

Accessory Design Guidelines for Apple Devices

Release R15

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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 devices.
- The specifications for hardware accessories that use the Bluetooth transport to communicate with iOS devices and Mac computers.
- The design of AC power adapters, battery packs, and Qi wireless power transmitters for iOS devices.
- The physical design of band accessories that are compatible with Apple Watch.

These guidelines do not address other aspects of accessory communication with iOS, iPadOS, tvOS, or watchOS devices. Instead, see the [Apple MFi Licensing Program](#) (page 19) and the [Accessory Interface Specification](#) (page 18).

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.

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

3.2 Accessory

Accessory refers to any product that connects to a *device* via the interfaces described in this specification.

3.3 Component

A *component* is a functional unit, i.e. a constituent part, of an accessory. Examples of components include:

- Data transport interface, such as a Lightning connector, USB connector, or Bluetooth radio.
- Power source, such as a battery.
- Human Interface Device (HID) [Control Surface](#) (page 17), such as a play/pause button.

A *component* may also refer to a 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 that enables user interaction with an accessory.

Examples of control surfaces include:

- Connectors

3. Terminology

3.5 Direct User Action

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

Specification references to specific types of control surfaces such as buttons or switches are only applicable to those control surface types. If a specification 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 via a [Control Surface](#) (page 17).

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

Examples of direct user action 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.

3.6 Captured Cable

A *captured cable* is a cable that has 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 19).

3. Terminology

3.8 Apple MFi Licensing Program

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 that communicate with devices.

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

Accessories

4. All Accessories

The requirements in this section apply to all accessories regardless of their feature sets.

4.1 Compliance Testing

Accessories shall not assume that evidence of functionality when attached to a device means the accessory is compliant with this specification. Such an approach does not account for future devices or software releases and runs a high risk of depending on un-documented device behavior that 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.

4.2 Integrated USB Receptacles

Accessories that incorporate 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 188).

4.3 User Supplied Cables and AC Power Adapters

Accessories that can reasonably be used with user-supplied cables and/or AC power adapters shall be designed to work with any cable, AC power adapter, or battery pack that is compliant with this specification, see [AC Power Adapters](#) (page 62) and [Battery Packs](#) (page 65), including Apple branded cables and AC power adapters. Such accessories shall not declare compatibility only with Apple branded USB cables or AC power adapters.

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

4. All Accessories

4.4 Attachments

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

Note:

Such accessories shall be tested with a wide variety of spec-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.

4.4 Attachments

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

4.5 Magnetic Interference

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

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

All accessories claiming compatibility with a device that has rear camera autofocus (AF) and/or optical image stabilization (OIS) features shall not affect the operation of these features.

The following devices feature optical image stabilization:

- iPhone 13 Pro Max
- iPhone 13 Pro
- iPhone 13
- iPhone 13 mini
- iPhone 12 Pro Max
- iPhone 12 Pro

4. All Accessories

4.6 Radio Frequency (RF) Performance

- 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)

4.6 Radio Frequency (RF) Performance

This section contains RF performance requirements and recommendations for all accessories.

4.6.1 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) the following:

- Steel, aluminum, magnesium, titanium, etc.
- Plastics with any carbon content
- Plastics with any glass content
- Plastics with metallic plating
- Metallic paints
- Black paints with high carbon loading

4. All Accessories

4.6 Radio Frequency (RF) Performance

- White paints with high titanium dioxide loading
- Metallic Physical Vapor Deposition (PVD) coatings

4.6.2 Antenna Keep-Out

Antenna keep-out regions can be found in [Device Dimensional Drawings](#) (page 192).

Accessory materials or coatings that absorb radio frequency energy, see [Materials and Coatings](#) (page 23), in the antenna keep-out region have a higher risk of degrading device wireless performance.

4.6.3 Over The Air (OTA) Transmission/Reception

Accessories shall not excessively degrade the 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 the 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 RF performance if they:

- Contain magnets.
- Intrude on device [Antenna Keep-Out](#) (page 24) 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 22).

4.6.4 Specific Absorption Rate (SAR)

A list of labs that can perform SAR testing with devices is available through the [Apple MFi Licensing Program](#) (page 19).

4.6.5 Near Field Communication (NFC)

Accessories that intrude on device [Antenna Keep-Out](#) (page 24) zones and claim compatibility with a device with NFC shall not degrade device NFC transaction performance.

The following devices are NFC enabled:

4. All Accessories

4.7 Thermal Management

- 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

4.7 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.

4.8 Tripod Connections

Tripod connections shall comply with ISO 1222:2010.

5. Cases

Accessories that substantially enclose 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 accessory has multiple user-detachable components that substantially enclose the device, the requirements and/or overrides shall be applied to each component separately.

5.1 Product Design

A well-designed case will securely house a device while not 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 192).

5.1.1 Device Protection

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

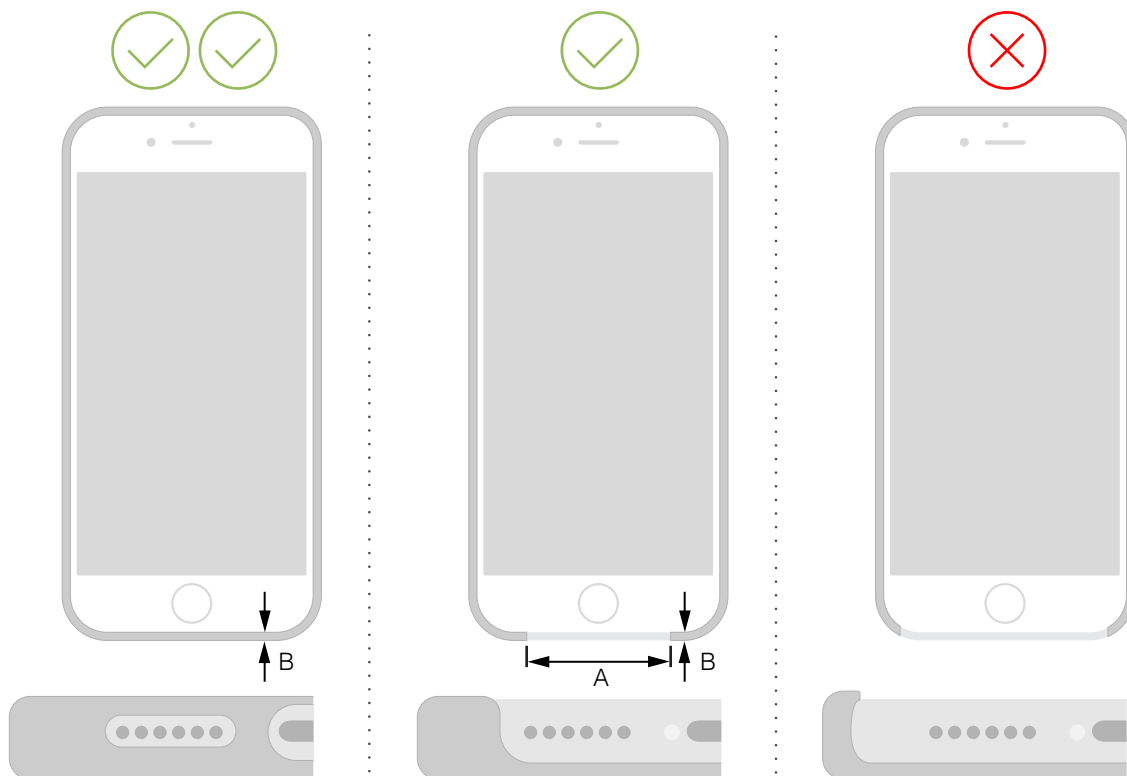
Exposed glass on the device shall not come within 0.85 mm of a flat surface, such as a table or floor, in any orientation when the case is attached. It should not come within 1.00 mm.

Device protection should be achieved by either creating features around the exposed glass that will space it away from the flat surface or covering the exposed glass.

Care should be given to the design of the bottom of the case to achieve both device protection and 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 27).
- Be made of polycarbonate (PC) at least 1.15 mm thick, see dimension B in [Figure 5-1](#) (page 27).

Figure 5-1 Device Protection



5.1.2 Access to Inputs and Interconnects

The accessory shall readily permit the user to access inputs and interconnects.

5.1.2.1 Access to Controls

The accessory shall readily permit the user to access and operate 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

The case shall provide ready access to a device's headset jack (if present).

The headset jack opening (i.e., keep-out area):

5. Cases

5.1 Product Design

- 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 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 accessory material.

5.1.2.3 Access to the Lightning Connector

If the case is for a device with the Lightning connector, the opening (i.e., 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.

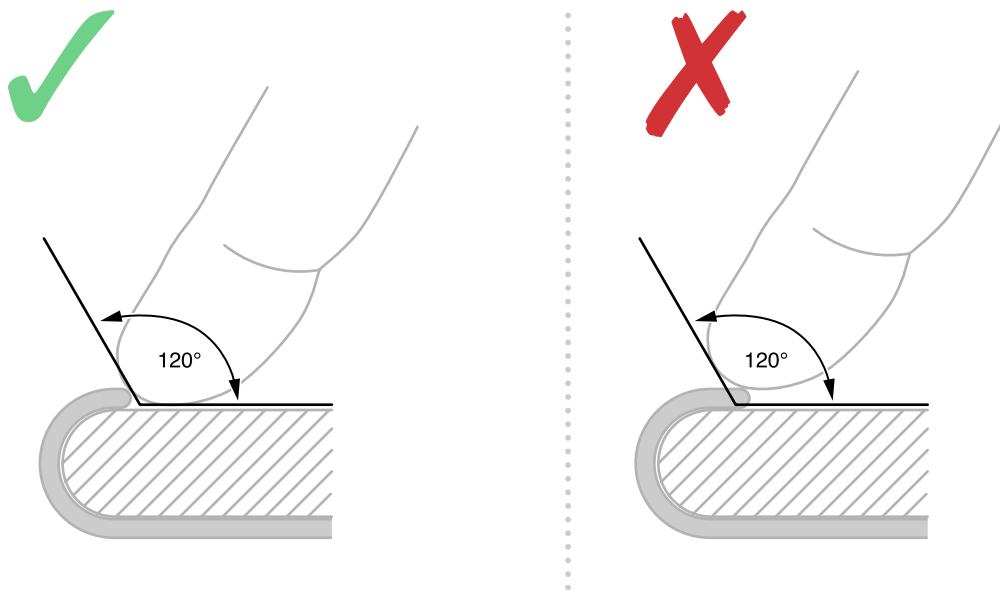
Lightning connector openings shall be designed with enough margin to compensate for shifting or dimensional changes of the accessory material.

5.1.2.4 Touchscreen

The accessory should not have any edges that can collect water on the touchscreen area when the device is held at a 30° angle relative to the horizon.

Accessories shall allow a 120° opening along the edges of the active area of the touchscreen to ensure compatibility with the device touchscreen features. See [Figure 5-2](#) (page 28) for more information on the keep-out and [Device Dimensional Drawings](#) (page 192) device specific active display areas.

Figure 5-2 Touchscreen keep-out area



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 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 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)

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

5. Cases

5.1 Product Design

- 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 that claim compatibility with the following devices should not contact the cover glass as defined in their dimensional drawings:

- 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
- iPhone 6 Plus
- iPhone 6

See [Device Dimensional Drawings](#) (page 192).

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 that claim compatibility with MagSafe or the Qi wireless power feature in devices 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

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

5.2.1 Call Quality

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

The accessory shall not obstruct any microphones during a phone call. Note that occluding any 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 192).

5.2.3.1 Thin Cases (≤ 2.25 mm)

Microphone/speaker openings in thin cases should:

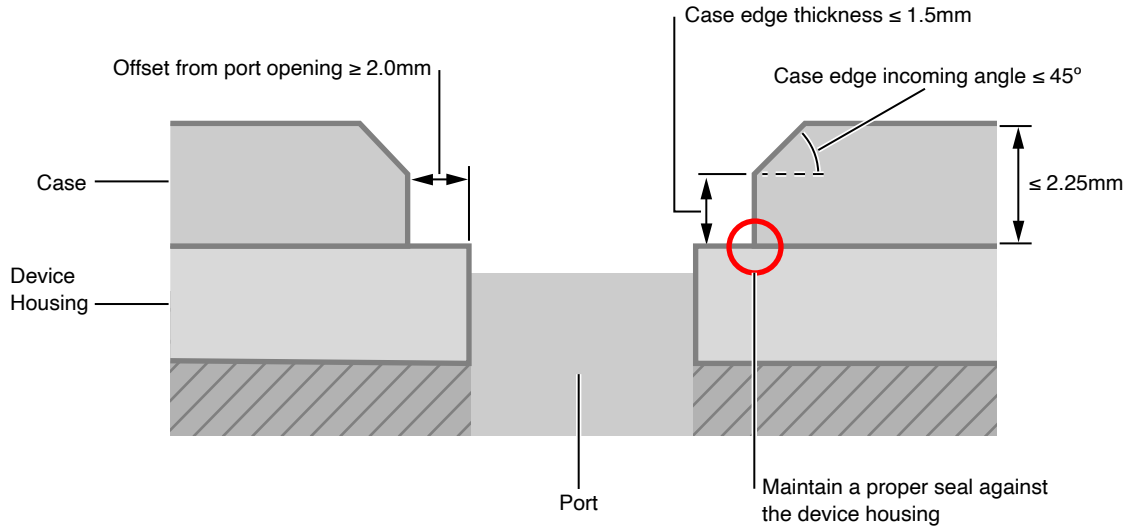
- Be offset at least 2.0 mm from the edge of any device speaker/microphone port.
- Be at most 1.5 mm thick along their inner diameter.
- Have a maximum 45° incoming angle to their inner diameter.

5. Cases

5.2 Acoustics

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

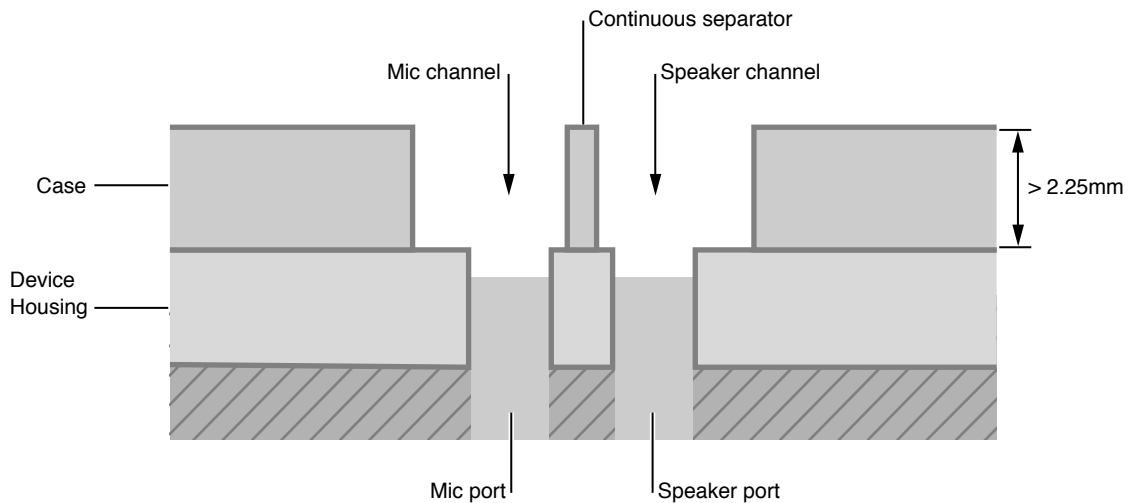
Figure 5-3 Microphone/speaker opening recommendations for thin cases



5.2.3.2 Thick Cases (>2.25 mm)

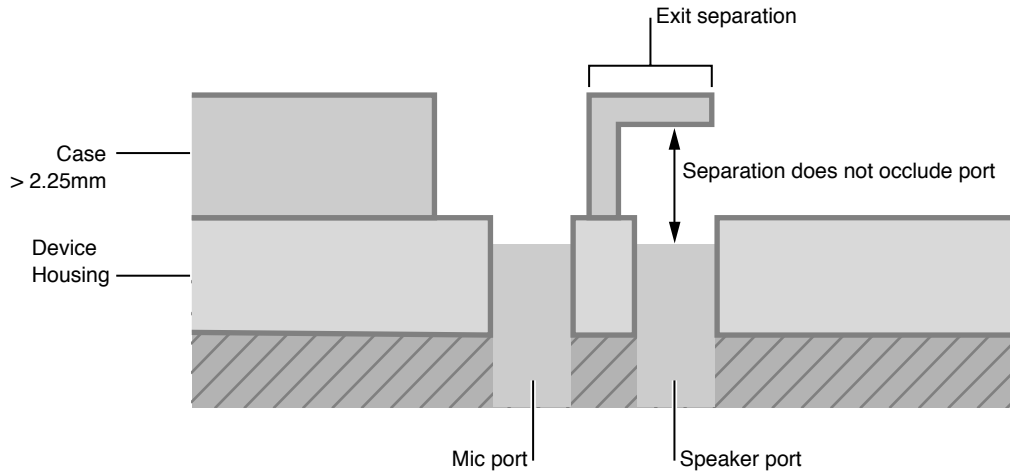
Speaker and microphone openings should be channeled independently and without interruption to/from the outside surface of a thick case.

Figure 5-4 Thick case acoustic channels



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

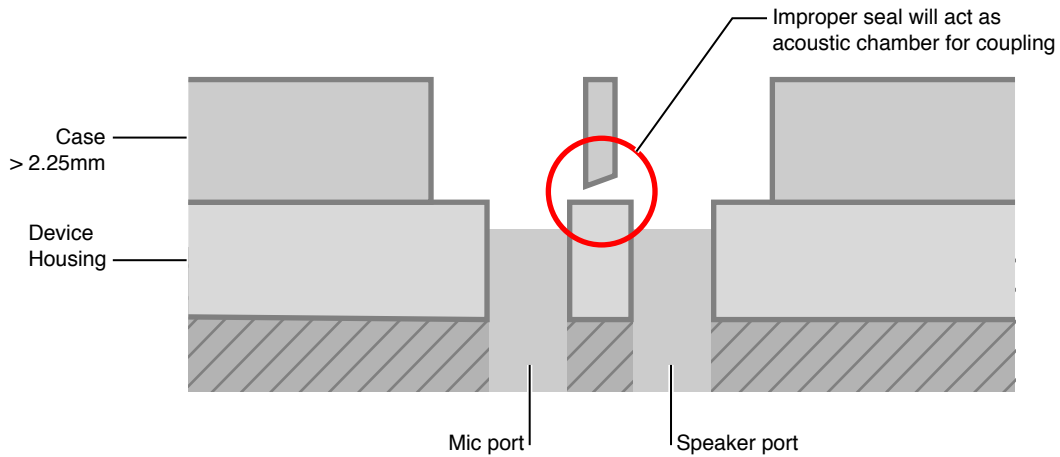
Figure 5-5 Thick case microphone and speaker exit separation



Thick case channels may act as a resonant 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 Interference

The ambient light sensor and proximity sensor locations for various devices are shown in the dimensional drawings cited in [Device Dimensional Drawings](#) (page 192). Some of the dimensional drawings specify a recommended keep-out area around these sensors. No material shall be allowed to cover these sensors or their keep-out areas, this includes films and privacy screens. Accessories that allow the device to slide around shall not obstruct any sensors.

5.4 Taptic Engine

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

The following devices contain a Taptic Engine:

- 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.

See [Magnetic Interference](#) (page 22) for additional details.

5.6 Home Button / Touch ID Sensor

Accessories shall not inhibit use of the device's Home button / Touch ID sensor including features such as Touch ID fingerprint recognition.

Home button / Touch ID sensor keep-outs for devices can be found in [Device Dimensional Drawings](#) (page 192).

Additionally, accessories that overlay the iPhone SE (2nd generation), iPhone 8 Plus, iPhone 8, iPhone 7 Plus, and iPhone 7 Home button / Touch ID sensor may cause users to have difficulty using the Home button / Touch ID sensor.

5.7 Camera

The field of view (FOV) of the camera and the illumination provided by the flash are designed for each device camera. It is imperative that manufacturers consult technical specifications released for each device and do not assume these parameters are shared between devices.

Images from the camera may be affected by the geometry, color, and surface finish of the accessory openings for camera and applicable flash.

5.7.1 Geometry

The camera lens FOV shall not be blocked. Making the accessory opening too small around the camera and flash may block the FOV of the lens and the illumination from the flash. Blocking the FOV may cause vignetting in the image, where one or more corners of the image reproduced are darker than the center. Blocking marginal rays just outside the FOV of the lens may also reduce the sharpness and contrast of the image. Blocking the illumination from the flash may cause haze in the image, which resulting in reduced contrast. See [Device Dimensional Drawings](#) (page 192) for the camera keep-out.

The accessory opening shall not be designed in a way that directs stray light into the camera. If the opening is too narrow or too steep, it may reflect light into the camera, washing out the image or adding an unwanted color cast. Adding a chamfer to the accessory opening trim may help to direct stray light away from the camera. Additionally, where the product is equipped with a flash, a narrow or steep

opening may reflect light from the accessory opening back into the camera. This may cause the image to appear washed out or contain unwanted artifacts. Designers should ensure that the mechanical keep-outs outlined in the [Device Dimensional Drawings](#) (page 192) are maintained with worst-case X-Y placement tolerances to minimize the risk of haze.

5.7.2 Color

Any light reflected from the accessory may pick up the color of the accessory. Black material or black coating may help avoid color bleeding into the camera from an external light source or the flash. The darker the color, the less light may be reflected from the source into the camera.

Note:

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

5.7.3 Surface Finish

The flash is a strong source of light and reflections from the camera accessory opening trim should be managed so that they do not reflect back into the camera. Semi-gloss material may direct light away from the camera. Matte or diffuse materials scatter light in all directions and will increase the likelihood that light from the flash or strong light sources in the scene is reflected into the camera.

5.7.4 Image Degradation Examples

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

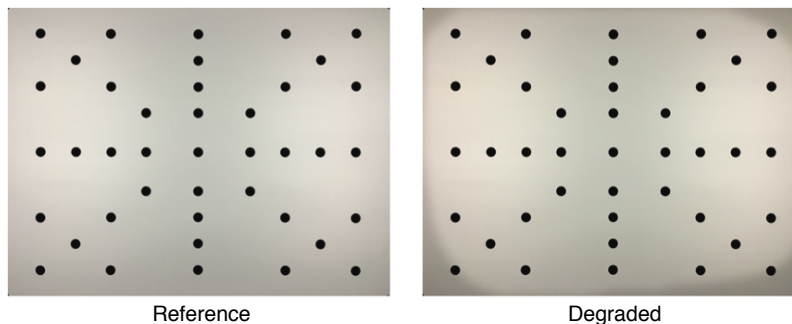


Figure 5-8 Sample image degradation by color shift through accessory with strong color

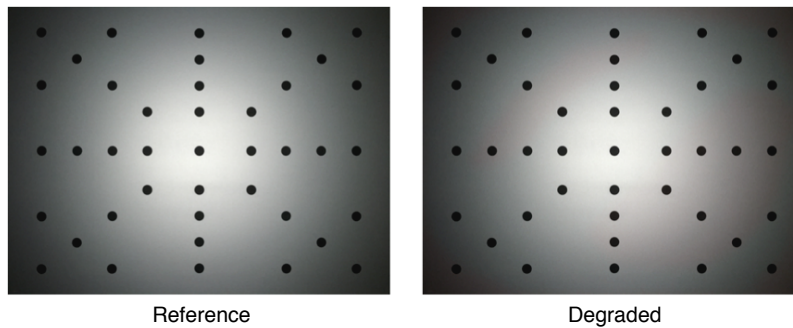
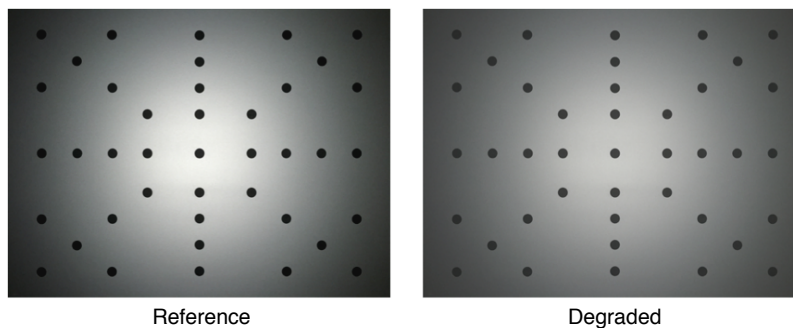


Figure 5-9 Sample image degradation by flash interference



5.8 Reliability

Cases for devices shall be tested to verify that they will withstand long-term use under typical use conditions, and that they do not impair or degrade the functionality of the device, damage it or its immediate surroundings, or adversely affect the user.

5.8.1 Device Insertion and Removal

The case shall hold the device securely while permitting its easy insertion and removal. The case and the enclosed device shall not be damaged 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

Any 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.

5.9 Environmental

Accessories shall comply with applicable environmental regulations in the regions in which such accessories are to be sold, and any applicable substance or material restrictions, including applicable restrictions on the following substances:

- 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 13 Pro Max

Table 5-1 iPhone 13 Pro Max Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone 13 Pro Max	
MagSafe Case Magnet Array (page 124)	iPhone 13 Pro Max	Cases supporting MagSafe only.
Taptic Engine (page 51)	iPhone 13 Pro Max	
Acoustics (page 52)	iPhone 13 Pro Max	

5. Cases

5.10 Test Procedures

5.10.1.2 iPhone 13 Pro

Table 5-2 iPhone 13 Pro Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone 13 Pro	
MagSafe Case Magnet Array (page 124)	iPhone 13 Pro	Cases supporting MagSafe only.
Taptic Engine (page 51)	iPhone 13 Pro	
Acoustics (page 52)	iPhone 13 Pro	

5.10.1.3 iPhone 13

Table 5-3 iPhone 13 Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone 13	
MagSafe Case Magnet Array (page 124)	iPhone 13	Cases supporting MagSafe only.
Taptic Engine (page 51)	iPhone 13	
Acoustics (page 52)	iPhone 13	

5.10.1.4 iPhone 13 mini

Table 5-4 iPhone 13 mini Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone 13 mini	
MagSafe Case Magnet Array (page 124)	iPhone 13 mini	Cases supporting MagSafe only.
Taptic Engine (page 51)	iPhone 13 mini	
Acoustics (page 52)	iPhone 13 mini	

5.10.1.5 iPhone 12 Pro Max

Table 5-5 iPhone 12 Pro Max Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone 12 Pro Max	
MagSafe Case Magnet Array (page 124)	iPhone 12 Pro Max	Cases supporting MagSafe only.
Taptic Engine (page 51)	iPhone 12 Pro Max	
Acoustics (page 52)	iPhone 12 Pro Max	

5.10.1.6 iPhone 12 Pro

Table 5-6 iPhone 12 Pro Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone 12 Pro	
MagSafe Case Magnet Array (page 124)	iPhone 12 Pro	Cases supporting MagSafe only.
Taptic Engine (page 51)	iPhone 12 Pro	
Acoustics (page 52)	iPhone 12 Pro	

5.10.1.7 iPhone 12

Table 5-7 iPhone 12 Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone 12	
MagSafe Case Magnet Array (page 124)	iPhone 12	Cases supporting MagSafe only.
Taptic Engine (page 51)	iPhone 12	
Acoustics (page 52)	iPhone 12	

5.10.1.8 iPhone 12 mini

Table 5-8 iPhone 12 mini Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone 12 mini	
MagSafe Case Magnet Array (page 124)	iPhone 12 mini	Cases supporting MagSafe only.
Taptic Engine (page 51)	iPhone 12 mini	
Acoustics (page 52)	iPhone 12 mini	

5.10.1.9 iPhone 11 Pro Max

Table 5-9 iPhone 11 Pro Max Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone 11 Pro Max	
Taptic Engine (page 51)	iPhone 11 Pro Max	
Acoustics (page 52)	iPhone 11 Pro Max	

5.10.1.10 iPhone 11 Pro

Table 5-10 iPhone 11 Pro Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone 11 Pro	
Taptic Engine (page 51)	iPhone 11 Pro	
Acoustics (page 52)	iPhone 11 Pro	

5.10.1.11 iPhone 11

Table 5-11 iPhone 11 Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone 11	
Taptic Engine (page 51)	iPhone 11	
Acoustics (page 52)	iPhone 11	

5.10.1.12 iPhone XS Max

Table 5-12 iPhone XS Max Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone XS Max	
Taptic Engine (page 51)	iPhone XS Max	
Acoustics (page 52)	iPhone XS Max	

5.10.1.13 iPhone XS

Table 5-13 iPhone XS Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone XS	
Taptic Engine (page 51)	iPhone XS	
Acoustics (page 52)	iPhone XS	

5.10.1.14 iPhone XR

Table 5-14 iPhone XR Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone XR	
Taptic Engine (page 51)	iPhone XR	
Acoustics (page 52)	iPhone XR	

5.10.1.15 iPhone X

Table 5-15 iPhone X Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone X	
Taptic Engine (page 51)	iPhone X	
Acoustics (page 52)	iPhone X	

5.10.1.16 iPhone 8 Plus/iPhone 7 Plus

Table 5-16 iPhone 8 Plus/iPhone 7 Plus Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone 8 Plus and iPhone 7 Plus	
Taptic Engine (page 51)	iPhone 8 Plus and iPhone 7 Plus	
Home Button / Touch ID Sensor Overlays (page 51)	iPhone 8 Plus and iPhone 7 Plus	
Acoustics (page 52)	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.

5.10.1.17 iPhone SE (2nd generation)/iPhone 8/iPhone 7

Table 5-17 iPhone SE (2nd generation)/iPhone 8/iPhone 7 Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone SE (2nd generation), iPhone 8, and iPhone 7	
Taptic Engine (page 51)	iPhone SE (2nd generation), iPhone 8, and iPhone 7	
Home Button / Touch ID Sensor Overlays (page 51)	iPhone SE (2nd generation), iPhone 8, and iPhone 7	
Acoustics (page 52)	iPhone SE (2nd generation), iPhone 8, and iPhone 7	

5. Cases

5.10 Test Procedures

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

5.10.1.18 iPhone 6s Plus/iPhone 6 Plus

Table 5-18 iPhone 6s Plus/iPhone 6 Plus Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone 6s Plus and iPhone 6 Plus	
Taptic Engine (page 51)	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.

5.10.1.19 iPhone 6s/iPhone 6

Table 5-19 iPhone 6s/iPhone 6 Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone 6s and iPhone 6	
Taptic Engine (page 51)	iPhone 6s	

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

5.10.1.20 iPhone 5/iPhone 5s/iPhone SE

Table 5-20 iPhone 5/iPhone 5s/iPhone SE Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	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.

5.10.1.21 iPhone 5c

Table 5-21 iPhone 5c Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPhone 5c	

5.10.1.22 iPad mini (6th generation)

Table 5-22 iPad mini (6th generation) Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPad mini (6th generation)	

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

Table 5-23 iPad (7th generation)/iPad (8th generation)/iPad (9th generation) Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	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) or only the iPad (9th generation).

5.10.1.24 iPad Pro (12.9-inch) 5th Generation

Table 5-24 iPad Pro (12.9-inch) 5th Generation Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPad Pro (12.9-inch) 5th Generation	

5.10.1.25 iPad Pro (11-inch) 3rd Generation

Table 5-25 iPad Pro (11-inch) 3rd Generation Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPad Pro (11-inch) 3rd Generation	

5. Cases

5.10 Test Procedures

5.10.1.26 iPad Air (4th generation)

Table iPad Air (4th generation) Case Testing Matrix
5-26

Test	Using	Notes
Product Design (page 48)	iPad Air (4th generation)	

5.10.1.27 iPad Pro (12.9-inch) 4th Generation

Table5-27 iPad Pro (12.9-inch) 4th Generation Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPad Pro (12.9-inch) 4th Generation	

5.10.1.28 iPad Pro (11-inch) 2nd Generation

Table iPad Pro (11-inch) 2nd Generation Case Testing Matrix
5-28

Test	Using	Notes
Product Design (page 48)	iPad Pro (11-inch) 2nd Generation	

5.10.1.29 iPad Air (3rd generation)

Table iPad Air (3rd generation) Case Testing Matrix
5-29

Test	Using	Notes
Product Design (page 48)	iPad Air (3rd generation)	

5.10.1.30 iPad mini (5th generation)

Table iPad mini (5th generation) Case Testing Matrix
5-30

Test	Using	Notes
Product Design (page 48)	iPad mini (5th generation)	

5. Cases

5.10 Test Procedures

5.10.1.31 iPad Pro (12.9-inch) 3rd Generation

Table 5-31 iPad Pro (12.9-inch) 3rd Generation Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPad Pro (12.9-inch) 3rd Generation	

5.10.1.32 iPad Pro (11-inch)

Table 5-32 iPad Pro (11-inch) Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPad Pro (11-inch)	

5.10.1.33 iPad Pro (10.5-inch)

Table 5-33 iPad Pro (10.5-inch) Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPad Pro (10.5-inch)	

5.10.1.34 iPad Pro (12.9-inch) 2nd Generation

Table 5-34 iPad Pro (12.9-inch) 2nd Generation Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPad Pro (12.9-inch) 2nd Generation	

5.10.1.35 iPad (5th and 6th generation)

Table 5-35 iPad (5th and 6th generation) Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPad (5th generation) or iPad (6th generation)	

5. Cases

5.10 Test Procedures

5.10.1.36 iPad Pro (9.7-inch)

Table iPad Pro (9.7-inch) Case Testing Matrix
5-36

Test	Using	Notes
Product Design (page 48)	iPad Pro (9.7-inch)	

5.10.1.37 iPad Pro (12.9-inch) 1st Generation

Table5-37 iPad Pro (12.9-inch) 1st Generation Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPad Pro (12.9-inch) 1st Generation	

5.10.1.38 iPad mini 4

Table iPad mini 4 Case Testing Matrix
5-38

Test	Using	Notes
Product Design (page 48)	iPad mini 4	

5.10.1.39 iPad mini/iPad mini 2/iPad mini 3

Table iPad mini/iPad mini 2/iPad mini 3 Case Testing Matrix
5-39

Test	Using	Notes
Product Design (page 48)	iPad mini 3	

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. Cases

5.10 Test Procedures

5.10.1.40 iPad Air 2

Table iPad Air 2 Case Testing Matrix
5-40

Test	Using	Notes
Product Design (page 48)	iPad Air 2	

5.10.1.41 iPad Air

Table 5-41 iPad Air Case Testing Matrix

Test	Using	Notes
Product Design (page 48)	iPad Air	

5.10.1.42 iPad (4th generation)

Table iPad (4th generation) Case Testing Matrix
5-42

Test	Using	Notes
Product Design (page 48)	iPad (4th generation)	

5.10.1.43 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
5-43 Testing Matrix

Test	Using	Notes
Product Design (page 48)	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

5. Cases

5.10 Test Procedures

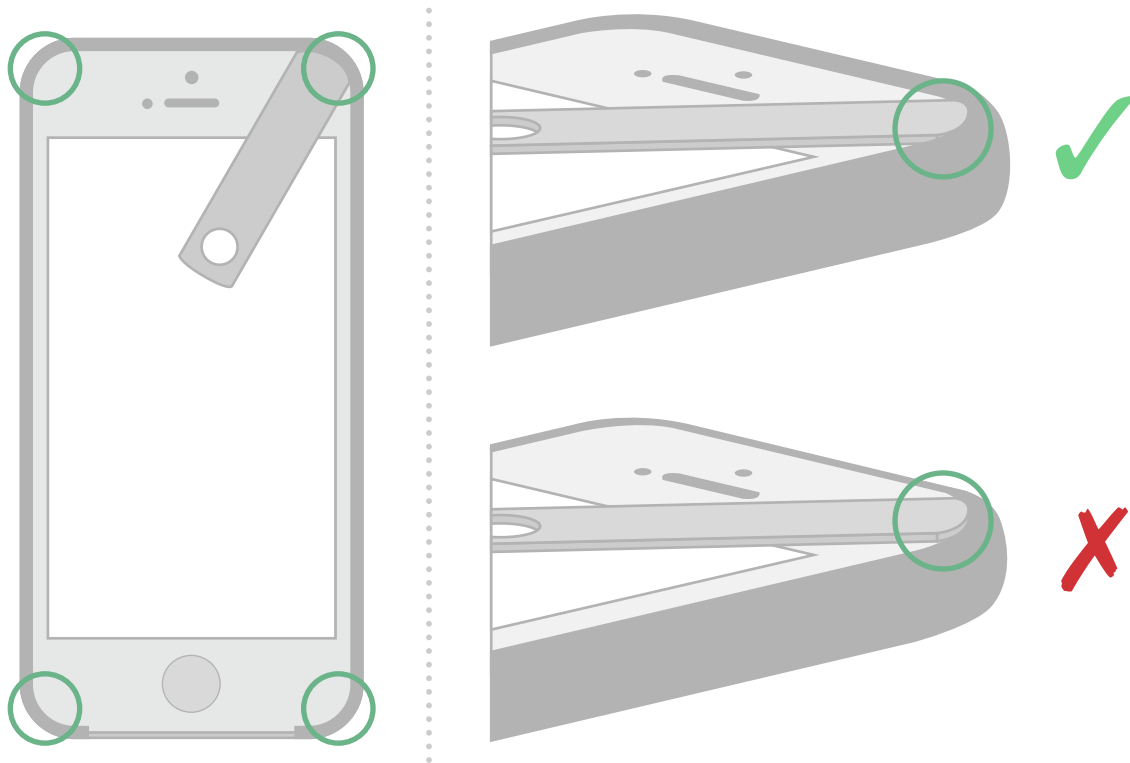
- Apple Lightning Digital AV Adapter
- Vernier calipers
- 0.85 mm plastic feeler gauge
- EarPods with 3.5 mm Headphone Plug

5.10.2.2 Procedure

1. Insert the device into the case.
2. Verify that the device completely fits inside the case.
3. Verify the device is not loose.
4. Verify that all buttons are accessible.
5. Inspect for button feel. Verify that all buttons are not too hard to press or take a lot of effort to press.
6. If the device has an Apple Lightning receptacle:
 - a. Insert the Apple Lightning Digital AV Adapter into the Lightning receptacle and verify that it fits.
 - b. Using vernier calipers, measure the Lightning connector opening on the case. Verify that the opening is measured to be at least 12.05 mm by 6.30 mm.
7. If the device has a 3.5 mm headset jack:
 - a. Insert EarPods with 3.5 mm Headphone Plug into the headset jack of the device and verify it fits.
 - b. Using vernier calipers, measure the headset jack opening on the case. Verify that the opening is measured to be at least 6 mm in diameter and no more than 14 mm deep.
8. If the device has a Touch ID sensor, use vernier calipers to verify that the case is at least 2 mm away from the Touch ID sensor.

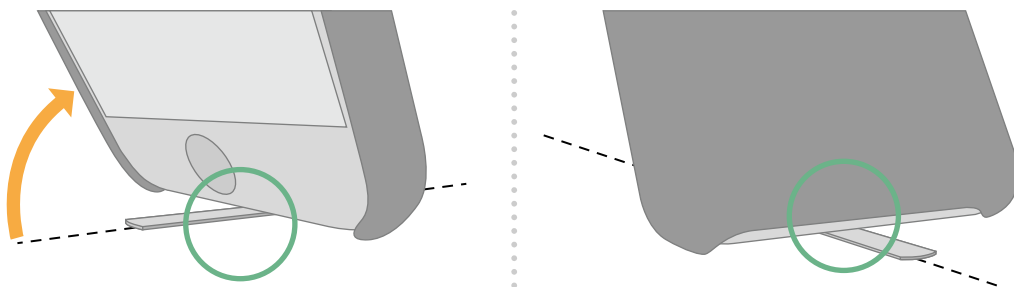
9. Verify that the case is always proud of the feeler gauge when the gauge is placed at each corner of the device. See [Figure 5-10](#) (page 50).

Figure 5-10 Device proudness test



10. Set the device flat on its face (screen facing down).
11. Roll the device towards any side that is not enclosed by the case until the gap between the device's exposed glass and flat surface is smallest.
12. Verify that the feeler gauge fits into the gap between the device's exposed glass and flat surface.

Figure 5-11 Device gap test



13. If the case has an overlay, verify that 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 *Vibrate on Silent* 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.
 - l. 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 Home Button / Touch ID Sensor Overlays

This test procedure is applicable to all iPhone SE (2nd generation), iPhone 8 Plus, iPhone 8, iPhone 7 Plus or iPhone 7 accessories that overlay the Home button or the Touch ID sensor.

5.10.4.1 Equipment

- Nitrile gloves (e.g. Ansell TNT Blue)
- Ethyl alcohol hand sanitizer (e.g. 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 device's Home button / Touch ID sensor with the glove's outer side facing away from the device.
5. Apply a small amount of hand sanitizer (approximately dime-sized) to the nitrile over the Home button / Touch ID sensor.
6. Repeat the following steps 10 times:
 - a. Press the Home button / Touch ID sensor with a thumb.
 - b. Verify that the device wakes (display on).
 - c. Press the sleep/wake or side button to place the device into a sleep state (display off).
7. Repeat the following steps 10 times:
 - a. Press the Home button / Touch ID sensor with an index finger.
 - b. Verify that the device wakes (display on).
 - c. Press the sleep/wake or side button to place the device into a sleep state (display off).

5.10.4.3 Pass/Fail Criteria

Verify the device wakes every time the Home button / 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 (e.g., 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.
 - i. Four hours of steady work faced us.
 - j. Large size in stockings is hard to sell.
6. Operator B: Evaluate the call. Ensure that the call is 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.).

5. Cases

5.10 Test Procedures

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 53).

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 that cover 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.

See [Magnetic Interference](#) (page 22) for additional details.

6.2 Smart Covers

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

- [iPad mini \(6th generation\) 3 of 6](#) (page 233)
- [iPad mini \(6th generation\) 4 of 6](#) (page 234)
- [iPad \(9th generation\), iPad \(8th generation\) and iPad \(7th generation\) 2 of 4](#) (page 238)
- [iPad Pro \(12.9-inch\) 5th Generation 3 of 5](#) (page 243)
- [iPad Pro \(11-inch\) 3rd Generation 3 of 5](#) (page 248)
- [iPad Air \(4th generation\) 3 of 5](#) (page 253)
- [iPad Pro \(12.9-inch\) 4th Generation 3 of 5](#) (page 258)
- [iPad Pro \(11-inch\) 2nd Generation 3 of 5](#) (page 263)
- [iPad Air \(3rd generation\) with Wi-Fi 2 of 3](#) (page 267)
- [iPad Air \(3rd generation\) with Wi-Fi + Cellular 2 of 3](#) (page 270)
- [iPad mini \(5th generation\) with Wi-Fi 2 of 3](#) (page 273)
- [iPad mini \(5th generation\) with Wi-Fi + Cellular 2 of 3](#) (page 276)
- [iPad Pro \(12.9-inch\) 3rd Generation 2 of 3](#) (page 279)
- [iPad Pro \(11-inch\) 2 of 3](#) (page 282)
- [iPad Pro \(12.9-inch\) 2nd Generation Magnet/Hall Effect Sensors 1 of 2](#) (page 286)
- [iPad Pro \(12.9-inch\) 2nd Generation Magnet/Hall Effect Sensors 2 of 2](#) (page 287)
- [iPad Pro \(10.5-inch\) Magnet/Hall Effect Sensors 1 of 2](#) (page 290)

6. Covers

6.2 Smart Covers

- [iPad Pro \(10.5-inch\) Magnet/Hall Effect Sensors 2 of 2 \(page 291\)](#)
- [iPad \(5th and 6th generation\) Magnet/Hall Effect Sensors 1 of 2 \(page 293\)](#)
- [iPad \(5th and 6th generation\) Magnet/Hall Effect Sensors 2 of 2 \(page 294\)](#)
- [iPad Pro \(9.7-inch\) Magnet/Hall Effect Sensors 1 of 2 \(page 297\)](#)
- [iPad Pro \(9.7-inch\) Magnet/Hall Effect Sensors 2 of 2 \(page 298\)](#)
- [iPad Pro \(12.9-inch\) 1st Generation Magnet/Hall Effect Sensors 1 of 2 \(page 301\)](#)
- [iPad Pro \(12.9-inch\) 1st Generation Magnet/Hall Effect Sensors 2 of 2 \(page 302\)](#)
- [iPad mini 4 Magnet/Hall Effect Sensors \(page 305\)](#)

7. Screen Overlays

The touch interface in a device senses the presence of one or more fingers on its surface. Any material between the surface and the user's hand, even a very thin sheet of plastic, may affect the performance of the touch interface.

7.1 Product Design

The screen overlay shall not degrade the performance of Multi-Touch or Apple Pencil.

The screen overlay thickness should not exceed 0.1 mm for devices supporting Apple Pencil.

The screen overlay thickness should not exceed 0.3 mm for all other devices.

Additionally, screen overlays shall not:

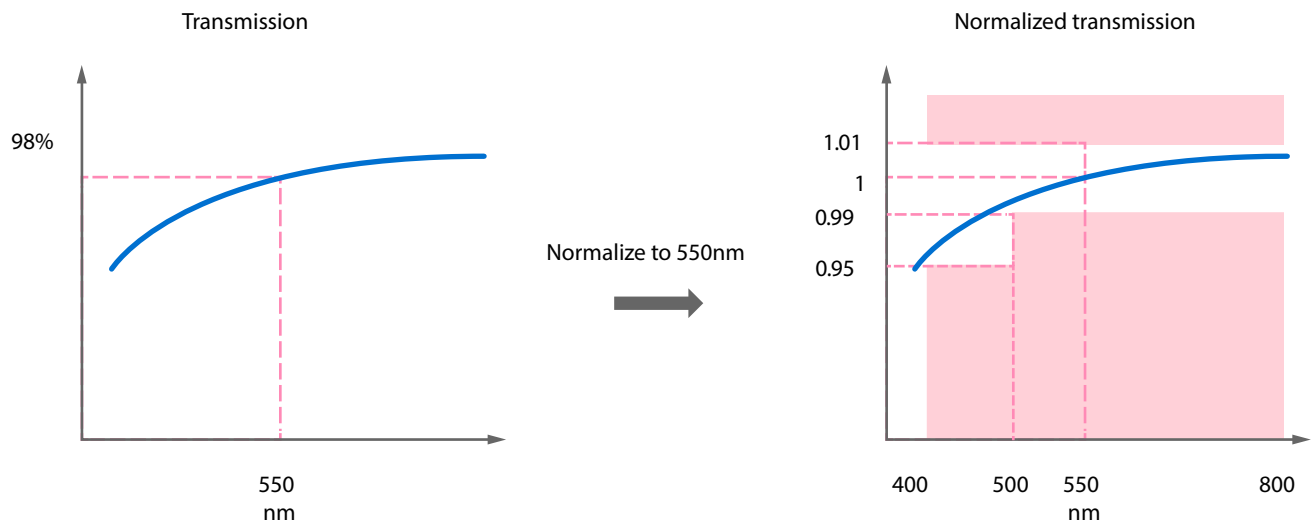
- Introduce air gaps between the touchscreen and overlay.
- Be electrically conductive.

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 192).
- Remain flat as defined in [Figure 7-1](#) (page 58). 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 Transmission Haze

Transmission haze is the percentage of light that is scattered at more than 2.5° from the normal transmission.

Transmission haze should:

- Not exceed 13%.
- Be measured with a haze meter, per ASTM D1003.

7.2 Edge Swipe and Edge Press Gestures

See [Edge Swipe Gestures](#) (page 29) and [Edge Press Gestures](#) (page 29).

8. Camera Attachments

This chapter is applicable to accessories that intentionally alter the 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.

See [Magnetic Interference](#) (page 22) for additional details.

9. Adapters

An adapter accessory is a dongle or a [Captured Cable](#) (page 18) that enables 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 18) for more information.

9.1 Headset Adapters (Lightning to 3.5 mm)

Lightning to 3.5 mm headset adapters are accessories that enable 3.5 mm audio connections.

See the [Accessory Interface Specification](#) (page 18) 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 that integrate a Lightning Receptacle (C37) to support Lightning headsets, speakers, and microphones.

See the [Accessory Interface Specification](#) (page 18) for more information.

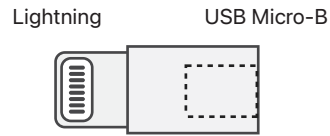
9.3 Ethernet Adapters (Lightning to RJ45)

A Lightning to Ethernet adapter is an accessory that enables 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 18) 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 that function 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 18) 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 via one or more of the following:

- [USB-C Receptacle](#) (page 188) combined with a USB-C to Lightning cable.
- [USB-A Receptacle](#) (page 185) combined with a USB-A to Lightning cable.
- [Device Power \(Inductive\)](#) (page 104).

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 63) and Table 10-1 (page 63). 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 63) were chosen to have trivial levels of impedance relative to the impedances of C1, C2, C3, and C4 at power line frequencies.

Figure 10-1 Typical AC power adapter diode bridge circuit

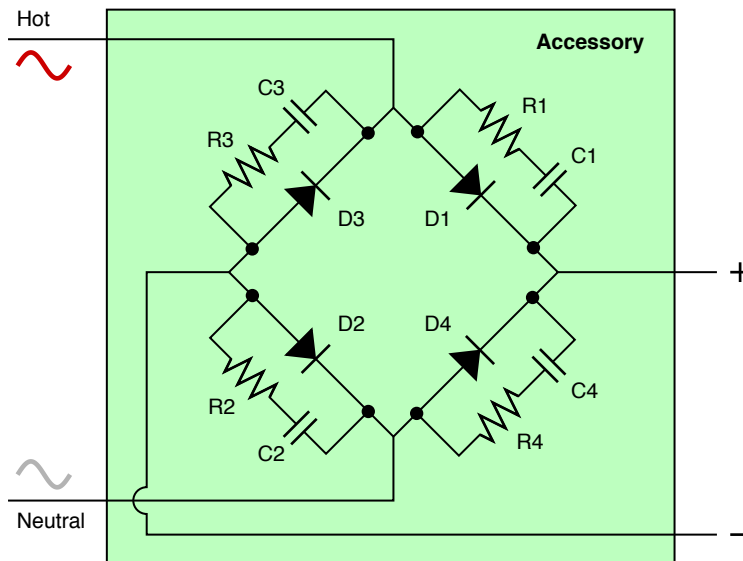


Table 10-1 Typical component values for an AC power adapter diode bridge circuit

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 that is designed to provide power to the device from an internal power supply.

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

- [USB-C Receptacle](#) (page 188) combined with a USB-C to Lightning cable.
- [USB-A Receptacle](#) (page 185) combined with a USB-A to Lightning cable.
- [Device Power \(Inductive\)](#) (page 104).

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 via the Lightning connector.

Figure 12-1 Example of integrated flash (left) vs. accessory strobe (right)



The following devices support strobe accessories:

- 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 18) for more information.

13. Keyboards

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

13.1 Requirements

Accessory keyboards shall support the [Human Interface Device \(HID\)](#) (page 161) protocol and comply with all the requirements listed in [Requirements](#) (page 161).

Note:

Accessory keyboards shall not identify themselves as Apple-branded accessories, e.g. using the Apple Vendor ID and/or Product IDs.

Accessory keyboard keys that exhibit any of the following behaviors are explicitly prohibited:

- Send anything other than 'key pressed' or 'key released' for the key(s) that have physically been pressed/released.
- Emulate combinations or sequences of other keys (e.g. a Copy button that sends ⌘-C or macros that generate 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 accessory shall occur in response to a [Direct User Action](#) (page 18).

Accessory 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.

Accessory keyboards shall not incorporate any other status LEDs as they are not supported by devices.

Accessory keyboards should be integrated with [Trackpads](#) (page 74) 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.

13. Keyboards

13.1 Requirements

The accessory keyboard HID descriptor 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*.

The HID report descriptor for a keyboard shall declare support for the HID Keyboard/Keypad Page. The HID report descriptor may declare a input usage minimum of 0 and input usage maximum of 255 as shown in [Example HID Report Descriptor](#) (page 72) for efficiency. Otherwise, the descriptor shall individually enumerate each HID Keyboard/Keypad page usage that the keyboard is capable of sending.

Accessory keyboards shall implement individual keys that emit 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	l and L	l 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

13. Keyboards

13.1 Requirements

Usage ID	Usage Name	Apple Function
0x001E	1 and !	1 and !
0x001F	2 and @	2 and @
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 / ⌘
0x00E5	RightShift	Right Shift
0x00E6	RightAlt	Right Option / Alt
0x00E7	RightGUI	Right Command / ⌘

13. Keyboards

13.1 Requirements

JIS keyboards shall also implement additional keys found on the Apple Wireless Keyboard (Japanese). Non-JIS keyboards shall not implement these keys.

