should be robust enough to handle any error gracefully. Pairing and Characteristic Value reads/writes may fail if the application owning the service is not in the foreground and is not entitled to run in the background.

If an ATT Prepare Write Request is used, all queued attributes are contained within the same GATT Service.

Connectors

42. USB-A Receptacle

Accessories may incorporate a USB-A receptacle to:

• Provide power to a device.

42.1 Mechanical

The USB-A receptacle shall meet or exceed all applicable USB-IF mechanical specifications.

42.2 Electrical

The USB-A receptacle shall meet or exceed all applicable USB-IF electrical specifications.

43. USB-C Plug

Accessories incorporating a USB-C plug shall comply with the *USB Type-C Cable and Connector Specification Release 1.3*.

Accessories may incorporate a USB-C plug to:

- Draw power from Apple branded or MFi certified USB power sources.
- Draw power from USB-C Current sources.
- Draw power from USB Power Delivery sources.
- Draw power from USB Dedicated Charging Ports and USB hosts, such as a Mac.
- Enable USB connection to a Mac.

Examples of accessories benefiting from including a USB-C plug include cables, battery packs, and adapters.

43.1 Mechanical

The USB-C plug shall have an assigned Connector Test ID from the USB-IF.

43.2 Electrical

Accessories shall not directly electrically connect a USB-C plug to the device.

Accessories drawing power from the USB-C plug shall:

- Correctly identify all Apple branded or MFi certified USB power sources using USB D+/D- Resistor Networks (page 165).
- Correctly identify all USB Dedicated Charging Ports (DCP) as defined in the USB Battery Charging 1.2 specification.
- Correctly identify all USB-C Current (page 169) sources.
- Enumerate as a USB device when connected to a USB host, such as a Mac, and:
 - Not draw more than 100 mA of current until they have been successfully enumerated.
 - Request no more than 500 mA of charging current in their USB device descriptor.
- Not draw more power than the USB power source claims it is capable of providing using one of the above methods.

Accessories may also correctly identify all USB Power Delivery (page 168) sources.

43.3 Test Procedures

43.3.1 Connector Test ID

Verify the accessory's USB-C plug has an assigned Connector Test ID from the USB-IF.

43.3.2 Drawing Power

This procedure applies to accessories drawing power using the USB-C plug.

The following equipment is needed:

- Apple 140W USB-C Power Adapter
- Apple 96W USB-C Power Adapter
- Apple 67W USB-C Power Adapter
- Apple 30W USB-C Power Adapter
- Apple 20W USB-C Power Adapter
- Apple 35W Dual USB-C Port Compact Power Adapter
- Apple 35W Dual USB-C Port Power Adapter
- Bundled USB-C power adapter (if applicable)

Verify the accessory correctly identifies all Apple branded or bundled power sources:

1. Verify each USB-C power adapter is correctly identified and provides power.

Verify the accessory correctly identifies a Mac:

1. Verify the Mac is correctly identified and provides power.

44. USB-C Receptacle

Accessories incorporating a USB-C receptacle shall comply with the *USB Type-C Cable and Connector Specification Release 1.3*.

Accessories may incorporate a USB-C receptacle to:

- Provide power to a device.
- Draw power from Apple branded or MFi certified USB power sources.
- Draw power from USB-C Current sources.
- Draw power from USB Power Delivery sources.
- Draw power from USB Dedicated Charging Ports and USB hosts, such as a Mac.
- Enable USB connection to a Mac.

Accessories shall not integrate a USB-C receptacle to enable passthrough USB charge/sync of a device.

Examples of accessories benefiting from including a USB-C receptacle include AC Power Adapters (page 66), Battery Packs (page 69), and speakers.

44.1 Mechanical

The USB-C receptacle shall be USB-IF certified and have a Connector Test ID from the USB-IF.

44.2 Electrical

Accessories shall not directly electrically connect a USB-C receptacle to the device.

44.2.1 Drawing Power

Accessories drawing power from the USB-C receptacle shall:

- Correctly identify all Apple branded or MFi certified USB power sources using USB D+/D- Resistor Networks (page 165).
- Correctly identify all USB Dedicated Charging Ports (DCP) as defined in the USB Battery Charging 1.2 specification.
- Correctly identify all USB-C Current (page 169) sources.
- Enumerate as a USB device when connected to a USB host, such as a Mac, and:

- Not draw more than 100 mA of current until they have been successfully enumerated.
- Request no more than 500 mA of charging current in their USB device descriptor.
- Not draw more power than the USB power source claims it is capable of providing using one of the above methods.

Accessories may also correctly identify all USB Power Delivery (page 168) sources.

44.2.2 Providing Power

Accessories providing power to a device using a USB-C receptacle:

- Shall provide at least 15 W (3 A at 5.0 V) of power.
- Shall support USB-C Current (page 169).
- Should support USB Power Delivery (page 168).
- Should label the receptacle indicating how much power is supplied in watts.

44.3 Test Procedures

44.3.1 Connector Test ID

Verify the accessory's USB-C receptacle has an assigned *Connector* Test ID from the USB-IF.

44.3.2 Drawing Power

This procedure applies to accessories drawing power using the USB-C receptacle.

The following equipment is needed:

- Apple USB-C Charge Cable (1 m)
- Apple USB-C Charge Cable (2 m)
- Bundled USB-C to USB-C cable (if applicable)
- Bundled USB-A to USB-C cable (if applicable)
- 3rd-party USB-A to USB-C cable
- Apple 140W USB-C Power Adapter
- Apple 96W USB-C Power Adapter
- Apple 67W USB-C Power Adapter
- Apple 30W USB-C Power Adapter
- Apple 20W USB-C Power Adapter
- Apple 35W Dual USB-C Port Compact Power Adapter
- Apple 35W Dual USB-C Port Power Adapter
- Apple 12W USB Power Adapter
- Apple 5W USB Power Adapter

- Bundled USB-C power adapter (if applicable)
- Bundled USB-A power adapter (if applicable)
- MFi USB-C power adapter(s)
- MFi USB-A power adapter(s)

Verify the accessory correctly identifies all Apple branded or bundled power adapters:

- 1. Using each USB-A to USB-C cable, verify each USB-A power adapter is correctly identified and provides power.
- 2. Using each USB-C to USB-C cable, verify each USB-C power adapter is correctly identified and provides power.

Verify the accessory correctly identifies a Mac:

1. Using each USB-A to USB-C cable and USB-C to USB-C cable, verify the Mac is correctly identified and provides power.

Verify the accessory correctly identifies MFi power adapters:

- 1. Using each USB-A to USB-C cable, verify each MFi USB-A power adapter is correctly identified and provides power.
- 2. Using each USB-C to USB-C cable, verify each MFi USB-C power adapter is correctly identified and provides power.

44.3.3 Providing Power

This procedure applies to accessories providing power using the USB-C receptacle.

The following equipment is needed:

- Apple USB-C to Lightning Cable (1 m)
- Apple USB-C to Lightning Cable (2 m)
- Apple USB-C Charge Cable (1 m)
- Apple USB-C Charge Cable (2 m)
- Bundled USB-C to USB-C cable (if applicable)

Verify the accessory correctly provides power to devices:

- 1. Using each USB-C to Lightning cable, verify the accessory uses USB-C Current or USB-PD to identify at least 15 W of power providing capability.
- 2. Using each USB-C to Lightning cable, verify the accessory provides power to the device.

Verify the accessory correctly identifies a Mac:

1. Using each USB-C to USB-C cable, verify the accessory is correctly identified and provides power to the Mac.

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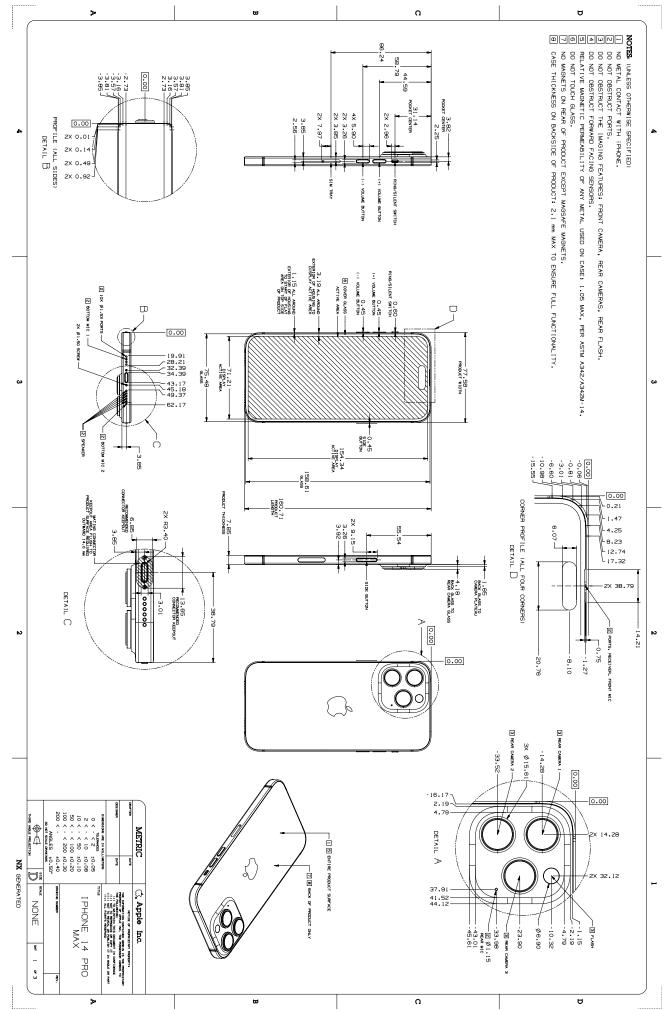
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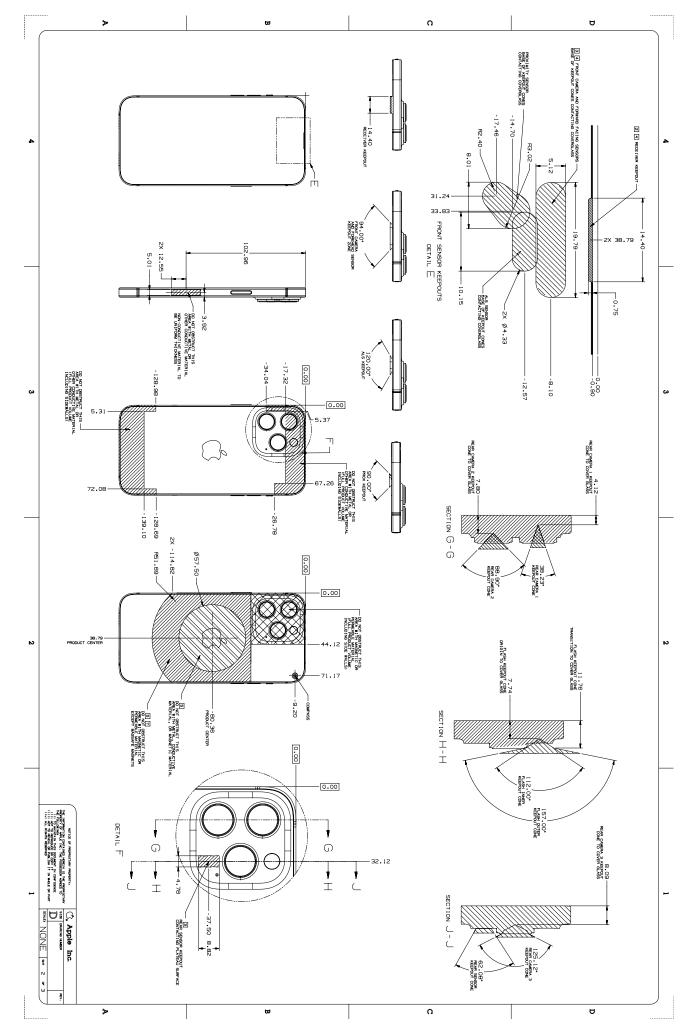
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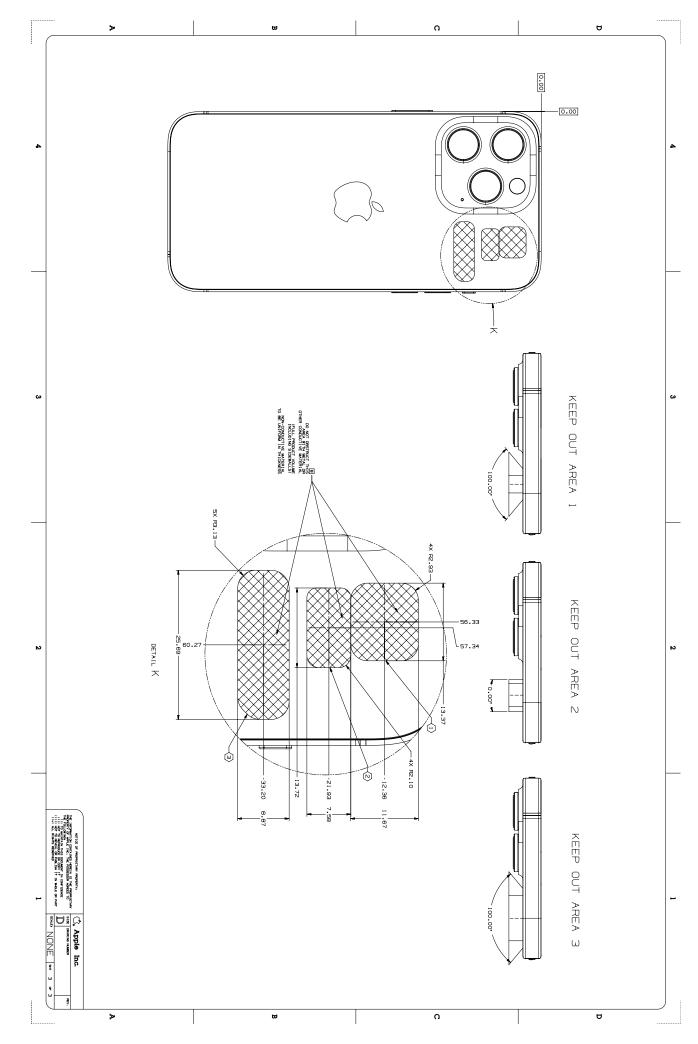
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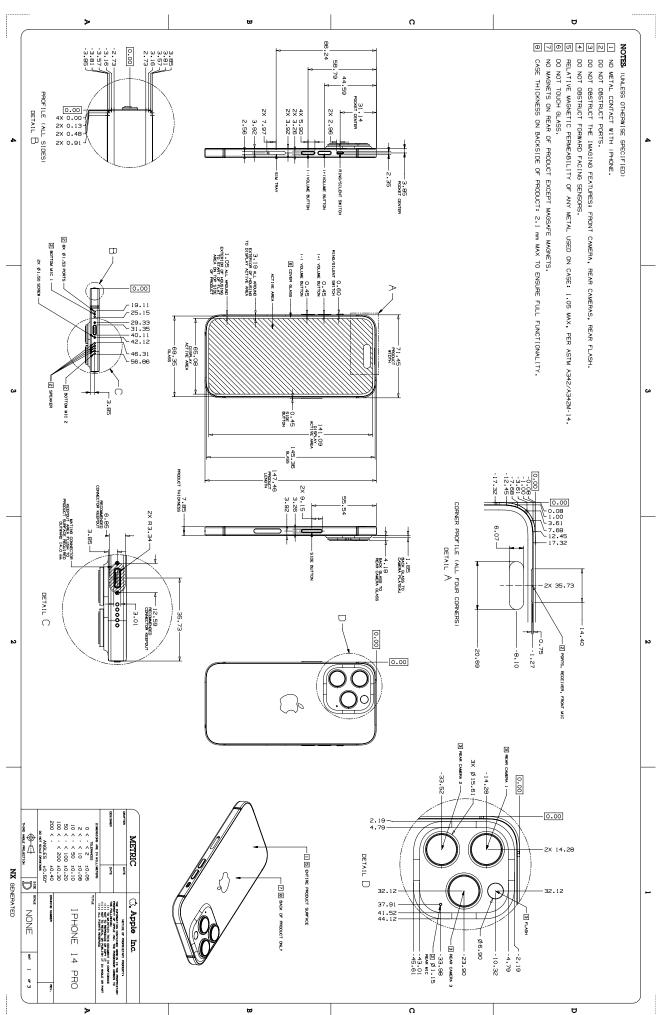


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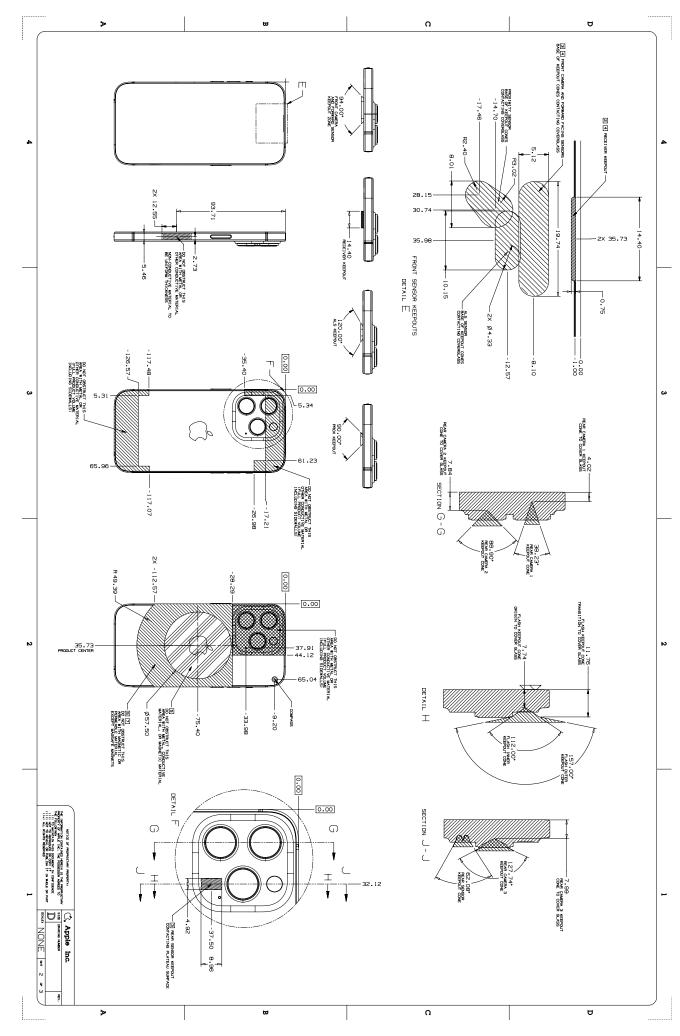


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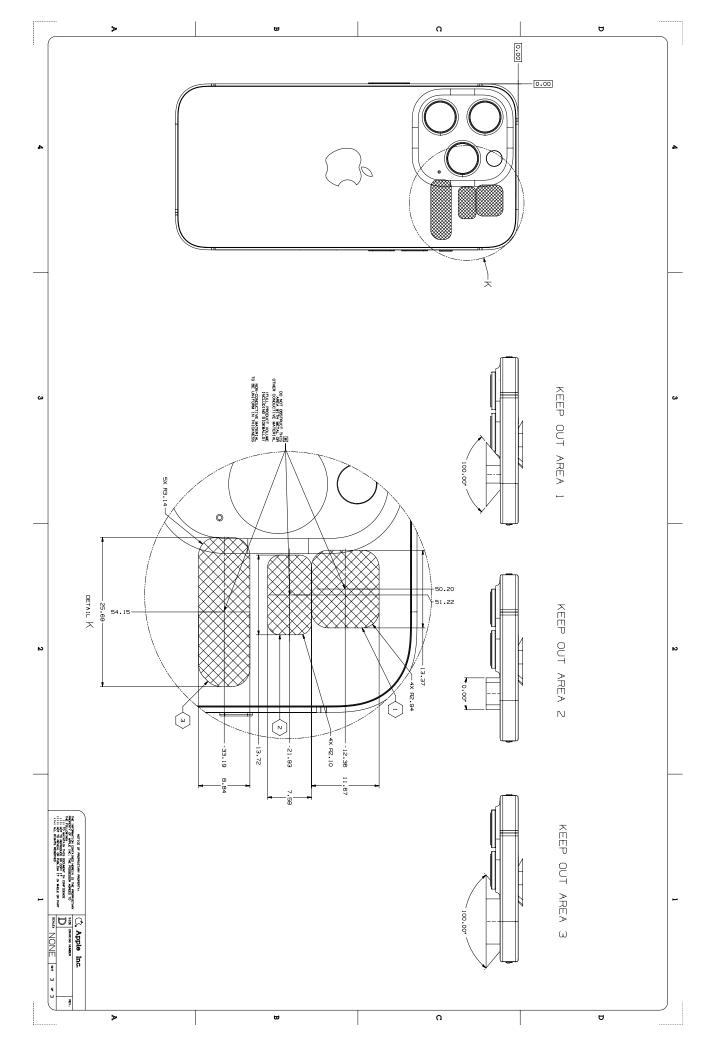


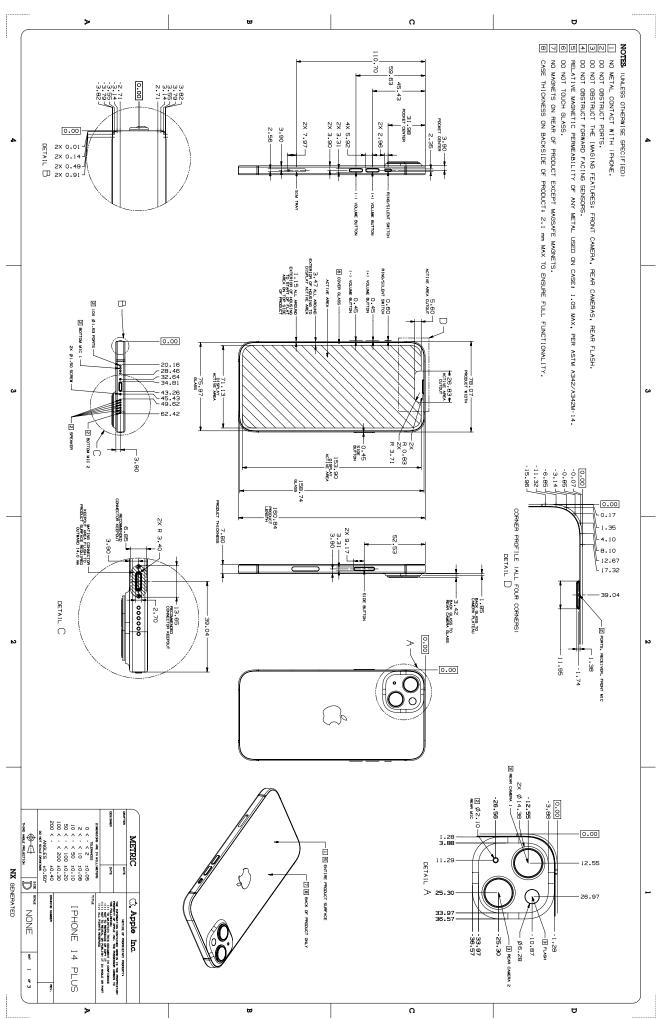


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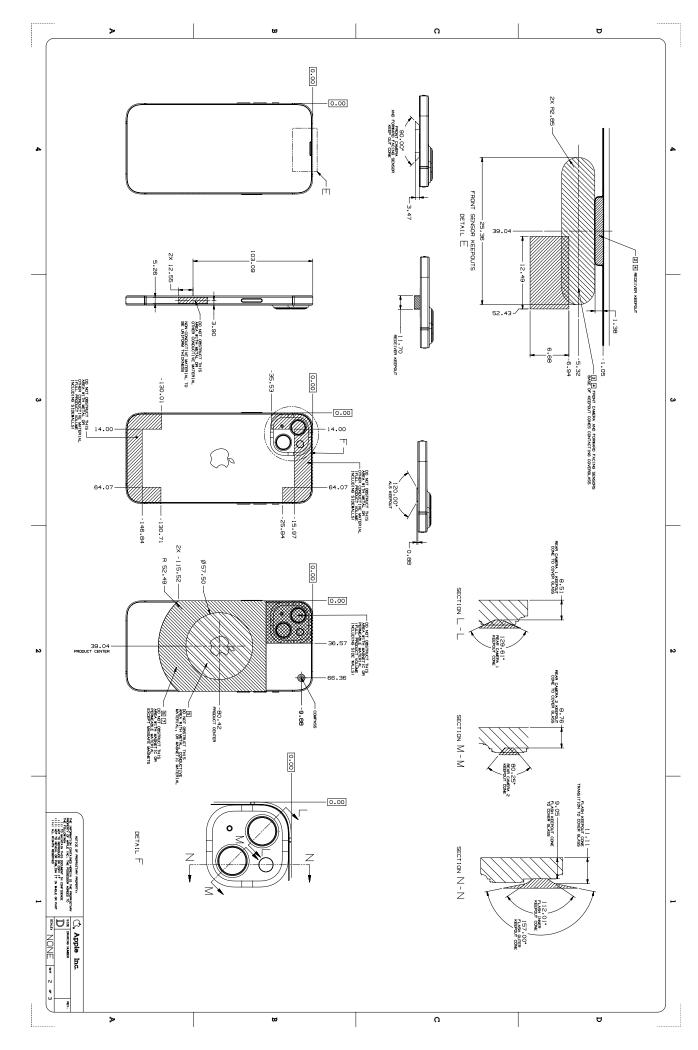


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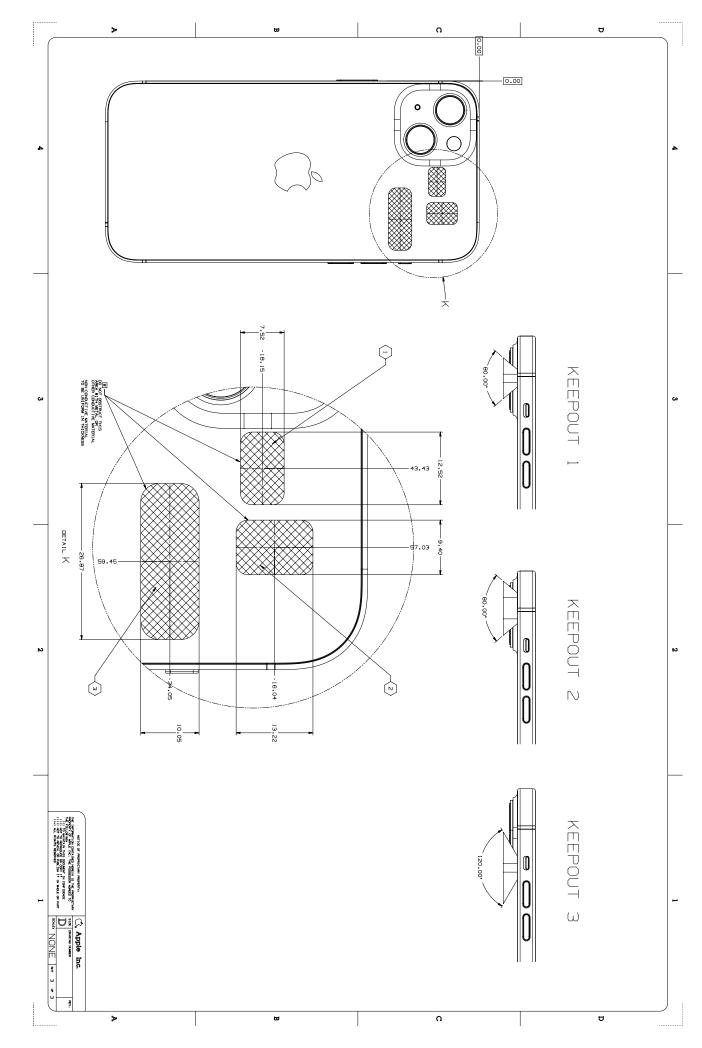


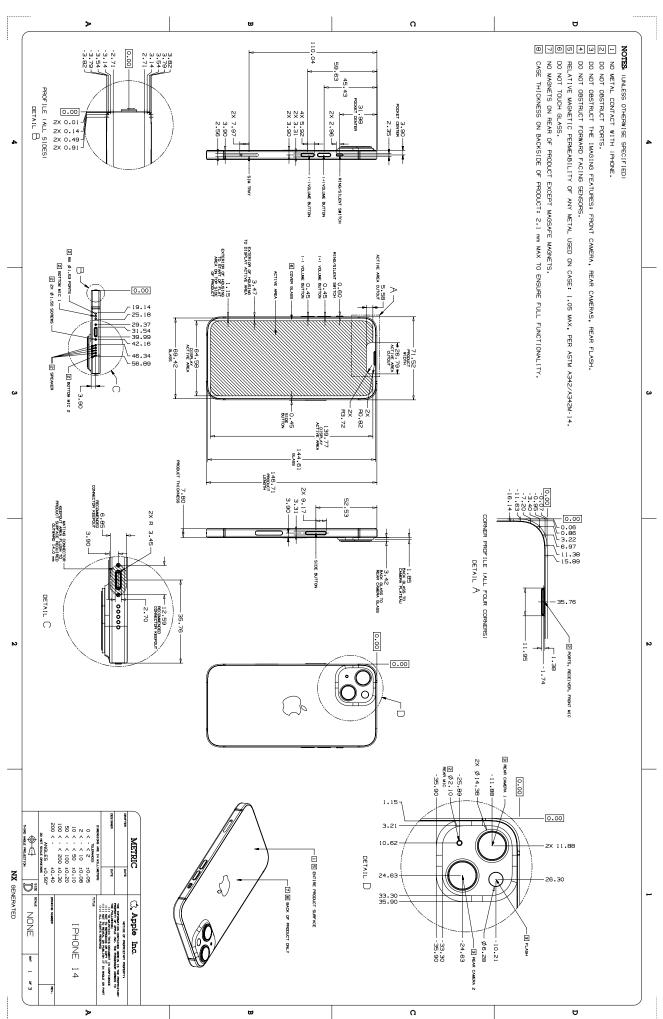


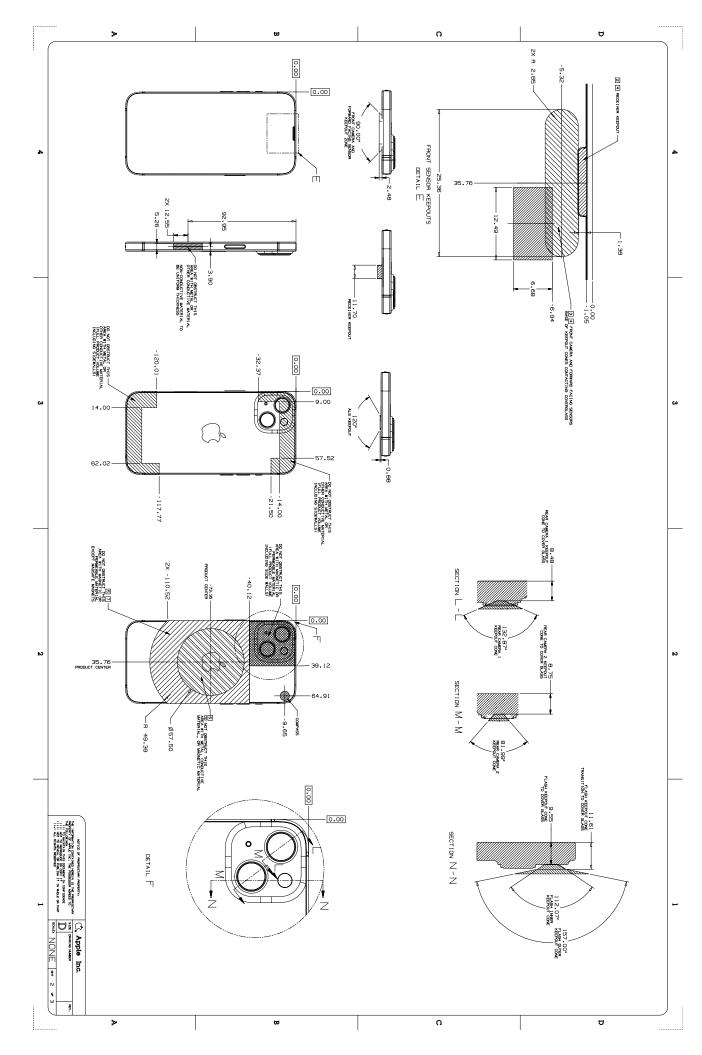
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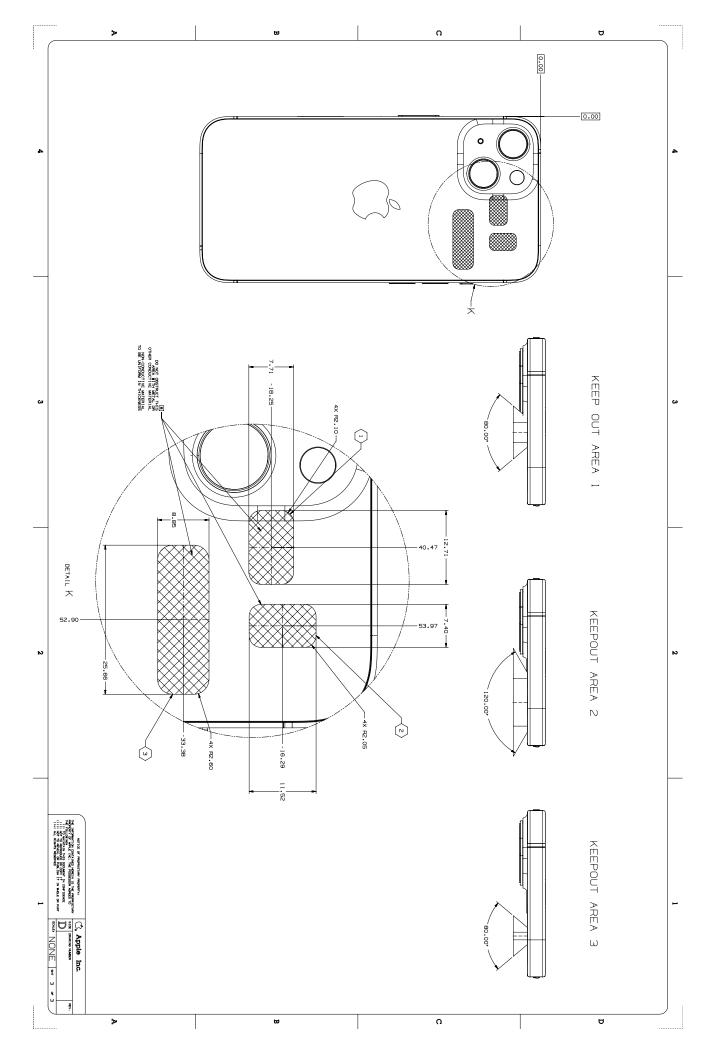