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

Usage ID	Usage Name	Apple Function
0x0032	Non-US # and ~	
0x0087	Keyboard International1	
0x0089	Keyboard International3	
0x0090	LANG1	Switch to Previous Language
0x0091	LANG2	Switch to Next Language

Accessory keyboards may implement individual keys that emit the following HID Keyboard/Keypad page usages:

Table 13-3 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 =

13. Keyboards

13.2 Examples

Accessory keyboards may implement individual keys that emit the following HID Consumer page usages:

Table 13-4 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
0x00EA	Volume Decrement	Softer
0x01AE	AL Keyboard Layout	Toggle Onscreen Keyboard
0x029D	AC Keyboard Layout Select	Toggle Language Switch / Emoji Keyboard
0x0221	AC Search	Spotlight
0x025B	Promote	Play More Like This
0x025C	Demote	Play Less Like This
0x0262	Add to Cart	Add to Wish List

13.2 Examples

13.2.1 Example HID Report Descriptor

USAGE PAGE (Generic Desktop)	05 01
USAGE (Keyboard)	09 06
COLLECTION (Application)	A1 01
USAGE PAGE (LEDs)	05 08
LOGICAL MINIMUM (0)	15 00
LOGICAL MAXIMUM (1)	25 01
USAGE (Caps Lock)	09 02
REPORT SIZE (1)	75 01
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

13. Keyboards

13.2 Examples

```
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
INPUT (Data,Ary,Abs) 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.

14.1 Requirements

Accessory trackpads shall support the [Human Interface Device \(HID\)](#) (page 161) protocol and comply with all the requirements listed in [Requirements](#) (page 161).

Note:

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

Accessory trackpads that exhibit 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 usages sent from the accessory trackpad shall occur in response to a [Direct User Action](#) (page 18).

Accessory 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 68) and simultaneously support both input methods. The following are examples of interactions that involve both keyboard and trackpad input:

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

14. Trackpads

14.1 Requirements

14.1.2 HID Report Descriptor

The HID report descriptor 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	Y	Y coordinate of contact position
0x38 or 0x51	Transducer Index or Contact ID	Index (from 0-4) that uniquely identifies 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 that are 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 gestures.
- Distinguish between a valid large thumb and an invalid lightly resting palm.
- Reject inputs that are ≥ 1 mm from the tracking surface.

14.1.6 Click to Wake

The device uses the Report ID usage to indicate to the accessory whether surface contacts shall be reported or not. The device will use the Surface Switch usage to tell the accessory to go into Click to Wake mode where only button clicks are accepted. The accessory trackpad 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. The device may query the accessory trackpad at any time after enumeration to learn about the current state of the Surface Switch, and also to get the accessory's Report Rate.

14.2 Examples

14.2.1 Example HID Report Descriptor

The following descriptor is for a 92.10 mm x 50.60 mm accessory trackpad with two buttons that supports up to 5 simultaneous contacts.

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

- Modify the physical maximum values for the X (0x30) and Y (0x31) of each finger positions to match the physical size of the accessory trackpad. The units are in tenths of a mm (0.1mm). In the example, X goes from 0x0 to 0x0399 (92.10 mm) and Y goes from 0x0 to 0x01FA (50.60 mm).
- Modify the 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)          05 0D
USAGE (Touch Pad)                          09 05
COLLECTION (Application)                   A1 01
  REPORT_ID (3)                             85 03
  LOGICAL MAXIMUM (65535)                   27 FF FF 00 00
  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
  USAGE (Surface Switch)                    09 57
  FEATURE (Data,Var,Abs)                    B1 02
  LOGICAL MAXIMUM (32767)                   26 FF 7F
  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
  USAGE MAXIMUM (Button 2)                  29 02
  REPORT COUNT (2)                          95 02
  REPORT SIZE (1)                           75 01
  INPUT (Data,Var,Abs)                      81 02
  REPORT COUNT (6)                          95 06
  INPUT (Cost, Ary, Abs)                    81 01
  USAGE PAGE (Digitizer Device Page)        05 0D
  USAGE (Finger)                            09 22
  COLLECTION (Physical)                     A1 00
  USAGE (Tip Switch)                        09 42
  USAGE (Confidence)                        09 47

```

14. Trackpads

14.2 Examples

REPORT COUNT (2)	95 02
INPUT (Data,Var,Abs)	81 02
LOGICAL MAXIMUM (5)	25 05
USAGE (Transducer Index)	09 38
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
PHYSICAL MINIMUM (0)	35 00
LOGICAL MAXIMUM (1105)	26 51 04
REPORT SIZE (12)	75 0C
UNIT EXPONENT (Unit Value x .01)	55 0E
GLOBAL UNIT (Distance in centimeters)	65 11
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)	A1 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 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)	A1 00
LOGICAL MAXIMUM (1)	25 01
USAGE (Tip Switch)	09 42
USAGE (Confidence)	09 47
REPORT SIZE (1)	75 01

14. Trackpads

14.2 Examples

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)	A1 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 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)	A1 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 02
USAGE (Transducer Index)	09 38

14. Trackpads

14.2 Examples

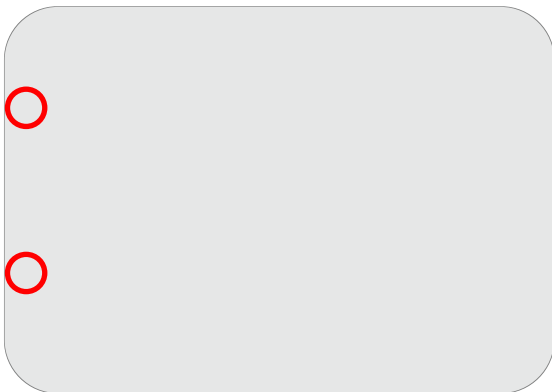
LOGICAL MAXIMUM (5)	25 05
REPORT SIZE (6)	75 06
REPORT COUNT (1)	95 01
INPUT (Data,Var,Abs)	81 02
USAGE PAGE (Generic Desktop Page)	05 01
PHYSICAL MAXIMUM (921)	46 99 03
LOGICAL MAXIMUM (1105)	26 51 04
REPORT SIZE (12)	75 0C
USAGE (X)	09 30
INPUT (Data,Var,Abs)	81 02
PHYSICAL MAXIMUM (506)	46 FA 01
LOGICAL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

14.2.2 Example Accessory Trackpad

The following HID events are for a 60 Hz accessory trackpad using the HID report descriptor in [Example HID Report Descriptor](#) (page 77):

1. Two contacts are made on the surface of the accessory trackpad.

```
03000000 0300100F 0700C016 00000000 00000000 00000000
```



2. Two contacts move simultaneously along the X axis.

```
03A70000 0314110F 0714C116 00000000 00000000 00000000
```

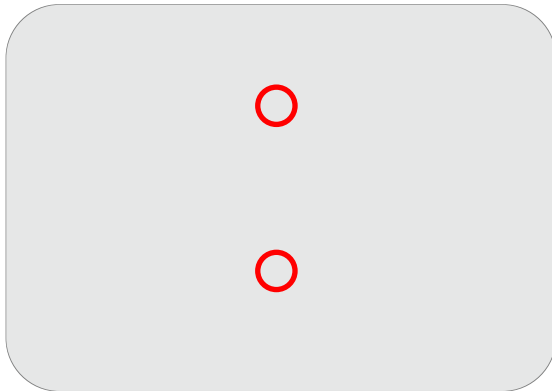

14. Trackpads

14.2 Examples



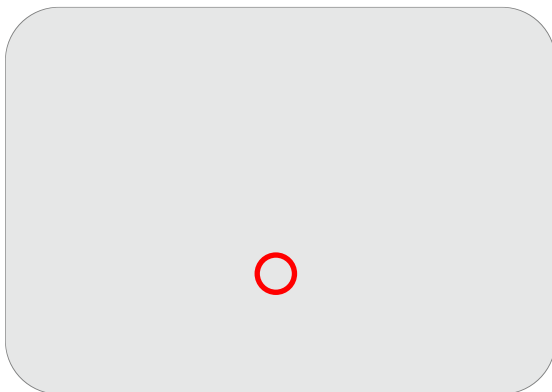
3. Two contacts continue moving until they reach the center of the digitizer surface.

```
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
```

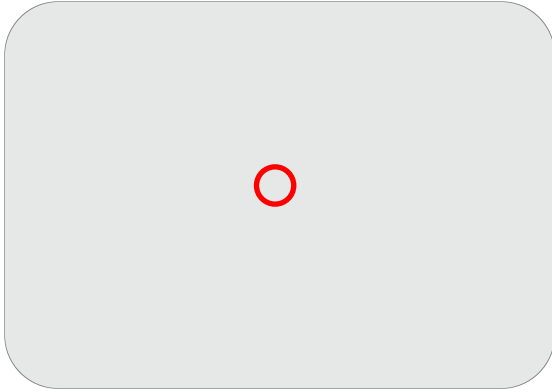


5. Remaining contact moves to the exact center of the digitizer surface. Confidence and coordinates of the removed contact are now 0.

```
039C0200 0328F212 00000000 00000000 00000000 00000000
```