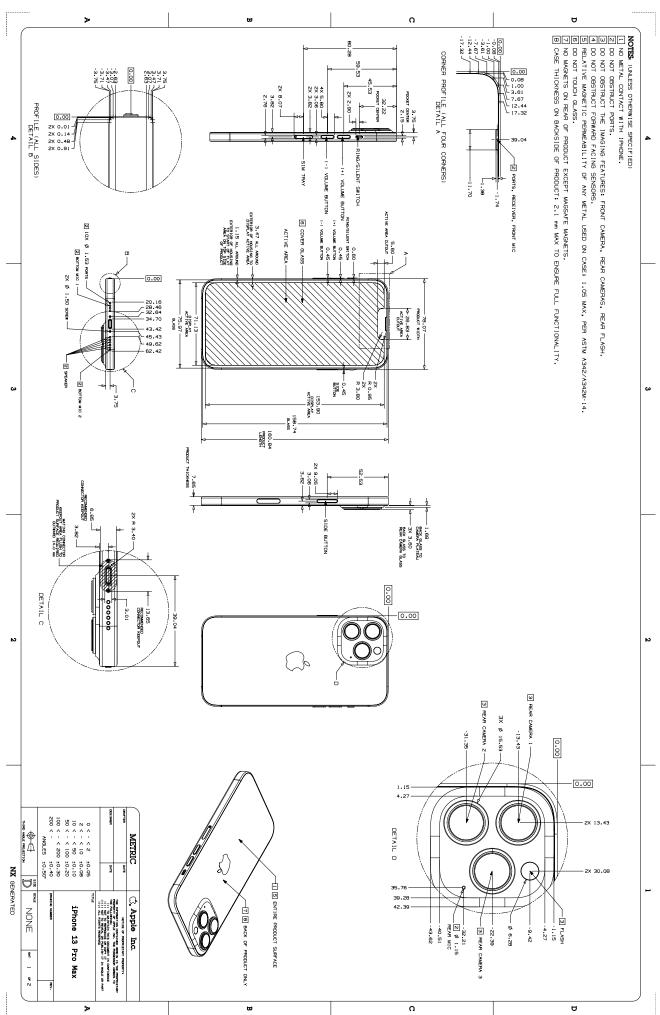
45.9 iPhone 14 Plus 3 of 3



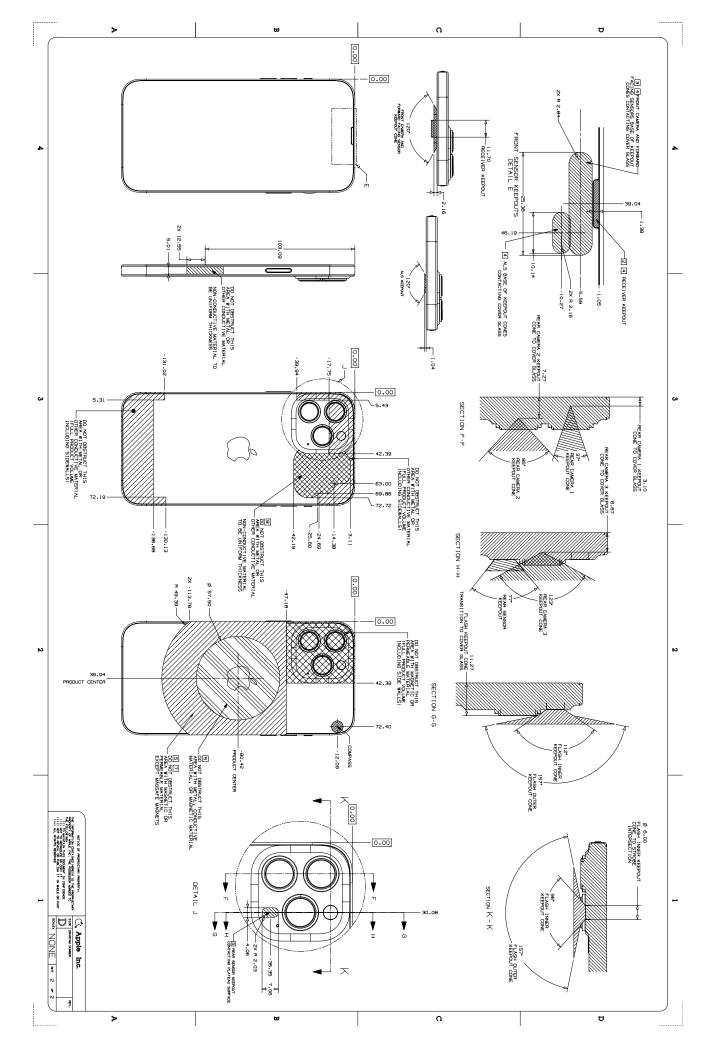


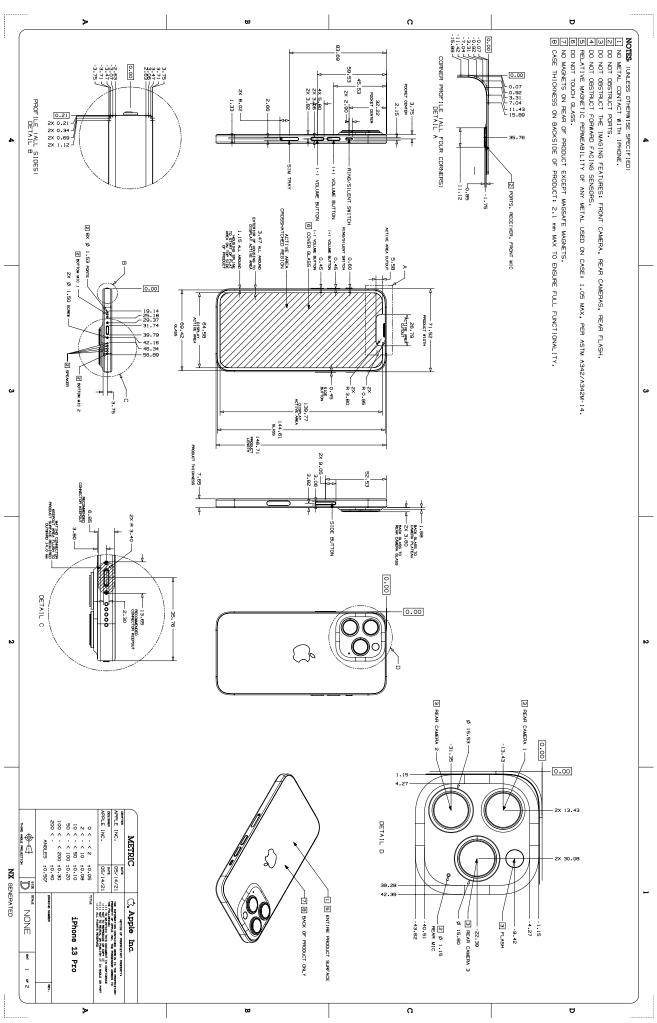




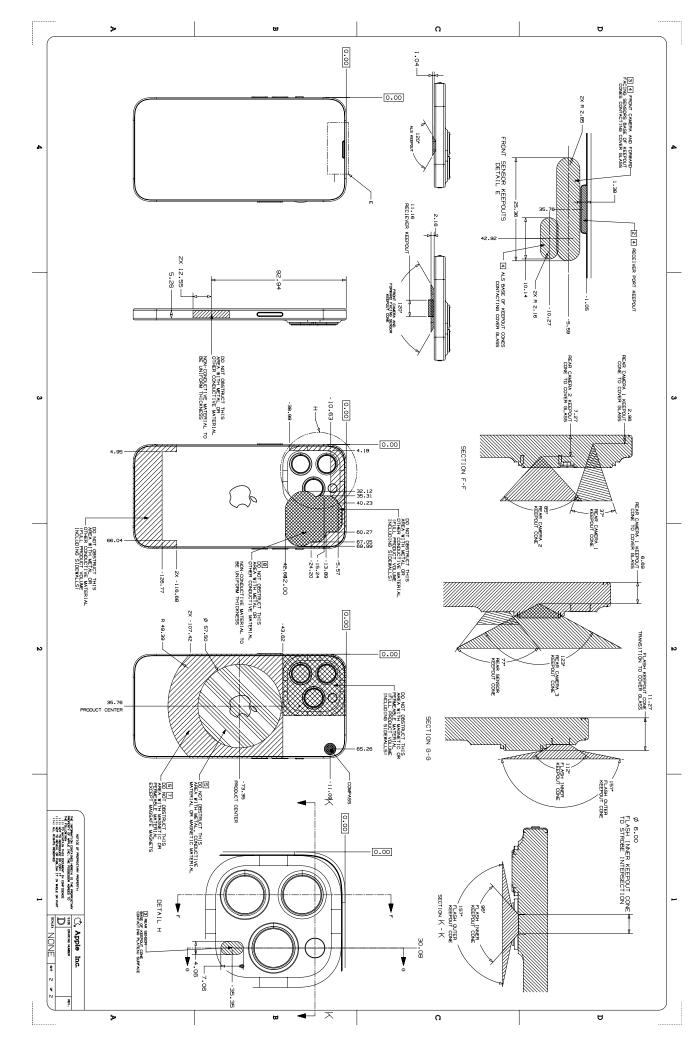


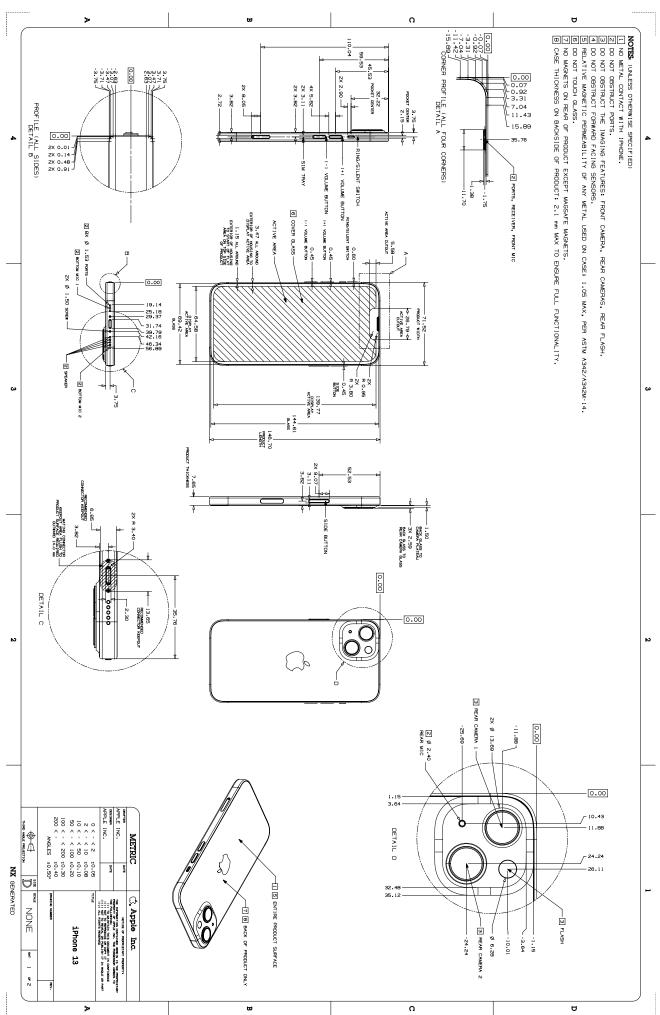
45.14 iPhone 13 Pro Max 2 of 2

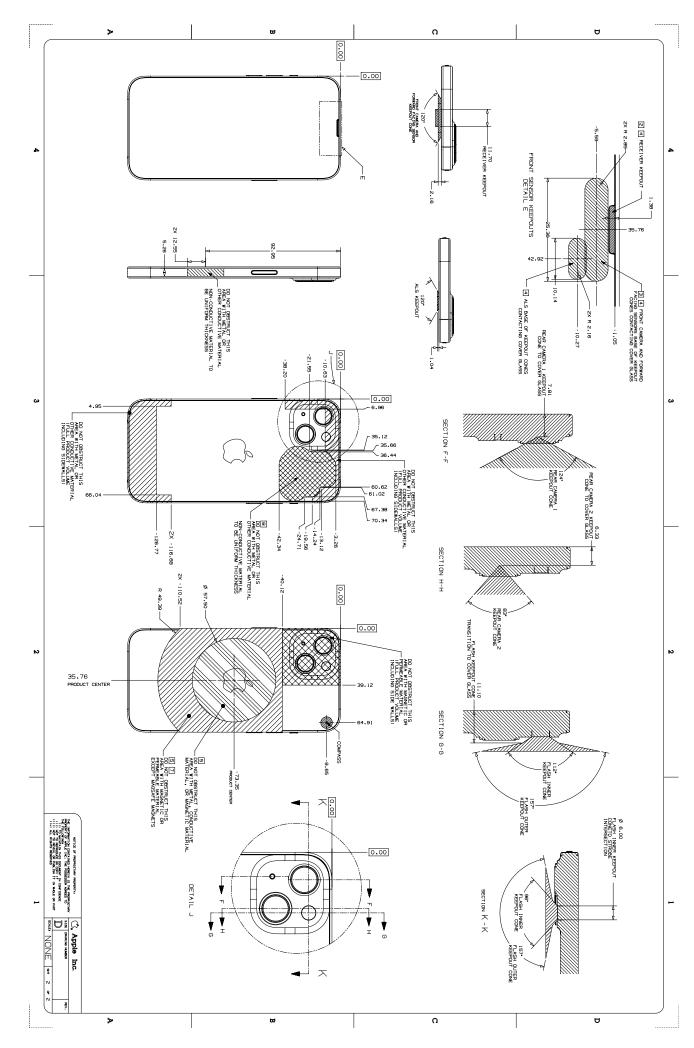


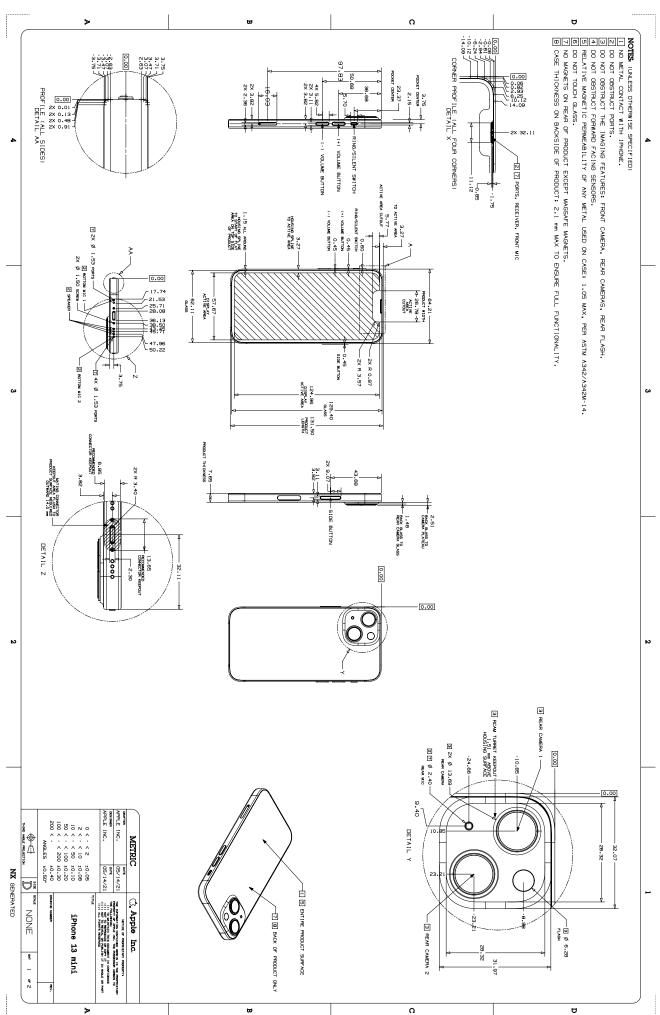


45.16 iPhone 13 Pro 2 of 2

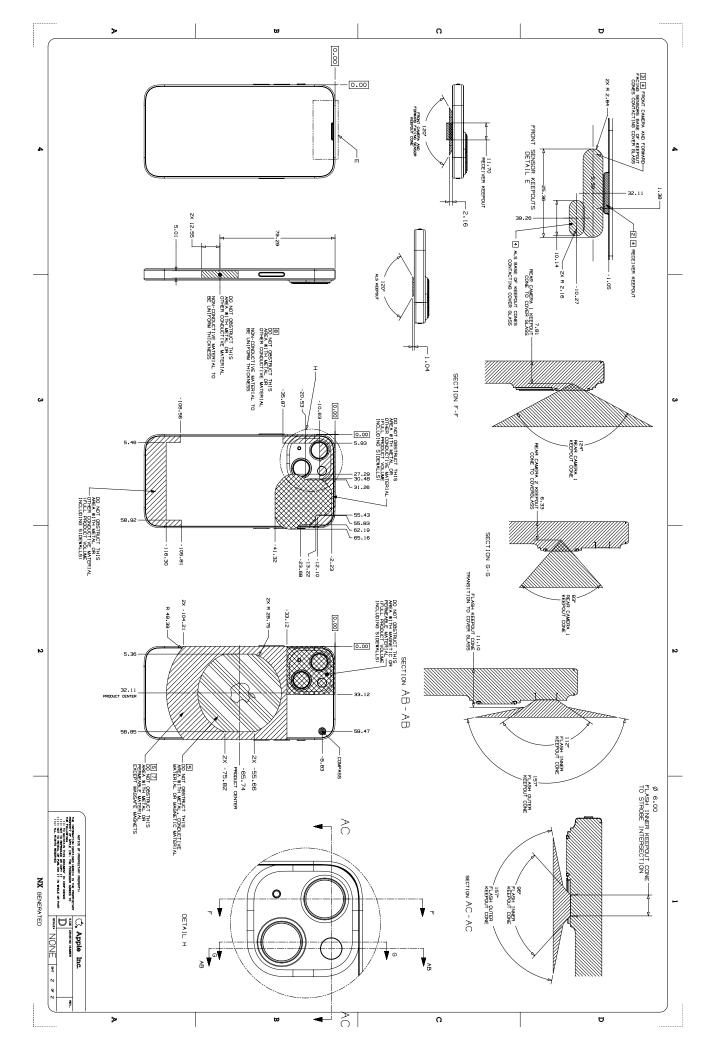


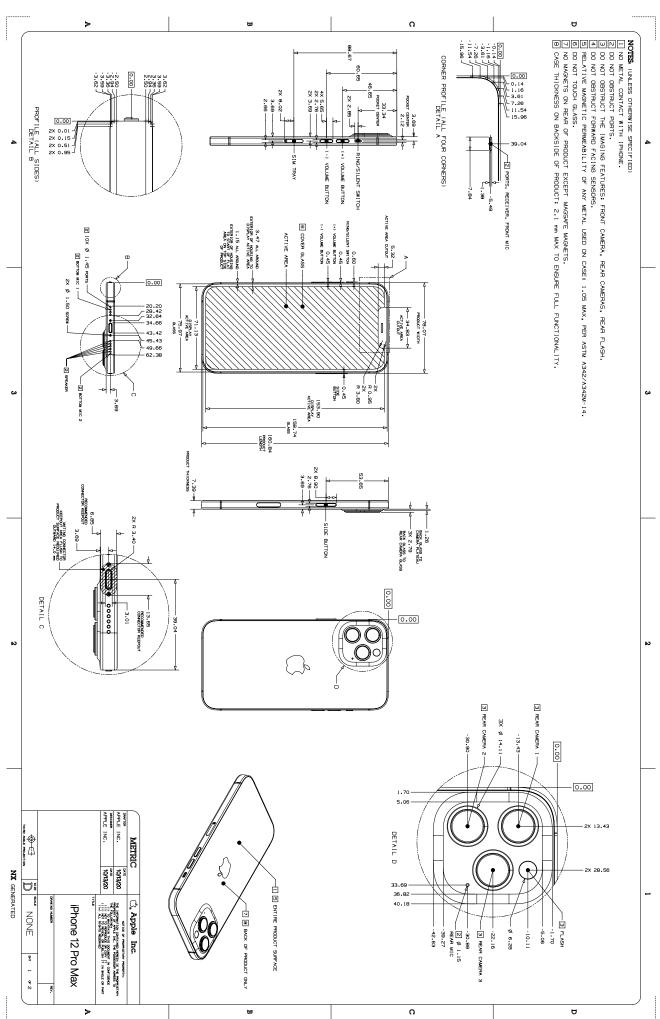




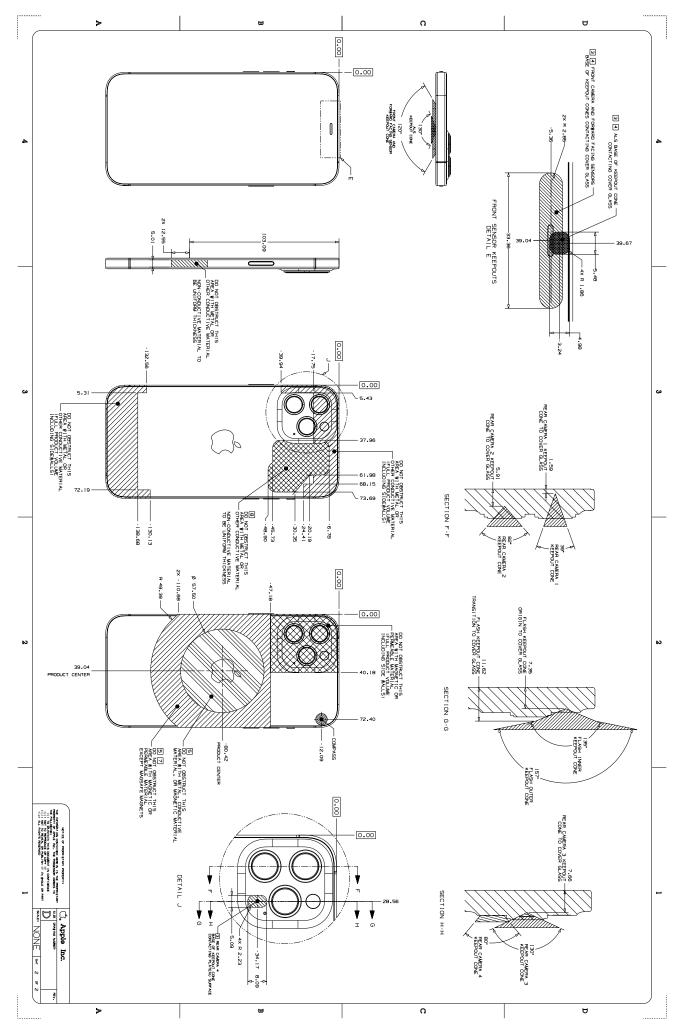


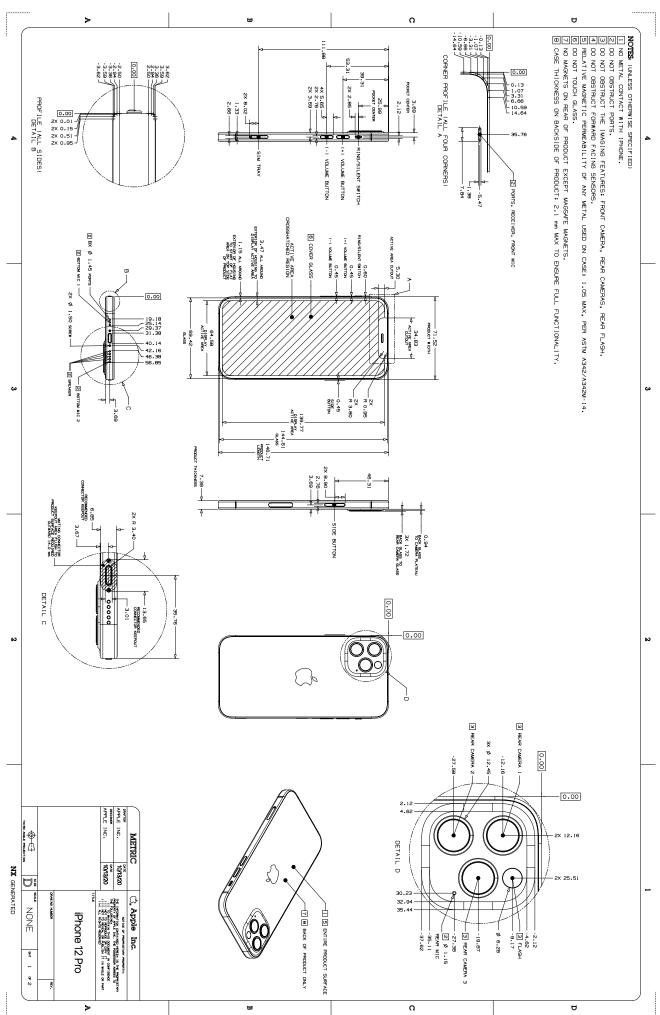
45.20 iPhone 13 mini 2 of 2



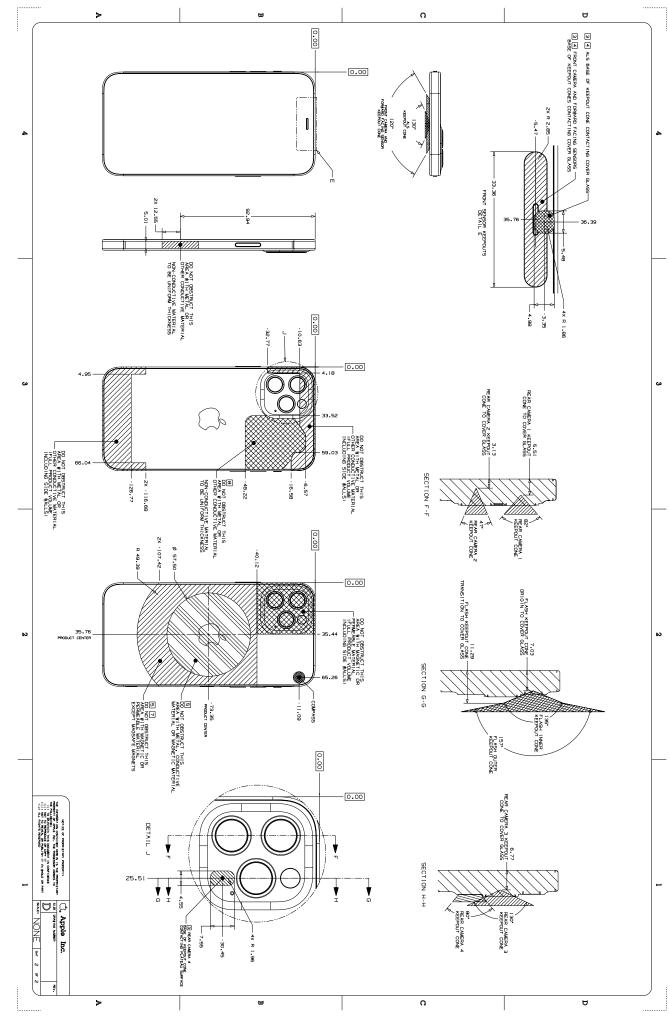


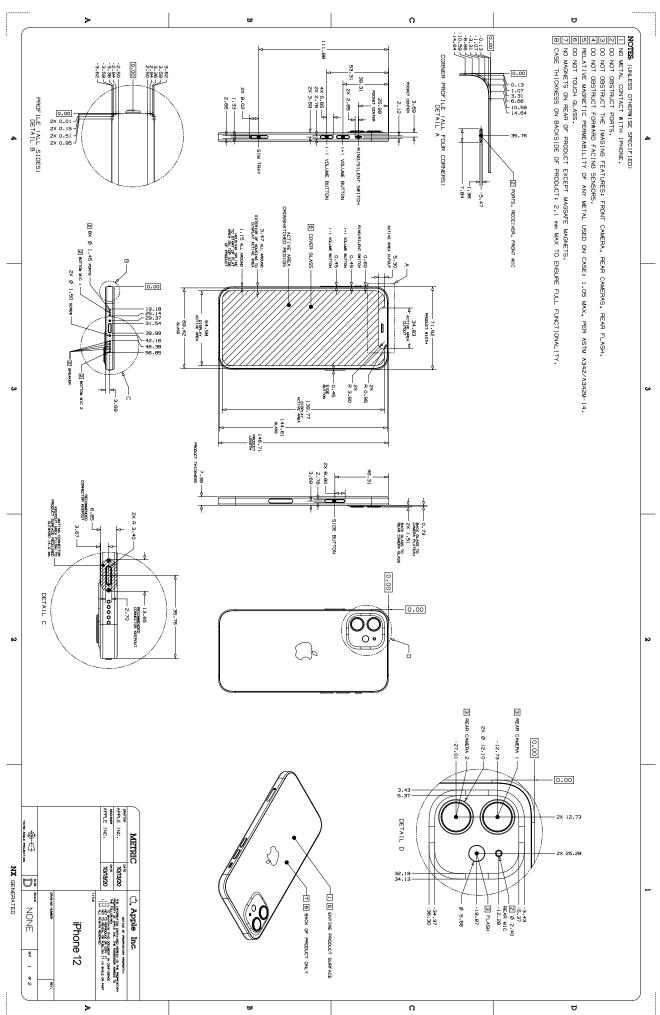
45.22 iPhone 12 Pro Max 2 of 2

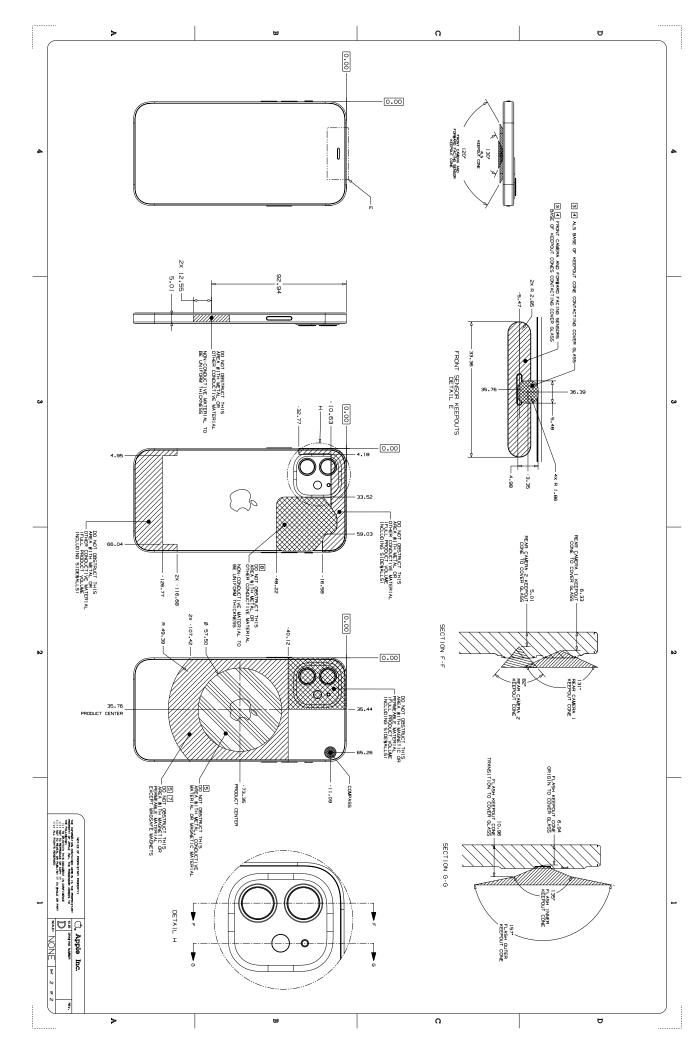


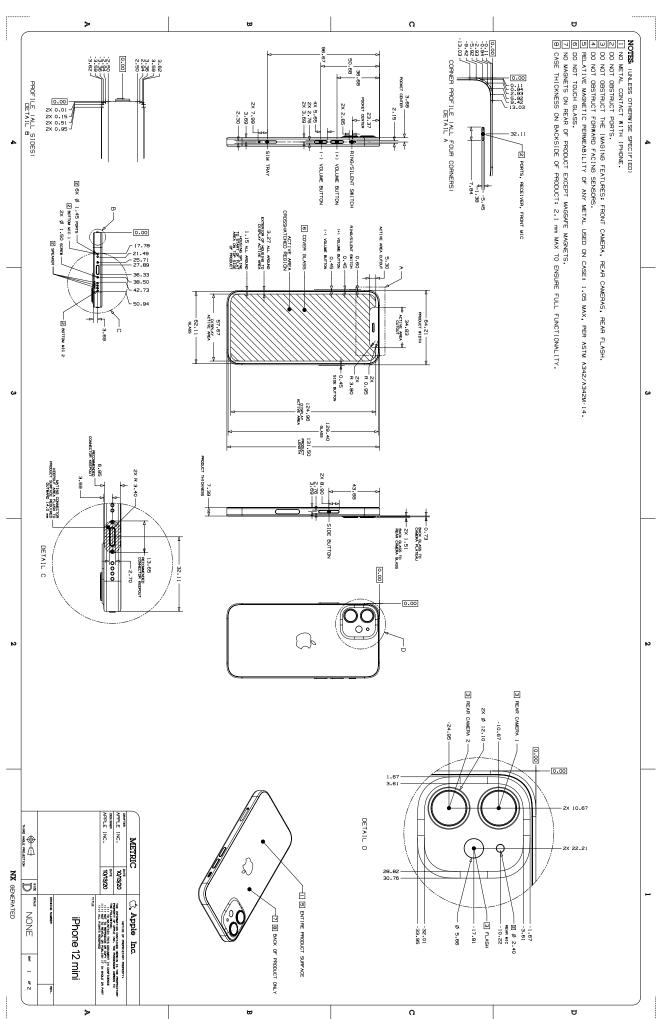


45.24 iPhone 12 Pro 2 of 2

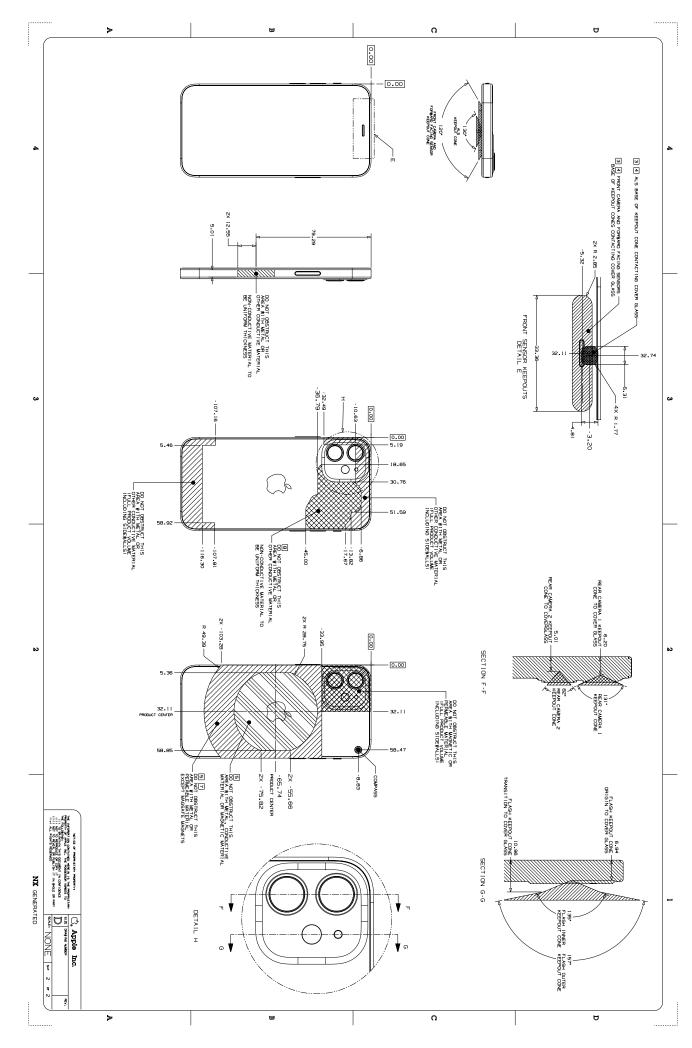




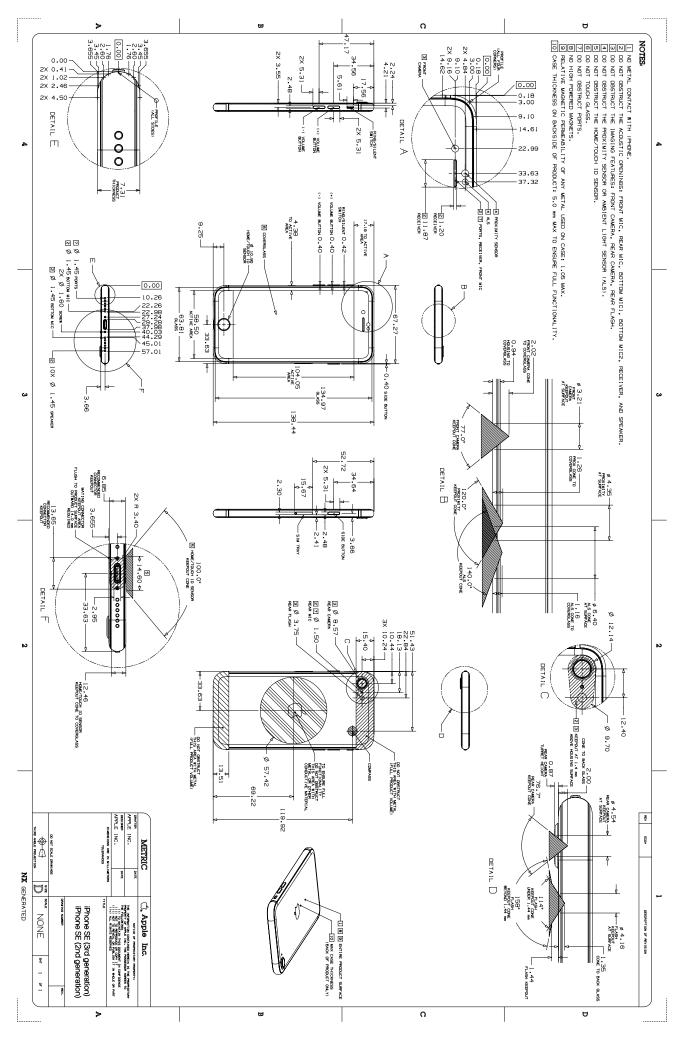


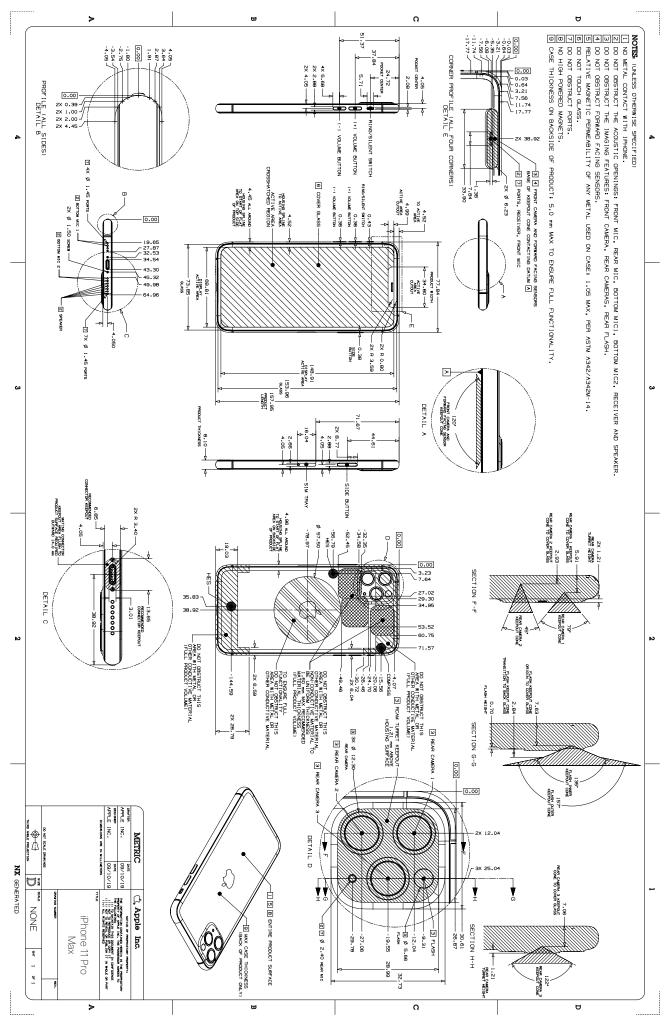


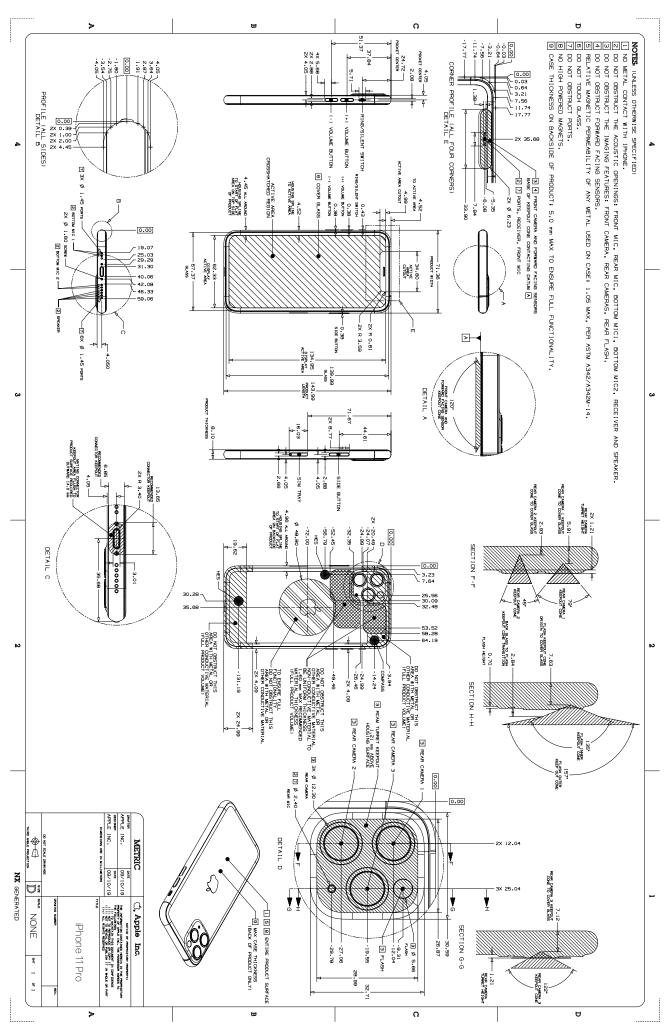
45.28 iPhone 12 mini 2 of 2

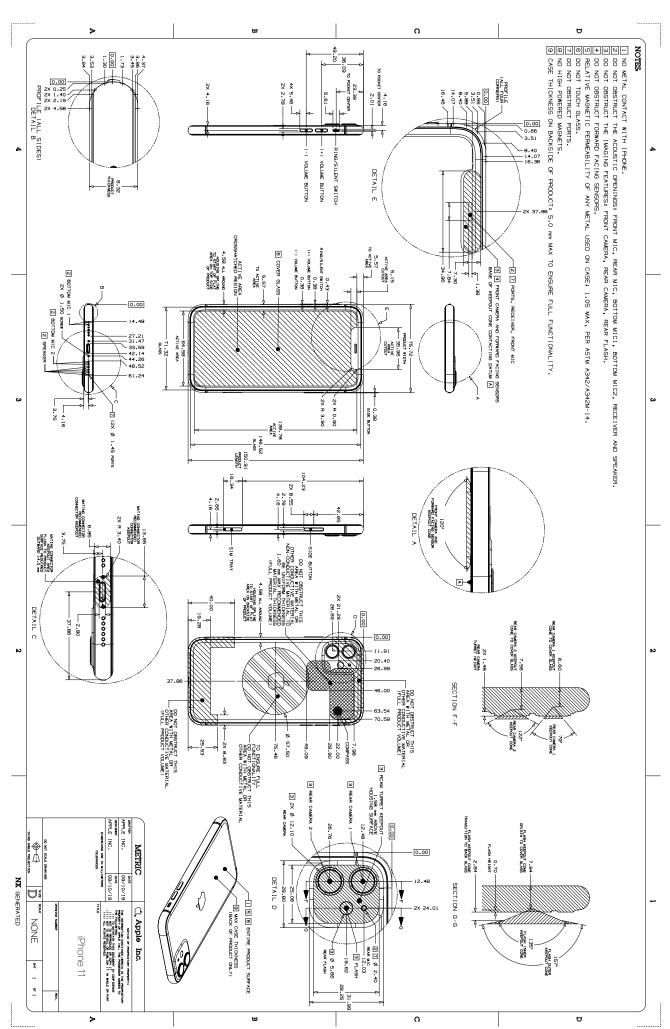


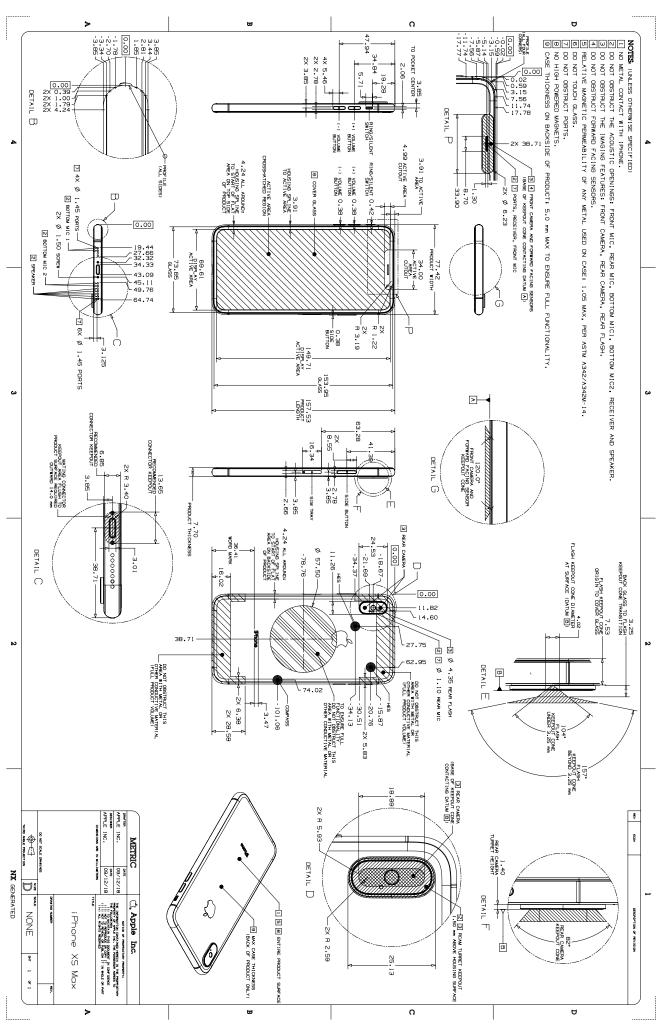
45.29 iPhone SE (3rd generation) and iPhone SE (2nd generation)



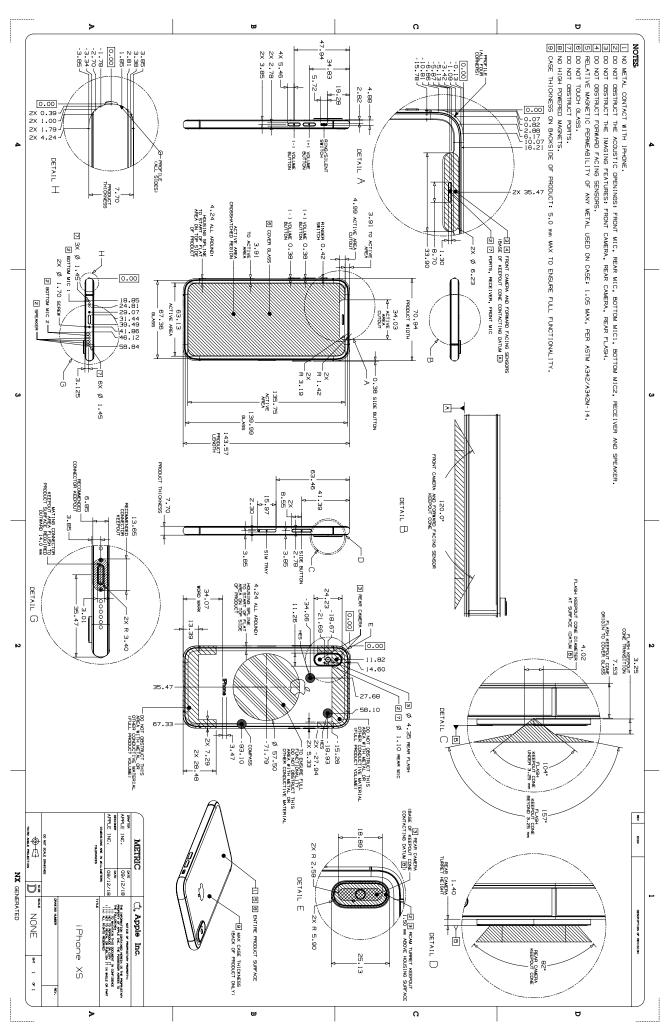


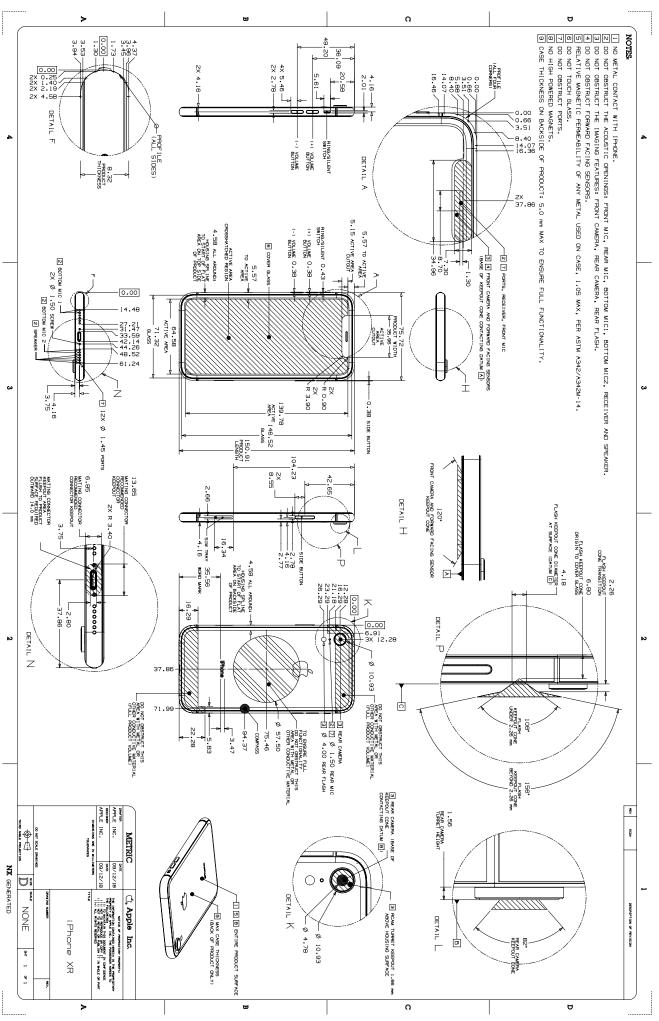


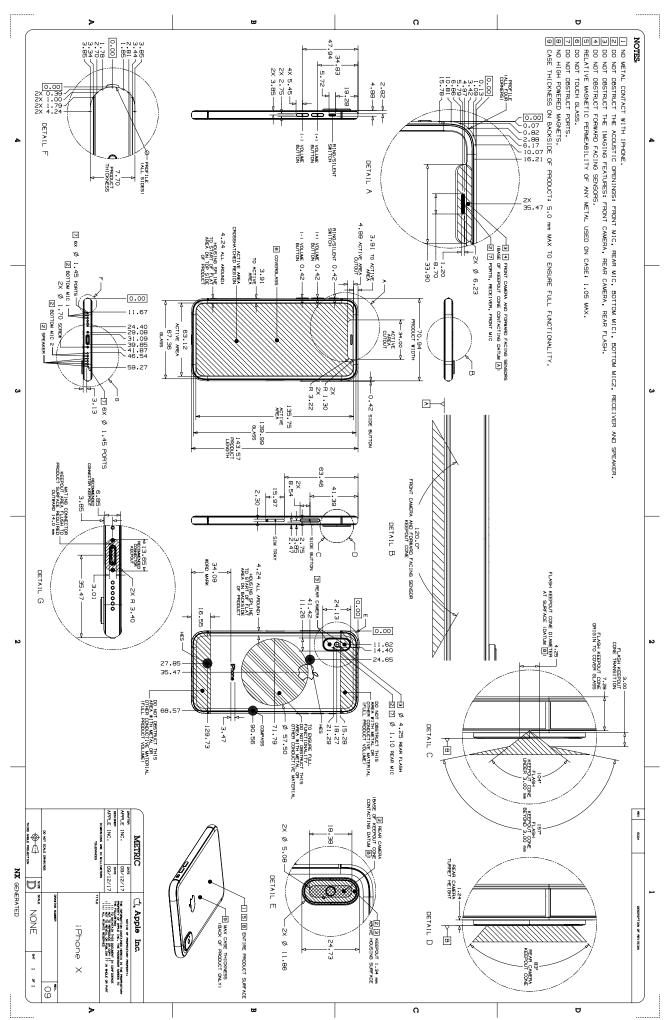




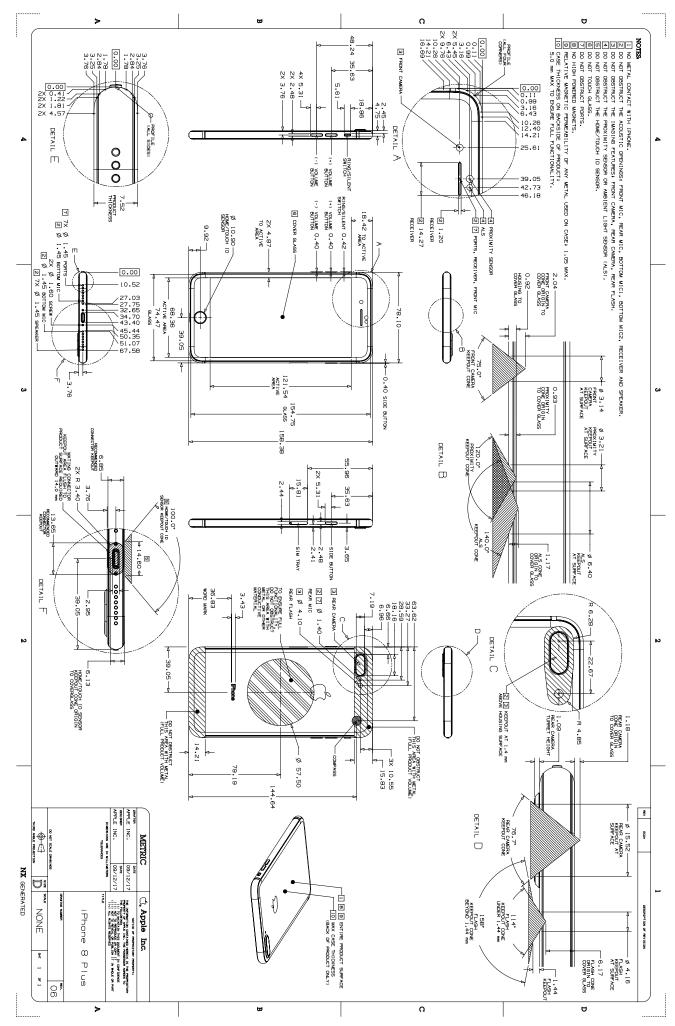
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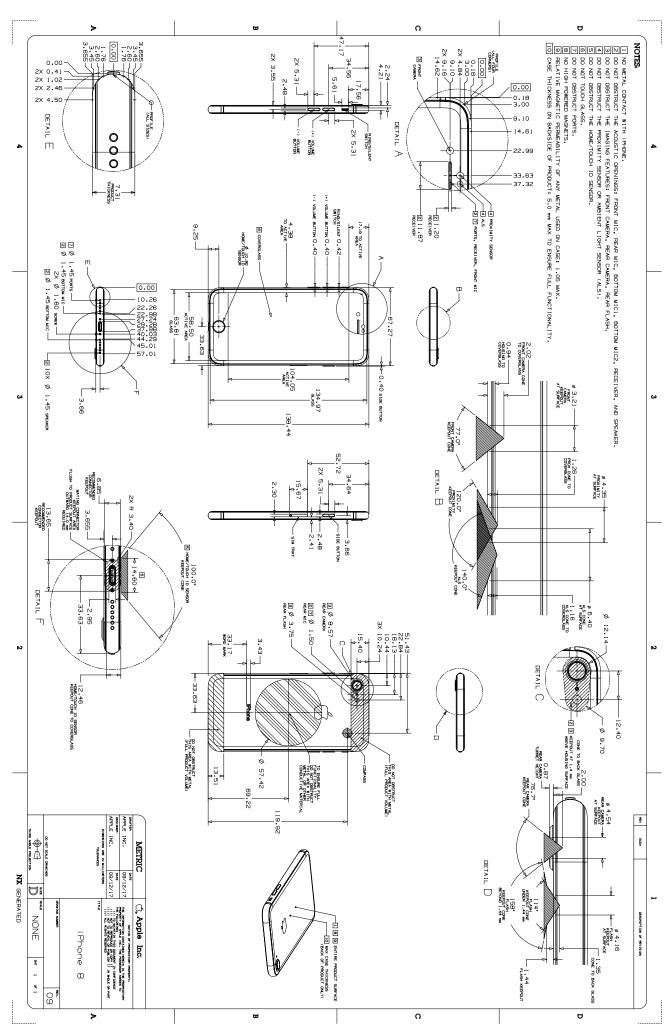