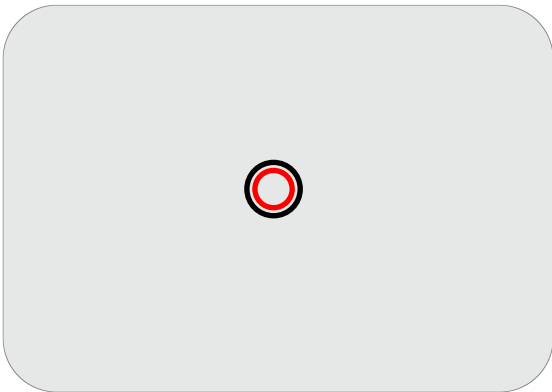
14. Trackpads

14.2 Examples



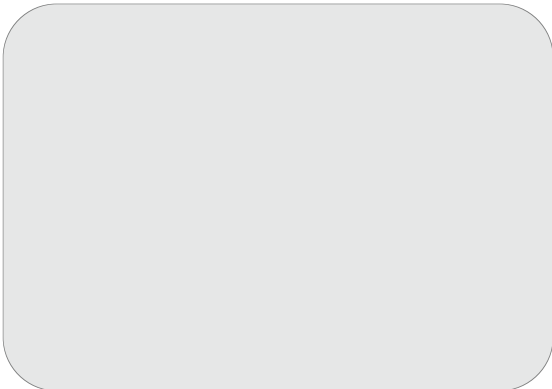
6. Button 1 is clicked.

```
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

Apple AirPods accessories shall not interfere with their operation.

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

- [AirPods Pro](#) (page 340).
- [AirPods](#) (page 341).

15.1 Charging Case Covers

Apple AirPods charging case covers shall not interfere with their operation.

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

- [AirPods Pro Wireless Charging Case](#) (page 338).
- [AirPods Wireless Charging Case](#) (page 339).

Charging case covers should have a uniform maximum thickness of 1.0 mm across the metal keep-out region to avoid impacting wireless charging performance.

15.2 Chargers

Apple AirPods charging accessories shall be physically compatible with AirPods and AirPods Pro charging cases.

Charging accessories with an integrated:

- Lightning connector shall meet the requirements for iPhone/iPod in [Device Power \(Lightning\)](#) (page 99).
- Qi transmitter shall meet the requirements in [Device Power \(Inductive\)](#) (page 104).

16. Watch Bands

A well-designed band will securely attach to Apple Watch while not interfering with its operation. See [Device Dimensional Drawings](#) (page 192) for Apple Watch dimensional drawings with defined keep-out zones.

16.1 Requirements

Bands for Apple Watch shall integrate two lugs that mate with the [Apple Watch Band Interface](#) (page 86). 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 band mating slot with a 'lug latch' feature that prevents accidental removal of the band.

Exposed edges of 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.

Bands shall not integrate magnetic chargers.

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 band release buttons are pressed.
- Take into account the weight of Apple Watch.

Bands shall not prevent the user's skin from maintaining direct contact with the Apple Watch heart sensors and back of Apple Watch, and shall incorporate sufficient margin to compensate for shifting or dimensional changes of the band material. Failure to do so may interfere with Apple Watch wrist detect and Apple Pay features. 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 that prevents movement of Apple Watch relative to skin.

16. Watch Bands

16.1 Requirements

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.

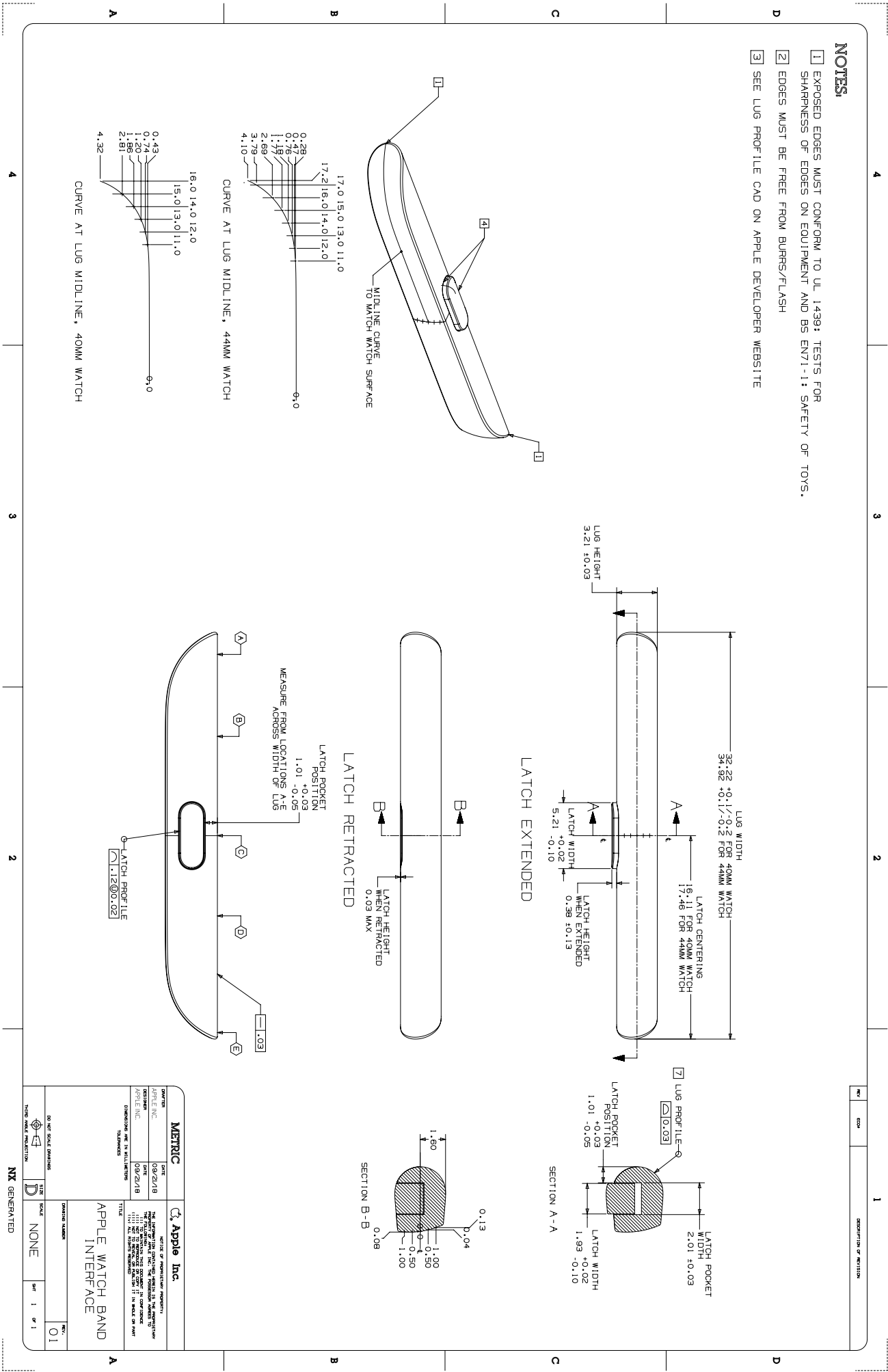
Bands for Apple Watch shall comply with applicable environmental regulations in the regions in which such bands are to be sold, and any applicable substance or material restrictions, including applicable restrictions on the following substances:

- 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

NOTES:

- 1 EXPOSED EDGES MUST CONFORM TO UL 1439: TESTS FOR SHARPNESS OF EDGES ON EQUIPMENT AND BS EN71-1: SAFETY OF TOYS.
- 2 EDGES MUST BE FREE FROM BURRS/FLASH
- 3 SEE LUG PROFILE CAD ON APPLE DEVELOPER WEBSITE



METRIC		Apple Inc.	
DATE	09/21/18	DATE	09/21/18
DESIGNED BY	Apple Inc.	DESIGNED BY	Apple Inc.
CHECKED BY	Apple Inc.	CHECKED BY	Apple Inc.
DATE	09/21/18	DATE	09/21/18
DESCRIPTION	APPLE WATCH BAND INTERFACE		
TOLERANCES	UNLESS OTHERWISE SPECIFIED		
FINISHES	UNLESS OTHERWISE SPECIFIED		
PROJECTION	FIRST ANGLE		
SCALE	NONE		
NO. OF SCALE SWINGS	NONE		
HAND MAKE PROJECTION	NONE		
DATE	09/21/18	DATE	09/21/18
DESIGNED BY	Apple Inc.	DESIGNED BY	Apple Inc.
CHECKED BY	Apple Inc.	CHECKED BY	Apple Inc.
DATE	09/21/18	DATE	09/21/18
DESCRIPTION	APPLE WATCH BAND INTERFACE		
TOLERANCES	UNLESS OTHERWISE SPECIFIED		
FINISHES	UNLESS OTHERWISE SPECIFIED		
PROJECTION	FIRST ANGLE		
SCALE	NONE		
NO. OF SCALE SWINGS	NONE		
HAND MAKE PROJECTION	NONE		
DATE	09/21/18	DATE	09/21/18
DESIGNED BY	Apple Inc.	DESIGNED BY	Apple Inc.
CHECKED BY	Apple Inc.	CHECKED BY	Apple Inc.
DATE	09/21/18	DATE	09/21/18
DESCRIPTION	APPLE WATCH BAND INTERFACE		
TOLERANCES	UNLESS OTHERWISE SPECIFIED		
FINISHES	UNLESS OTHERWISE SPECIFIED		
PROJECTION	FIRST ANGLE		
SCALE	NONE		
NO. OF SCALE SWINGS	NONE		
HAND MAKE PROJECTION	NONE		

16.3 Example Apple Watch Lug Assembly

These assembly instructions are based on [Example Apple Watch Lug](#) (page 89) and an assembly fixture with a clamping mechanism.

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

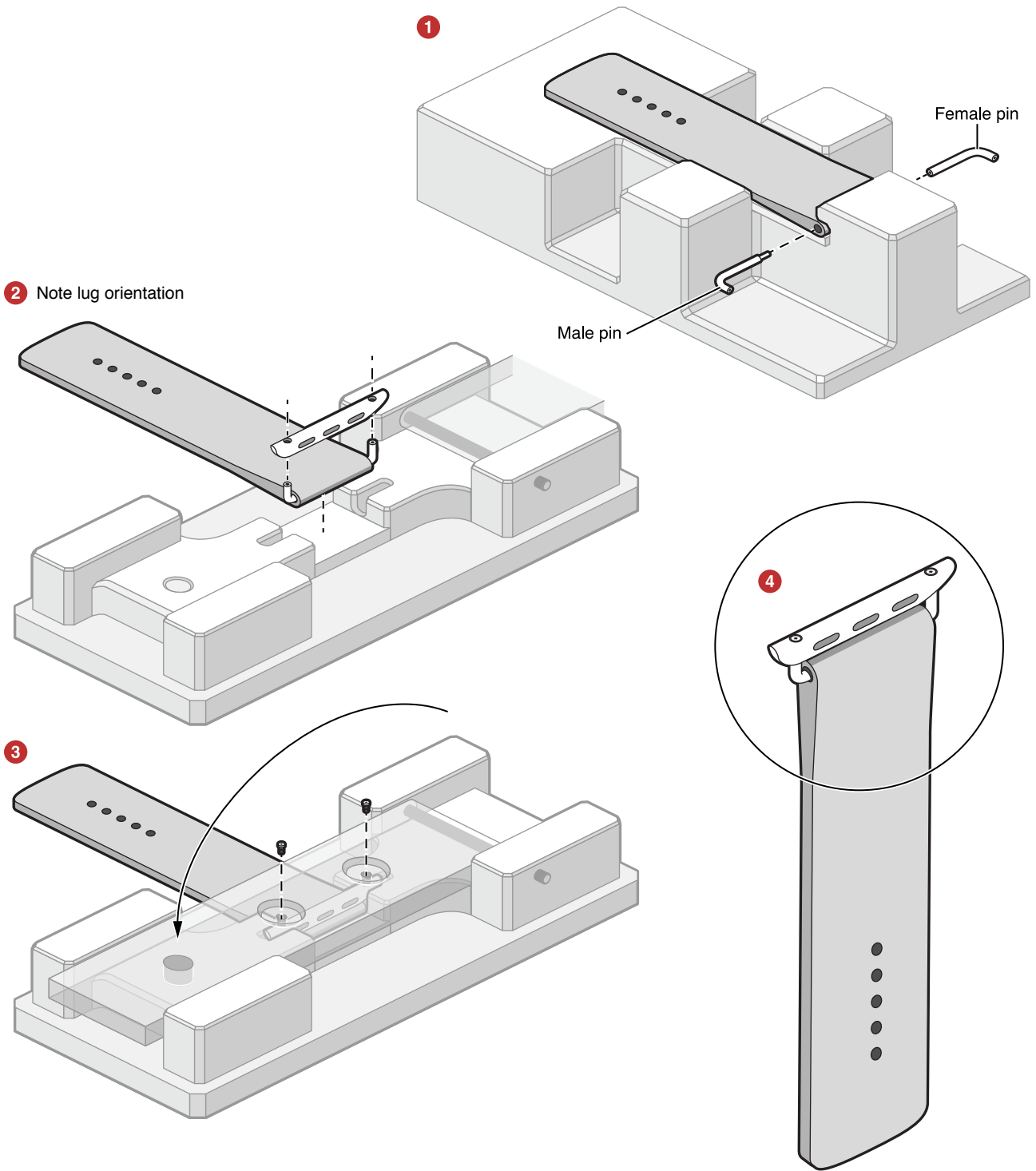
Screw threads should be secured with Loctite 435. Screws that have been previously installed/used should not be reused.

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

Assemble the band and lug as follows, see [Figure 16-1](#) (page 88).

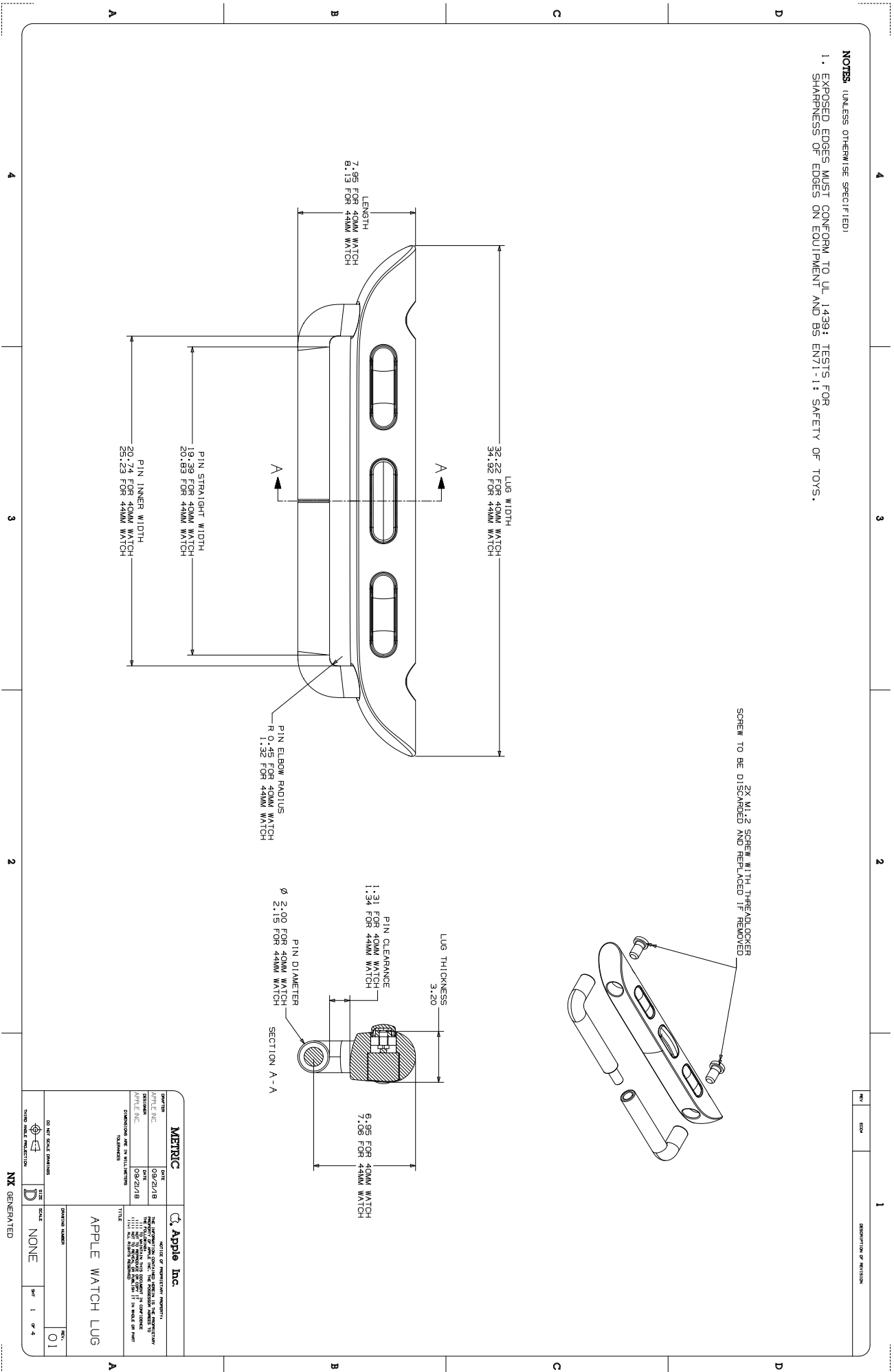
1. Lightly insert the long end of the female pin in the band until hard stop. Ensure there is no warping or damage in the band.
2. Lightly insert the long end of the male pin in the other side of the band until it interlocks with the female pin and both pins are seated together. Ensure there is no warping or damage in the 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 band. Latch shall be on the side of the band against the wrist.
4. Apply Loctite 435 to screw threads.
5. Install both screws using the following specification:
 - Torque: 1.1 kgf-cm \pm 10%
 - RPM: 120 \pm 10%
6. Inspect for screw proudness and cross-threading visually at 1200-1400 lux.
7. Ensure screw is just sub-flush to the lowest part of the counterbore and appears parallel to the long axis of the lug.
8. Ensure screw is flat and concentric with the counterbore, without damage.

Figure 16-1 Apple Watch Lug Assembly Fixture



16.4 Example Apple Watch Lug

NOTES: (UNLESS OTHERWISE SPECIFIED)
 1. EXPOSED EDGES MUST CONFORM TO UL 1439: TESTS FOR SHARPNESS OF EDGES ON EQUIPMENT AND BS EN71-1: SAFETY OF TOYS.



METRIC		Apple Inc.	
DATE	09/21/18	DATE	09/21/18
DESIGNED BY	APPLE INC.	DESIGNED BY	APPLE INC.
DATE	09/21/18	DATE	09/21/18
DIMENSIONS ARE IN MILLIMETERS			
TOLERANCES			
NONE			
DRAWING NUMBER			
APPLE WATCH LUG			
DO NOT SCALE DIMENSIONS		SCALE	
NONE		NONE	
HARD COPY PROJECTION		SHEET	
1		OF 4	
01		REV.	

MX GENERATED

Features

17. Bluetooth Accessory Identification

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

To enable Apple-specific features, the accessory shall support [HFP Command AT+XAPL](#) (page 91), 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 131) and [Bluetooth Headset Battery Level Indication](#) (page 98).

17.1 HFP Command AT+XAPL

Description: Enables custom AT commands from an accessory.

Initiator: Bluetooth accessory

Format: AT+XAPL=*vendorID-productID-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 revision of the software.
- *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)

17. Bluetooth Accessory Identification

17.1 HFP Command AT+XAPL

Response: +XAPL=iPhone,*features*

18. 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 that temporarily connect to the device are good candidates for this feature. Additionally, the accessory should integrate the Lightning Receptacle (C37) and implement Lightning Receptacle (C37) Passthrough Power so users can charge the device from an external power source while the accessory is attached.

See the [Accessory Interface Specification](#) (page 18) for more information.

19. App Discovery

The App Discovery feature enables accessories to retrieve a list of installed apps on the device that can communicate with the accessory. See [App Launch](#) (page 95) to make use of the list.

See the [Accessory Interface Specification](#) (page 18) for more information.

20. App Launch

An accessory that supports the App Launch feature can request that a device launch an app on its behalf.

Figure 20-1 App Launch Alert



See the [Accessory Interface Specification](#) (page 18) for more information.

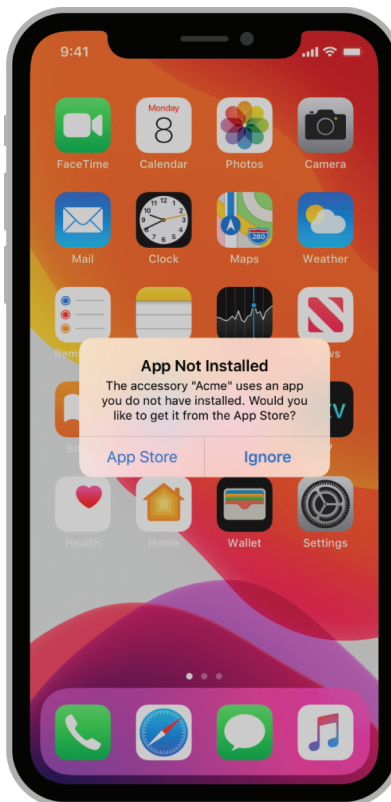
21. App Match

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

When connected for the first time, the device will ask the user if they would like to visit the App Store and view apps that work with the accessory. Subsequently, this action may be repeated by the user via *Settings > General > About > 'Accessory Name' > 'Find App for this Accessory'*.

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

Figure App Match Alert
21-1



See the [Accessory Interface Specification](#) (page 18) for more information.

22. Bluetooth Headset Battery Level Indication

Any Hands-Free Bluetooth headset accessory can show its battery level to the user as an indicator icon in the device status bar. This feature is supported on all devices that support 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 91) and [HFP Command AT+IPHONEACCEV](#) (page 98)

22.1 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

23. 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 that provide 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 19).

Accessories that provide power to a device shall either:

- Provide direct power, see [Direct Power Source](#) (page 99).
- Manage power from external sources, see [External Power Source](#) (page 99).

All accessories that do not have the potential for data communication with the device shall provide direct power to the device, see [Direct Power Source](#) (page 99).

23.1 Direct Power Source

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

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

23.2 External Power Source

Accessories that draw power from external power sources and provide all or a portion of that 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 via USB Connectors](#) (page 100).

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

See [AC Power Adapters](#) (page 62), [Integrated USB Receptacles](#) (page 21), and [User Supplied Cables and AC Power Adapters](#) (page 21) for additional requirements specific to external USB power supplies/cables.

23.3 Declaring Capability

If the accessory provides power via a:

- USB-A receptacle, then it shall use one of the following to declare its power providing capability:
 - [USB Power Capability Vendor Request](#) (page 150).
 - [USB D+/D- Resistor Networks](#) (page 151).
- USB-C receptacle, then:
 - It shall use one of the following to declare its power providing capability:
 - [USB-C Current](#) (page 155).
 - [USB Power Delivery](#) (page 154).
 - 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.

23.4 Providing Power via USB Connectors

If the accessory connects via a USB-A receptacle, see [USB-A Receptacle](#) (page 185).

If the accessory connects via a USB-C receptacle, see [USB-C Receptacle](#) (page 188).

23.5 Labeling Multiple Connectors

If the accessory has multiple connectors with different device compatibilities, then 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.

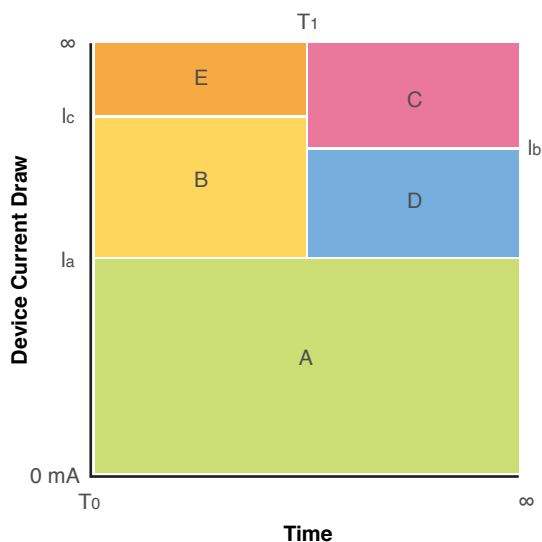
23.6 Fast Charge for iPhone (20 W)

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

- Support [USB Power Delivery](#) (page 154).
- 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 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

23.7 Overcurrent and Short Circuit Protection

Figure 23-1 Overcurrent and Short Circuit Protection



Power-providing accessories shall implement overcurrent and short circuit protection for each region in Figure 23-1 (page 102) according to Table 23-1 (page 102), Table 23-2 (page 102), and Table 23-3 (page 103).

Table 23-1 Overcurrent/Short Circuit Protection Current Thresholds

Threshold	Definition
I_a	Nominal accessory output current (i.e. 1000 mA, 2100 mA, 2400 mA, 3000 mA).
I_b	$I_a + 60\%$.
I_c	Lowest device current draw that will cause accessory output voltage (measured at Lightning Device Power) to drop below 2 V.

Table 23-2 Overcurrent/Short Circuit Protection Time Thresholds

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.

23. Device Power (Lightning)

23.8 Overcurrent and Short Circuit Protection Resets

Table 23-3 Overcurrent/Short Circuit Protection Behaviors

Region	Name	Accessory Behavior
A	Normal Operation	Accessory shall not limit or shutdown output current.
B	Overcurrent Transient	Accessory shall not shutdown output current. Accessory may limit output current to I_a or higher.
C	Overcurrent	Accessory shall shutdown output current.
D	Potential Overcurrent	Accessory may shutdown output current.
E	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.

23.8 Overcurrent and Short Circuit Protection Resets

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

23.9 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 (such as mains electricity or battery) is connected to or disconnected from the accessory.
- The accessory's internal power source (such as 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.

24. Device Power (Inductive)

Accessories may provide power to devices via integration of a Qi transmitter.

The following devices support this feature:

- 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

This feature is supported on iOS 11.2 or later.

24.1 Qi Wireless Power

Accessories that incorporate a Qi transmitter shall be certified according to *The Qi Wireless Power Transfer System, Power Class 0 Specification*, version 1.2.4, see <https://www.wirelesspowerconsortium.com>.

24.2 Electromagnetic Compatibility (EMC)

Accessories that provide inductive device power should be designed for electromagnetic compatibility.

24. Device Power (Inductive)

24.2 Electromagnetic Compatibility (EMC)

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. The implementation, final compliance testing, report preparation, and labeling are the responsibility of the company marketing the product.

Cable termination is critical for reduced emissions. Cable termination and connectors should be kept away from the charging coil 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 the emissions. The selected ferrite/absorber material 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 96W USB-C Power Adapter
 - Apple 61W USB-C Power Adapter
 - Apple 30W USB-C Power Adapter
 - Apple 20W USB-C Power Adapter
- Apple USB 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

If different power sources are used than listed above, emission testing should be performed while those power sources are on.

In addition to the cases above, the charging device 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

24. Device Power (Inductive)

24.2 Electromagnetic Compatibility (EMC)

- 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

Once the highest emissions combination is identified, complete testing should be performed on that configuration. Some regulatory domains may require EMC certification.

25. Location Information

The location feature provides compatible accessories with a means to provide external Global Navigation Satellite System (GNSS) information and other sensor data (like speed) in the form of National Marine Electronics Association (NMEA) sentences to devices. Devices that support this feature can take advantage of this additional information to augment their built-in location services. For example, some external Location-enabled accessories can provide more accurate or more frequent position updates. Additionally, devices can conserve power by using location information from a self-powered external accessory instead of using on-board positioning technologies.

See the [Accessory Interface Specification](#) (page 18) for more information.

26. MagSafe Attach

The following devices support MagSafe Attach:

- 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 26) shall:

- Claim compatibility with a MagSafe-capable device.
- Integrate a [MagSafe Case Magnet Array](#) (page 109).

Other MagSafe accessories shall:

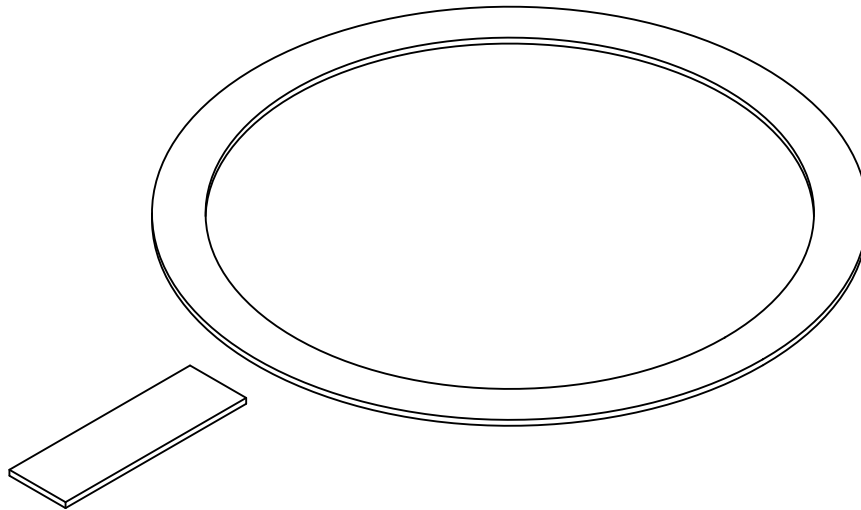
- Claim compatibility with a MagSafe-capable device.
- Integrate a [MagSafe Accessory Magnet Array](#) (page 116).

Apple recommends the following magnet array vendors:

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

26.1 MagSafe Case Magnet Array

Figure 26-1 MagSafe Case Magnet Array



26.1.1 Product Design

All cases that integrate a MagSafe case magnet array shall:

- Enclose the device.
- Have a uniform maximum thickness of 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 26).
- Work with:
 - Apple MagSafe Charger.
 - Apple MagSafe Battery Pack.
 - iPhone Leather Wallet.

26.1.2 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.

26. MagSafe Attach

26.1 MagSafe Case Magnet Array

26.1.2.1 Magnets

All MagSafe case magnets shall be N45SH NdFeB with a 7 μm - 13 μm NiCuNi plating finish (or similar) and shall meet the requirements in [Table 26-1](#) (page 110).

Table 26-1 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

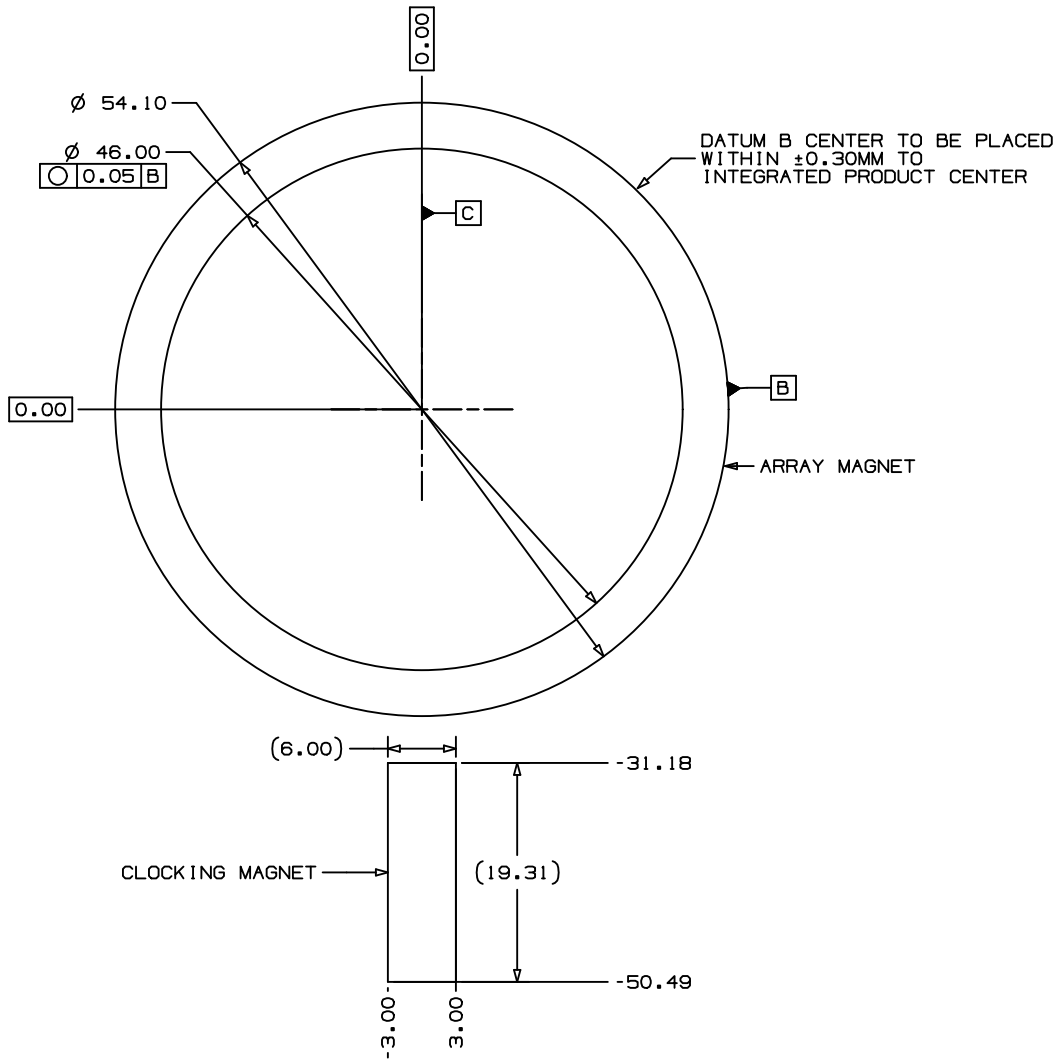
26.1.2.2 Magnet Array

The magnets shall be positioned in the case following the dimensions and polarity shown in [Figure 26-2](#) (page 111), [Figure 26-3](#) (page 112) and [Figure 26-4](#) (page 112).

26. MagSafe Attach

26.1 MagSafe Case Magnet Array

Figure 26-2 MagSafe Magnet Array Dimensions



26. MagSafe Attach

26.1 MagSafe Case Magnet Array

Figure 26-3 MagSafe Magnet Ring Dimensions and Polarity

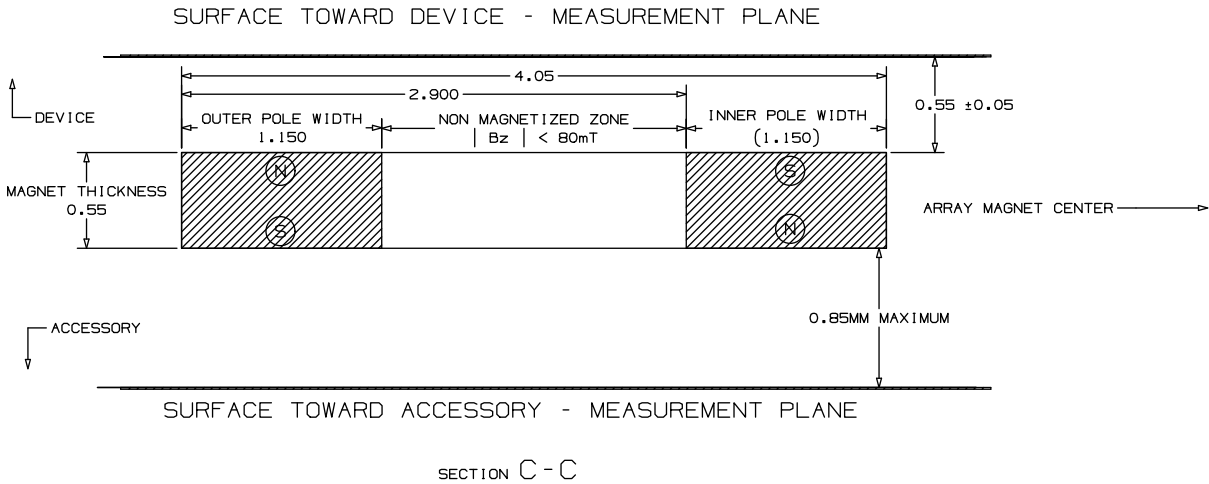
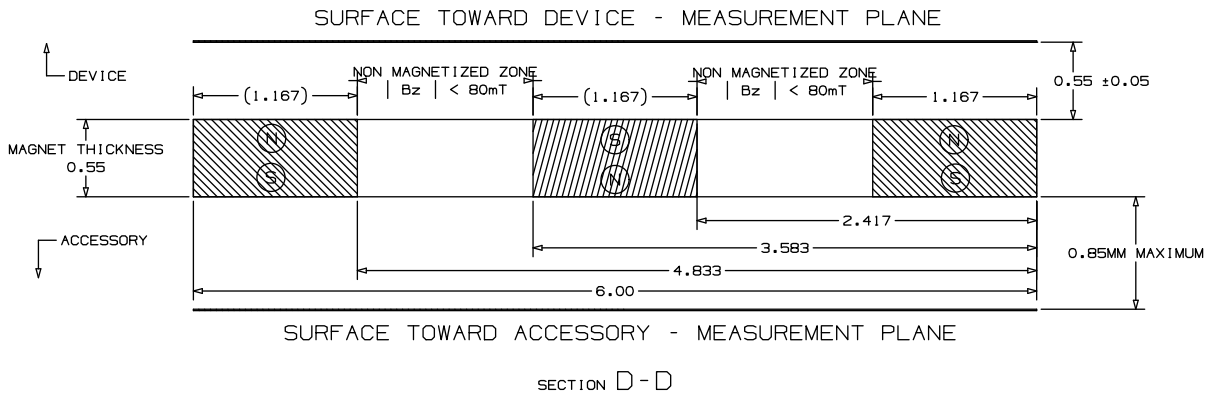


Figure 26-4 MagSafe Orientation Magnet Dimensions and Polarity



The flux density of a MagSafe case magnet ring shall comply with [Table 26-2](#) (page 113) and [Table 26-3](#) (page 114) across the 8 lines (S1 - S8) in [Figure 26-5](#) (page 113).

26. MagSafe Attach

26.1 MagSafe Case Magnet Array

Figure 26-5 MagSafe Flux Density Measurement Plane

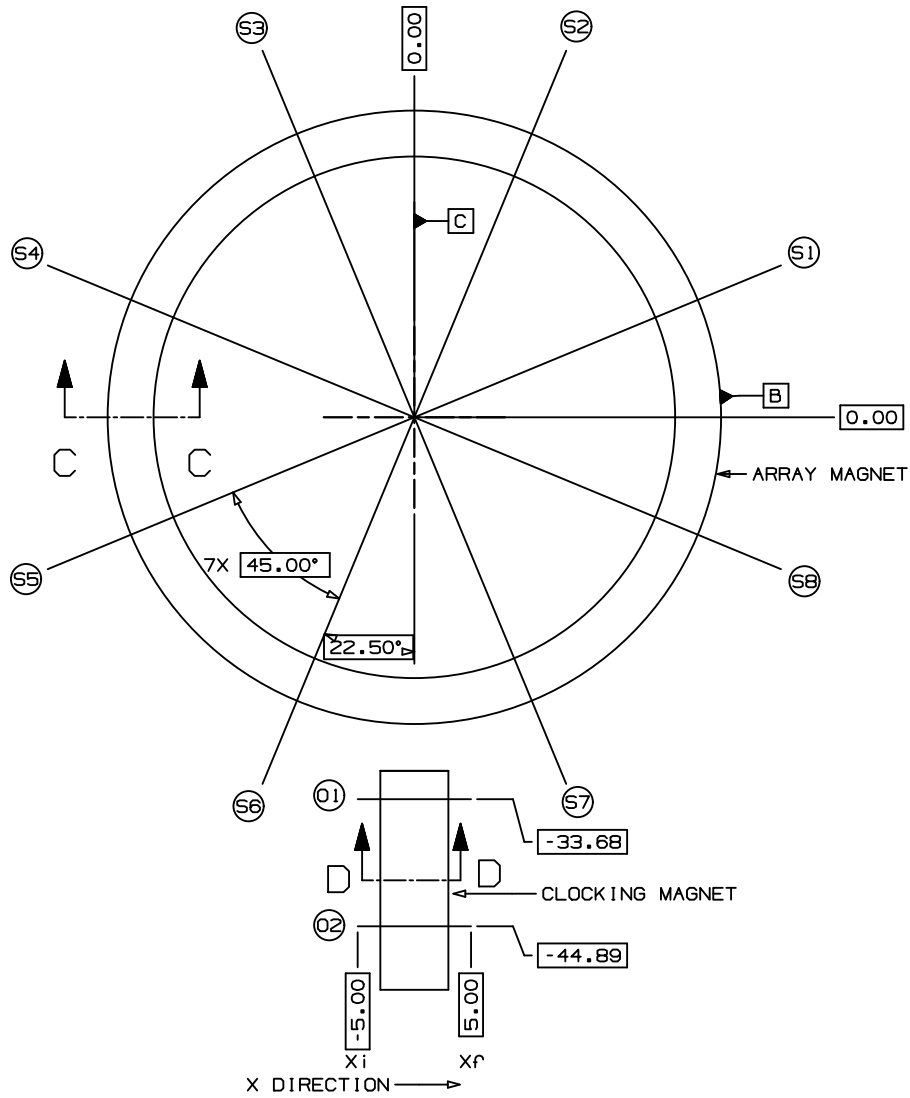


Table 26-2 Device side flux density at 0.55 mm from magnet ring surface

Minimum r	Maximum r	Minimum Bz	Maximum Bz	Minimum Bxy	Maximum Bxy
	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. MagSafe Attach

26.1 MagSafe Case Magnet Array

Minimum r	Maximum r	Minimum Bz	Maximum Bz	Minimum Bxy	Maximum Bxy
26 mm	27 mm	0.125 T	0.170 T		
27 mm	30 mm				0.075 T
30 mm		-0.020 T	0.000 T		0.025 T

Table 26-3 Accessory side flux density at 0.80 mm from magnet ring surface

Minimum r	Maximum r	Minimum Bz	Maximum Bz	Minimum Bxy	Maximum Bxy
	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 26-4](#) (page 114) and [Table 26-5](#) (page 115) across the 2 lines (O1 and O2) in [Figure 26-5](#) (page 113).

Table 26-4 Device side flux density at 0.55 mm from orientation magnet surface

Minimum x	Maximum x	Minimum Bz	Maximum Bz	Minimum Bxy	Maximum Bxy
	-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

26. MagSafe Attach

26.1 MagSafe Case Magnet Array

Table 26-5 Accessory side flux density at 0.80 mm from orientation magnet surface

Minimum x	Maximum x	Minimum Bz	Maximum Bz	Minimum Bxy	Maximum Bxy
	-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			0.050 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

26.1.2.3 Magnetic Force

The force normal to the back of the case that is needed to dislodge a MagSafe accessory, such as the Apple MagSafe Charger, shall meet the requirements in [Table 26-6](#) (page 115).

Table 26-6 Magnetic force

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

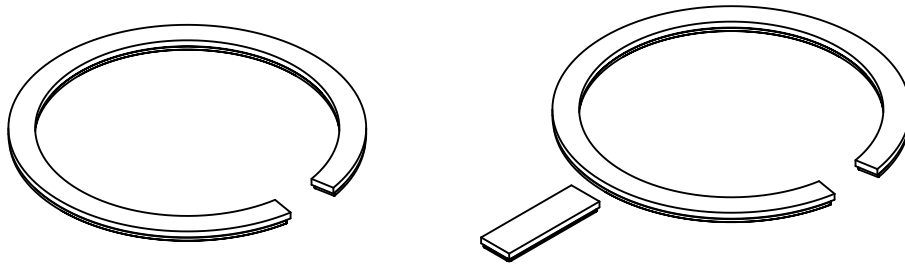
26.1.3 Magnetic Interference

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

- Device wireless charging functionality.
- Magnetic stripe cards in an attached iPhone Leather Wallet.

26.2 MagSafe Accessory Magnet Array

Figure 26-6 MagSafe Accessory Magnet Array Options



The MagSafe accessory magnet array may be implemented via a:

- [Magnet Ring](#) (page 117), enabling the device and accessory to be attached in any orientation.
- [Magnet Ring](#) (page 117) plus an [Orientation Magnet](#) (page 119), enabling the device and accessory to be attached at a specific orientation.

26.2.1 Product Design

All accessories integrating the MagSafe accessory magnet array shall not enclose the device.

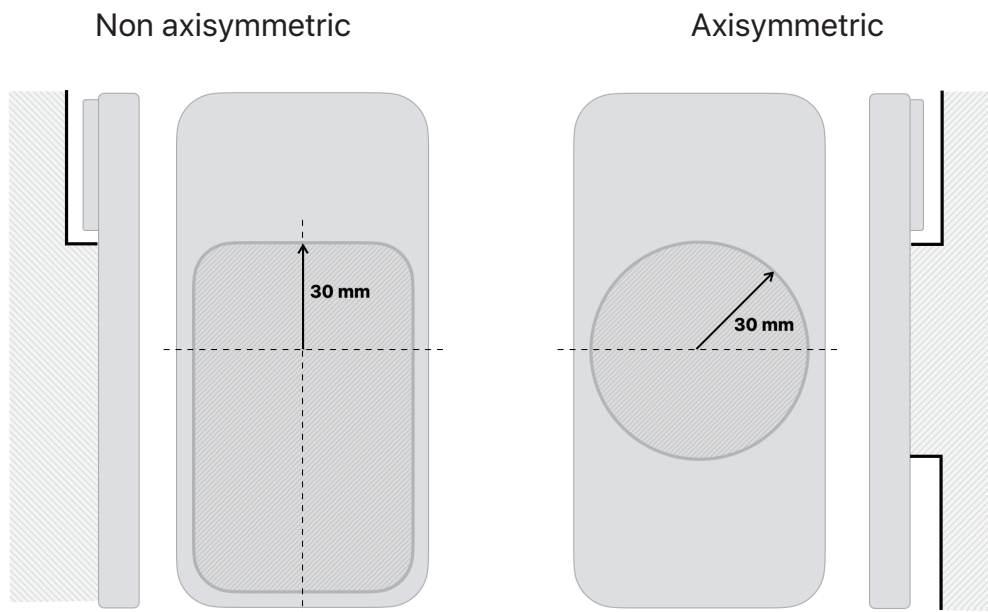
26.2.2 Mechanical

The accessory shall not interfere with, scratch, or damage 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 123).

Figure 26-7 MagSafe Accessory Clearance



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 117) shall magnetically self align to the device's magnet ring within a 1.55 mm radial maximum.

26.2.2.1 Magnets

All MagSafe accessory magnets shall be N48H NdFeB with a 7 μm - 13 μm NiCuNi plating finish (or similar) and shall meet the requirements in [Table 26-7](#) (page 117).

Table 26-7 Magnet Properties

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

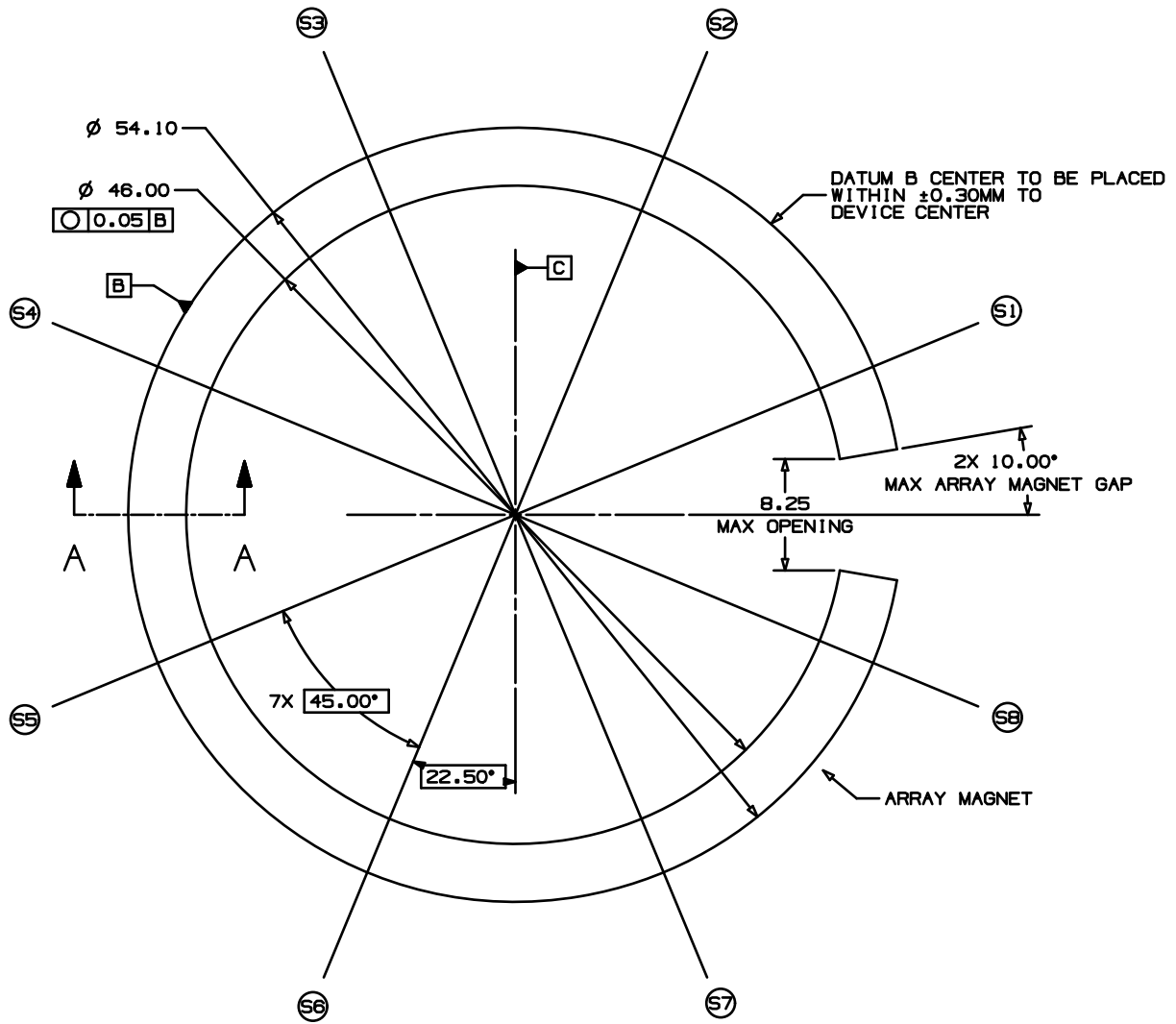
26.2.2.2 Magnet Ring

The magnet ring shall be positioned in the accessory following the dimensions and polarity shown in [Figure 26-8](#) (page 118) and [Figure 26-9](#) (page 119).

26. MagSafe Attach

26.2 MagSafe Accessory Magnet Array

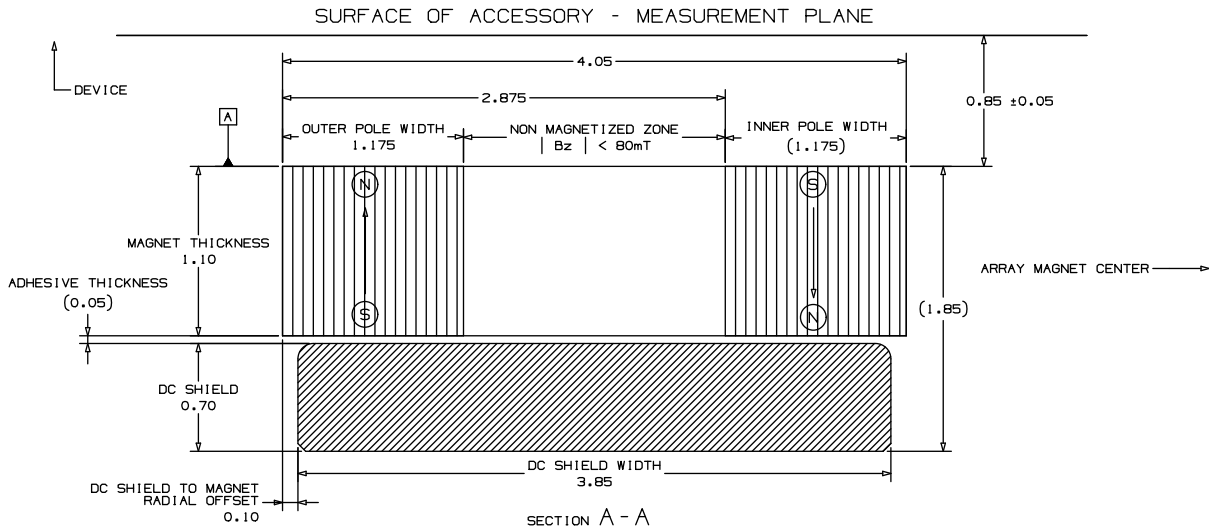
Figure 26-8 MagSafe Magnet Ring Dimensions



26. MagSafe Attach

26.2 MagSafe Accessory Magnet Array

Figure 26-9 MagSafe Magnet Ring Dimensions and Polarity



See [DC Shield](#) (page 122) for additional requirements of the DC shield specified in [Figure 26-9](#) (page 119).

The flux density of a MagSafe accessory magnet ring shall comply with [Table 26-8](#) (page 119) across the 8 lines (S1 - S8) in [Figure 26-8](#) (page 118).

Table 26-8 Flux density at 0.85 mm from magnet ring surface

Minimum r	Maximum r	Minimum Bz	Maximum Bz	Minimum Bxy	Maximum Bxy
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

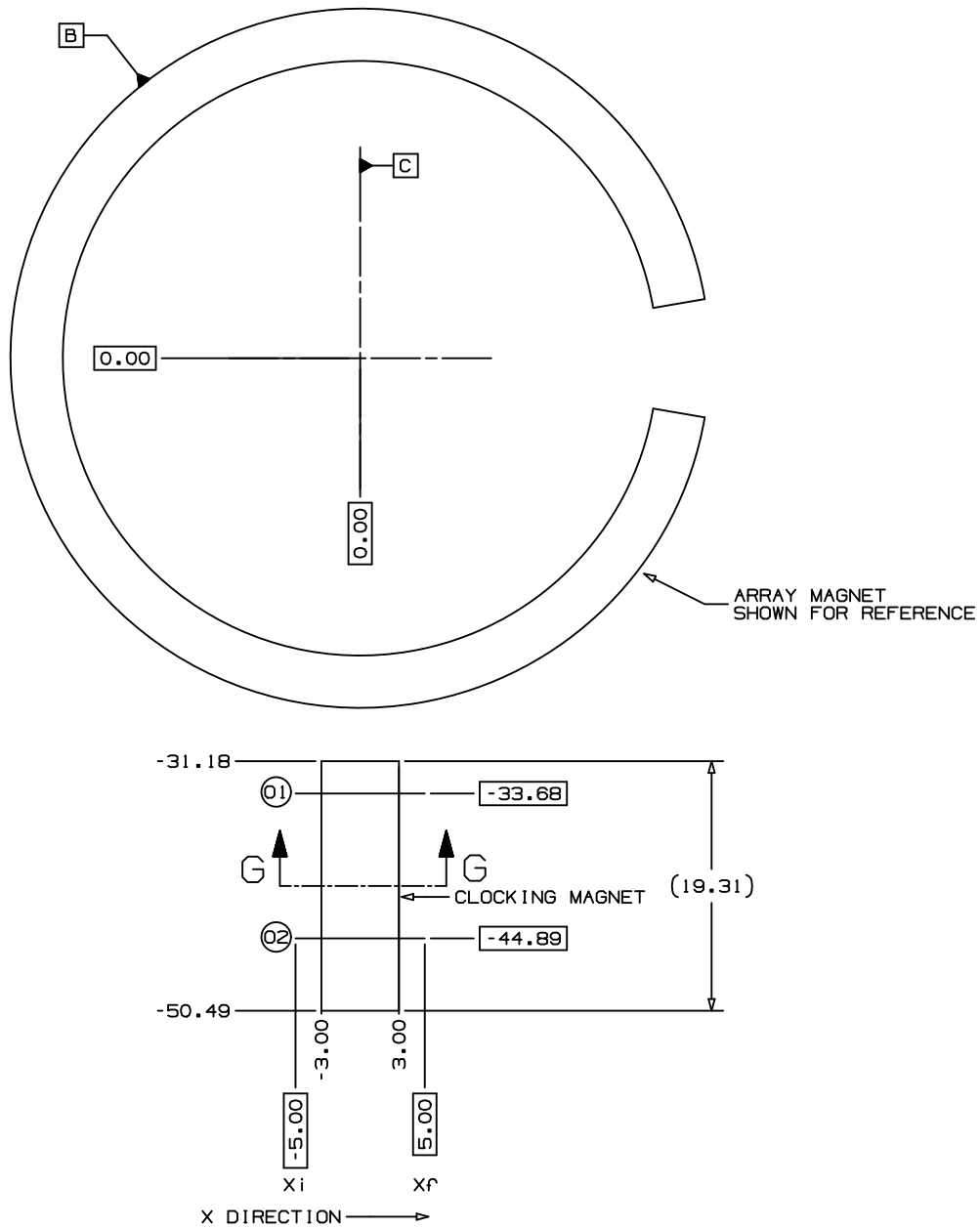
26.2.2.3 Orientation Magnet

If orientation magnets are included, they shall be positioned according to [Figure 26-10](#) (page 120) and [Figure 26-11](#) (page 121).

26. MagSafe Attach

26.2 MagSafe Accessory Magnet Array

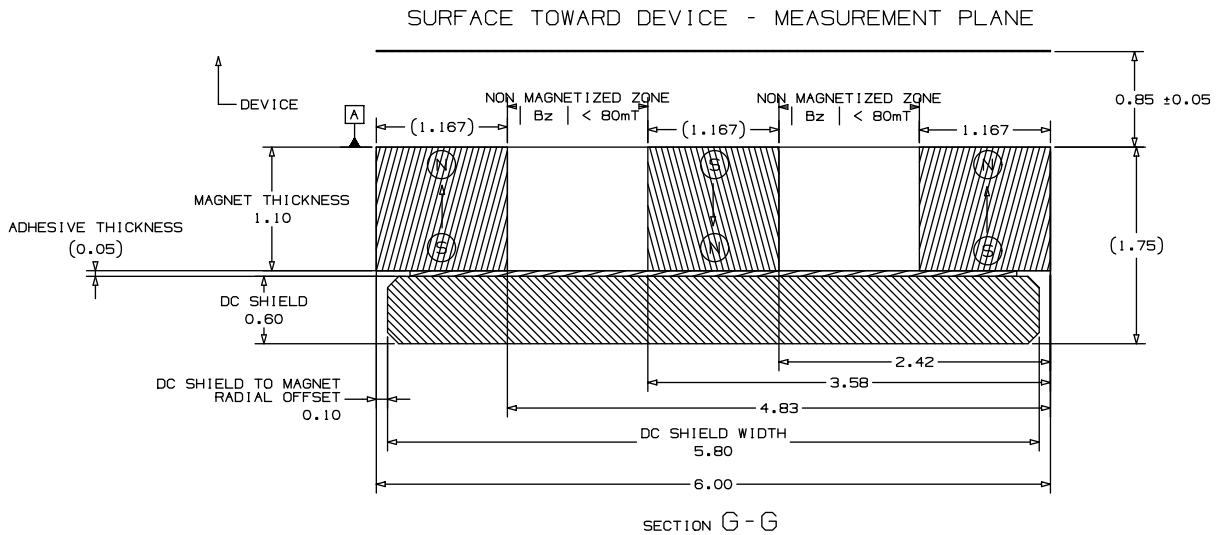
Figure 26-10 MagSafe Orientation Magnet Dimensions



26. MagSafe Attach

26.2 MagSafe Accessory Magnet Array

Figure 26-11 MagSafe Orientation Magnet Dimensions and Polarity



See [DC Shield](#) (page 122) for additional requirements of the DC shield specified in [Figure 26-11](#) (page 121).

The flux density of a MagSafe accessory orientation magnet shall comply with [Table 26-9](#) (page 121) across the 2 lines (O1 and O2) in [Figure 26-10](#) (page 120).

Table 26-9 Flux density at 0.85 mm from orientation magnet surface

Minimum x	Maximum x	Minimum Bz	Maximum Bz	Minimum Bxy	Maximum Bxy
	-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

26.2.2.4 Magnetic Force

The force normal to the back of the device that is needed to dislodge the MagSafe accessory shall meet the requirements in [Table 26-10](#) (page 122).

Table Magnetic force
26-10

Scenario	Minimum	Maximum
Accessory attached to device	650 gf	900 gf

26.2.2.5 DC Shield

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

The DC shield shall have a saturation flux density (B_{sat}) of at least 2.0 T.

26.3 MagSafe Accessory Enclosure Geometry

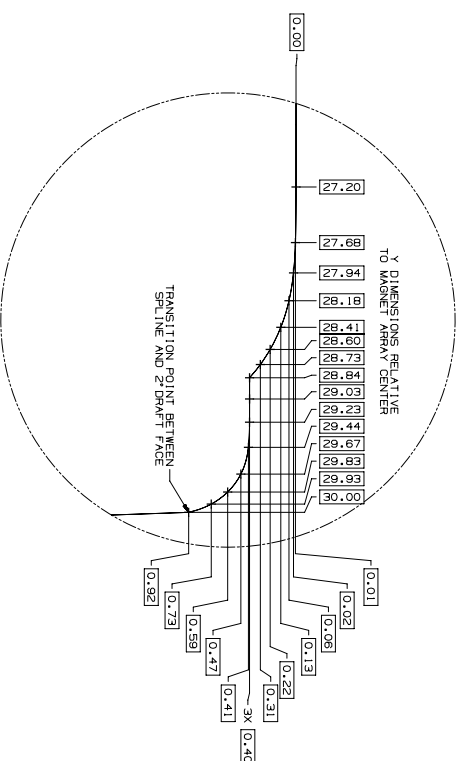
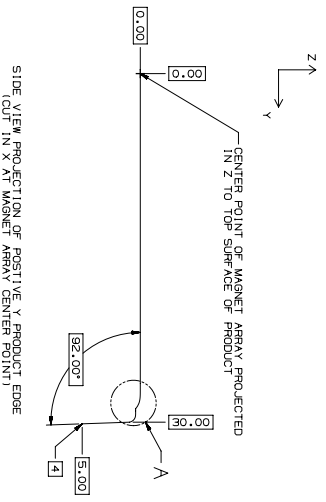
4

3

2

1

- NOTES** (UNLESS OTHERWISE SPECIFIED):
1. SPLINE REPRESENTS MAX MATERIAL CONDITION FOR AN EXTERIOR PRODUCT SURFACE. MAGSAFE COMPATIBLE ACCESSORIES SHALL STAY WITHIN THE PROVIDED SPLINE.
 2. FOR NON AXISYMMETRIC APPLICATIONS, SPLINE REPRESENTS MAX MATERIAL CONDITION WHEN VIEWED ALONG X AXIS
 3. FOR AXISYMMETRIC APPLICATIONS, A REVOLUTION OF THE SPLINE AROUND THE Z AXIS THROUGH THE CENTER POINT OF THE MAGNET ARRAY REPRESENTS THE MAX MATERIAL CONDITION
4. ANY CURVATURE DEVIATING BEYOND SPLINE TO EXIST BEYOND 5MM Z CLEARANCE FROM TOP OF PRODUCT



DETAIL A
SCALE 50:1

4

3

2

1

METRIC		Apple Inc.	
DATE	DATE	VERSION	DESCRIPTION
APRIL 11 2021	APRIL 11 2021	001	INITIAL RELEASE
APRIL 11 2021	APRIL 11 2021	002	DESIGN CHANGES
DIMENSIONS ARE IN MILLIMETERS (UNLESS OTHERWISE SPECIFIED)			
TOLERANCES		TITLE	
0.25	0.13	MAGSAFE COMPATIBLE ENCLOSURE GEOMETRY	
0.13	0.05	DRAWING NUMBER	
0.05	0.02	SCALE	
NONE		NONE	
DO NOT SCALE DRAWING		SHEET 1 OF 1	
HIDDEN AREA PROJECTION		NX GENERATED	

26.4 Test Procedures

26.4.1 MagSafe Case Magnet Array

26.4.1.1 Case Thickness

26.4.1.1.1 Equipment

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

26.4.1.1.2 Procedure

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

26.4.1.2 Accessory Clearance

26.4.1.2.1 Equipment

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

26.4.1.2.2 Procedure

1. Attach the case to the device.
2. Attach the Apple MagSafe Battery Pack to the back of the case.
3. Verify that the case doesn't interfere with the Apple MagSafe Battery Pack and that only the mating surface is in contact.

26.4.1.3 Magnetic Force

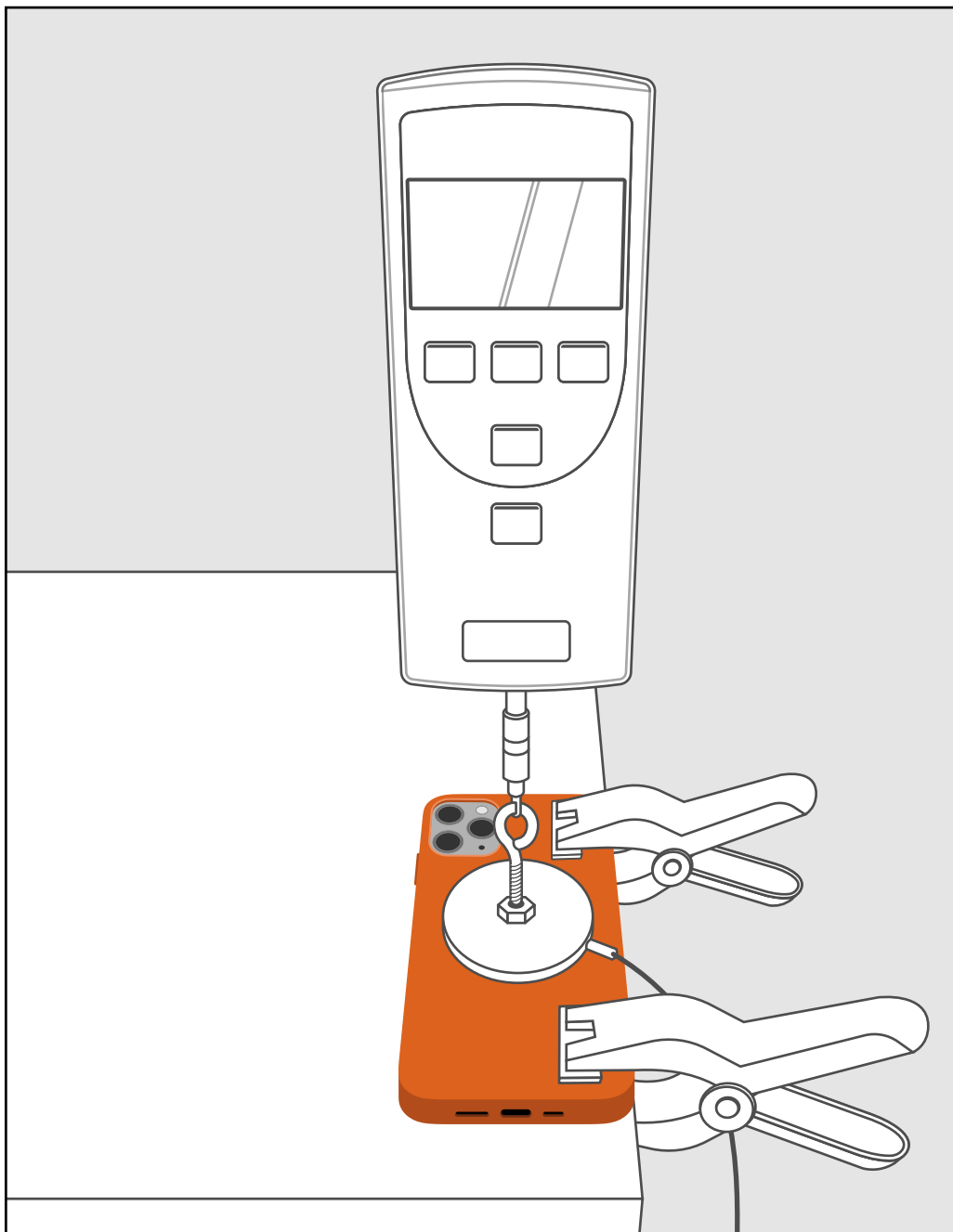
26.4.1.3.1 Equipment

- 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 with hook attachment that can capture peak values, such as the Chatillon DFX II.
- Clamps.

26.4.1.3.2 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 26-12](#) (page 126).
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 26-12](#) (page 126).
 - 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 that the average force is within the range of 800 gf to 1100 gf.

Figure 26-12 Magnetic Force Test Setup



26.4.1.4 iPhone Leather Wallet Detection

26.4.1.4.1 Equipment

- MagSafe-capable device.

- iPhone Leather Wallet.

26.4.1.4.2 Procedure

1. Attach the case to the device.
2. Attach the iPhone Leather Wallet to the back of the case.
3. Verify that the device displays the iPhone Leather Wallet animation.

26.4.1.5 Magnetic Stripe Cards in iPhone Leather Wallet

26.4.1.5.1 Equipment

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

26.4.1.5.2 Procedure

1. Attach the accessory to the device.
2. Repeat this procedure for 3 different brands of LoCo cards:
 - a. Write to the LoCo card and confirm readability.
 - b. Insert the LoCo card into the iPhone Leather Wallet with the magnetic stripe facing the magnets of the iPhone Leather Wallet.
 - c. Place additional cards into the pocket to ensure LoCo card is in contact with the magnet side of the iPhone Leather Wallet.
 - d. Attach the iPhone Leather Wallet to the accessory (attached to the device).
 - e. Wait 10 seconds.
 - f. Remove the iPhone Leather Wallet from the accessory.
 - g. Remove the LoCo card from the iPhone Leather Wallet.
 - h. Verify that the LoCo card can be read and that it displays the correct information.

27. 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 available media libraries 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 the media library.

See the [Accessory Interface Specification](#) (page 18) for more information.

28. 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 Music and Video apps on devices and certain third-party iOS apps that support 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.

See the [Accessory Interface Specification](#) (page 18) for more information.

29. Out-of-Band Bluetooth Pairing

Accessories with the ability to connect to a device via 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 via the Settings app.
- Download the accessory's companion app and initiate pairing from the app.

See the [Accessory Interface Specification](#) (page 18) for more information.

30. 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 that resembles the Siri microphone icon.

The rest of this chapter is applicable to accessories that support 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 19).

30.1 Enabling Custom Siri Commands

Every accessory that supports Siri over Bluetooth using HFP commands shall support [HFP Command AT+XAPL](#) (page 91). 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.

30.2 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.

30.2.1 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.

30.2.1.1 HFP Command AT+APLSIRI?

Description: AT command to retrieve Siri status information.

30. Siri

30.2 Obtaining Siri Availability 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)

30.2.2 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 that Siri is available and enabled.

30.2.2.1 HFP Command +APLSIRI

Description: Unsolicited event indicating a change in Siri status.

Initiator: Device

Format: +APLSIRI : *value*

Defined Values:

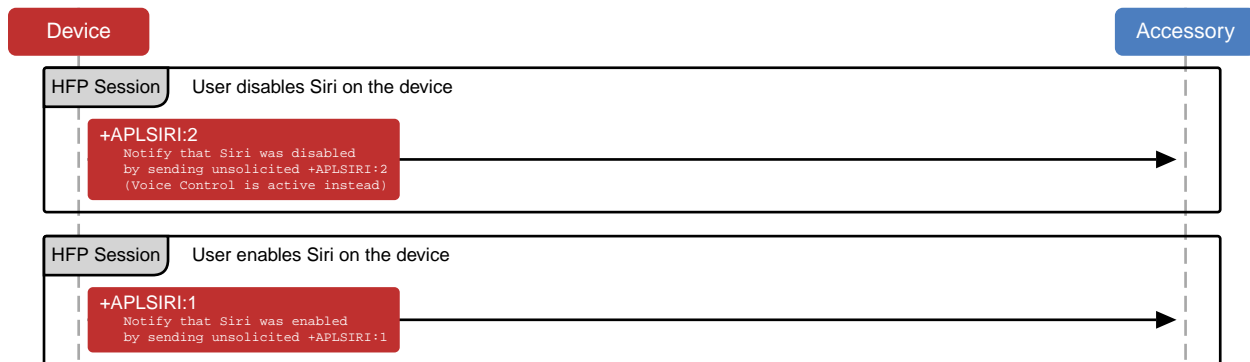
- 1 = Siri is available and enabled.
- 2 = Siri is available but not enabled.

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

30. Siri

30.3 Initiating a Siri Session

Figure 30-1 Siri is Disabled/Enabled from the Device's Settings



30.3 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.

30.3.1 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 launches 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.

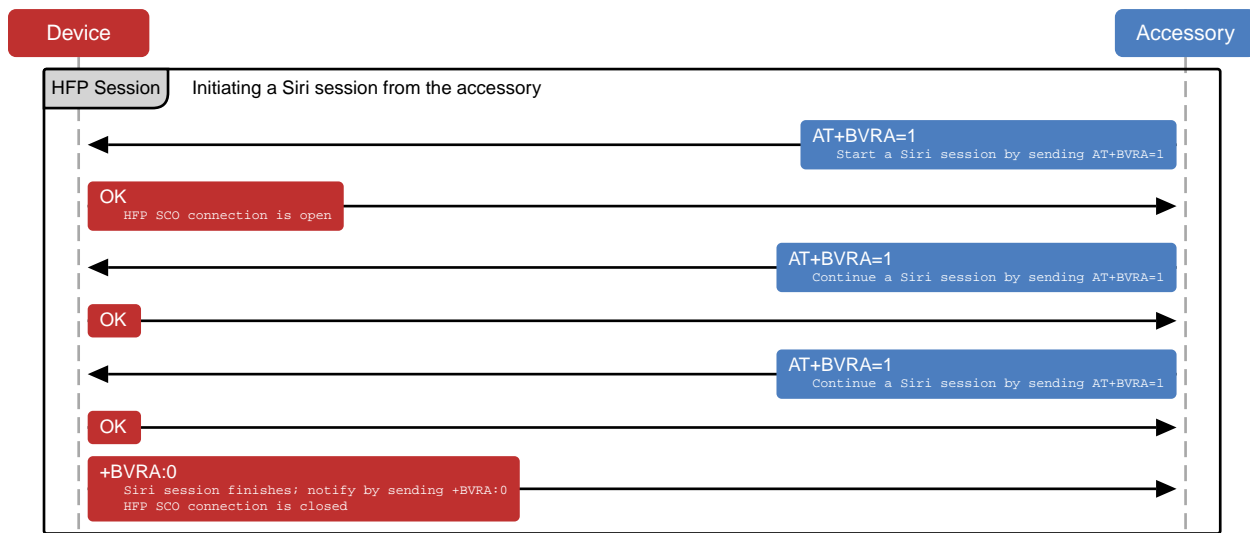
While a Siri session is active, the accessory shall let the user continue the conversation and ask follow up questions within the current context. In order to do so, the accessory shall be able to send an AT+BVRA=1 command to the device even after Siri has been already activated and before +BVRA:0

30. Siri

30.3 Initiating a Siri Session

is received. [Figure 30-2](#) (page 134) 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 30-2 Initiating a Siri Session from the Accessory



30.3.2 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.

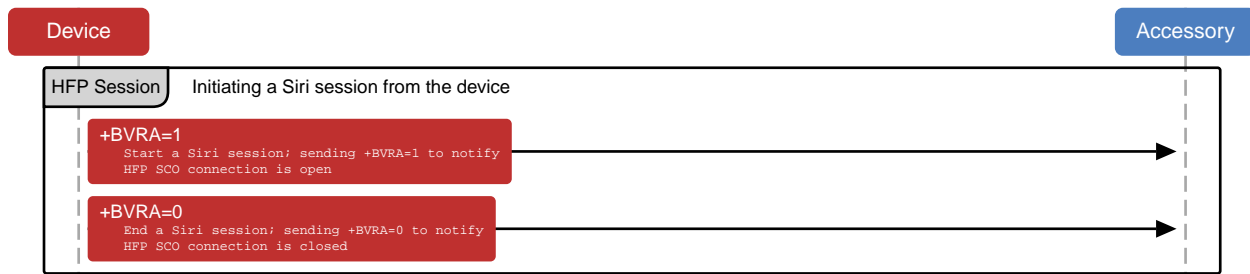
The accessory should expect the following command sequence:

- The device sends a +BVRA:1 event to the accessory.
- The device launches 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.

30. Siri

30.4 Siri Eyes Free Mode

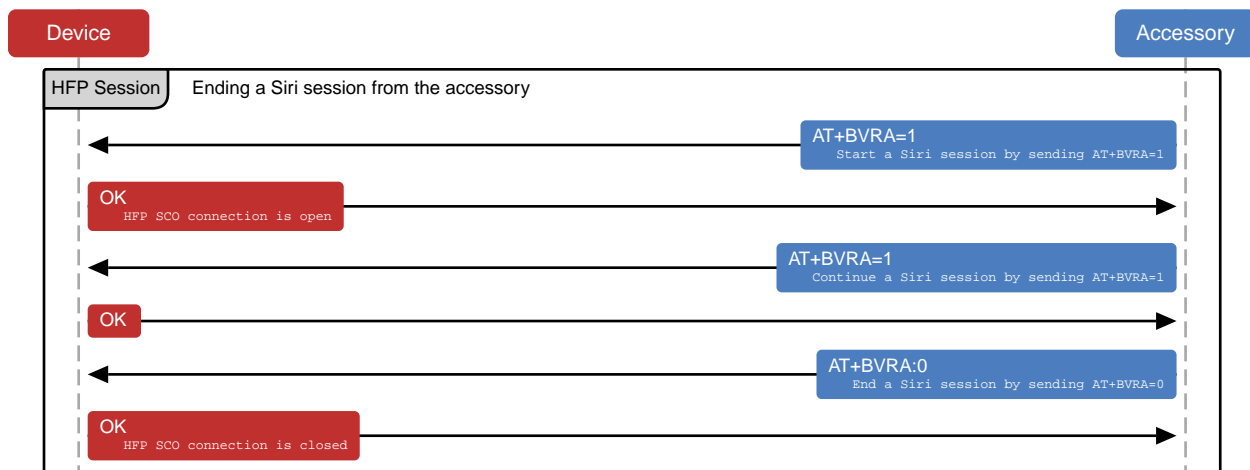
Figure 30-3 Initiating a Siri Session from the Device



30.3.3 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 30-4](#) (page 135) 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 30-4 Ending a Siri Session from the Accessory



30.4 Siri Eyes Free Mode

Siri Eyes Free mode is a feature to control Siri responses that include 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 via 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 via 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 that contain visual information or require user interaction. Suitable audio feedback and voice commands will be available to the user based on the Siri use case that was initiated.

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.

30.4.1 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

30.5 Improving Voice Recognition

The microphone audio that the 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 (such as 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 $-30 \text{ dB} \pm 2 \text{ dB}$ root-mean-square (RMS), expressed in units relative to full-scale (dBFS(A)). Alternatively, the nominal level may be $13 \text{ dB} \pm 2 \text{ dB}$ 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.

30.5.1 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.

30.6 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.

30.7 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.

30.7.1 Initialization Procedure After Connection is Established

Figure 30-5 (page 138) 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 30-6 (page 139).

Figure 30-5 Siri Initialization Procedure

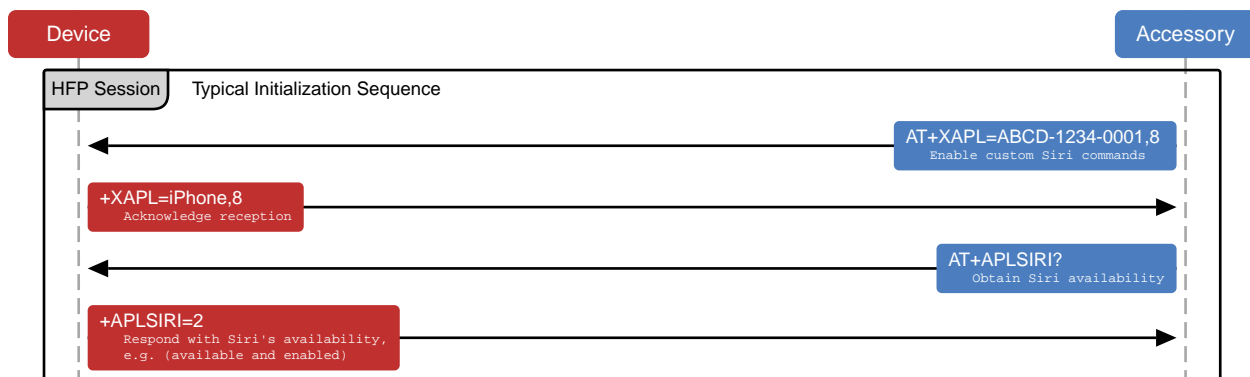
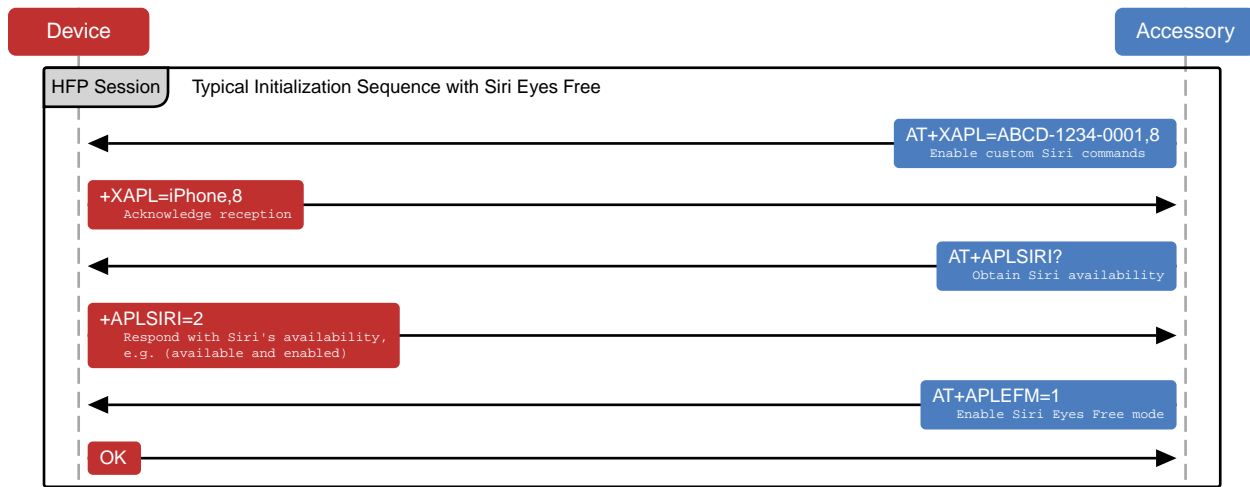


Figure 30-6 Siri Initialization Procedure with Siri Eyes Free



30.7.2 Phone Dialing Using Siri

Upon the user's 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 164). 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.

30.7.3 Audio Routing and Media Playback Using Siri

Siri can control the media playback on a device, and if Siri determines that the user wants to play or pause music it 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 those notifications, start or stop the music playback as requested, as well as update the correct playback state (e.g. 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 (via 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 172) and [Audio Data Received via A2DP Profile](#) (page 174).
- Wired audio routes shall use iAP2.

30.7.4 Turn-By-Turn Directions Using Siri

Siri can initiate active route guidance that will play 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 172).

30.8 User Interaction with Siri Eyes Free in a Vehicle

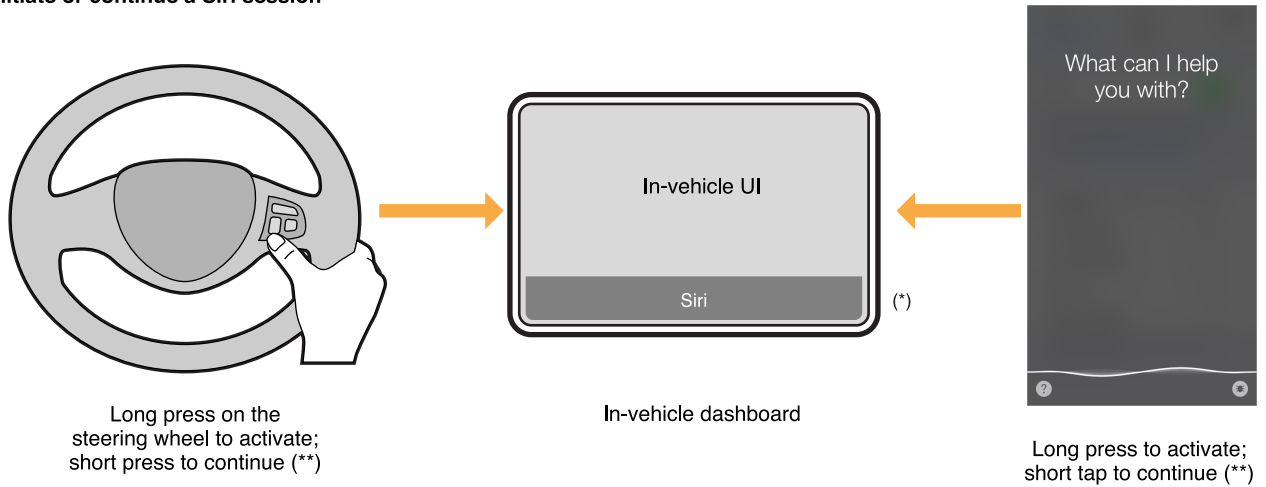
A vehicle that uses Siri Eyes Free mode shall integrate the Siri experience with the existing in-vehicle entertainment system and controls. The vehicle should provide a convenient interface to initiate, continue, and end a Siri session. Once a Siri session is running, the vehicle shall display a visual cue that voice recognition is in process. [Figure 30-7](#) (page 141) outlines how a Siri interaction should be designed.

30. Siri

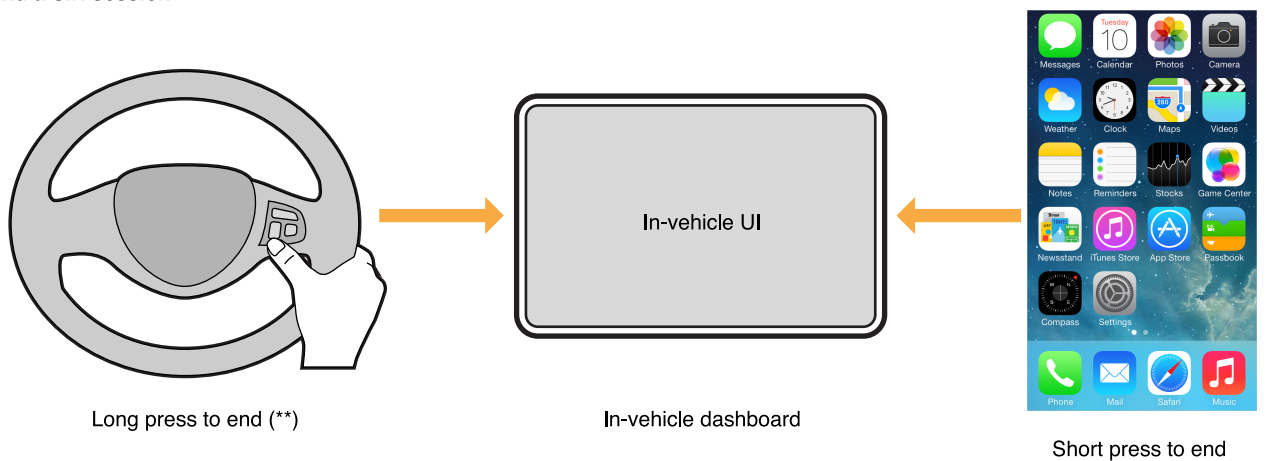
30.8 User Interaction with Siri Eyes Free in a Vehicle

Figure 30-7 Siri Eyes Free User Interaction

Initiate or continue a Siri session



End a Siri session



(*) If the accessory wishes to indicate that 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 that does not resemble 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 that the device is in an active Siri session but there will be no visual Siri content displayed.

30.9 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 launch Voice Control with no further changes, in the same way Siri is launched as in [Figure 30-8](#) (page 142) or display a warning message and not send an activation command to the device as in [Figure 30-9](#) (page 143).

Figure 30-8 Siri is Deactivated - Launching Voice Control

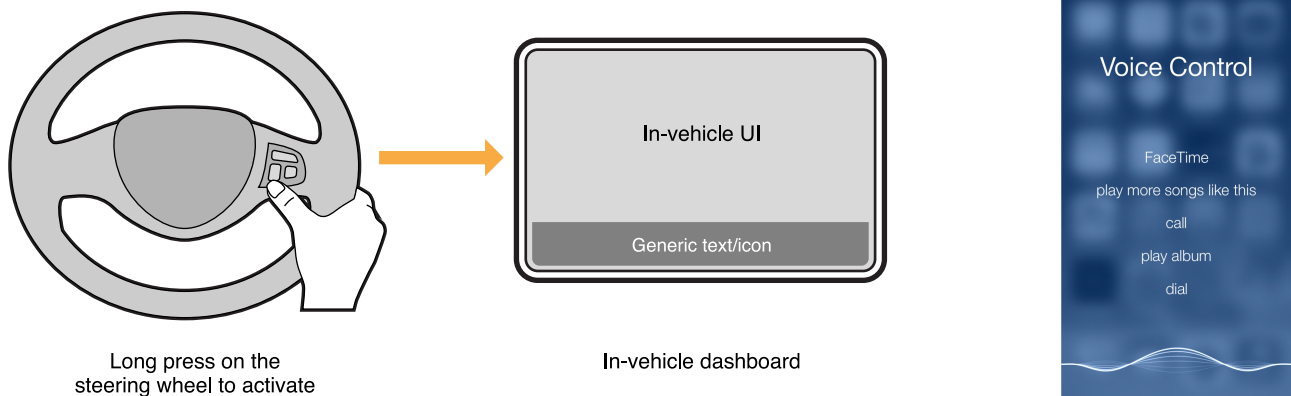
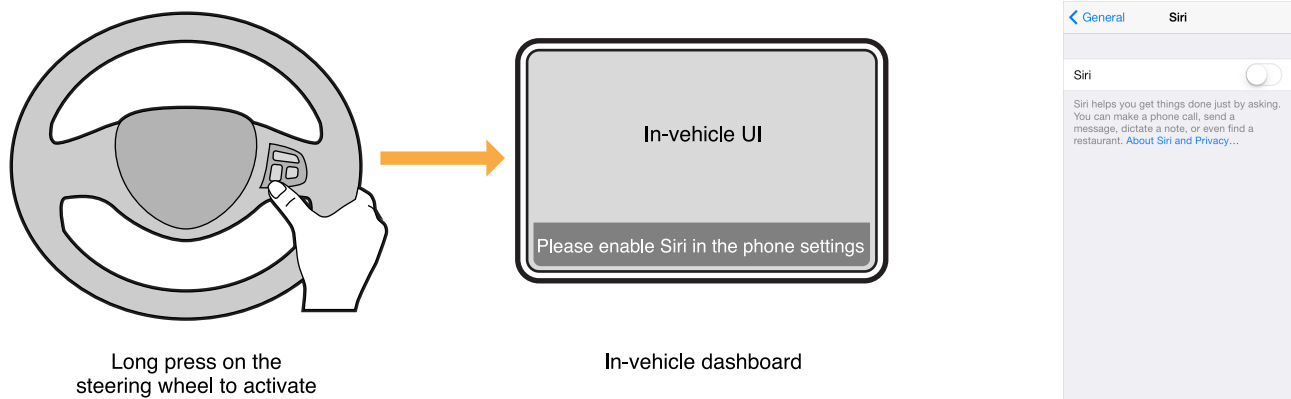


Figure 30-9 Siri is Deactivated - Displaying a Warning Message



30.10 Test Procedures

30.10.1 Siri Eyes Free

The following test procedures are applicable to accessories that interact 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.

30.10.1.1 General