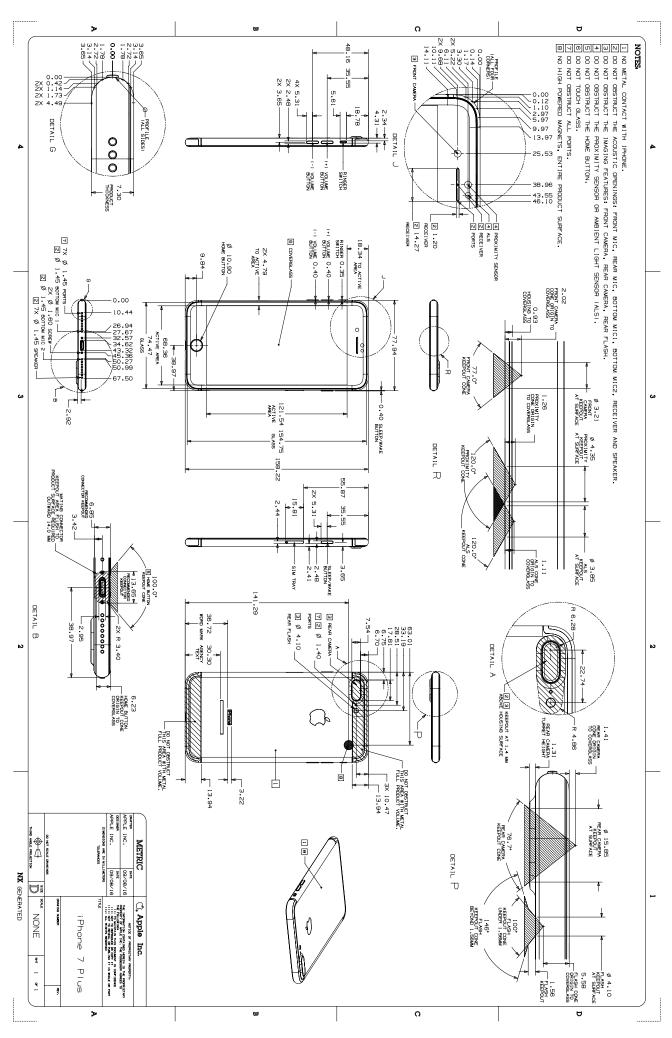


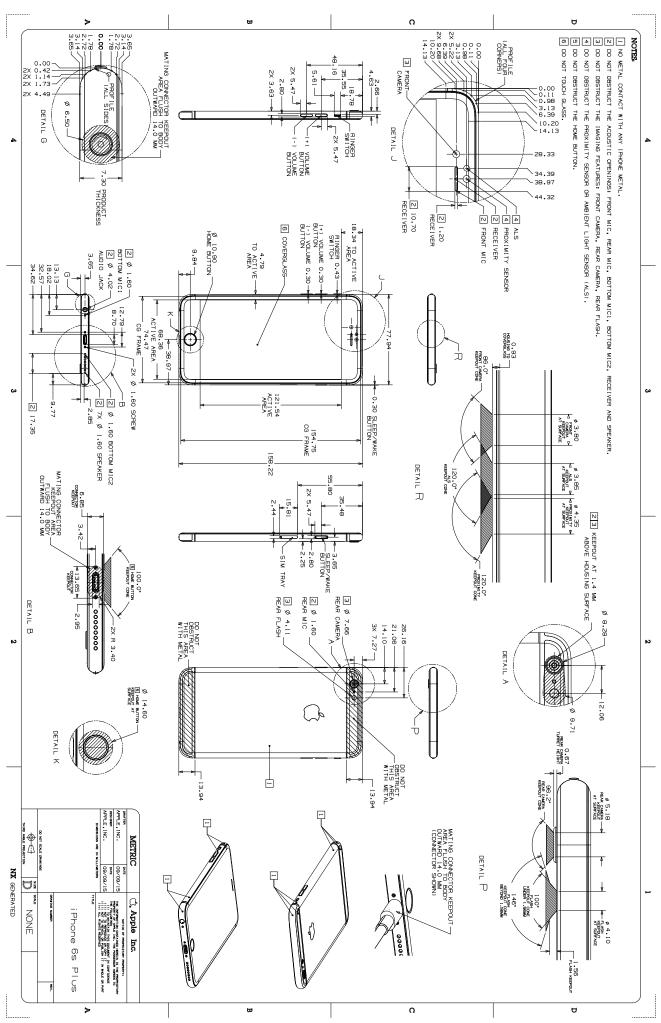


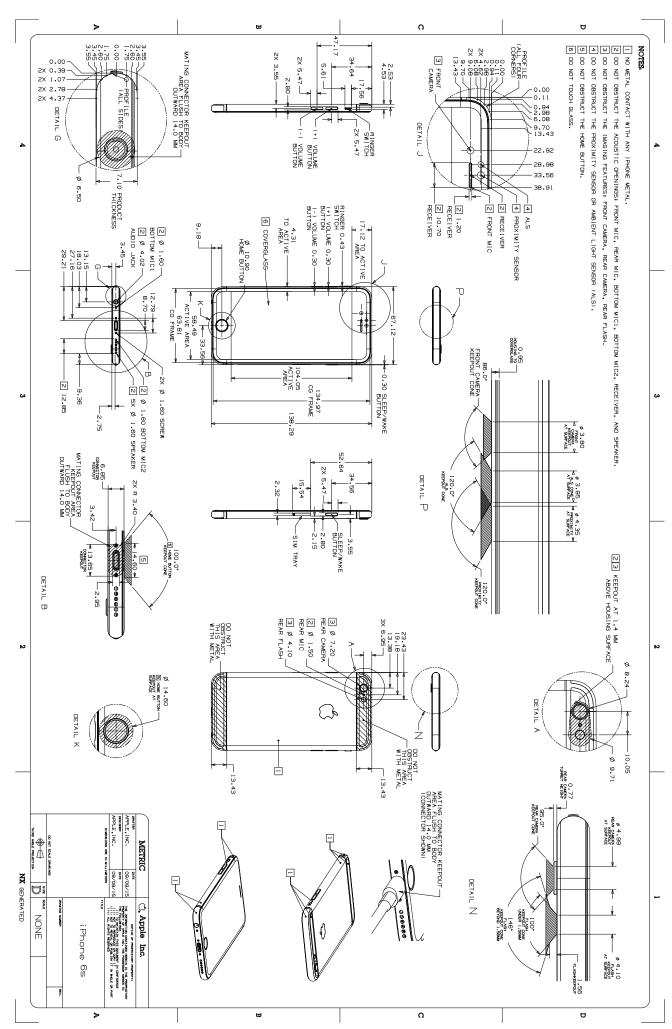
45.37 iPhone 8 Plus



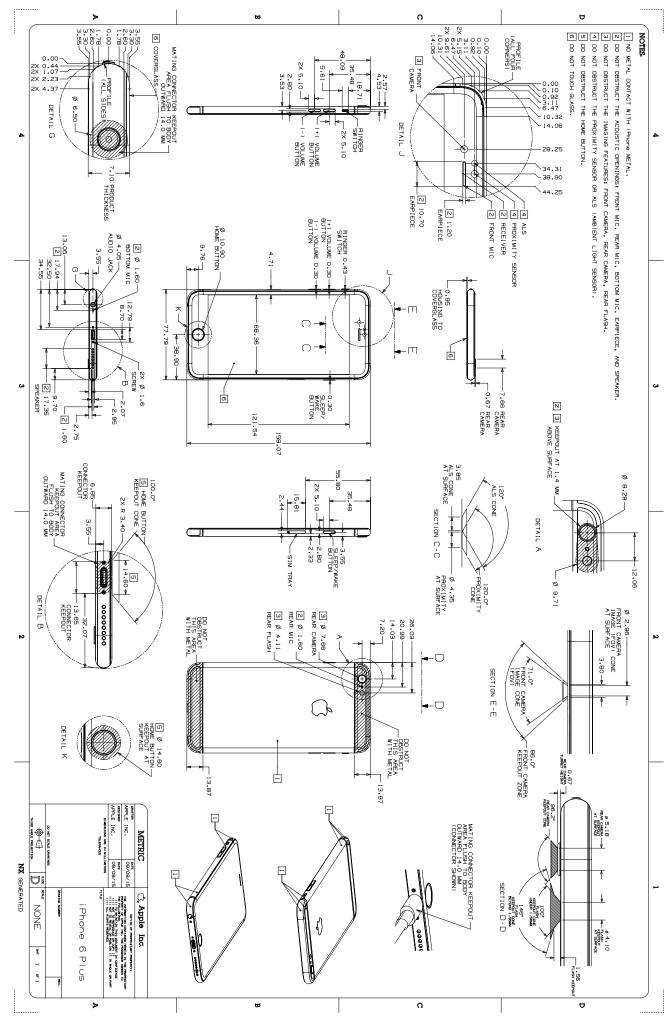


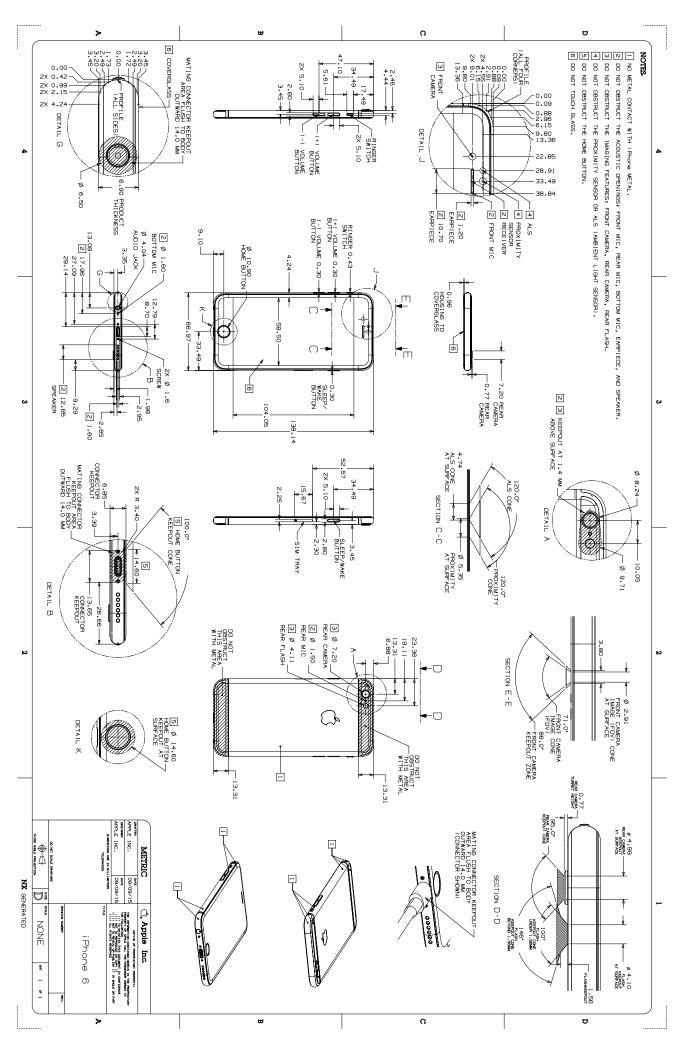




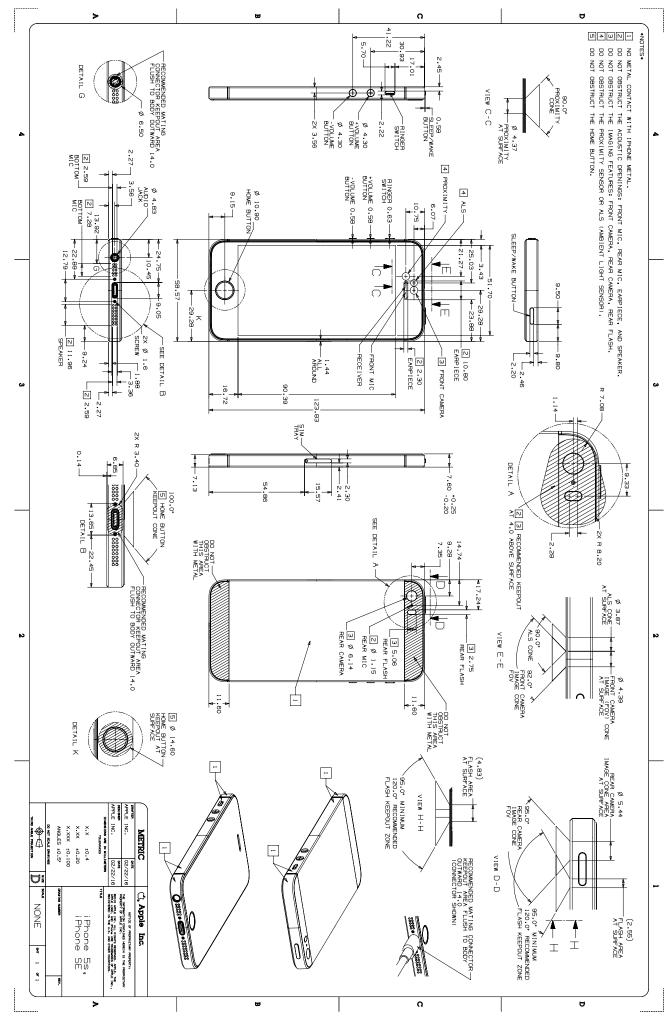


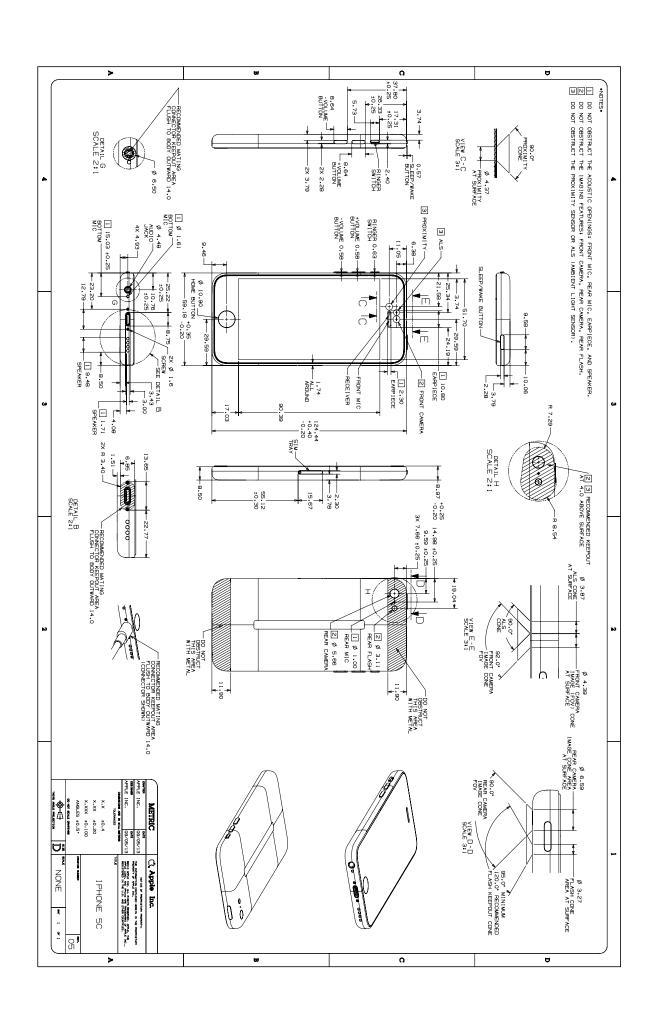
45.43 iPhone 6 Plus

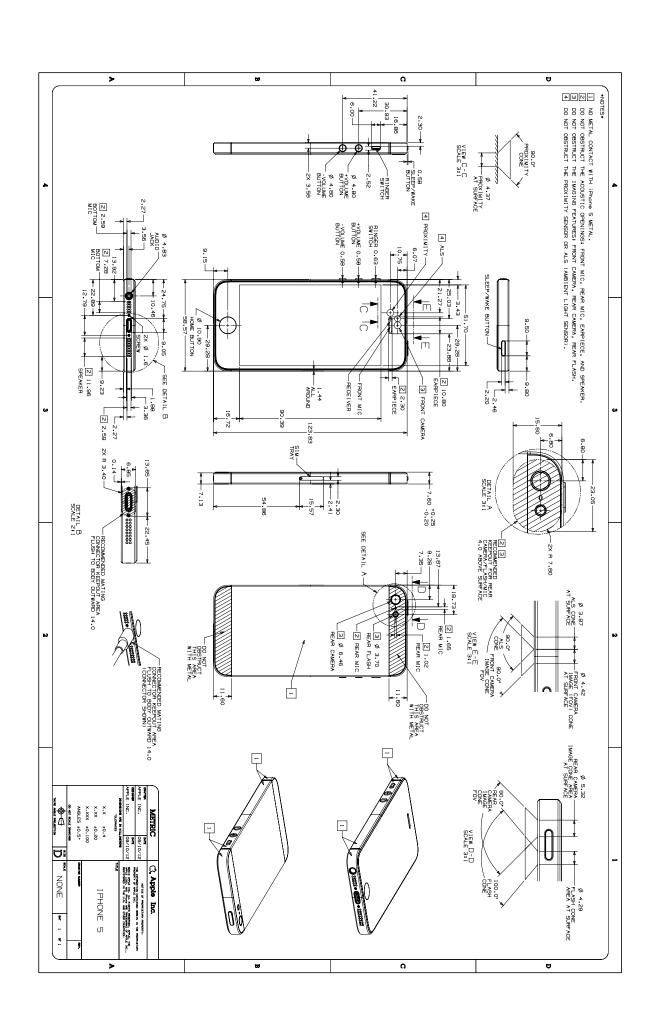




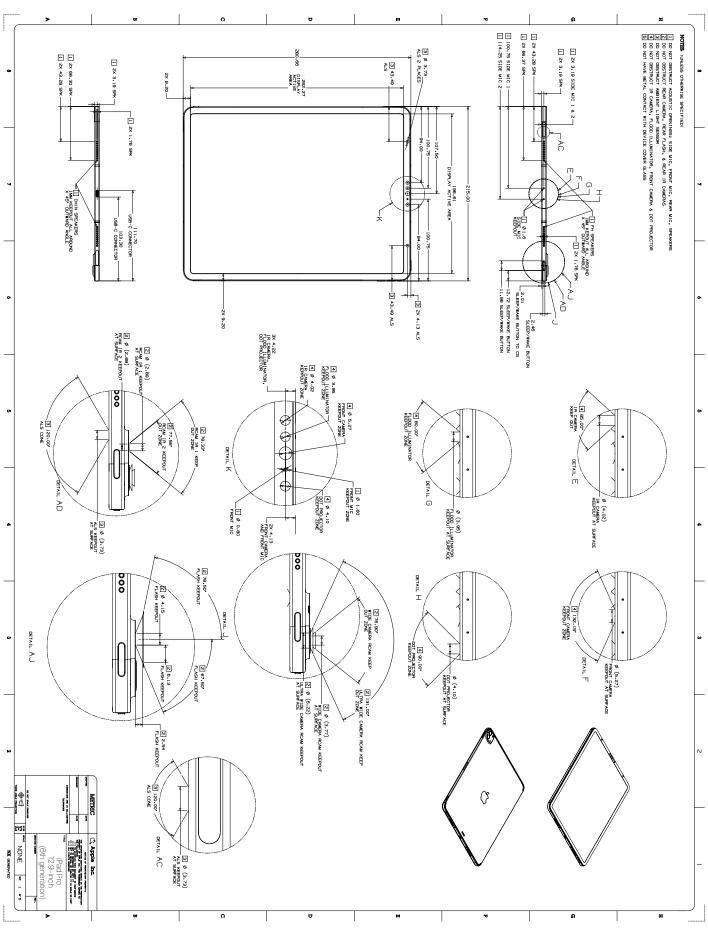
45.45 iPhone 5s and iPhone SE

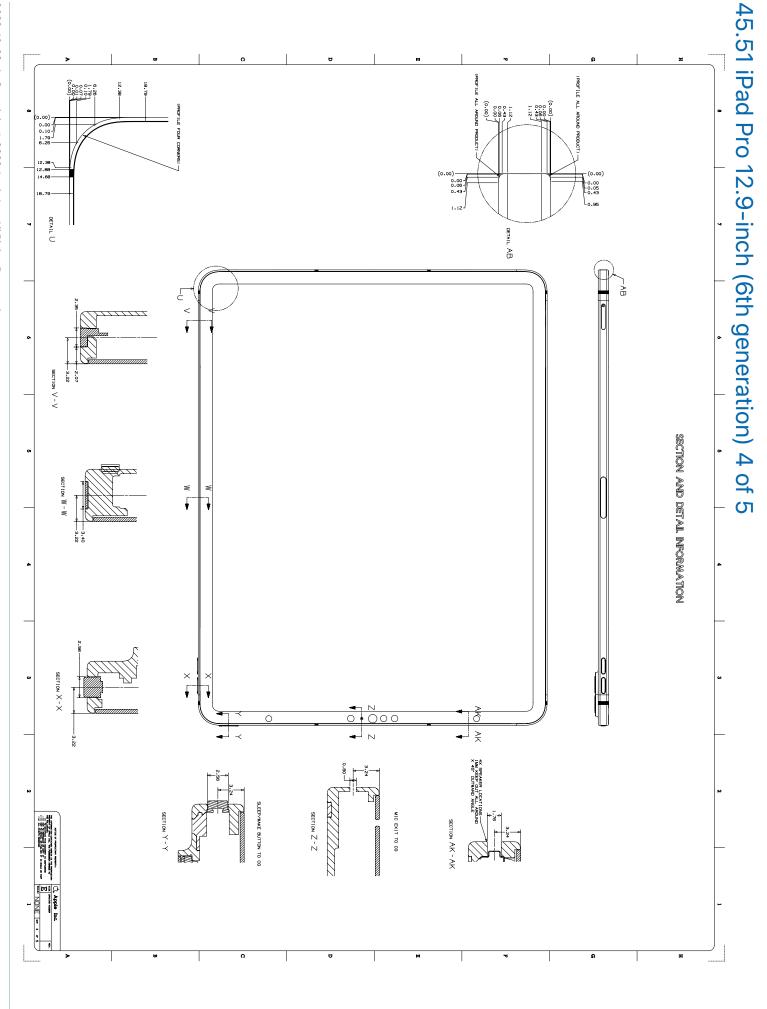


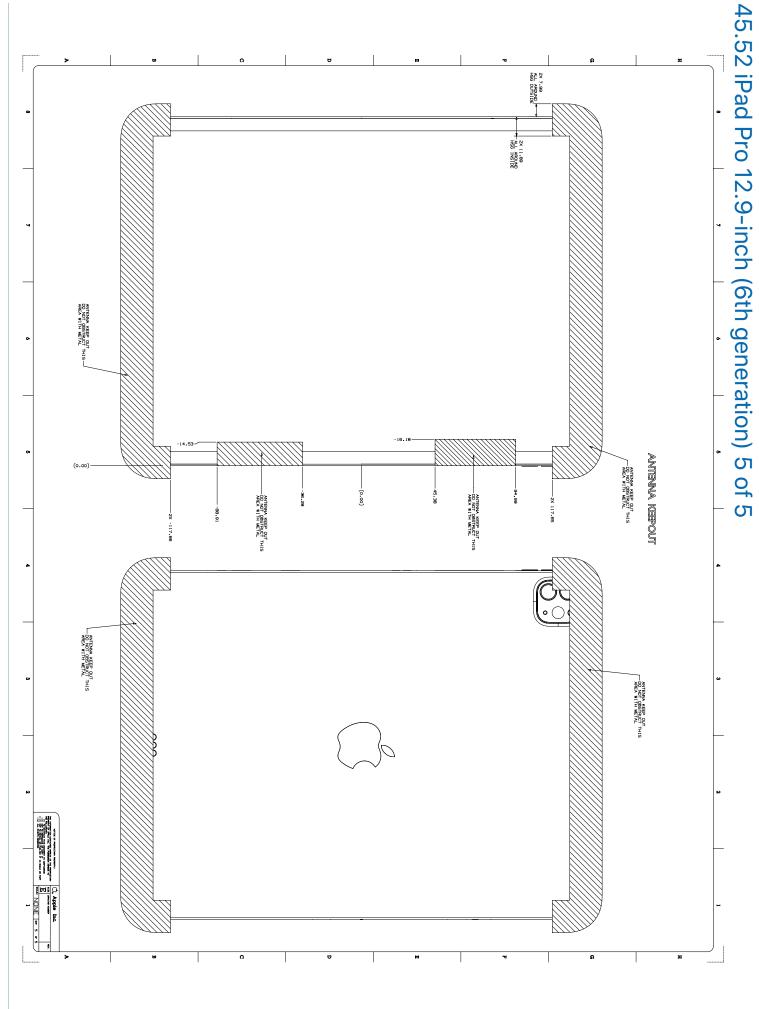




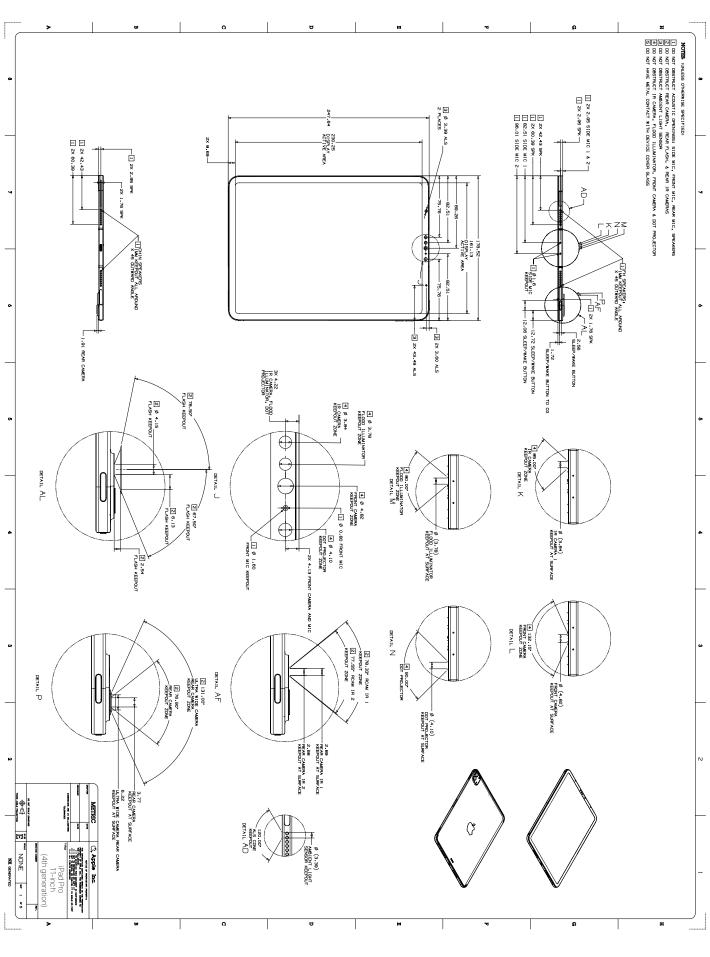
45.48 iPad Pro 12.9-inch (6th generation) 1 of 5



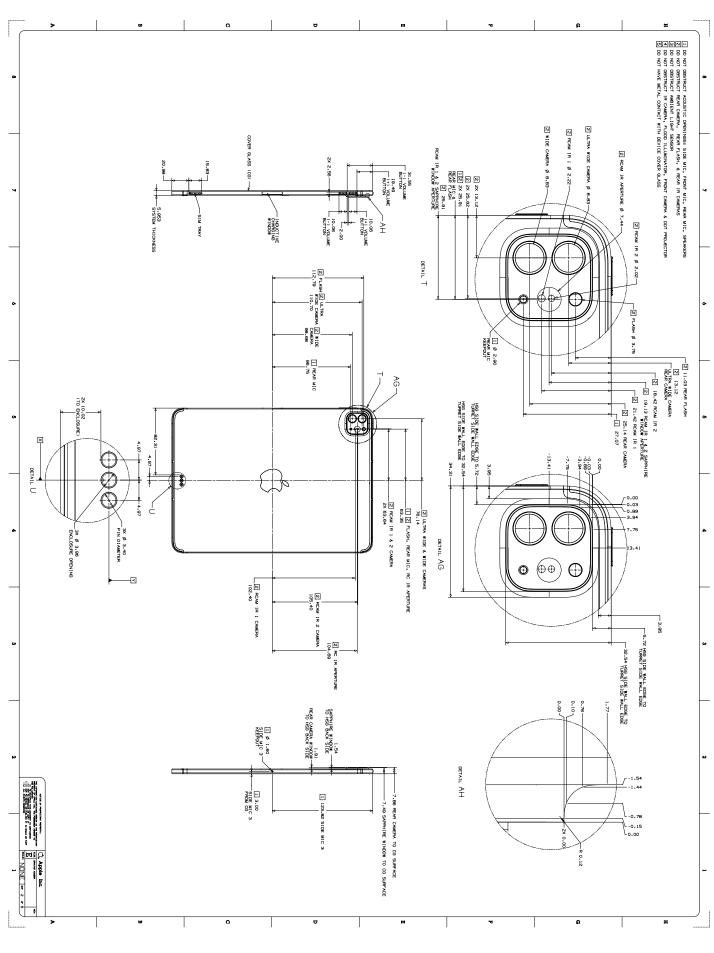


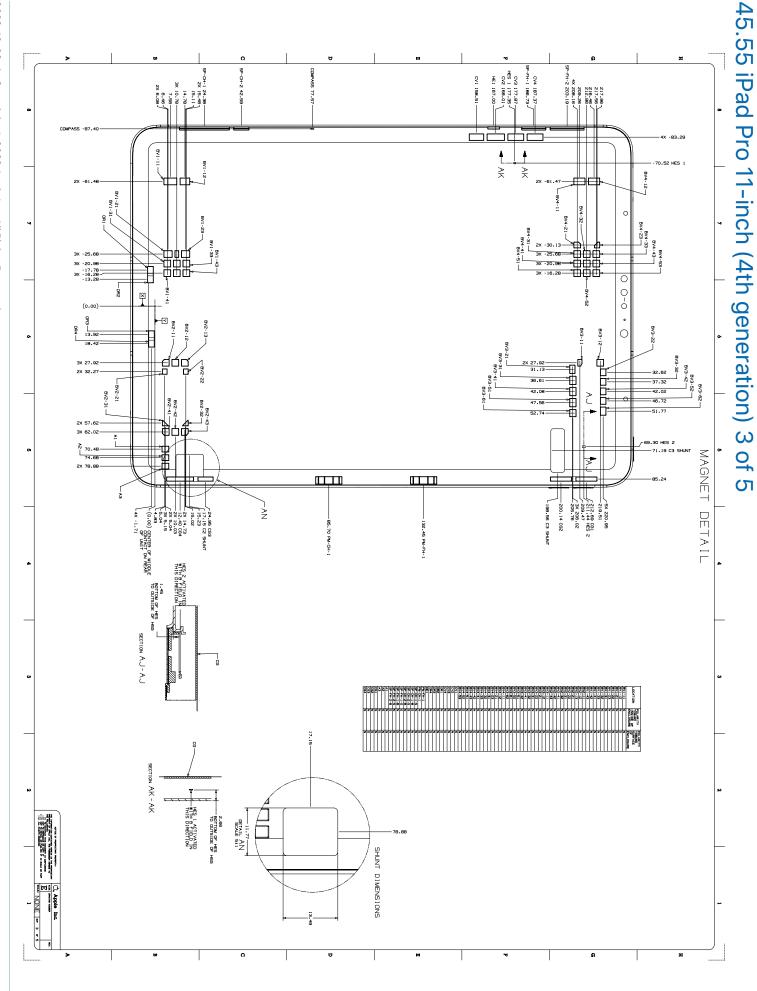


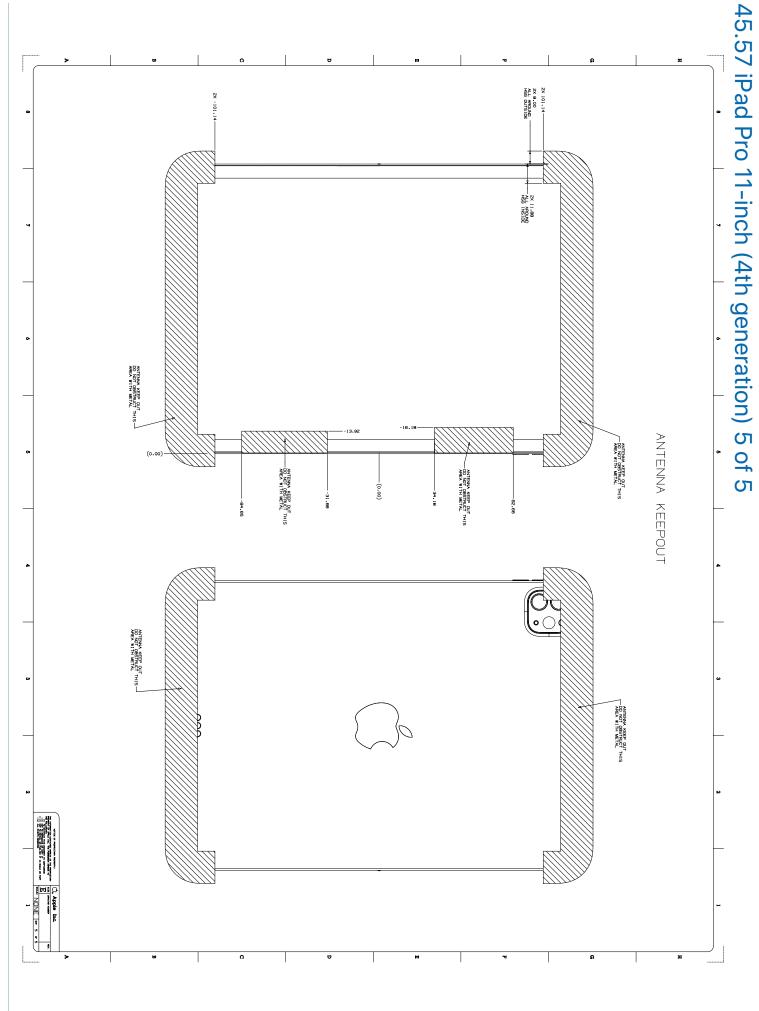
45.53 iPad Pro 11-inch (4th generation) 1 of 5 NOTES (UNLESS OTHERWISE SPECIFIED)



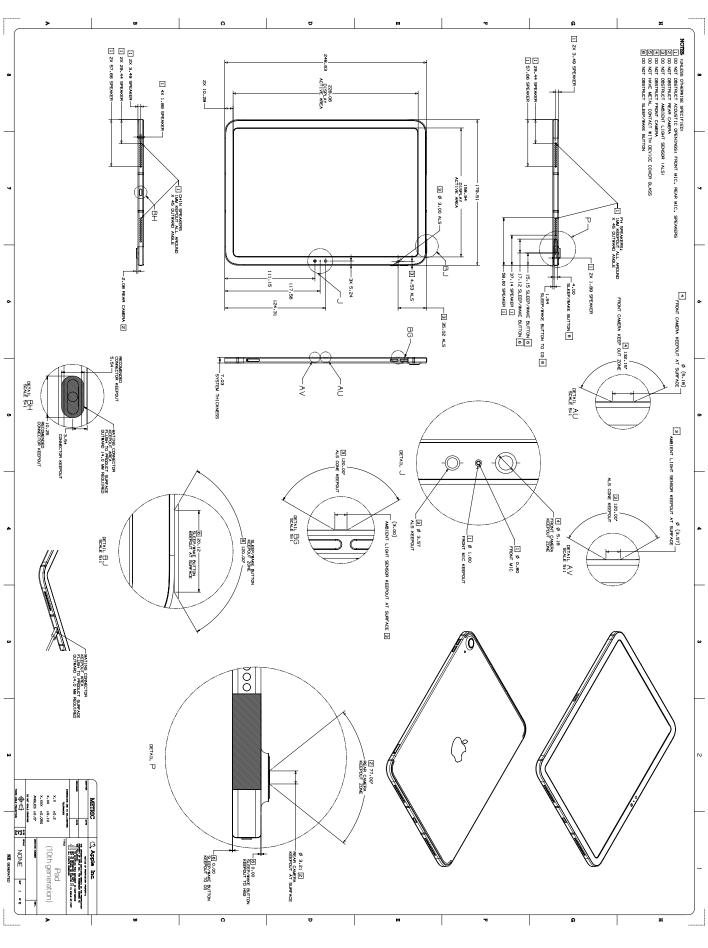
45.54 iPad Pro 11-inch (4th generation) 2 of 5

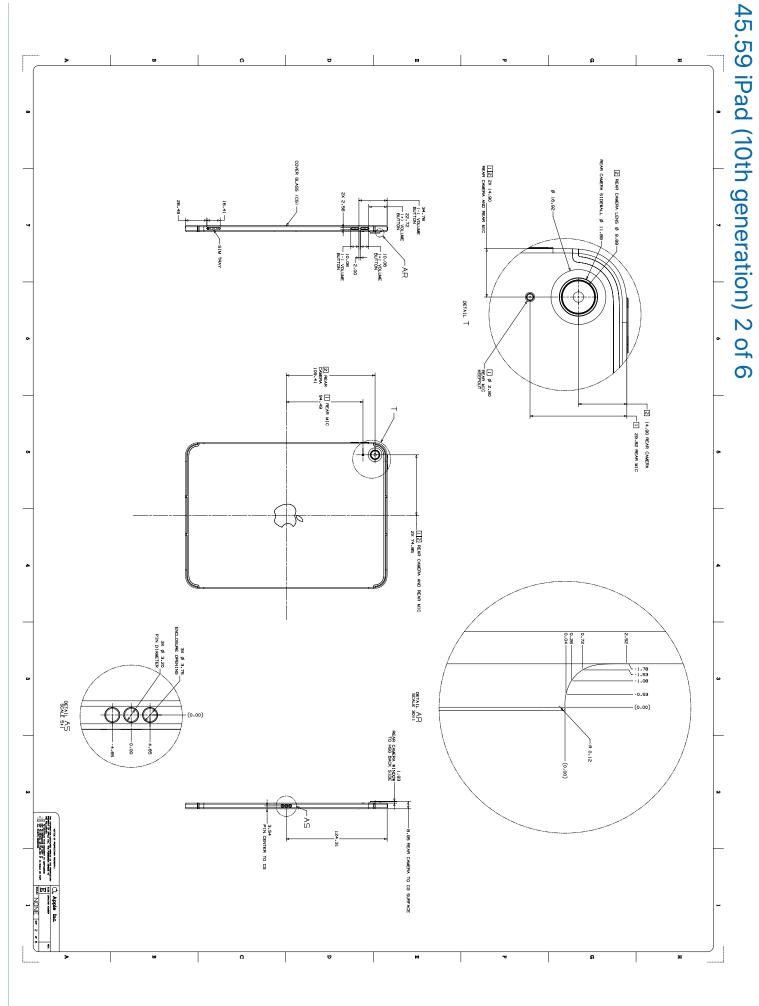


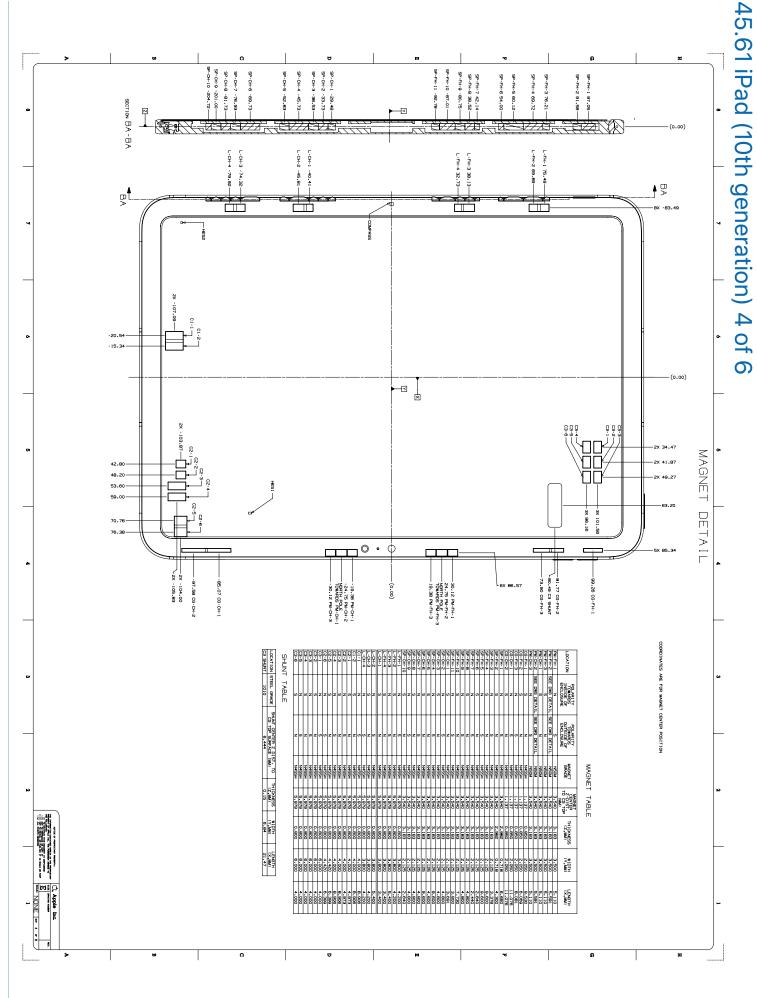


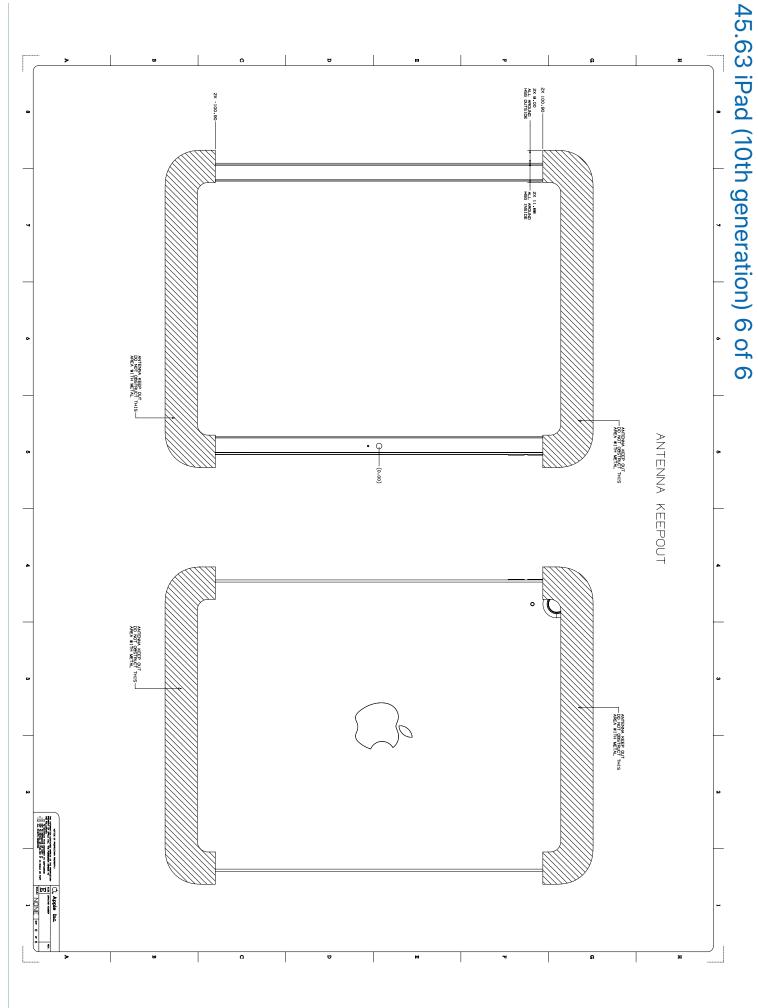


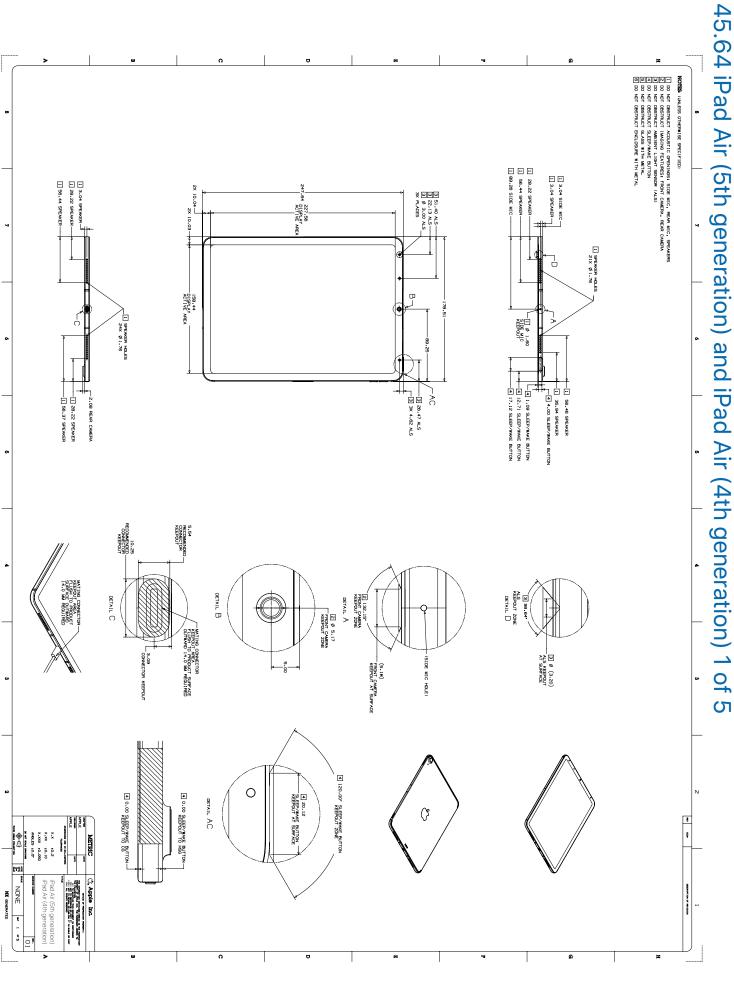
45.58 iPad (10th generation) 1 of 6



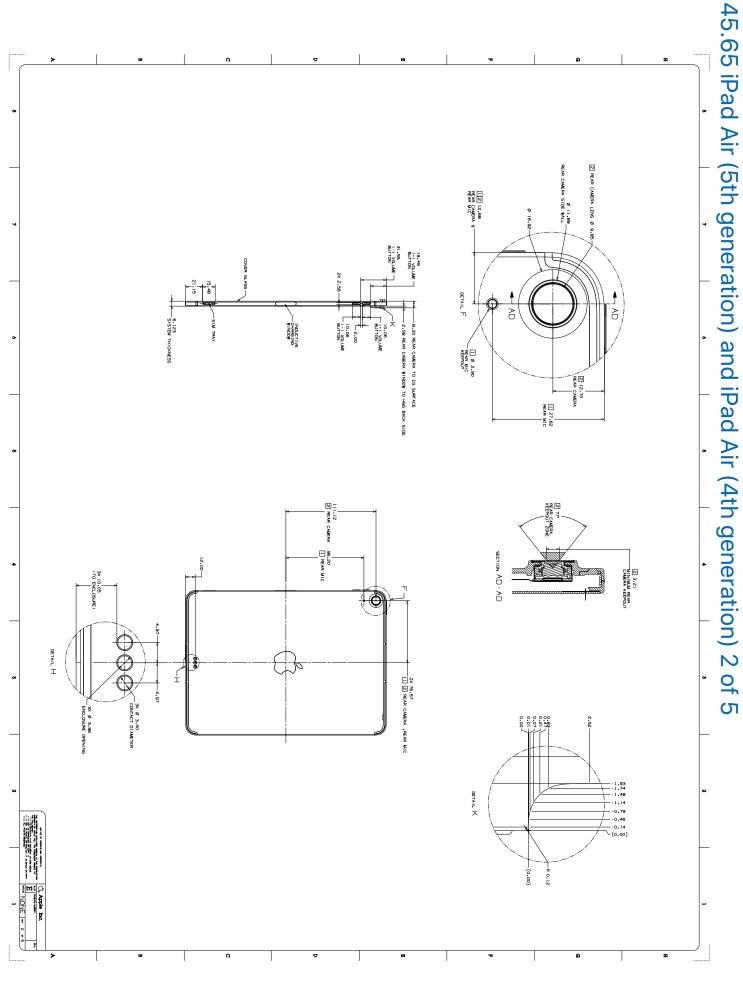


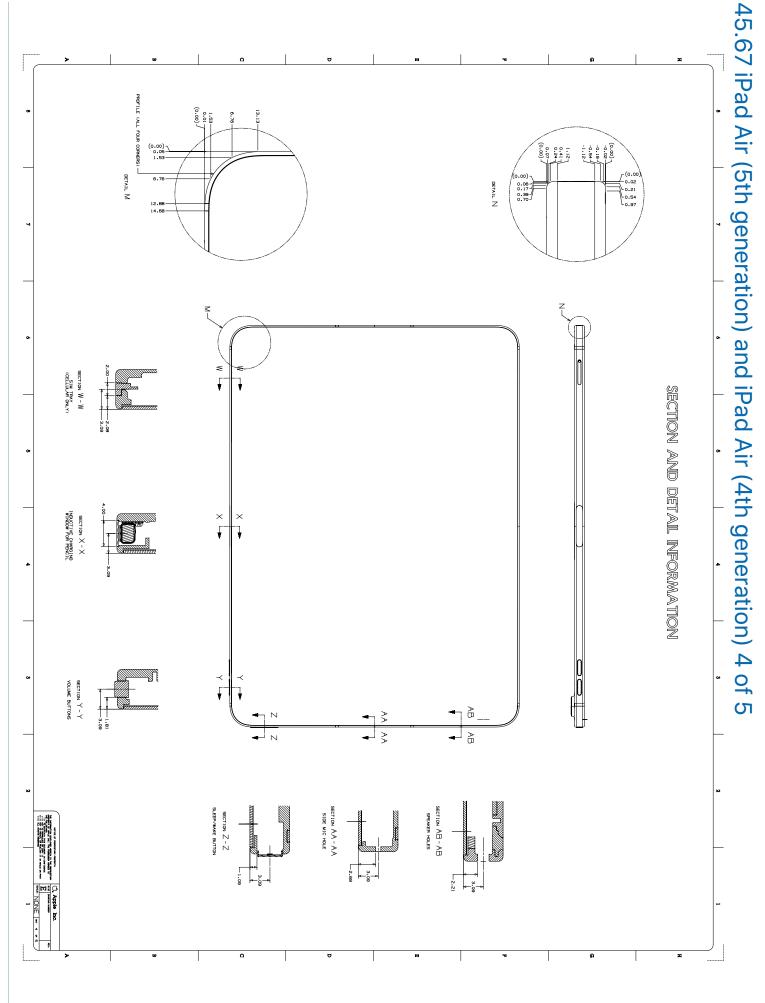


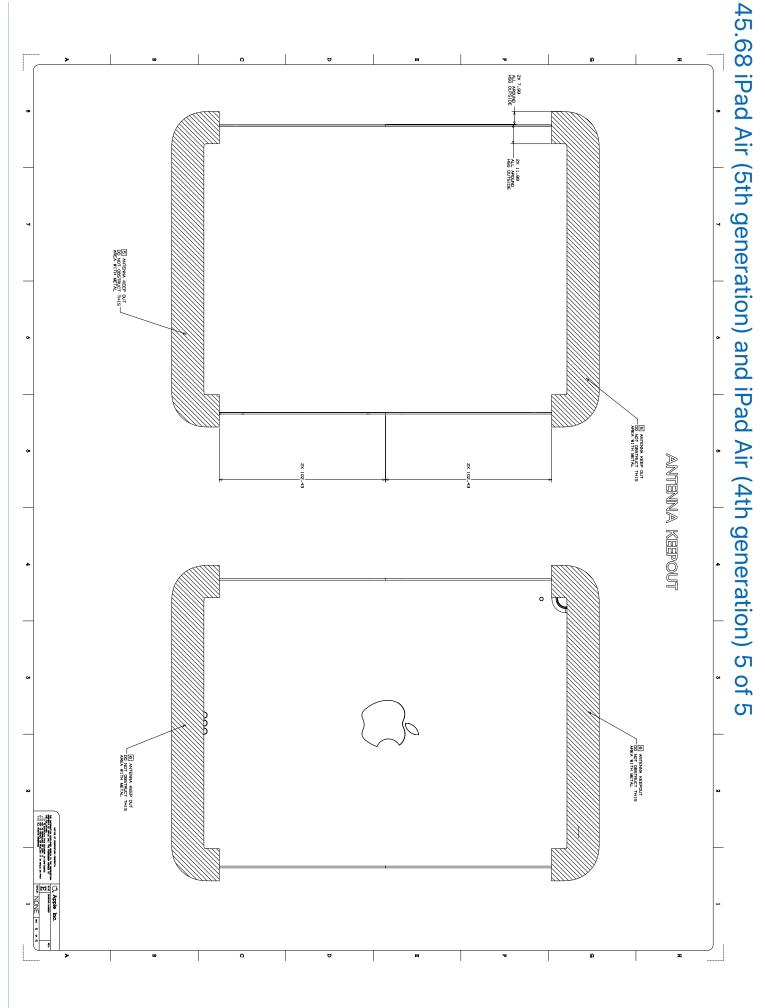




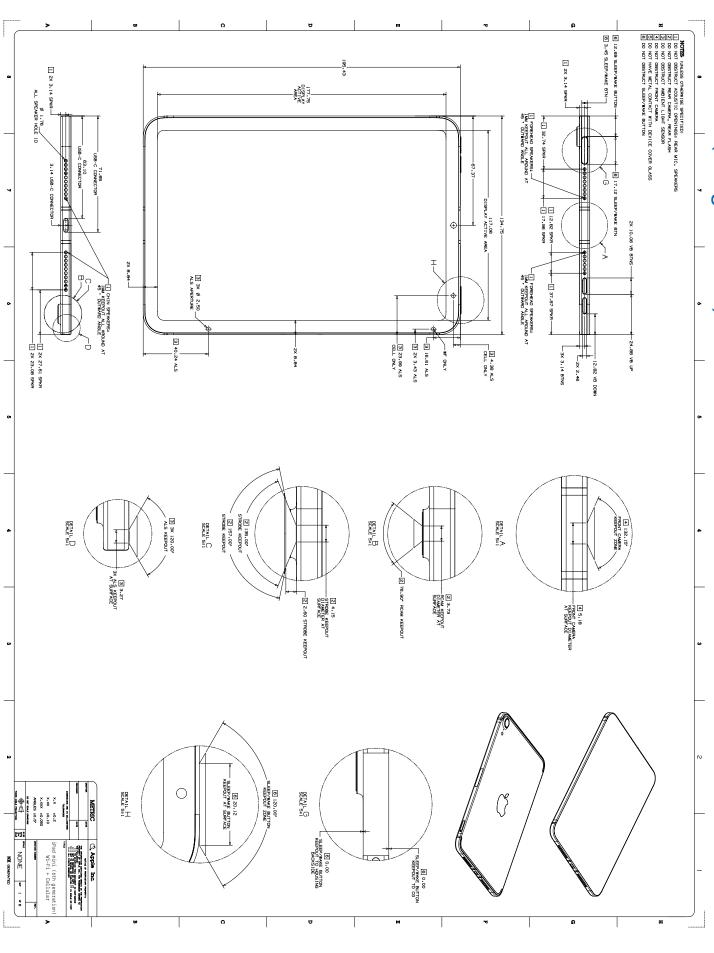
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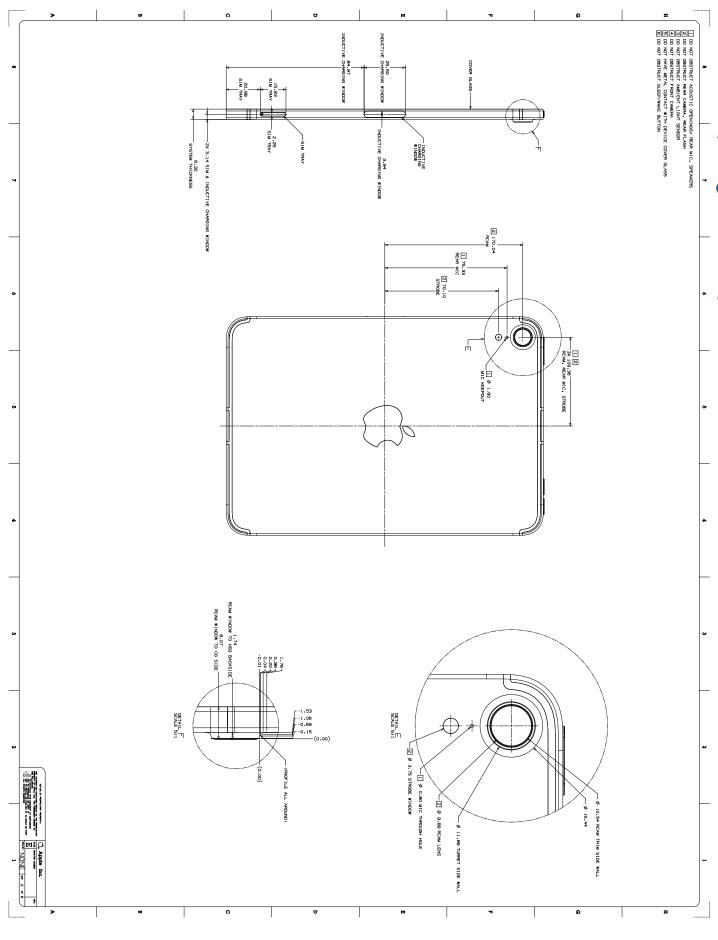






45.69 iPad mini (6th generation) 1 of 6

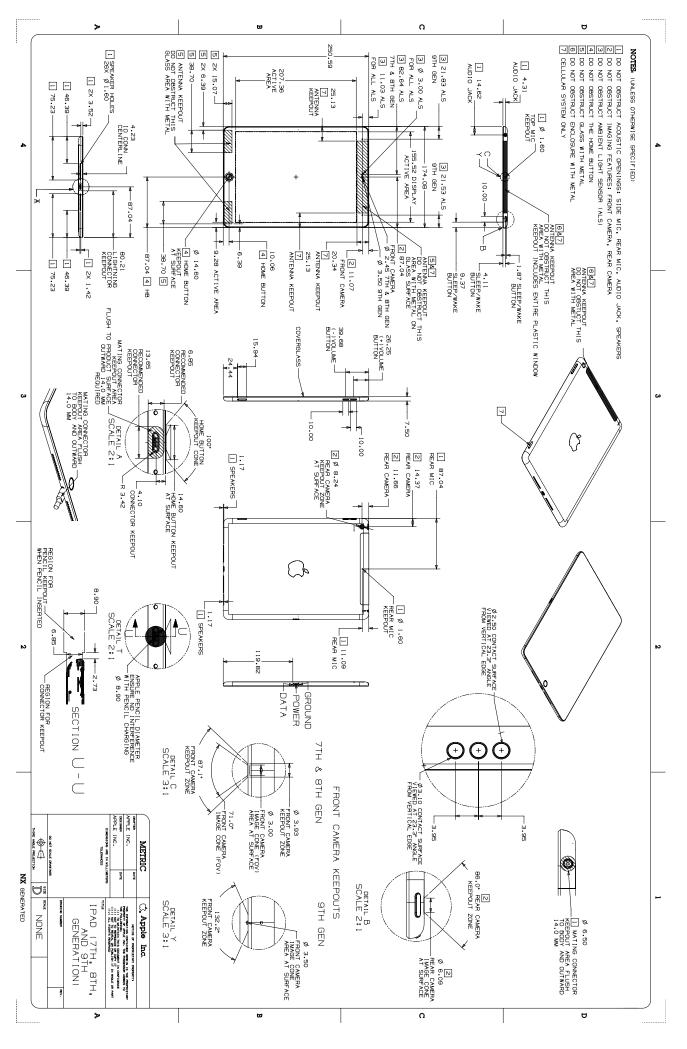




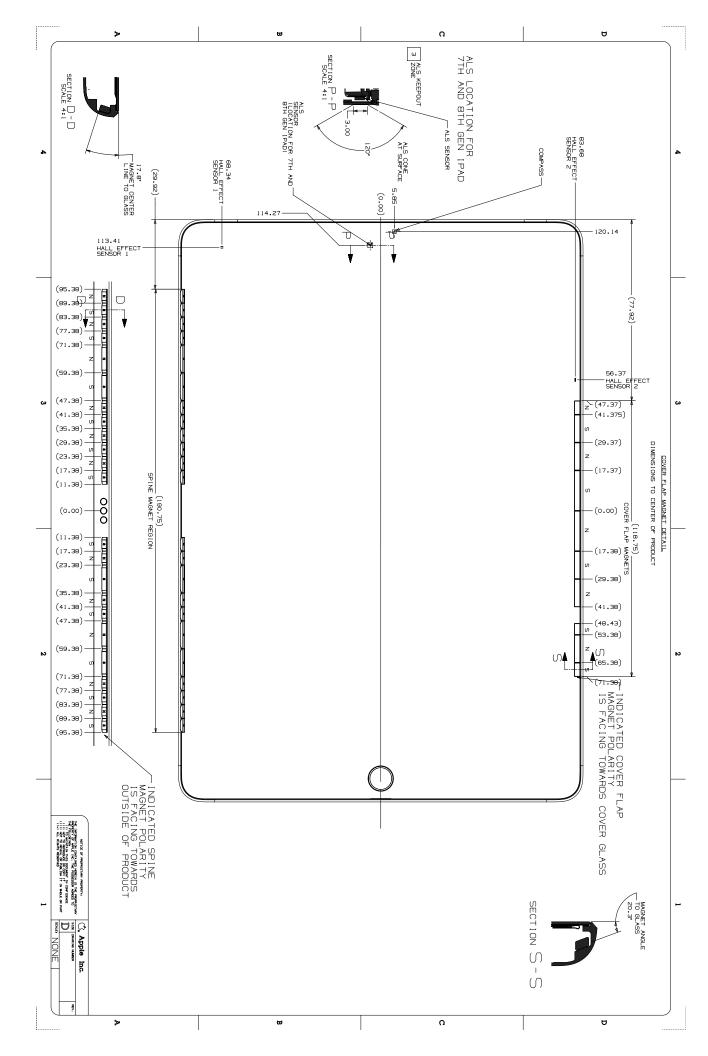
45.72 iPad mini (6th generation) 4 of 6

MAGNET, HES, COMPASS DETAIL -PT 2

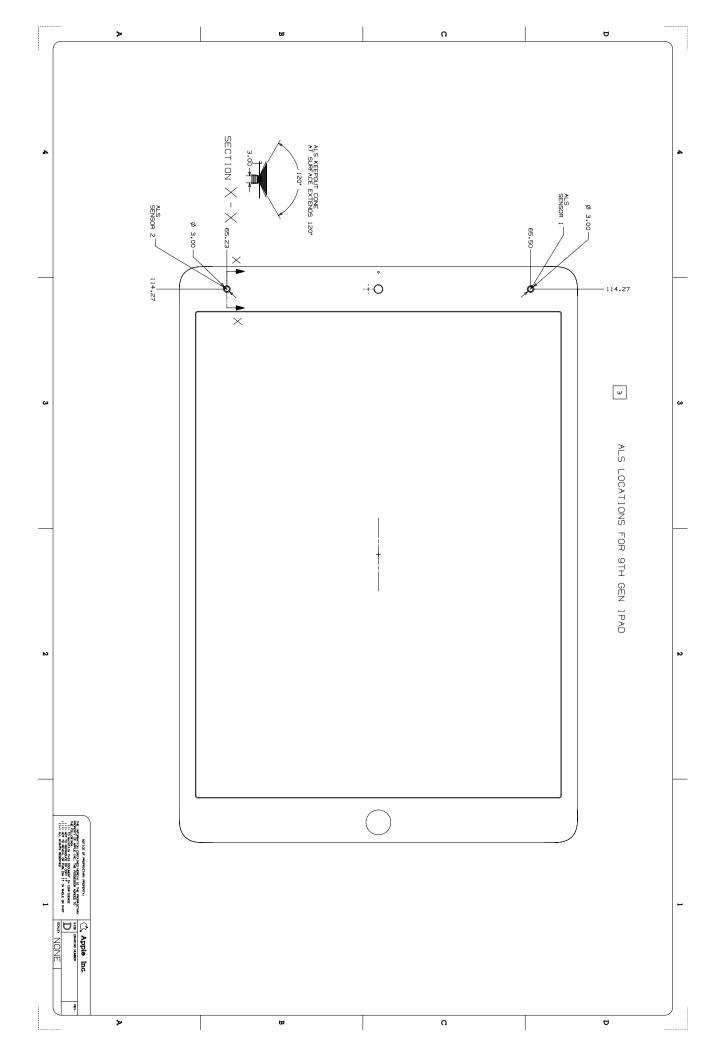
45.75 iPad (9th generation), iPad (8th generation) and iPad (7th generation) 1 of 4



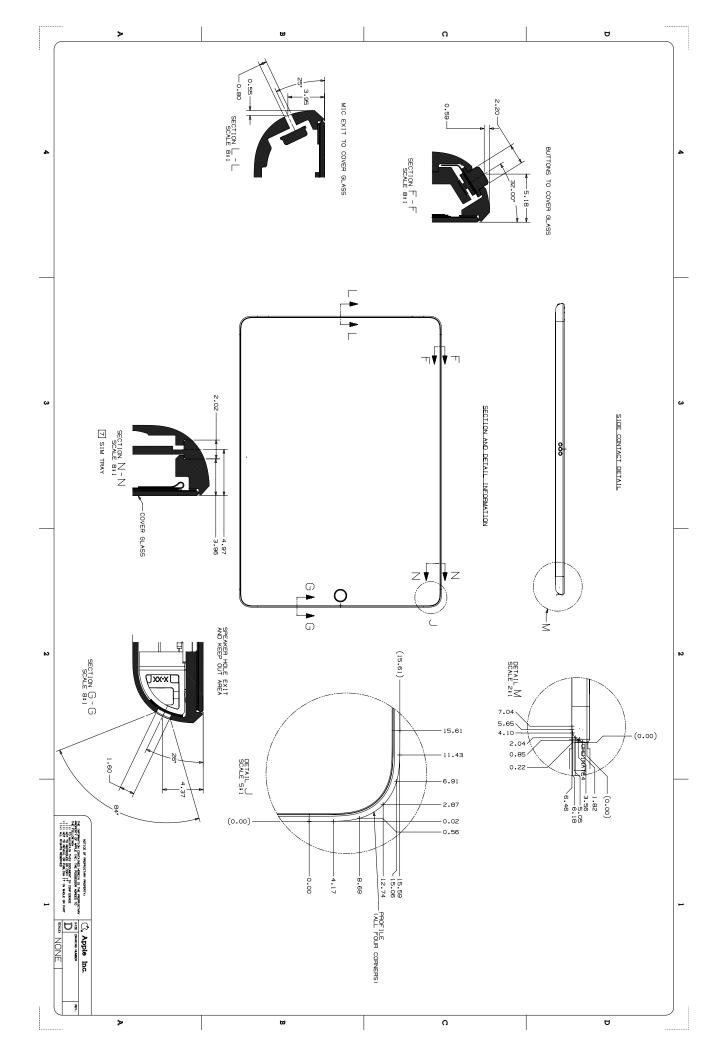
45.76 iPad (9th generation), iPad (8th generation) and iPad (7th generation) 2 of 4



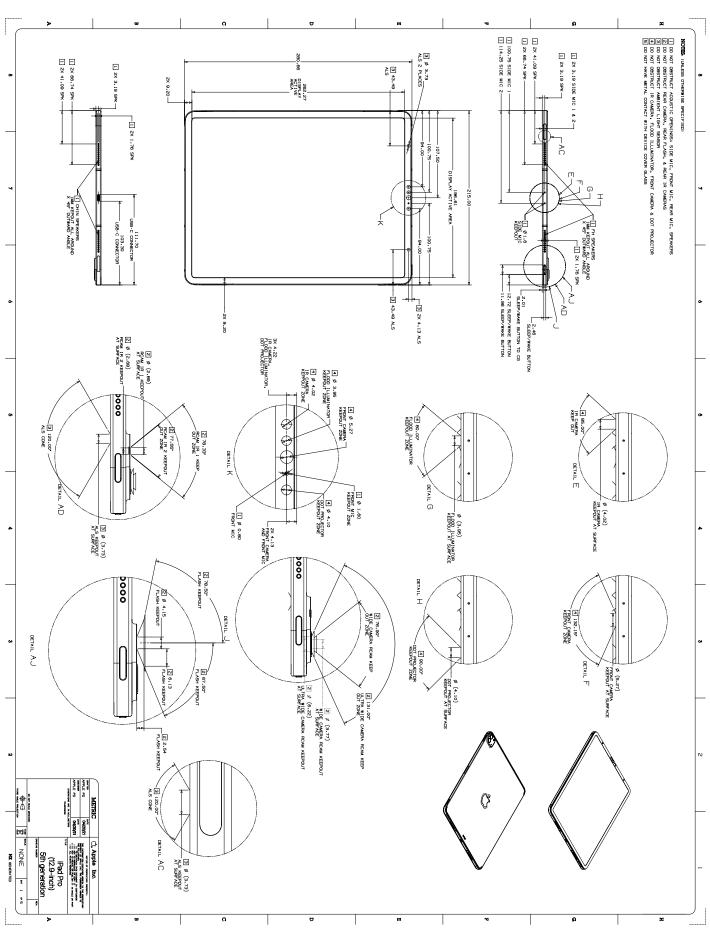
45.77 iPad (9th generation), iPad (8th generation) and iPad (7th generation) 3 of 4

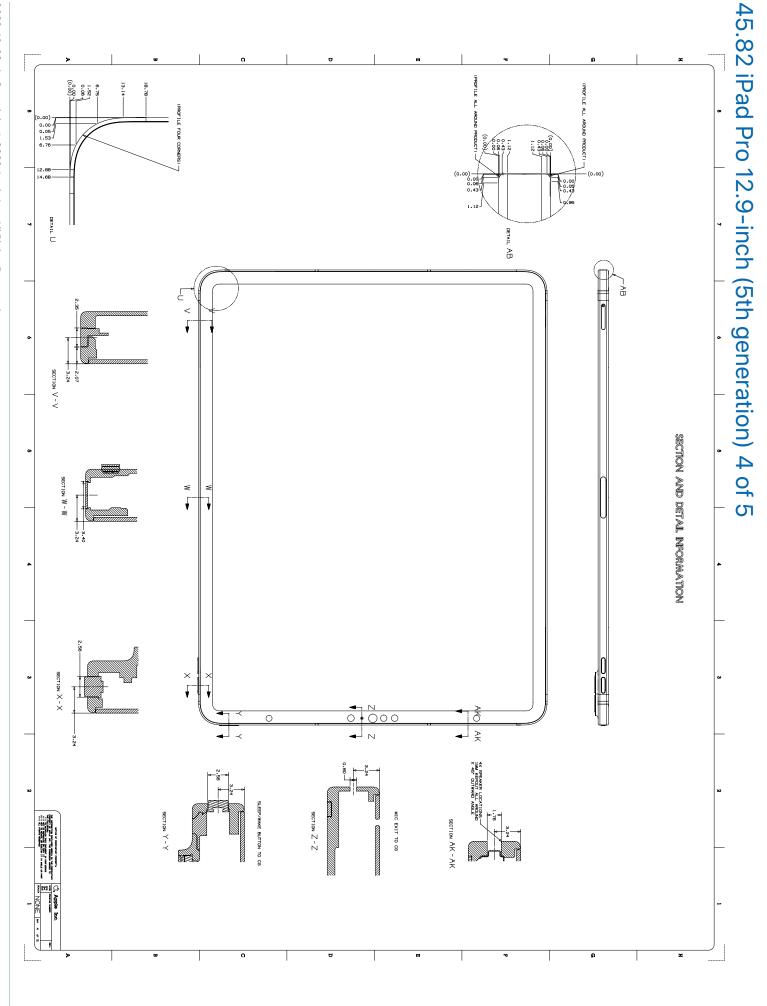


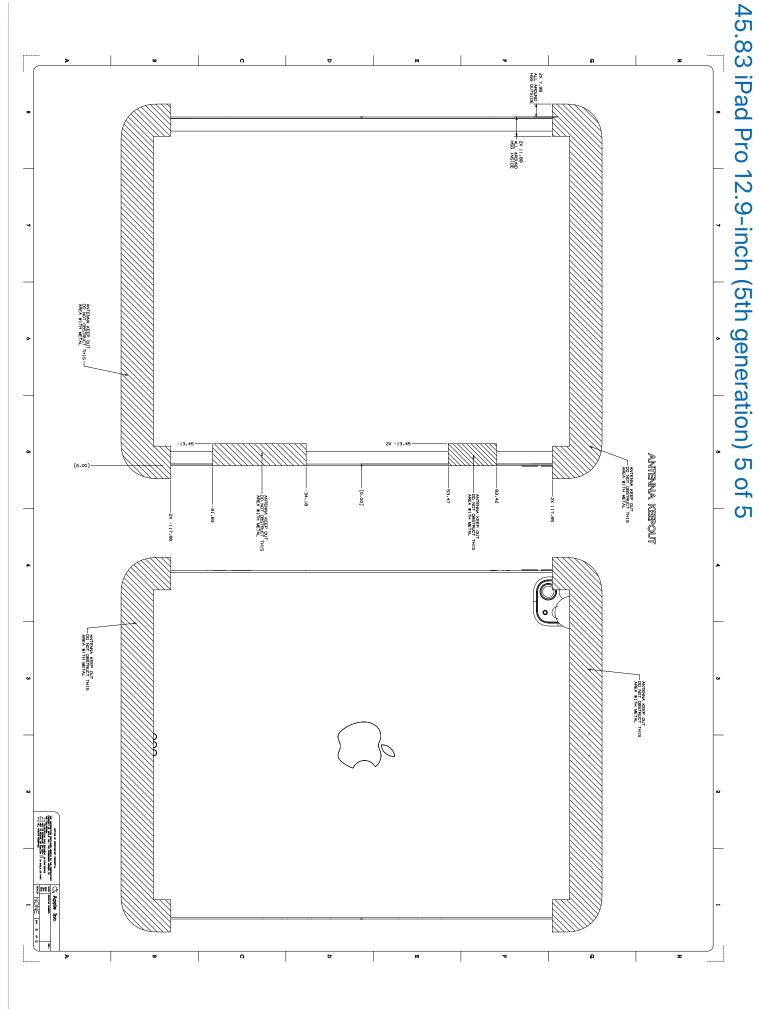
45.78 iPad (9th generation), iPad (8th generation) and iPad (7th generation) 4 of 4



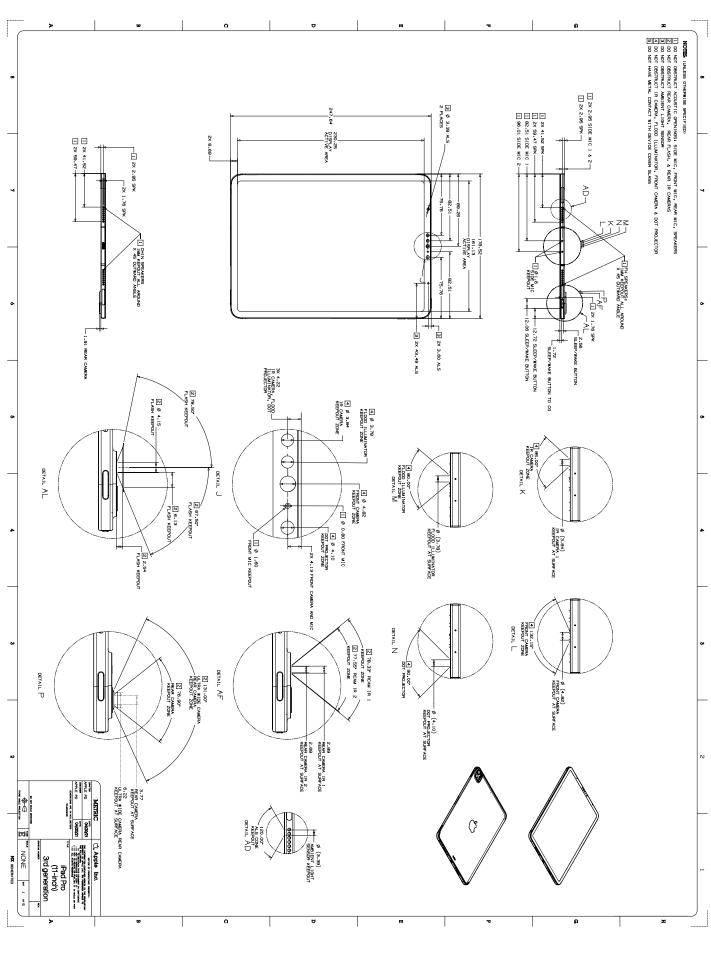
45.79 iPad Pro 12.9-inch (5th generation) 1 of 5



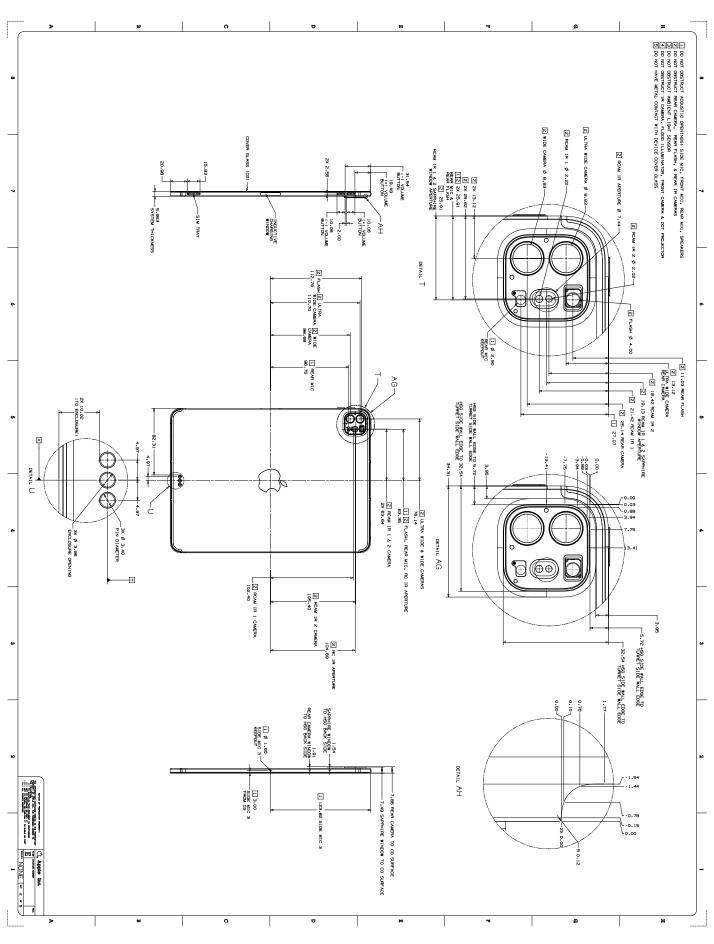


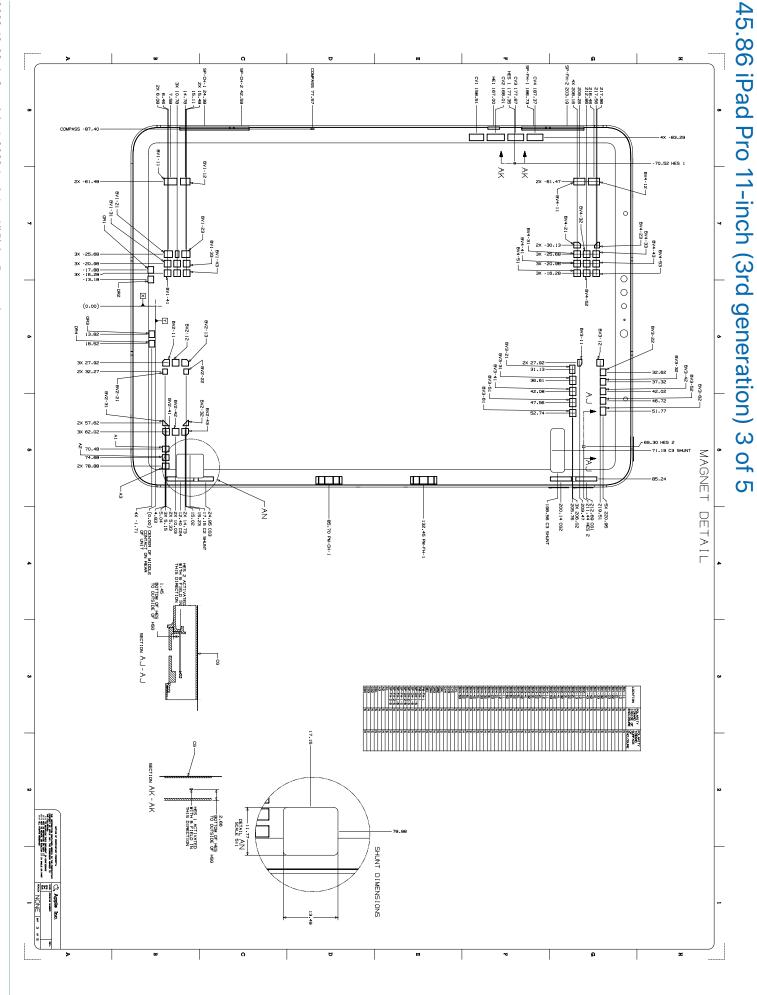


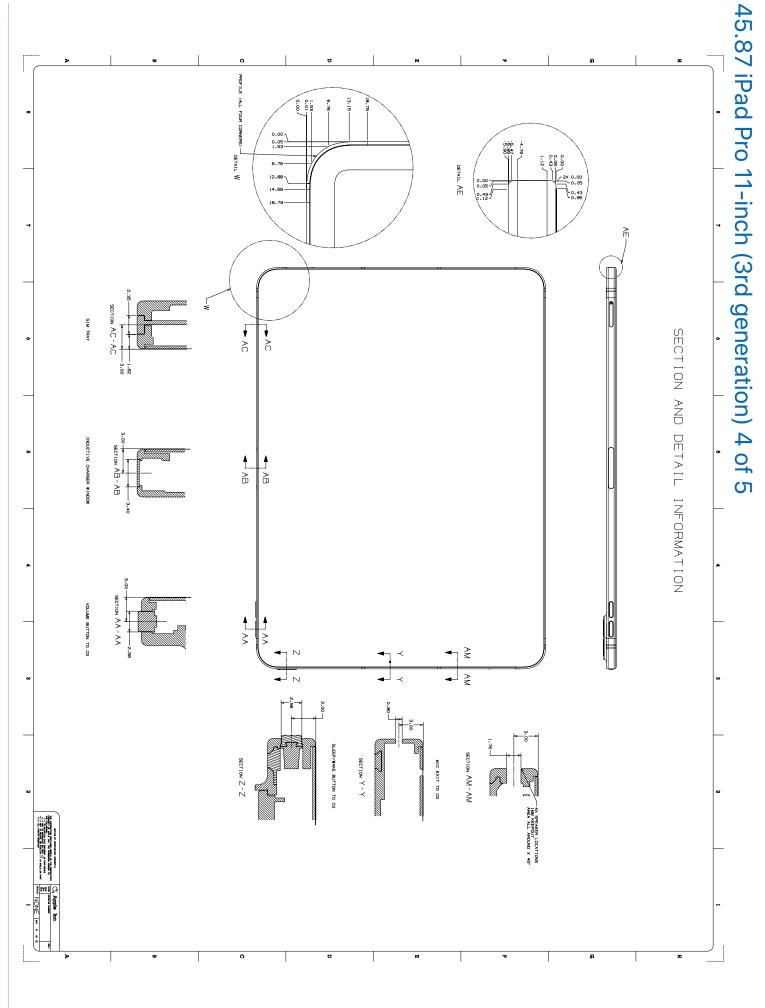
45.84 iPad Pro 11-inch (3rd generation) 1 of 5

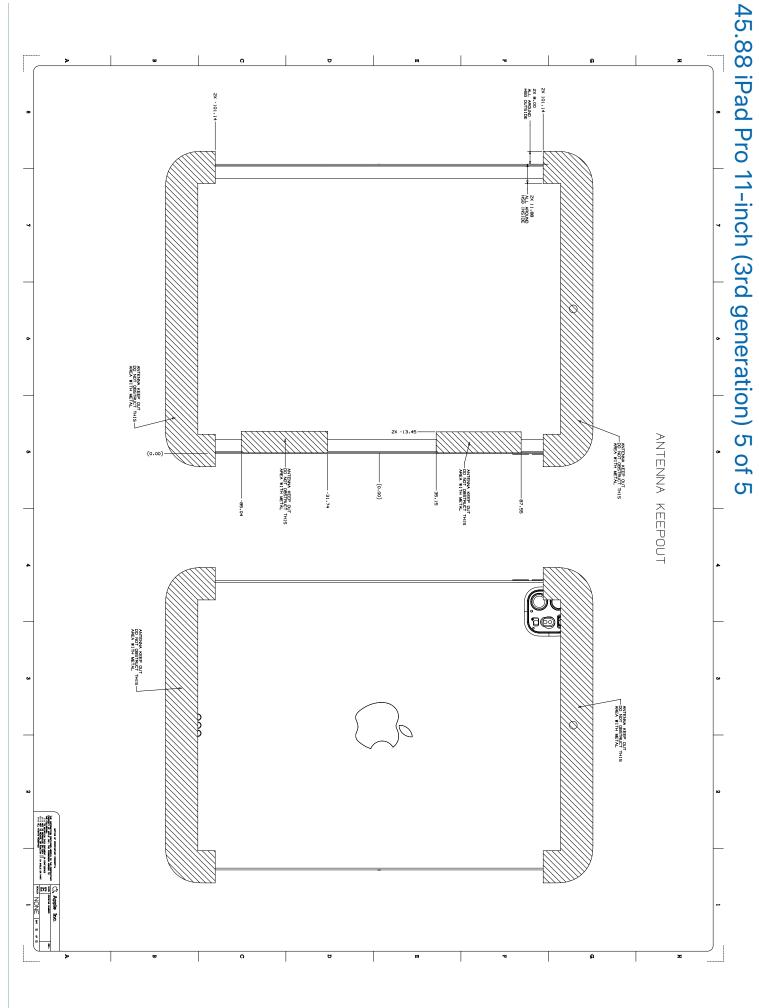


45.85 iPad Pro 11-inch (3rd generation) 2 of 5

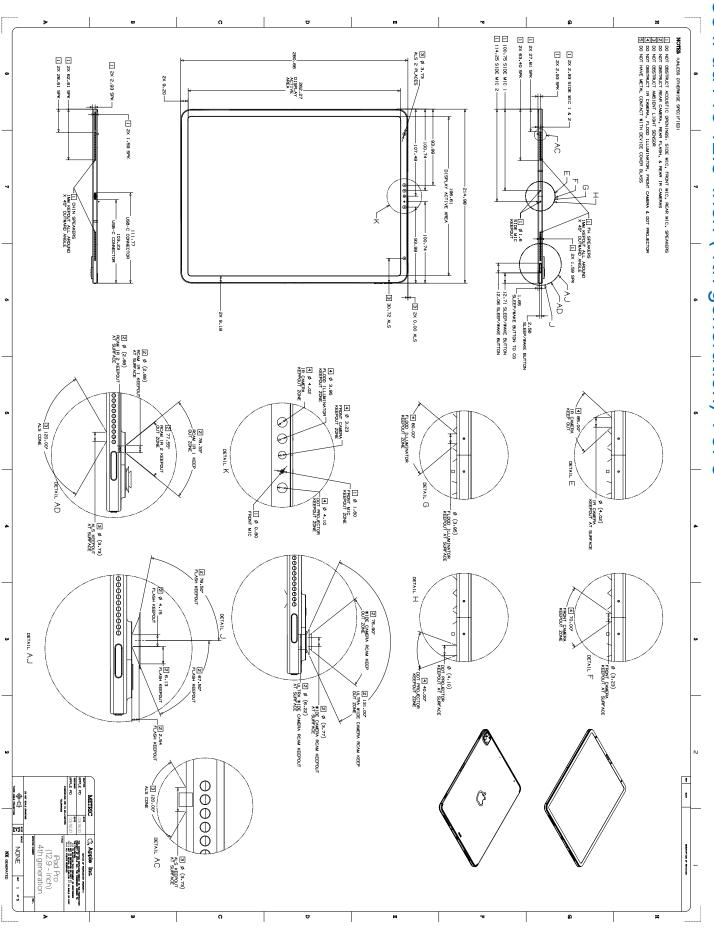




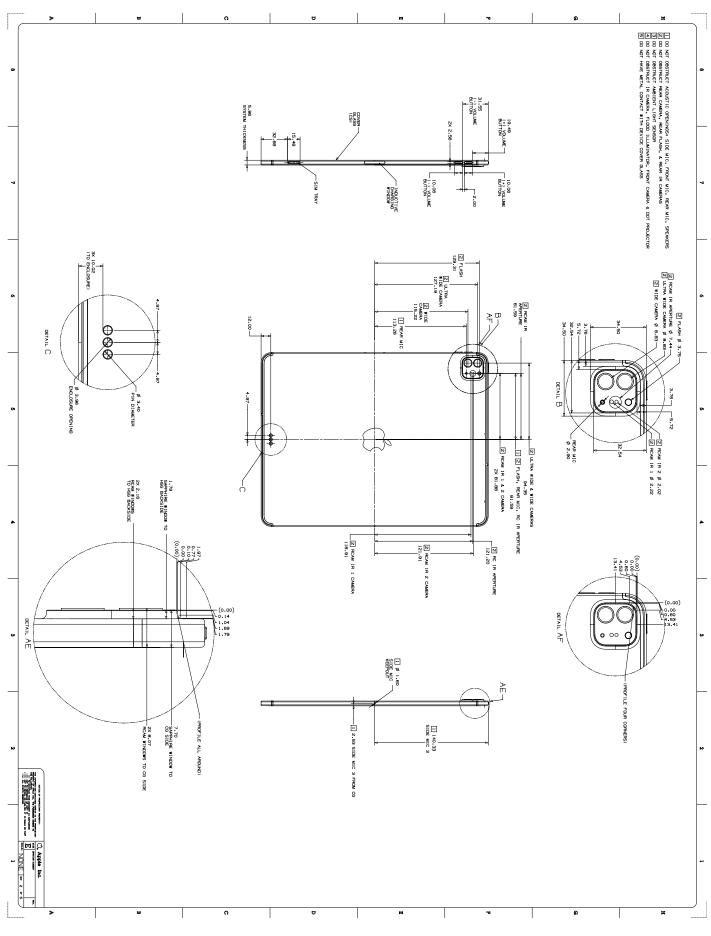




45.89 iPad Pro 12.9-inch (4th generation) 1 of 5

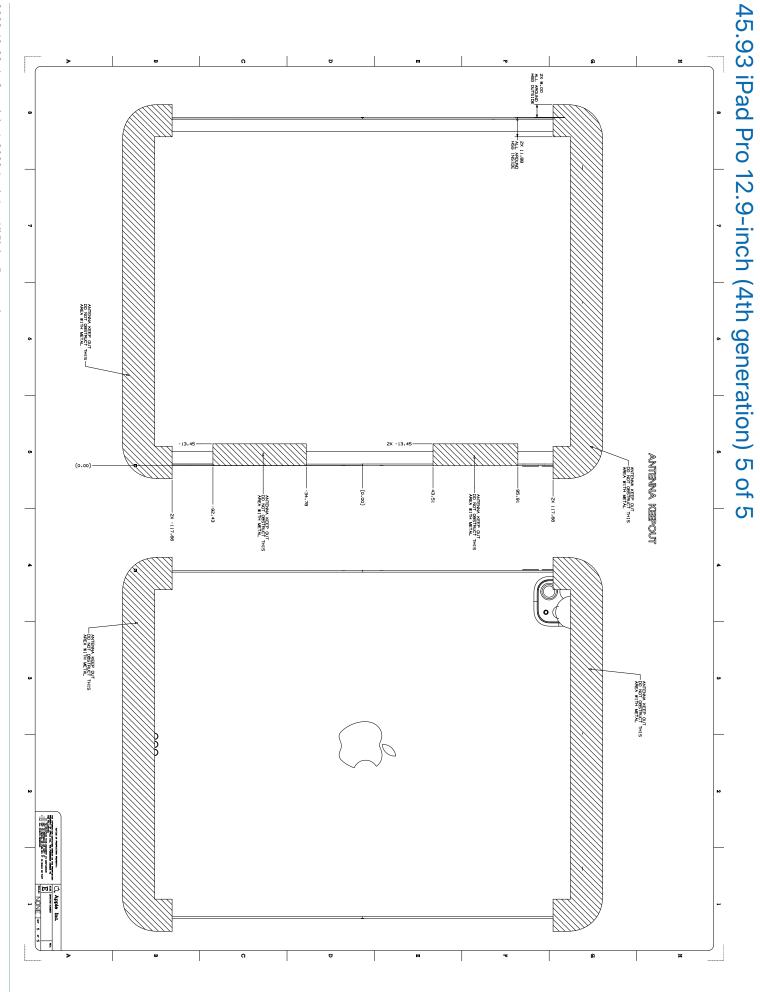


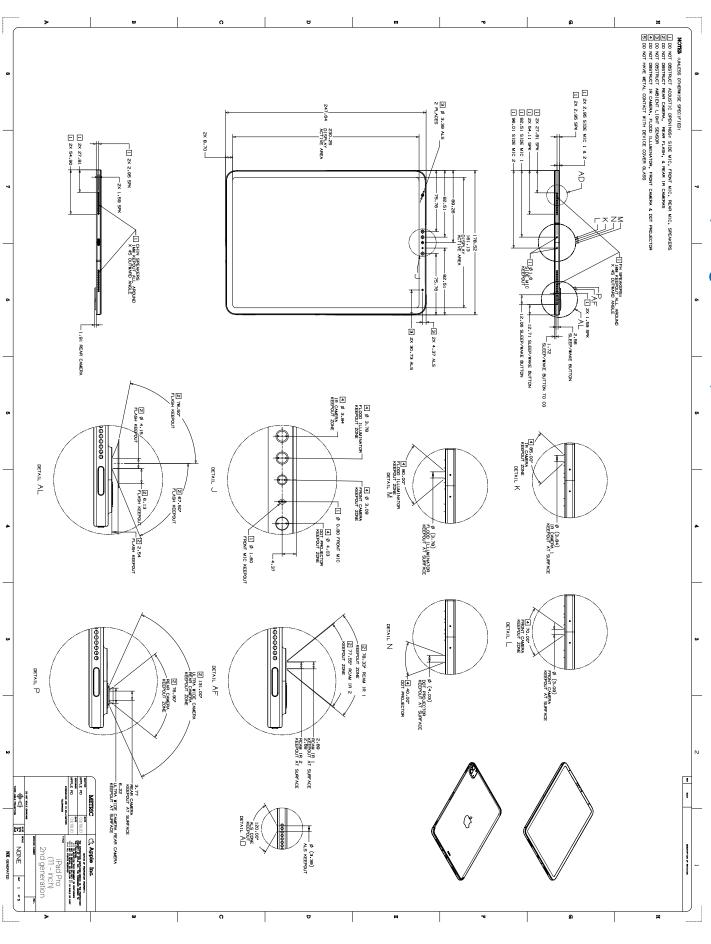
45.90 iPad Pro 12.9-inch (4th generation) 2 of 5 11 DO NOT DESTRUCT POSATIO CORRINANS INDE MIC, FROM MIC, REAR MIC, SPEAKERS 2 DO NOT DESTRUCT REAR DAMEN, A EARL RICKMENS 3 DO NOT DESTRUCT MEDIOT LUCION LUCIALINATION, FROM CAMERA & DOT PROJECTOR 5 DO NOT HAVE METAL CONTACT IT IN DEVICE CORER BLASS Z FLASH Ø 3.75Z RCM IR APERTURE Ø 7.44 Z ULTRA WIDE CAMERA Ø 8.83 Z WIDE CAMERA Ø 8.83 -2 RCAM IR 2 Ø 2.02



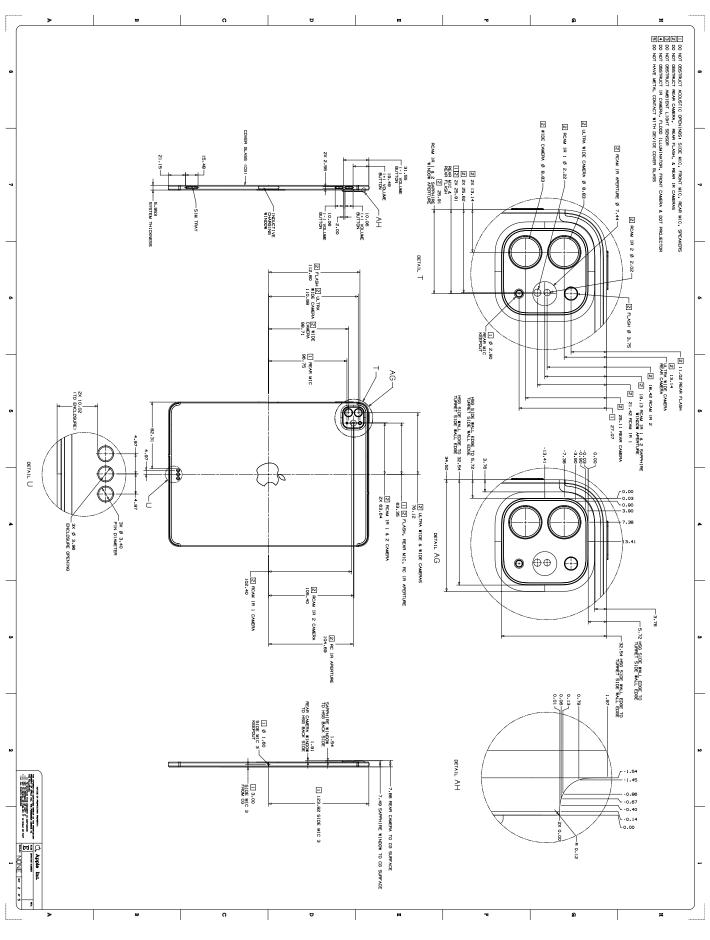
45.91 iPad Pro 12.9-inch (4th generation) 3 of SP-FH-3 225.57 CV4 195.70 CV3 185.27 CV3 185.27 LFE1 183.51 CV1 168.27 CV2 174.83 Ī. ž -BV4-12 000.0 -11 Bv2-28 -6v2-15 BV3-54-BV2-36 <u>-</u>∂ MAGNET DETAIL 15.71 METH 41 148.10 PM-FH-37 PM-FH-48 148.10 PM-FH-38 PM-FH-38 148.88 PM-FH-3 O ∠244.12 ∠002 ∠2x 231.72 ∠231.57 — 2x 227.02 104.96 PM-CH-36 104.96 PM-CH-37 PM-CH-46 101.35 PM-CH-38 PM-CH-28 -BV2-62 -244.47 HES 2 L2x -3.50 ------DETAIL P DETAIL S DETAIL N DETAIL R -00000 3x 25.42 3x 20.72 3x 16.02 15.39 6x 11.32 6X -26.21 6X -21.51 6X -16.81 3x 11.8 - 3x 249.93 - 3x 245.23 - 3x 240.53 - 3x 235.83 - 3x 231.13 - 3x 226.43 SECTION AH - AH HES I ACTIVATED WITH B FIELD IN HES 2 ACTIVATED WITH S DIRECTION THIS DIRECTION T BOTTOM OF HES TO OUTSIDE OF HSG THE STATE OF PROPERTY AND AND THE STATE OF SHAPE SECTION AG-AG E ROLL NONE | ser 3 or 5 3.28 BOTTOM OF HES TO OUTSIDE OF HSG

45.92 iPad Pro 12.9-inch (4th generation) 4 of 5 00 00000°C ветлік АВ < [SECTION AND DETAIL INFORMATION SECTION AA-AA SECTION Z-Z 4X SPEAKER LOCATIONS IMM KEPOUT ALL AROUND X 45° OUTWARD ANGLE

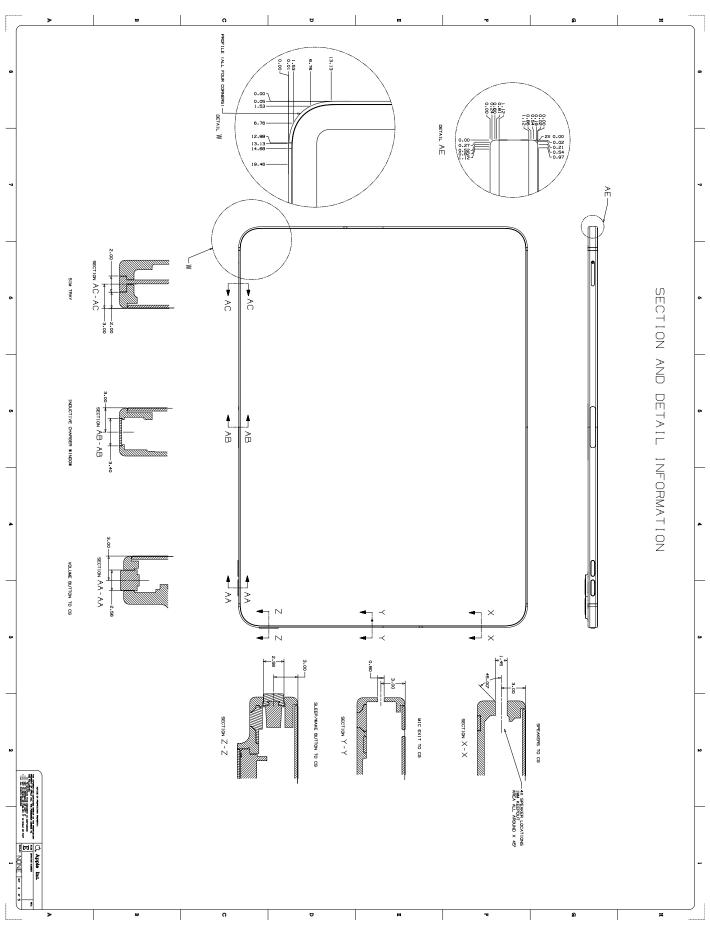




45.95 iPad Pro 11-inch (2nd generation) 2 of 5

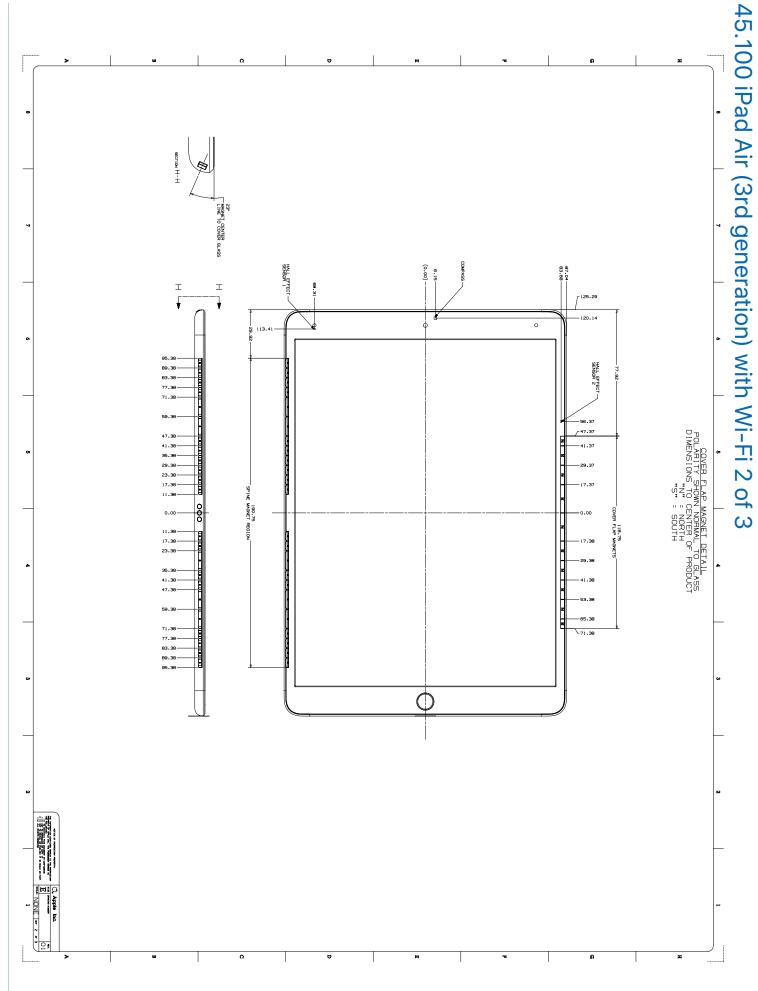


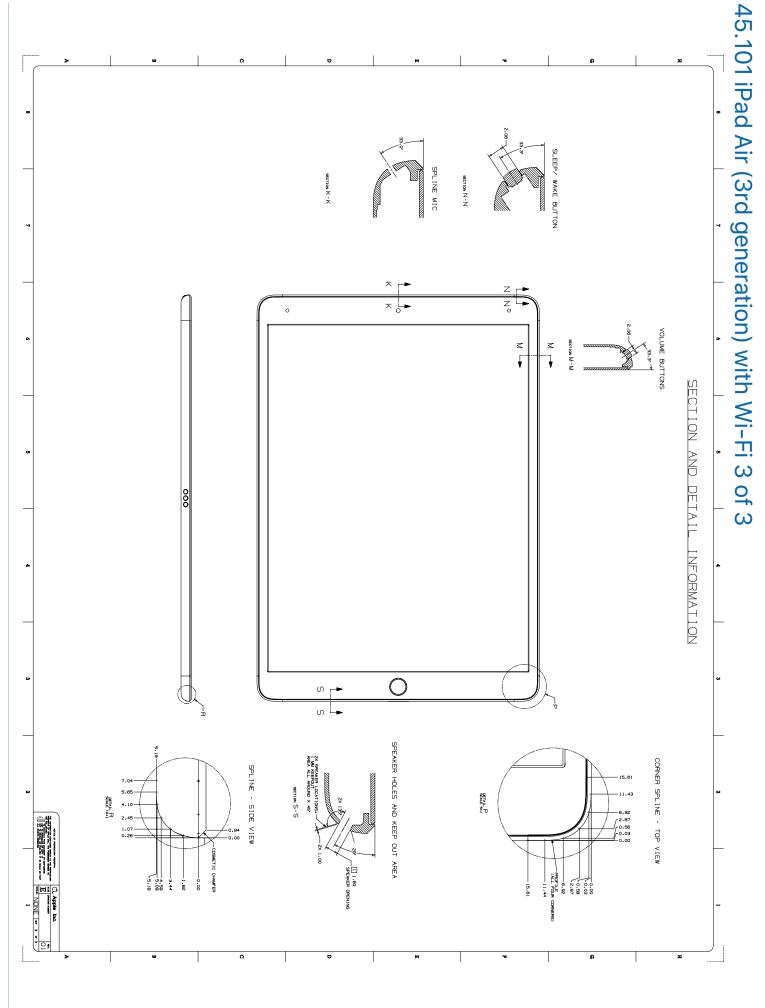
45.97 iPad Pro 11-inch (2nd generation) 4 of 5