1. Pair and establish a Bluetooth Handsfree Profile (HFP) connection between the iPhone and the head unit. Activate Siri from the vehicle steering wheel button (e.g. by press hold):
 - a. Observe that 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 that Siri opening chime is heard completely through the vehicle speakers.
 - c. Observe a visual notification in the in-car User Interface (UI) that a Siri session is active (textual notification, on-screen UI, etc.).
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 (e.g. by press):
 - a. Ensure the iPhone screen remains inactive (if manually activated, the visual indicator on the phone will disappear).
 - b. Verify that the in-car UI for Siri interaction dismisses and the head unit resumes the state before Siri's 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. Observe that the visual indicator is still active on the phone.
 - b. Listen for the Siri opening chime.
 - c. The vehicle UI should be displaying an on-going Siri session.
 - d. Verify that 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 that the visual indicator on the phone is no longer visible.
 - b. The in-car UI for Siri interaction should be dismissed.
 - c. The head unit should resume the state before Siri's interaction.
6. Listen to FM radio from the car speakers (no A2DP streaming active). Press and hold phone's Home button to activate Siri from the phone:
 - a. Observe a visual notification in the in-car UI that 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 off Siri. 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 that Siri Eyes Free is not available.
8. On the phone go to Settings and turn Siri back on. Verify that Siri can be activated/cancelled from the head unit and from the Home button on the phone.
9. Turn Bluetooth off from the Settings on the phone. Verify that Siri cannot be started.
10. Turn Bluetooth back on from the Settings on the phone. Verify that Bluetooth HFP profile reconnects and that Siri can be activated/cancelled from the head unit and from the Home button on the phone.
11. Make sure there is no accessory battery status level indicator icon displayed on the phone's status bar.

30.10.1.2 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 your dictated message, say "Review it". After Siri has read back the message again, say "Review it" again. Repeat this cycle ~5 times to ensure that the head unit is able to handle a long interaction with Siri. At the end say "Send it" and verify that the message is sent. Verify that

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 before Siri was started, i.e. if it was paused remains paused, if it was playing remains 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 that the Siri session is closed and that the audio playback goes back to the state it was before Siri was started, e.g. if it was paused remains paused, if it was playing remains playing.
3. Start Siri from the vehicle's steering wheel button and say "Search the web for polar bears". Verify that Eyes Free mode is on and that this use case is blocked by Siri. Note: In some implementations the vehicle has to be in motion before 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 has answered but before ~5 seconds have elapsed, resume Siri (e.g. by a short press on the steering wheel button) and verify that Siri is initiated again. Say "What about San Francisco?". Repeat (with a different city) and verify that this can continue indefinitely as long as you short press on the steering wheel button within 5 seconds of the last response.

30.10.1.3 Bluetooth HFP A2DP Music

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

30.10.1.4 Call

1. Activate Siri and call a contact with more than one phone number (home and mobile). Wait for Siri's response to ask for which phone number to call. Answer with "home". Verify that 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 name to call*". Verify that call transition is handled correctly by the head unit. Verify that iPhone music playback resumes after the call has been answered and terminated on the far end. Verify that the Siri in-car UI is dismissed and the head unit goes back to its initial state.
3. While iPhone music is playing, start Siri and say "Call *insert contact name to call*". Verify that call transition is handled correctly by the head unit. Verify that iPhone music playback resumes after the call has been answered and terminated on the near end (i.e. on the head unit). Verify that the Siri in-car UI is dismissed and the head unit goes back to its initial state.
4. While in a Siri session, receive an incoming call on the head unit. Verify that head unit handles call-signaling correctly and transitions to phone UI once the call has been accepted. Verify that the Siri in-car UI is dismissed and the head unit goes back to its initial state.

30.10.1.5 Bluetooth + Wired iAP2

1. Connect device to head unit via a Lightning connector (iPhone 5). Switch to iPod music and verify that audio is playing. Activate Siri and say "Next track". Verify that track advances and head unit displays track metadata correctly. Verify that the Siri in-car UI is dismissed and the head unit goes back 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 that the new song starts playing and that the head unit displays the track metadata for this new song correctly. Verify that the Siri in-car UI is dismissed and the head unit goes back to its initial state.
3. Turn Shuffle off on the head unit UI. Then start Siri and say "Shuffle all songs". Verify that 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 that 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 that head unit is able to automatically switch to iPOD audio source and that audio starts playing through the speakers. Verify that there is no skipping of audio at the beginning of the selected track. Verify that the Siri in-car UI is dismissed and the head unit goes back to its initial state.
5. Pause music playback on the head unit (via iAP2 commands). Activate Siri and ask "What time is it?". Verify that music playback remains paused after Siri session has been dismissed. Verify that the Siri in-car UI is dismissed and the head unit goes back to its initial state.

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

31. 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 31-1 Wi-Fi Information Sharing Alert



See the [Accessory Interface Specification](#) (page 18) for more information.

Protocols

32. USB Power Capability Vendor Request

If the accessory is a USB host, and it does not implement [iAP2](#) (page 160), then it may send an Apple-specific USB vendor request to communicate 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 32-1 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.	Charging current available, expressed as an offset from 500 mA. Shall be 500 (1000 mA charging current available), 1000 (1500 mA charging current available), 1600 (2100 mA charging current available), 1900 (2400 mA charging current available), or 2500 (3000 mA charging current available).
wIndex	See comments.	Shall be the same as wValue.
wLength	0	0 bytes expected.

33. USB D+/D- Resistor Networks

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

- [iAP2](#) (page 160).
- [USB Power Capability Vendor Request](#) (page 150).
- [USB-C Current](#) (page 155).
- [USB Power Delivery](#) (page 154).

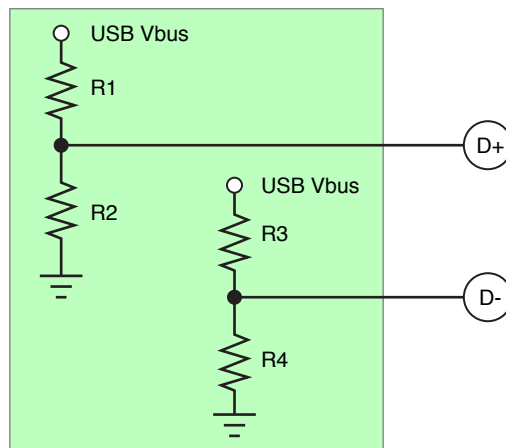
Note:

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

33.1 Declaring Power Source Capability

The accessory shall connect the USB D+ and USB D- pins to resistor networks as shown in [Figure 33-1](#) (page 151).

Figure 33-1 USB D+/D- resistor networks



Note:

Every iOS device-compatible connector on an accessory that uses 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.
- The accessory senses the attachment of the device via 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 33-1](#) (page 151) 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 33-1 USB D+/D- resistor values

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

33.2 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 limit should be identified using the following procedure:

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.

33. USB D+/D- Resistor Networks

33.2 Identifying Power Source Current Limit

4. Read the D+ and D- voltages using an ADC (to determine the value for R1 and R3 respectively):
 - If the voltage is >2.995 V (based on 1 M Ω load impedance), then assume a resistor value of 24.9 k Ω .
 - If the voltage is between 2.320 V and 2.995 V (based on 1 M Ω load impedance), then assume a resistor value of 43.2 k Ω .
 - If the voltage is < 2.320 V (based on 1 M Ω load impedance), then assume a resistor value of 75.0 k Ω .
5. Determine the max current based on [Table 33-2](#) (page 153).
6. If resistor values could not be identified, proceed to identify the power available based on the *USB Battery Charging 1.2* specification.

Table 33-2 USB D+/D- resistor values

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

34. USB Power Delivery

Accessories either providing USB Power Delivery (USB-PD) or drawing power from USB-PD sources shall comply with the *USB Power Delivery Specification, Revision 3.0*, version 1.2.

Accessories implementing USB-PD shall incorporate a PD controller that is USB-IF certified 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, Revision 3.0*, version 1.2.

Apple recommends the GRL-USB-PD-C2 (see <https://graniteriverlabs.com/usb-pd-c2/>) for USB-PD testing and compliance verification.

35. USB-C Current

Accessories either providing direct power via 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://graniteriverlabs.com/usb-pd-c2/>) for USB-C Current testing and compliance verification.

36. Advanced Audio Distribution Profile (A2DP)

Accessories may implement the Advanced Audio Distribution Profile (A2DP) over [Bluetooth](#) (page 164) 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 that implement A2DP shall satisfy all requirements stated in [Bluetooth](#) (page 164).

36.1 Bluetooth A2DP Specification

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

36.1.1 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.

36.2 SubBand Codec (SBC)

The SBC Codec Specific Information Elements, defined in Section 4.3.2 of the A2DP specification, that are applicable to iOS devices and Mac computers are listed in [Table 36-1](#) (page 156).

Table 36-1 SubBand Codec Information Elements for iOS devices and Mac computers

Element	Value
Sampling Frequency	44,100 Hz
Channel Mode	Stereo

36. Advanced Audio Distribution Profile (A2DP)

36.3 MPEG 2/4 AAC Codecs

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.

36.3 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 it 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, that are applicable to devices are listed in [Table 36-2](#) (page 157).

Table 36-2 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 36-3](#) (page 157).

Table 36-3 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 36-3](#) (page 157).

- 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.

36.4 Test Procedures

36.4.1 Audio Quality

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

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

36.4.2 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.

36.4.3 HFP Interaction

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

36.4.4 Siri

1. Trigger Siri during A2DP.
2. Audio should be resumed after the Siri session.

36.4.5 Video Playback

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

37. 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 via the iOS External Accessory Framework (<http://developer.apple.com/library/ios/#featuredarticles/ExternalAccessoryPT/Introduction/Introduction.html>).

See the [Accessory Interface Specification](#) (page 18) for more information.

38. 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 18) for more information.

The HID protocol can be implemented over:

- USB
- Bluetooth

38.1 Requirements

All 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 that generate HID reports shall be labeled with appropriate iconography or text that corresponds 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.

38.1.1 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, the Report Count number shall match the number of Usages specified.

38.1.2 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>.

38.2 Test Procedures

38.2.1 General

1. Verify that the accessory generates and receives all HID usages declared in the component's HID descriptor.
2. Verify that the accessory does not send a HID report if there has not been any change in the state of the control surfaces (i.e., no polling of HID reports).
3. Verify that if any accessory has physical or virtual control surfaces that generate accessory HID usages, the controls are labeled with appropriate iconography or text that corresponds to the resulting device behavior (i.e., 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 (e.g. Play button only sends Play commands, not Play/Pause).
5. Verify that 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

39. Bluetooth

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

Every accessory that is compatible with a device shall support the *Bluetooth Core Specification* Version 2.1 + EDR or higher. This specification introduced the important security feature Secure Simple Pairing as well as Extended Inquiry Response.

39.1 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:

- It provides higher data rates compared to Basic Data Rate (BDR).
- It communicates more efficiently, transferring more data bits per unit of time.
- It reduces the power consumption used per bit transferred.
- It improves coexistence with Wi-Fi and other connected Bluetooth accessories because it frees up more air time.
- It improves performance in multipoint configurations.

39.2 Adaptive Frequency Hopping

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

39.3 Sniff Mode for Low Power Consumption

Minimizing power consumption is critical for all mobile devices. Therefore, every accessory that is compatible with a device:

- Shall support and should request Bluetooth sniff mode.
- Shall accept requests for sniff mode and support all valid parameters listed in the Bluetooth specification.
- Shall support a sniff interval of 15 ms.

- Should use the following recommended sniff mode values:
 - Max Interval: 15 ms
 - Min Interval: 15 ms
 - Sniff Attempt: 1
 - Sniff Timeout: 0
- Shall not renegotiate sniff after being established.
- Shall support sniff subrating.

Accessories that are compatible with iOS devices and Mac computers should also use sniff mode as much as possible, especially when there is little or no data being transmitted over the Bluetooth link. Besides its power consumption advantages, sniff mode enables better antenna sharing with Wi-Fi.

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

If the accessory sets the sniff mode parameters, the accessory shall set the sniff interval to less than a third of the Bluetooth baseband [Link Supervision Timeout](#) (page 167). This makes 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.

39.4 Role and Topology Management

Every accessory that is compatible with a device shall:

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

In a Bluetooth connection, there are two entities:

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

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

A scatternet creates complications since the device has to alternate between the two piconets and thus wastes valuable bandwidth. Managing the topology of the network is therefore important for maximum 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 request for a Role Switch because of topology concerns. Having a suboptimal topology may degrade the audio quality and the user's experience.

The accessory should avoid requesting to be the Central as the device will need to be the Central in more frequently occurring scenarios. Accessories that always insist on being the Central may impact the overall user experience.

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

39.5 Extended Inquiry Response

Every accessory that is compatible with a device shall provide the following information in its Extended Inquiry Response packet:

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

During the Bluetooth discovery process, the device prefers to display the Friendly Name of discovered accessories. Before the 2.1 version of the Bluetooth specification the device would have to set up a connection to the accessory and do a Remote Name Request, which takes power, antenna time, and user's time. The Extended Inquiry Response feature, introduced in Bluetooth 2.1, lets an accessory send its Local Name and other information as part of the Inquiry Response and thereby increase the speed and efficiency of the discovery process.

The Local Name should match the accessory's markings and packaging and not contain ':' or ';'. The accessory may append up to 6 differentiating characters to the Local Name, such as the last few digits of the serial number or MAC address, if a user is likely to encounter more than one of the accessories at the same time.

If the accessory allows the user to customize the Local Name parameter, the accessory should provide a means to restore the factory default name.

39.6 Secure Simple Pairing

Every accessory that is compatible with a device 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 introduced 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.

39.7 Pairing Button

If the accessory has a dedicated pairing control surface and it is labeled, it should use official Bluetooth branding. See <https://www.bluetooth.com/marketing-branding/brand-best-practices-guidelines>.

39.8 Class of Device (CoD)

iOS devices and Mac computers use the accessory's Class of Device for UI purposes or to configure specific features.

Every accessory that is compatible with a device shall accurately set its 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*.

39.9 Link Supervision Timeout

The link supervision timeout is used to detect link loss between the accessory and the device.

The accessory shall set the link supervision timeout to 2 seconds or greater when it is the Central to account for the unpredictable nature of RF signals as well as the device's need to service other concurrent wireless systems.

39.10 Delay Reporting

Devices (as of iOS 8.2) support the Delay Reporting commands as specified in the Bluetooth *Audio/Video Distribution Transport Protocol*, Version 1.3. Accessories should provide this information as it is used 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.

39.11 Profiles

The Apple knowledge base article <https://support.apple.com/kb/ht3647> provides a complete list of the Bluetooth profiles that certain devices support. The Bluetooth specifications are the starting point for designing accessories that are compatible with these products. The following sections add information and requirements for some profiles, which can help accessory developers achieve superior results.

39.11.1 Device ID Profile (DID)

Every accessory that is compatible with a device shall:

- Support the Bluetooth Device ID Profile, version 1.3 or higher.
- Use the company identifier from the Assigned Numbers specification assigned by the Bluetooth SIG as its Vendor ID value (VID). See <http://www.bluetooth.org/Technical/AssignedNumbers/identifiers.htm> (requires login). Bluetooth HID Profile accessories may use a VID assigned by the USB Implementers Forum (USB-IF at <http://www.usb.org>) 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 Vendor ID field value. See Section 5.6 of the *Bluetooth Device ID Profile Specification*.
- Use a ProductID value that uniquely identifies the product.
- Use a Version value that uniquely identifies the software version.

The Device ID record lets the device identify the implementation of the remote accessory. This is valuable information and can be used to bridge alternate interpretations of the Bluetooth specification when communicating with a remote accessory. Therefore it is important that the information in the Device ID record uniquely identify the implementation.

In the case of Bluetooth car kit devices, the same car kit might go into two 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.

39.11.2 Service Discovery Protocol (SDP)

To facilitate caching of Service Discovery Protocol (SDP) service records, every accessory that is compatible with a device shall:

- Support the ServiceDiscoveryServer Service Class.
- Support the ServiceDatabaseState attribute.

- The attribute's value shall change whenever any SDP service record or attributes within a record are added, removed, or modified.
- The attribute's value shall not change based on RFCOMM channel protocol parameters since devices query these values separately at connection time.

39.11.3 Hands-Free Profile (HFP)

Every accessory that is compatible with a device and supports the Handsfree Profile should meet the requirements of the *Bluetooth Hands-Free Profile Specification*, Version 1.5 or higher. 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.

39.11.3.1 Remote Audio Volume Control

Every accessory that is compatible with a device and supports HFP should:

- Support Remote Audio Volume Control so the 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 passenger (or-if the car is parked-the driver) in a car could use the volume slider on the phone to control the audio volume. Volume control synchronization is outlined in Section 4.48.2 in the *Bluetooth Hands-Free Profile Specification* version 1.5.

39.11.3.2 Indicator Event Reporting

Every accessory that is compatible with a device and supports HFP should use indicator events reporting and not perform repetitive polling of status.

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 polling of status using the AT+CIND? command, the remote accessory should enable indicator events reporting by sending an AT+CMER command. The device will then send a +CIEV event when there is a change in status of an indicator. The remote accessory should request the initial status using the AT+CIND=? and AT+CIND? commands, according to the HFP specification.

39.11.3.3 Voice Recognition Activation

Every accessory that is compatible with a device and supports 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.

39.11.3.4 Echo Cancellation and Noise Reduction

When echo cancellation and noise reduction are performed locally on a Hands-Free accessory, it 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; these features are active by default. If a Hands-Free accessory also does echo cancellation and noise reduction it needs to turn these features off on the device (the Audio Gateway). This avoids unnecessary degradation of audio quality due to double audio processing.

39.11.3.5 In-Band Ringing

Every accessory that is compatible with a device and supports 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.

39.11.3.6 Synchronous Connection

Every accessory that is compatible with a device and supports 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. Note that eSCO parameter set S1 should not be requested.
- Render audio within 40 ms after the SCO/eSCO connection has been set up.

The eSCO packet types offers retransmission of packets; traditional SCO packets are not retransmitted. This improves audio quality and the user's experience. The 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 does not allow for retransmission of audio packets which impacts the audio performance in presence of RF interference.

39.11.3.7 Wide Band Speech

Every accessory that is compatible with a device and supports 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, it should support the T2 link parameter settings.

All devices running iOS 5 or later support Wide Band Speech. If both the device and the accessory support Wide Band Speech then Wide Band Speech link will be used for eSCO connection for use cases like cellular calls, FaceTime and Siri.

39.11.4 Message Access Profile (MAP)

Every accessory that is compatible with a device and supports the Message Access Profile shall:

- Support Message Notification as described in Section 4.1 of the *Bluetooth Message Access Profile Specification*, version 1.1.
- Register for notifications immediately after the connection is established, as described in Section 4.5 in the *Message Access Profile Specification*, version 1.1.

All devices running iOS 13.0 or later support MAP 1.1.

39.11.5 Audio/Video Remote Control Profile (AVRCP)

Every accessory that is compatible with a device and supports the 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.

39.11.5.1 Supported Operations

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

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

39.11.5.2 Repeat and Shuffle Modes

Every device supports Repeat and Shuffle modes in the role of an AVRCP target. 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.

39.11.5.3 Notifications

Every accessory that is compatible with a device and supports AVRCP should register for notifications and not perform repetitive polling to determine the status of the device.

Every device supports registering for notifications in the role of an AVRCP Target, 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`

39.11.5.4 Play/Pause Button

All accessories that support AVRCP and implement a Play/Pause control surface shall confirm the playback status of the device via AVRCP [Notifications](#) (page 172) before sending a Play or Pause command, see [Supported Operations](#) (page 171). Specifically:

- If the device has notified the accessory that it is paused, pressing the accessory's Play/Pause control surface should send a Play command.
- If the device has notified the accessory that 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.

39.11.5.5 Volume Handling

Every accessory that is compatible with a device and supports 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 supports volume handling in the role of AVRCP Controller.

39.11.5.6 Browsing

Every accessory that is compatible with a device and supports 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, each present multiple times in the hierarchy.
- When browsing a specific folder, do not fetch all its items. Only fetch those that are displayed to the user. It may prefetch a few items to improve the responsiveness of the user interface.
- Not reorder items (e.g. alphabetically).
- 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.
- Send the `SetBrowsedPlayer` command after receiving an `EVENT_UIDS_CHANGED` notification.
- Not assume that the UID passed to the `PlayItem` command will result in the media player playing that 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 then 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.

39.11.5.7 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. The device supplies this metadata to the accessory using AVRCP.

Requirements and usage for these messages may be found in the `MPNowPlayingInfoCenter` class in Apple Media Player Framework documentation.

39.11.6 Advanced Audio Distribution Profile (A2DP)

See [Advanced Audio Distribution Profile \(A2DP\)](#) (page 156).

39.12 Audio Routing

This section describes how an accessory can differentiate between various audio contents coming from a device and use this information to decide playback behavior.

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

- HFP using eSCO channel
- A2DP using ACL channel

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

39.12.1 Audio Data Received via HFP Profile

Most of the audio content sent via HFP (eSCO) routes requires two way communication. Cases 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.

39.12.2 Audio Data Received via A2DP Profile

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

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

39.12.2.1 Differentiating Audio Content from System Sounds

Music-like content can be differentiated from system sound 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 state in the device, using notifications. See [Audio/Video Remote Control Profile \(AVRCP\)](#) (page 171).

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 that playback status has changed to play state. See Section 6.7.2 of the *Audio/Video Remote Control Profile* specification, version 1.4. This indicates that audio data via the A2DP profile contains music. When a device initiates audio playback over an A2DP channel for playing system sound, no AVRCP notification is sent.

[Figure 39-1](#) (page 175) and [Figure 39-2](#) (page 175) show the difference between the notifications for music playback and for system sounds.

Figure 39-1 Initiate Audio Playback (e.g. music)

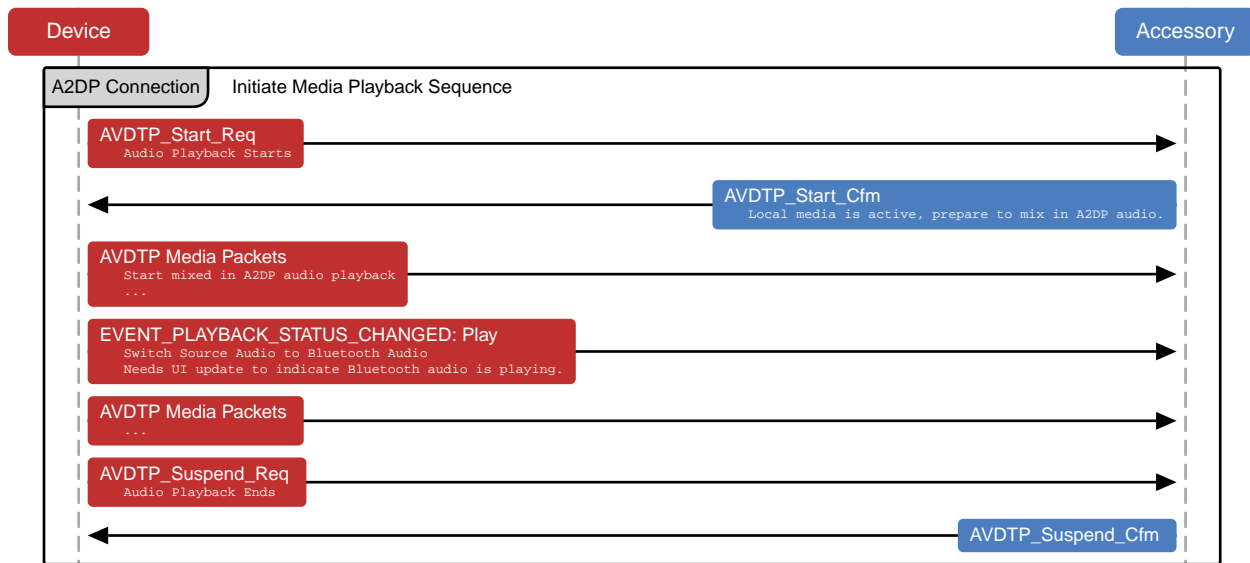
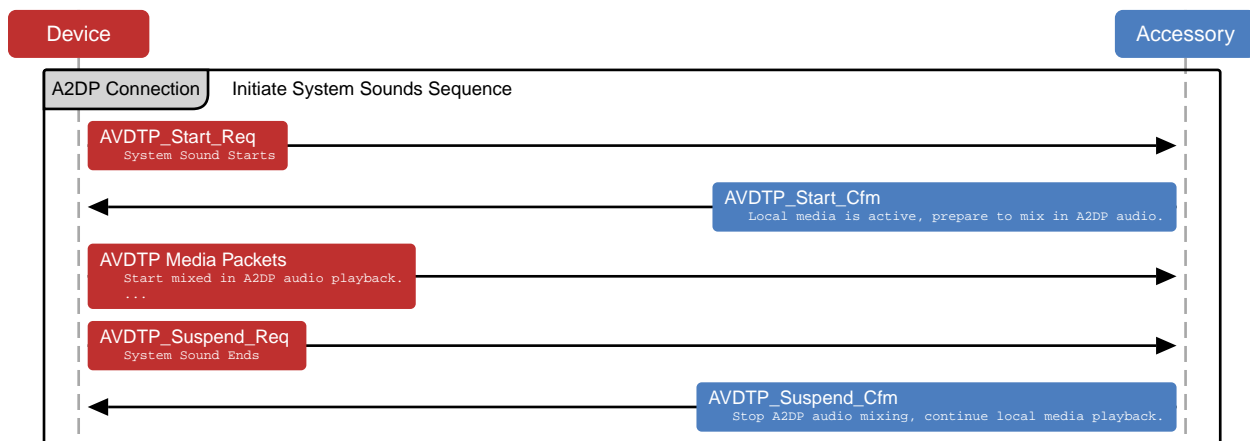


Figure 39-2 Initiate System Sound (e.g. turn-by-turn directions)



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

39.13 HID

When implementing HID over Bluetooth, the accessory:

- Should support Bluetooth HID Profile 1.1.
- Should support [Sniff Mode for Low Power Consumption](#) (page 164).
- 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.

40. 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.

40.1 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.

40.2 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.

40.3 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.

40.4 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

40. Bluetooth Low Energy (BLE)

40.5 Advertising Interval

- Local Name
- Services

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

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. Note that, 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.

40.5 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.

40.6 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 that 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.

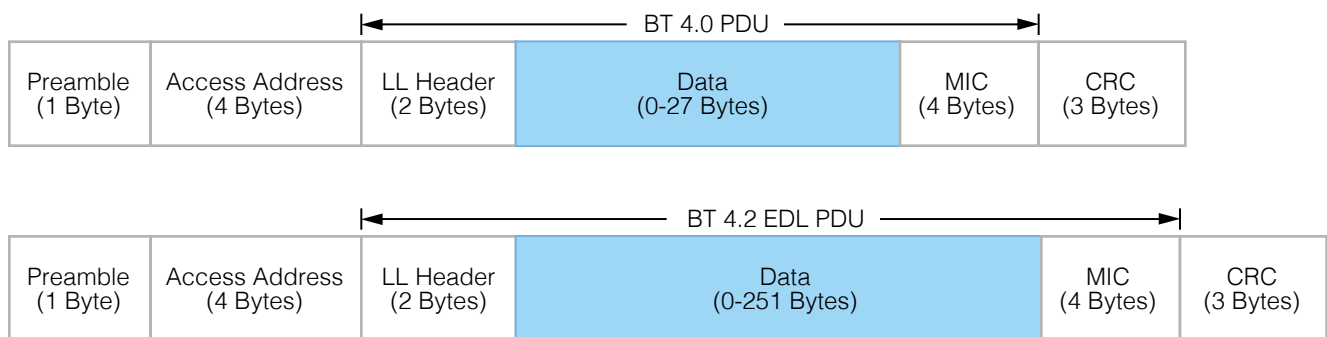
40.7 Data Packet Length Extension

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.

40. Bluetooth Low Energy (BLE)

40.8 Privacy

Figure 40-1 Data Packet Length Extension



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.

40.8 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.

40.9 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.

40.10 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, it 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.

40.11 MTU Size

An accessory that supports packet length extension shall perform the packet length update procedure before performing the Exchange MTU Request handshake, see [Data Packet Length Extension](#) (page 179).

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 that is equal to or greater than the device's MTU request.

40.12 Services

40.12.1 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.

40.12.2 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.

40.12.3 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
- Model Number String
- Firmware Revision String
- Software Revision String

40.12.4 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.

40.13 GATT Server

With iOS 6.0, applications may contribute services and characteristics to the GATT server that 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 that owns 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

41. USB-A Receptacle

Accessories may incorporate a USB-A receptacle to:

- Provide power to a device.

41.1 Mechanical

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

41.2 Electrical

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

42. USB-C Plug

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 that may benefit from including a USB-C plug include cables, battery packs, and adapters.

42.1 Mechanical

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

42.2 Electrical

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

Accessories that draw power from the USB-C plug shall:

- Correctly identify all Apple branded or MFi certified USB power sources that use [USB D+/D- Resistor Networks](#) (page 151).
- 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 155) 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 via one of the above methods.

Accessories may also correctly identify all [USB Power Delivery](#) (page 154) sources.

42.3 Test Procedures

42.3.1 Connector Test ID

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

42.3.2 Drawing Power

This procedure applies to accessories that draw power via the USB-C plug.

The following equipment is needed:

- Apple 29W USB-C Power Adapter
- Bundled USB-C power adapter (if applicable)

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

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

Verify that the accessory correctly identifies a Mac:

1. Verify that the Mac is correctly identified and provides power.

43. USB-C Receptacle

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 that may benefit from including a USB-C receptacle include [AC Power Adapters](#) (page 62), [Battery Packs](#) (page 65), and speakers.

43.1 Mechanical

The USB-C receptacle shall be USB-IF certified and have a *Connector* Test ID from the USB-IF.

43.2 Electrical

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

43.2.1 Drawing Power

Accessories that draw power from the USB-C receptacle shall:

- Correctly identify all Apple branded or MFi certified USB power sources that use [USB D+/D- Resistor Networks](#) (page 151).
- 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 155) 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.