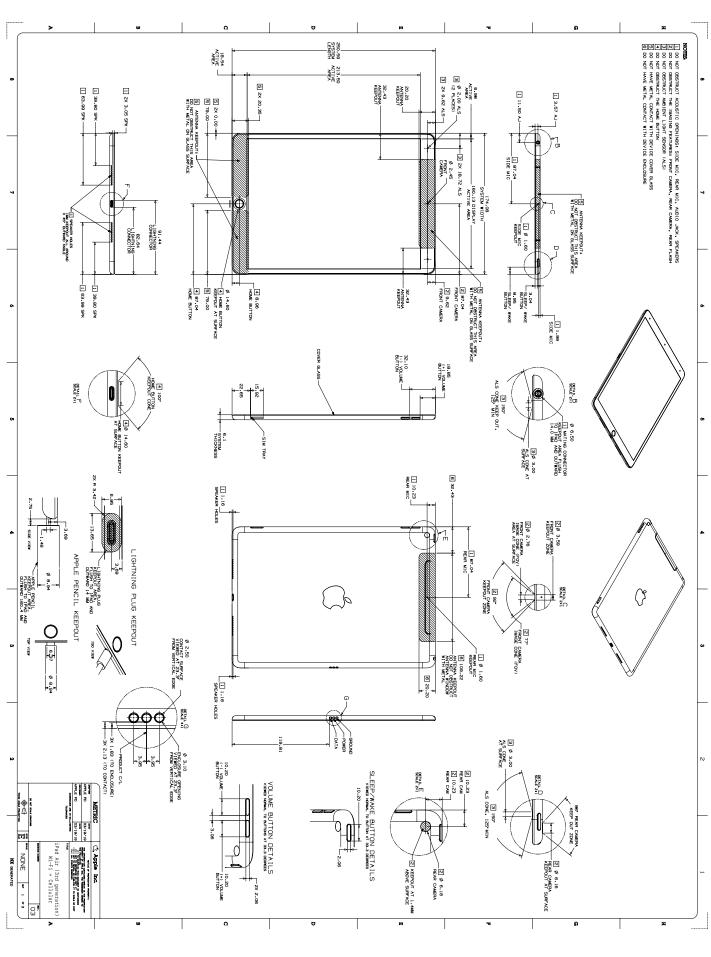
45.98 iPad Pro 11-inch (2nd generation) 5 of 5 2X 8.00 2X 8.00 ALL AROUND HSG OUTSIDE ALL AROUND SX 11.88 ANTENNA KEEP OUT DO NOT OBSTRUCT THIS-AREA WITH METAL ANTENNA KEEPOUT ANTENNA KEEP OUT DO NOT OBSTRUCT THIS AREA WITH METAL ANTENNA KEEP OUT -DO NOT OBSTRUCT THIS AREA WITH METAL ANTENNA KEEP OUT DO NOT OBSTRUCT THIS AREA WITH METAL ANTENNA KEEP OUT DO NOT OBSTRUCT THIS AREA WITH METAL

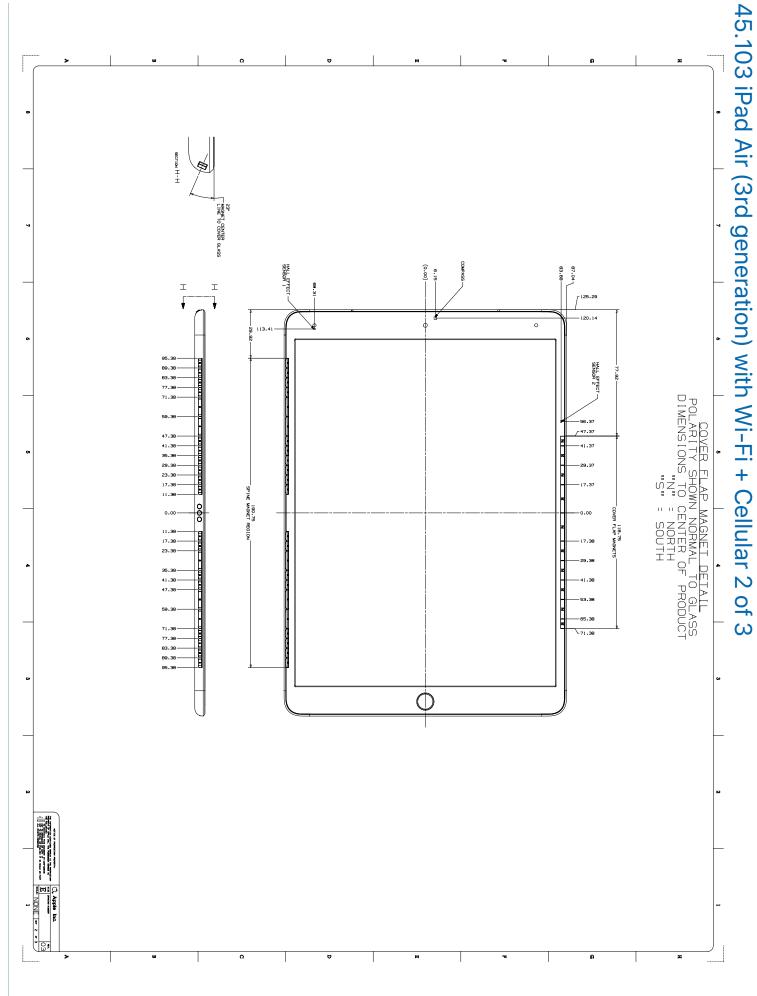
45.99 iPad Air (3rd generation) with Wi-Fi 1 of 3 NOTES 11 DO NOT DESTRUCT ACQUISITIC OPENINGS; SIDE WIC., REAR WIC., AUDIO JACK, SPEWERS 22 DO NOT DESTRUCT THE IMMOING FEATURES; FRONT CAMERA, REAR CAMERA 30 NOT DESTRUCT AMERICA LOFF DESCRI (ALS) 40 DO NOT DESTRUCT THE HOME BUTTOT THE HOME OFFICE COVER GLASS ACTIVE AREA 6.98 AOTIVE -AOTIVE -12 PLACES) 1 2x 3.05 SPK ∐ 63.99 SPK-1 39.80 SPK 5 2x 20.35 II 11.50 ∧-SYSTEM WIDTH— SYSTEM WIDTH— ACTIVE MEEN ACTIVE MEEN Ø 2.4E SIDE MIC Ø 2.45 FRONT -CAMERA SIDE MIC KEEPOUT SPEAKER HOLES AS' OUTWARD ANGLE AS' OUTWARD ANGLE 91.44 -LIGHTNING CONNECTOR BZ.84 -LIGHTNING CONNECTOR __ Z 87.04 FRONT CAMERA -[] 63.99 SPK -[1] 39.80 SPK -5 79.00 4 87.04 HOME BUTTON Ø 14.60 —4 HOME BUTTON KEEPOUT AT SURFACE FRONT CAMERA 8.95 -SLEEP/ WAKE BUTTON 3.04 MAKE SIDE MIC (+) VOLUME: ALS CONE KEEP OUT. BETAIL B HOME BUTTON KEEPOUT CONE DETAIL F Ø 6.50 II MATING CONNECTOR KEEPOUT AREA FLUSH TO IPAD AND OUTWARD 14.0 MM SYSTEM THICKNESS ALS CONE AT HOME BUTTON KEEPOUT AT SURFACE II 10.23 SPEAKER HOLES ZØ 2.78 FRONT CAMERA IMAGE CONE (FOV AREA AT SURFACE ZØ 3.59 FRONT CAMERA KEEPOUT ZONE SIDE VIEW LIGHTNING PLUG KEEPOUT APPLE PENCIL KEEPOUT ()° FRONT CAMERA KEEPOUT ZONE BETAIL C 77* FRONT CAMERA IMAGE CONE (FOV) Ø 2.50 CONTACT SUBFACE VIENED AT 23.3* FROM VERTICAL EDGE REAR MIC KEEPOUT Main OSI I 1.18 SPEAKERS HOLES VIEW SCALE 411 APPLE PENCIL KEEPOUT FLUSH TO IPAD AND OUTWARD 180.4 MM $\phi\phi\phi$ ALS CONE AT SURFACE Ø 3.10 ENCLOSURE OPENING VIEWED AT 23.3° FROM VERTICAL EDGE -3x 1.83 (TO ENCLOSURE) 10.20 (-) VOL PRODUCT C/L BETAIL E Z 10.23 REAR CAMERA SEVER 211 2 10.23-SLEEP/WAKE BUTTON DETAILS VICTOR BUTTON DETAILS ALS CONE, 125*MIN Apple Inc. The apple inc. The apple in accompany means a second apple in accompany means as a second apple in accompany means a second apple in accompany means are a second apple in accompany means a second apple in ac d iPad Air (3rd generation Wi-Fi NONE REAR CAMERA KEEPOUT AT SURFACE ABOVE SURFACE REAR CAMERA 1 43

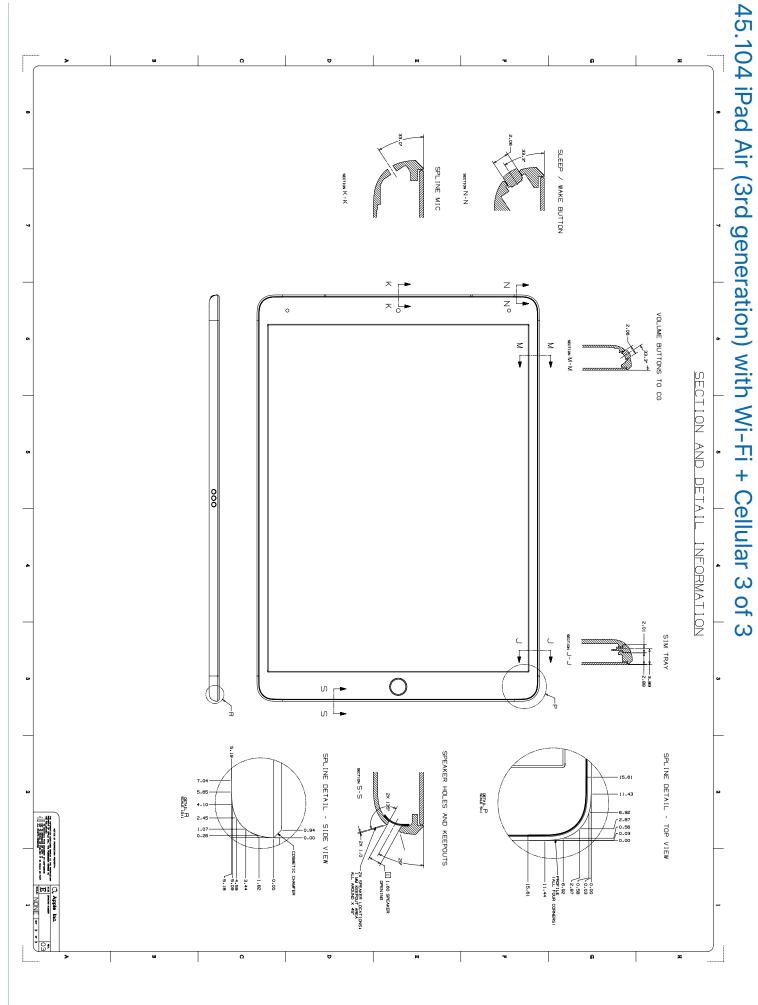




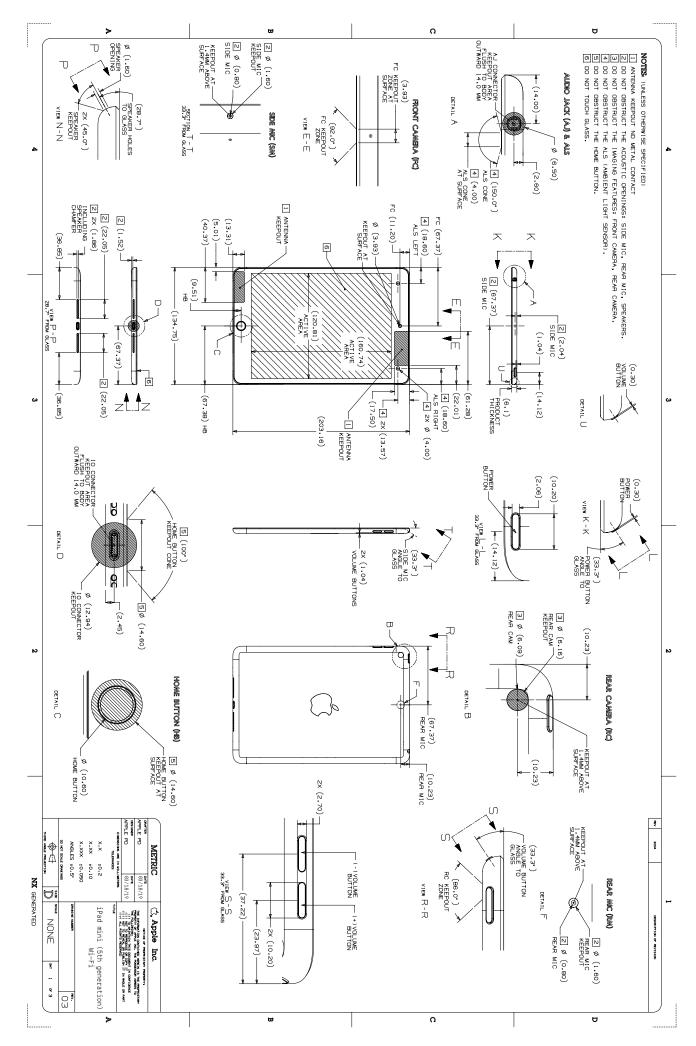
45.102 iPad Air (3rd generation) with Wi-Fi + Cellular 1 of 3



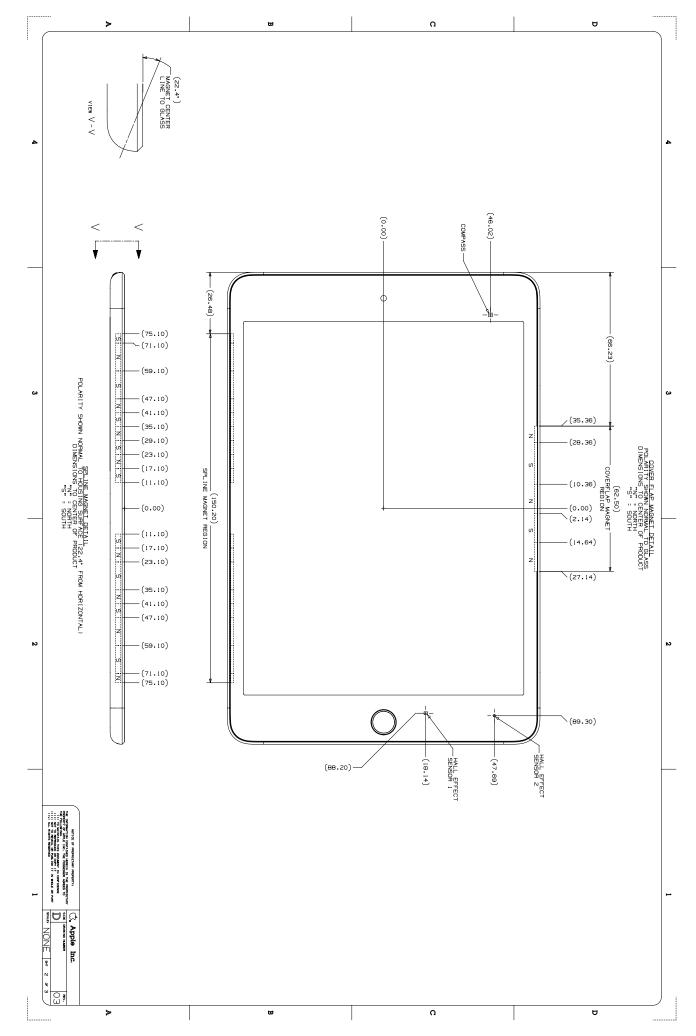




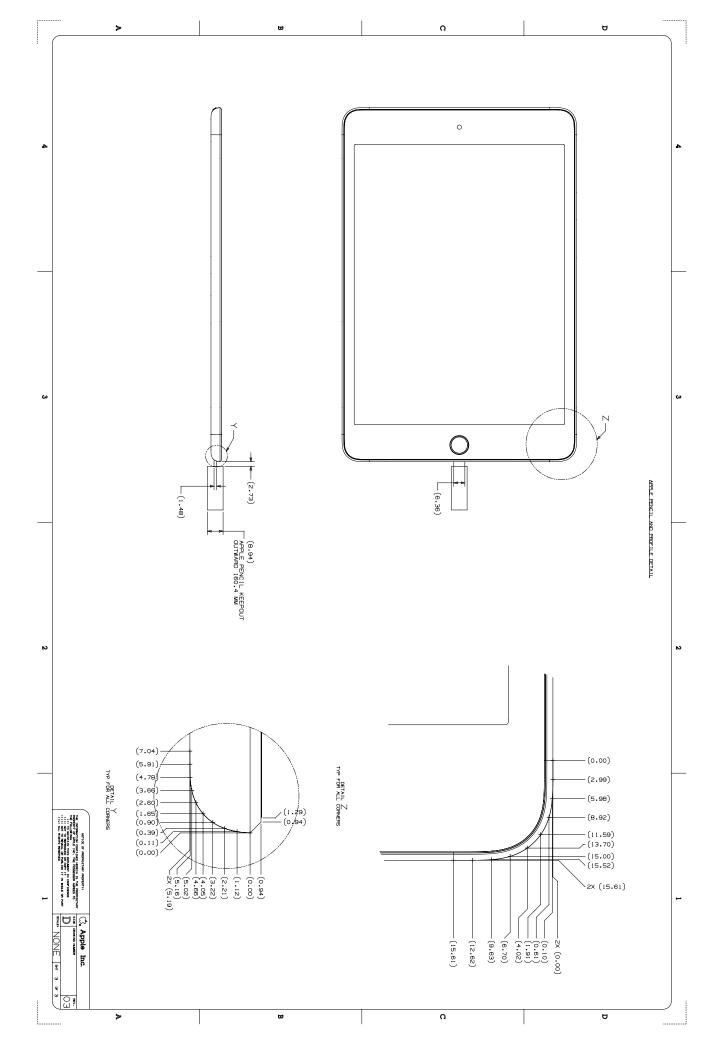
45.105 iPad mini (5th generation) with Wi-Fi 1 of 3



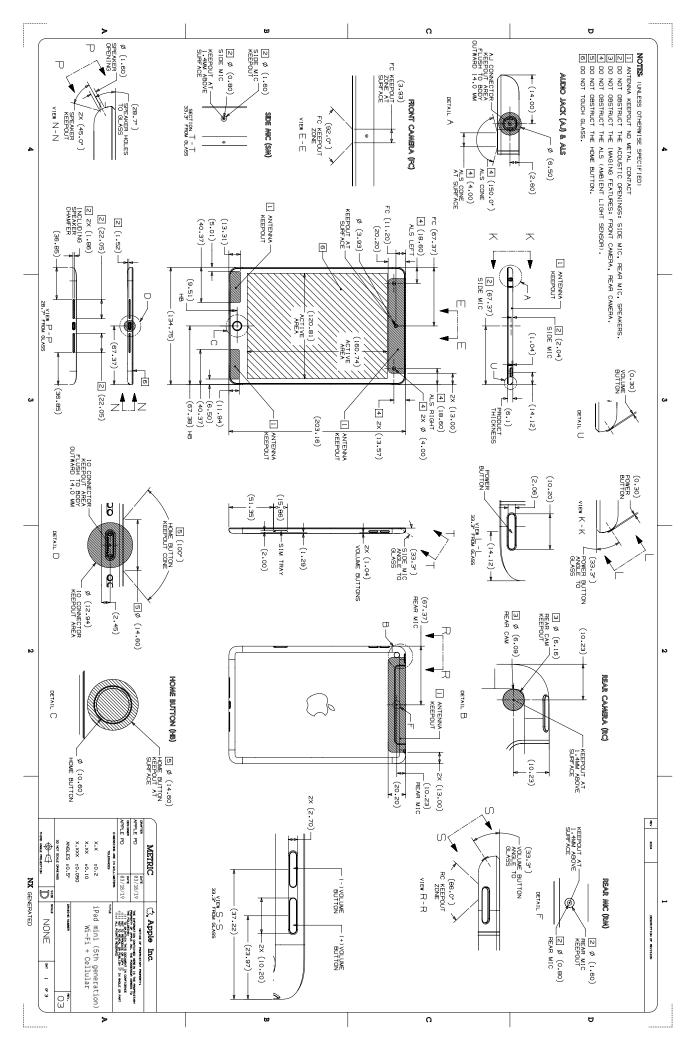
45.106 iPad mini (5th generation) with Wi-Fi 2 of 3



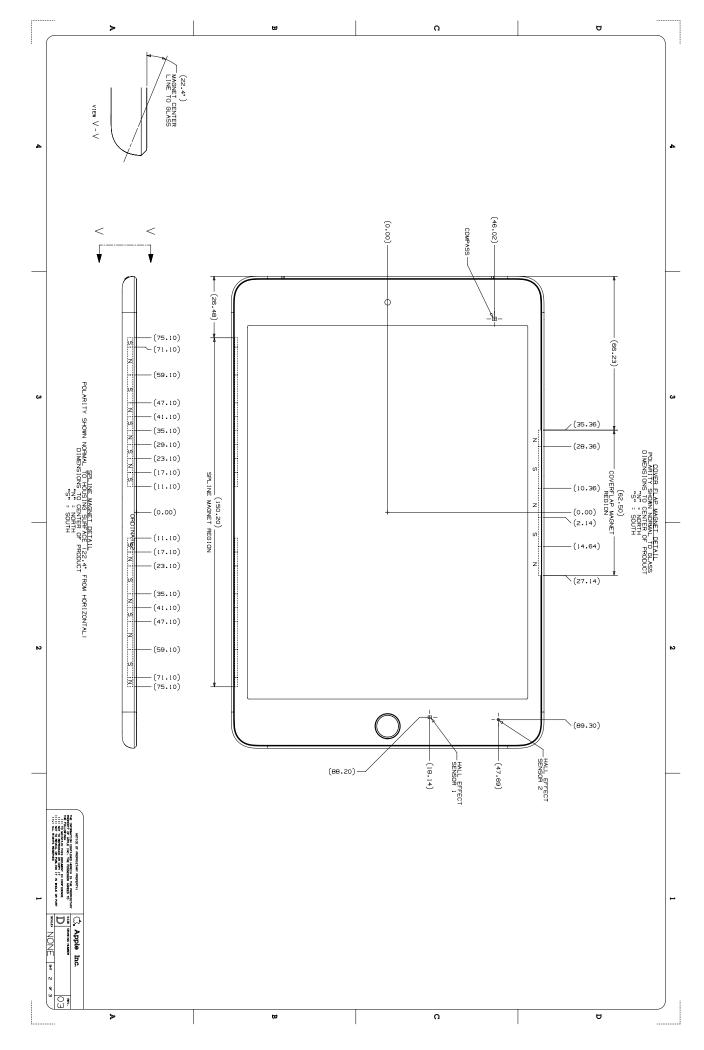
45.107 iPad mini (5th generation) with Wi-Fi 3 of 3



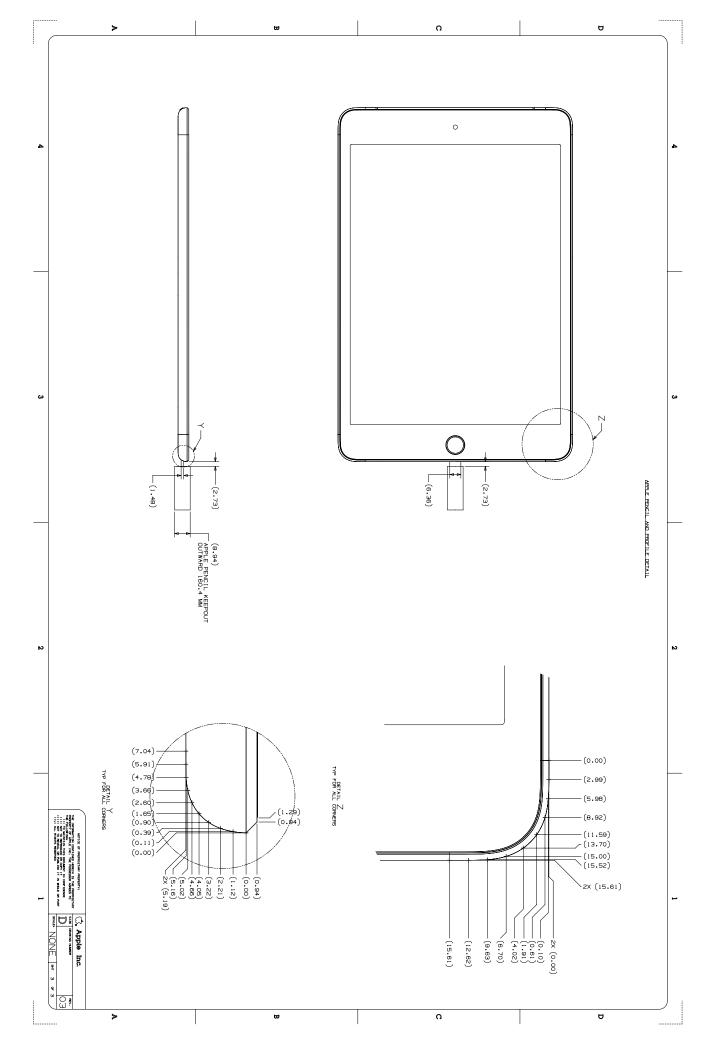
45.108 iPad mini (5th generation) with Wi-Fi + Cellular 1 of 3

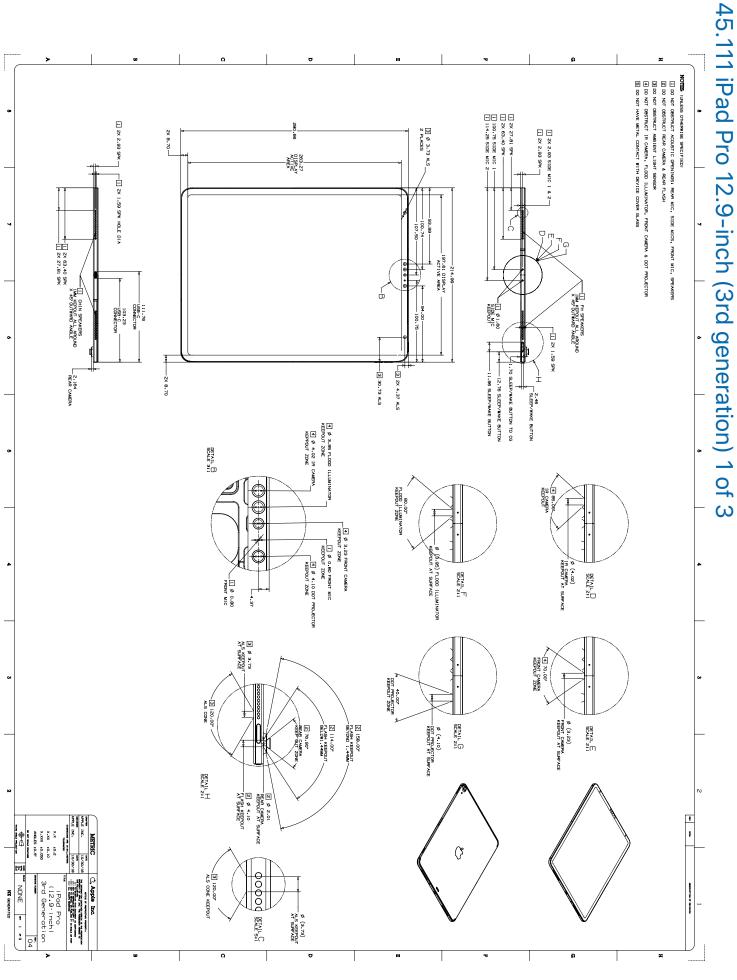


45.109 iPad mini (5th generation) with Wi-Fi + Cellular 2 of 3

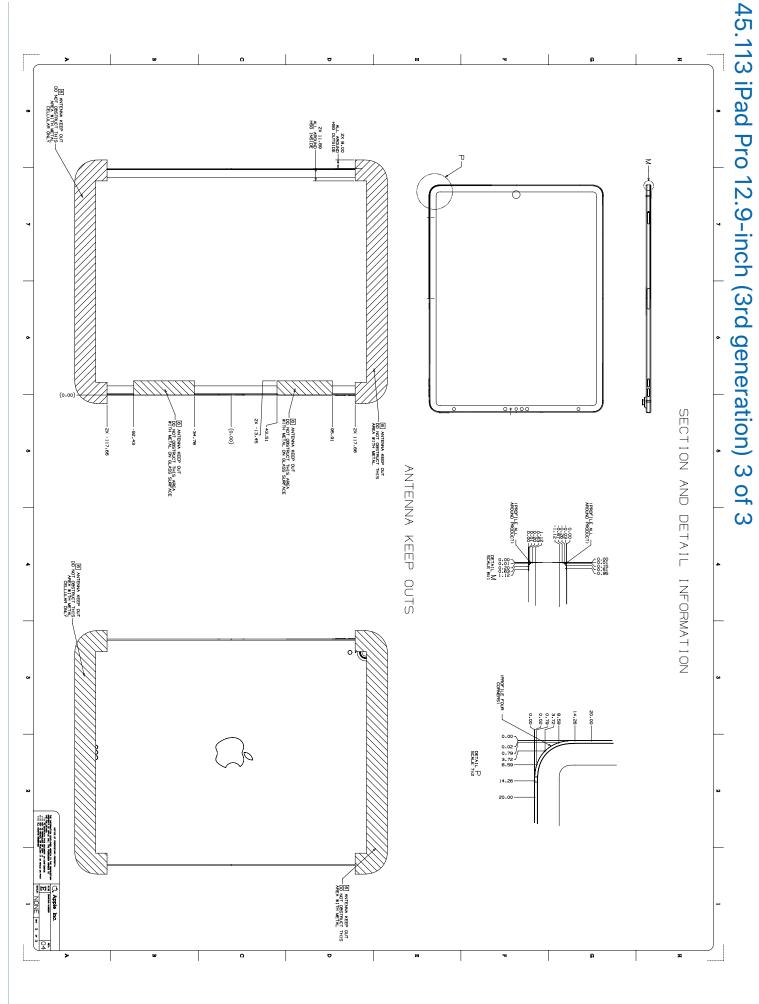


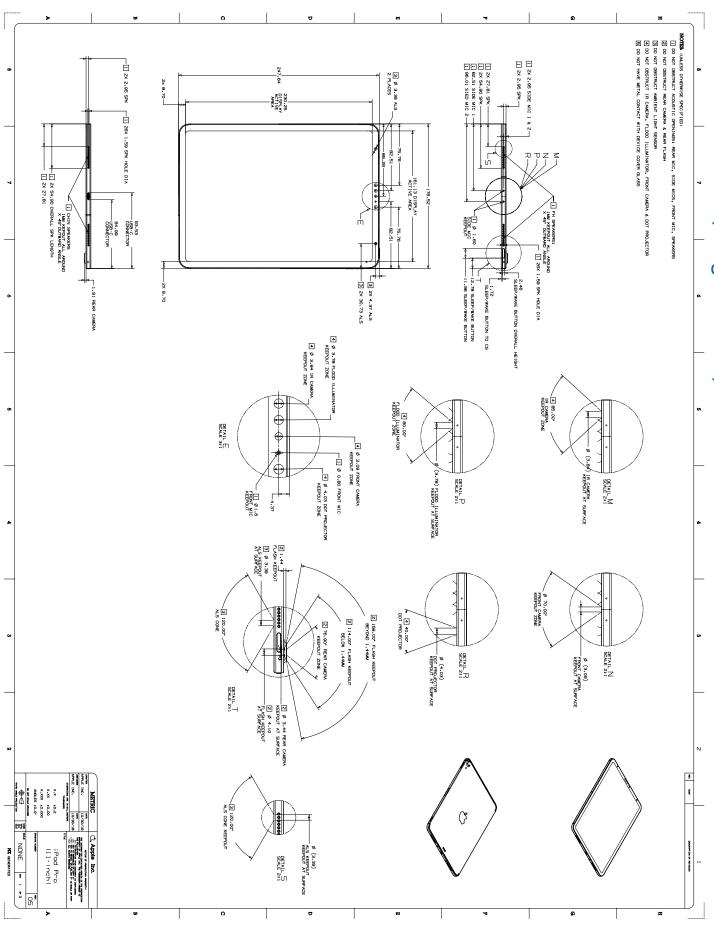
45.110 iPad mini (5th generation) with Wi-Fi + Cellular 3 of 3



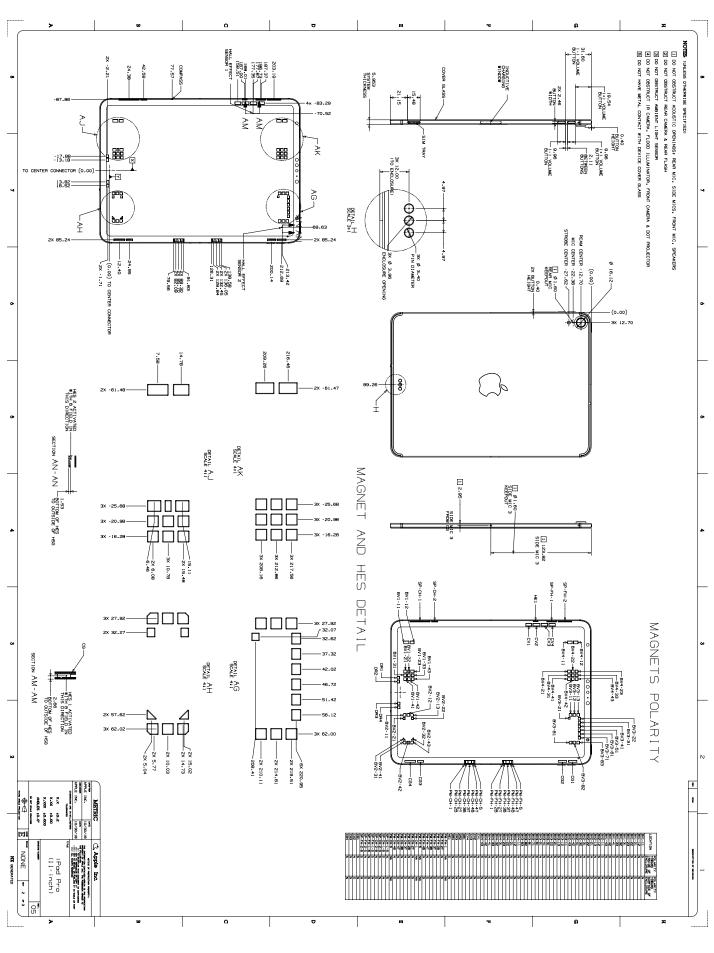


45.112 iPad Pro 12.9-inch (3rd generation) 2 of 3 31.60 (-) VOLUME □ DO NOT DESTRUCT ACCUSTIC OPENINESS HEAR MIC, SIDE MICS, FRONT MIC, SPEMBERS DO NOT DESTRUCT HEAR CAMENA, A REAR PLOSE DO NOT DESTRUCT HEAR CAMENA, A REAR PLOSE DO NOT DESTRUCT HE CAMENA, FLOOD ILLUMINATION, FRONT CAMENA & DOT PROJECTION DO NOT HAVE METAL CONTACT WITH DEVICE COVER BLASS INDUCTIVE CHARGING WINDOW 19.54 BUTTON BUTTON SCALE 311 -106.10 HALL EFFECT SENSOR 1 --3X 12.70 888 -21.41 -14.36 CONNECTOR (0.00 13.18-888888 88888 SIDE MIC 3 108.56 SENSOR 2 244.12 242.79 155.31 151.71 148.10 FROM CG 23.54 SECTION AK - AK SCALE 111 SCALE 111 MAGNET POLARITY BV1-24-BV1-33-BV1-33-BV1-22-8v4-24 8v4-23 8v4-22 Bv4-11 HES I ACTIVATED WITH B FIELD IN THIS DIRECTION 2.48 BOTTOM OF HES TO OUTSIDE OF HSG 4X -26.21 — 5X -21.51 — 5X -16.81 — 6X -26.21 6X -21.51 6X -16.81 MAGNET AND 3x 248.83 3x 246.523 3x 236.523 3x 236.83 3x 236.83 3x 236.83 32 25.9 32 16.52 32 16.52 32 16.52 8v3-23 8v3-23 8v3-23 2v3-23 8V2-38 8V2-33 8V2-33 1 WITH B FIELD IN-THIS DIRECTION SH SECTION AL - AL 5X 37:19 -----6X 37:19-88888 DETAIL DETAIL AB SCALE 1:1 THE PROPERTY OF STATE OF THE PROPERTY OF THE P 1.53 BOTTOM OF HES TO OUTSIDE OF HSG 3x 246.58 3x 246.58 3x 241.88 3x 237.18 3x 232.48 3x 232.48 E NONE or 2

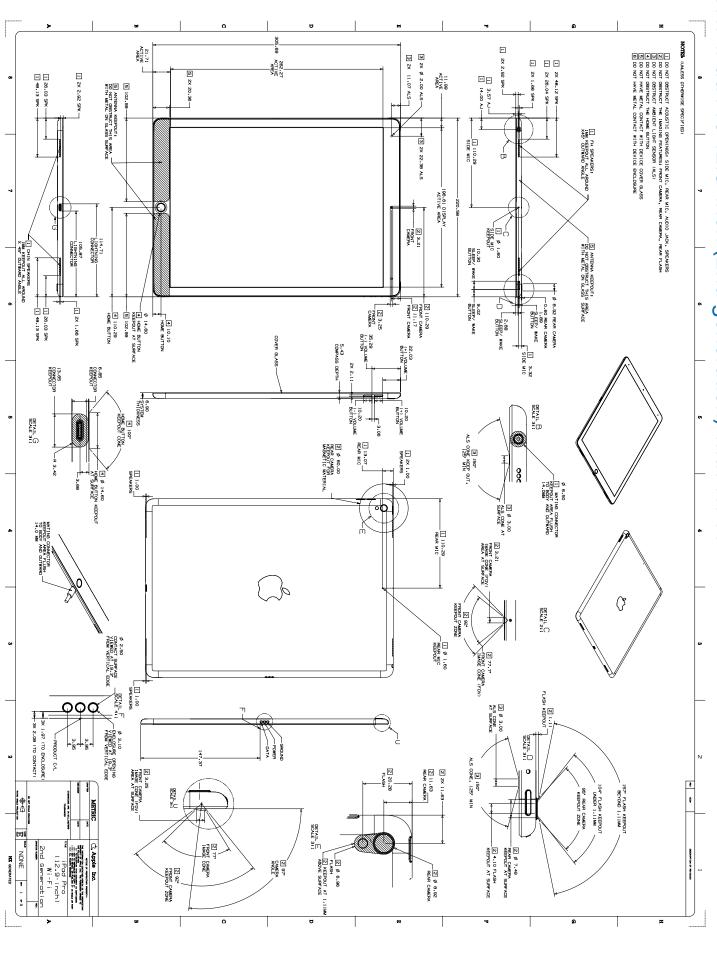




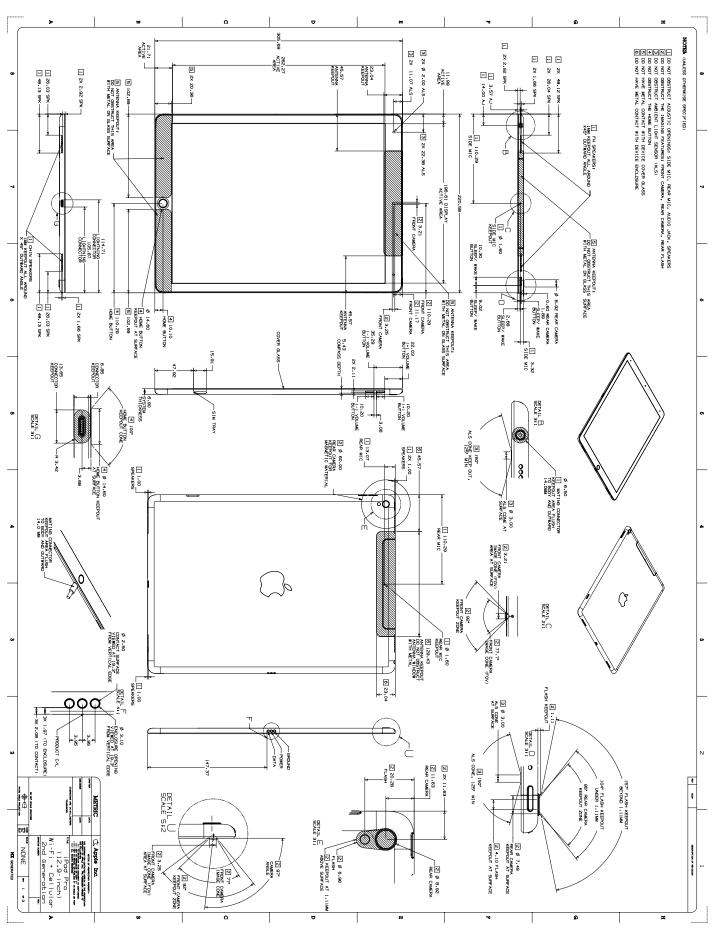
45.115 iPad Pro 11-inch (1st generation) 2 of 3

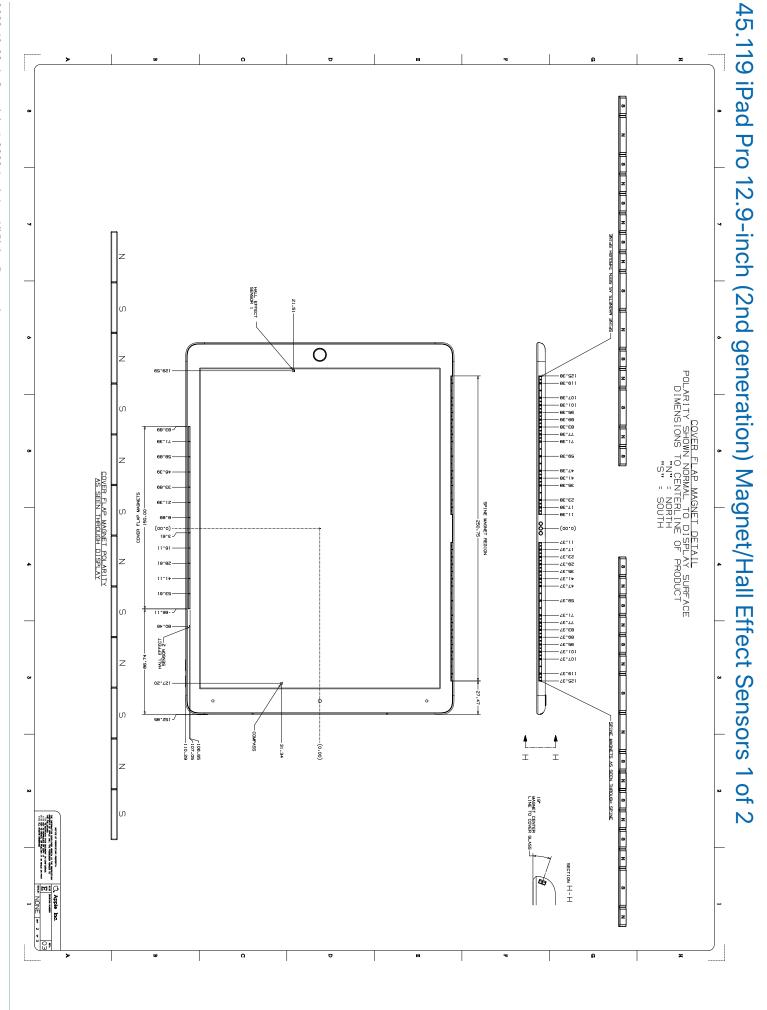


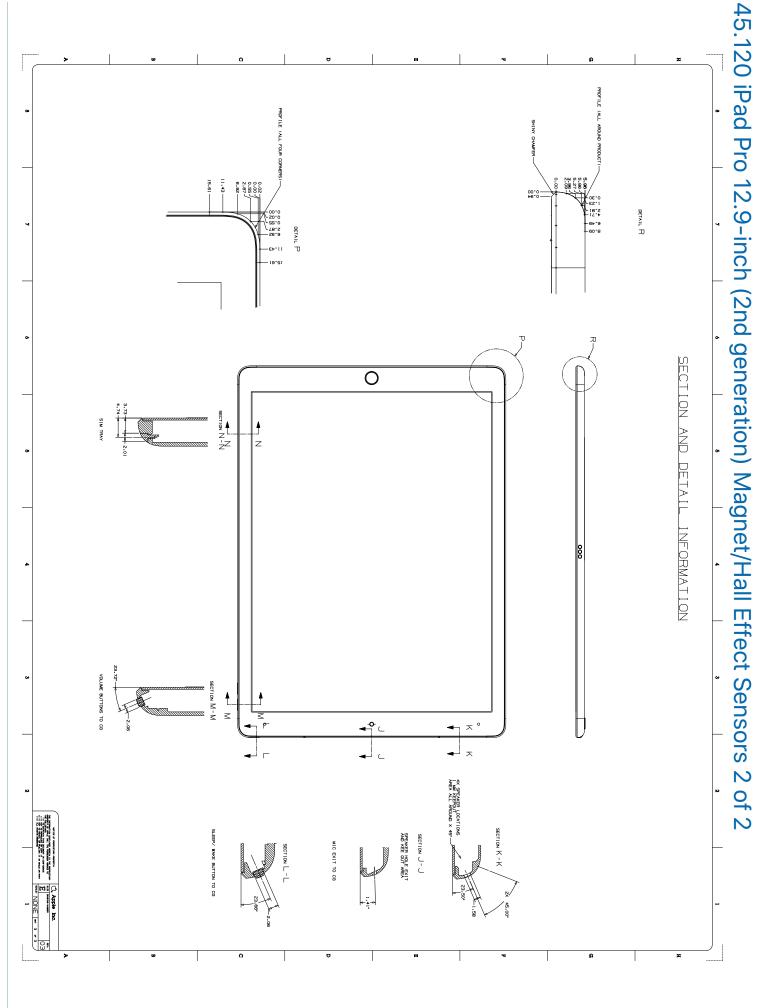
45.117 iPad Pro 12.9-inch (2nd generation) with Wi-Fi



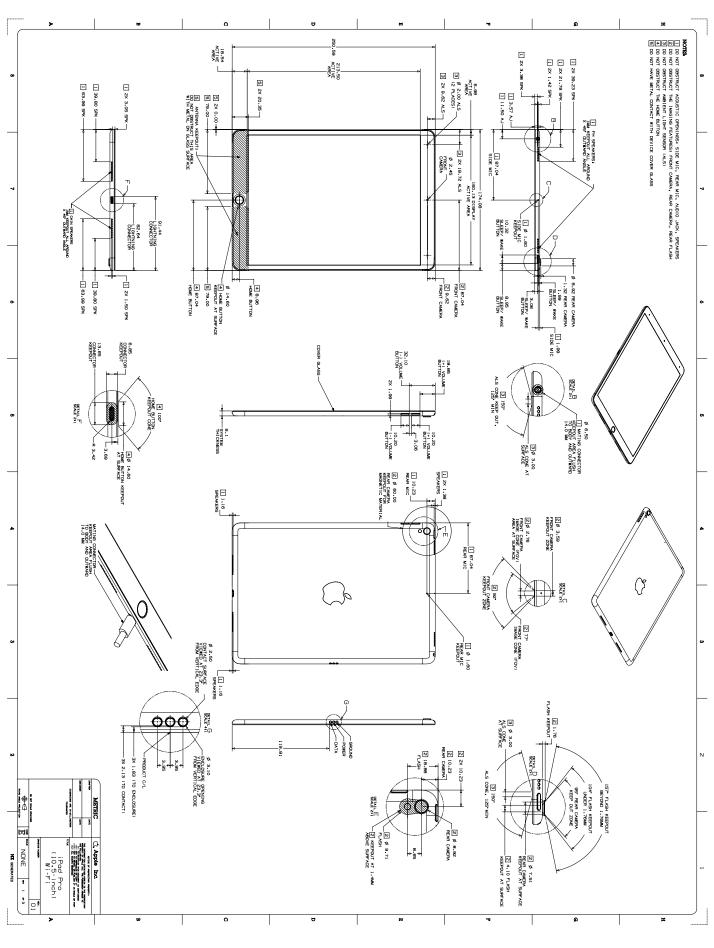
45.118 iPad Pro 12.9-inch (2nd generation) with Wi-Fi + Cellular



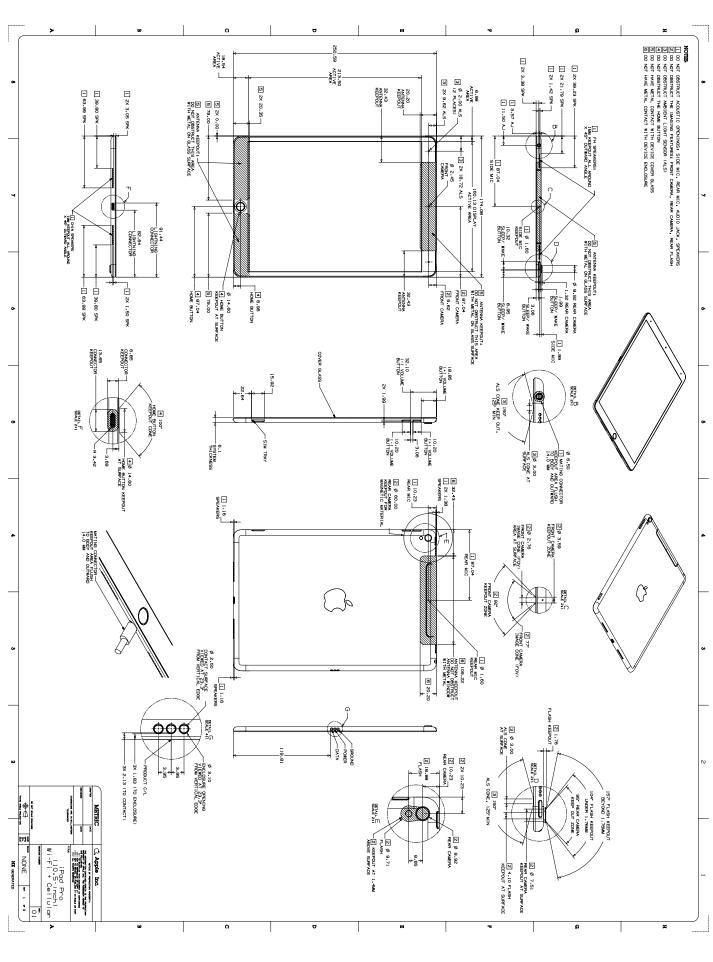


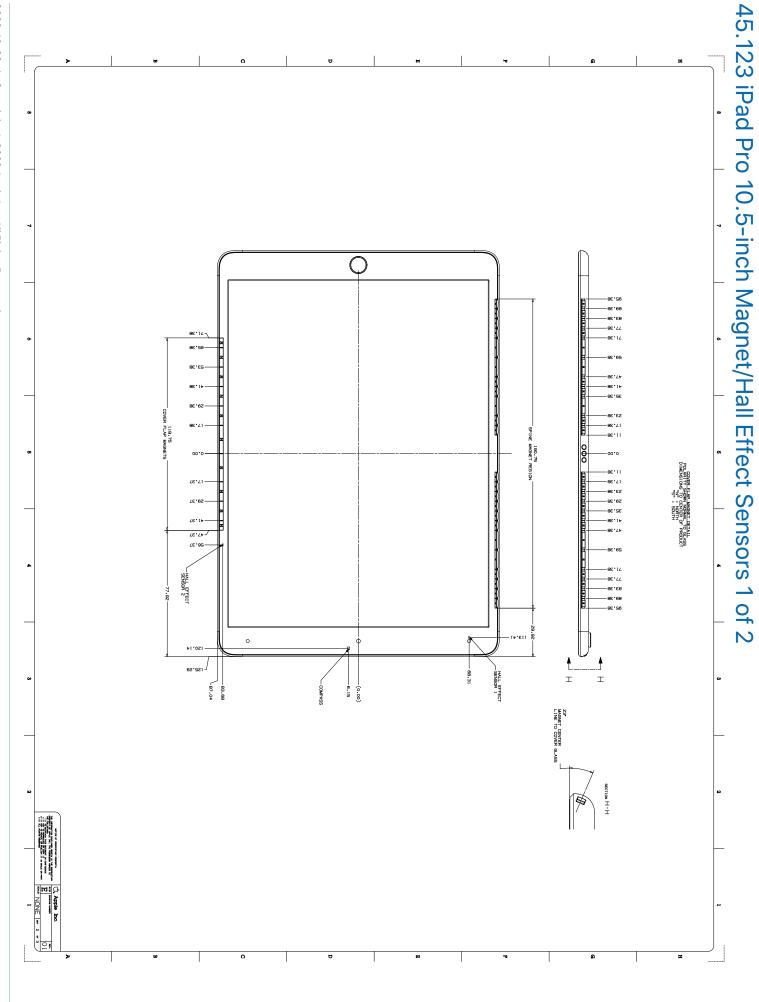


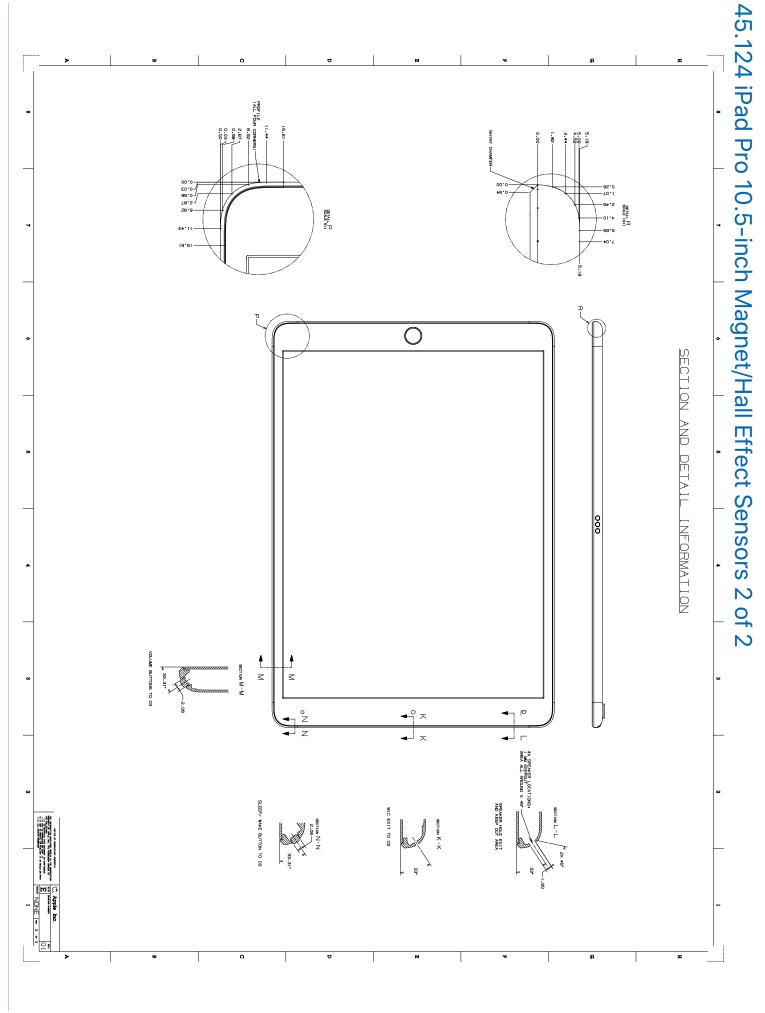
45.121 iPad Pro 10.5-inch with Wi-Fi



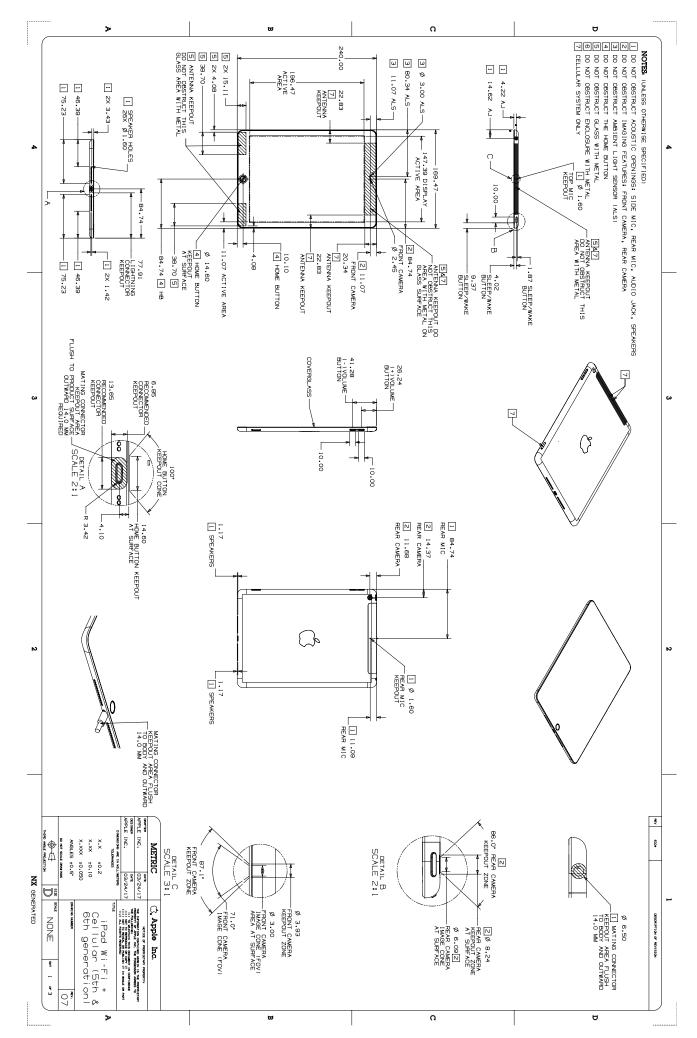
45.122 iPad Pro 10.5-inch with Wi-Fi + Cellular



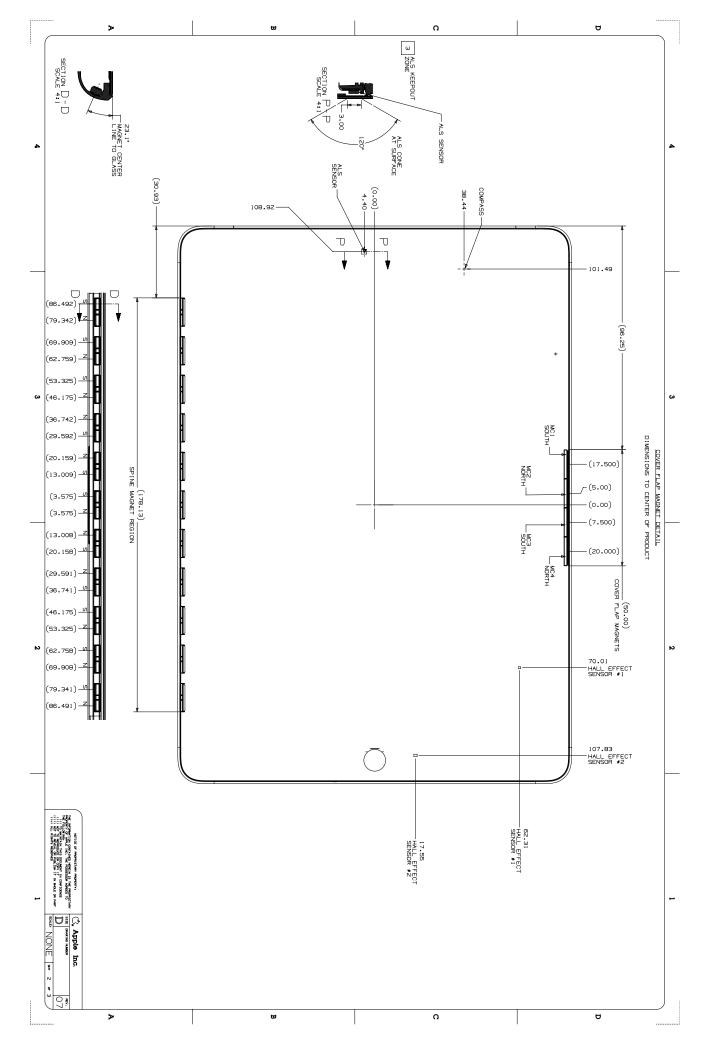




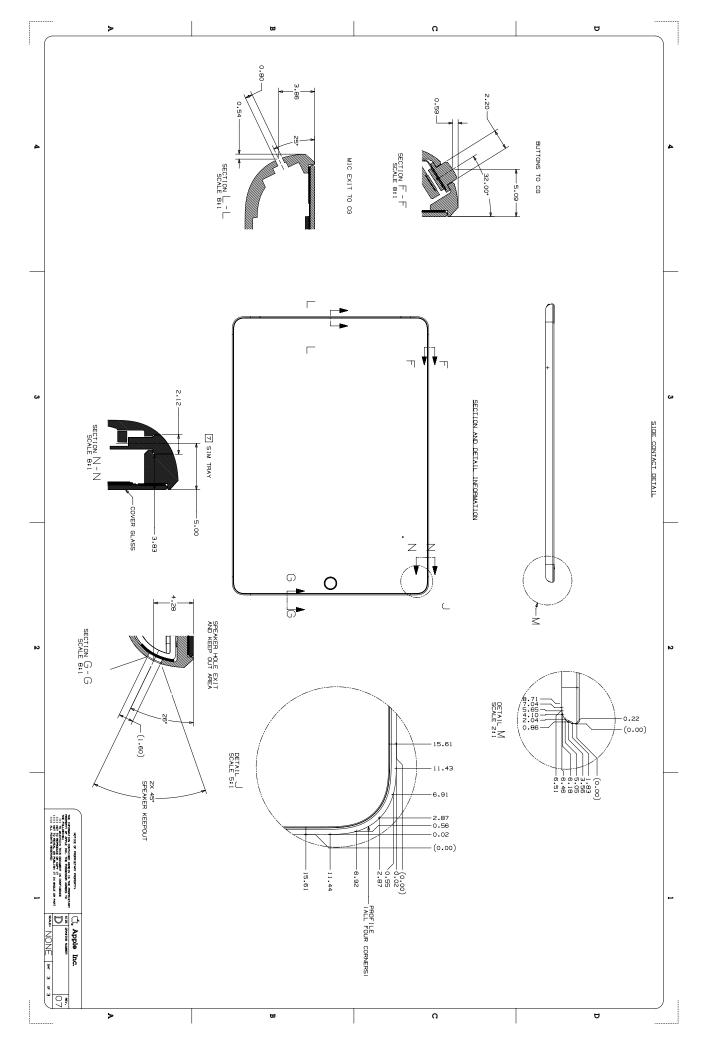
45.125 iPad (5th and 6th generation) with Wi-Fi + Cellular

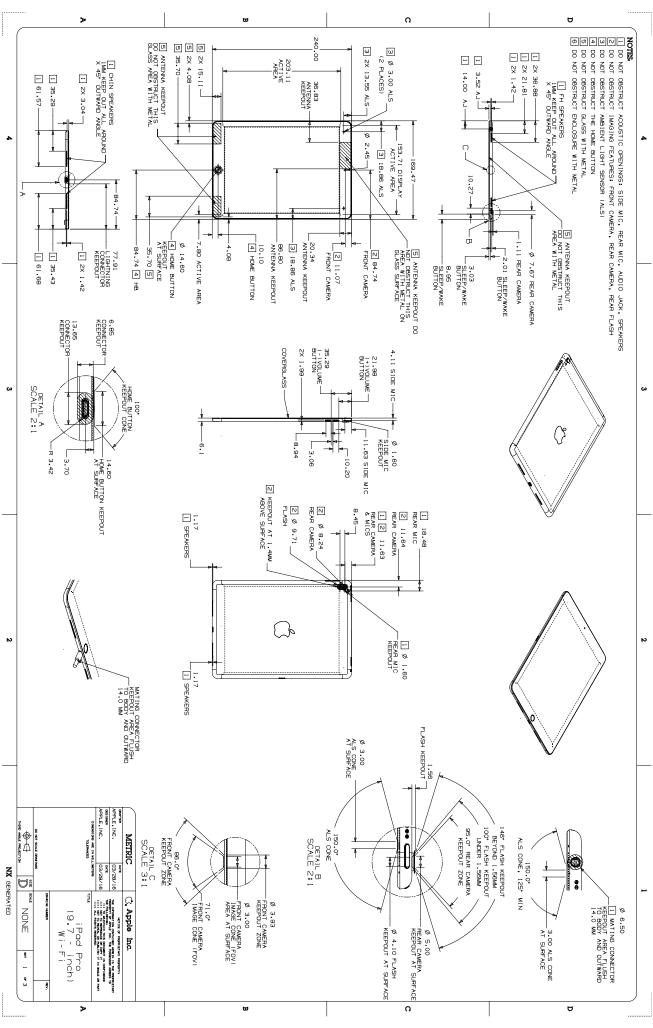


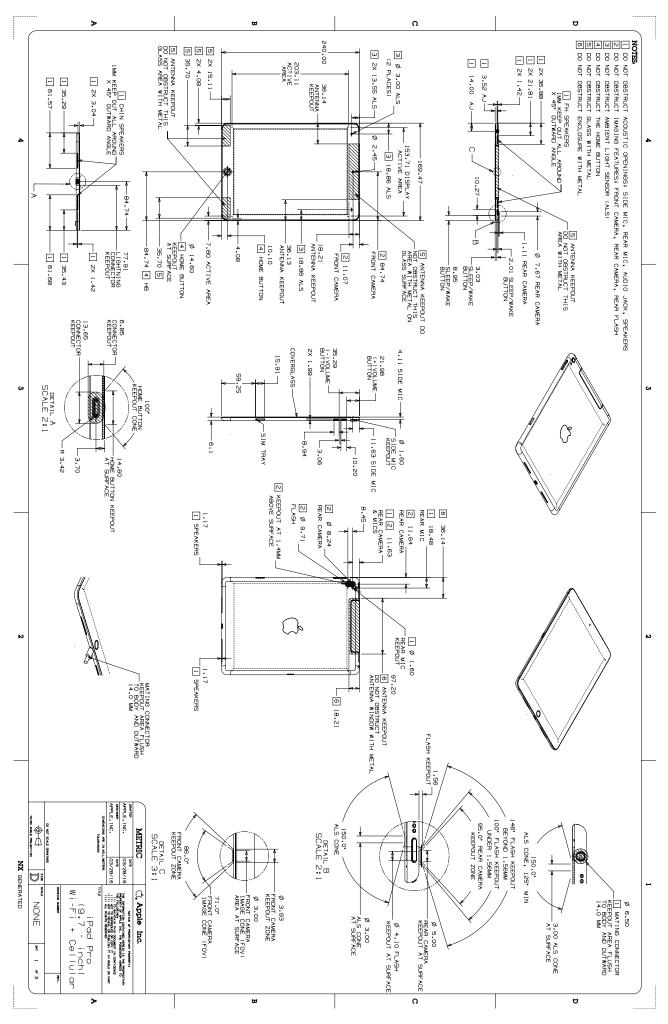
45.126 iPad (5th and 6th generation) Magnet/Hall Effect Sensors 1 of 2



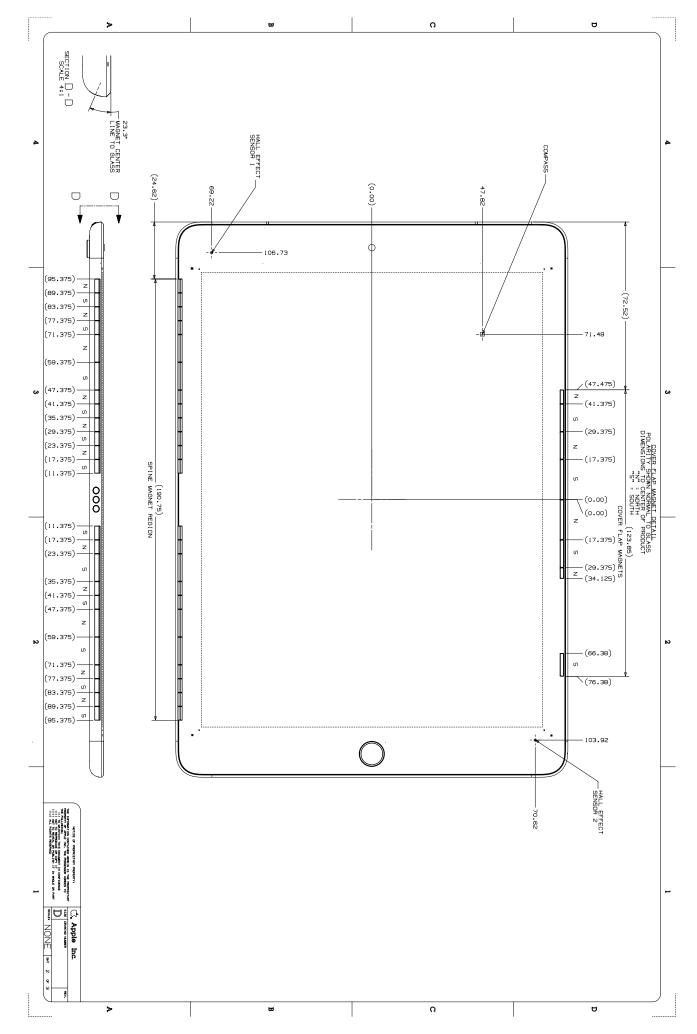
45.127 iPad (5th and 6th generation) Magnet/Hall Effect Sensors 2 of 2



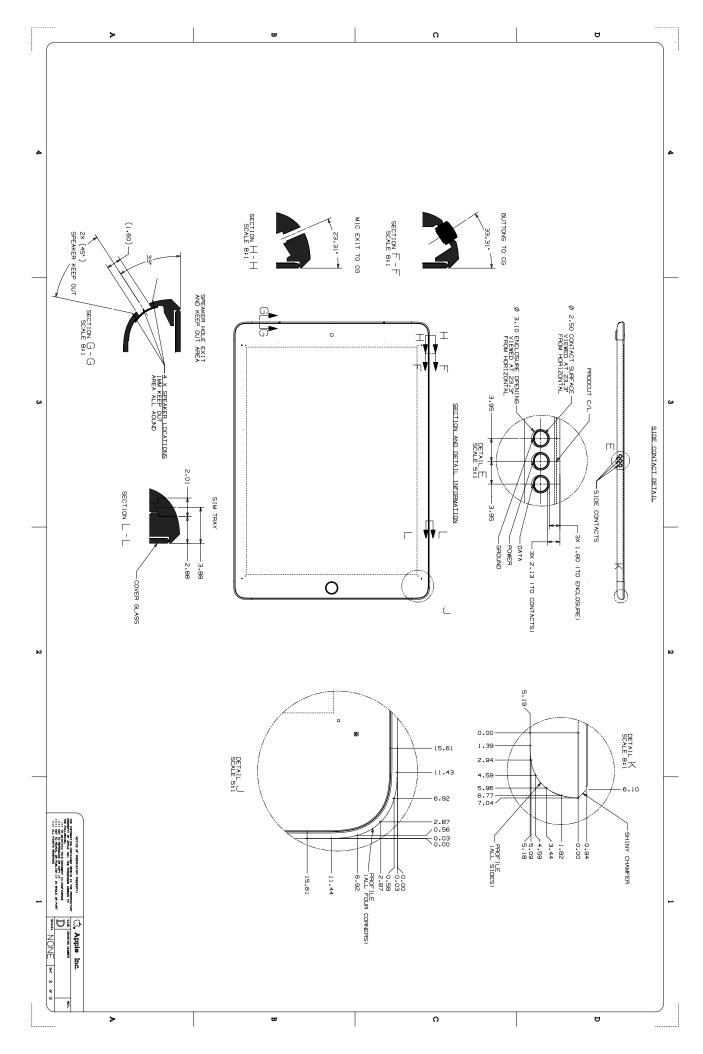




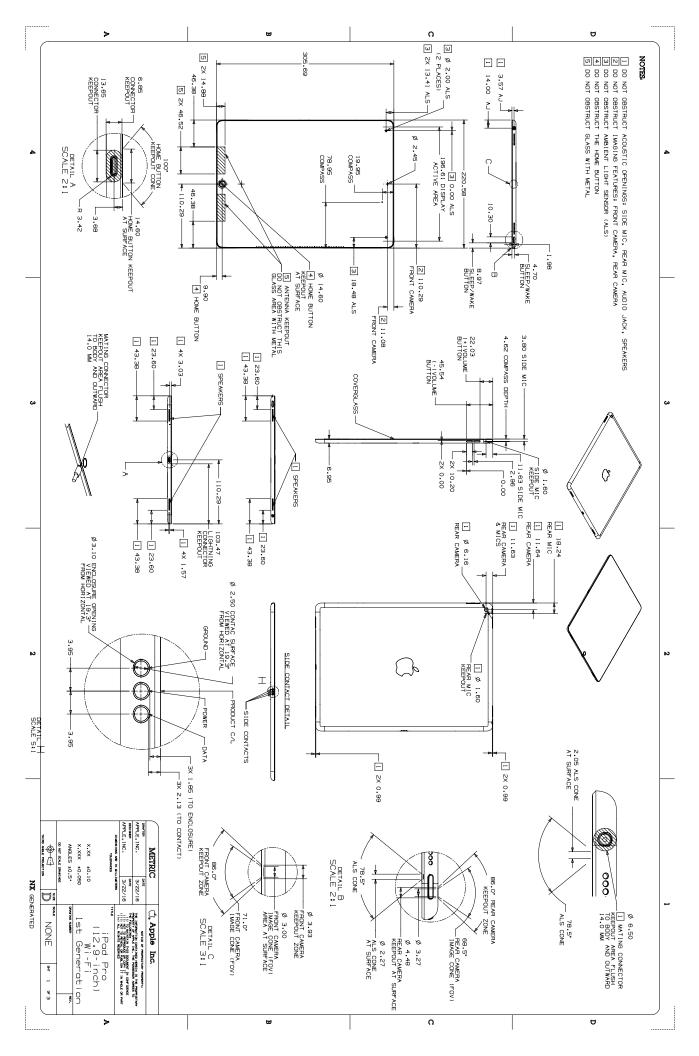
45.130 iPad Pro 9.7-inch Magnet/Hall Effect Sensors 1 of 2



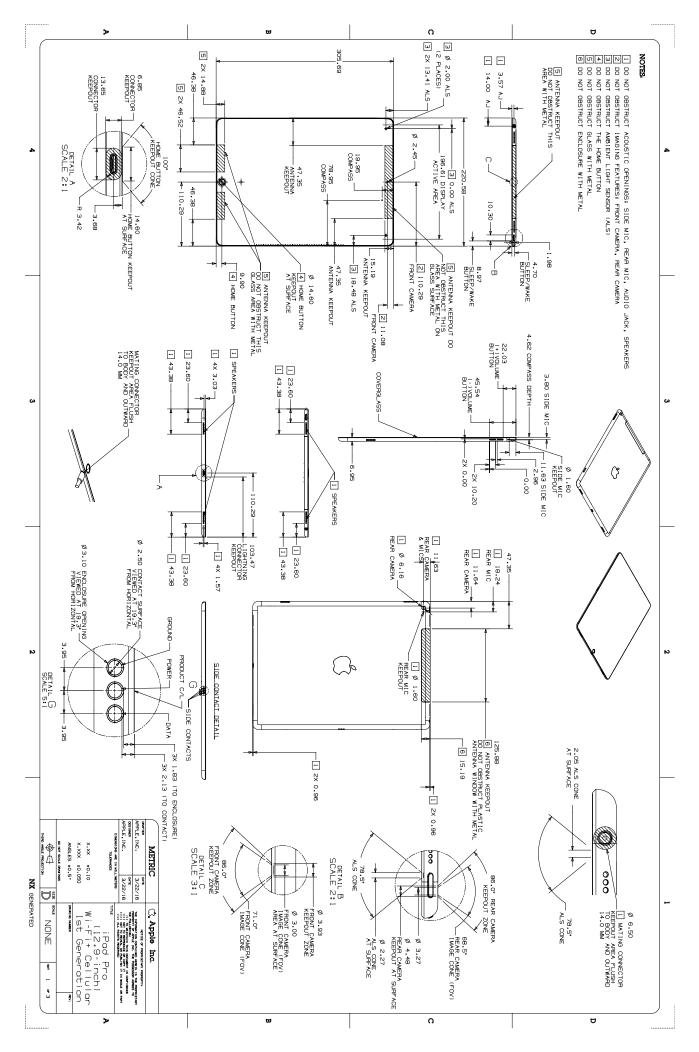
45.131 iPad Pro 9.7-inch Magnet/Hall Effect Sensors 2 of 2



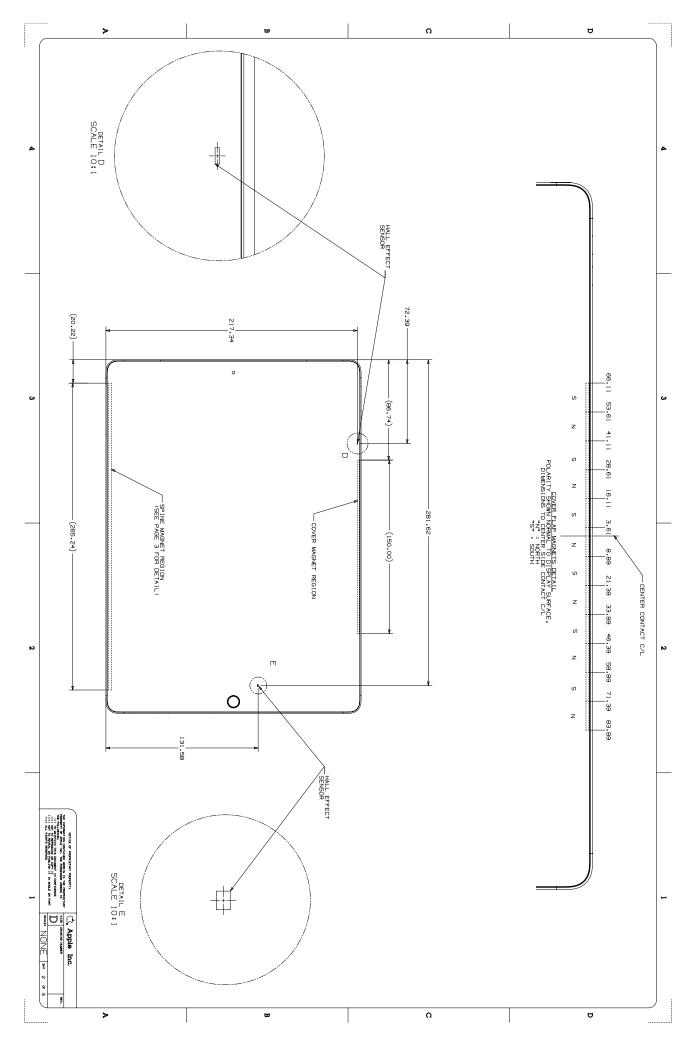
45.132 iPad Pro 12.9-inch (1st generation) with Wi-Fi



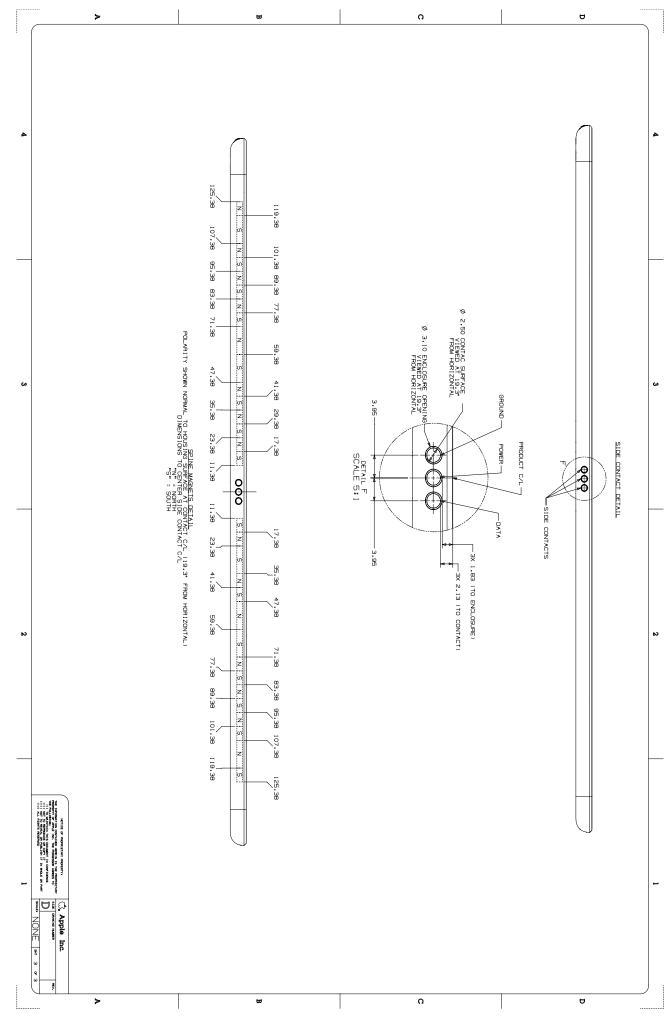
45.133 iPad Pro 12.9-inch (1st generation) with Wi-Fi + Cellular



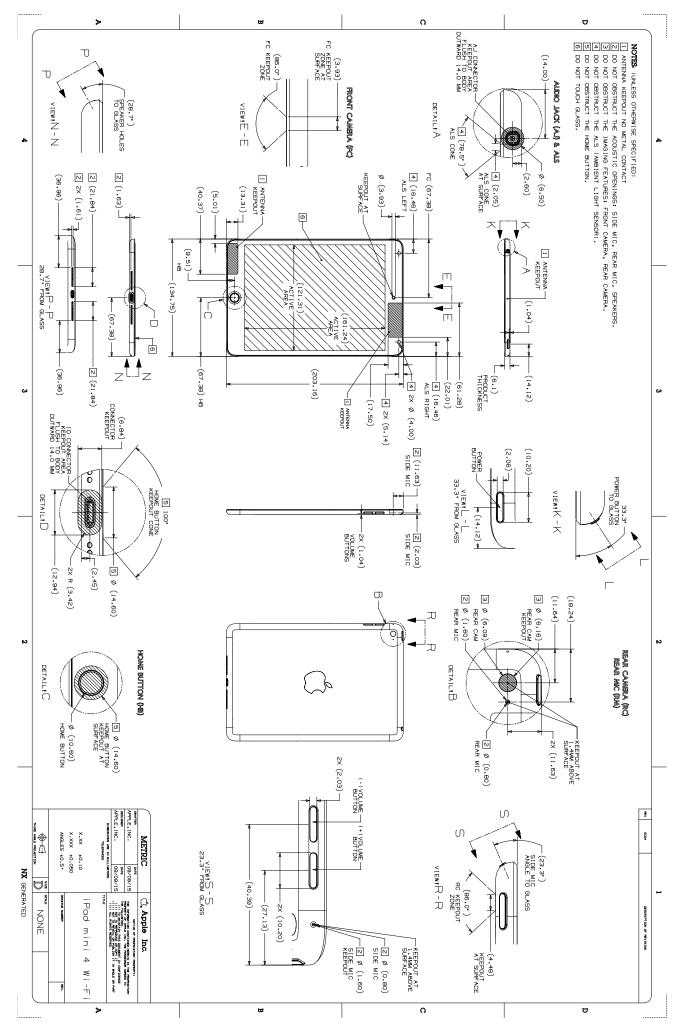
45.134 iPad Pro 12.9-inch (1st generation) Magnet/Hall Effect Sensors 1 of 2

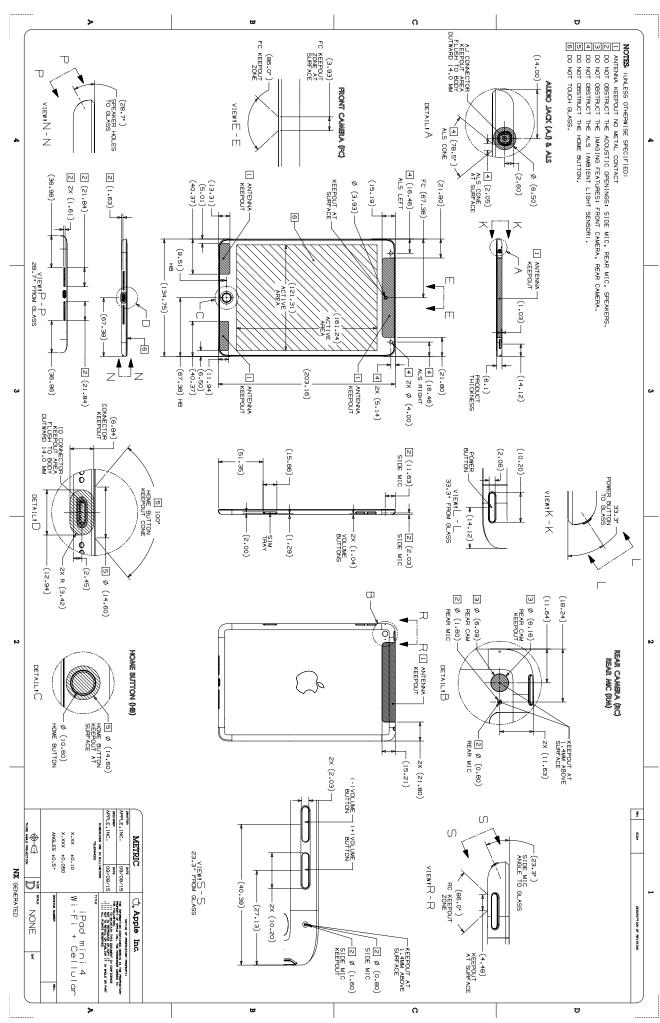


45.135 iPad Pro 12.9-inch (1st generation) Magnet/Hall Effect Sensors 2 of 2

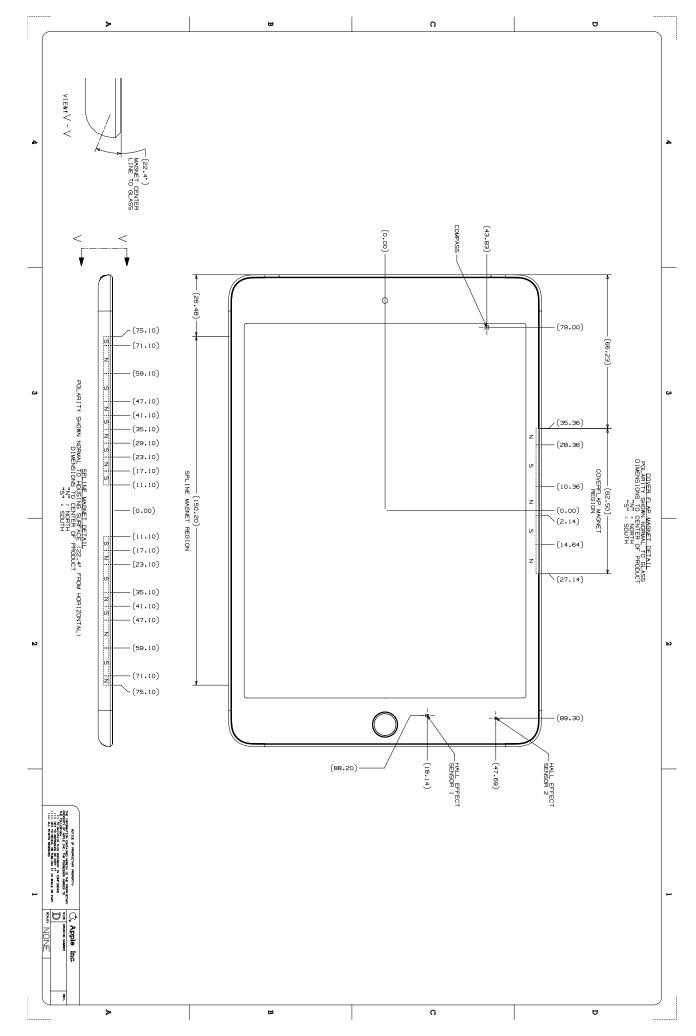


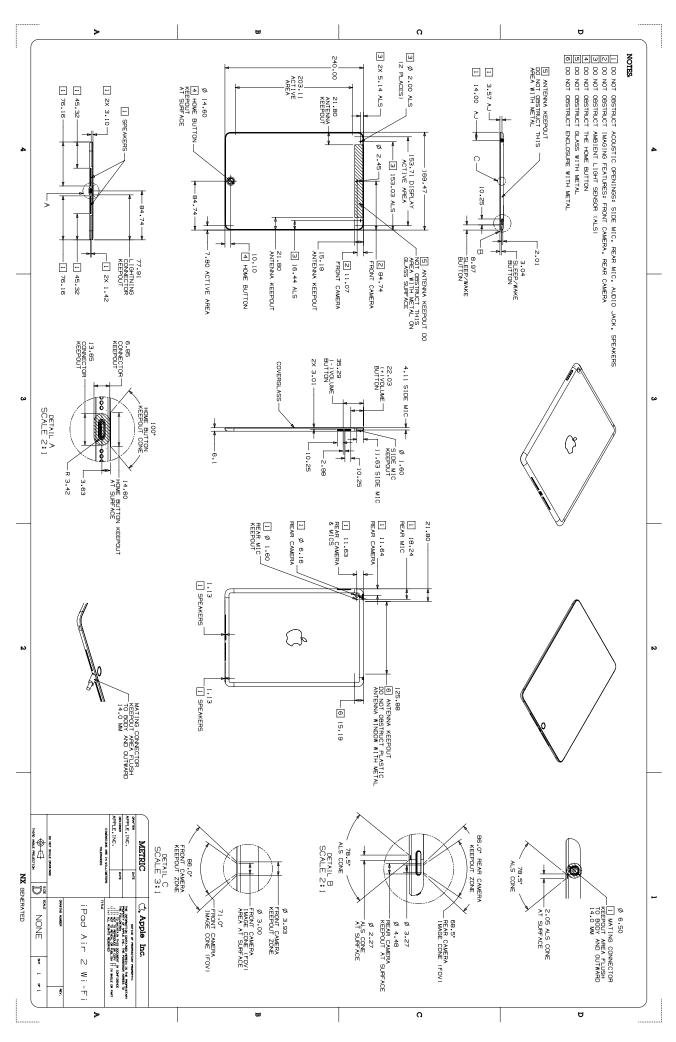
45.136 iPad mini 4 with Wi-Fi

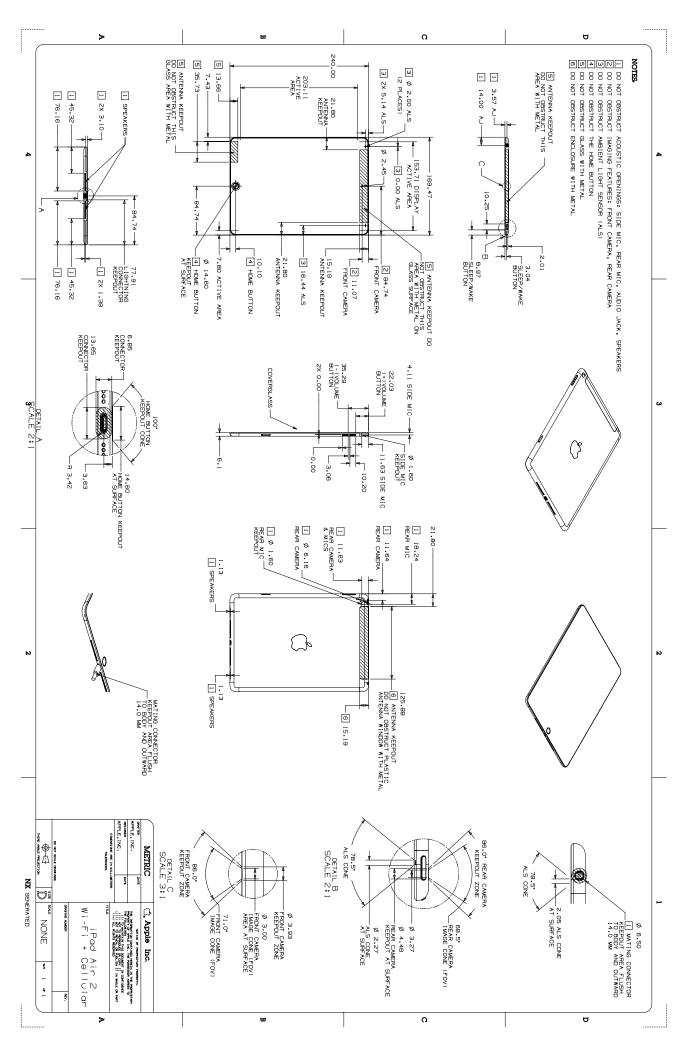




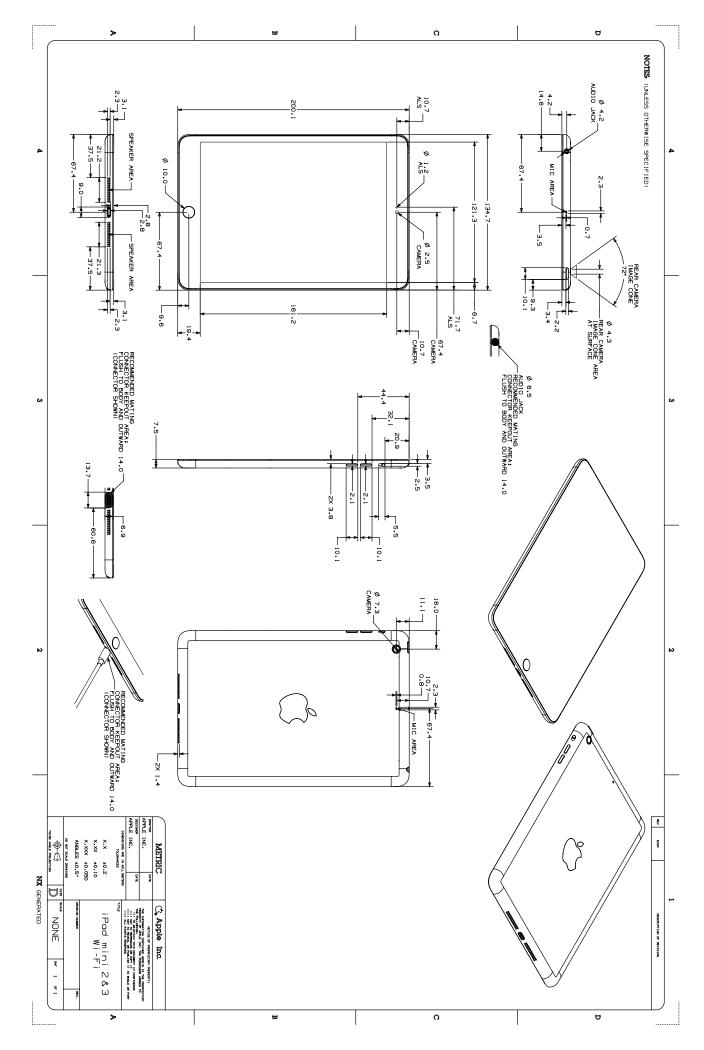
45.138 iPad mini 4 Magnet/Hall Effect Sensors