43. USB-C Receptacle

43.3 Test Procedures

- Not draw more power than the USB power source claims it is capable of providing via one of the above methods.

Accessories may also correctly identify all [USB Power Delivery](#) (page 154) sources.

43.2.2 Providing Power

Accessories that provide power to a device via a USB-C receptacle:

- Shall provide at least 15 W (3 A at 5.0 V) of power.
- Shall support [USB-C Current](#) (page 155).
- Should support [USB Power Delivery](#) (page 154).
- Should label the receptacle indicating how much power is supplied in watts.

43.3 Test Procedures

43.3.1 Connector Test ID

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

43.3.2 Drawing Power

This procedure applies to accessories that draw power via 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 5W USB Power Adapter
- Apple 10W USB Power Adapter
- Apple 18W USB Power Adapter
- Apple 12W USB Power Adapter
- Apple 29W USB-C Power Adapter
- Apple 30W USB-C 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 that the accessory correctly identifies all Apple branded or bundled power adapters:

1. Using each USB-A to USB-C cable, verify that each USB-A power adapter is correctly identified and provides power.
2. Using each USB-C to USB-C cable, verify that each USB-C power adapter is correctly identified and provides power.

Verify that the accessory correctly identifies a Mac:

1. Using each USB-A to USB-C cable and USB-C to USB-C cable, verify that the Mac is correctly identified and provides power.

Verify that the accessory correctly identifies MFi power adapters:

1. Using each USB-A to USB-C cable, verify that each MFi USB-A power adapter is correctly identified and provides power.
2. Using each USB-C to USB-C cable, verify that each MFi USB-C power adapter is correctly identified and provides power.

43.3.3 Providing Power

This procedure applies to accessories that provide power via 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 that the accessory correctly provides power to devices:

1. Using each USB-C to Lightning cable, verify that 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 that the accessory provides power to the device.

Verify that the accessory correctly identifies a Mac:

1. Using each USB-C to USB-C cable, verify that the accessory is correctly identified and provides power to the Mac.

References

44. Device Dimensional Drawings

This chapter contains the following dimensional drawings:

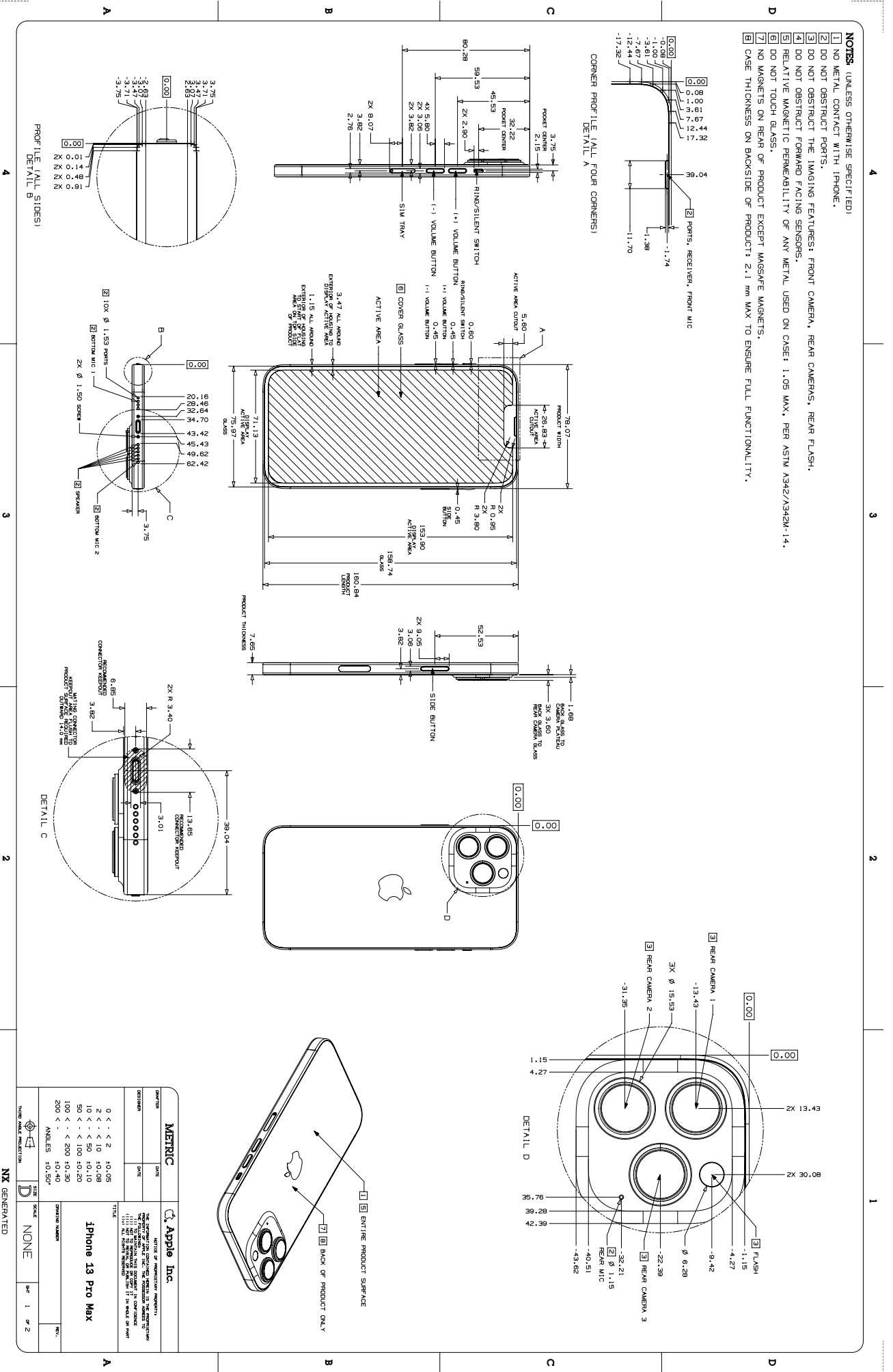
- [iPhone 13 Pro Max 1 of 2](#) (page 196)
- [iPhone 13 Pro Max 2 of 2](#) (page 197)
- [iPhone 13 Pro 1 of 2](#) (page 198)
- [iPhone 13 Pro 2 of 2](#) (page 199)
- [iPhone 13 1 of 2](#) (page 200)
- [iPhone 13 2 of 2](#) (page 201)
- [iPhone 13 mini 1 of 2](#) (page 202)
- [iPhone 13 mini 2 of 2](#) (page 203)
- [iPhone 12 Pro Max 1 of 2](#) (page 204)
- [iPhone 12 Pro Max 2 of 2](#) (page 205)
- [iPhone 12 Pro 1 of 2](#) (page 206)
- [iPhone 12 Pro 2 of 2](#) (page 207)
- [iPhone 12 1 of 2](#) (page 208)
- [iPhone 12 2 of 2](#) (page 209)
- [iPhone 12 mini 1 of 2](#) (page 210)
- [iPhone 12 mini 2 of 2](#) (page 211)
- [iPhone SE \(2nd generation\)](#) (page 212)
- [iPhone 11 Pro Max](#) (page 213)
- [iPhone 11 Pro](#) (page 214)
- [iPhone 11](#) (page 215)
- [iPhone XS Max](#) (page 216)
- [iPhone XS](#) (page 217)
- [iPhone XR](#) (page 218)
- [iPhone X](#) (page 219)
- [iPhone 8 Plus](#) (page 220)
- [iPhone 8](#) (page 221)
- [iPhone 7 Plus](#) (page 222)
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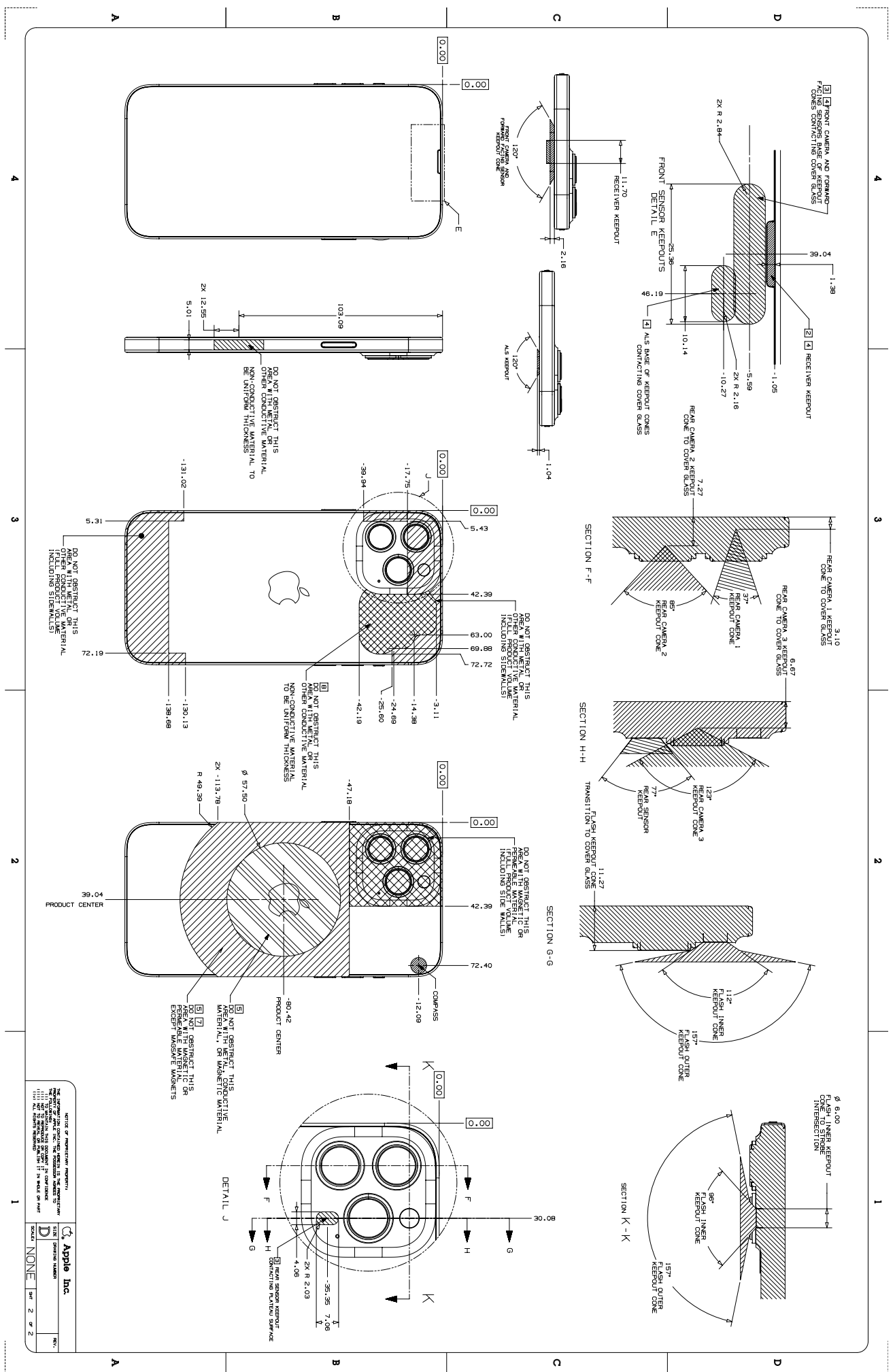
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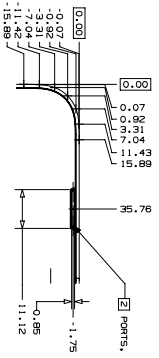
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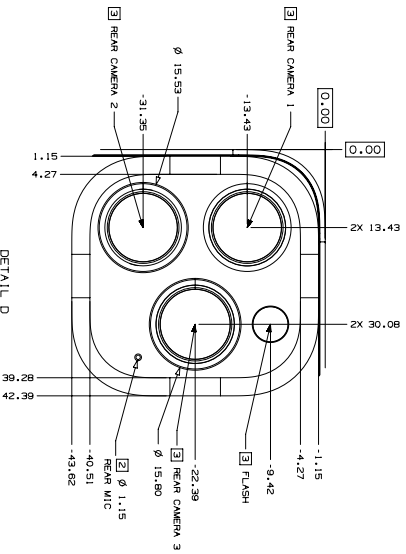
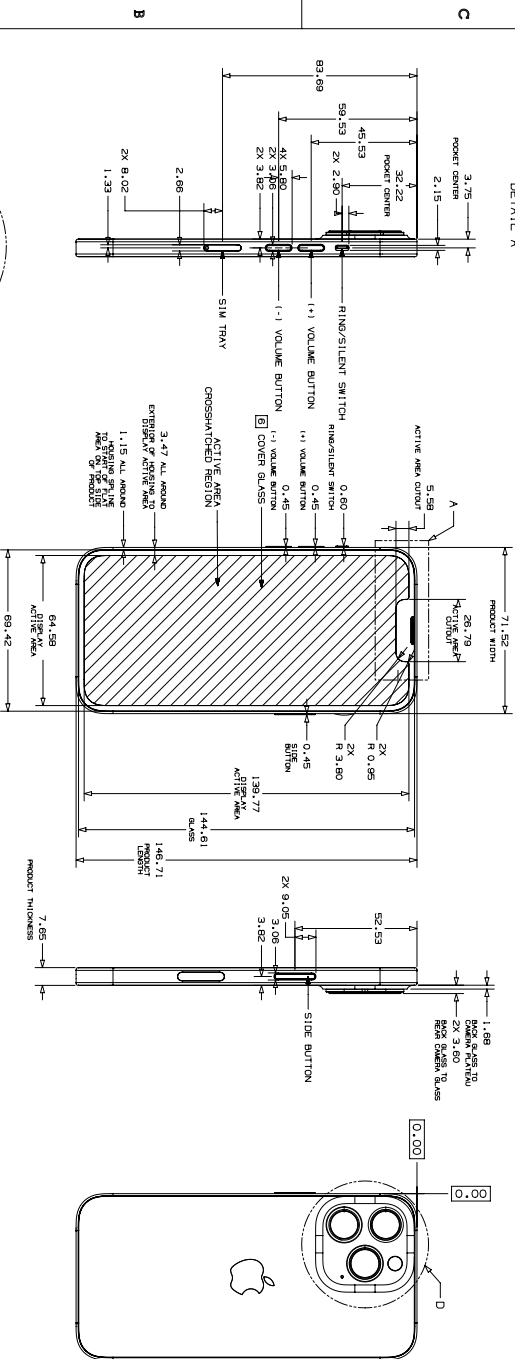
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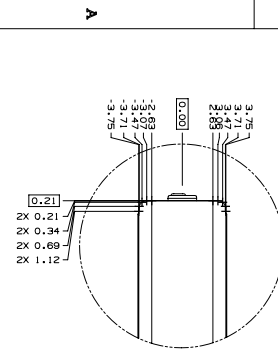
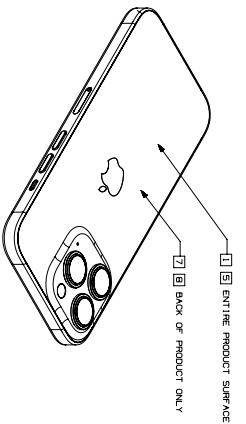
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 - 8 CASE THICKNESS ON BACKSIDE OF PRODUCT: 2.1 mm MAX TO ENSURE FULL FUNCTIONALITY.



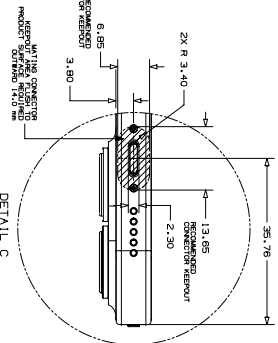
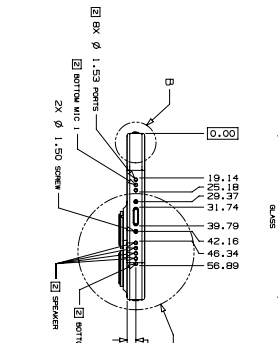
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DETAIL D



PROFILE (ALL SIDES) DETAIL B



DETAIL C

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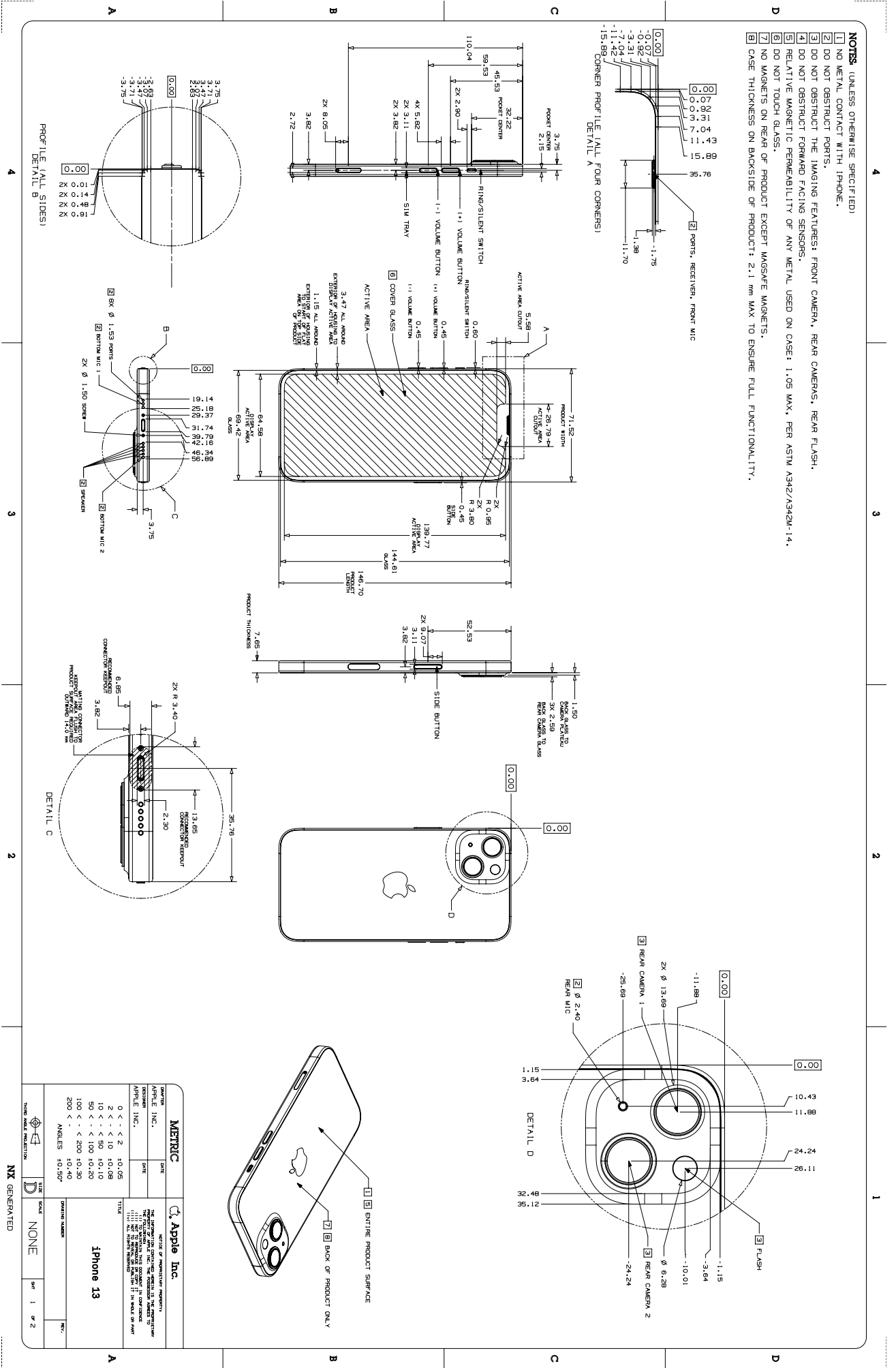
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APPL E INC.	05/14/21	APPL E INC.	05/14/21
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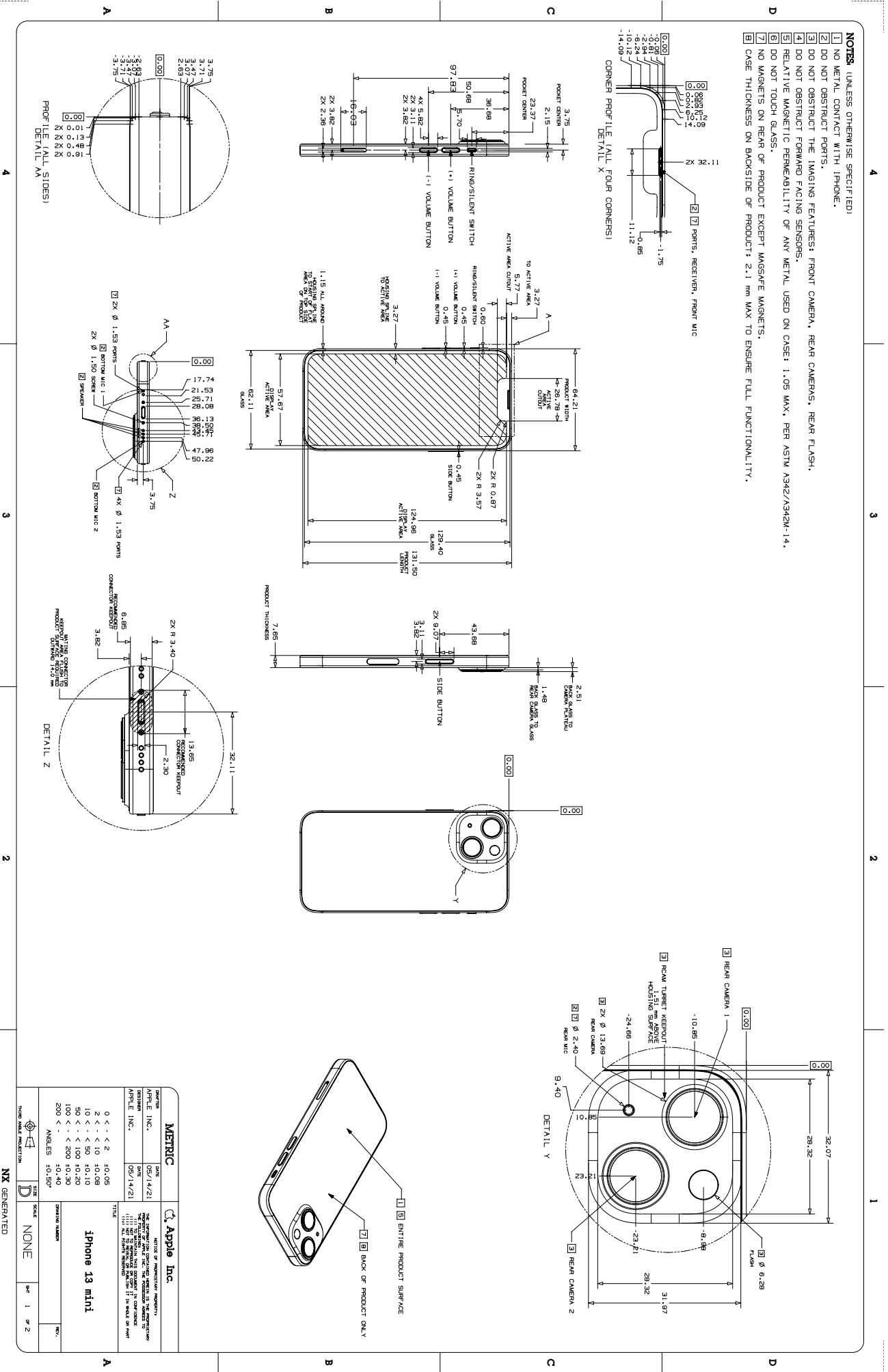
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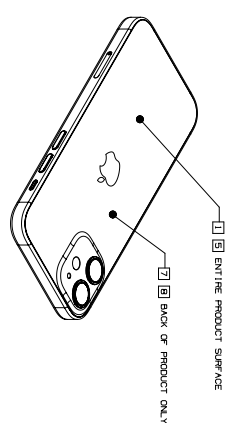
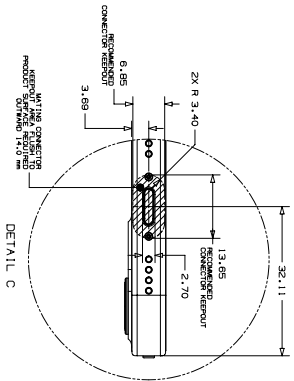
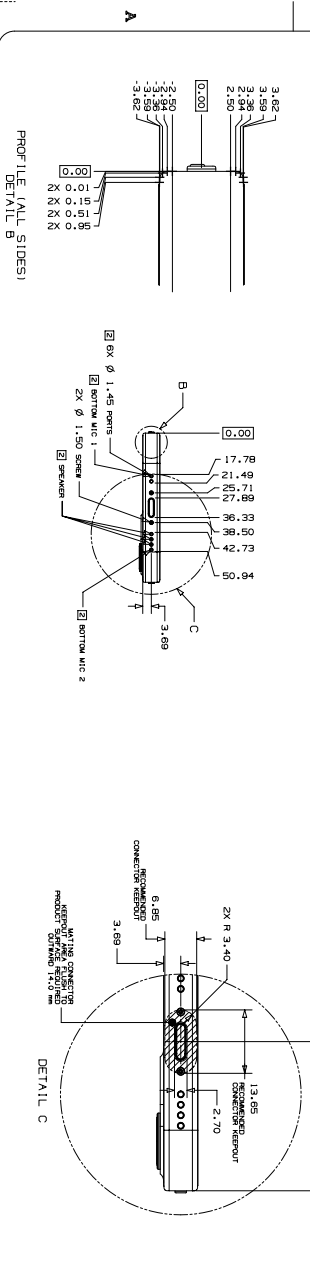
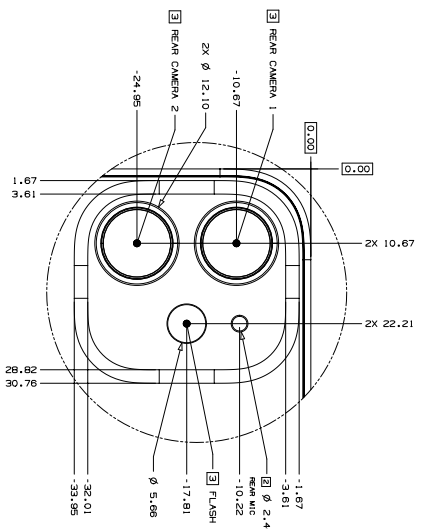
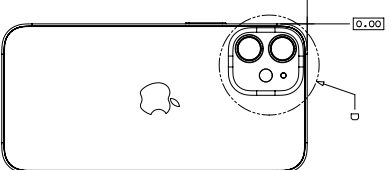
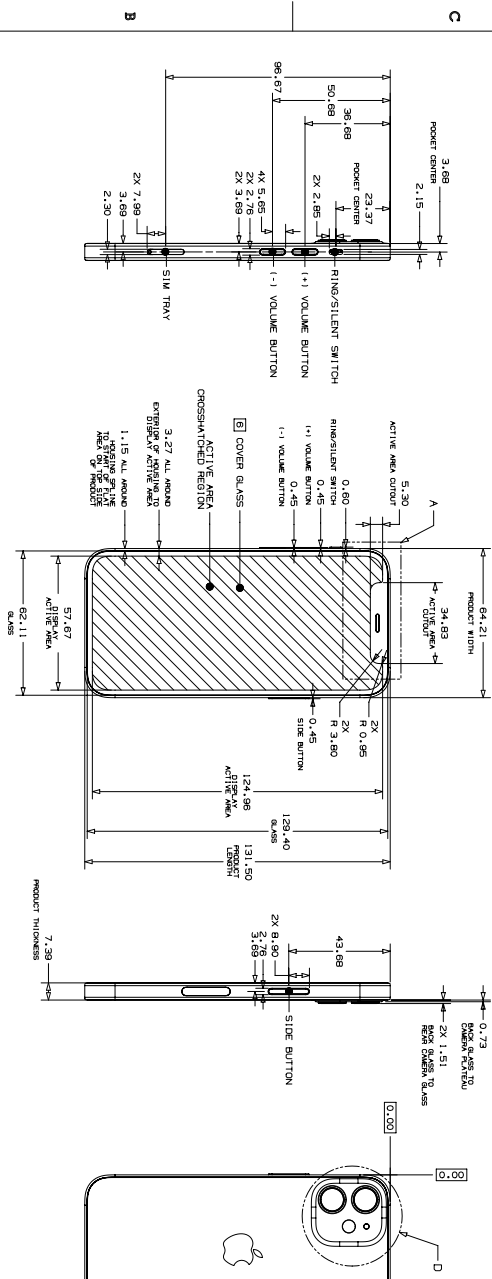
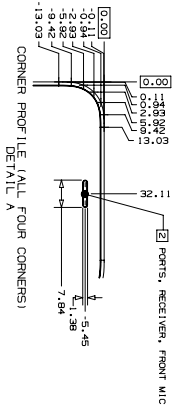
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- 3 DO NOT OBSTRUCT THE IMAGING FEATURES: FRONT CAMERA, REAR CAMERAS, REAR FLASH.
- 4 DO NOT OBSTRUCT FORWARD FACING SENSORS.
- 5 RELATIVE MAGNETIC PERMEABILITY OF ANY METAL USED ON CASE: 1.05 MAX. PER ASTM A342/A342M-14.
- 6 DO NOT TOUCH GLASS.
- 7 NO MAGNETS ON REAR OF PRODUCT EXCEPT MAGSAFE MAGNETS.
- 8 CASE THICKNESS ON BACKSIDE OF PRODUCT: 2.1 mm MAX TO ENSURE FULL FUNCTIONALITY.



METRIC		Apple Inc.	
DATE	DESCRIPTION	DATE	DESCRIPTION
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05/14/21	REVISION 2	05/14/21	REVISION 2
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05/14/21	REVISION 19	05/14/21	REVISION 19
05/14/21	REVISION 20	05/14/21	REVISION 20

44.15 iPhone 12 mini 1 of 2

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 - 2 DO NOT OBSTRUCT PORTS.
 - 3 DO NOT OBSTRUCT THE IMAGING FEATURES: FRONT CAMERA, REAR CAMERAS, REAR FLASH.
 - 4 DO NOT OBSTRUCT FORWARD FACING SENSORS.
 - 5 RELATIVE MAGNETIC PERMEABILITY OF ANY METAL USED ON CASE: 1.05 MAX, PER ASTM A342/A342M-14.
 - 6 DO NOT TOUCH GLASS.
 - 7 NO MAGNETS ON REAR OF PRODUCT EXCEPT MAGSAFE MAGNETS.
 - 8 CASE THICKNESS ON BACKSIDE OF PRODUCT: 2.1 mm MAX TO ENSURE FULL FUNCTIONALITY.



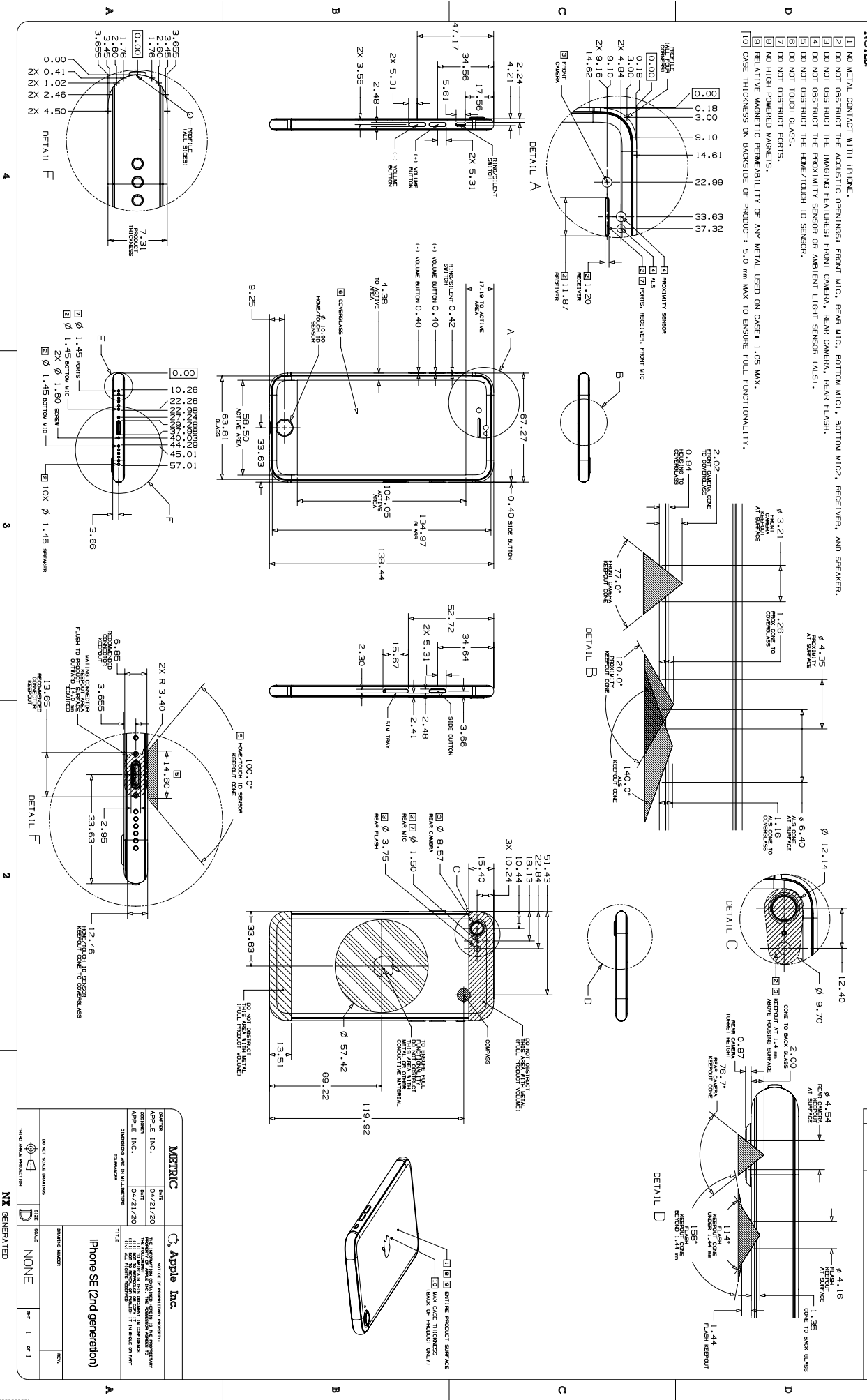
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SHEET	DATE	VERSION	TITLE
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DESIGNED BY	DRAWN BY	DATE	APPROVED BY
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DRAWING NUMBER		REV.	
NONE		1 OF 2	

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44.17 iPhone SE (2nd generation)

NOTES:

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- 3 DO NOT OBSTRUCT THE IMAGING FEATURES: FRONT CAMERA, REAR CAMERA, REAR FLASH.
- 4 DO NOT OBSTRUCT THE PROXIMITY SENSOR OR AMBIENT LIGHT SENSOR (ALS).
- 5 DO NOT OBSTRUCT THE HOME/TOUCH ID SENSOR.
- 6 DO NOT TOUCH GLASS.
- 7 DO NOT OBSTRUCT PORTS.
- 8 NO HIGH POWERED MAGNETS.
- 9 RELATIVE MAGNETIC PERMEABILITY OF ANY METAL USED ON CASE: 1.05 MAX.
- 10 CASE THICKNESS ON BACKSIDE OF PRODUCT: 5.0 mm MAX TO ENSURE FULL FUNCTIONALITY.



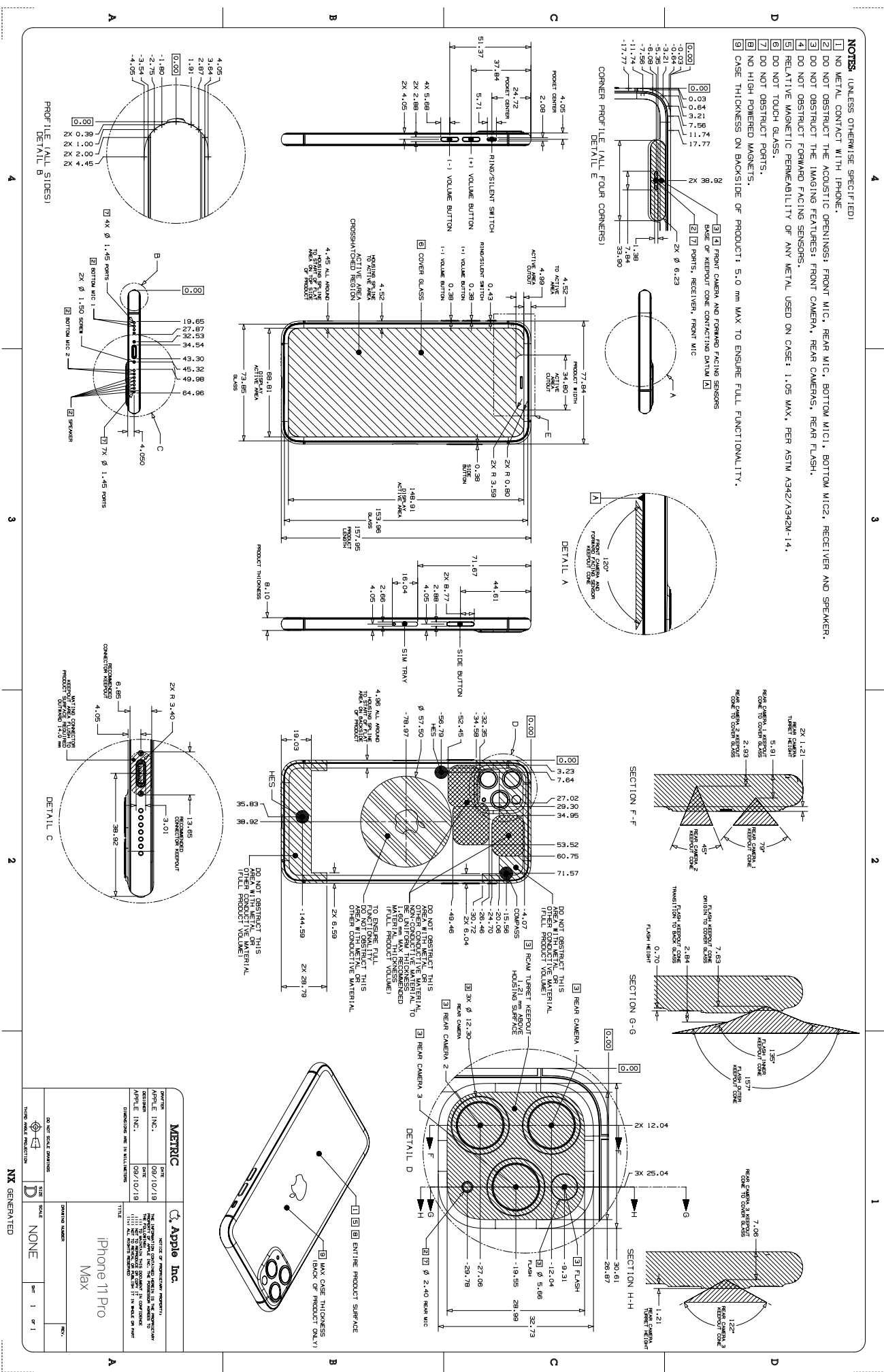
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APPLE INC.	04/21/20					

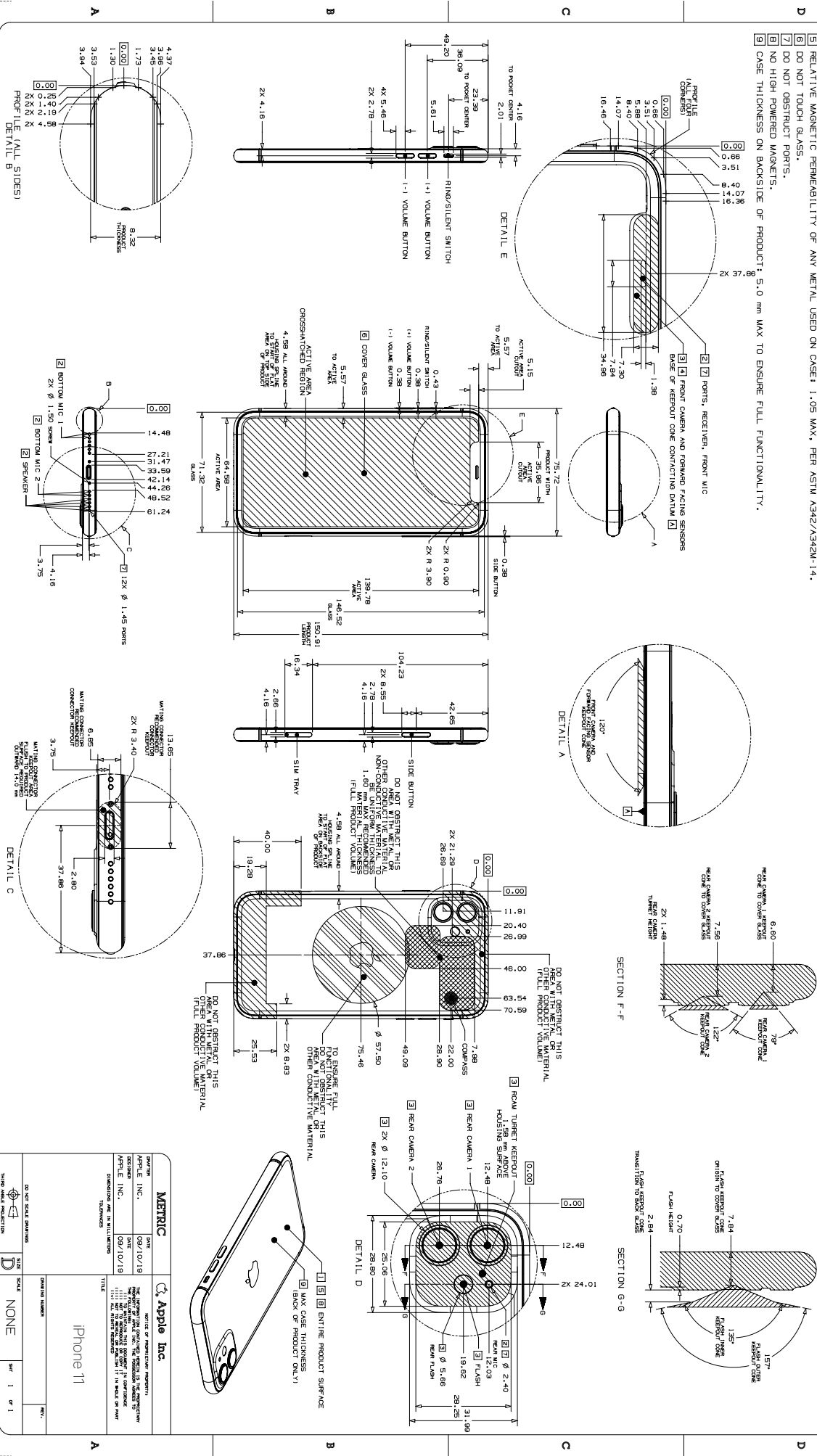
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TITLE	DRAWING NUMBER	REV.
iPhone SE (2nd generation)		

4.4.18 iPhone 11 Pro Max

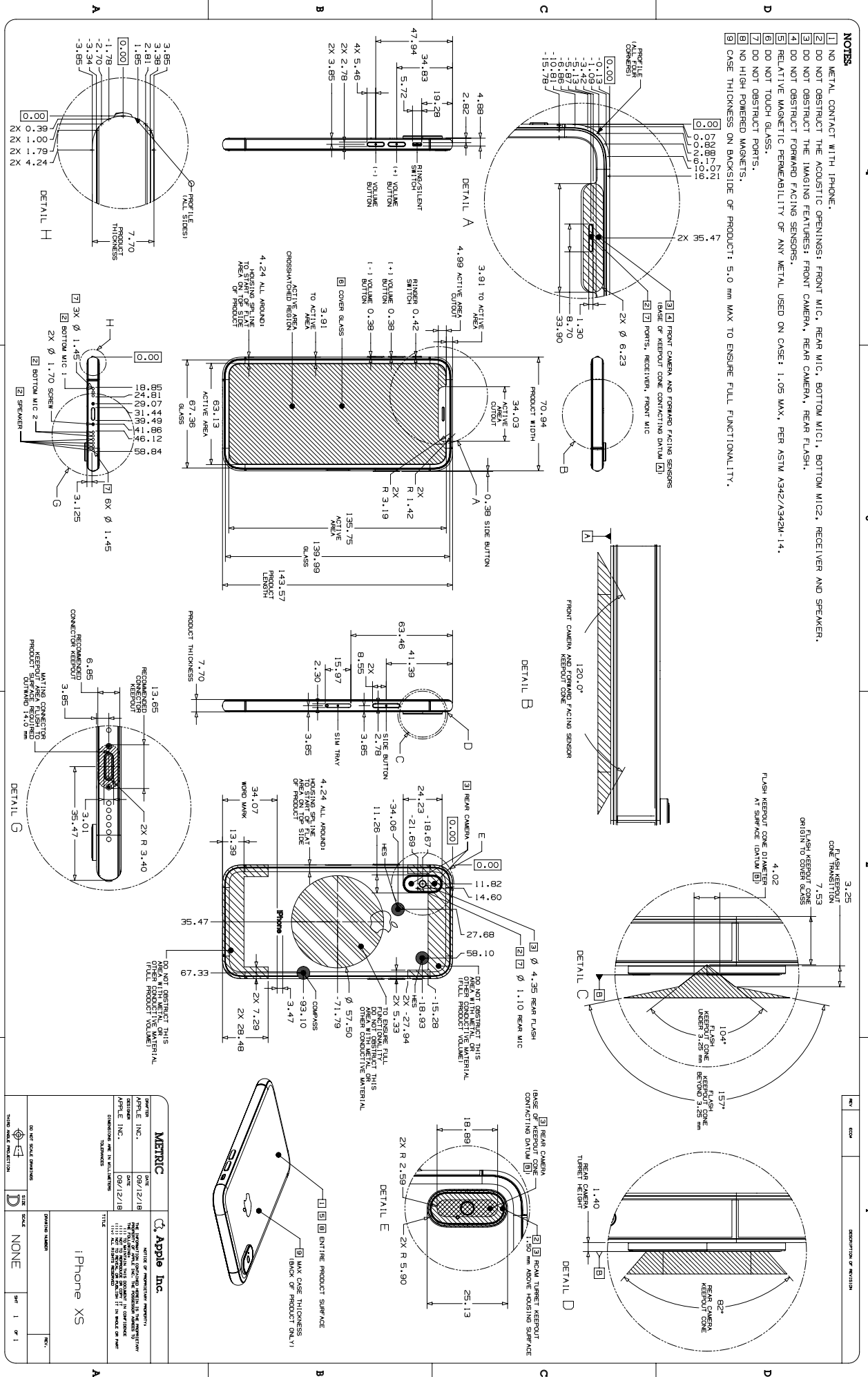


- NOTES:**
- NO METAL CONTACT WITH IPHONE.
 - DO NOT OBSTRUCT THE ACOUSTIC OPENINGS: FRONT MIC, REAR MIC, BOTTOM MIC1, BOTTOM MIC2, RECEIVER AND SPEAKER.
 - DO NOT OBSTRUCT THE IMAGING FEATURES: FRONT CAMERA, REAR CAMERA, REAR FLASH.
 - DO NOT OBSTRUCT FORWARD FACING SENSORS.
 - RELATIVE MAGNETIC PERMEABILITY OF ANY METAL USED ON CASE: 1.05 MAX, PER ASTM A342/A342M-14.
 - DO NOT TOUGH GLASS.
 - DO NOT OBSTRUCT PORTS.
 - NO HIGH POWERED MAGNETS.
 - CASE THICKNESS ON BACKSIDE OF PRODUCT: 5.0 mm MAX TO ENSURE FULL FUNCTIONALITY.



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- NOTES:**
- 1 NO METAL CONTACT WITH IPHONE.
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 - 3 DO NOT OBSTRUCT THE IMAGING FEATURES: FRONT CAMERA, REAR CAMERA, REAR FLASH.
 - 4 DO NOT OBSTRUCT FORWARD FACING SENSORS.
 - 5 RELATIVE MAGNETIC PERMEABILITY OF ANY METAL USED ON CASE: 1.05 MAX, PER ASTM A342/A342M-14.
 - 6 DO NOT TOUCH GLASS.
 - 7 DO NOT OBSTRUCT PORTS.
 - 8 NO HIGH POWERED MAGNETS.
 - 9 CASE THICKNESS ON BACKSIDE OF PRODUCT: 5.0 mm MAX TO ENSURE FULL FUNCTIONALITY.



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DESIGNED BY	Apple Inc.	DESIGNED BY	Apple Inc.
APPREVED BY	Apple Inc.	APPREVED BY	Apple Inc.
DATE	09/12/18	DATE	09/12/18
DESCRIPTION	Dimensions are in millimeters		
TOLERANCES			
TITLE	iPhone XS		
DRAWING NUMBER			
REV.	NONE		
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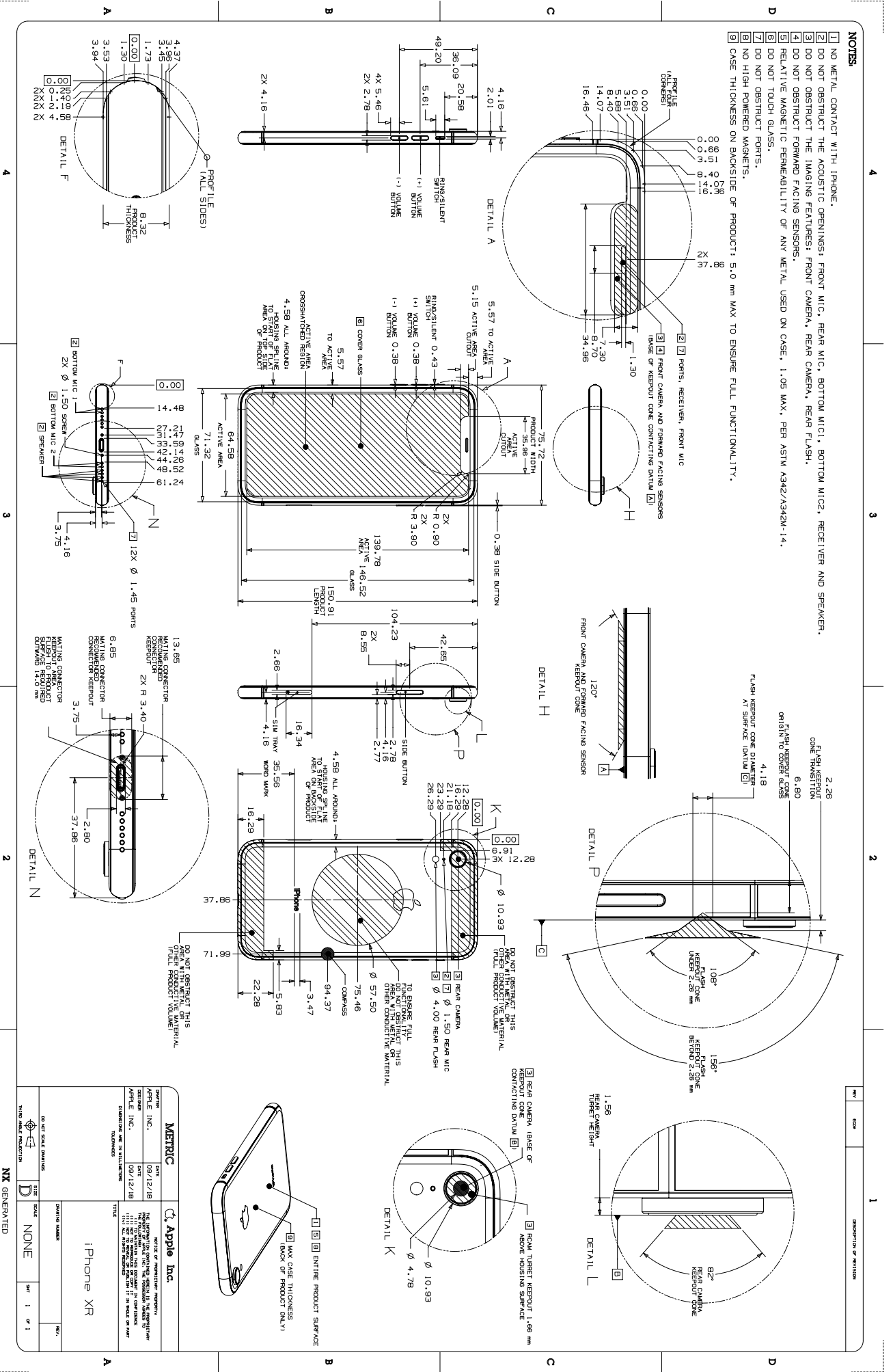
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4.4.23 iPhone XR



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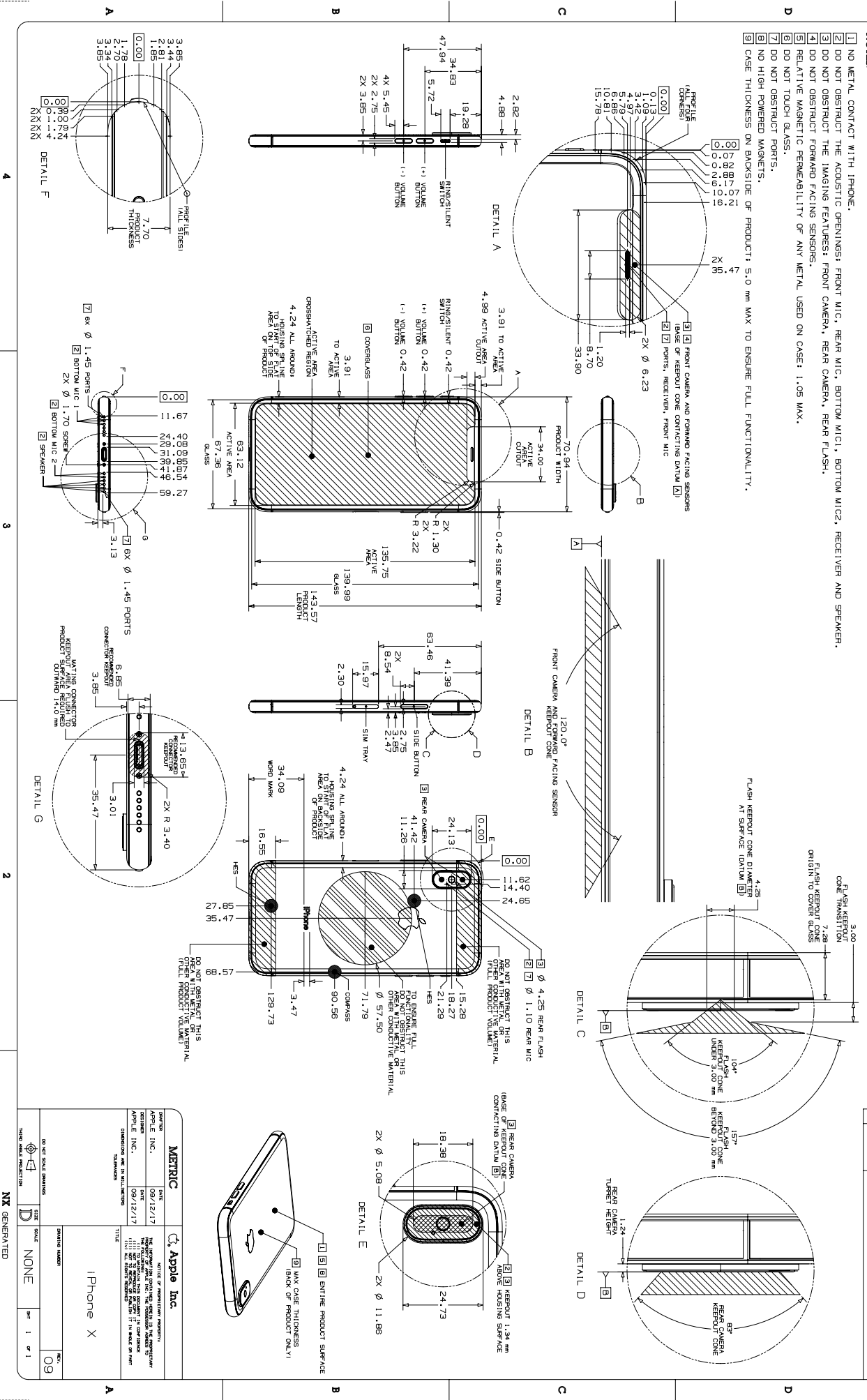
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 - DO NOT OBSTRUCT THE IMAGING FEATURES: FRONT CAMERA, REAR CAMERA, REAR FLASH.
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 - DO NOT TOUGH GLASS.
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4.4.24 iPhone X

NOTES

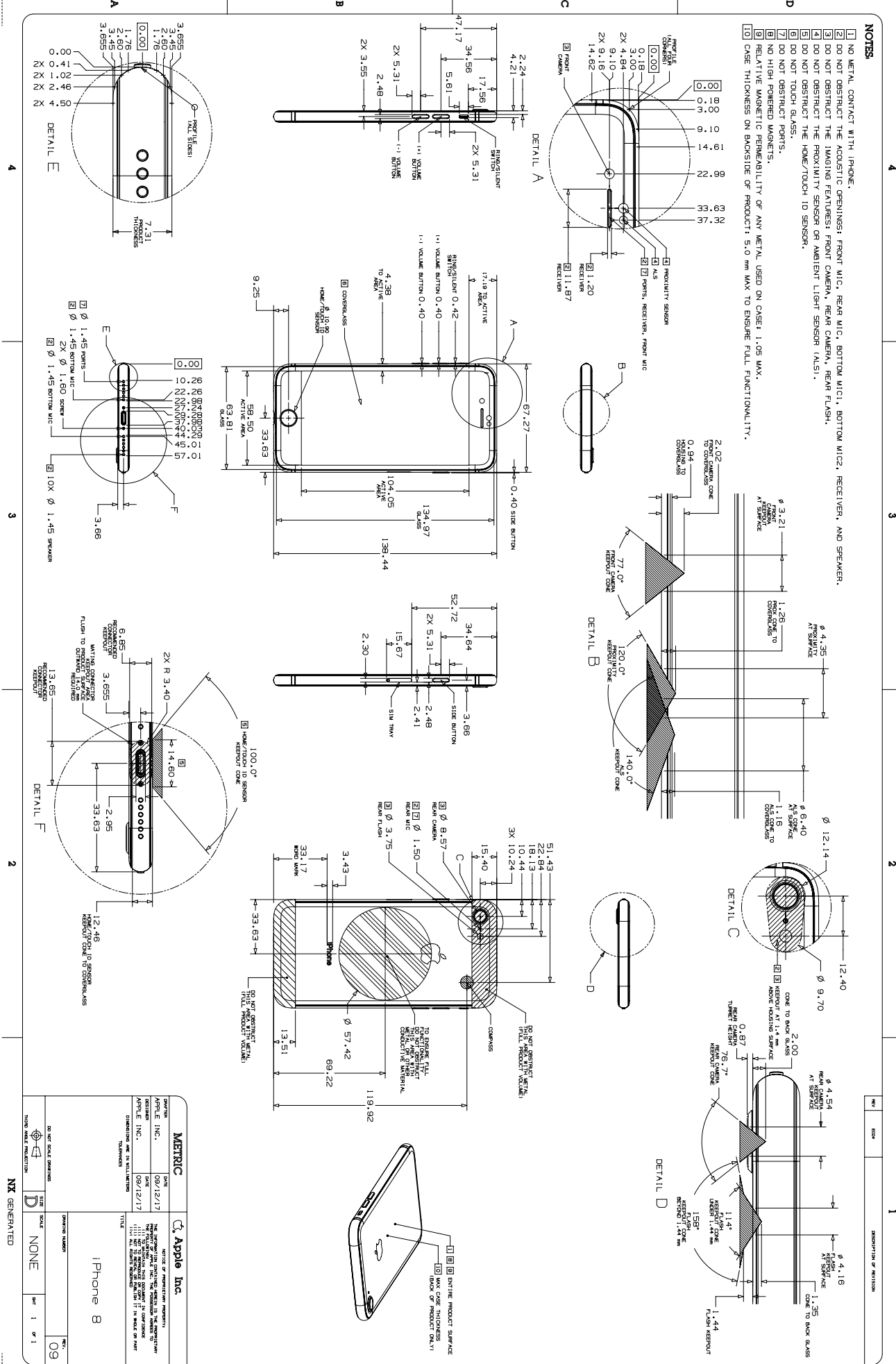
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- 3 DO NOT OBSTRUCT THE IMAGING FEATURES: FRONT CAMERA, REAR CAMERA, REAR CAMERA, REAR FLASH.
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- 6 DO NOT OBSTRUCT PORTS.
- 7 NO HIGH POWERED MAGNETS.
- 8 CASE THICKNESS ON BACKSIDE OF PRODUCT: 5.0 mm MAX TO ENSURE FULL FUNCTIONALITY.



REV	ECO	DESCRIPTION OF REVISION
1		
2		
3		
4		

METRIC	Apple Inc.
DATE: 09/12/17	DATE: 09/12/17
DESIGNED BY: MEX	DESIGNED BY: MEX
CHECKED BY: MEX	CHECKED BY: MEX
DRAWN BY: MEX	DRAWN BY: MEX
TITLE: iPhone X	TITLE: iPhone X
SCALE: NONE	SCALE: NONE
SHEET: 1 OF 1	SHEET: 1 OF 1

- NOTES:**
- NO METAL CONTACT WITH IPHONE.
 - DO NOT OBSTRUCT THE ACOUSTIC OPENINGS: FRONT MIC, REAR MIC, BOTTOM MIC2, RECEIVER, AND SPEAKER.
 - DO NOT OBSTRUCT THE IMAGING FEATURES: FRONT CAMERA, REAR CAMERA, REAR FLASH.
 - DO NOT OBSTRUCT THE PROXIMITY SENSOR OR AMBIENT LIGHT SENSOR (ALS).
 - DO NOT TOUCH GLASS.
 - DO NOT OBSTRUCT PORTS.
 - NO HIGH POWERED MAGNETS.
 - RELATIVE MAGNETIC PERMEABILITY OF ANY METAL USED ON CASE: 1.05 MAX.
 - CASE THICKNESS ON BACKSIDE OF PRODUCT: 5.0 mm MAX TO ENSURE FULL FUNCTIONALITY.



REV	ECO	DESCRIPTION OF REVISION
1		

DATE	REV	SCALE	TITLE
09/12/17	1	NONE	iPhone 8

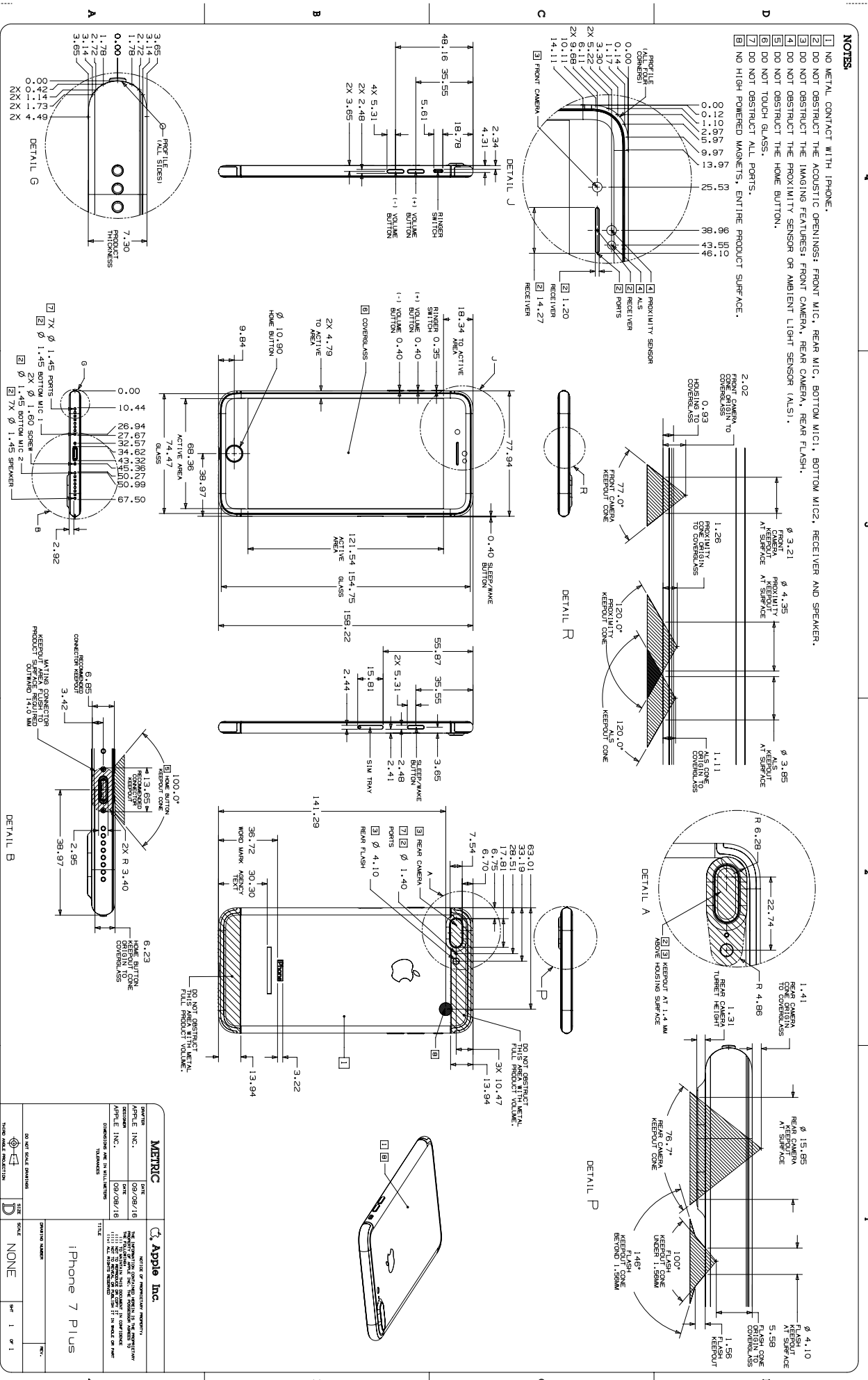
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09/12/17	1	NONE	iPhone 8

DATE	REV	SCALE	TITLE
09/12/17	1	NONE	iPhone 8

DATE	REV	SCALE	TITLE
09/12/17	1	NONE	iPhone 8

NOTES

- [1] NO METAL CONTACT WITH IPHONE.
- [2] DO NOT OBSTRUCT THE ACOUSTIC OPENINGS; FRONT MIC, REAR MIC, BOTTOM MIC1, BOTTOM MIC2, RECEIVER AND SPEAKER.
- [3] DO NOT OBSTRUCT THE IMAGING FEATURES: FRONT CAMERA, REAR CAMERA, REAR FLASH.
- [4] DO NOT OBSTRUCT THE PROXIMITY SENSOR OR AMBIENT LIGHT SENSOR (ALS).
- [5] DO NOT OBSTRUCT THE HOME BUTTON.
- [6] DO NOT TOUCH GLASS.
- [7] DO NOT OBSTRUCT ALL PORTS.
- [8] NO HIGH POWERED MAGNETS, ENTIRE PRODUCT SURFACE.

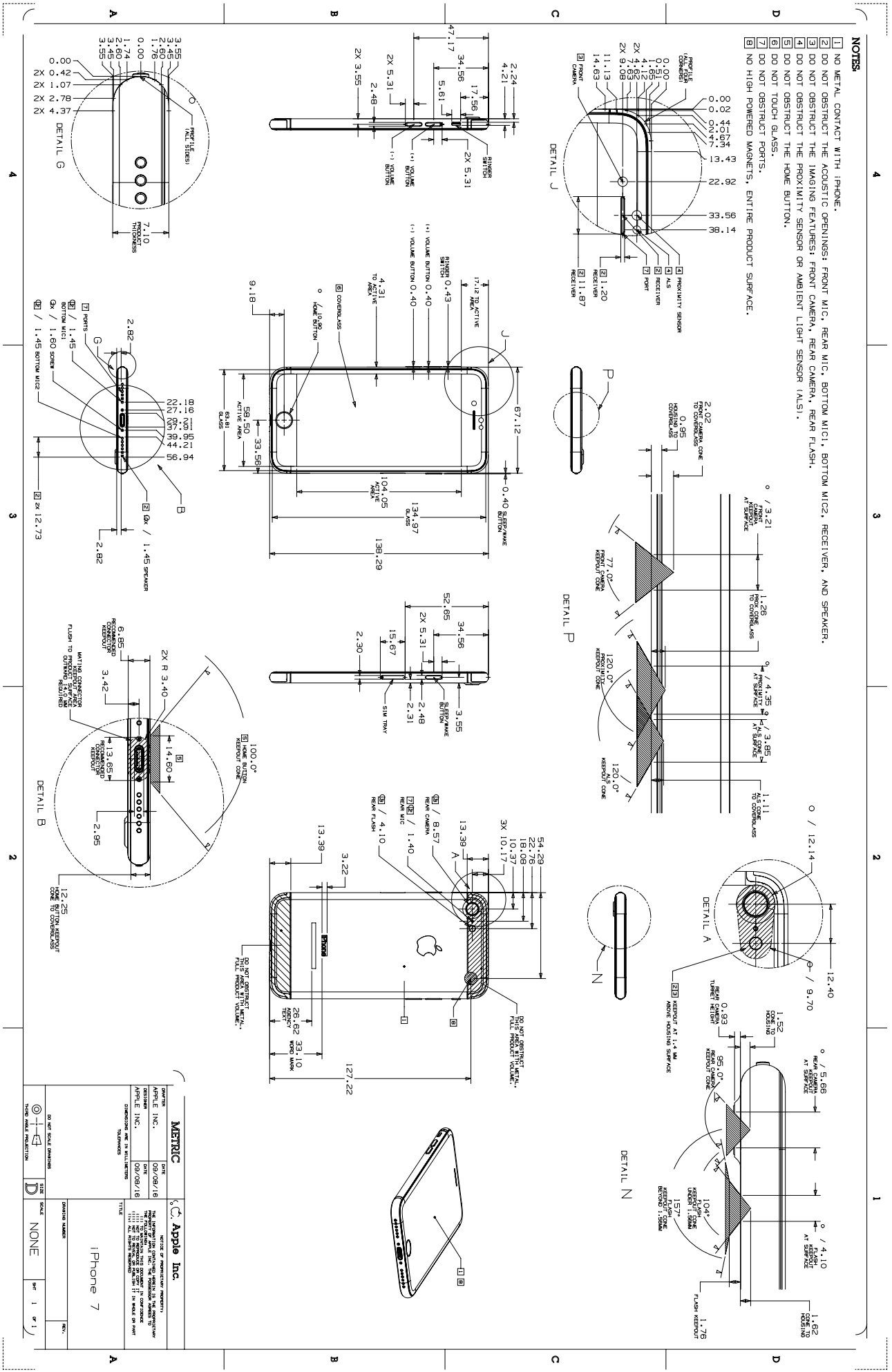


METRIC		Apple Inc.	
DATE	DATE	REV.	REV.
09/08/16	09/08/16	1	1
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DRAWING NAME: iPhone 7 Plus TITLE:		DRAWING NUMBER:	
DRAWING SCALE: NONE		SHEET: 1 OF 1	

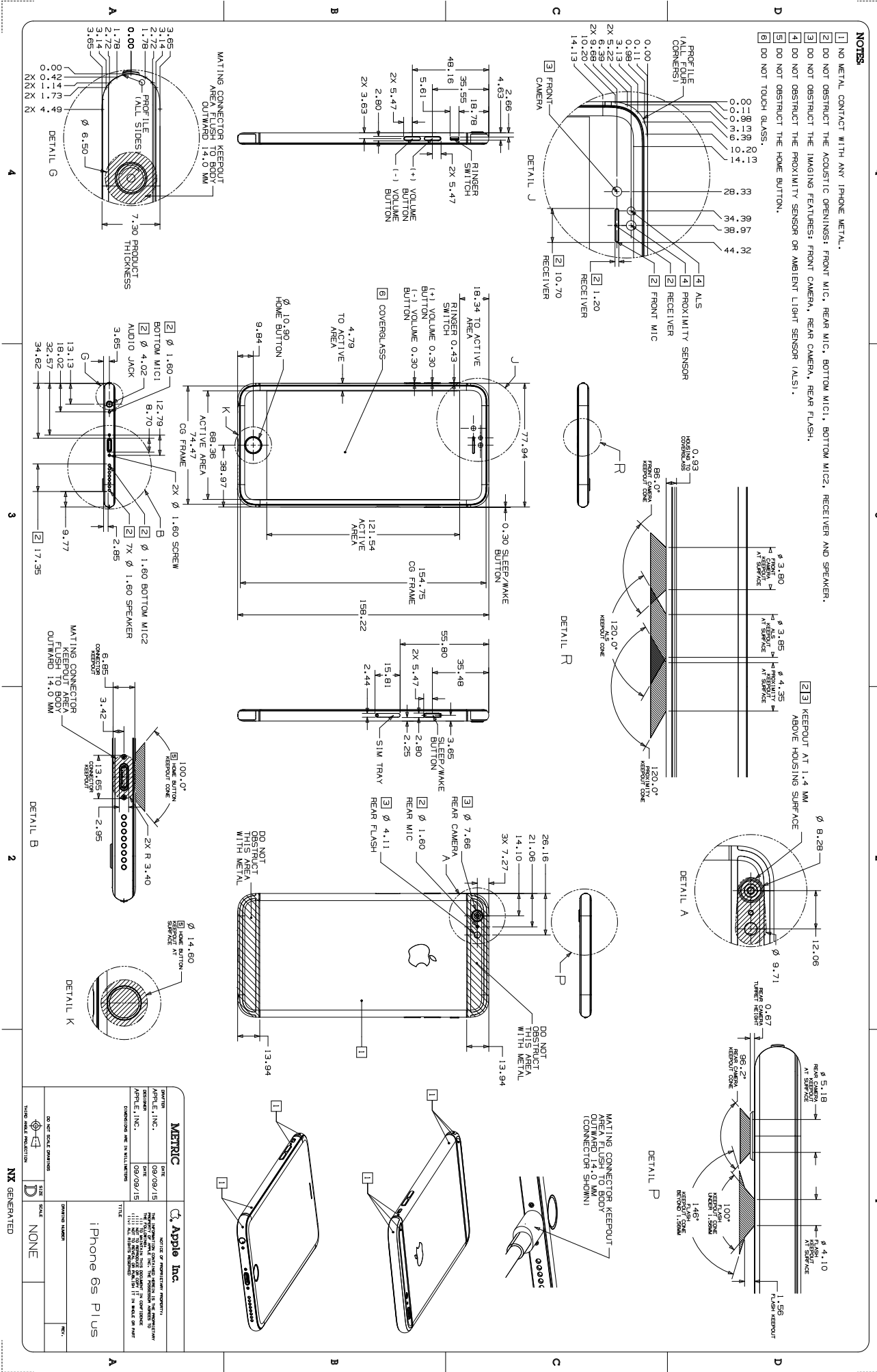
44.28 iPhone 7

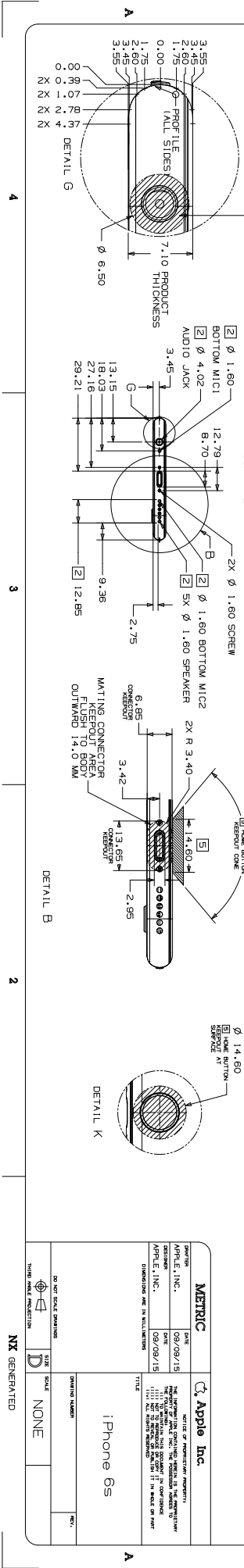
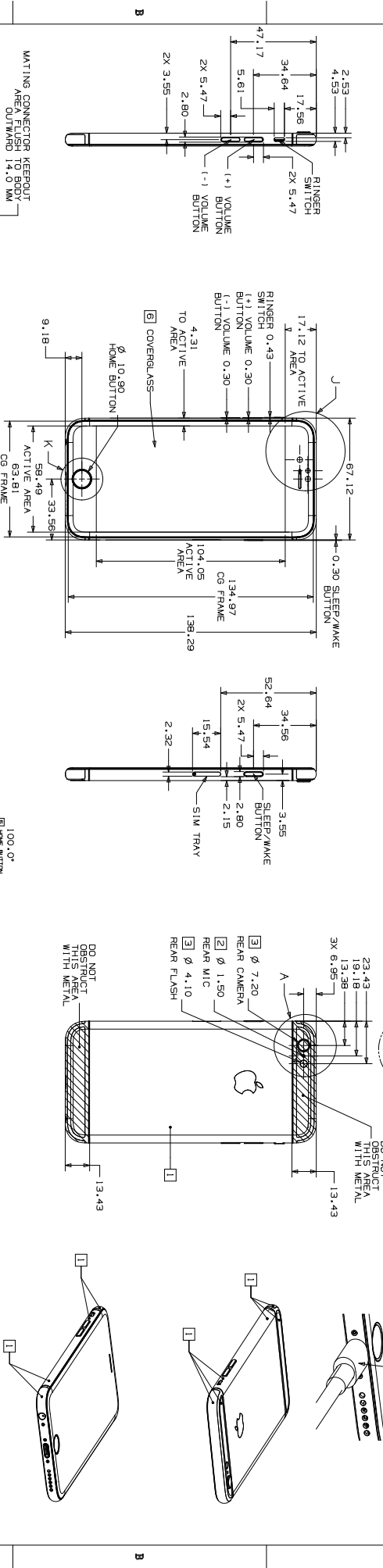
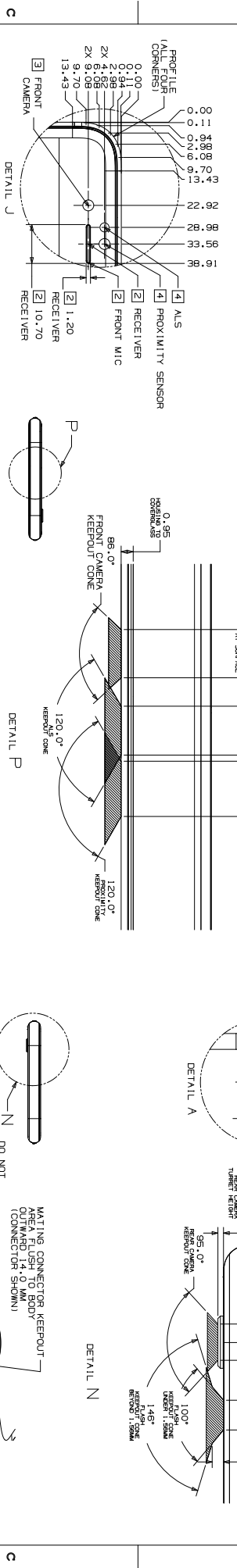
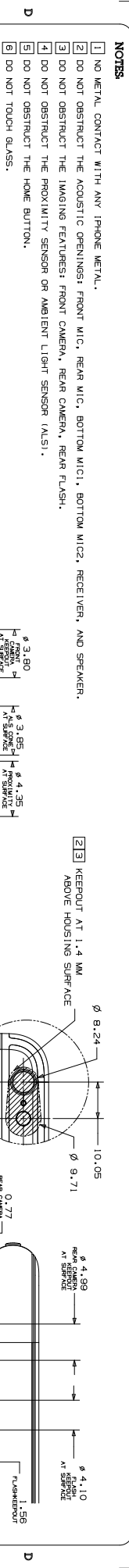
NOTES

- 1 NO METAL CONTACT WITH IPHONE.
- 2 DO NOT OBSTRUCT THE ACOUSTIC OPENINGS: FRONT MIC, REAR MIC, BOTTOM MIC1, BOTTOM MIC2, RECEIVER, AND SPEAKER.
- 3 DO NOT OBSTRUCT THE IMAGING FEATURES: FRONT CAMERA, REAR CAMERA, REAR FLASH.
- 4 DO NOT OBSTRUCT THE PROXIMITY SENSOR OR AMBIENT LIGHT SENSOR (ALS).
- 5 DO NOT TOUCH GLASS.
- 6 DO NOT OBSTRUCT THE HOME BUTTON.
- 7 DO NOT OBSTRUCT PORTS.
- 8 NO HIGH POWERED MAGNETS, ENTIRE PRODUCT SURFACE.



METRIC		Apple Inc.	
DATE	09/08/18	DATE	09/08/18
APPROVED BY	[Signature]	APPROVED BY	[Signature]
DESIGNED BY	[Signature]	DESIGNED BY	[Signature]
CHECKED BY	[Signature]	CHECKED BY	[Signature]
TITLE	iPhone 7	TITLE	iPhone 7
<p>THIS DRAWING IS THE PROPERTY OF APPLE INC. IT IS TO BE USED ONLY FOR THE PURPOSES SPECIFIED HEREIN. IT IS NOT TO BE REPRODUCED, COPIED, OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC OR MECHANICAL, INCLUDING PHOTOCOPYING, RECORDING, OR BY ANY INFORMATION STORAGE AND RETRIEVAL SYSTEM, WITHOUT THE EXPRESS WRITTEN PERMISSION OF APPLE INC.</p>		<p>THIS DRAWING IS THE PROPERTY OF APPLE INC. IT IS TO BE USED ONLY FOR THE PURPOSES SPECIFIED HEREIN. IT IS NOT TO BE REPRODUCED, COPIED, OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC OR MECHANICAL, INCLUDING PHOTOCOPYING, RECORDING, OR BY ANY INFORMATION STORAGE AND RETRIEVAL SYSTEM, WITHOUT THE EXPRESS WRITTEN PERMISSION OF APPLE INC.</p>	
SCALE	NONE	SCALE	NONE
SHEET	1	SHEET	1
<p>DO NOT SCALE DIMENSIONS</p>		<p>DO NOT SCALE DIMENSIONS</p>	

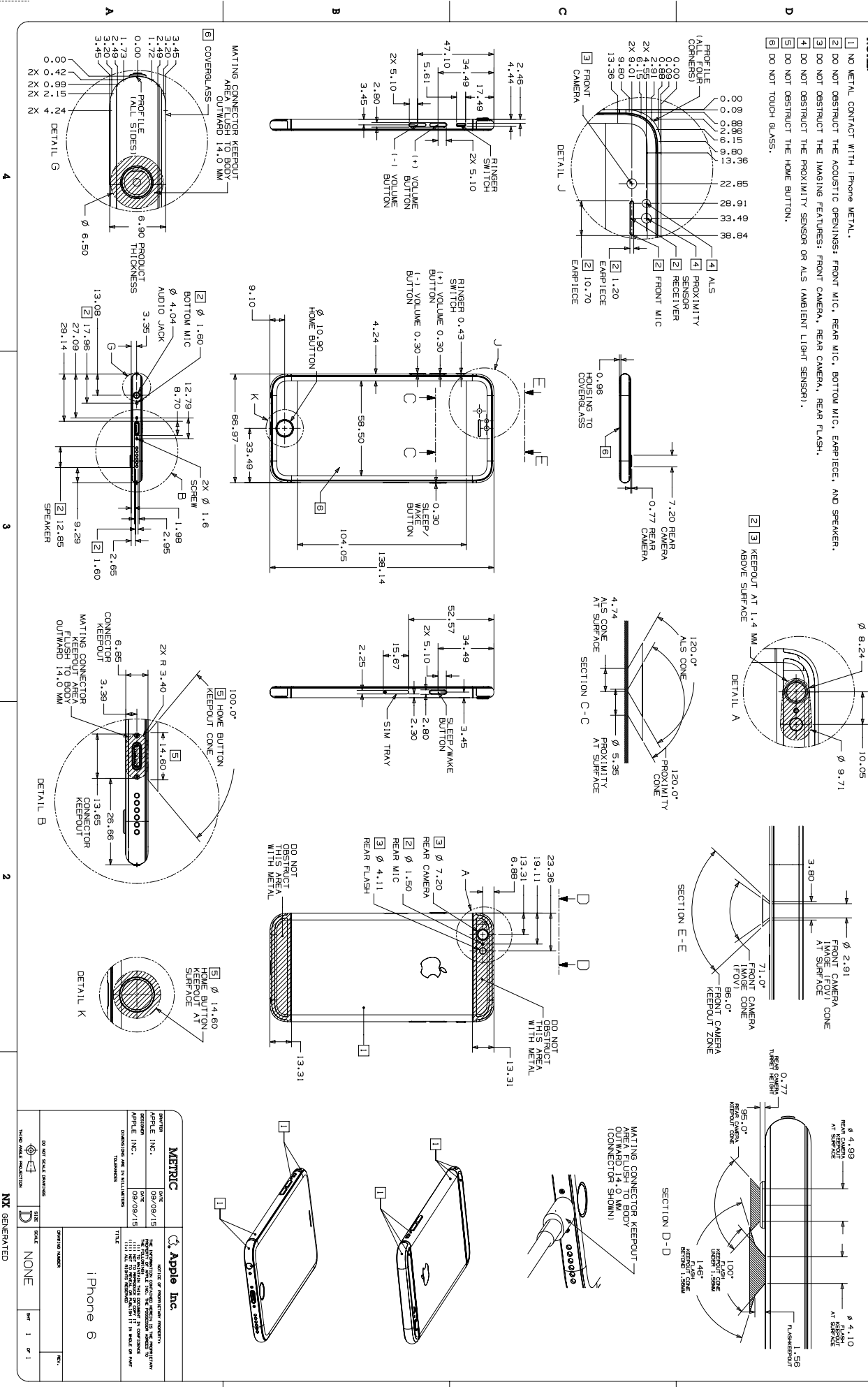




METRIC		Apple Inc.	
DATE	REV	DATE	REV
09/09/15		09/09/15	
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TITLE: iPhone 6s			
DO NOT SCALE DRAWINGS		DRAWING NUMBER:	
THIRD ANGLE PROJECTION		NONE	
MX GENERATED			

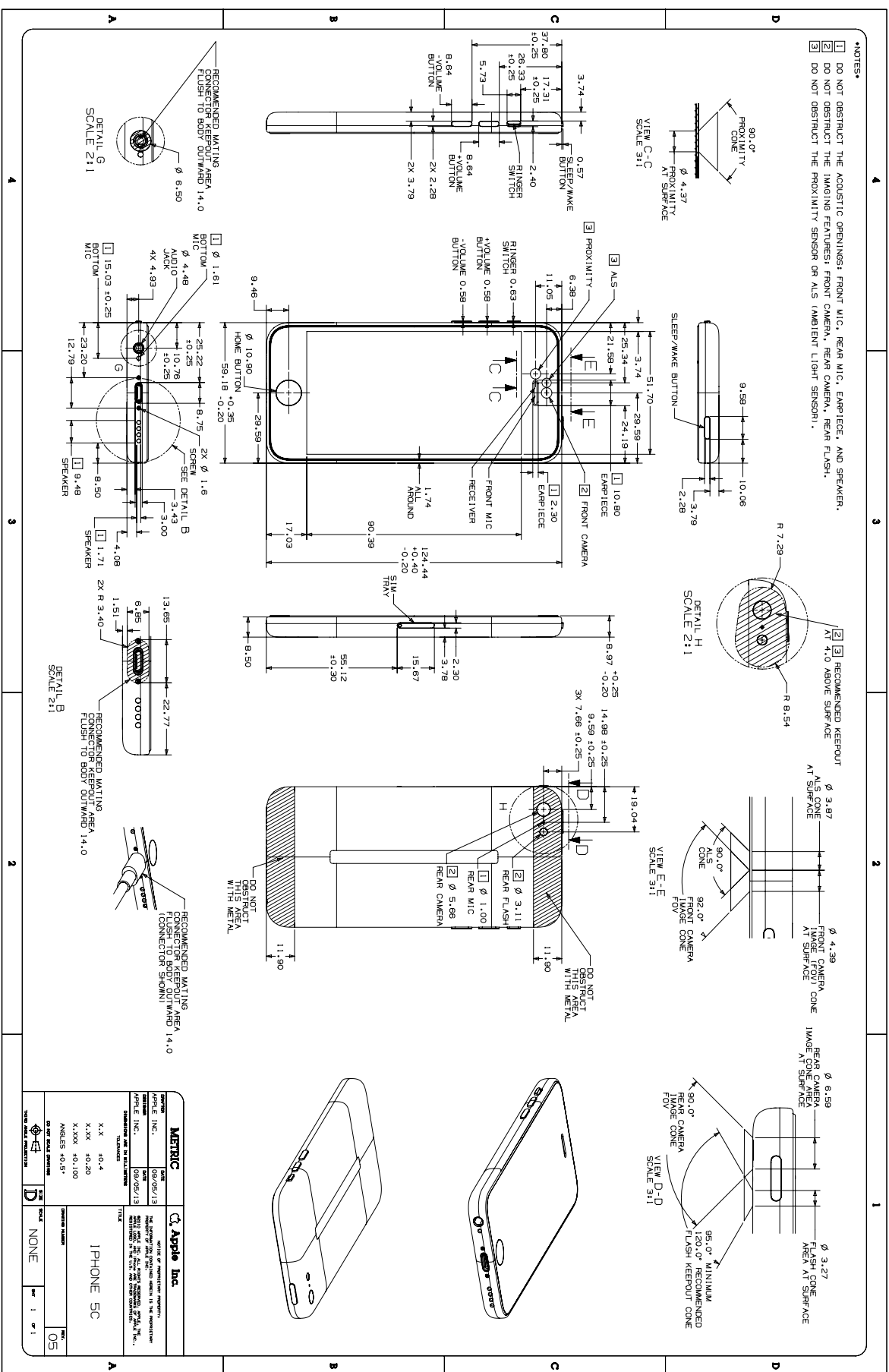
NOTES

- 1 NO METAL CONTACT WITH iPhone METAL.
- 2 DO NOT OBSTRUCT THE ACOUSTIC OPENINGS: FRONT MIC, REAR MIC, BOTTOM MIC, EARPIECE, AND SPEAKER.
- 3 DO NOT OBSTRUCT THE IMAGING FEATURES: FRONT CAMERA, REAR CAMERA, REAR FLASH.
- 4 DO NOT OBSTRUCT THE PROXIMITY SENSOR OR ALS (AMBIENT LIGHT SENSOR).
- 5 DO NOT OBSTRUCT THE HOME BUTTON.
- 6 DO NOT TOUCH GLASS.



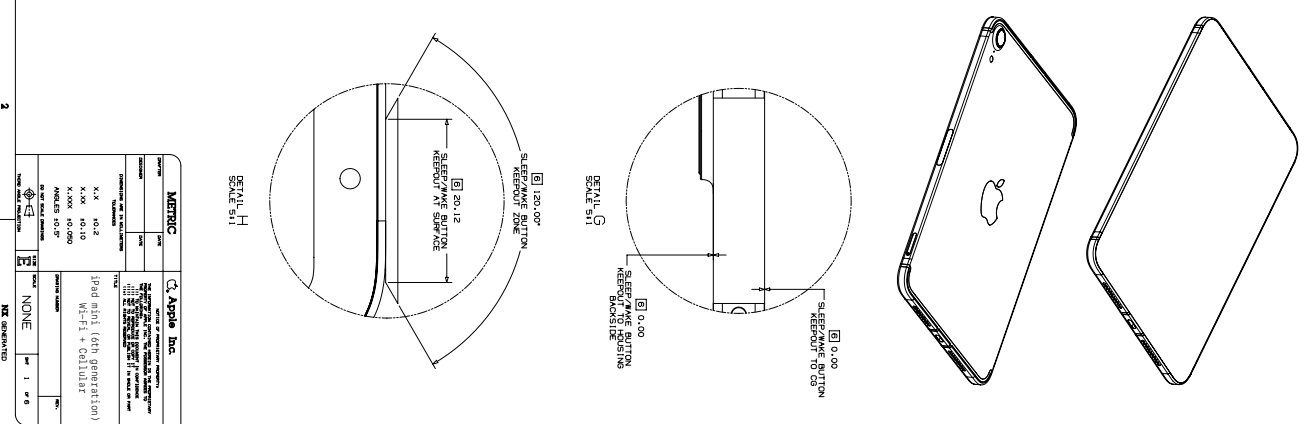
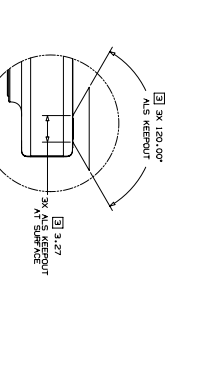
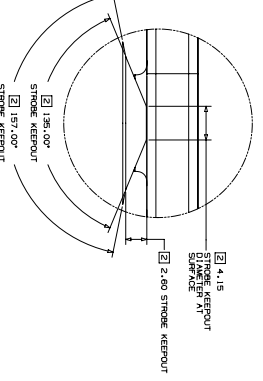
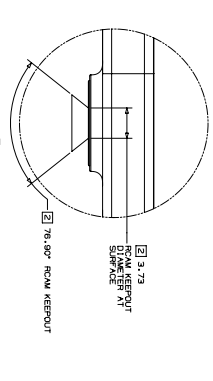
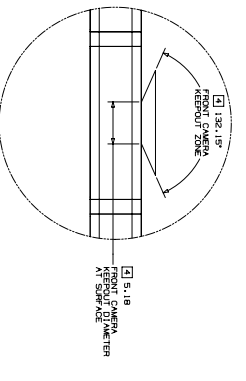
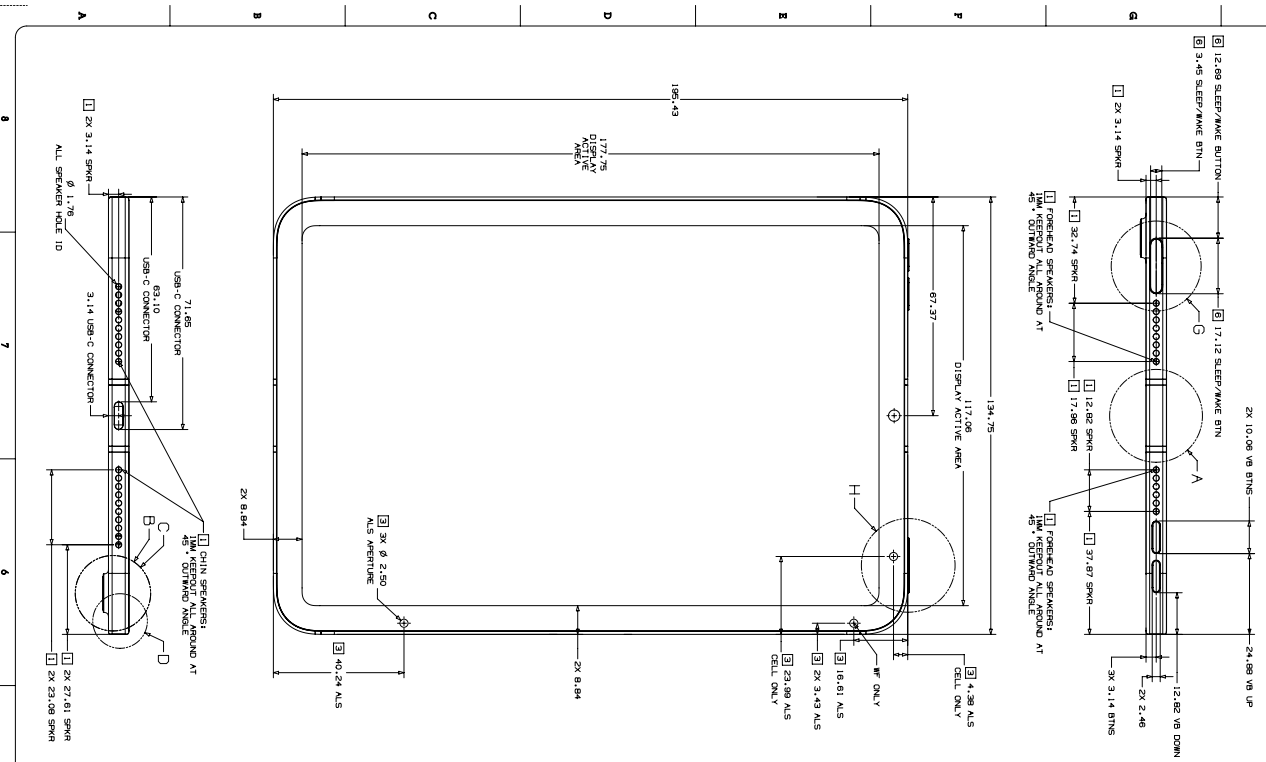
METRIC		Apple Inc.	
DATE	09/09/15	DATE	09/09/15
DESIGNED BY	Apple Inc.	DESIGNED BY	Apple Inc.
DATE	09/09/15	DATE	09/09/15
DESIGNED BY	Apple Inc.	DESIGNED BY	Apple Inc.
DATE	09/09/15	DATE	09/09/15
DESIGNED BY	Apple Inc.	DESIGNED BY	Apple Inc.
DATE	09/09/15	DATE	09/09/15
DESIGNED BY	Apple Inc.	DESIGNED BY	Apple Inc.
DATE	09/09/15	DATE	09/09/15
DESIGNED BY	Apple Inc.	DESIGNED BY	Apple Inc.
DATE	09/09/15	DATE	09/09/15
DESIGNED BY	Apple Inc.	DESIGNED BY	Apple Inc.
DATE	09/09/15	DATE	09/09/15
DESIGNED BY	Apple Inc.	DESIGNED BY	Apple Inc.
DATE	09/09/15	DATE	09/09/15
DESIGNED BY	Apple Inc.	DESIGNED BY	Apple Inc.
DATE	09/09/15	DATE	09/09/15
DESIGNED BY	Apple Inc.	DESIGNED BY	Apple Inc.

DO NOT SCALE DIMENSIONS
 NONE
 NONE
 1 of 1
 MX GENERATED



4.4.36 iPad mini (6th generation) 1 of 6

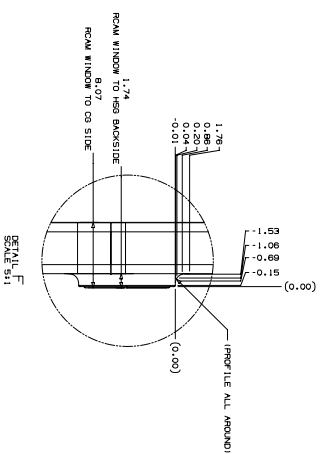
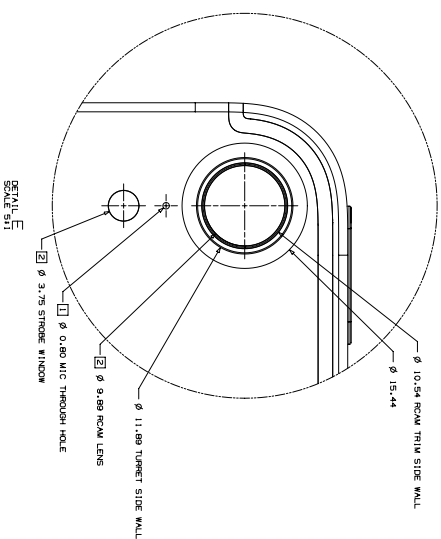
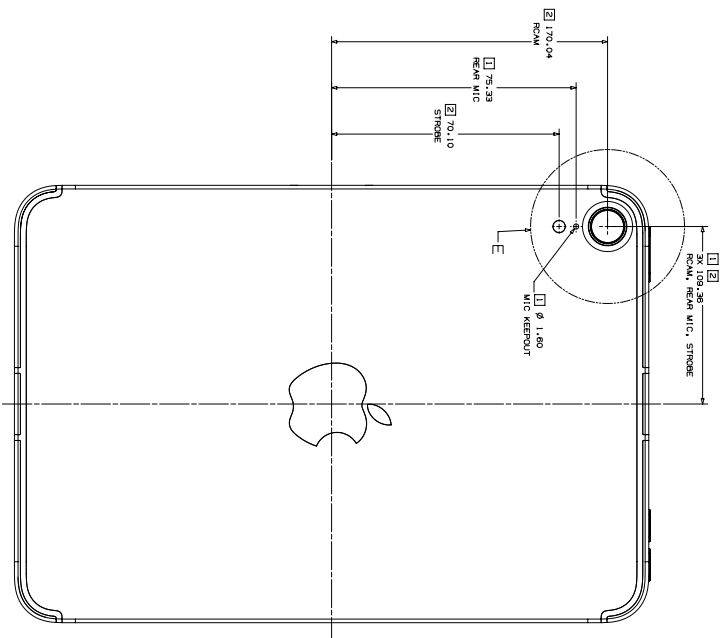
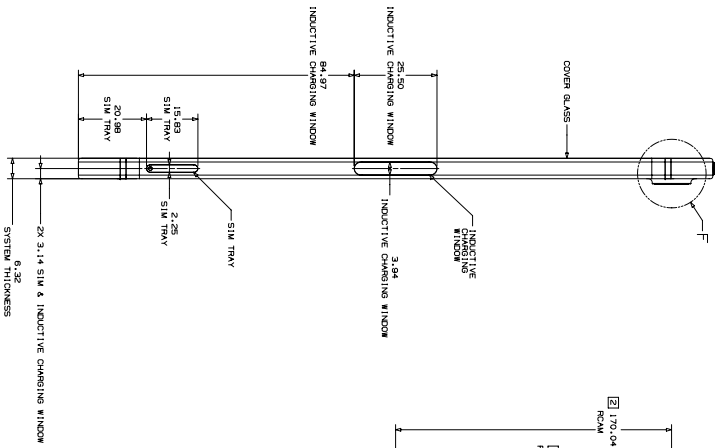
NOTES: UNLESS OTHERWISE SPECIFIED:
 1. DO NOT OBSTRUCT ACoustic OPENINGS, REAR MIC, SPEAKERS
 2. DO NOT OBSTRUCT REAR CAMERA, REAR FLASH
 3. DO NOT OBSTRUCT AMBIENT LIGHT SENSOR
 4. DO NOT OBSTRUCT FRONT CAMERA
 5. DO NOT OBSTRUCT FRONT CAMERA SERVICE COVER GLASS
 6. DO NOT OBSTRUCT SLEEP/WAKE BUTTON



METRIC		Apple Inc.
DATE	10/20/20	
VERSION	1.0	
DESCRIPTION	iPad mini (6th generation)	
DESIGNED BY	Apple Inc.	
ENGINEERED BY	Apple Inc.	
TESTED BY	Apple Inc.	
APPROVED BY	Apple Inc.	
DATE	10/20/20	
SCALE	1:1	
UNIT	MM	
STANDARD	ASME Y14.5M	
PROPERTY	NONE	
DATE	10/20/20	
SCALE	1:1	
UNIT	MM	
STANDARD	ASME Y14.5M	
PROPERTY	NONE	
DATE	10/20/20	
SCALE	1:1	
UNIT	MM	
STANDARD	ASME Y14.5M	
PROPERTY	NONE	
DATE	10/20/20	
SCALE	1:1	
UNIT	MM	
STANDARD	ASME Y14.5M	
PROPERTY	NONE	

44.37 iPad mini (6th generation) 2 of 6

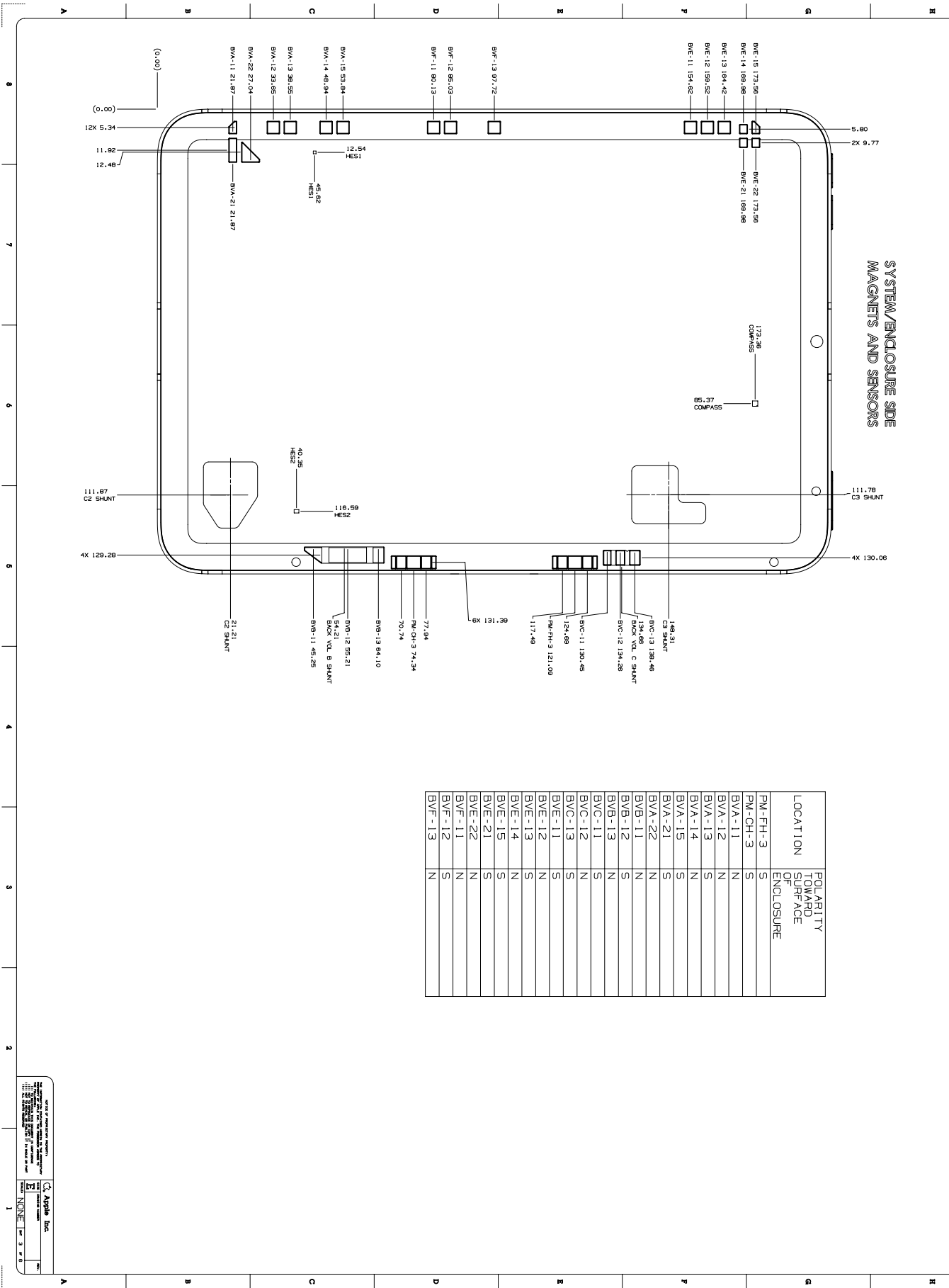
- 1 DO NOT OBSTRUCT ACOUSTIC OPENINGS! REAR MIC, SPEAKERS
- 2 DO NOT OBSTRUCT REAR CAMERA, REAR FLASH
- 3 DO NOT OBSTRUCT FRONT CAMERA, LIGHT SENSOR
- 4 DO NOT OBSTRUCT FRONT CAMERA, LIGHT SENSOR
- 5 DO NOT HAVE METAL CONTACT WITH DEVICE COVER GLASS
- 6 DO NOT OBSTRUCT SLEEP/WAKE BUTTON



Apple Inc.	
Part Name	44.37
Quantity	1
Material	None
Notes	1

MAGNET, HES, COMPASS DETAIL

SYSTEM/ENCLOSURE SIDE
MAGNETS AND SENSORS



LOCATION	POLARITY TOWARD SURFACE OF ENCLOSURE
PM-FH-3	S
PM-CH-3	S
BVA-11	N
BVA-12	N
BVA-13	S
BVA-14	N
BVA-15	S
BVA-21	N
BVA-22	N
BVB-11	N
BVB-12	S
BVB-13	N
BVC-11	S
BVC-12	N
BVC-13	S
BVE-11	N
BVE-12	N
BVE-13	S
BVE-14	N
BVE-15	S
BVE-21	N
BVE-22	N
BVF-11	N
BVF-12	N
BVF-13	N

Apple logo

Apple Inc.

Model: A2302

Version: 1.0

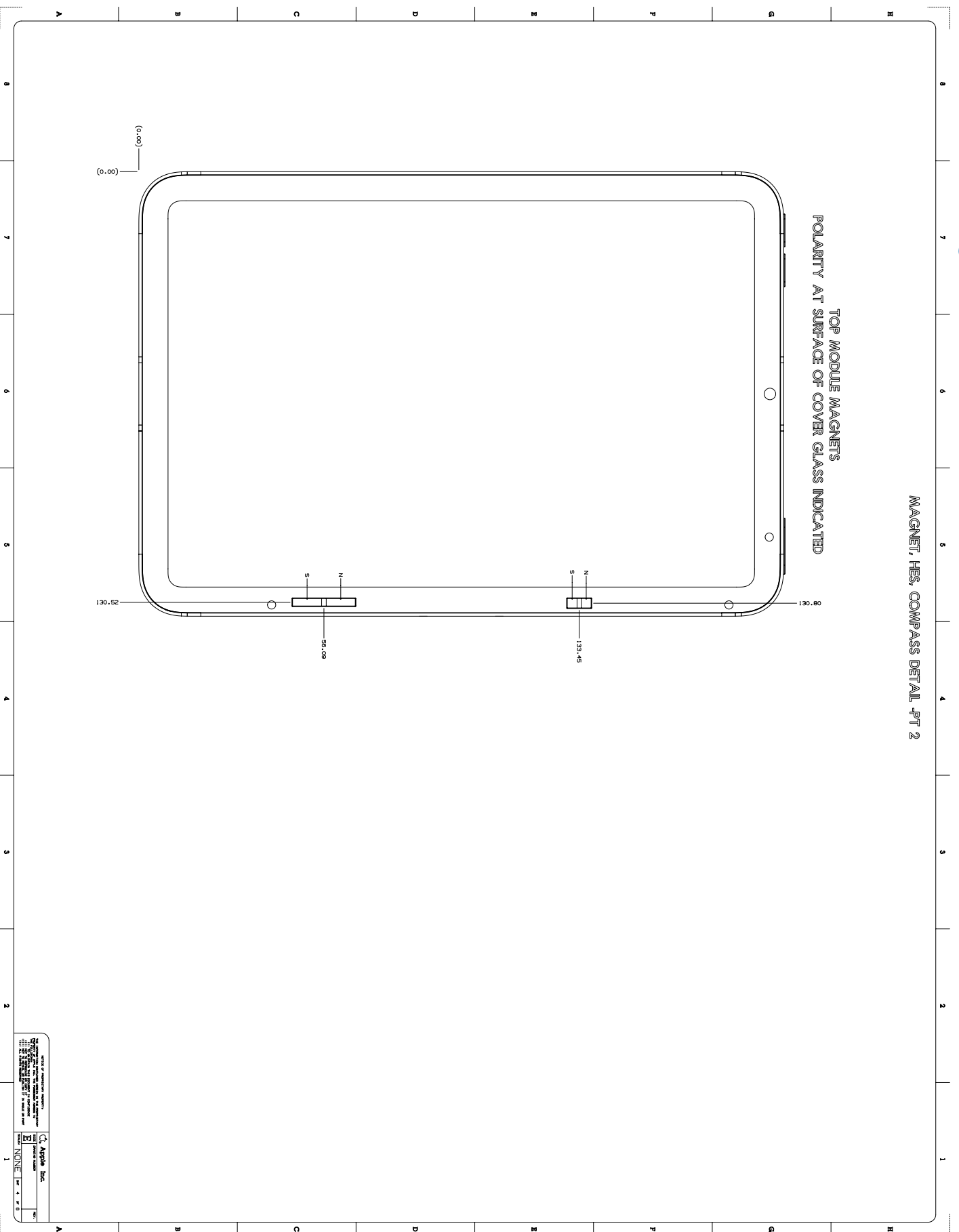
Created: 2021-09-28

Author: Apple Inc.

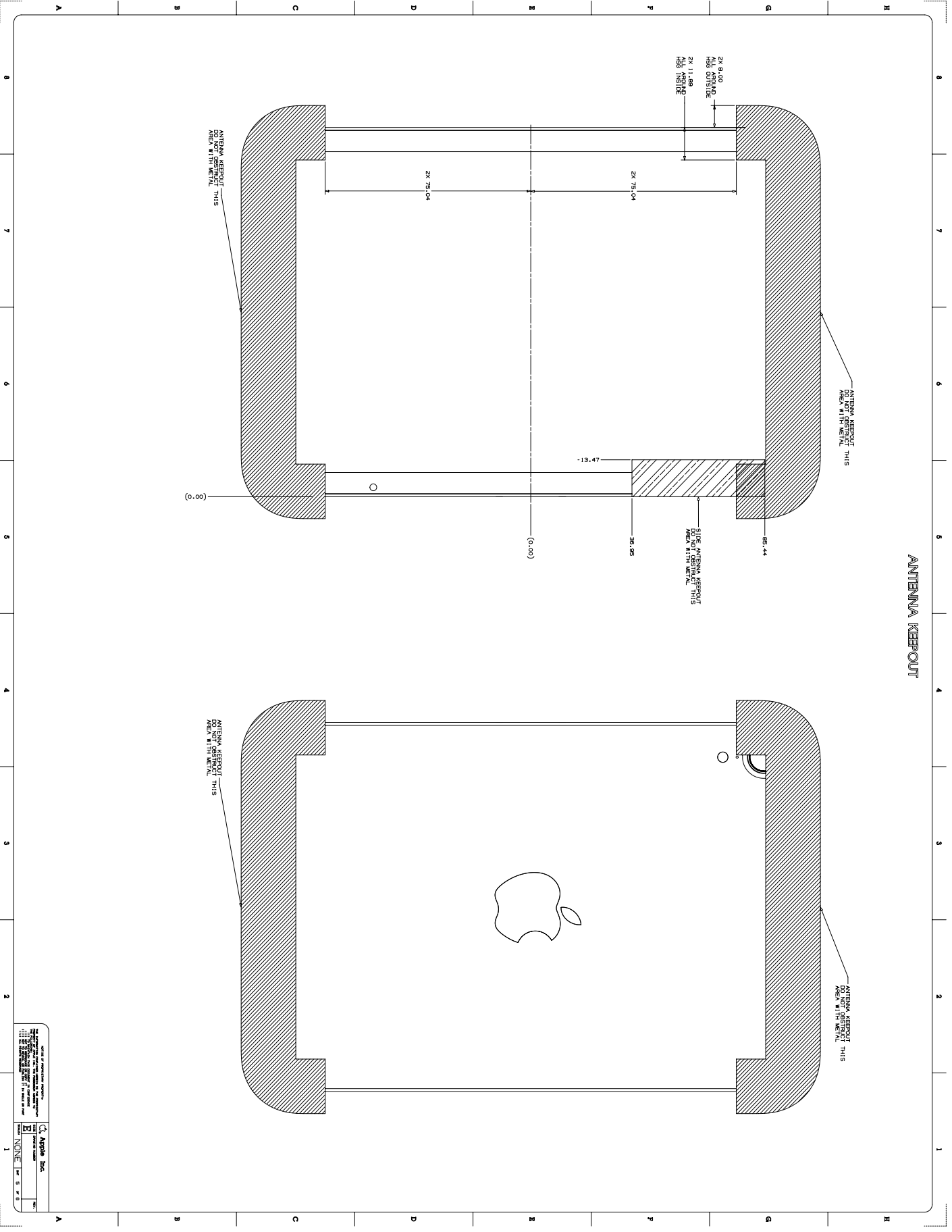
Approved: Apple Inc.

44.39 iPad mini (6th generation) 4 of 6

MAGNET, HES. COMPASS DETAIL -PT 2



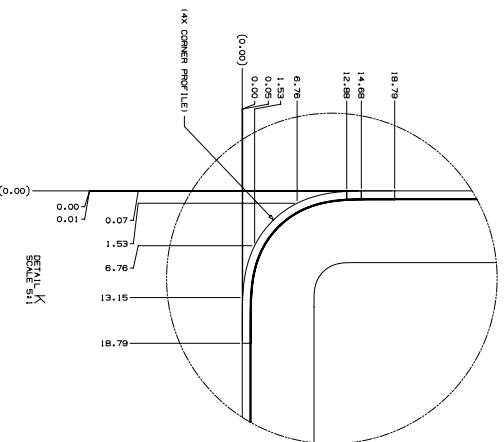
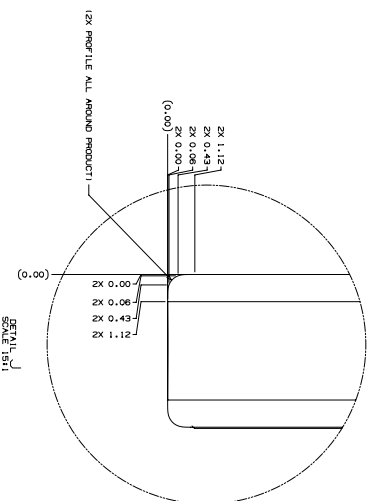