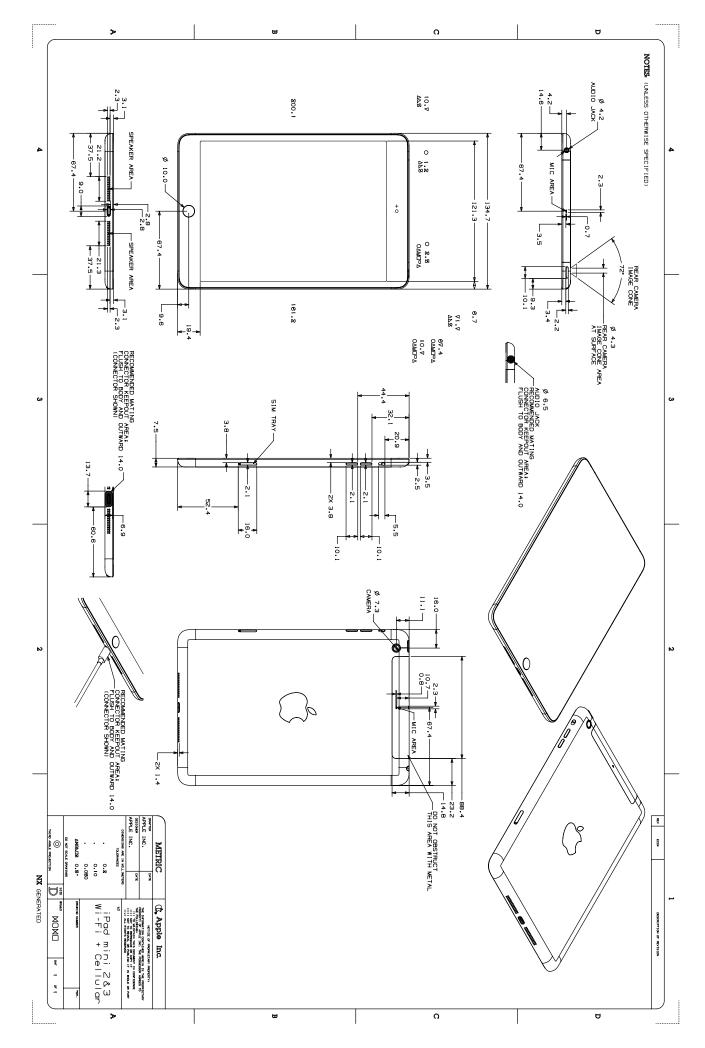


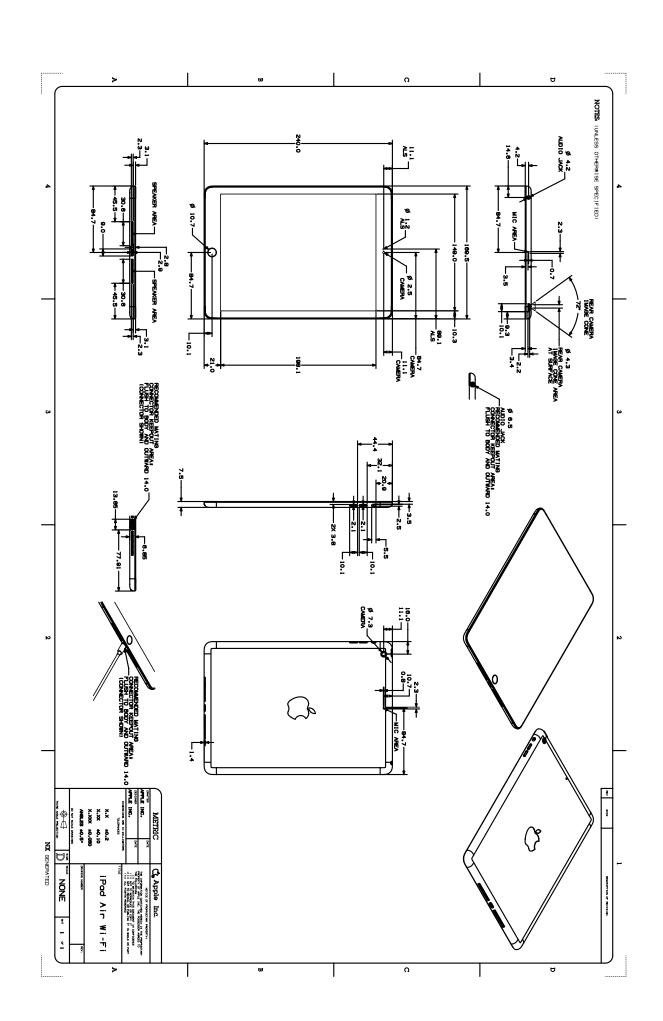


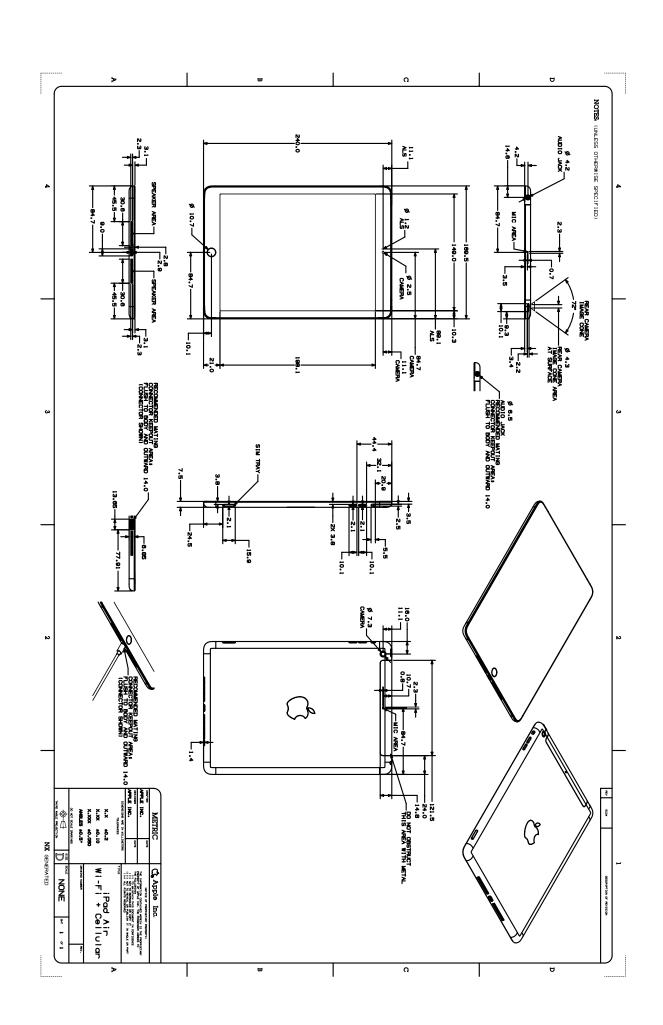
45.141 iPad mini 2 and iPad mini 3 with Wi-Fi



45.142 iPad mini 2 and iPad mini 3 with Wi-Fi + Cellular

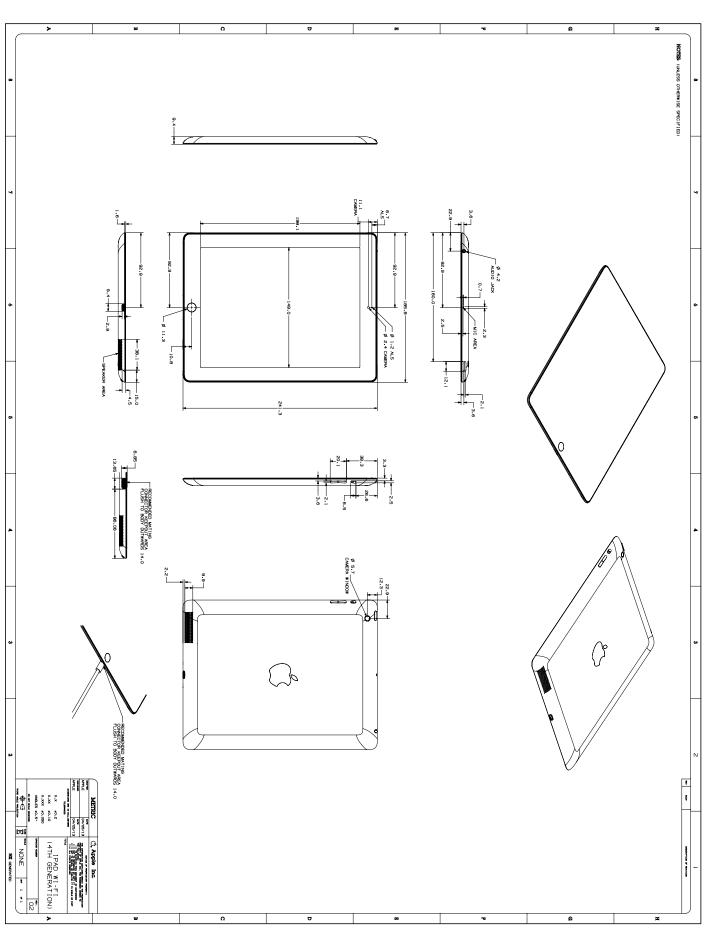




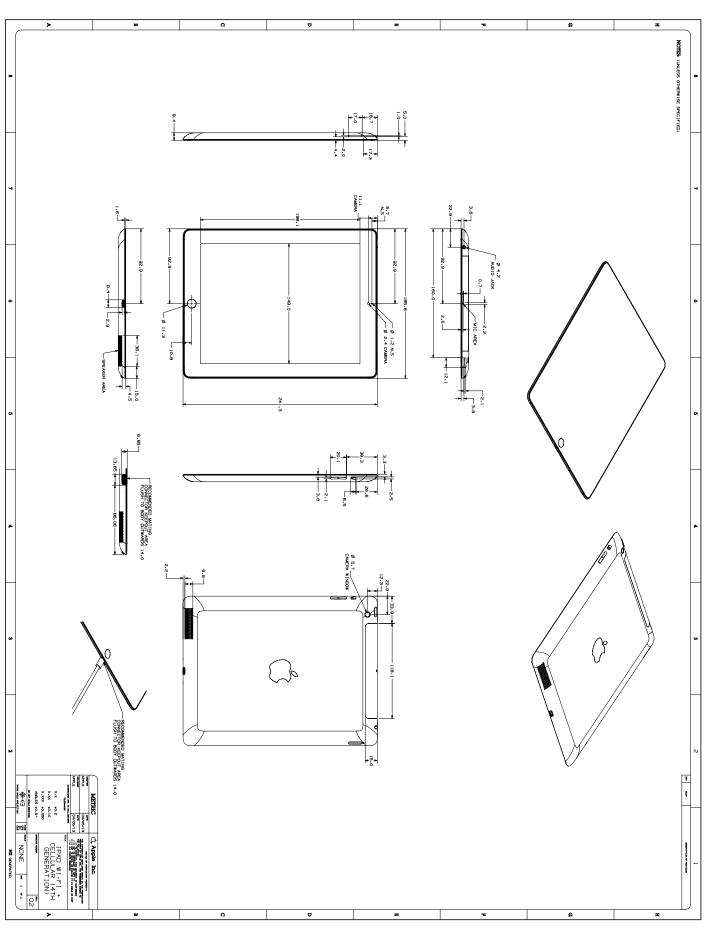


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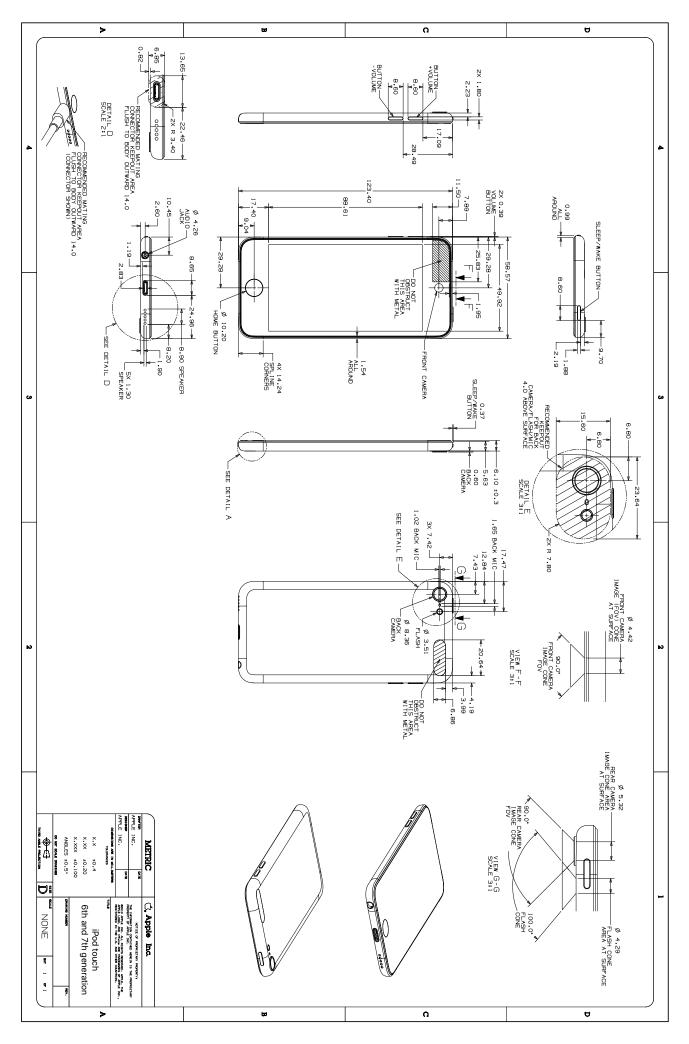
45.147 iPad (4th generation) with Wi-Fi

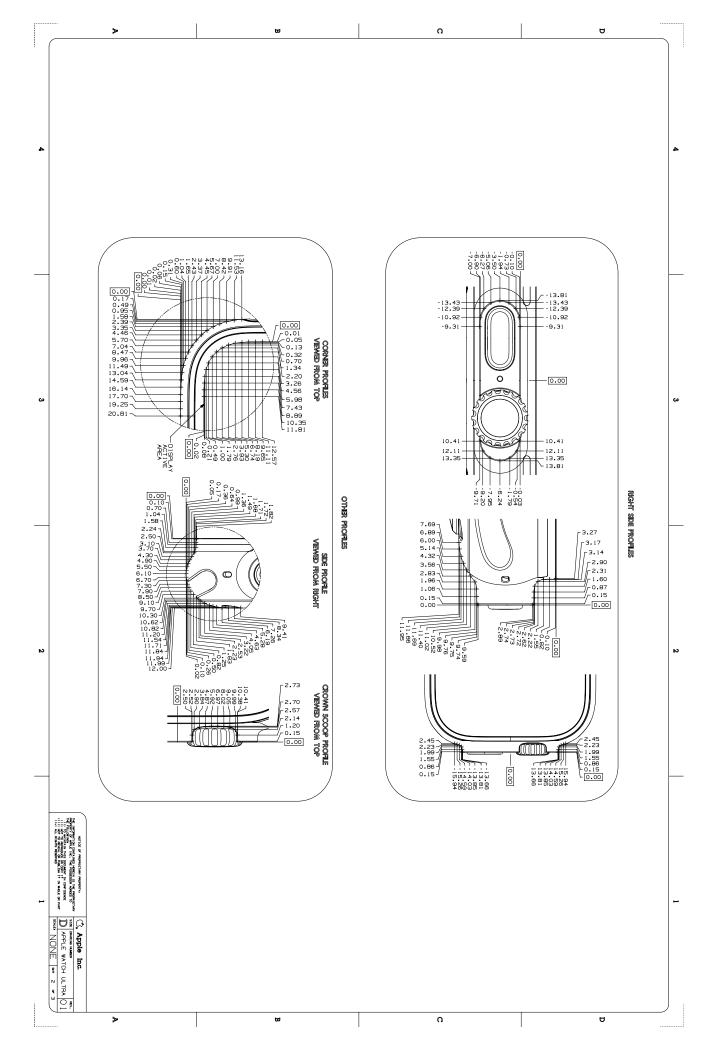


45.148 iPad (4th generation) with Wi-Fi + Cellular

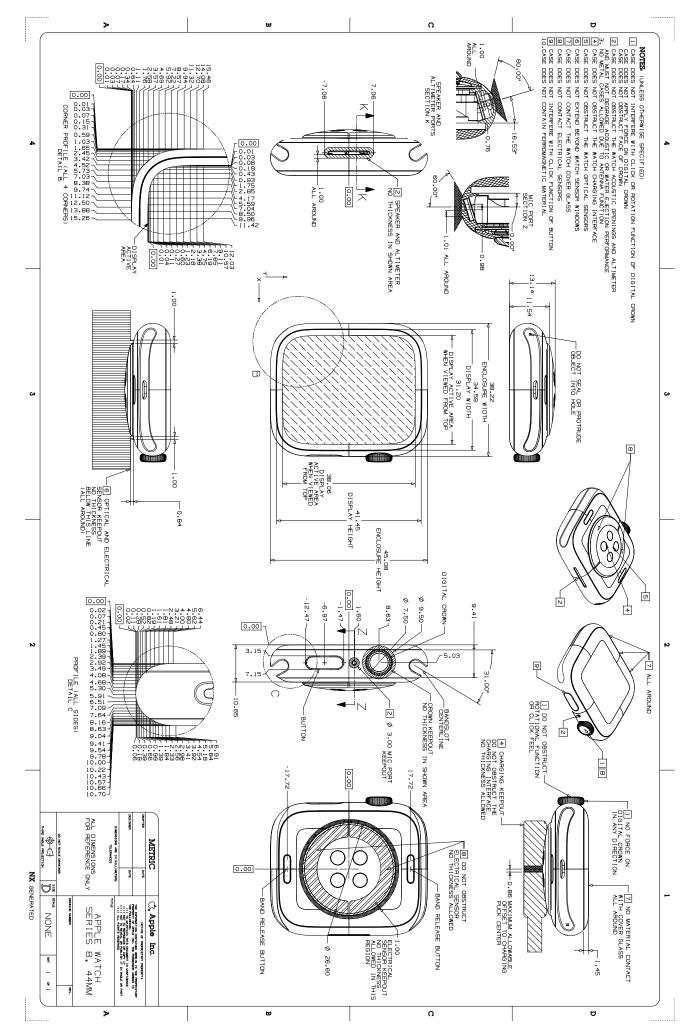


45.149 iPod touch (6th generation) and iPod touch (7th generation)

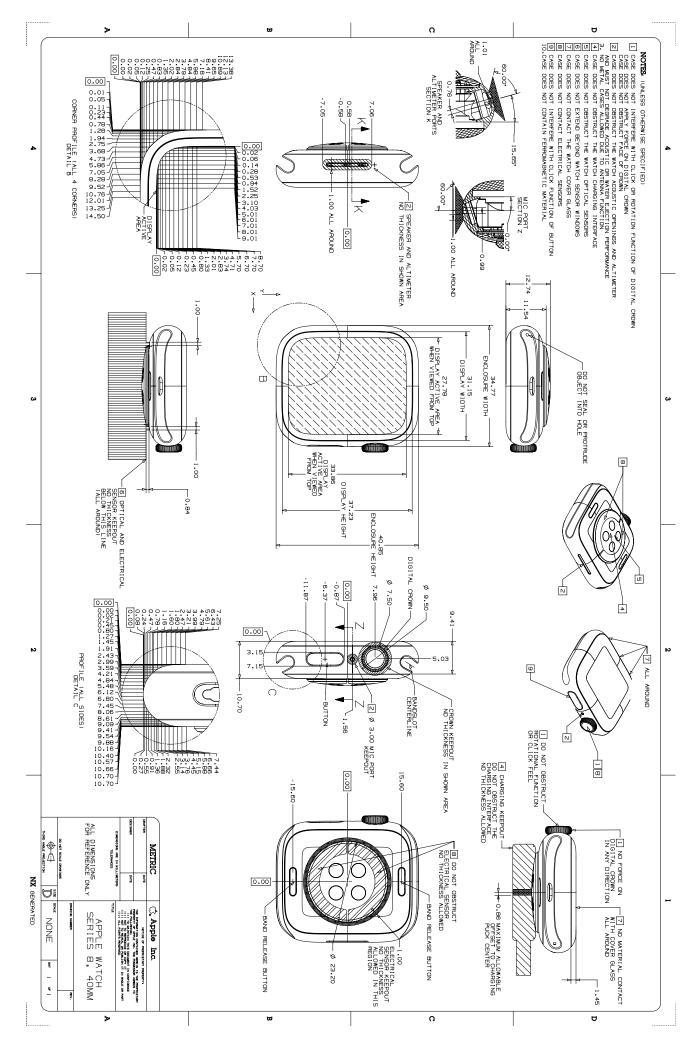




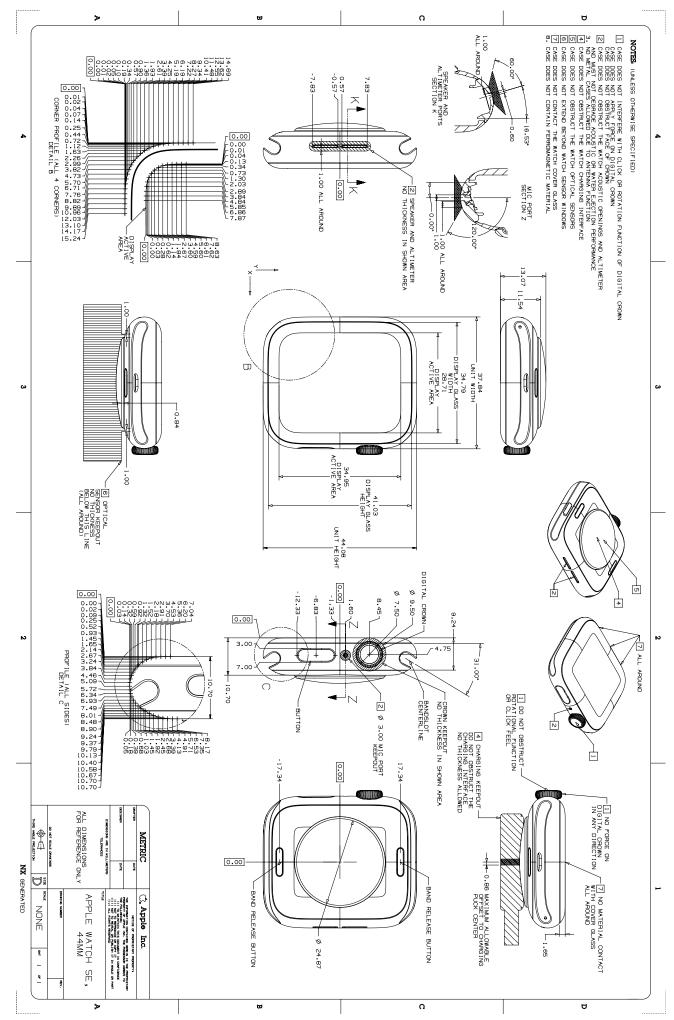
45.154 Apple Watch Series 8, 45 mm



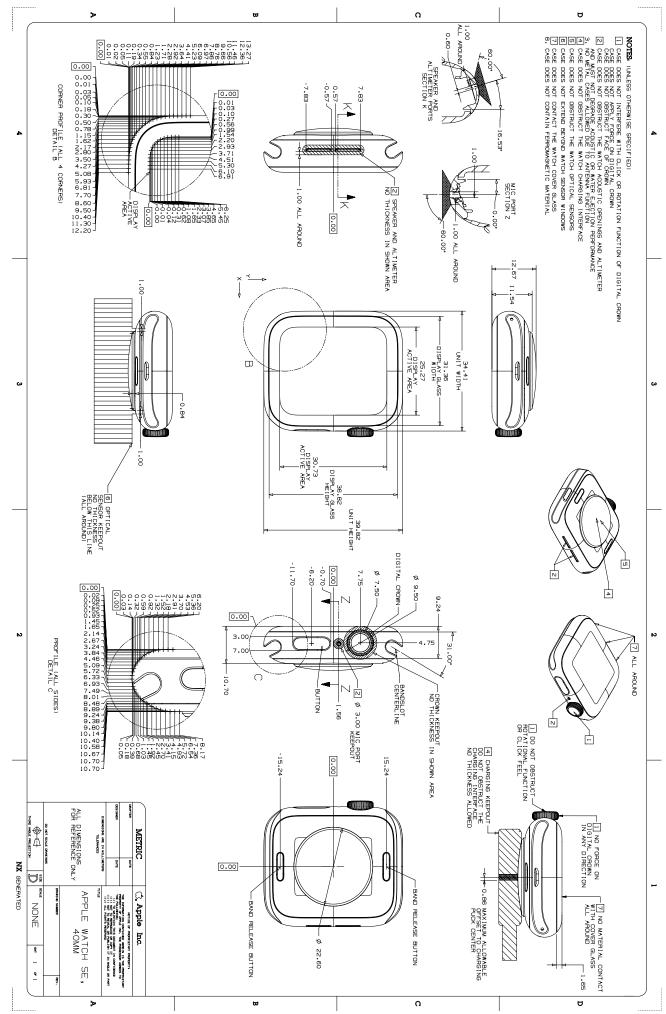
45.155 Apple Watch Series 8, 41 mm



45.156 Apple Watch SE, 44 mm

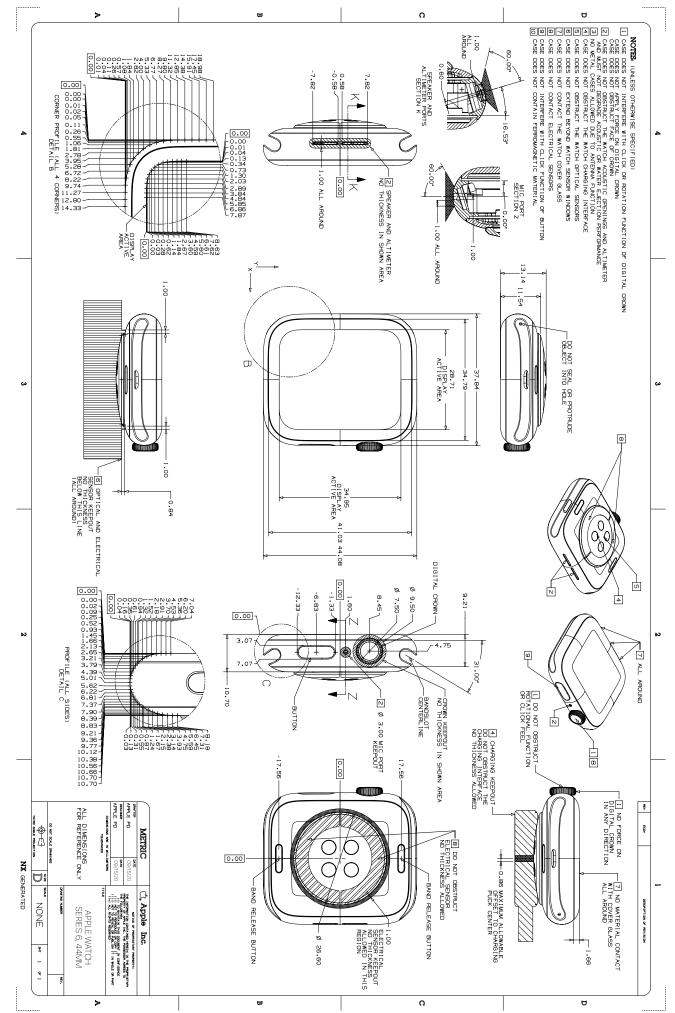


45.157 Apple Watch SE, 40 mm

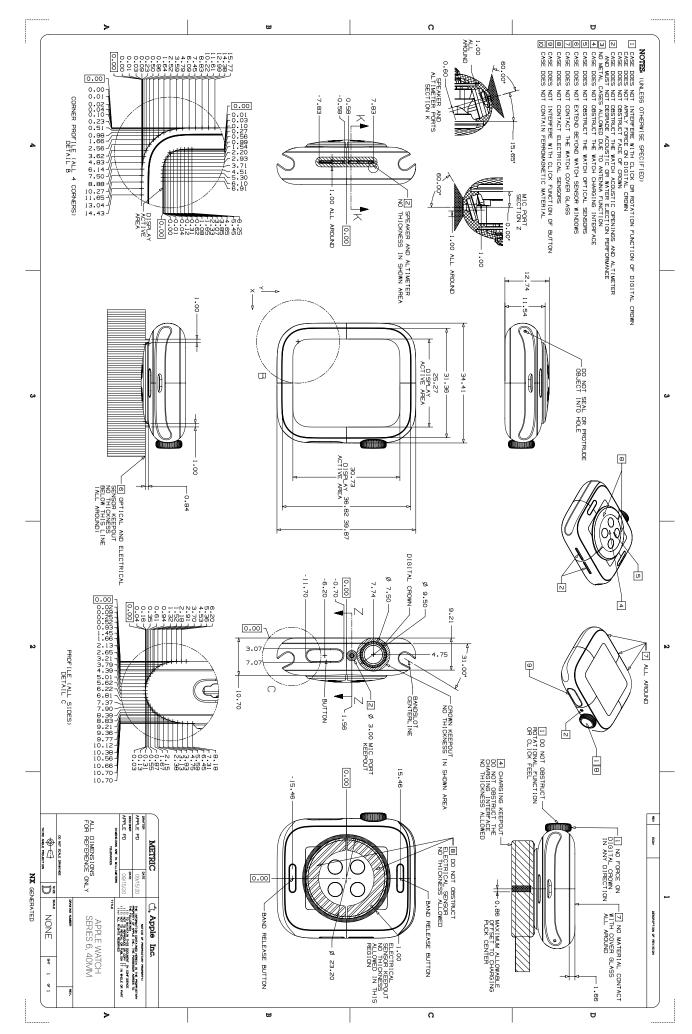


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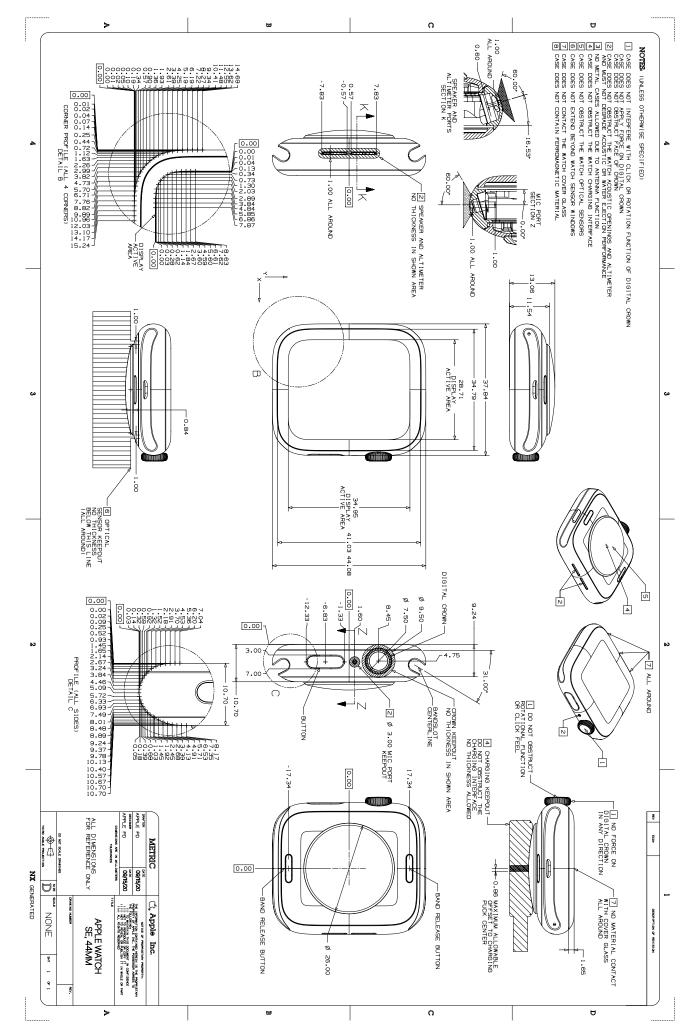
45.160 Apple Watch Series 6, 44 mm



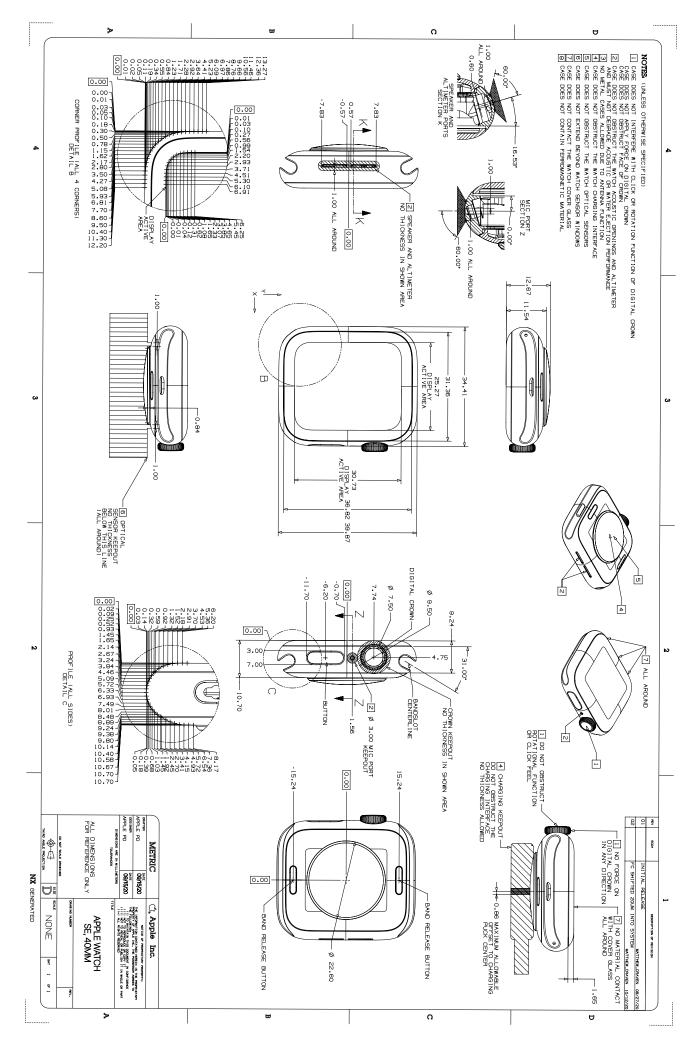
45.161 Apple Watch Series 6, 40 mm



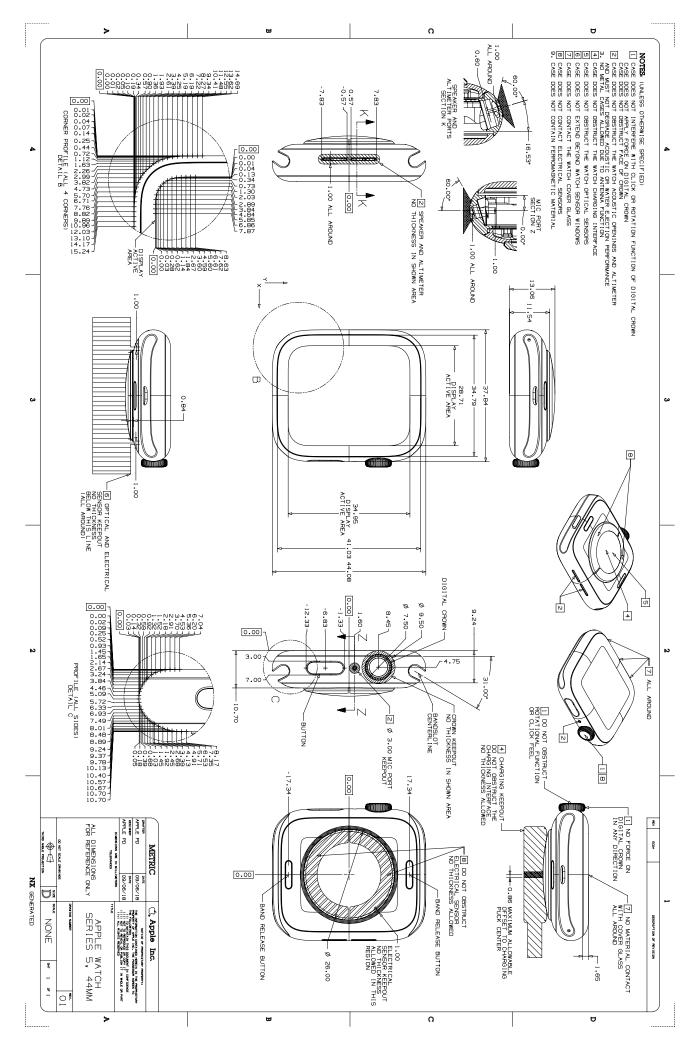
45.162 Apple Watch SE (1st generation), 44 mm



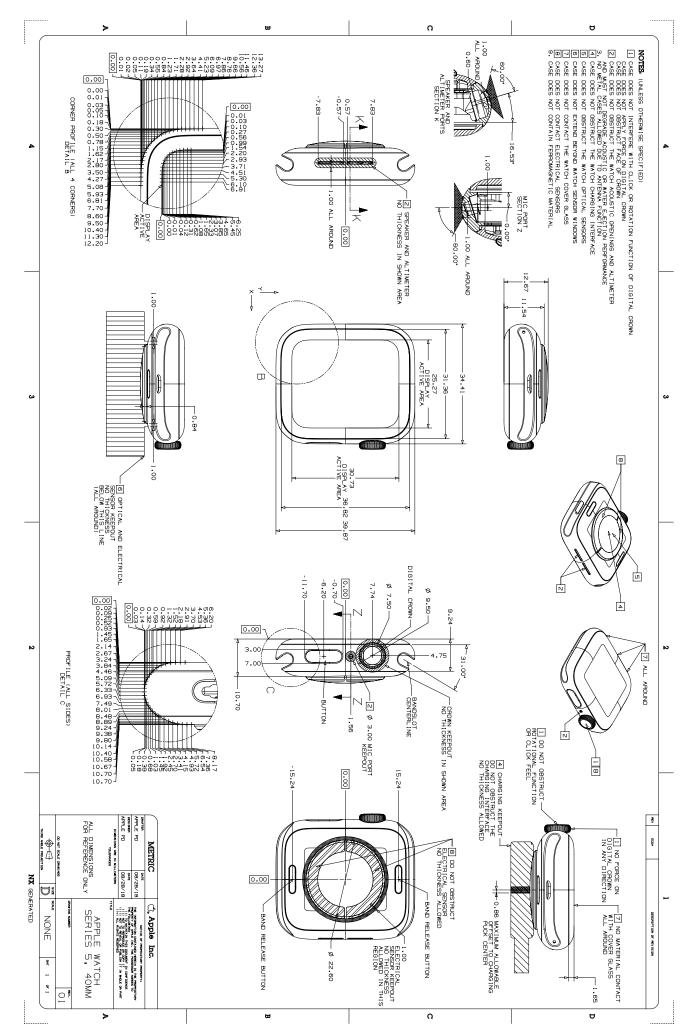
45.163 Apple Watch SE (1st generation), 40 mm



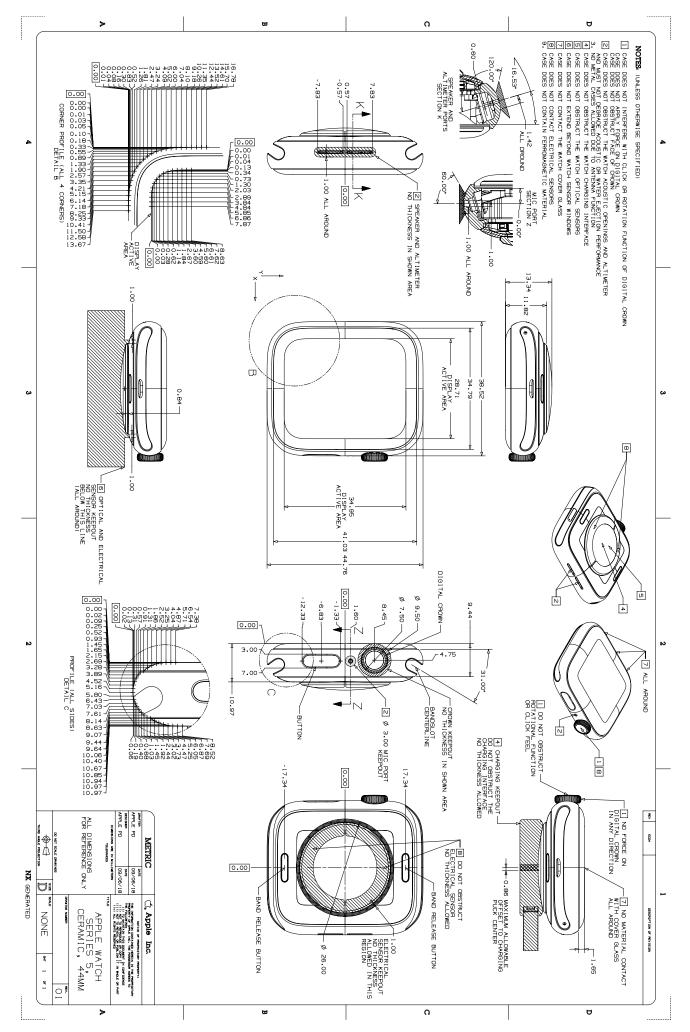
45.164 Apple Watch Series 5, 44 mm



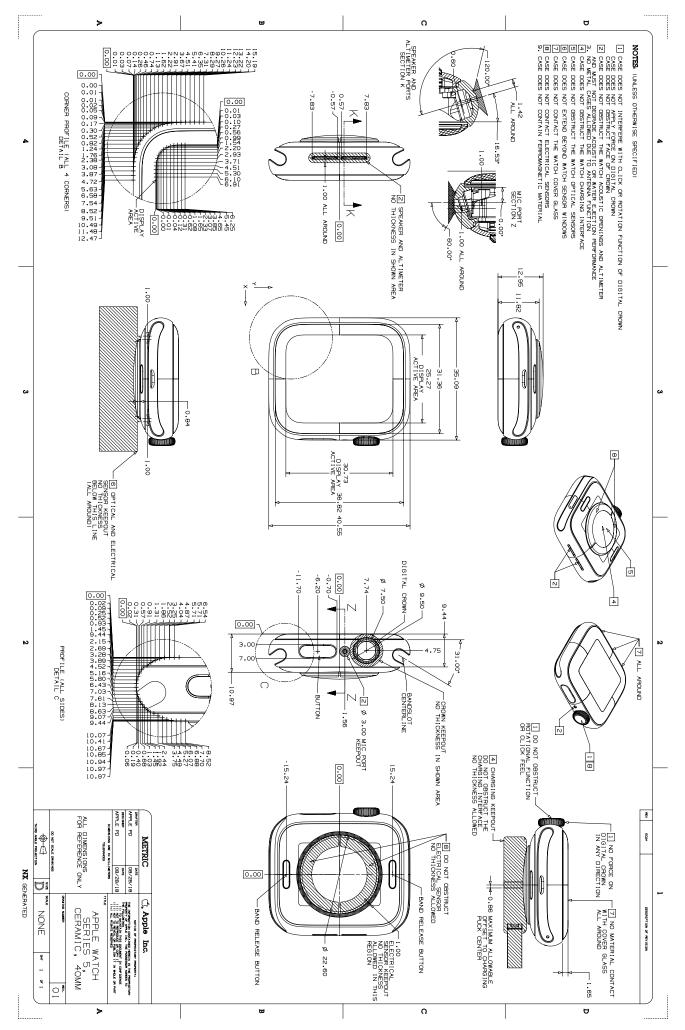
45.165 Apple Watch Series 5, 40 mm



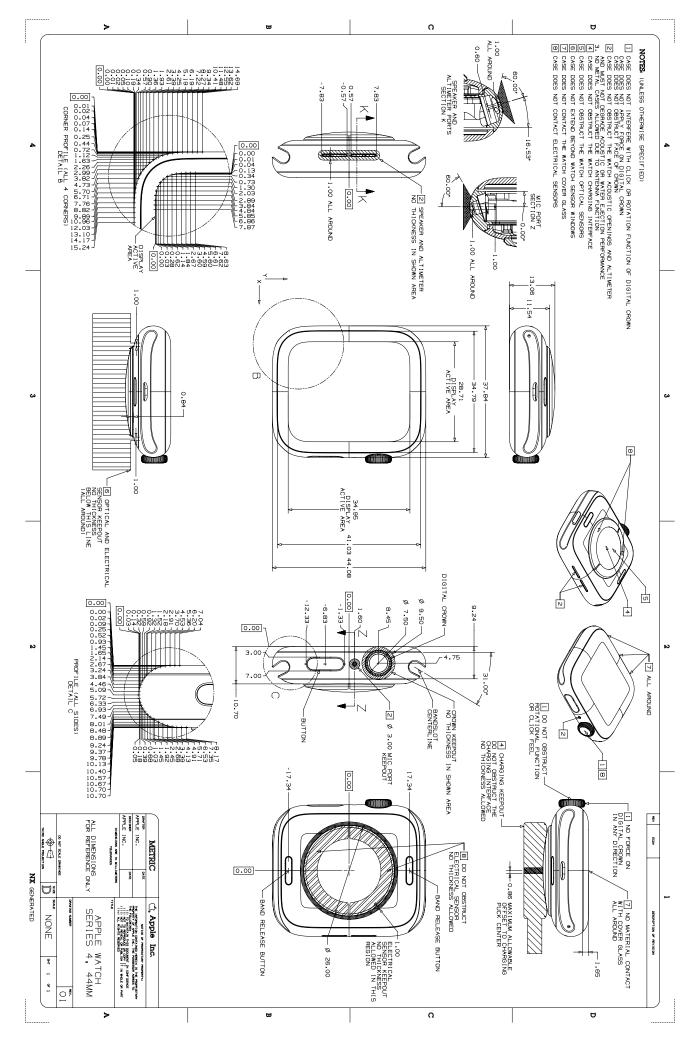
45.166 Apple Watch Series 5 Ceramic, 44 mm



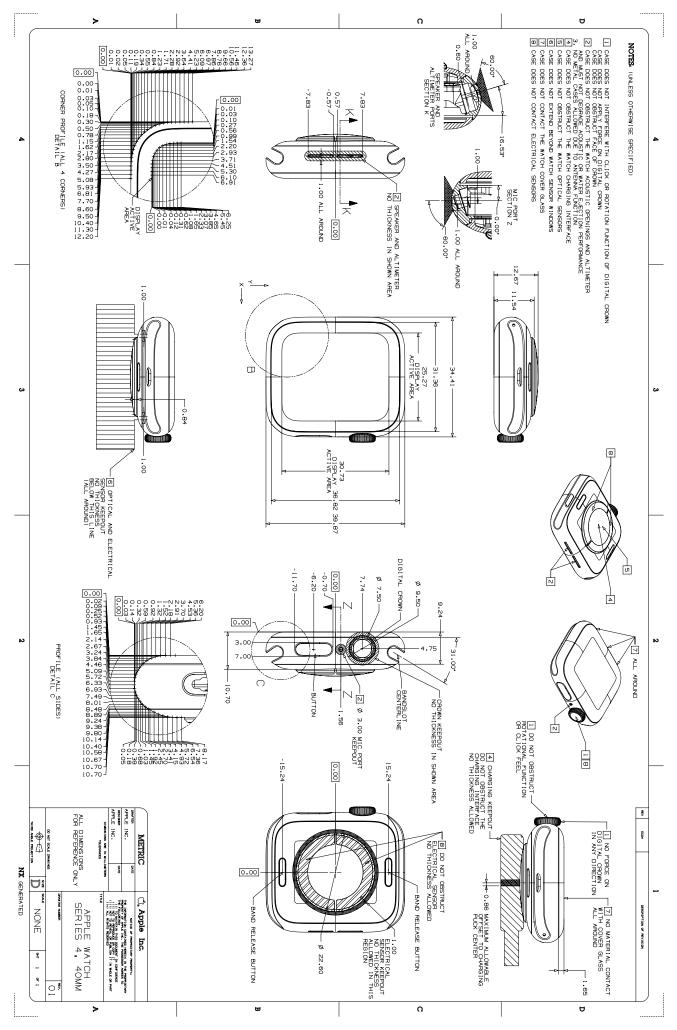
45.167 Apple Watch Series 5 Ceramic, 40 mm



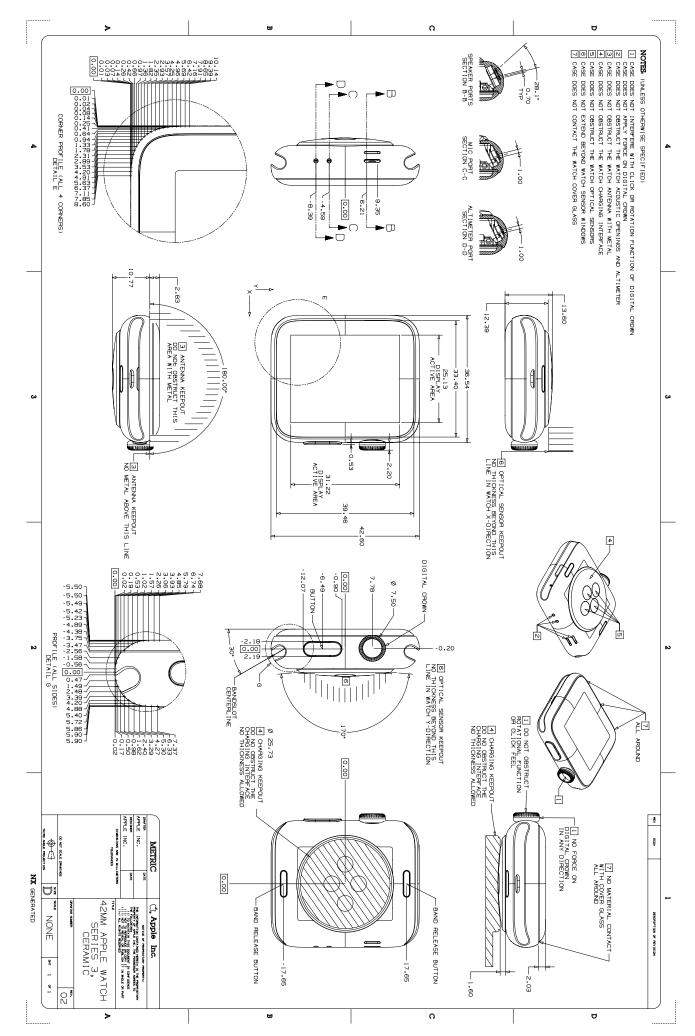
45.168 Apple Watch Series 4, 44 mm



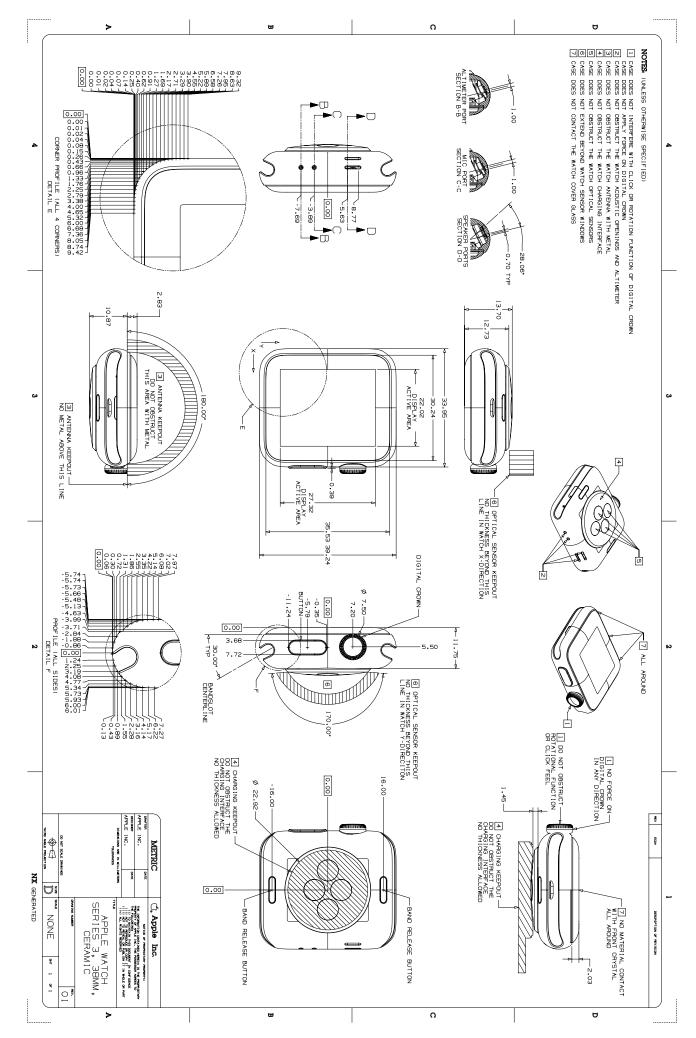
45.169 Apple Watch Series 4, 40 mm



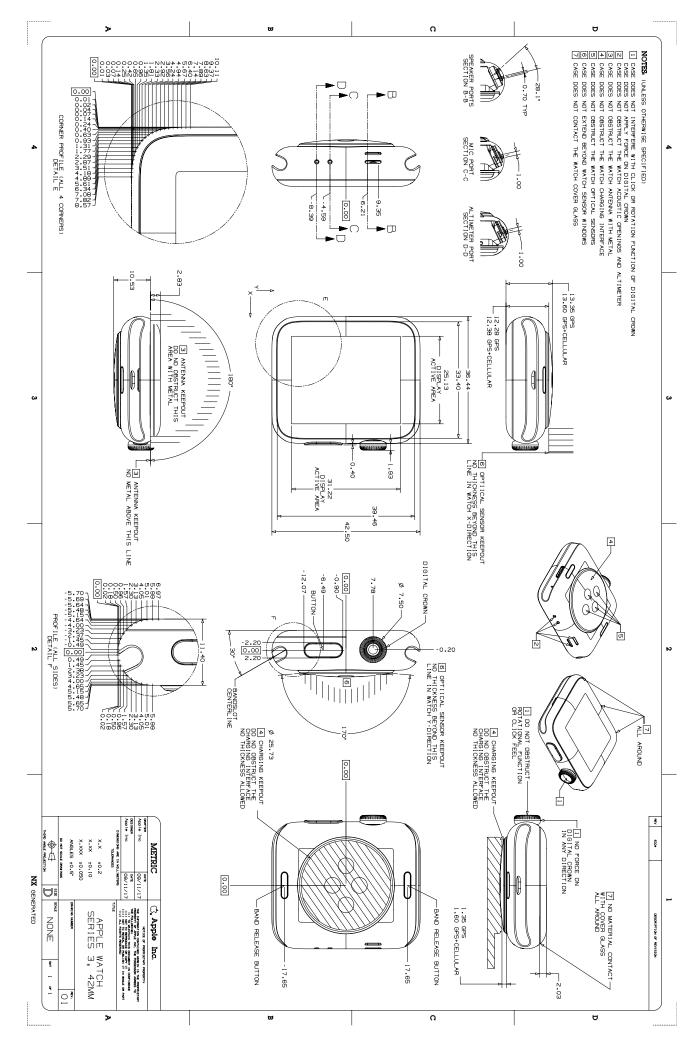
45.170 Apple Watch Series 3 Ceramic, 42 mm



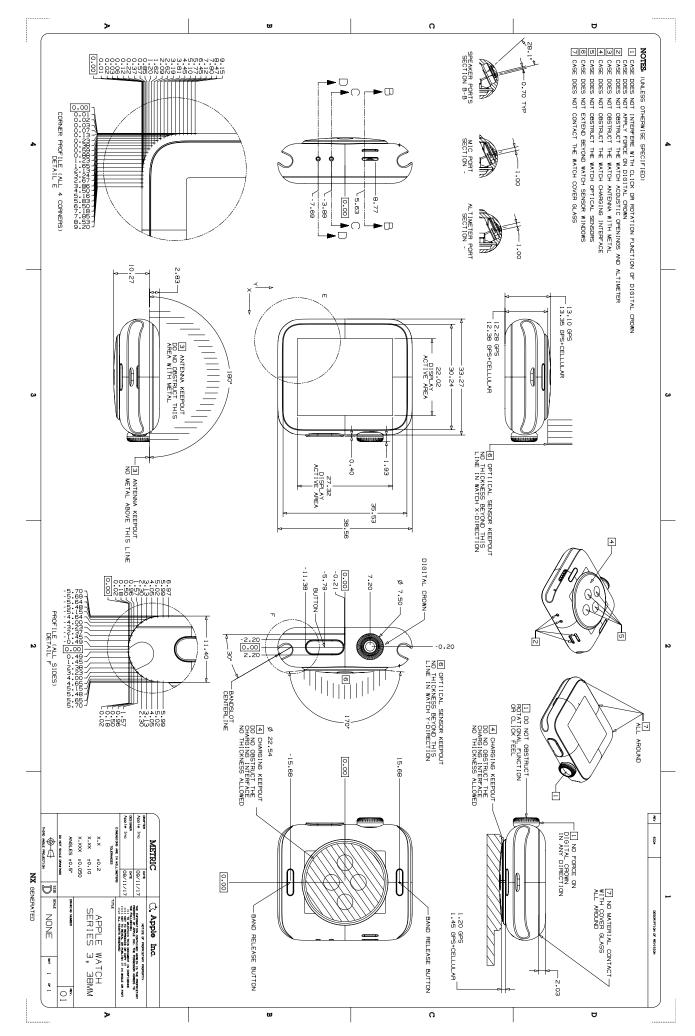
45.171 Apple Watch Series 3 Ceramic, 38 mm



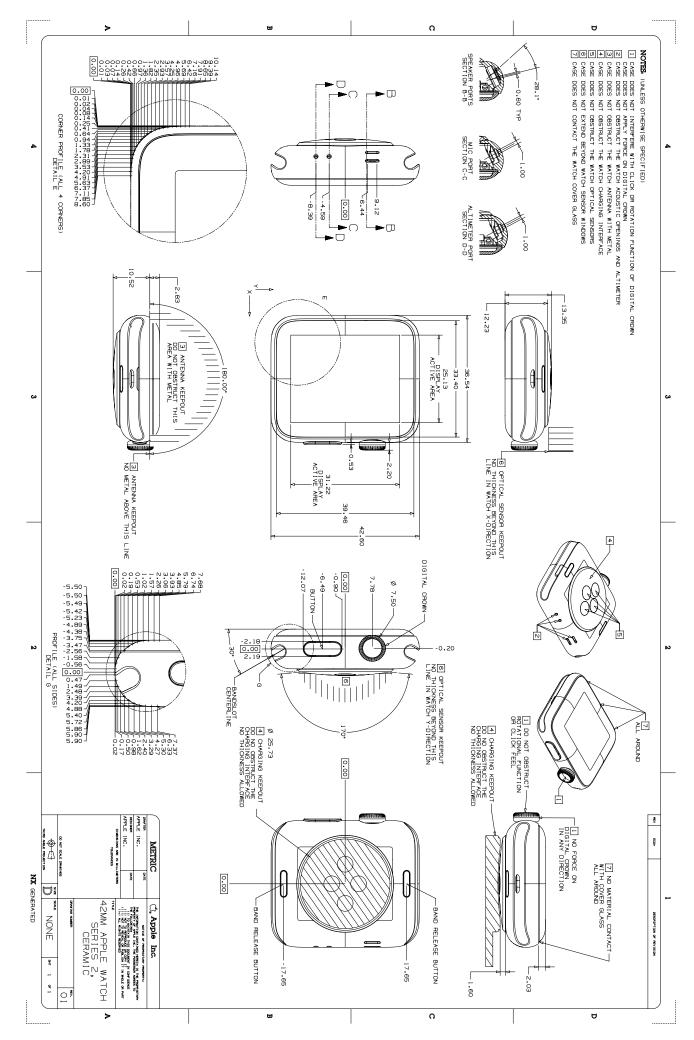
45.172 Apple Watch Series 3 Metal, 42 mm



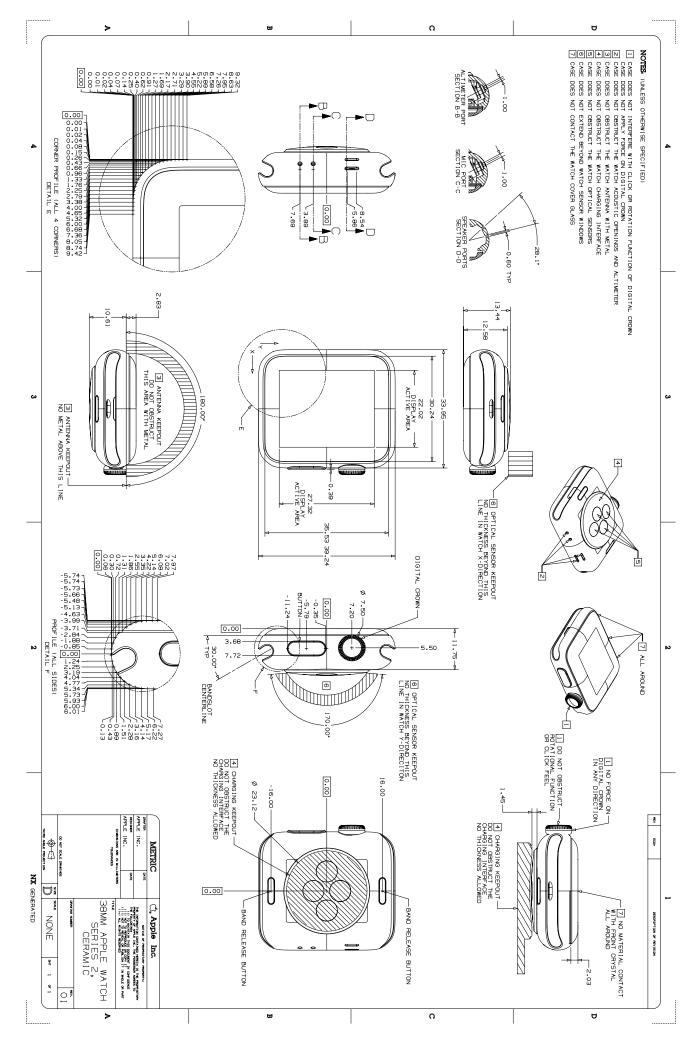
45.173 Apple Watch Series 3 Metal, 38 mm



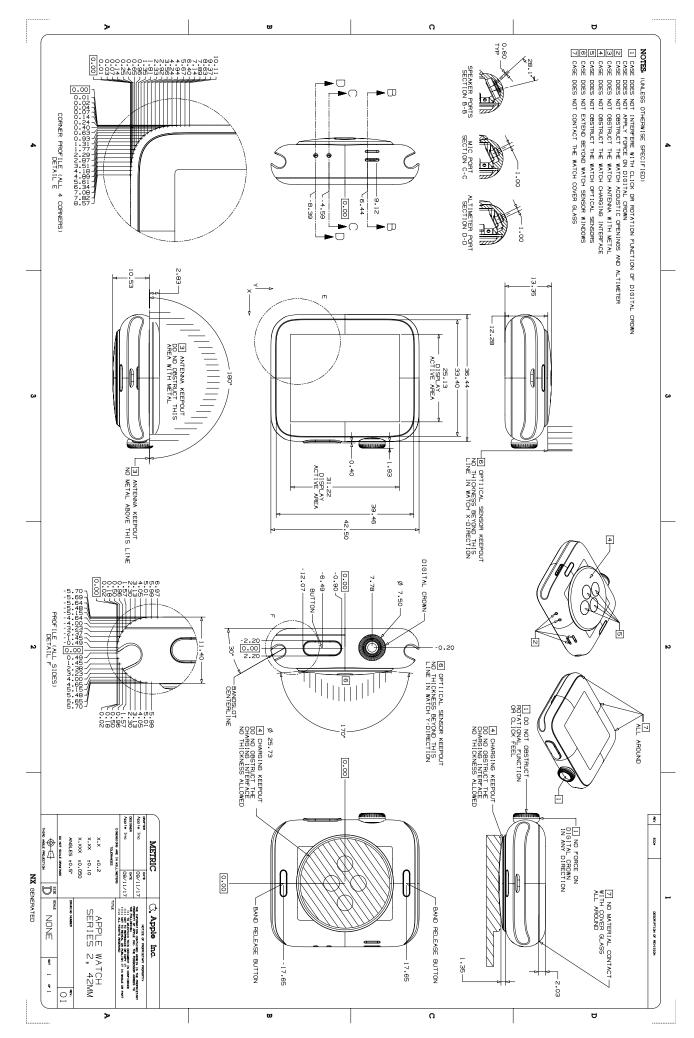
45.174 Apple Watch Series 2 Ceramic, 42 mm



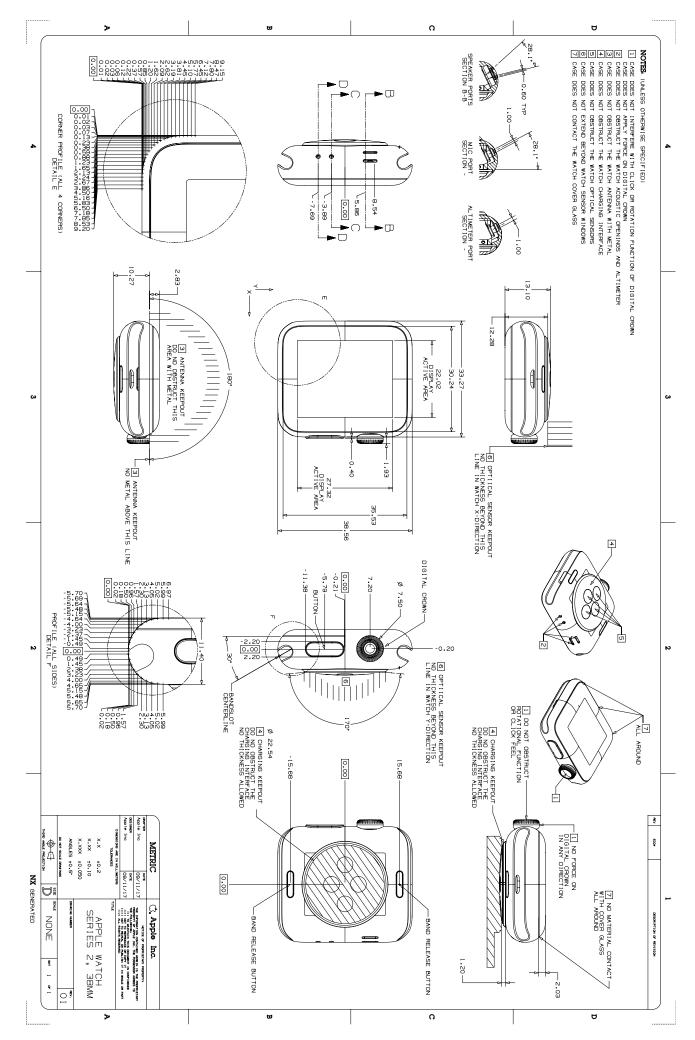
45.175 Apple Watch Series 2 Ceramic, 38 mm



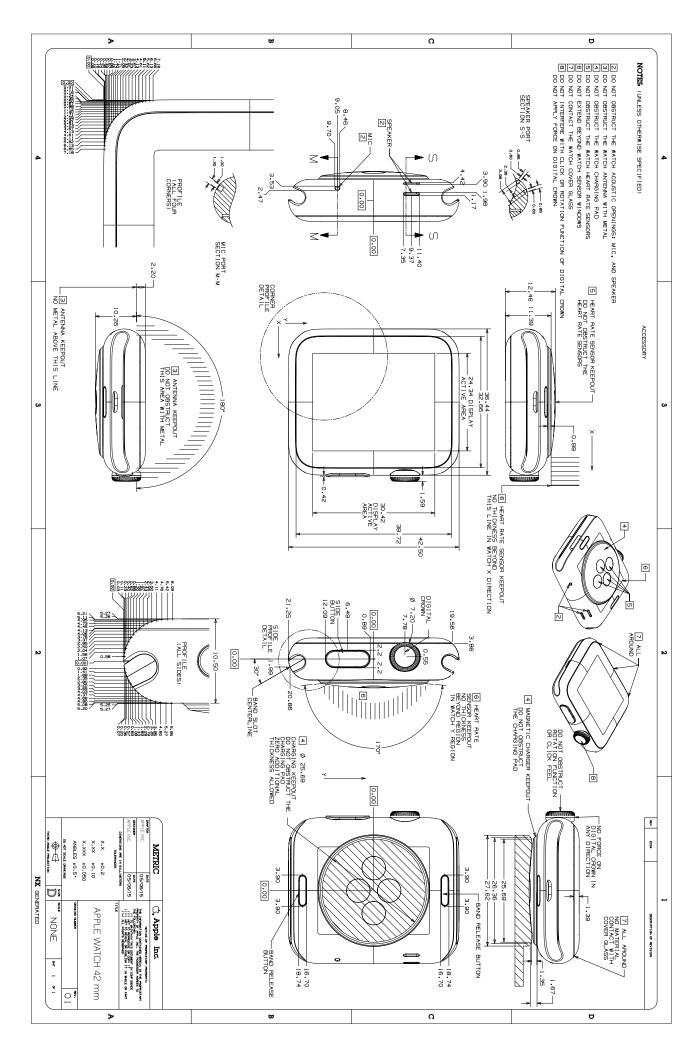
45.176 Apple Watch Series 2 Metal, 42 mm



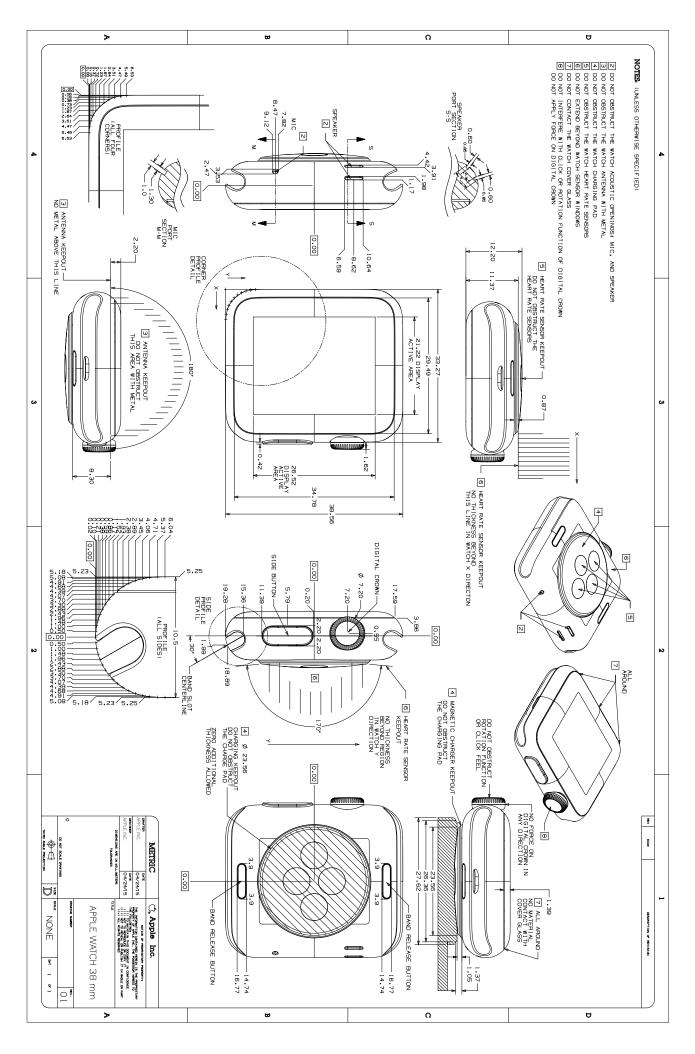
45.177 Apple Watch Series 2 Metal, 38 mm

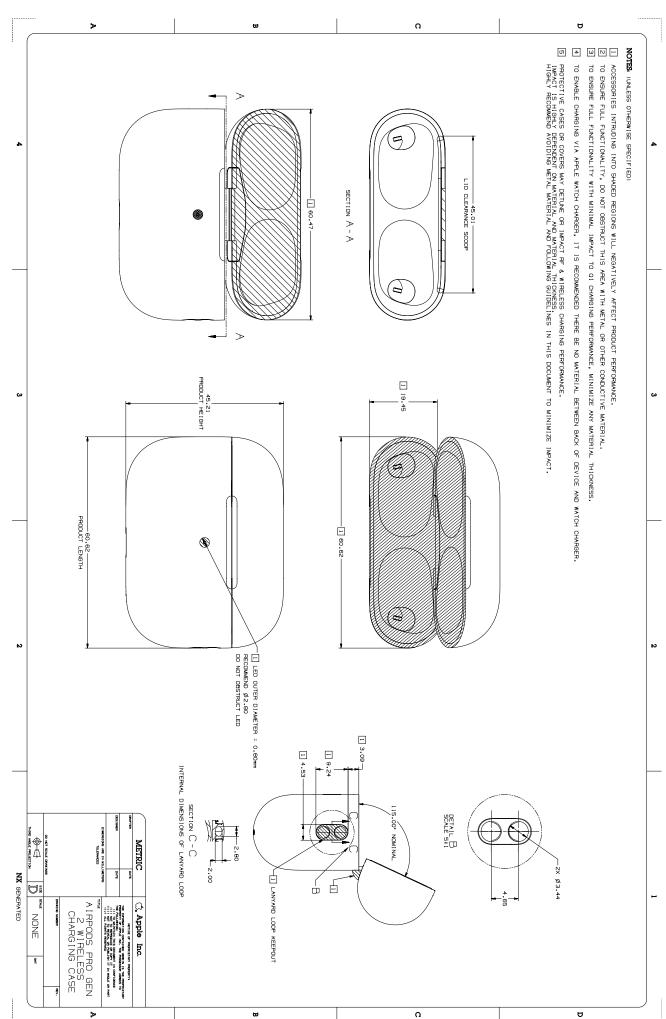


45.178 Apple Watch (1st generation) and Apple Watch Series 1, 42 mm

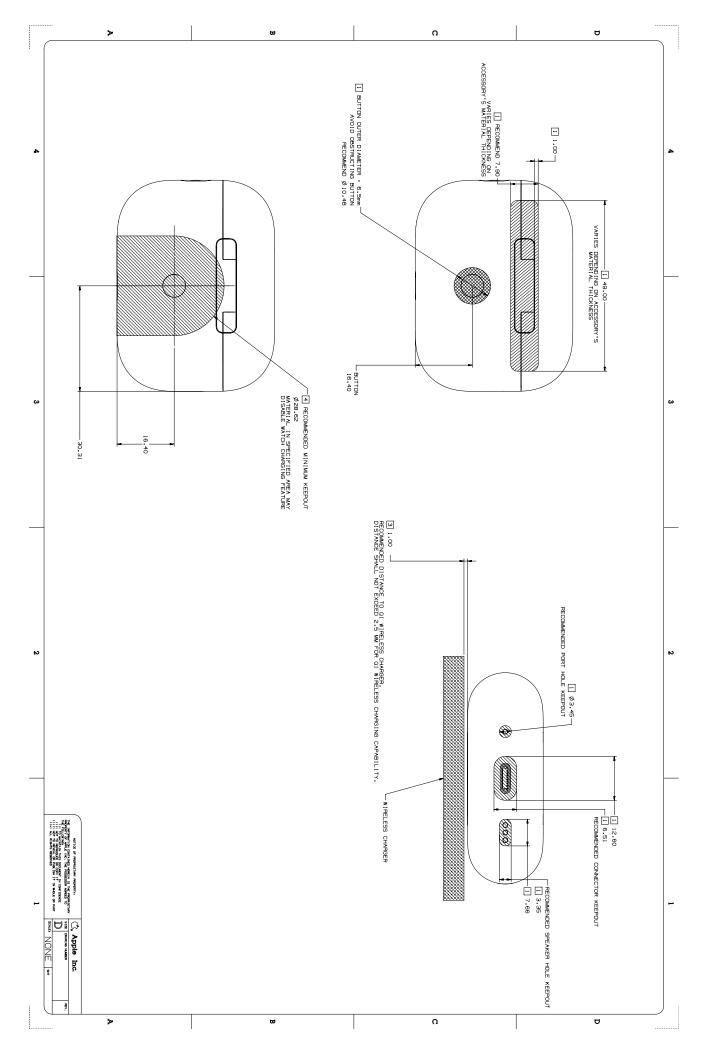


45.179 Apple Watch (1st generation) and Apple Watch Series 1, 38 mm

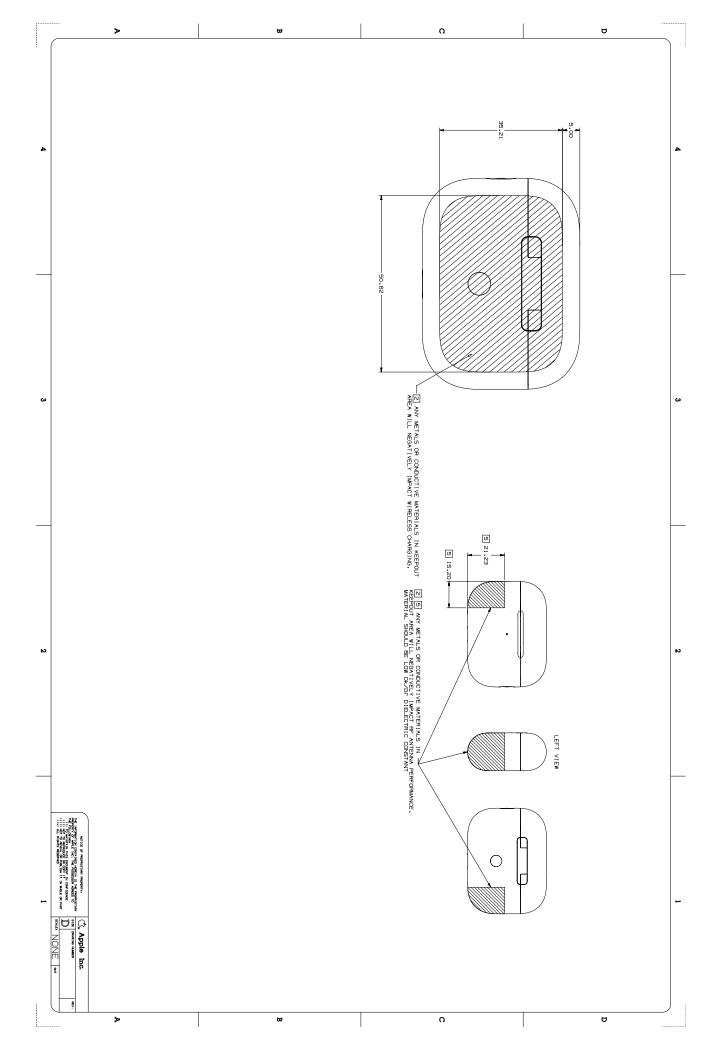


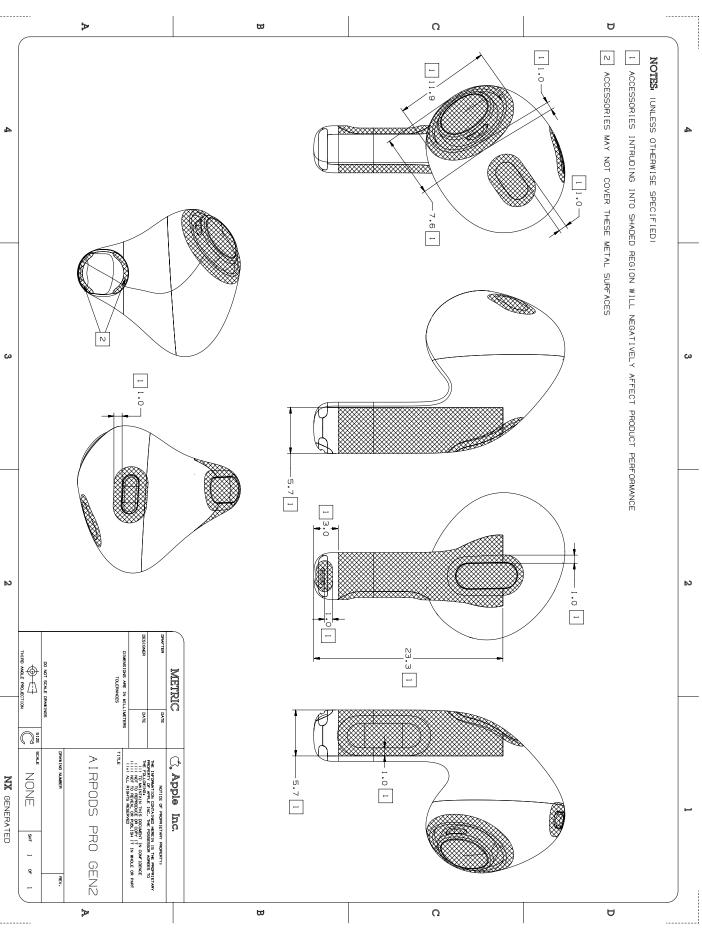


45.181 MagSafe Charging Case for AirPods Pro (2nd generation) 2 of 3

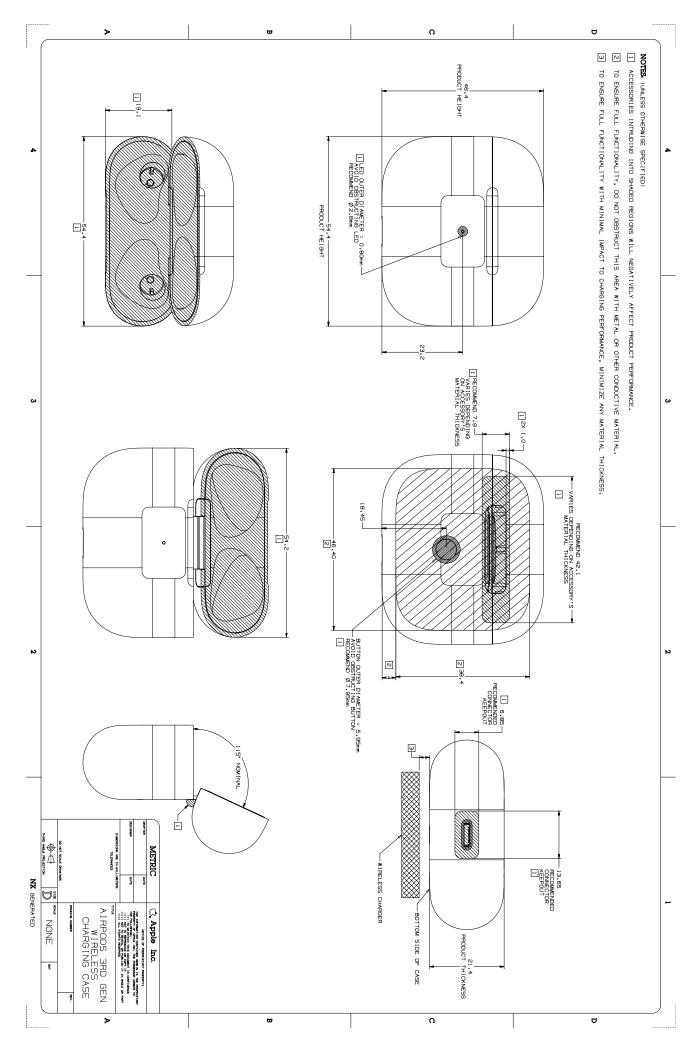


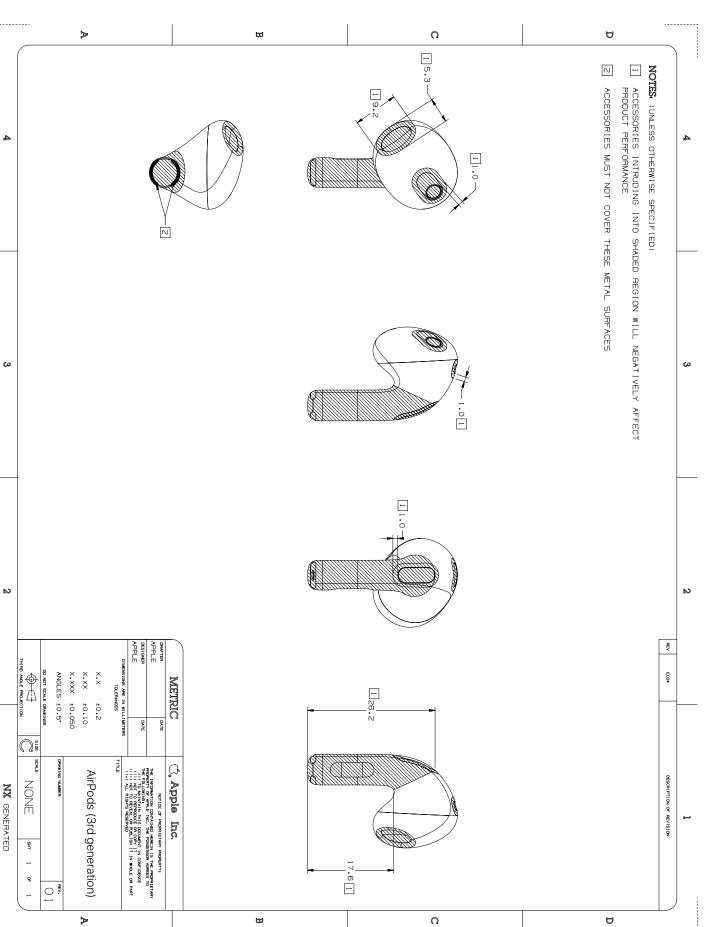
45.182 MagSafe Charging Case for AirPods Pro (2nd generation) 3 of 3



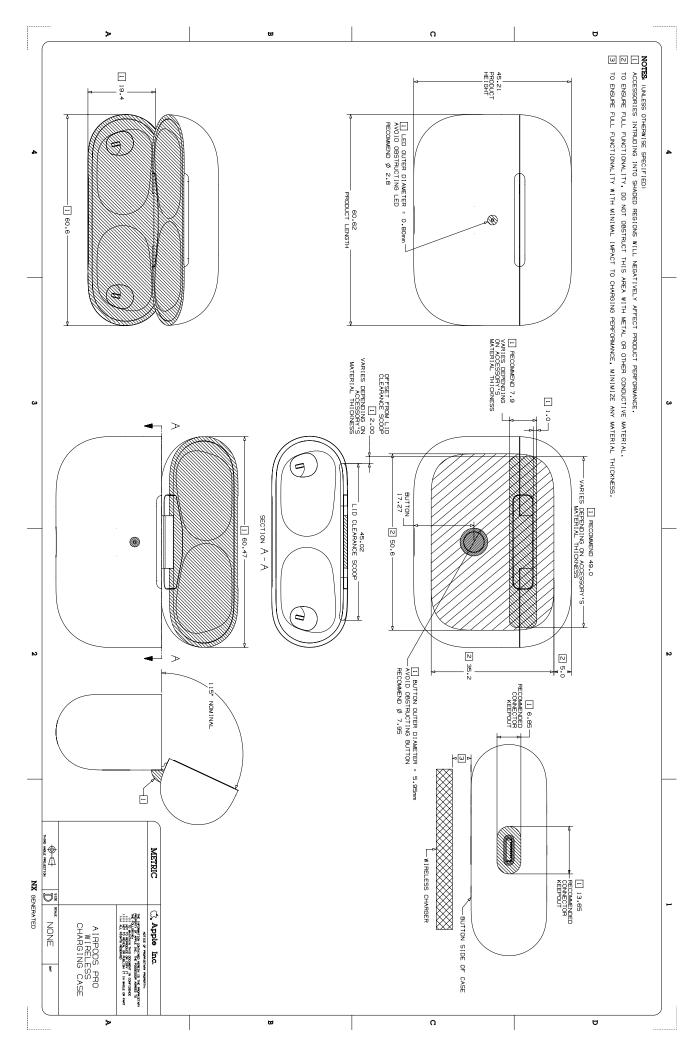


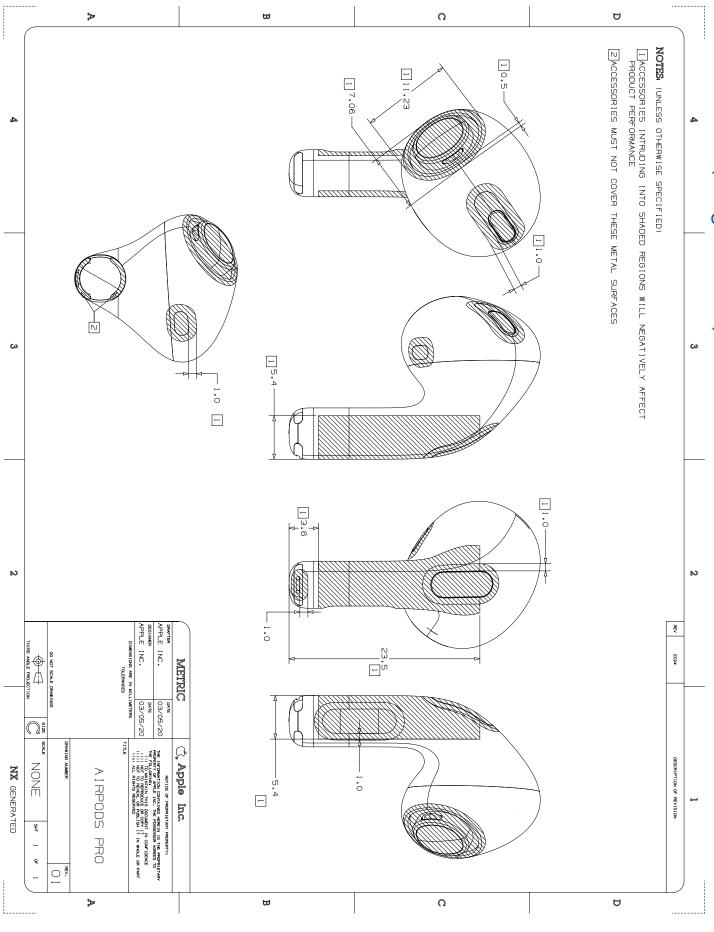
45.184 MagSafe Charging Case for AirPods (3rd generation)



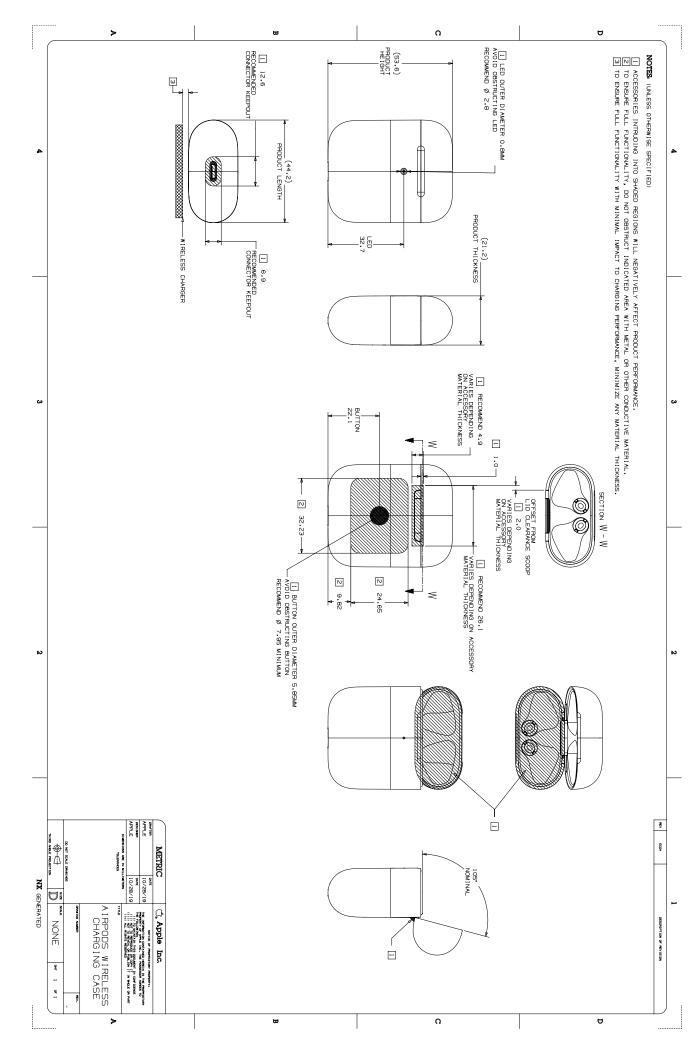


45.186 Wireless Charging Case for AirPods Pro (1st generation)

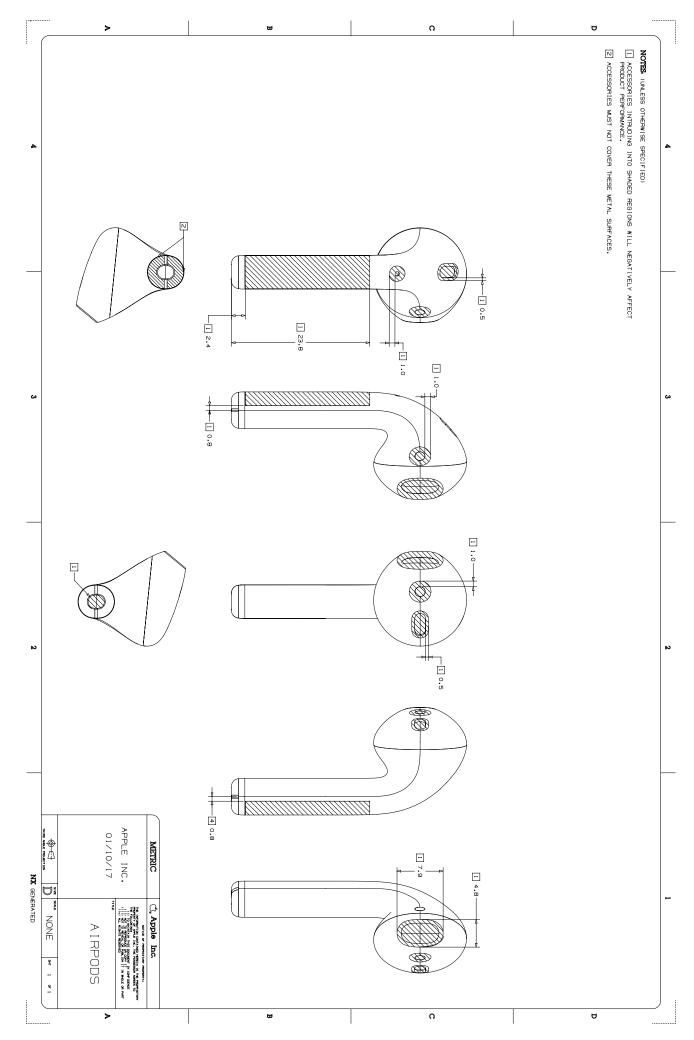




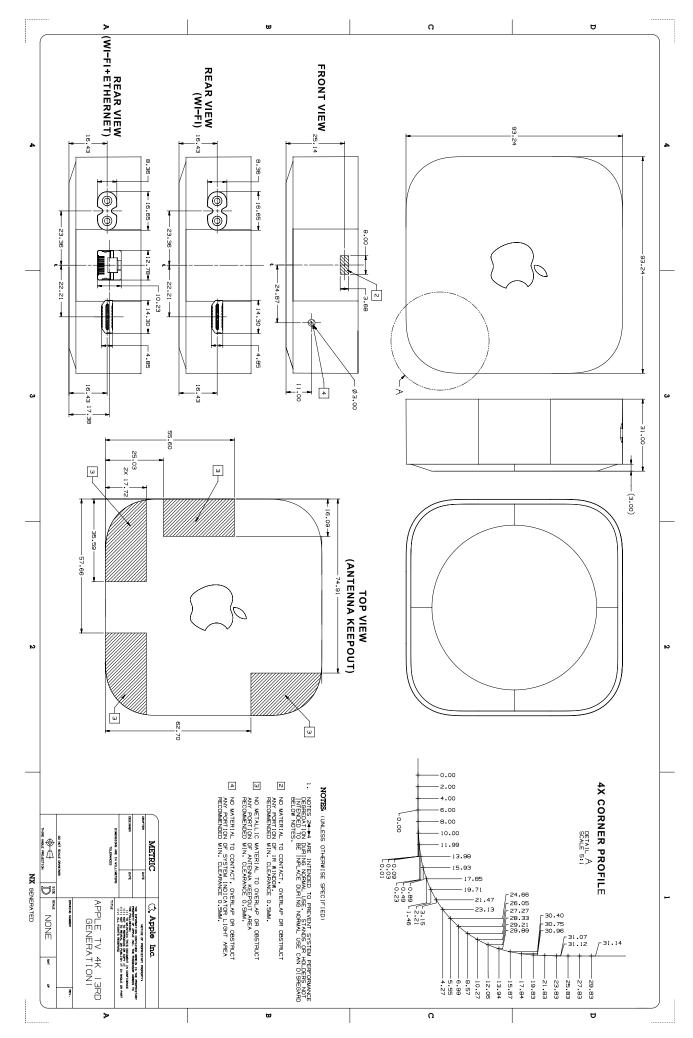
45.188 Wireless Charging Case for AirPods



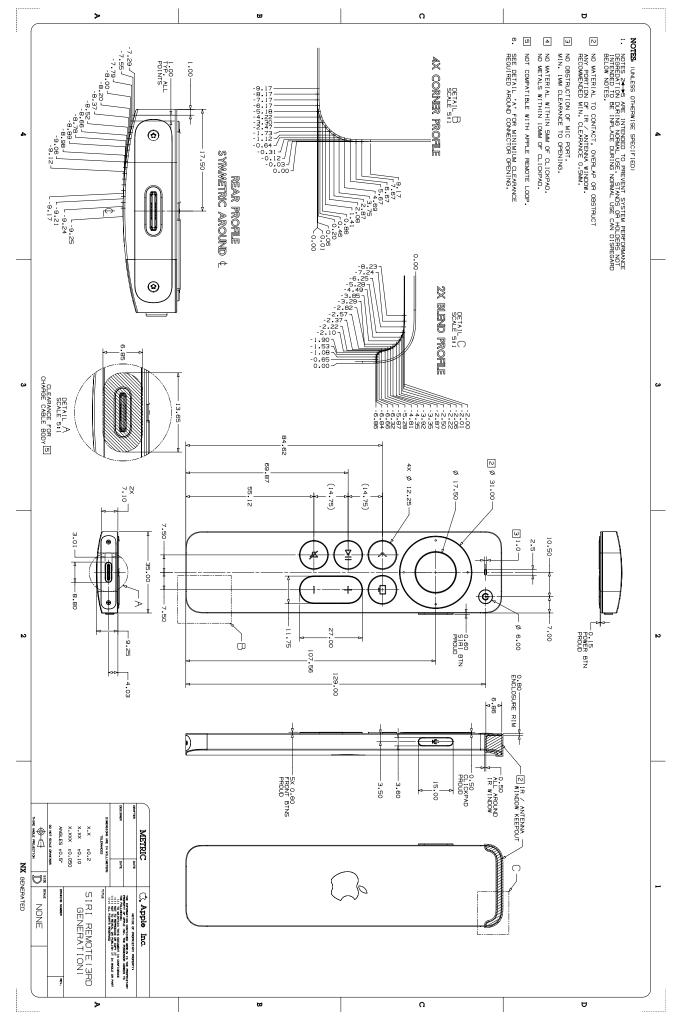
45.189 AirPods (1st generation) and AirPods (2nd generation)



45.191 Apple TV 4K (3rd generation)



45.192 Siri Remote (3rd generation)



46. Revision History

This chapter describes changes to the Accessory Design Guidelines for Apple Devices from the previous revision, excluding stylistic and editorial changes.

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- iPad Pro 12.9-inch (6th generation) 3 of 5 (page 260)
- iPad Pro 12.9-inch (6th generation) 4 of 5 (page 261)
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- iPad Pro 11-inch (4th generation) 1 of 5 (page 263)
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- iPad (10th generation) 1 of 6 (page 268)
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- iPad (10th generation) 6 of 6 (page 273)
- Apple TV 4K (3rd generation) (page 401)
- Siri Remote (3rd generation) (page 402)

Updated Content

- Terminology (page 19)
- Edge Swipe Gestures (page 32)
- Device Models (page 41)
- Product Design (page 53)
- Smart Covers (page 59)
- Keyboards (page 72)

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