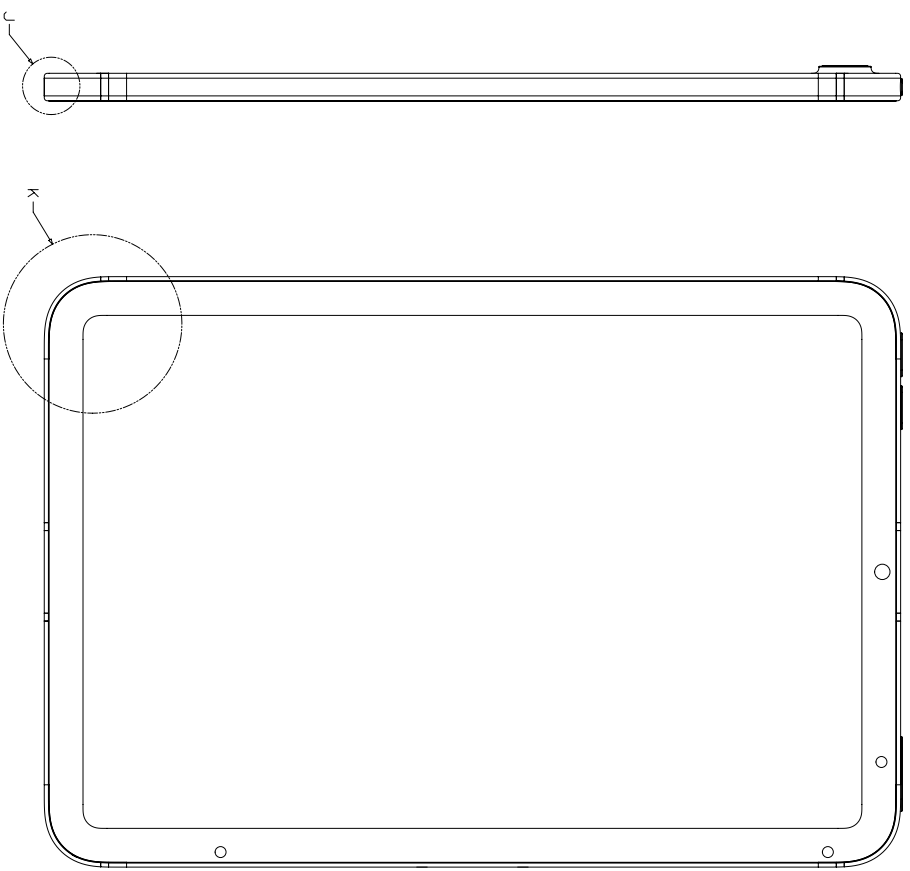
44.40 iPad mini (6th generation) 5 of 6



Apple Inc.
Apple logo
Apple Inc. 2021
Apple logo
Apple Inc. 2021

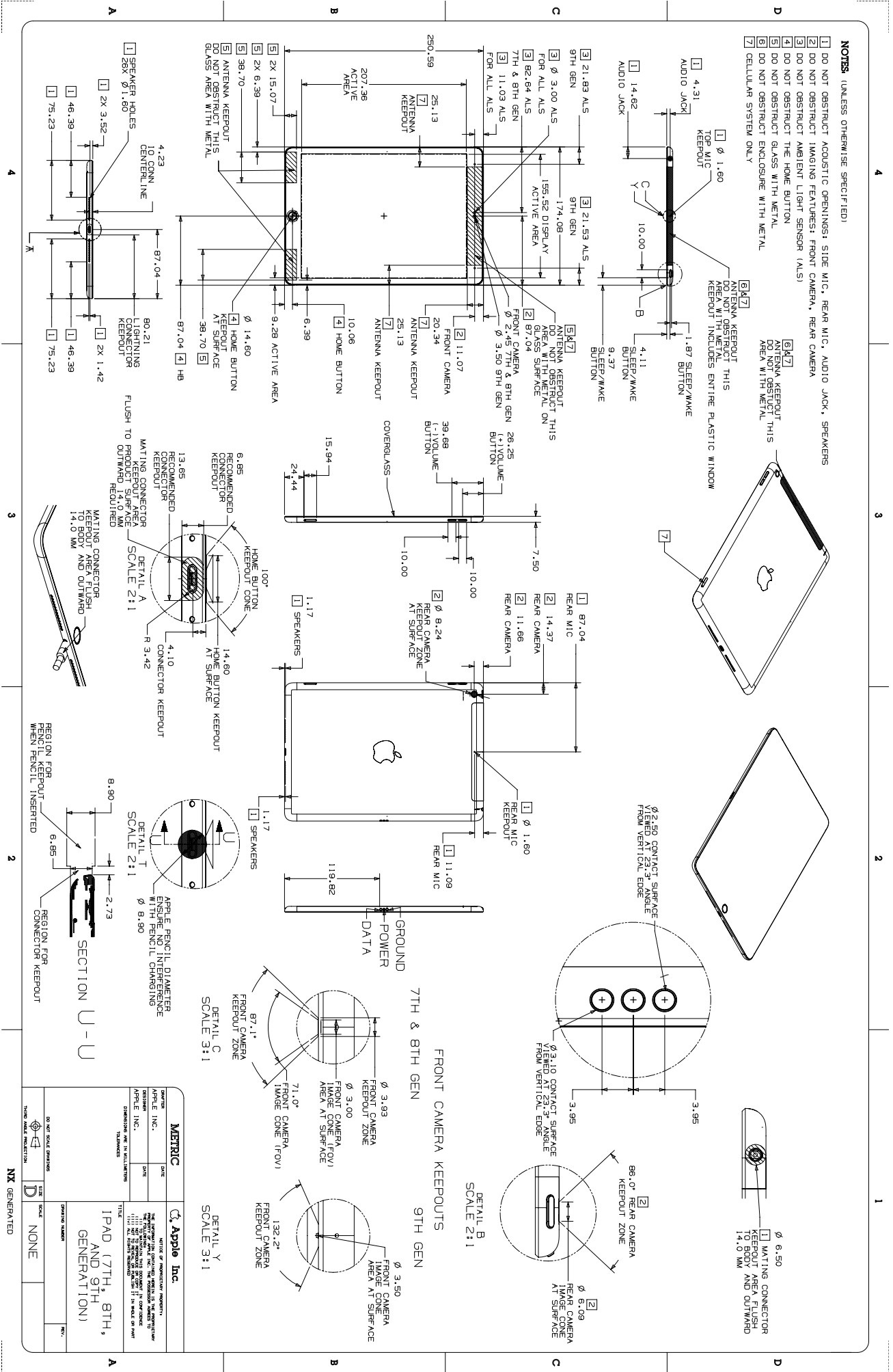
4.4.41 iPad mini (6th generation) 6 of 6

PROFILE DETAIL

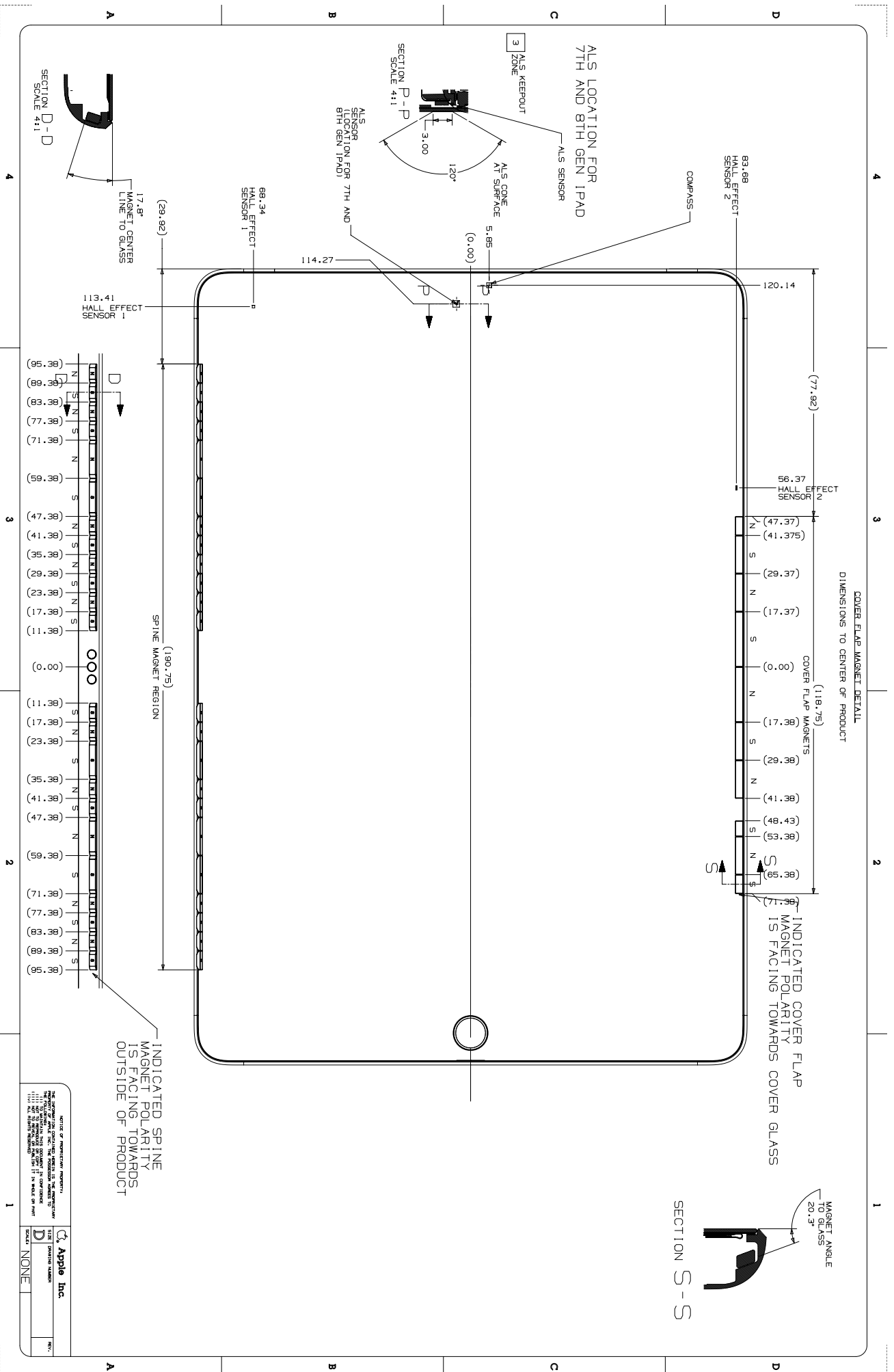


Apple Inc.	
Model	None
Part	None
Rev	0
Created	09/28/2021
By	Apple Inc.
Checked	Apple Inc.
Approved	Apple Inc.

4.4.42 iPad (9th generation), iPad (8th generation) and iPad (7th generation) 1 of 4



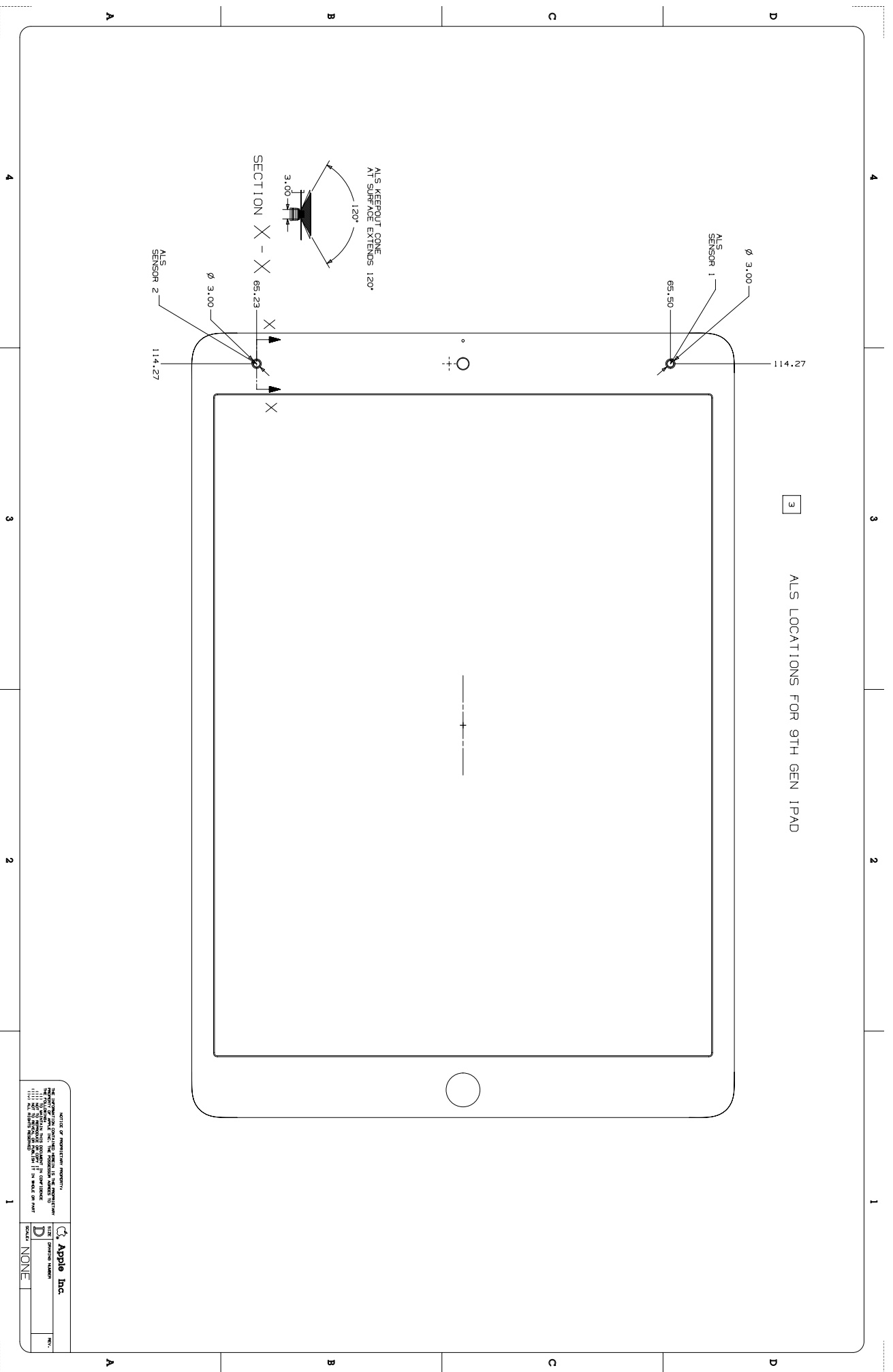
4.4.4.3 iPad (9th generation), iPad (8th generation) and iPad (7th generation) 2 of 4



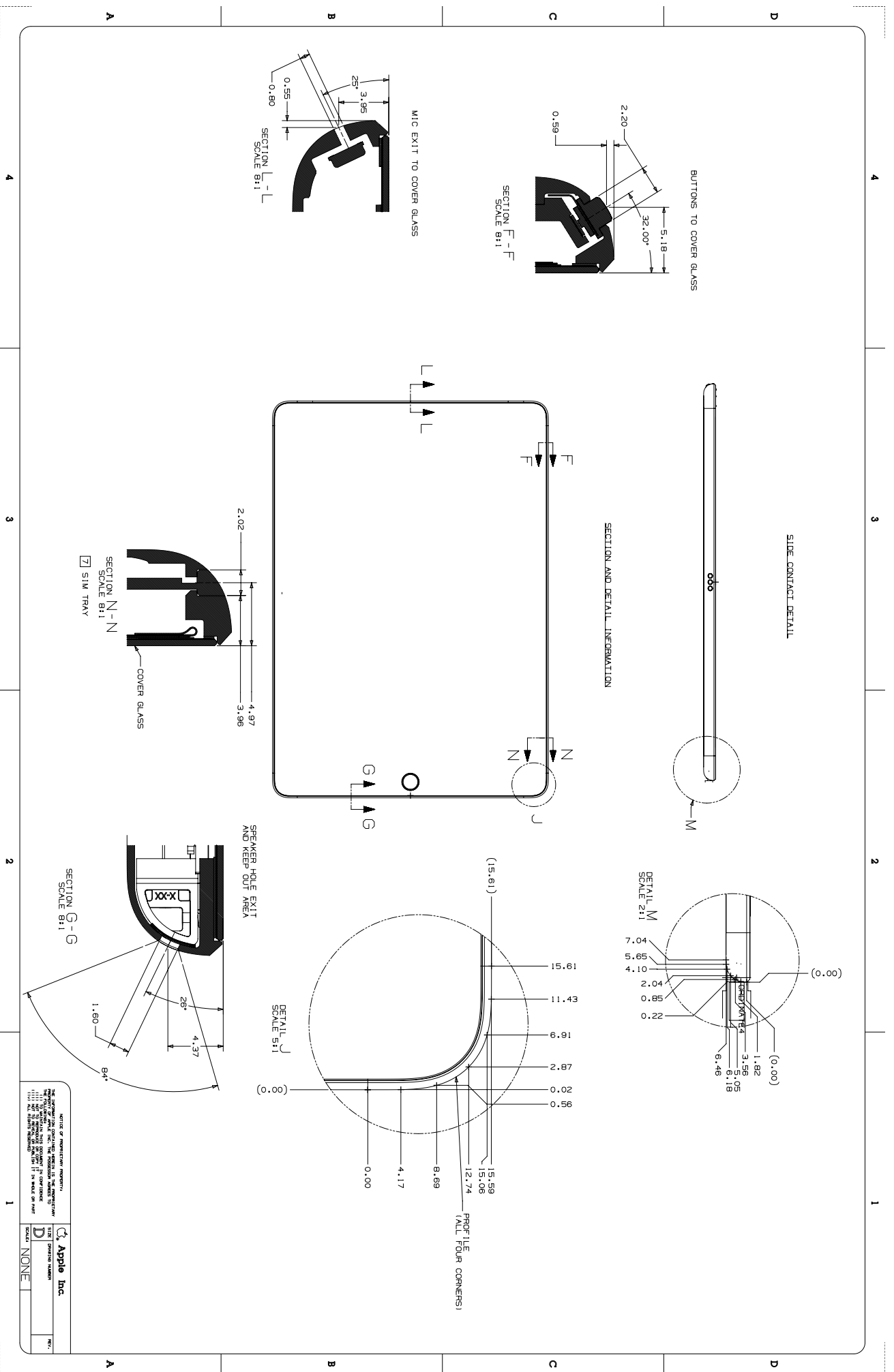
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Apple Inc.
TYPE: PRODUCT NUMBER
D
PATTERN: NONE

4.4.44 iPad (9th generation), iPad (8th generation) and iPad (7th generation) 3 of 4



44.45 iPad (9th generation), iPad (8th generation) and iPad (7th generation) 4 of 4

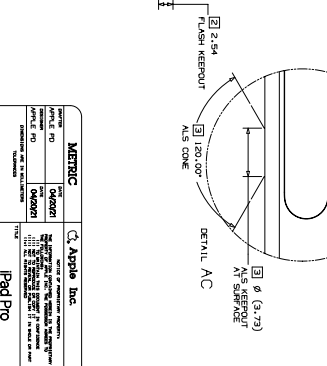
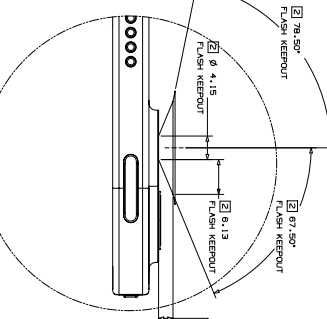
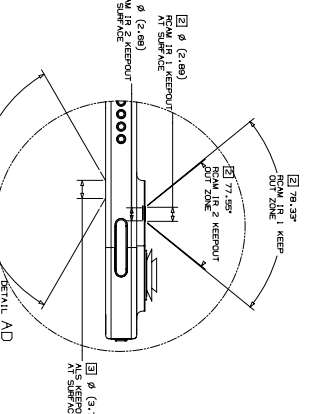
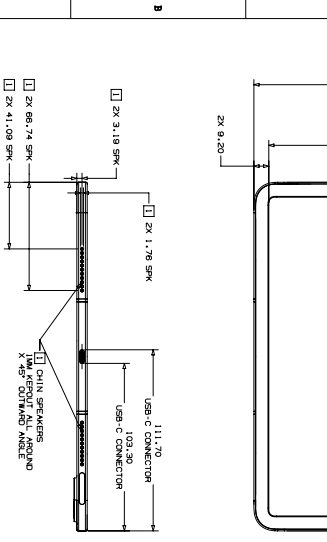
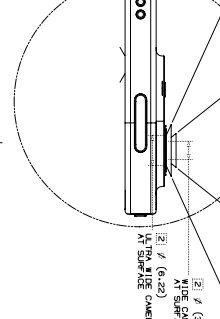
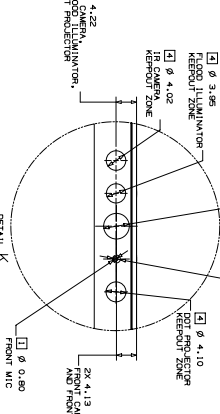
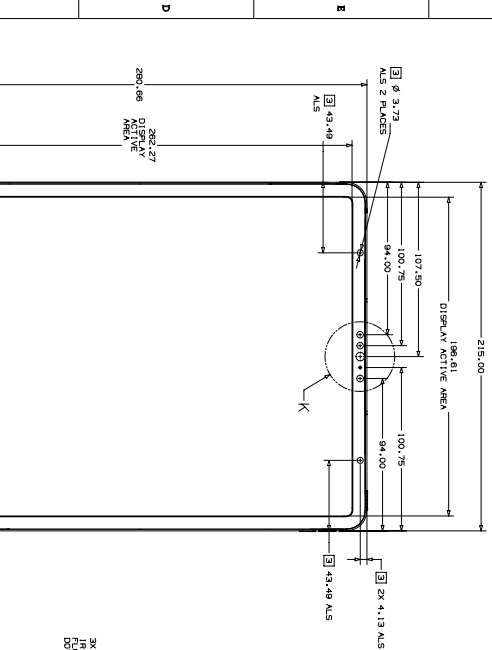
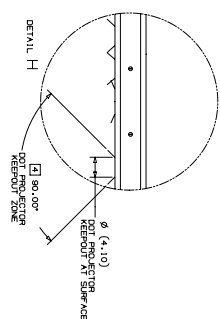
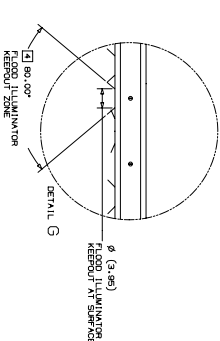
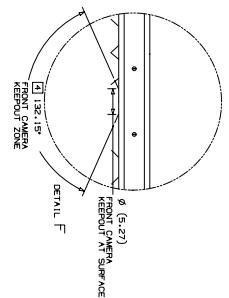
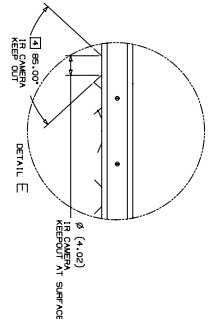
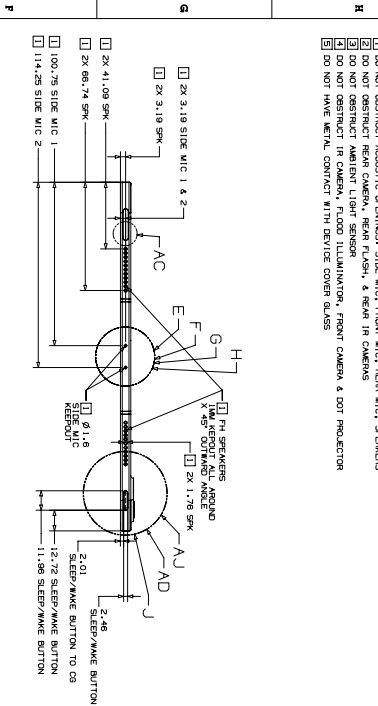


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Apple Inc.
PART NUMBER: NONE
REVISION: NONE

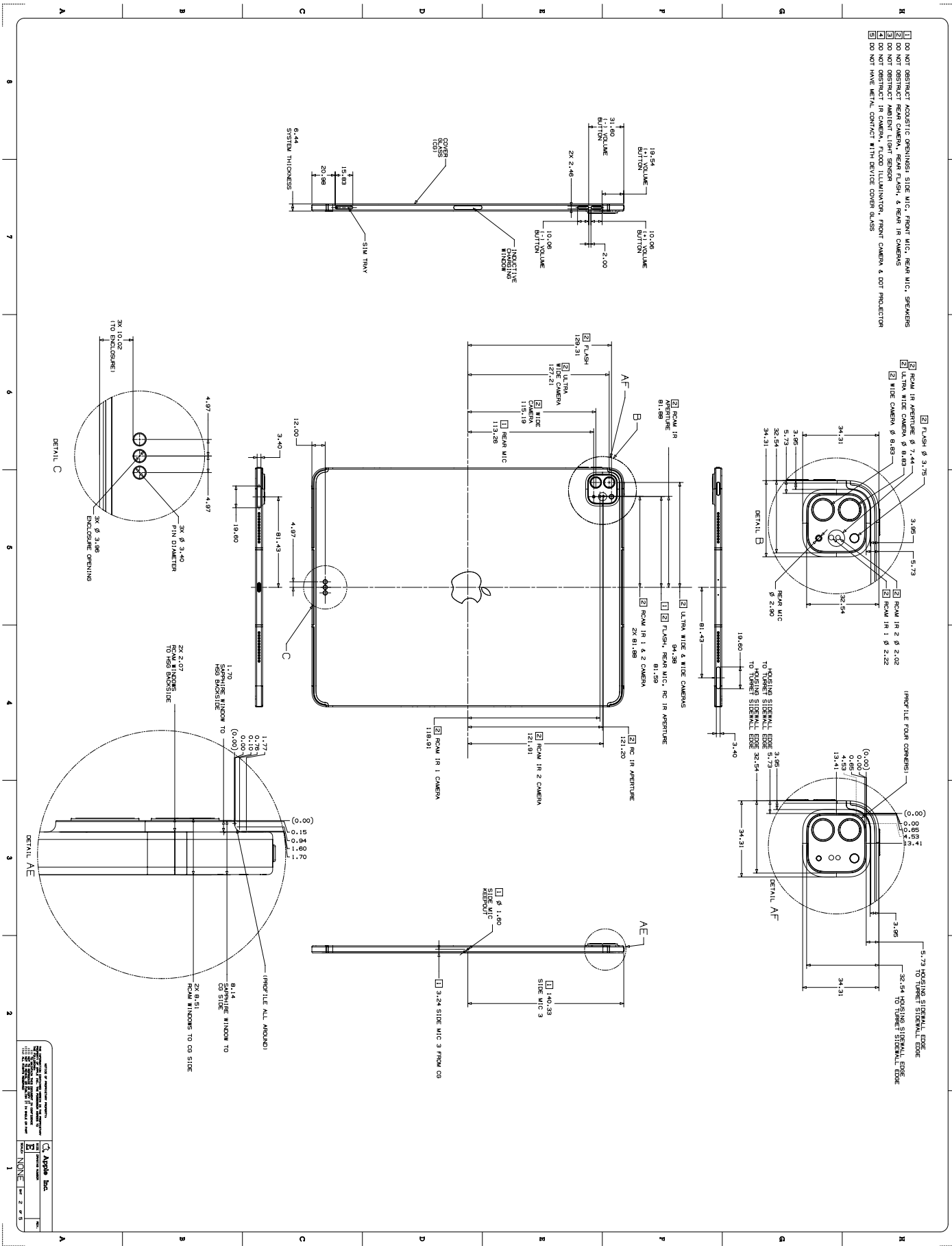
44.46 iPad Pro (12.9-inch) 5th Generation 1 of 5

NOTES: UNLESS OTHERWISE SPECIFIED:
 [1] DO NOT OBTURUSATE ACUSTIC PENINGSI SIZE MIC, FRONT MIC, REAR MIC, SPEAKERS
 [2] DO NOT OBTURUSATE REAR CAMERA, REAR FLASH, & REAR IR CAMERA
 [3] DO NOT OBTURUSATE REAR CAMERA, REAR FLASH, REAR IR CAMERA & DOT PROJECTOR
 [4] DO NOT OBTURUSATE REAR CAMERA, REAR FLASH, REAR IR CAMERA, FRONT CAMERA & DOT PROJECTOR
 [5] DO NOT HAVE METAL CONTACT WITH DEVICE COVER GLASS



<p>Apple Inc. iPad Pro (12.9-inch) 5th Generation</p>	
MATERIAL	Aluminum
FINISH	Space Gray / Silver
COLOR	Space Gray / Silver
PROCESSING	None
PROTOS	None
TESTING	None
INSPECTION	None
APPROVAL	None
DATE	2021-09-28
REV	1
REV	1
REV	1

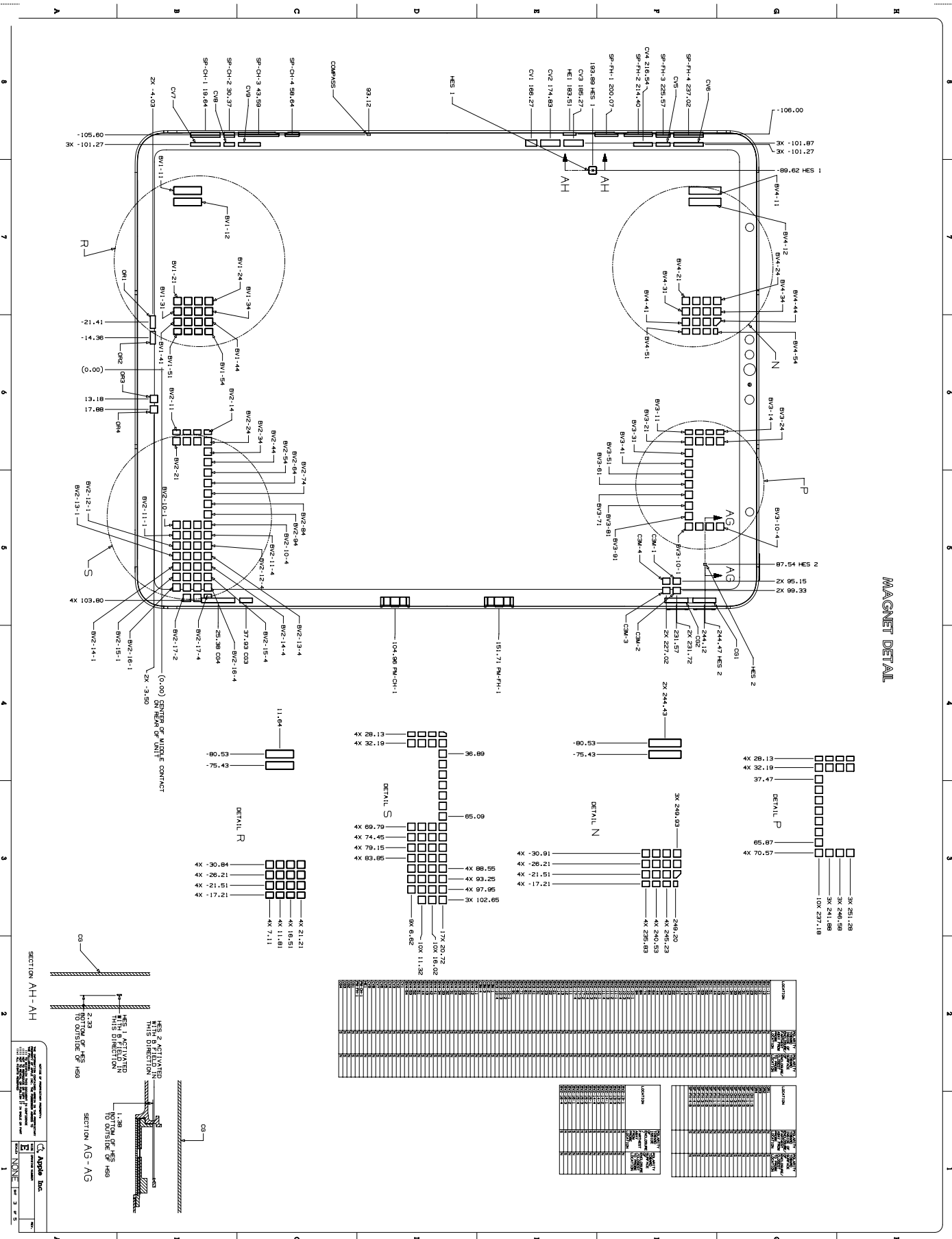
44.47 iPad Pro (12.9-inch) 5th Generation 2 of 5



- DO NOT OBSTRUCT ACOUSTIC OPENINGS: SIDE MIC, FRONT MIC, REAR MIC, SPEAKERS
- DO NOT OBSTRUCT FRONT IR SHIM & REAR IR CAMERAS
- DO NOT OBSTRUCT AMBIENT LIGHT SENSOR
- DO NOT OBSTRUCT IR CAMERA, FLUORO ILLUMINATOR, FRONT CAMERA & DOT PROJECTOR
- DO NOT HAVE METAL CONTACT WITH DEVICE COVER GLASS

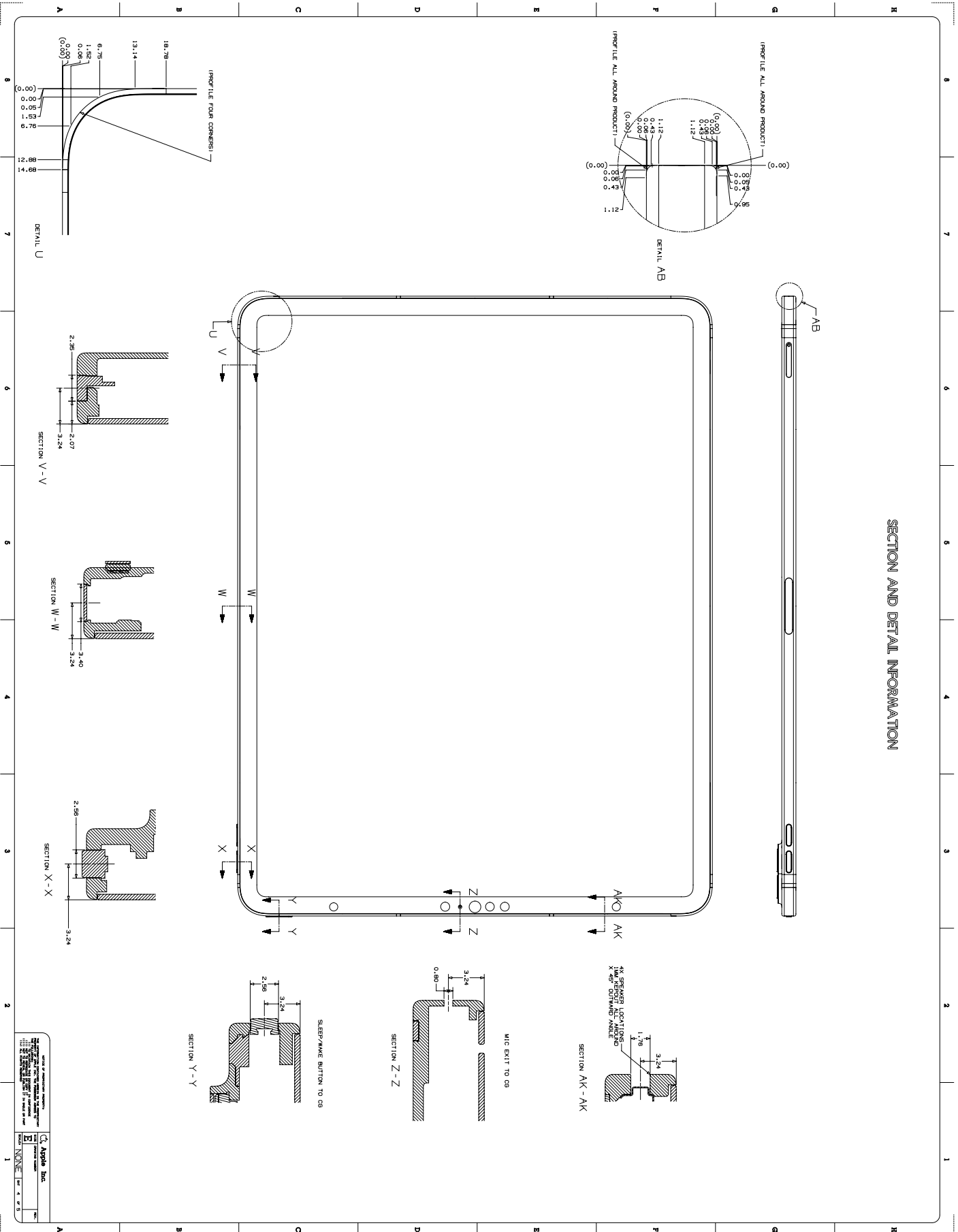
Apple Inc.	
Model: A2709	Part Number: 44.47
Revision: 1	Release Date: 2021-09-28
Manufacturer: Apple Inc.	Country of Origin: USA
Material: Aluminum	Color: Space Gray
Weight: 686g	Dimensions: 308.13 x 215.99 x 6.44 mm

MAGNET DETAIL



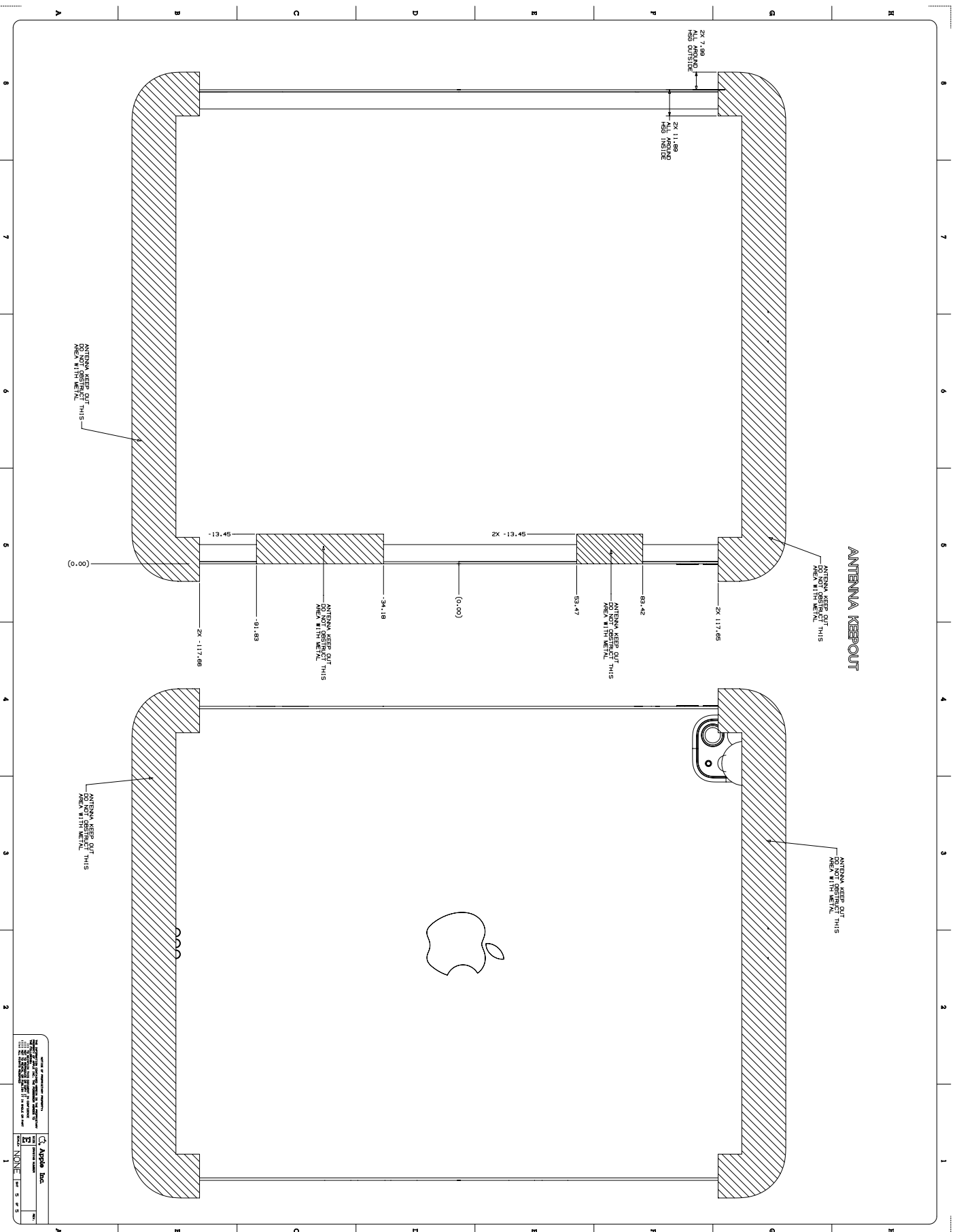
44.49 iPad Pro (12.9-inch) 5th Generation 4 of 5

SECTION AND DETAIL INFORMATION



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DATE: 20210928	DRAWN BY: NONE	

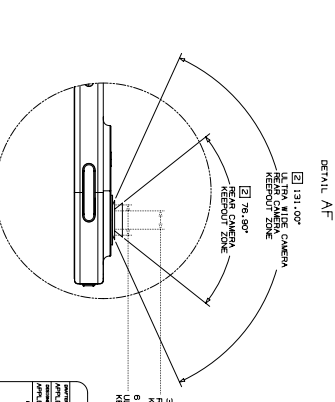
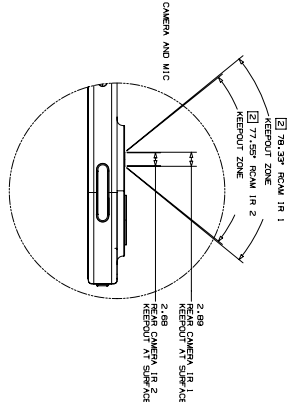
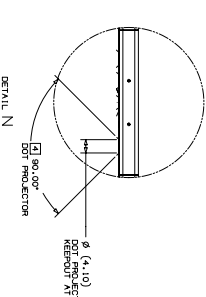
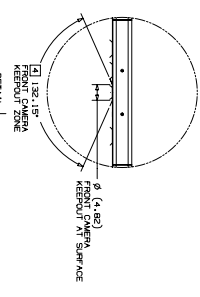
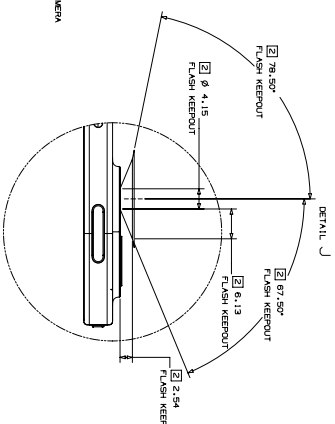
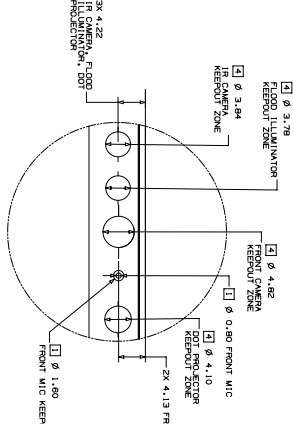
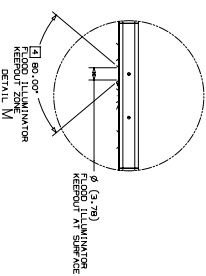
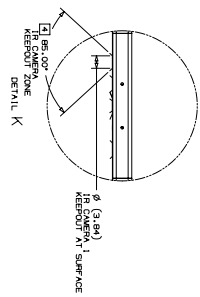
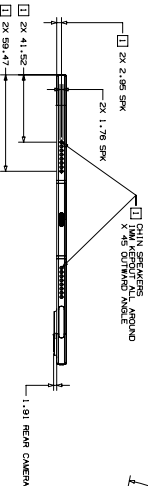
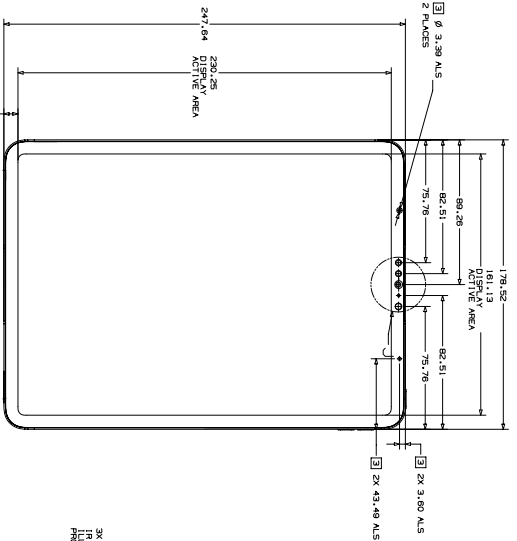
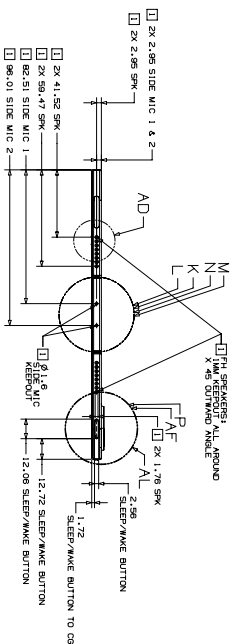
44.50 iPad Pro (12.9-inch) 5th Generation 5 of 5



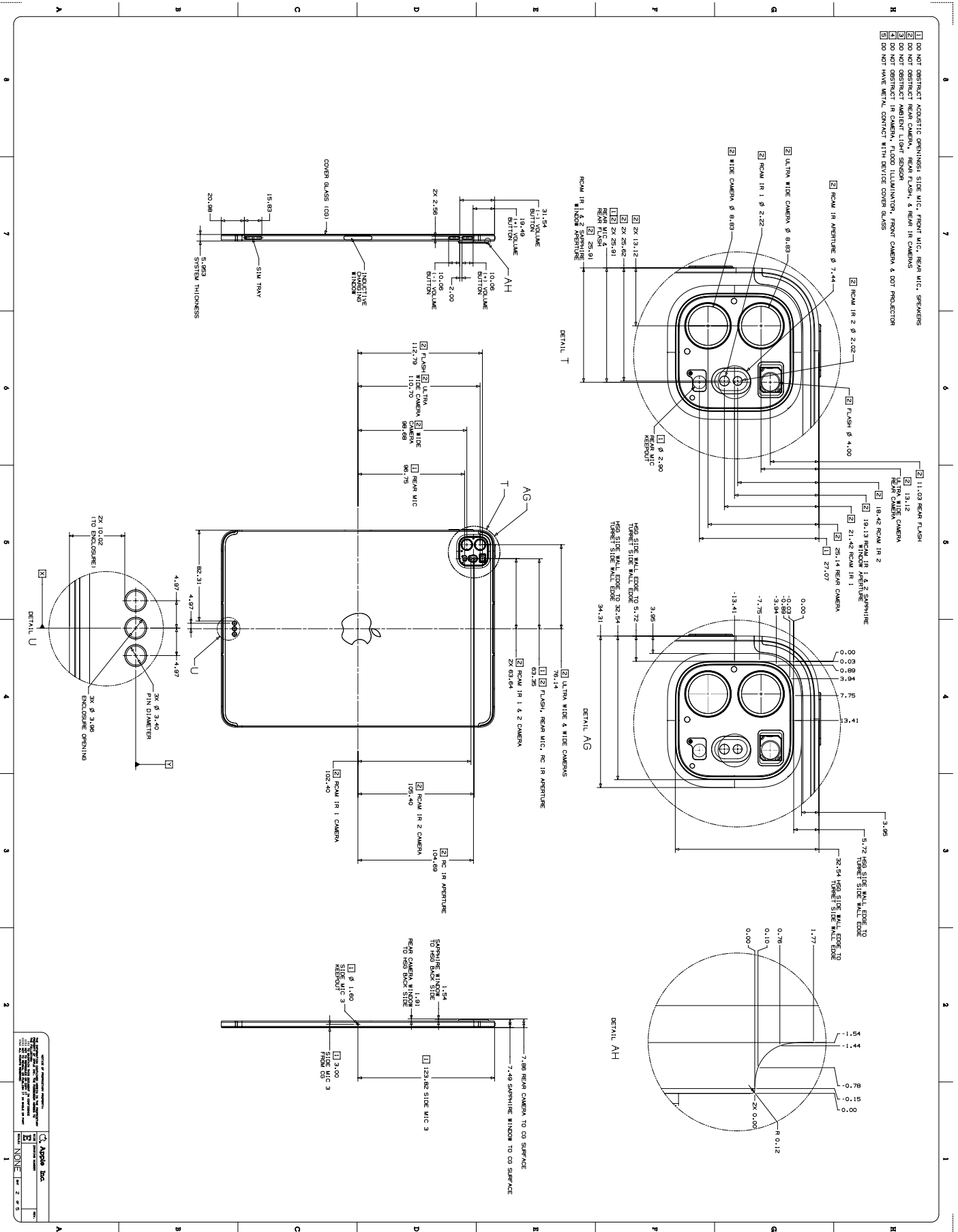
<small>Apple Inc. is not responsible for any damage to your device or any data on your device that may occur as a result of using this product.</small>	
<small>Apple Inc.</small>	<small>Apple Inc.</small>
<small>Apple Inc.</small>	<small>Apple Inc.</small>

4.4.51 iPad Pro (11-inch) 3rd Generation 1 of 5

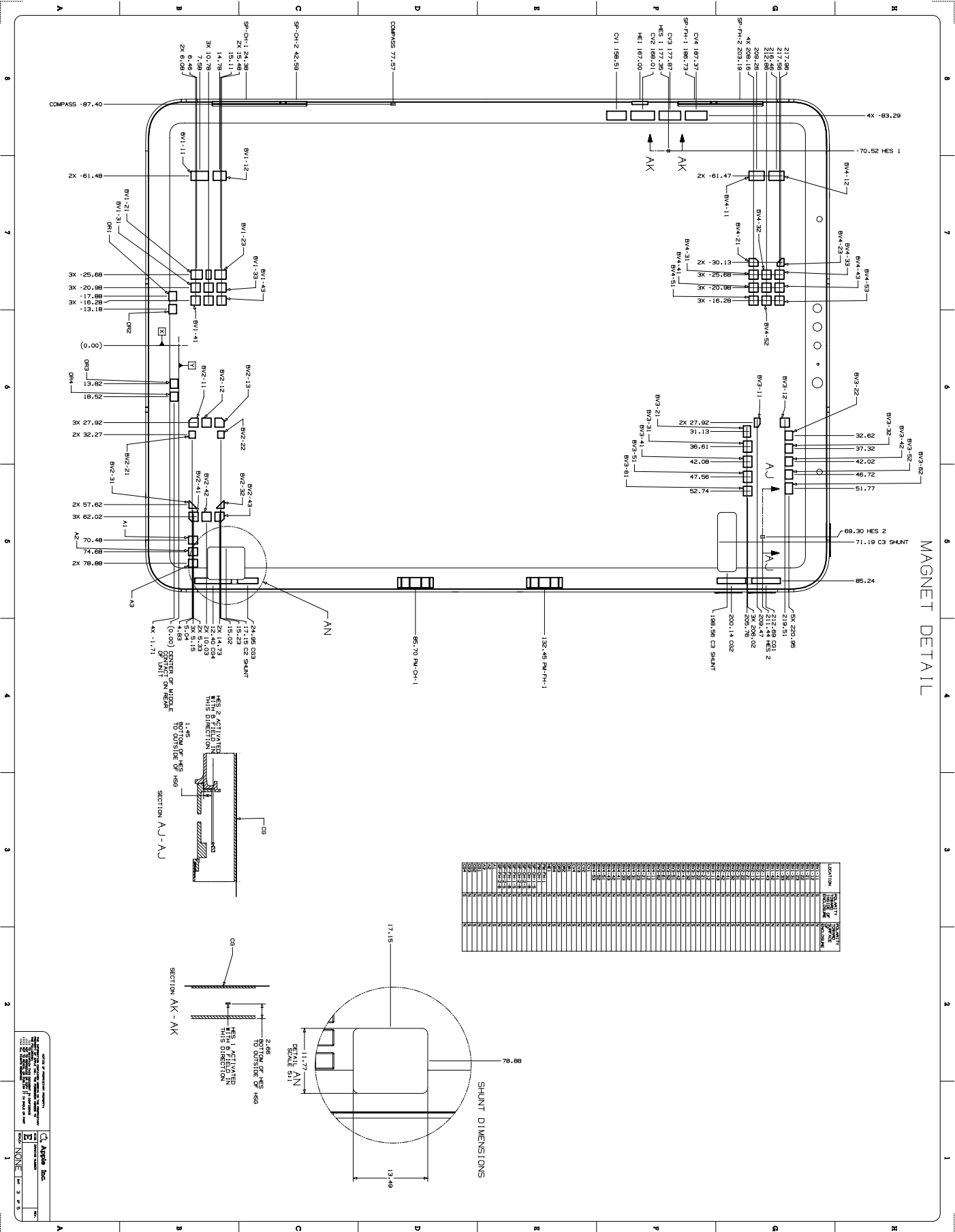
- NOTE: UNLESS OTHERWISE SPECIFIED:
 - DO NOT OBSTRUCT ACOUSTIC OPENINGS: SIDE MIC, FRONT MIC, REAR MIC, SPEAKERS
 - DO NOT OBSTRUCT LIGHT SOURCES: FLUORESCENT LIGHT, LED LIGHT, RED LIGHT
 - DO NOT OBSTRUCT AMBIENT LIGHT SENSOR
 - DO NOT OBSTRUCT IR CAMERA, FLOOD ILLUMINATOR, FRONT CAMERA, & DOT PROJECTION
 - DO NOT HAVE METAL CONTACT WITH DEVICE COVER GLASS



METRIC		Apple Inc.	
DATE	12/14/20	REVISION	
SYMBOL	000000	DESCRIPTION	000000
UNIT	MILLIMETER	SCALE	NONE
NUM OF SHEETS	5	SHEET NO.	1
PART NAME		DATE	
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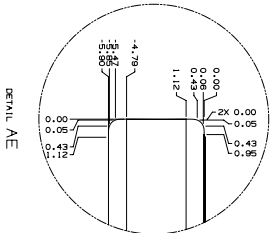


MAGNET DETAIL

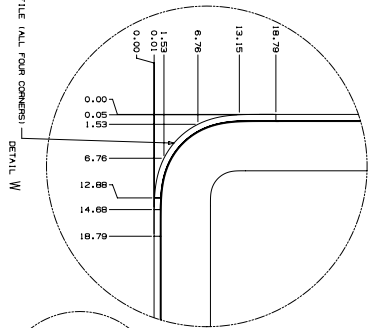


SECTION AND DETAIL INFORMATION

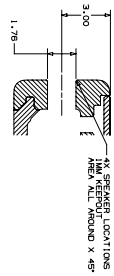
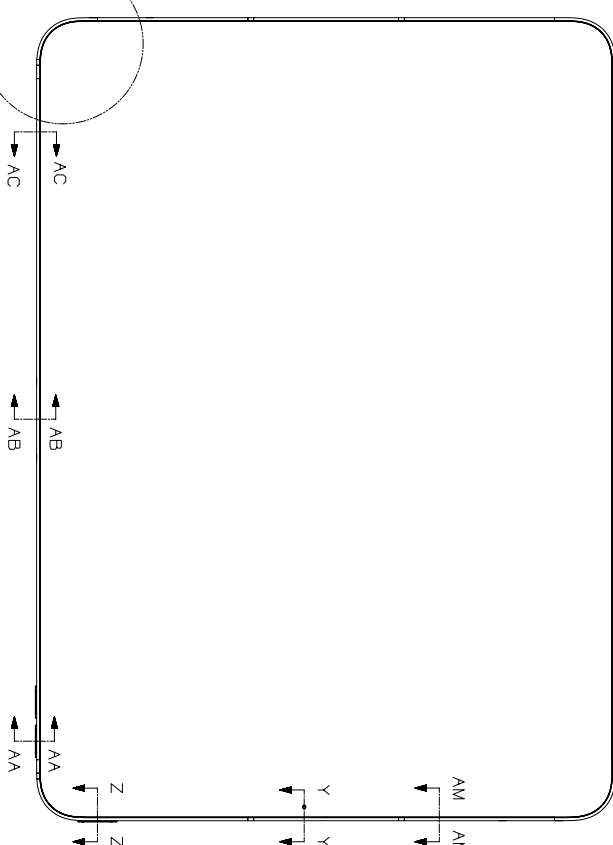
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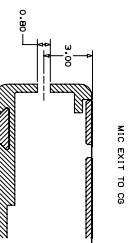
DETAIL AE



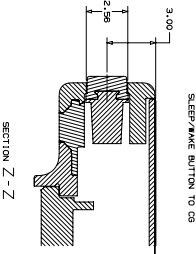
DETAIL W



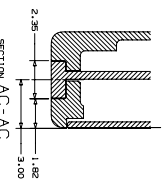
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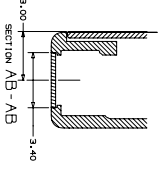
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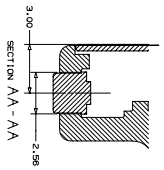
SECTION Z - Z



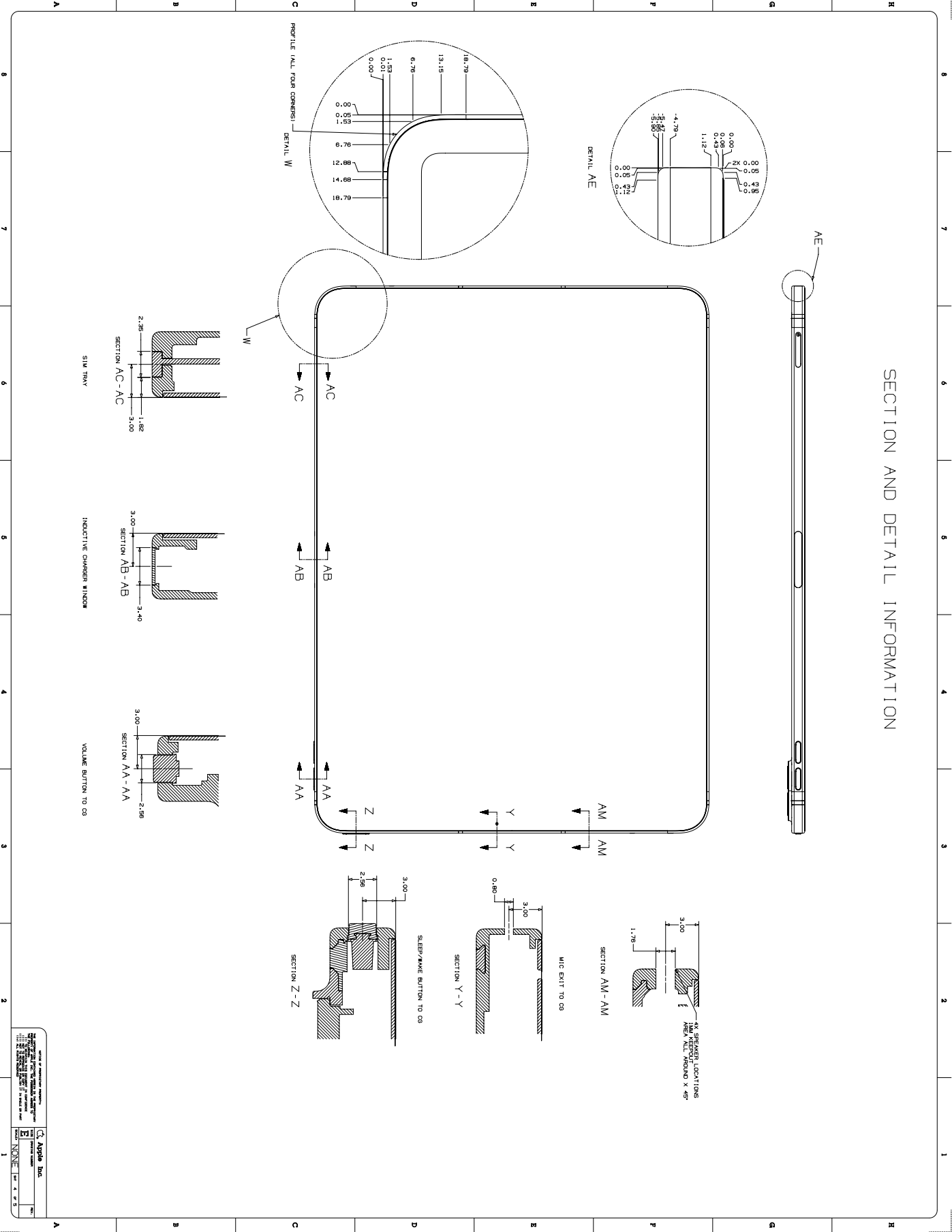
SIM TRAY



INDUCTIVE CHARGER WINDOW

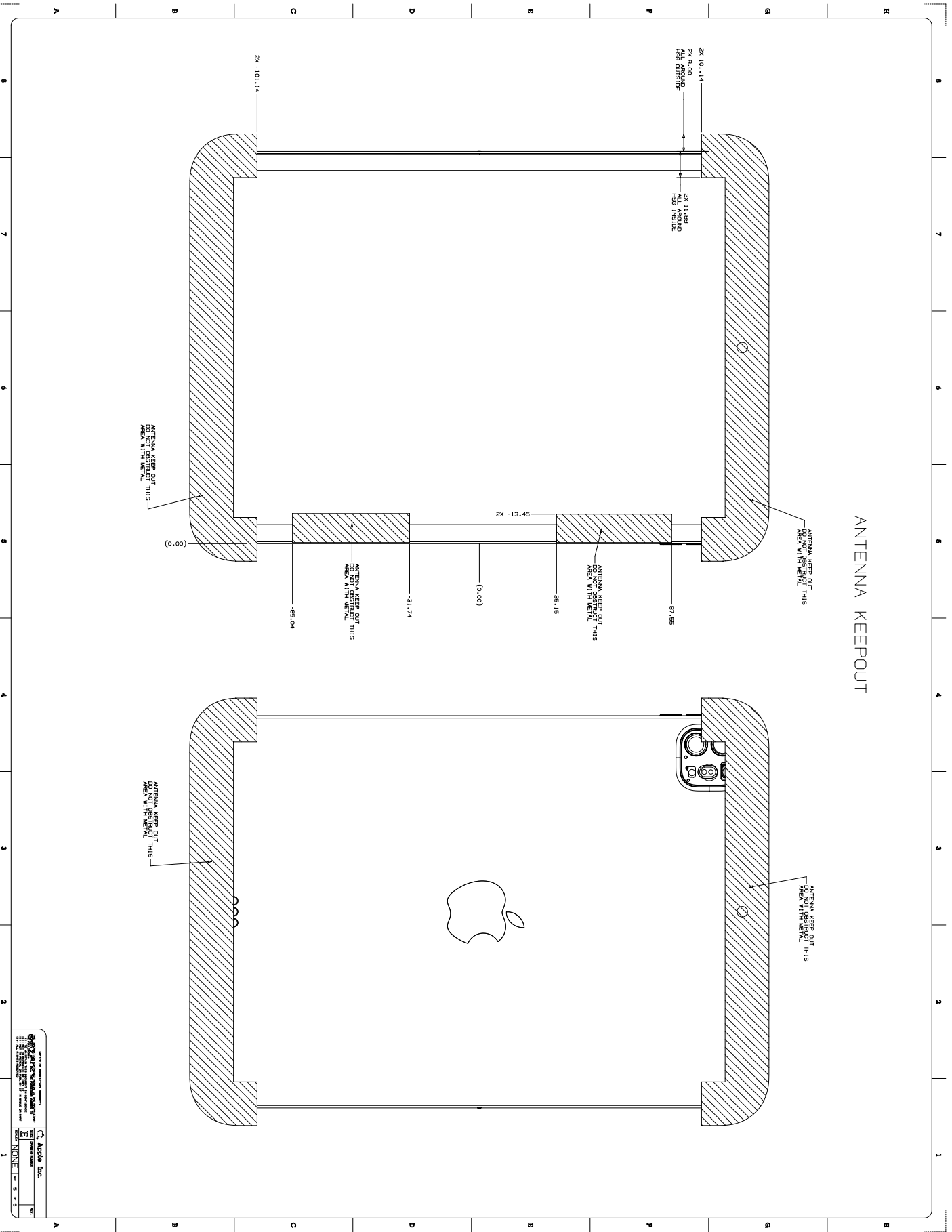


VOLUME BUTTON TO OS



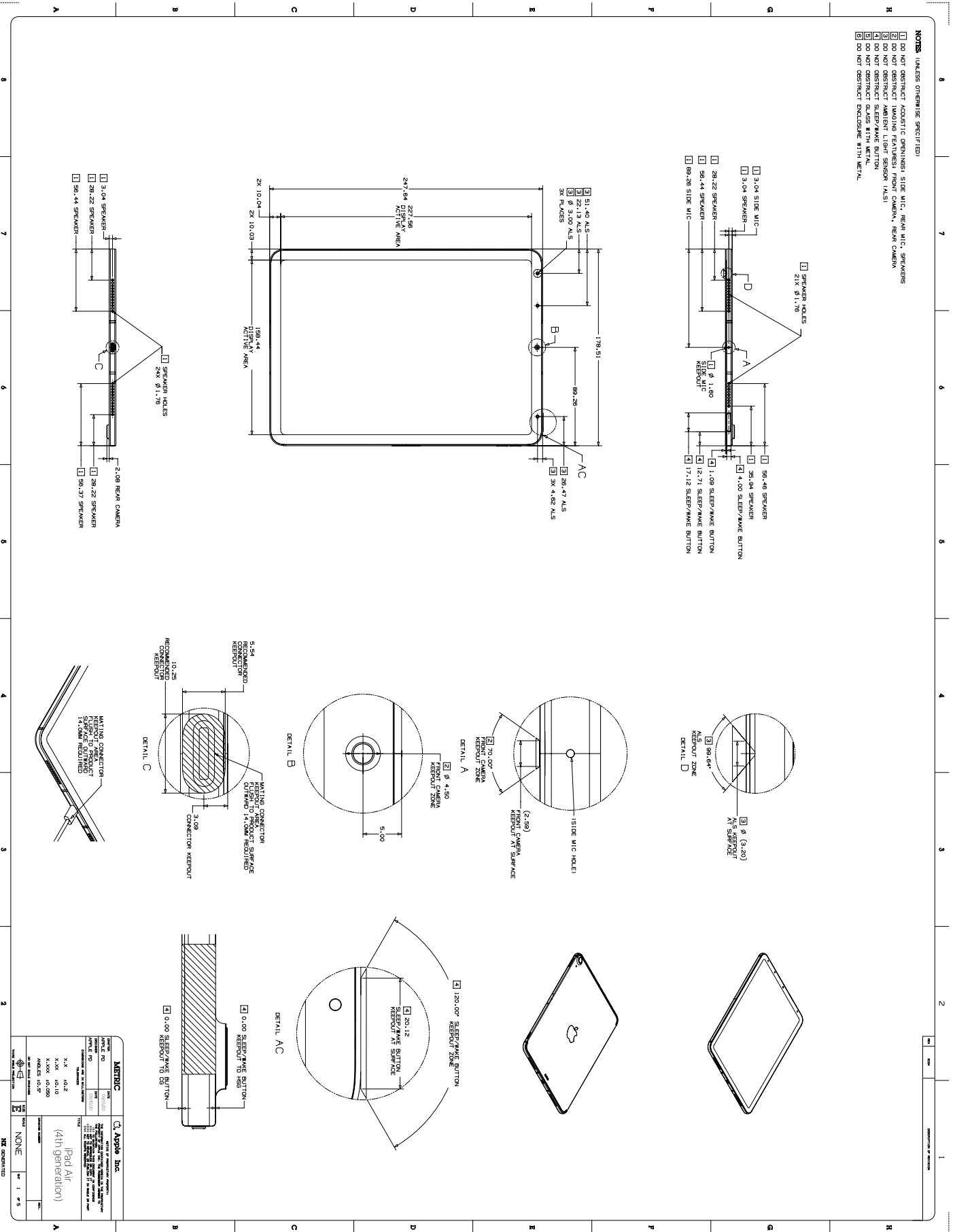
4.4.55 iPad Pro (11-inch) 3rd Generation 5 of 5

ANTENNA KEEPOUT



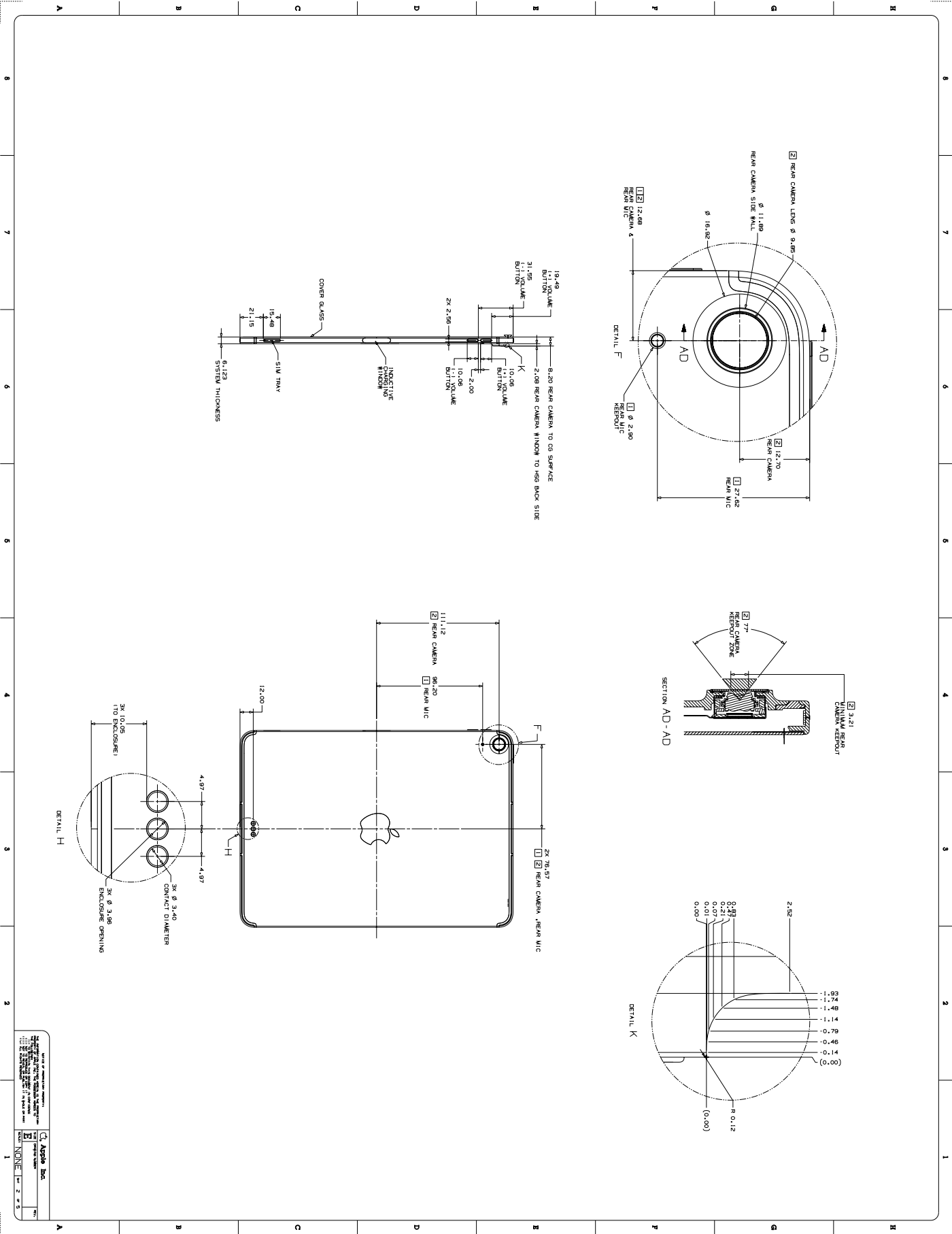
<small> Apple Inc. 1 Apple Park Way Cupertino, CA 95014 © 2021 Apple Inc. All rights reserved. </small>	
<small> Revision 1 Description ANTENNA KEEPOUT </small>	<small> Date 09/28/21 </small>
<small> Author [Name] </small>	<small> Checked [Name] </small>
<small> Approved [Name] </small>	<small> Date 09/28/21 </small>

44.56 iPad Air (4th generation) 1 of 5

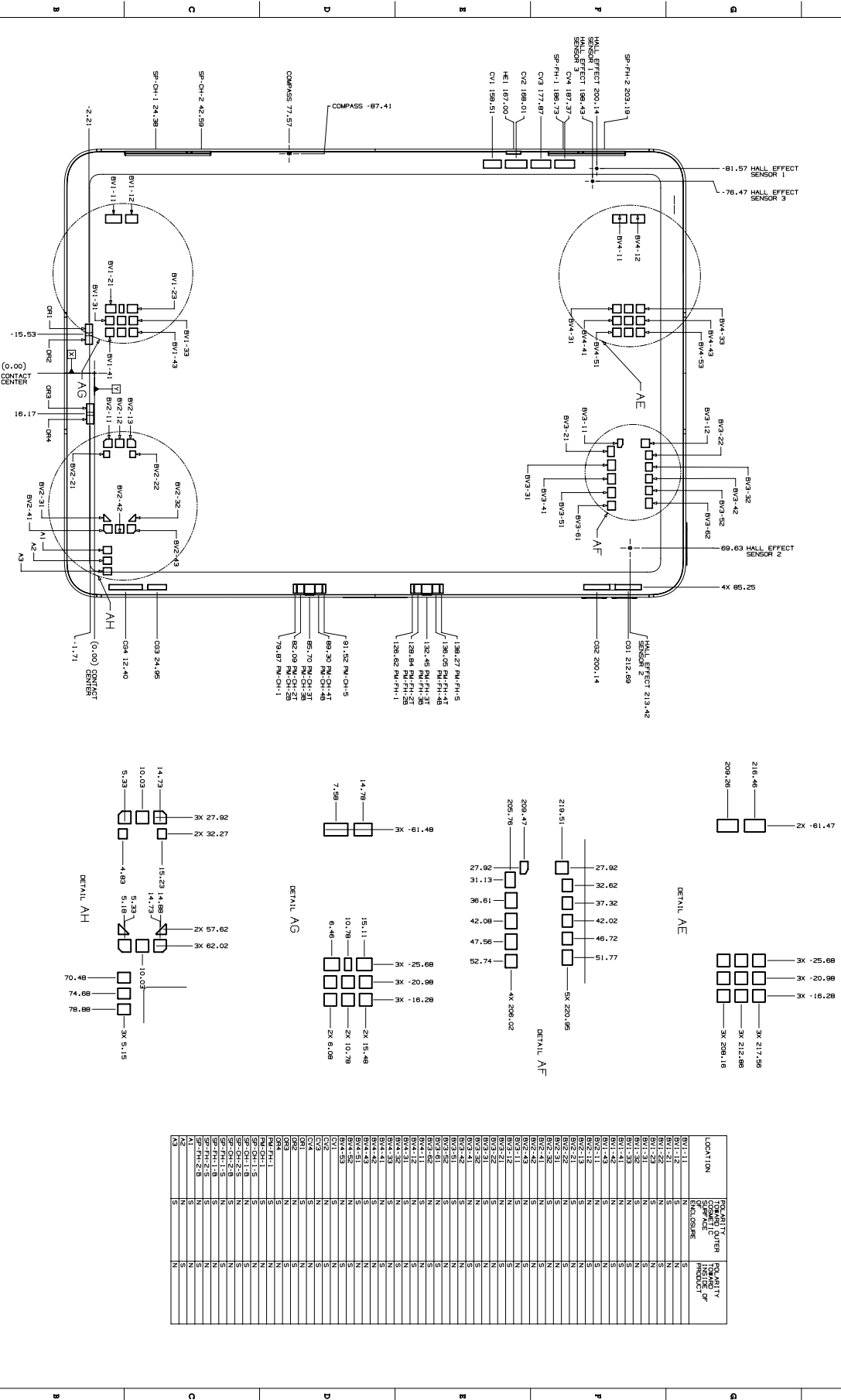


- NOTES: (UNLESS OTHERWISE SPECIFIED)**
- 1 ̢ DO NOT OBSTRUCT ACOUSTIC OPENINGS: SIDE MIC, NEAR MIC, SPEAKERS
 - 2 ̢ DO NOT OBSTRUCT IMAGING FEATURES: FRONT CAMERA, REAR CAMERA
 - 3 ̢ DO NOT OBSTRUCT IMAGING FEATURES: FRONT CAMERA, REAR CAMERA
 - 4 ̢ DO NOT OBSTRUCT SLEEP/WAKE BUTTON
 - 5 ̢ DO NOT OBSTRUCT GLASS WITH METAL
 - 6 ̢ DO NOT OBSTRUCT ENCLOSURE WITH METAL

METRIC		Apple Inc.	
DATE	15/10/2020	REVISION	
DRAWN		CHECKED	
PART NO.	110174471	DATE	15/10/2020
TITLE	IPAD AIR (4th generation)		
DESCRIPTION	IPAD AIR (4th generation)		
SCALE	1:1	DATE	15/10/2020
BY		DATE	15/10/2020
CHECKED		DATE	15/10/2020
APPROVED		DATE	15/10/2020
STATUS	NONE		
APPROVAL	NONE		

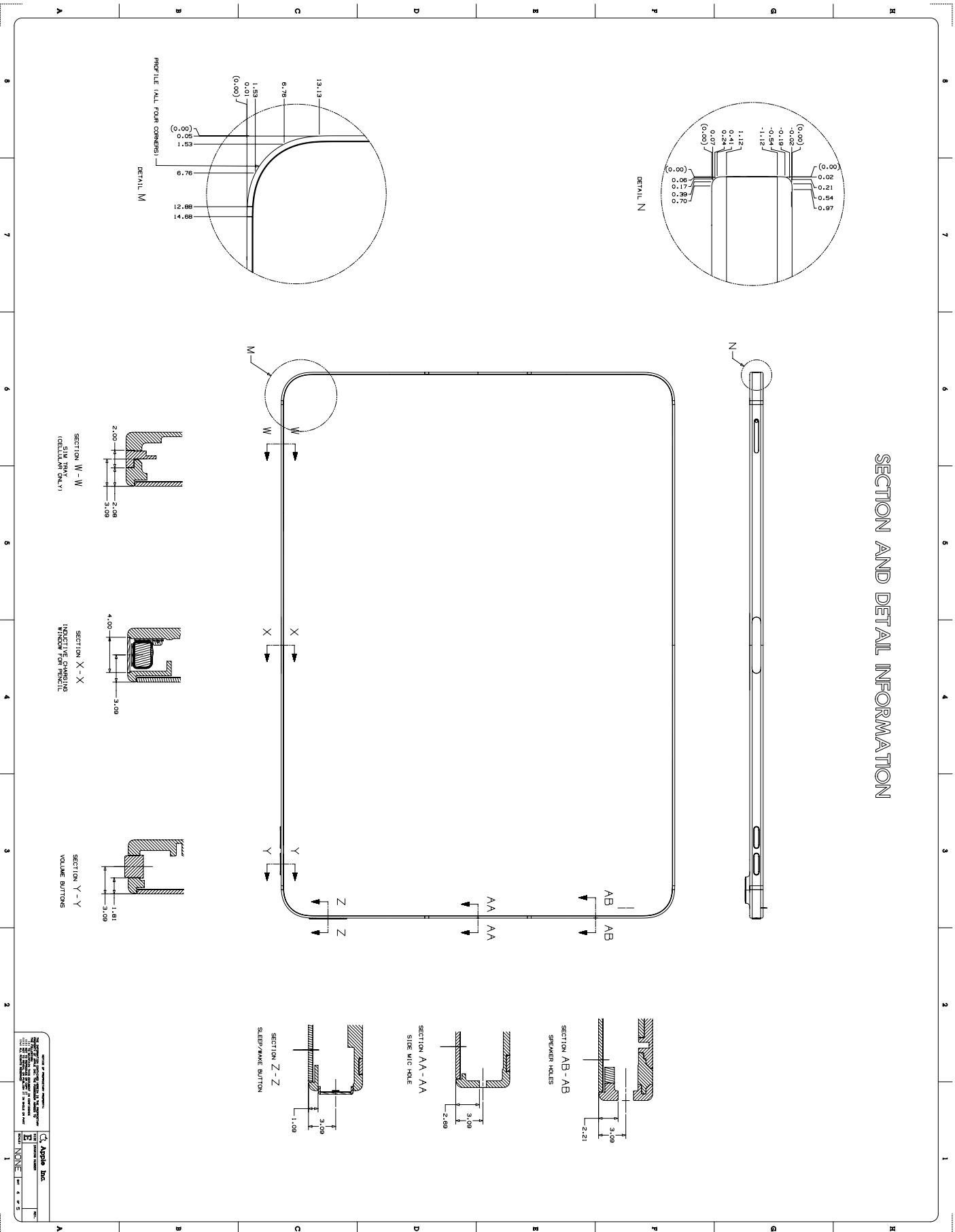


MAGNET DETAIL

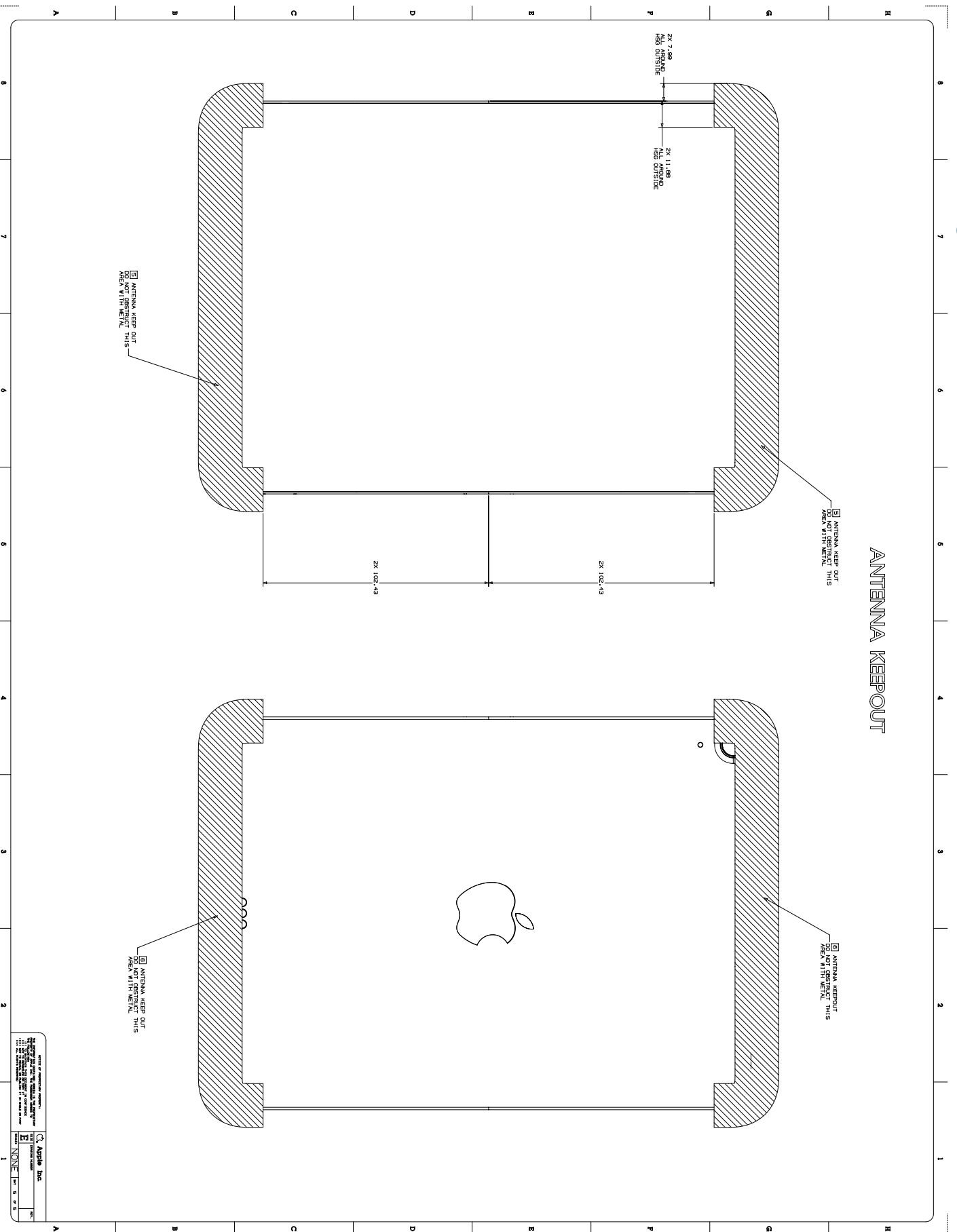


LOCATION	PART NUMBER	QUANTITY	REMARKS
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BV1-12	76.47 HALL EFFECT SENSOR 3	1	
BV1-13	69.63 HALL EFFECT SENSOR 2	1	
BV1-14	213.42 HALL EFFECT SENSOR 2	1	
BV1-15	213.89 HALL EFFECT SENSOR 2	1	
BV1-16	212.89 HALL EFFECT SENSOR 2	1	
BV1-17	77.57 COMPASS	1	
BV1-18	87.41 COMPASS	1	
BV1-19	124.98 SP-CH-1	1	
BV1-20	42.59 SP-CH-2	1	
BV1-21	24.95 SP-CH-3	1	
BV1-22	24.40 COG-12	1	
BV1-23	1.71 COG-13	1	
BV1-24	1.71 COG-14	1	
BV1-25	1.71 COG-15	1	
BV1-26	1.71 COG-16	1	
BV1-27	1.71 COG-17	1	
BV1-28	1.71 COG-18	1	
BV1-29	1.71 COG-19	1	
BV1-30	1.71 COG-20	1	
BV1-31	1.71 COG-21	1	
BV1-32	1.71 COG-22	1	
BV1-33	1.71 COG-23	1	
BV1-34	1.71 COG-24	1	
BV1-35	1.71 COG-25	1	
BV1-36	1.71 COG-26	1	
BV1-37	1.71 COG-27	1	
BV1-38	1.71 COG-28	1	
BV1-39	1.71 COG-29	1	
BV1-40	1.71 COG-30	1	
BV1-41	1.71 COG-31	1	
BV1-42	1.71 COG-32	1	
BV1-43	1.71 COG-33	1	
BV1-44	1.71 COG-34	1	
BV1-45	1.71 COG-35	1	
BV1-46	1.71 COG-36	1	
BV1-47	1.71 COG-37	1	
BV1-48	1.71 COG-38	1	
BV1-49	1.71 COG-39	1	
BV1-50	1.71 COG-40	1	
BV1-51	1.71 COG-41	1	
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BV1-71	1.71 COG-61	1	
BV1-72	1.71 COG-62	1	
BV1-73	1.71 COG-63	1	
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BV1-75	1.71 COG-65	1	
BV1-76	1.71 COG-66	1	
BV1-77	1.71 COG-67	1	
BV1-78	1.71 COG-68	1	
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BV1-84	1.71 COG-74	1	
BV1-85	1.71 COG-75	1	
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BV1-89	1.71 COG-79	1	
BV1-90	1.71 COG-80	1	
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BV1-97	1.71 COG-87	1	
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BV1-100	1.71 COG-90	1	

SECTION AND DETAIL INFORMATION



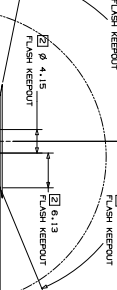
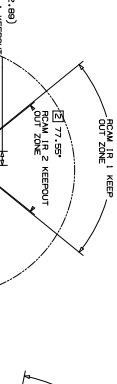
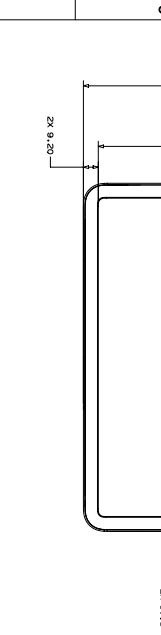
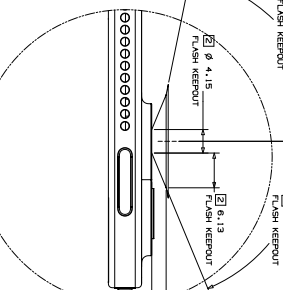
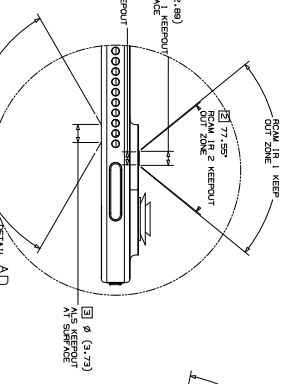
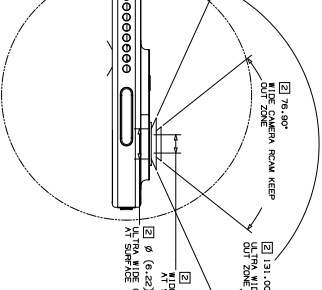
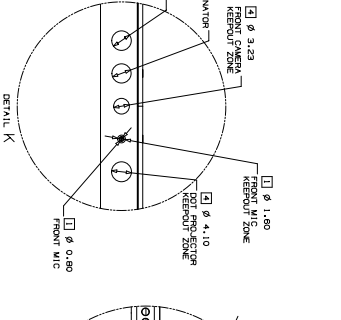
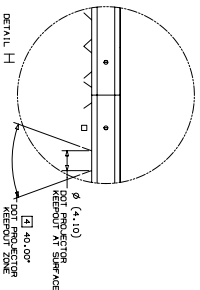
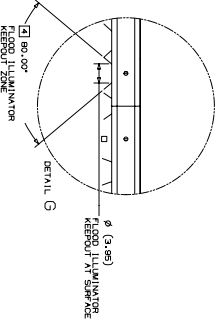
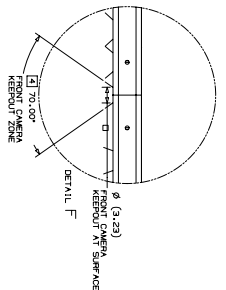
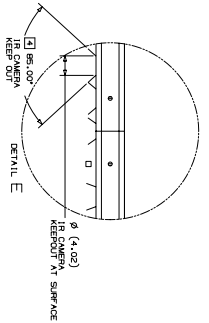
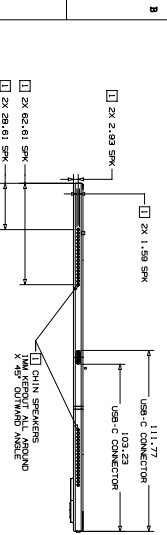
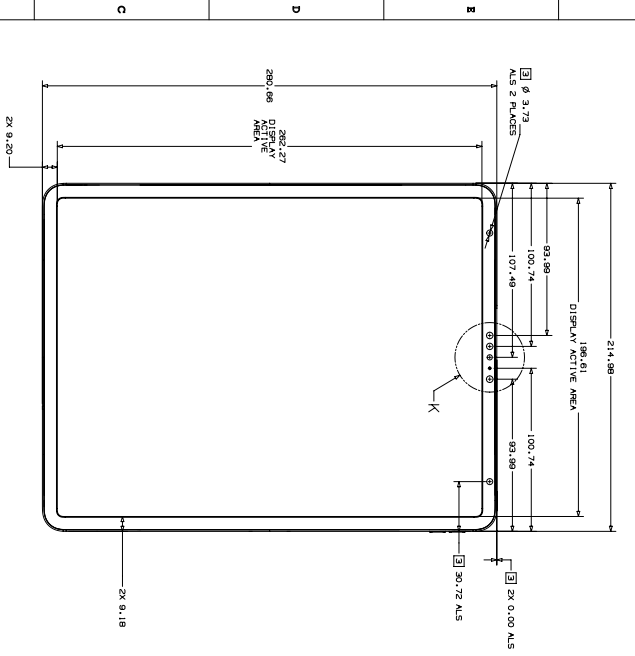
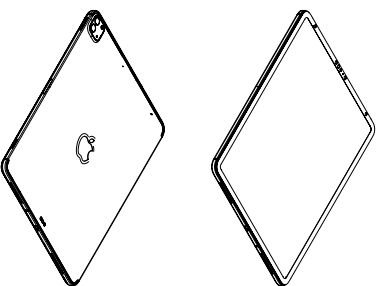
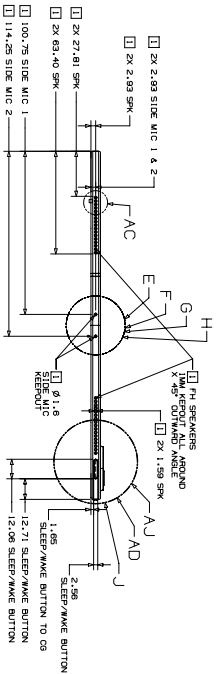
44.60 iPad Air (4th generation) 5 of 5



<small> MODEL: A2402 PART: 44.60 DATE: 2021-09-28 DRAWN BY: [REDACTED] CHECKED BY: [REDACTED] </small>		Apple Inc. Copyright © 2021 Apple Inc. All Rights Reserved.
NONE	NONE	NONE

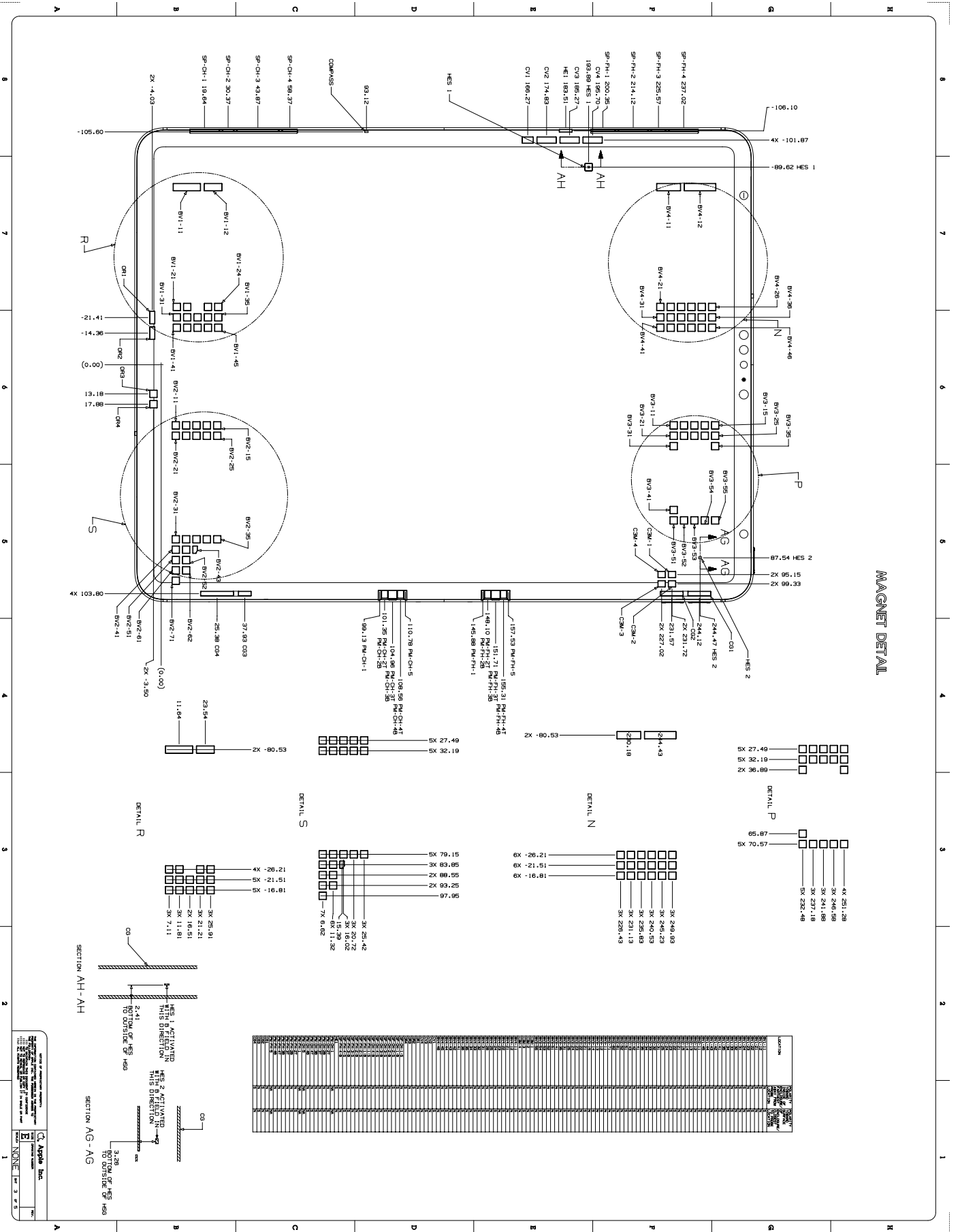
44.61 iPad Pro (12.9-inch) 4th Generation 1 of 5

- NOTES:** DIMENSIONS UNLESS OTHERWISE SPECIFIED
- DO NOT OBSTRUCT ACOUSTIC PENETRATIONS, SIDE MIC, FRONT MIC, REAR MIC, SPEAKERS
 - DO NOT OBSTRUCT REAR CAMERA, REAR FLASH, & REAR IR CAMERA
 - DO NOT OBSTRUCT REAR LIGHT SENSOR, BAR CODE SCANNER, FRONT CAMERA & DOT PROJECTOR
 - DO NOT OBSTRUCT FRONT LIGHT SENSOR
 - DO NOT HAVE METAL CONTACT WITH DEVICE COVER GLASS

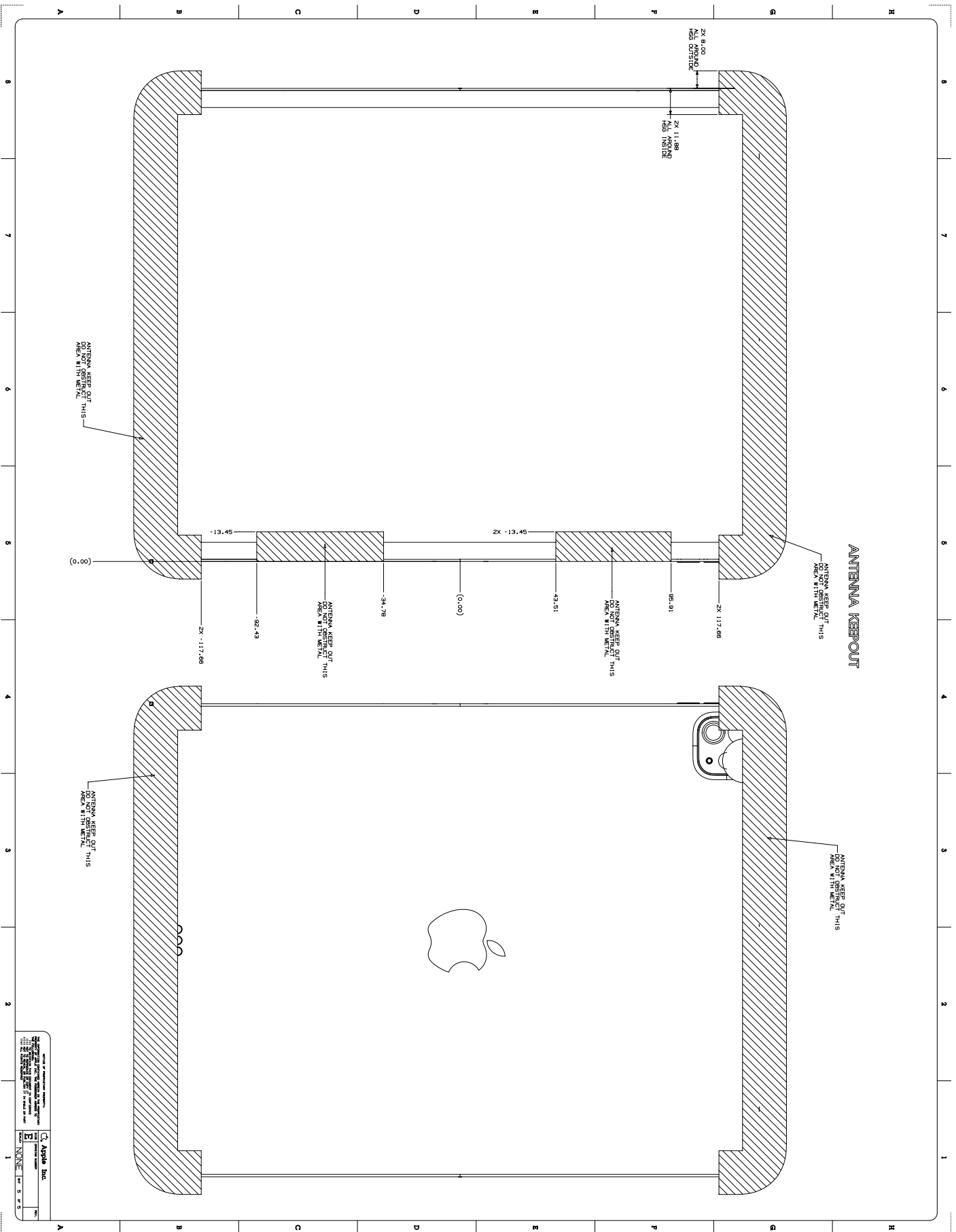


METRIC		Apple Inc.	
DATE	11/20/20	VERSION	1
DESCRIPTION	4th generation		
PART NAME	iPad Pro (12.9 - inch)		
PART NUMBER	A1701		
REV	1	DATE	11/20/20
BY	NONE		
CHECKED	NONE		
APPROVED	NONE		

MAGNET DETAIL



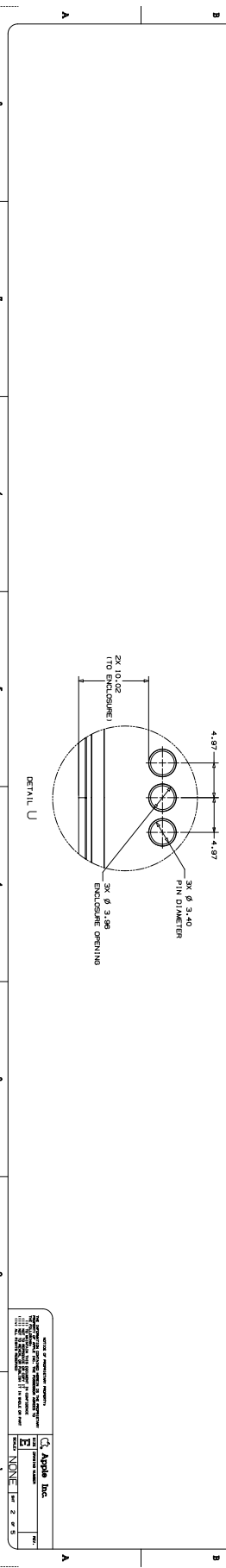
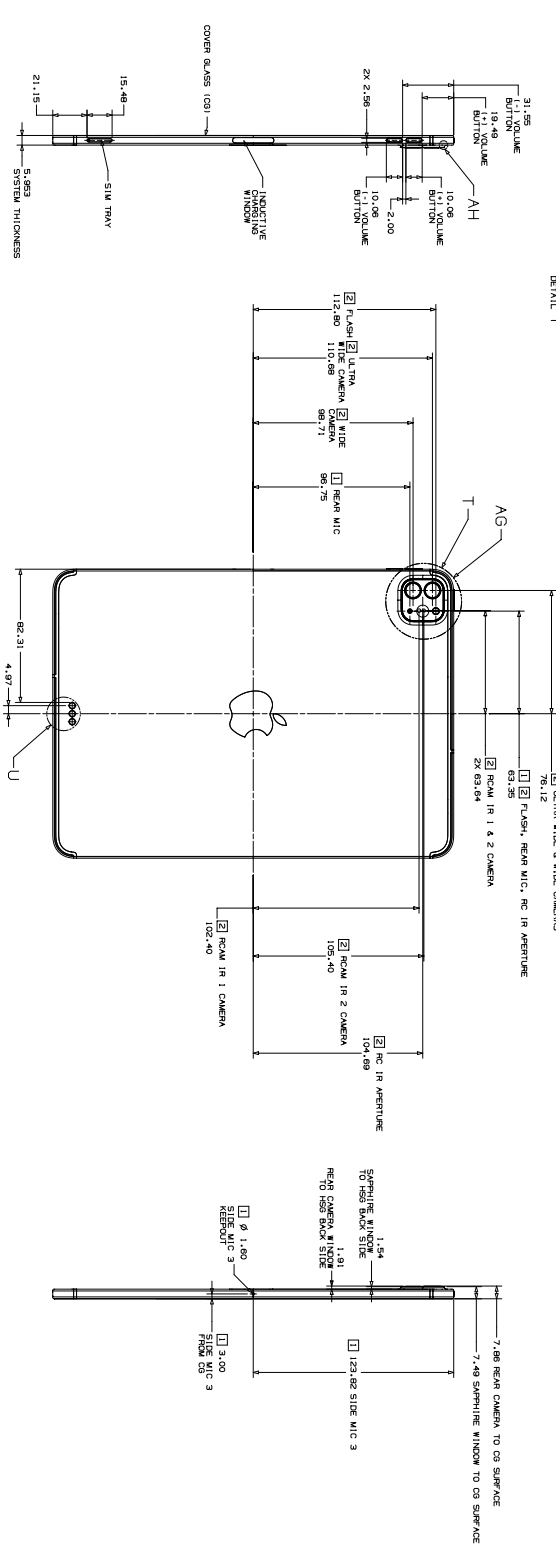
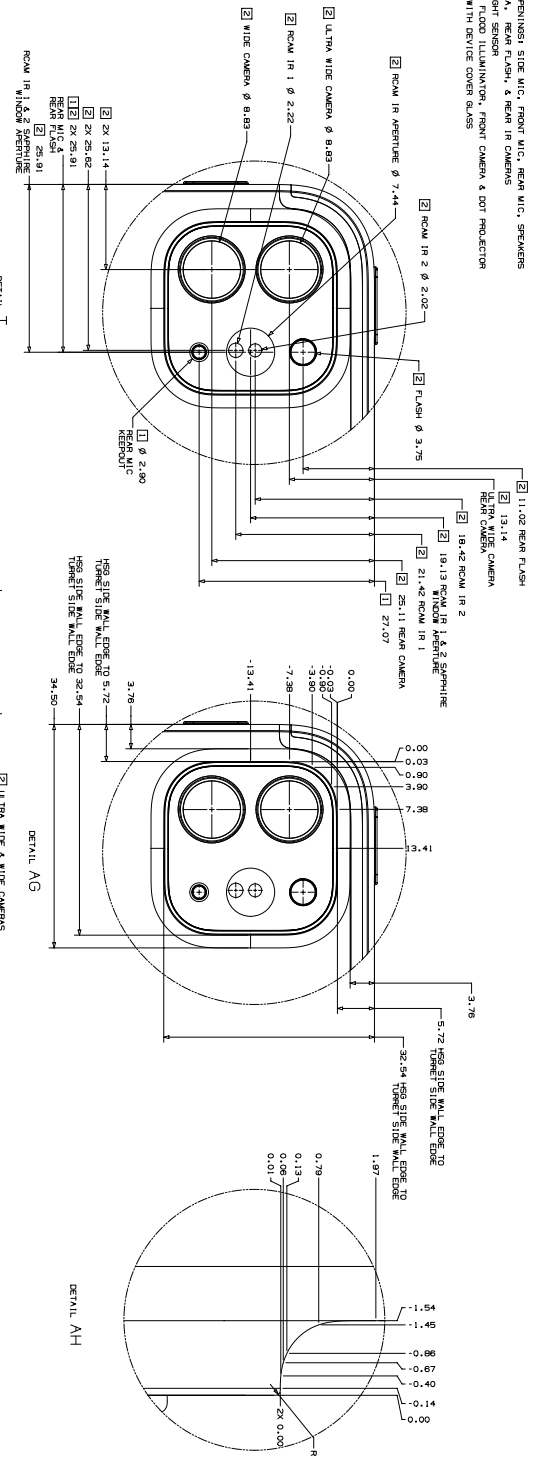
44.65 iPad Pro (12.9-inch) 4th Generation 5 of 5



Apple Inc.	
Model	None
Part	None
Rev	1
Date	2021-09-28
Author	Apple Inc.
Checked	Apple Inc.
Approved	Apple Inc.

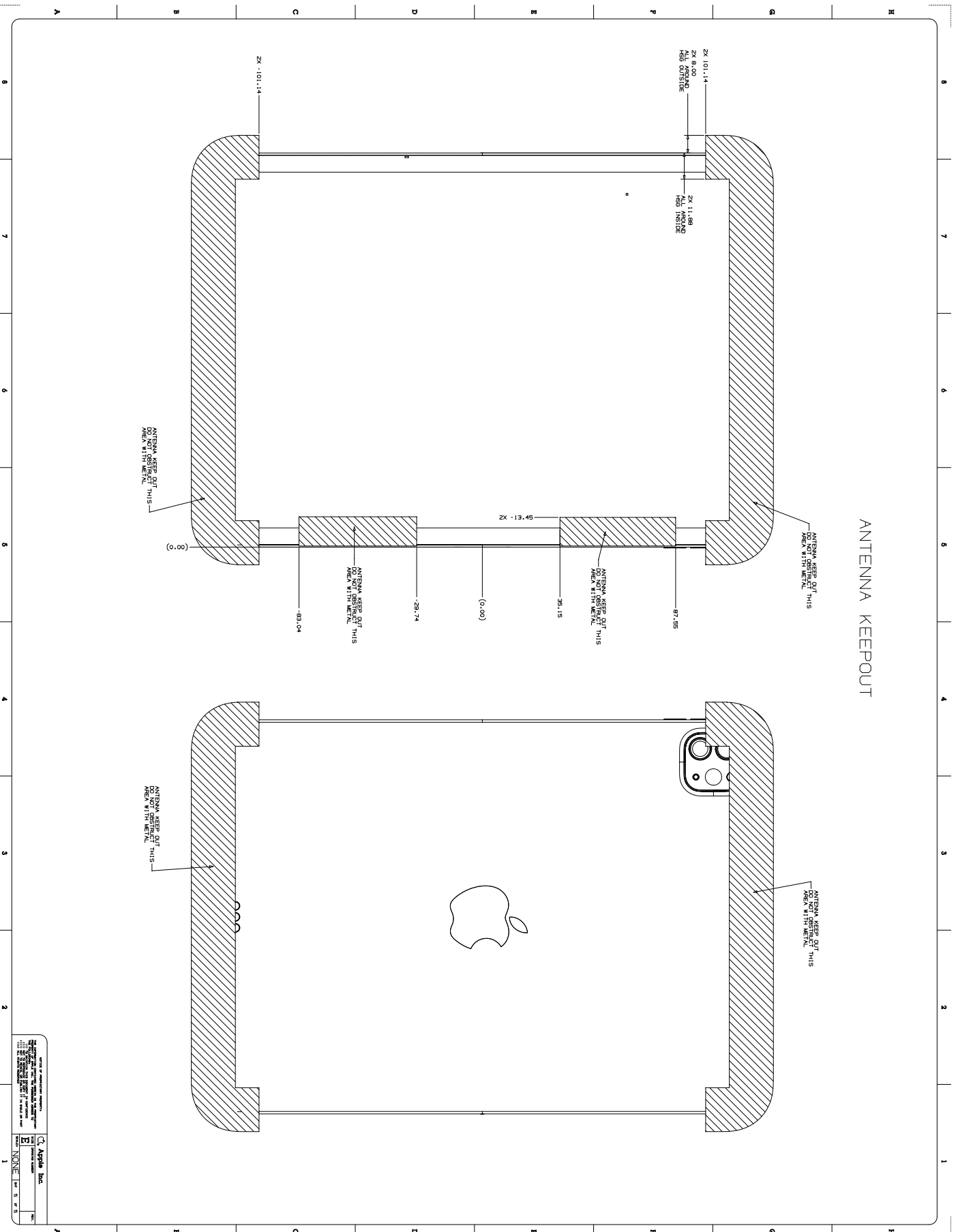
4.4.67 iPad Pro (11-inch) 2nd Generation 2 of 5

- ❑ DO NOT OBSTRUCT ACOUSTIC OPENINGS, SIDE MIC, FRONT MIC, REAR MIC, SPEAKERS
- ❑ DO NOT OBSTRUCT REAR CAMERA, REAR FLASH, & REAR IR CAMERAS
- ❑ DO NOT OBSTRUCT IR CAMERA, FLASH ILLUMINATOR, FRONT CAMERA & DOT PROJECTOR
- ❑ DO NOT HAVE METAL CONTACT WITH DEVICE COVER GLASS



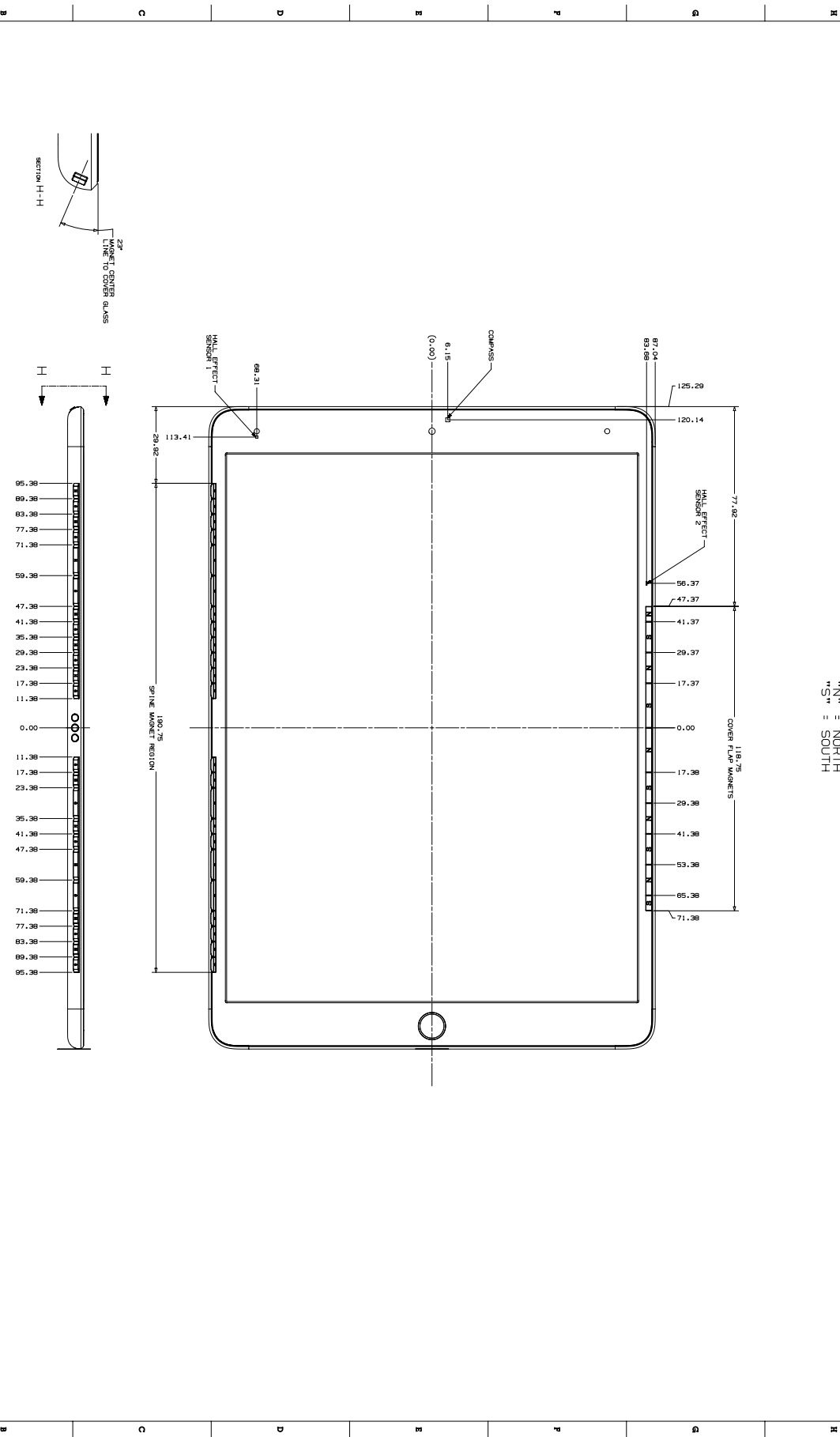
44.70 iPad Pro (11-inch) 2nd Generation 5 of 5

ANTENNA KEEPOUT



44.72 iPad Air (3rd generation) with Wi-Fi 2 of 3

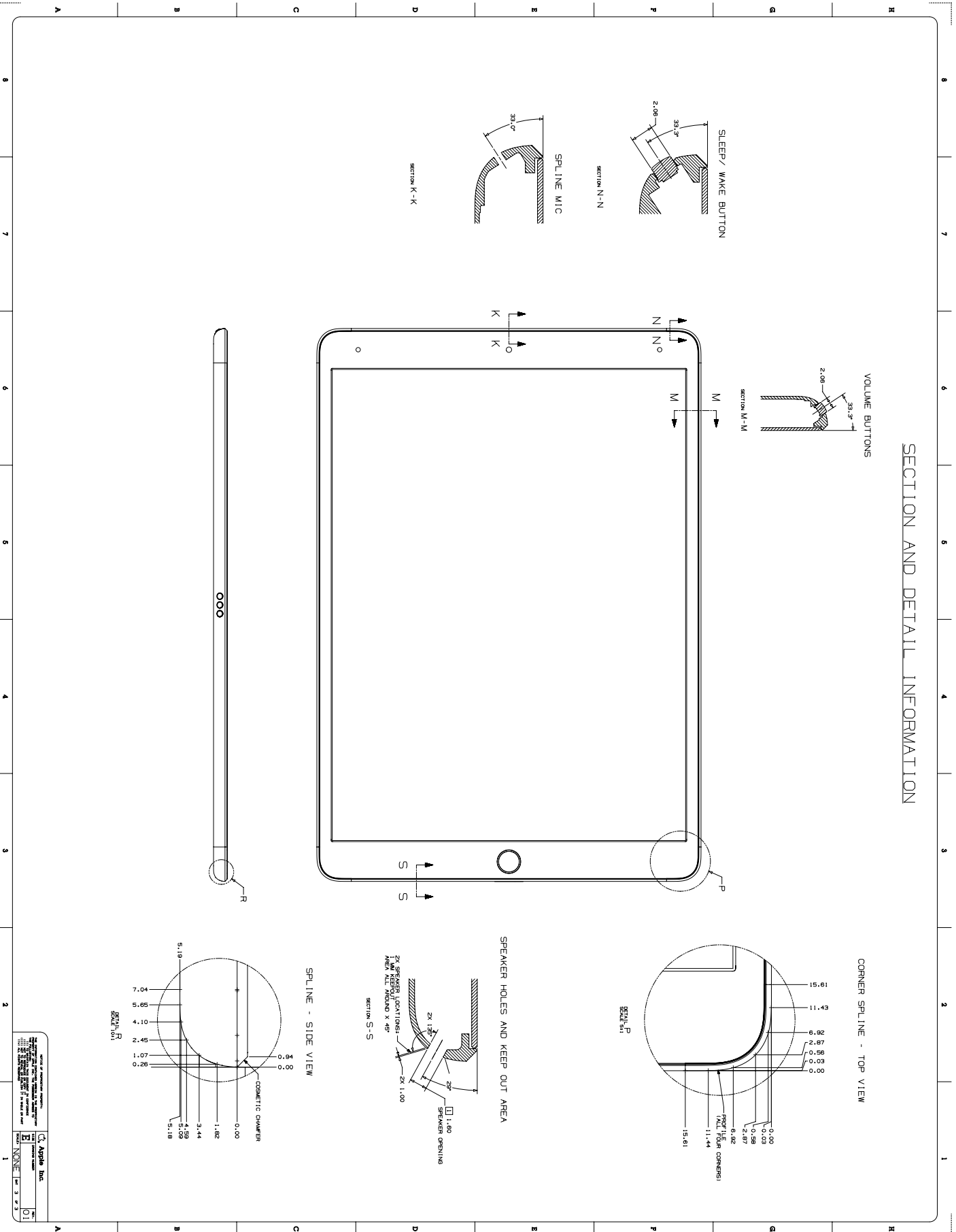
COVER FLAP MAGNET DETAIL
 POLARITY SHOWN NORMAL TO GLASS
 DIMENSIONS TO CENTER OF PRODUCT
 N = NORTH
 S = SOUTH



DATE OF REVISION	DESCRIPTION
01	INITIAL RELEASE
02	REVISION
03	REVISION
04	REVISION
05	REVISION
06	REVISION
07	REVISION
08	REVISION
09	REVISION
10	REVISION
11	REVISION
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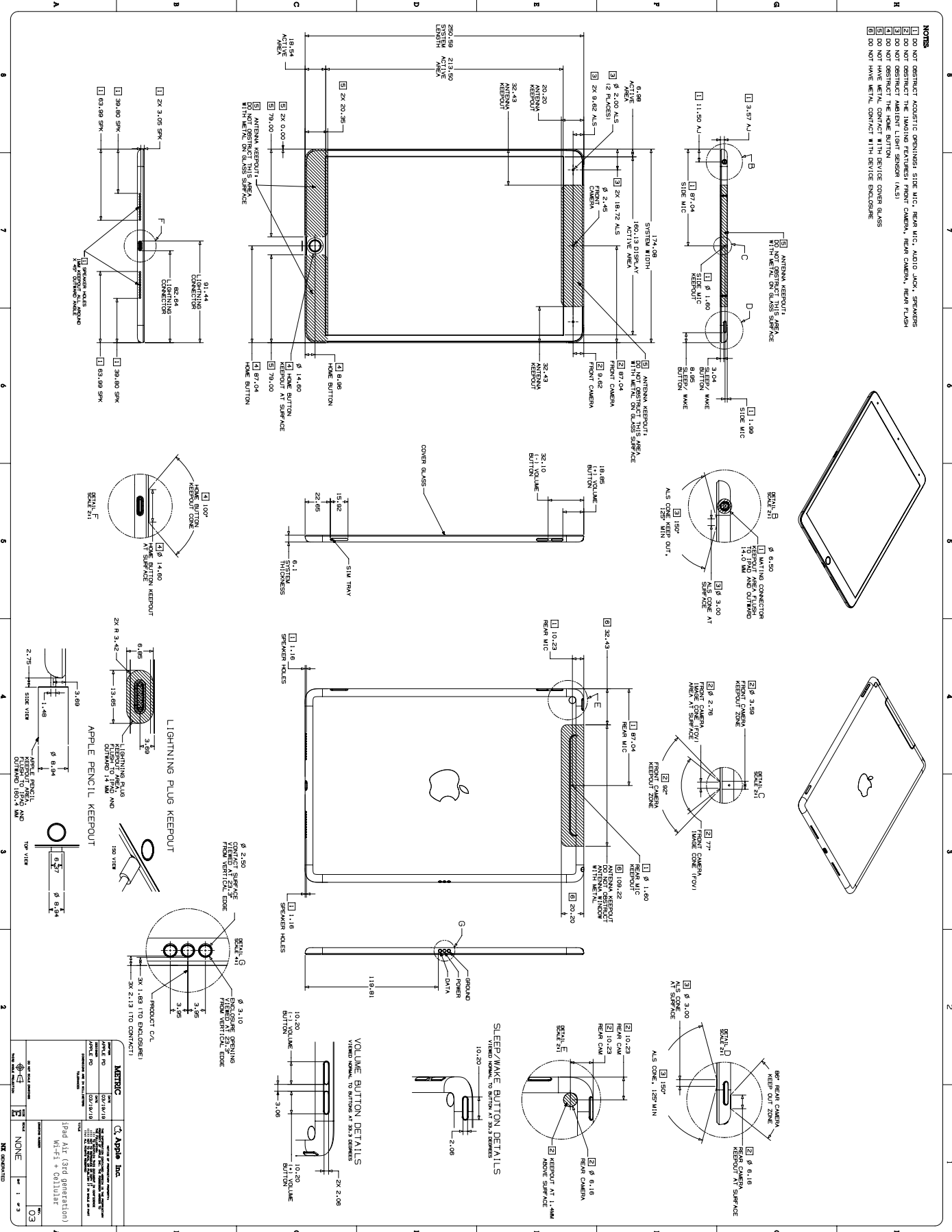
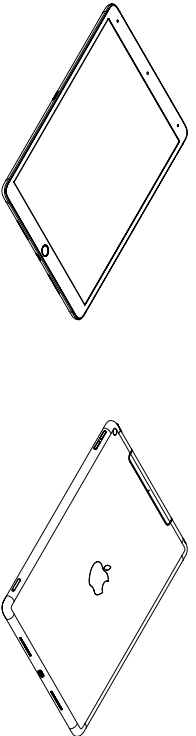
44.73 iPad Air (3rd generation) with Wi-Fi 3 of 3

SECTION AND DETAIL INFORMATION

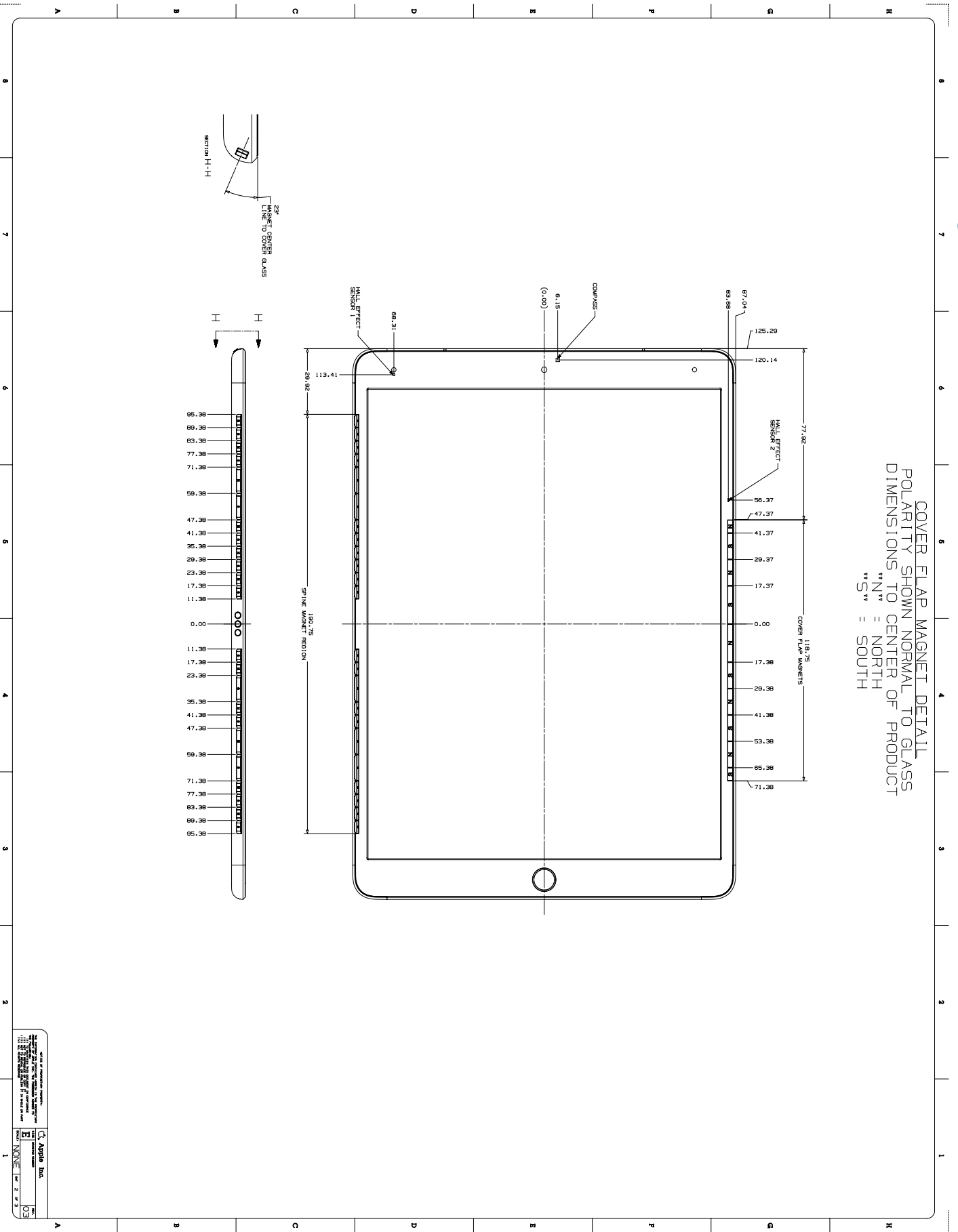


4.4.74 iPad Air (3rd generation) with Wi-Fi + Cellular 1 of 3

- NOTE:**
- 1 DO NOT OBSTRUCT ACOUSTIC GRILLINGS, SIDE MIC, REAR MIC, AUDIO JACK, SPEAKERS
 - 2 DO NOT OBSTRUCT THE IMAGING FEATURES: FRONT CAMERA, REAR CAMERA, REAR FLASH
 - 3 DO NOT OBSTRUCT THE AMBIENT LIGHT SENSOR (ALS)
 - 4 DO NOT OBSTRUCT THE HOME BUTTON
 - 5 DO NOT HAVE METAL CONTACT WITH DEVICE COVER GLASS
 - 6 DO NOT HAVE METAL CONTACT WITH DEVICE ENCLOSURE



4.4.75 iPad Air (3rd generation) with Wi-Fi + Cellular 2 of 3

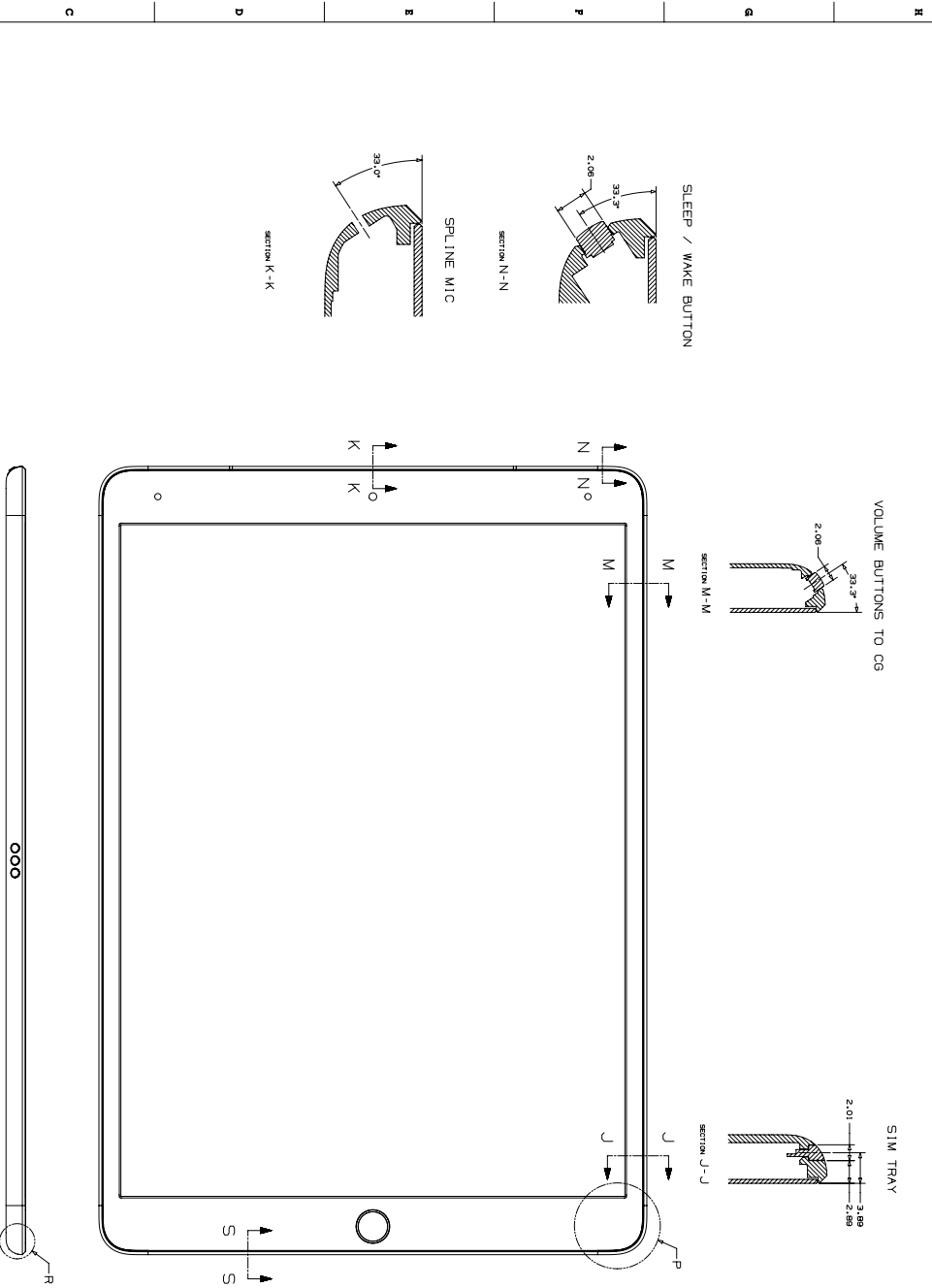


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 100 Apple Park Blvd
 Cupertino, CA 95014
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 Wi-Fi is a trademark of Apple Inc., registered in the U.S. and other countries.
 All other marks contained herein are the property of their respective owners.

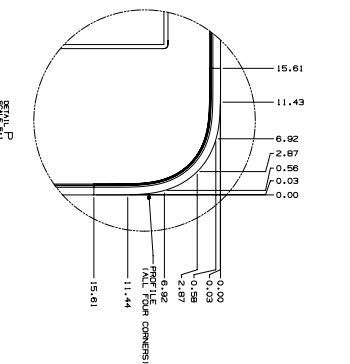
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4.4.76 iPad Air (3rd generation) with Wi-Fi + Cellular 3 of 3

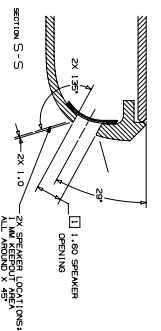
SECTION AND DETAIL INFORMATION



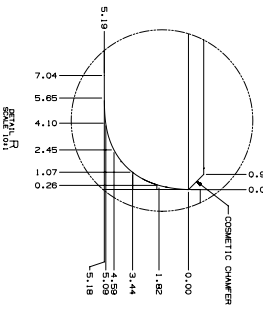
SPLINE DETAIL - TOP VIEW



SPEAKER HOLES AND KEEPOUTS



SPLINE DETAIL - SIDE VIEW



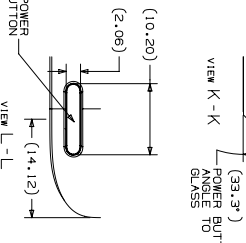
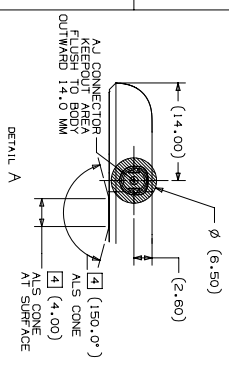
DATE: 08/14/13	DESIGNED BY: JOHN C. MULLINS	DRAWN BY: JOHN C. MULLINS	CHECKED BY: JOHN C. MULLINS
PART: iPad Air (3rd generation) SIM TRAY			
ASSEMBLY: iPad Air (3rd generation)			
PROJECT: iPad Air (3rd generation)			
DRAWING NO: 4.4.76			
REV: 03			
DATE: 08/14/13			
SCALE: 1:1			

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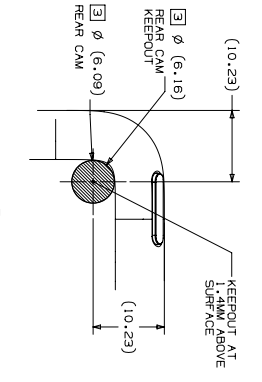
NOTES (UNLESS OTHERWISE SPECIFIED)

- 1 ANTENNA KEEPCUT NO METAL CONTACT
- 2 DO NOT OBSTRUCT THE ACOUSTIC OPENINGS: SIDE MIC, REAR MIC, SPEAKERS.
- 3 DO NOT OBSTRUCT THE IMAGING FEATURES: FRONT CAMERA, REAR CAMERA.
- 4 DO NOT OBSTRUCT THE ALS (AMBIENT LIGHT SENSOR).
- 5 DO NOT OBSTRUCT THE HOME BUTTON.
- 6 DO NOT TOUCH GLASS.

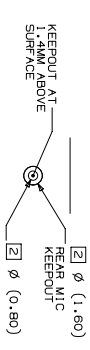
AUDIO JACK (A₁) & ALS



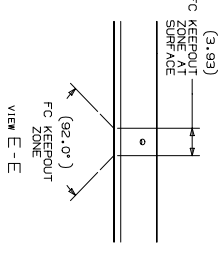
REAR CAMERA (RC)



REAR MIC (RM)



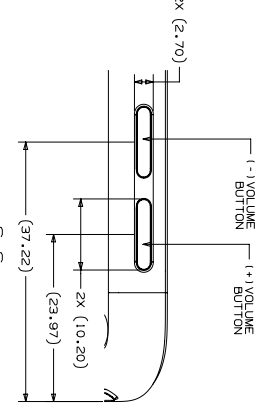
FRONT CAMERA (FC)



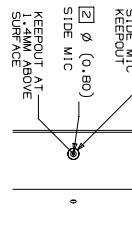
VOLUME BUTTONS



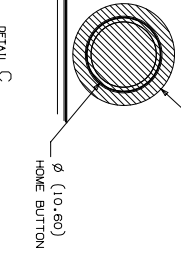
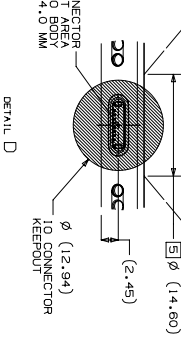
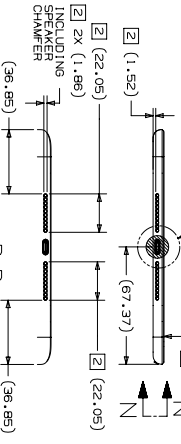
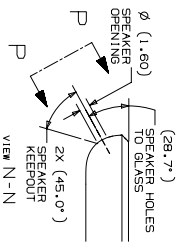
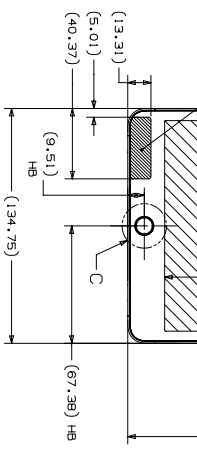
VOLUME BUTTONS



SIDE MIC (SM)



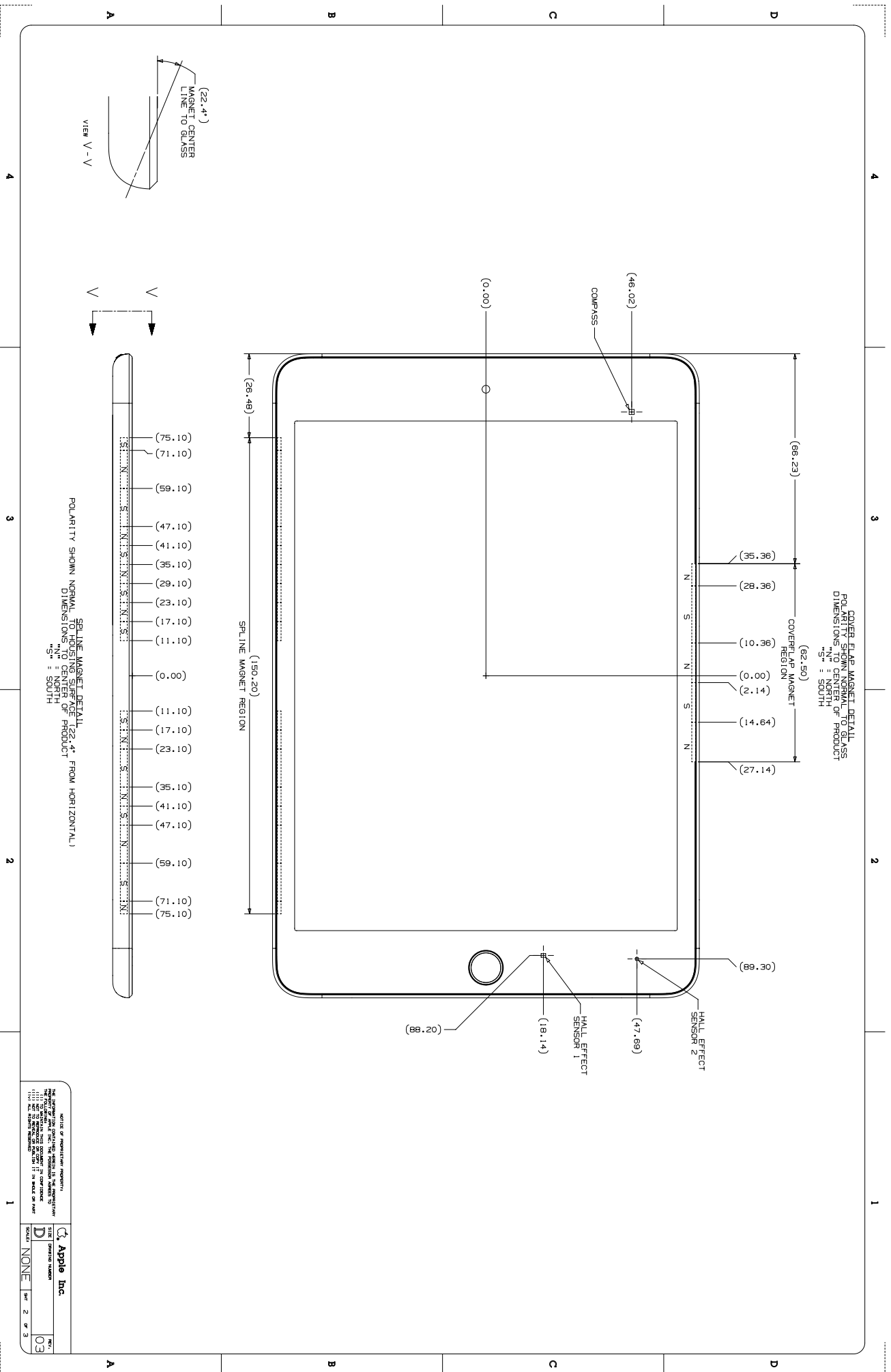
ANTENNA KEEPCUT



METRIC			Apple Inc.	
SYMBOL	UNIT	VALUE	DATE	DESCRIPTION
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APPL.E PD	MIL	87/18/19		REVISIONS
THIS DRAWING IS THE PROPERTY OF APPLE INC. IT IS TO BE USED ONLY FOR THE PURPOSES INTENDED AND NOT BE REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS WITHOUT THE WRITTEN PERMISSION OF APPLE INC.				
TITLE: iPad mini (5th generation) Wi-Fi				
REV	DATE	DESCRIPTION	BY	CHK
03				

NX GENERATED

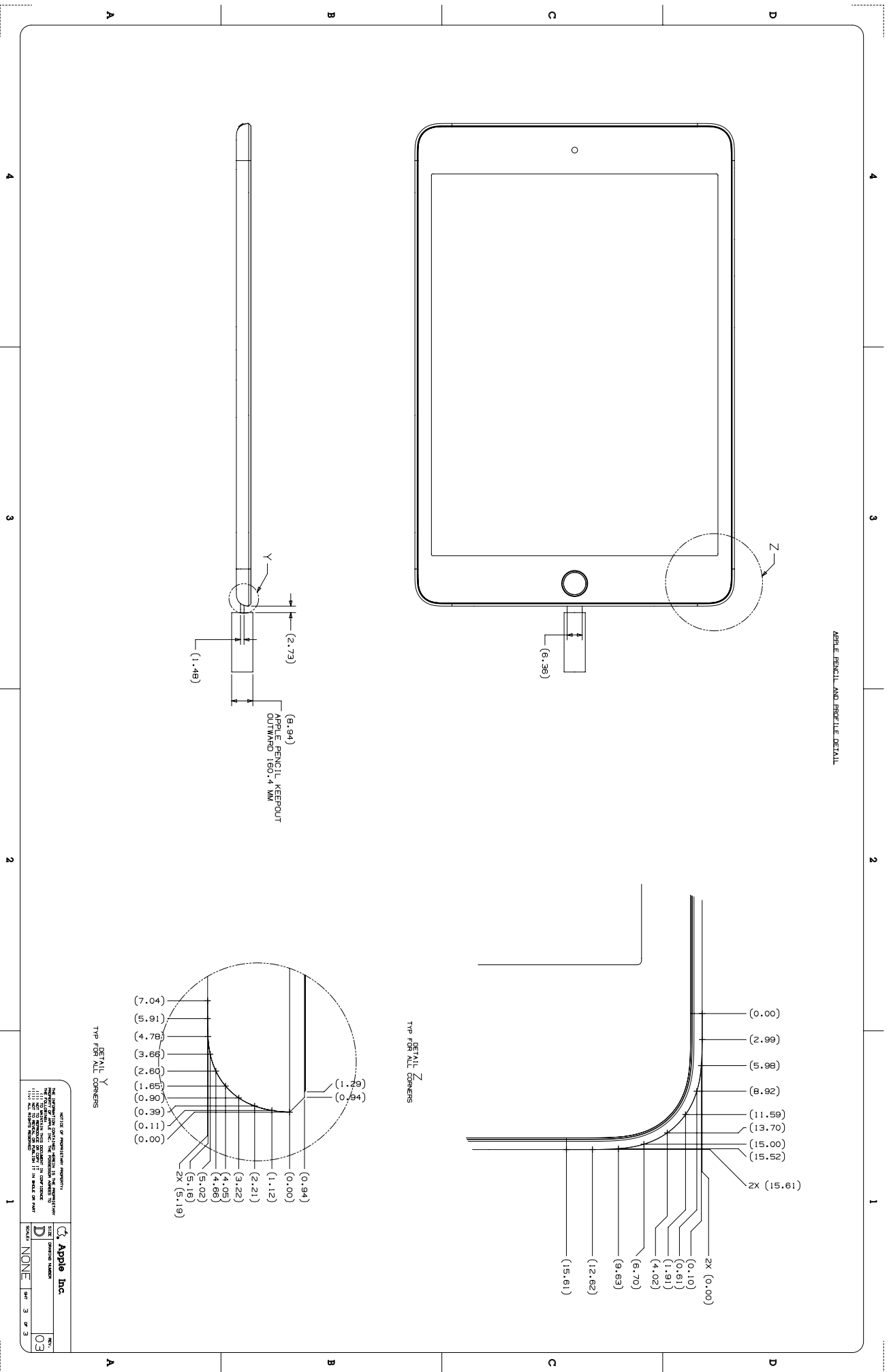
44.78 iPad mini (5th generation) with Wi-Fi 2 of 3



Apple Inc.
Apple logo
D NONE 2 of 3

44.79 iPad mini (5th generation) with Wi-Fi 3 of 3

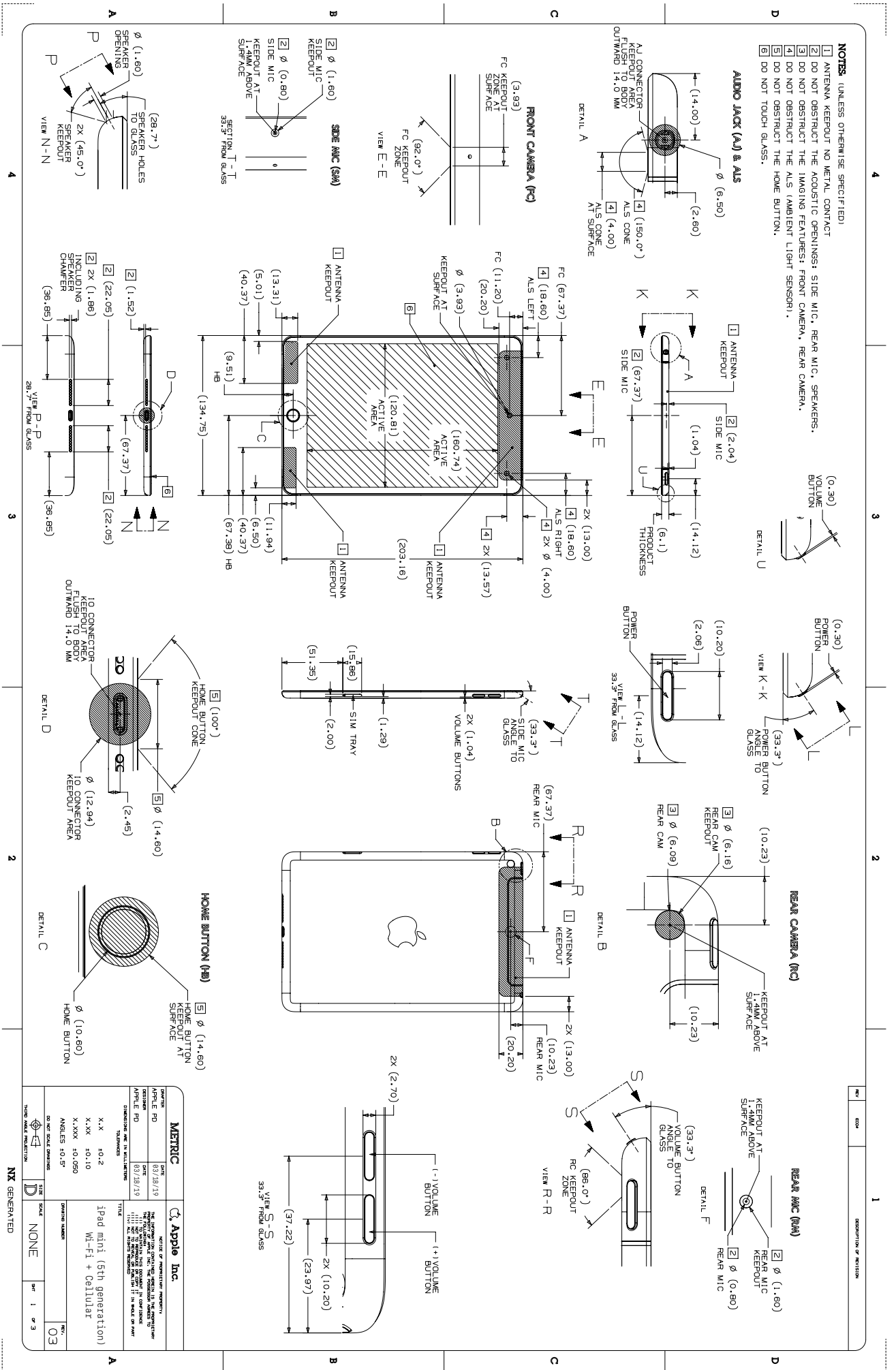
APPLE PENCIL AND PROFILE DETAIL



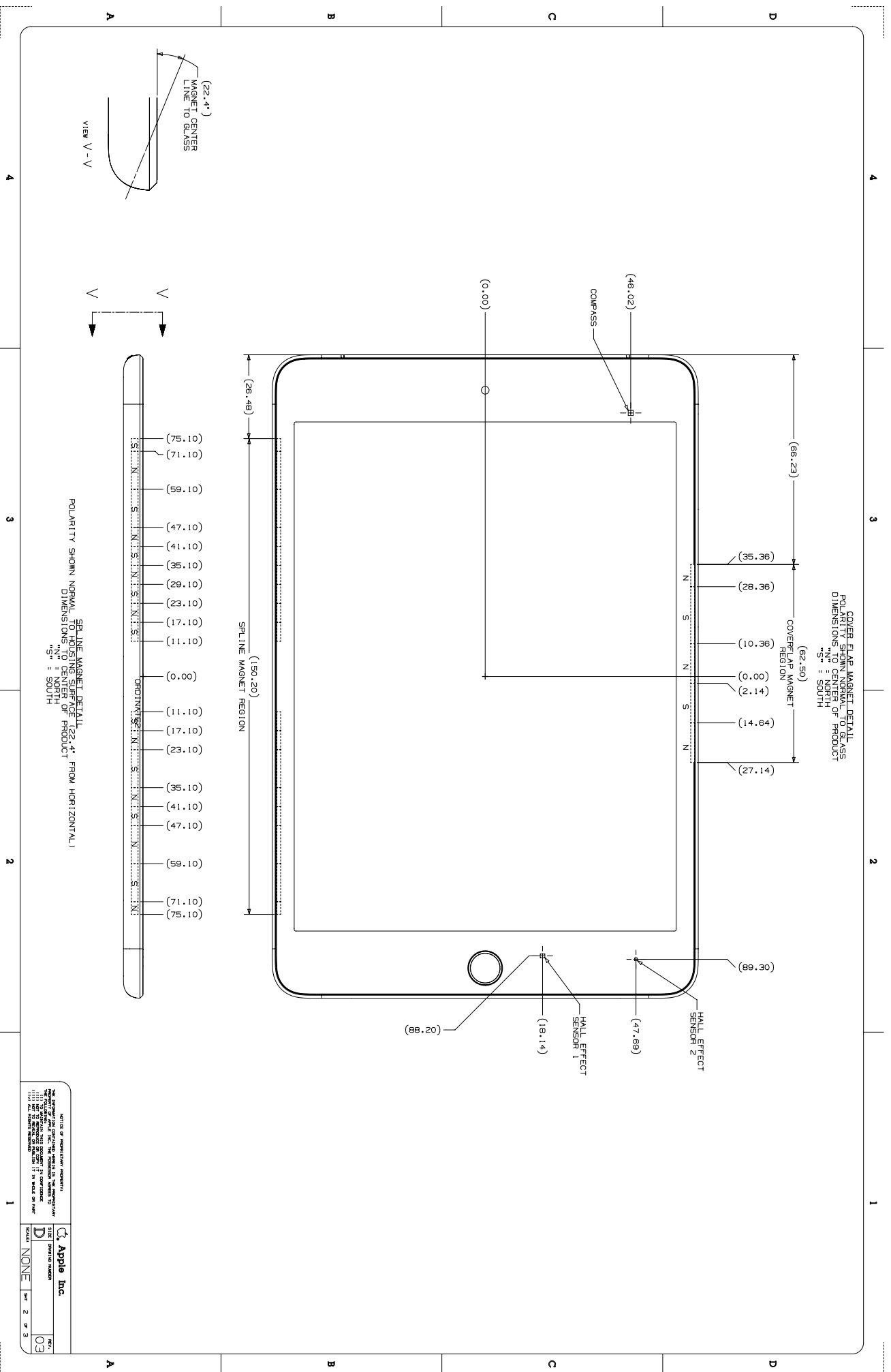
Apple Inc. logo and text: APPLE INC. 100 Apple Park Blvd, Cupertino, CA 95014. Includes a table with columns for 'NONE' and '3 of 3'.

NONE	3 of 3
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4.4.80 iPad mini (5th generation) with Wi-Fi + Cellular 1 of 3



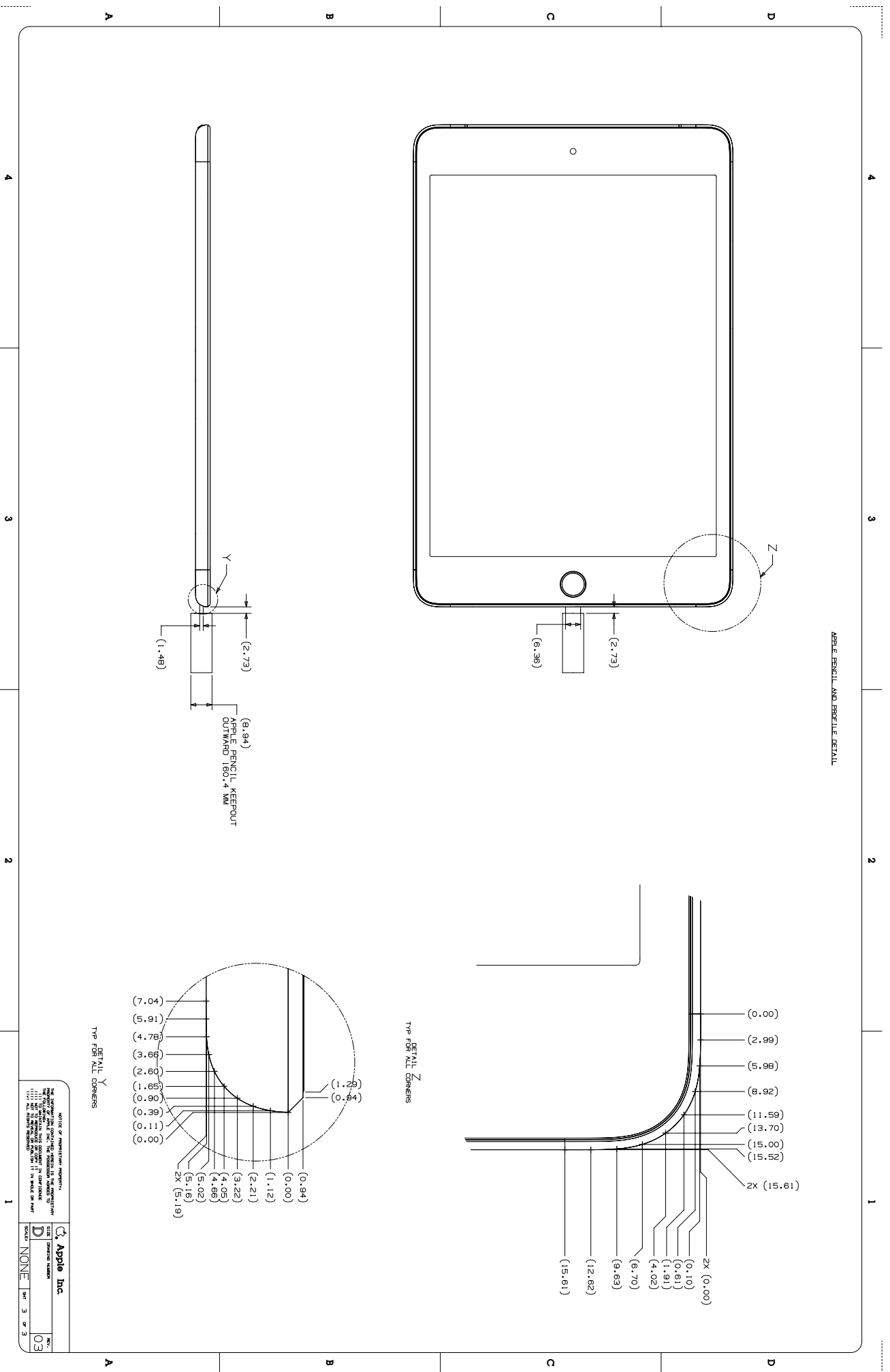
44.81 iPad mini (5th generation) with Wi-Fi + Cellular 2 of 3



Apple Inc.
 Apple logo
 Apple Inc.
 03

4.4.82 iPad mini (5th generation) with Wi-Fi + Cellular 3 of 3

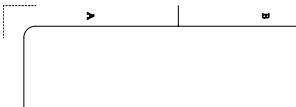
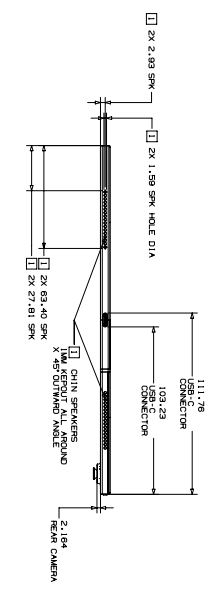
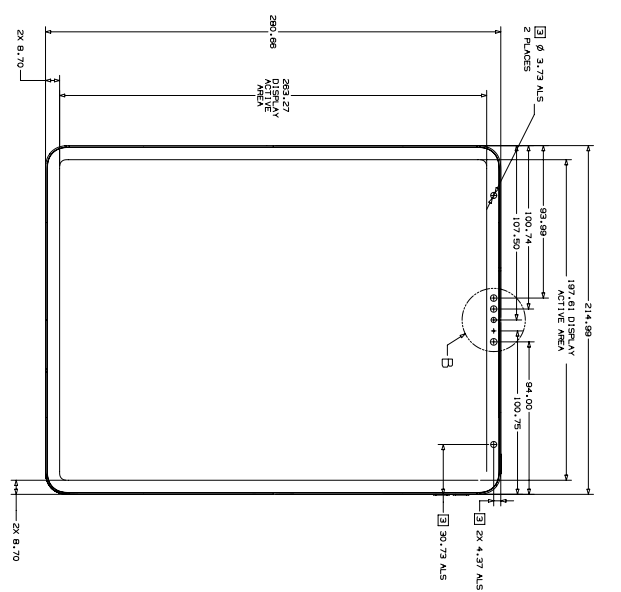
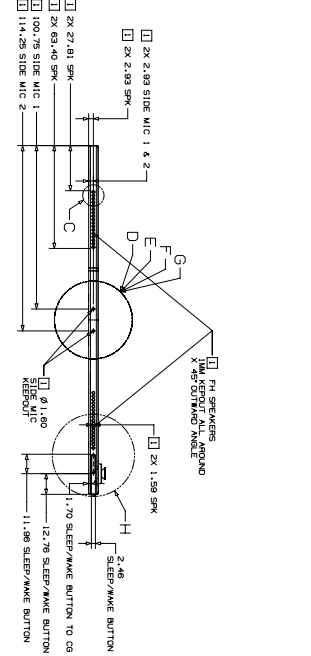
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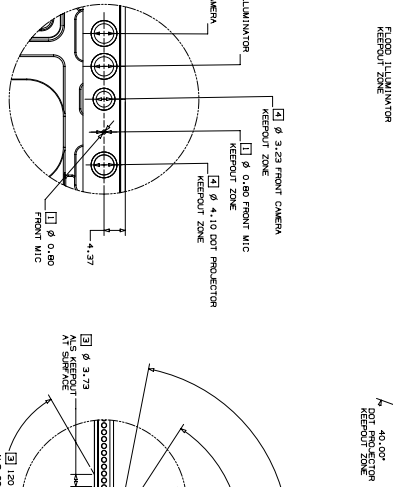
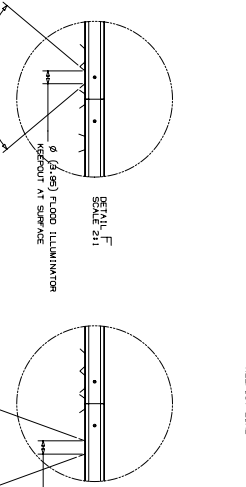
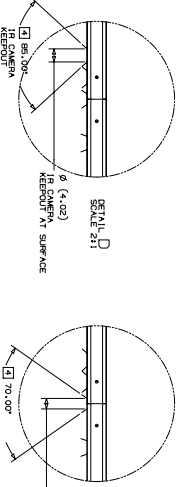
4.4.83 iPad Pro (12.9-inch) 3rd Generation 1 of 3

NOTES: (UNLESS OTHERWISE SPECIFIED)

- 1 DO NOT OBSTRUCT ACOUSTIC OPENINGS; REAR MIC, SIDE MICs, FRONT MIC, SPEAKERS
- 2 DO NOT OBSTRUCT REAR CAMERA & REAR FLASH
- 3 DO NOT OBSTRUCT AMBIENT LIGHT SENSOR
- 4 DO NOT OBSTRUCT IR CAMERA, FLOOD ILLUMINATOR, FRONT CAMERA & DOT PROJECTOR
- 5 DO NOT HAVE METAL CONTACT WITH DEVICE COVER GLASS



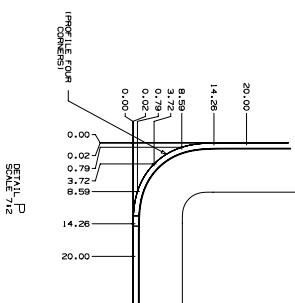
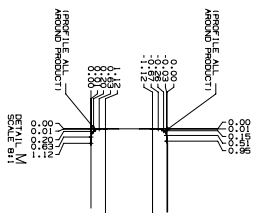
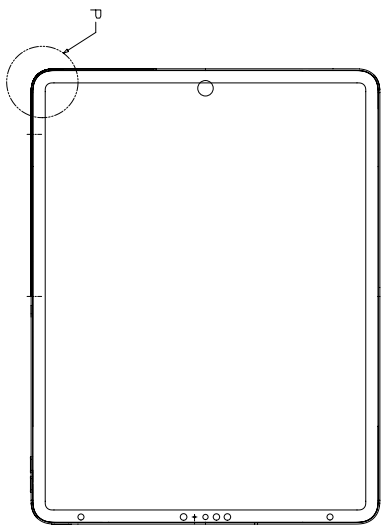
SYMBOLS & ABBREVIATIONS



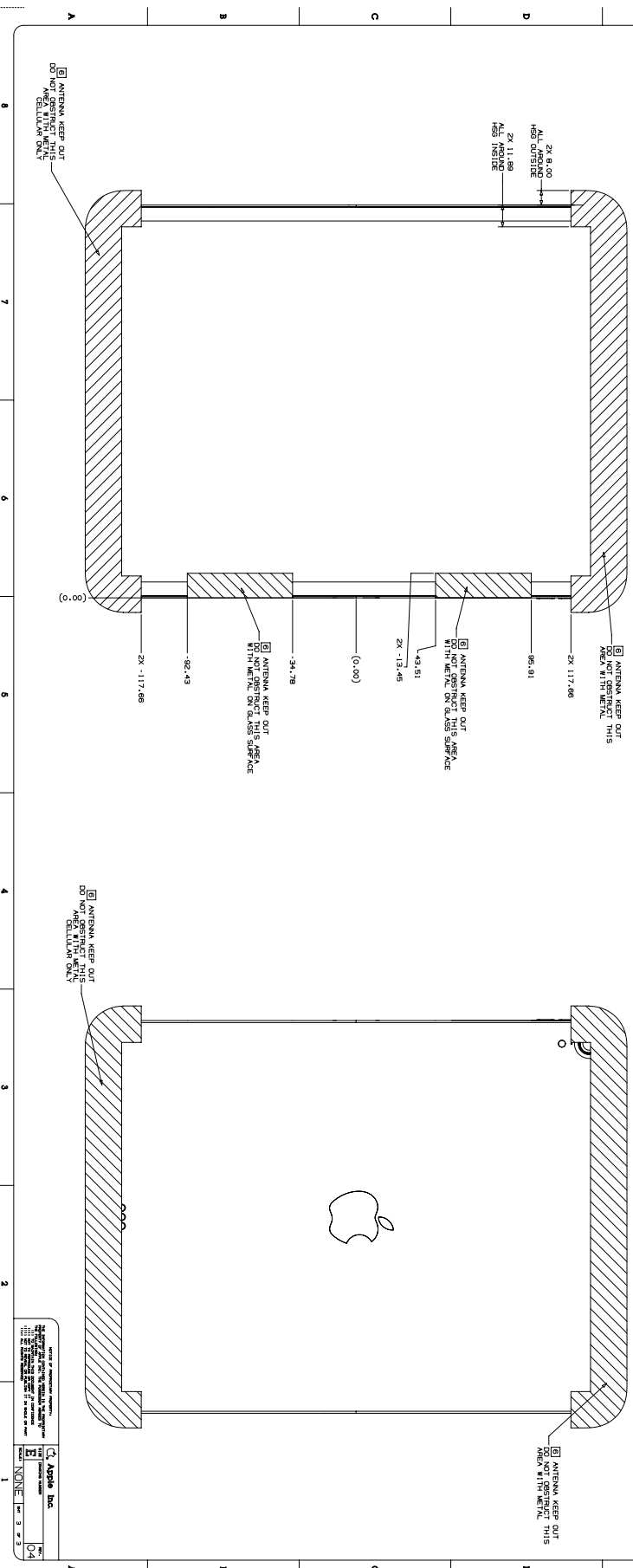
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DESIGNER	J.P. [unreadable]	DESIGNER	J.P. [unreadable]
APPRAVER	[unreadable]	APPRAVER	[unreadable]
DATE	12/27/18	DATE	12/27/18
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4.4.85 iPad Pro (12.9-inch) 3rd Generation 3 of 3

SECTION AND DETAIL INFORMATION



ANTENNA KEEP OUTS

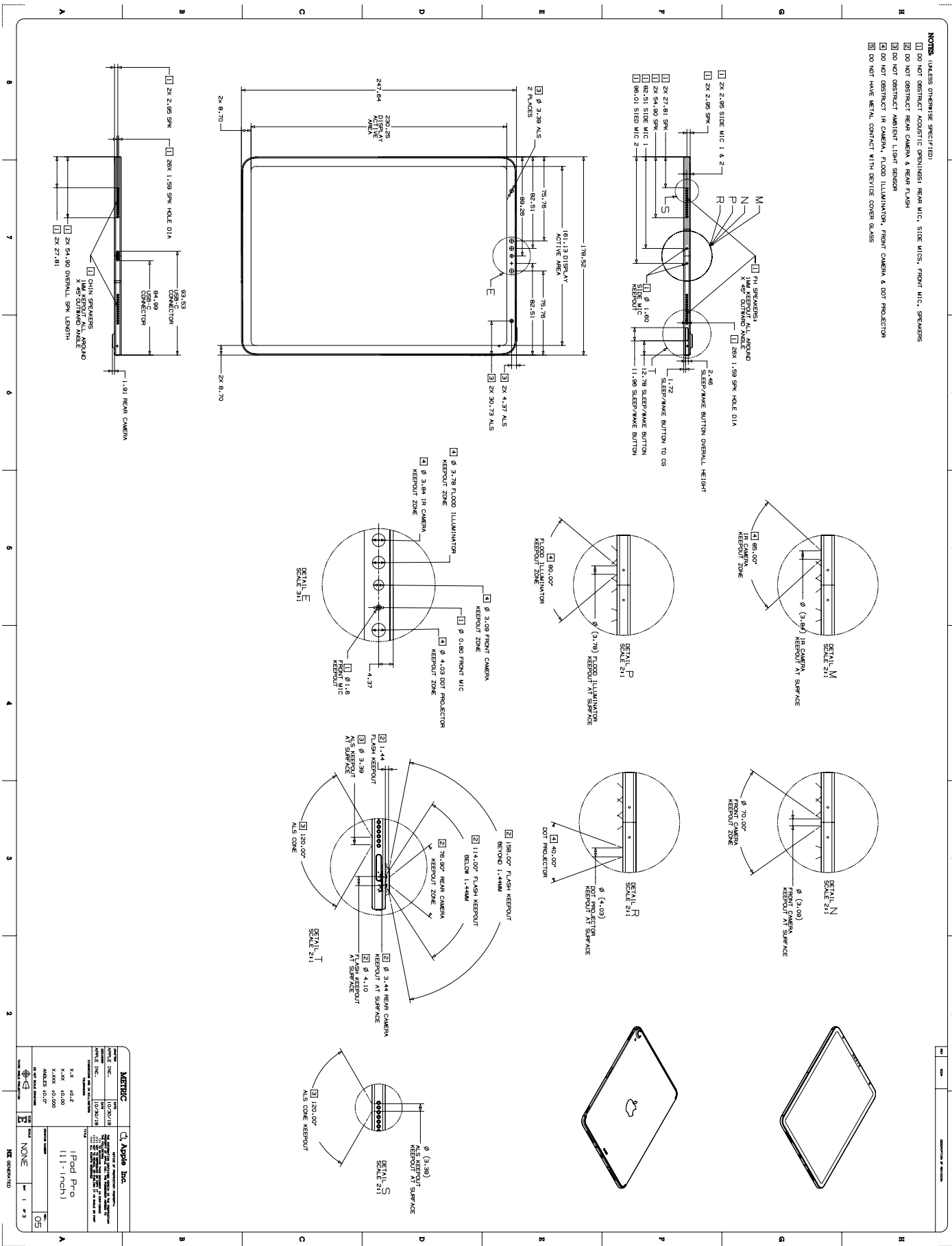


REVISION	DATE	BY	CHK	APP	DESCRIPTION
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44.86 iPad Pro (11-inch) 1 of 3

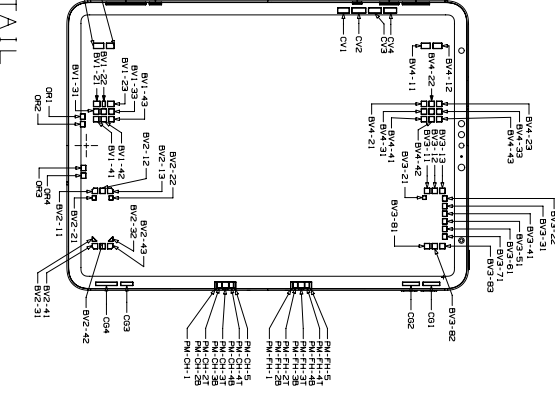
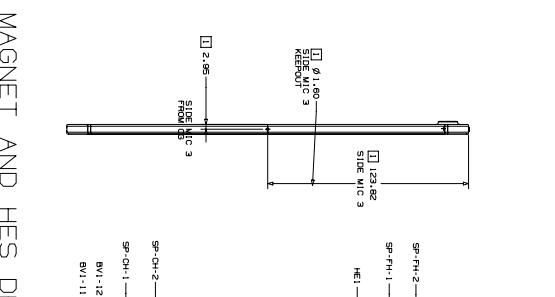
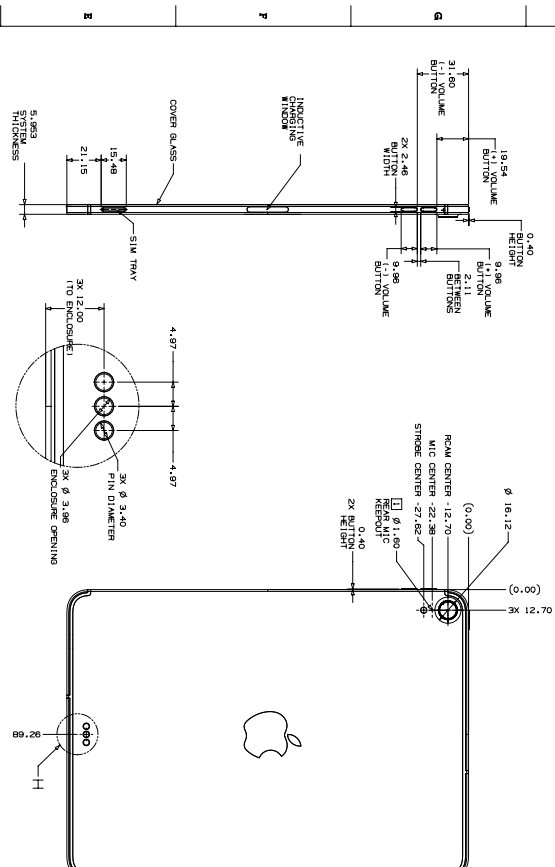
NOTES UNLESS OTHERWISE SPECIFIED:

- 1 DO NOT OBSTRUCT HOUSTON OPENINGS: REAR MIC, SIDE MICS, FRONT MIC, SPEAKERS
- 2 DO NOT OBSTRUCT REAR CAMERA & REAR FLASH
- 3 DO NOT OBSTRUCT AMBIENT LIGHT SENSOR
- 4 DO NOT OBSTRUCT IR CAMERA, FLOOD ILLUMINATOR, FRONT CAMERA & DOT PROJECTOR
- 5 DO NOT HAVE METAL CONTACT WITH DEVICE COVER GLASS

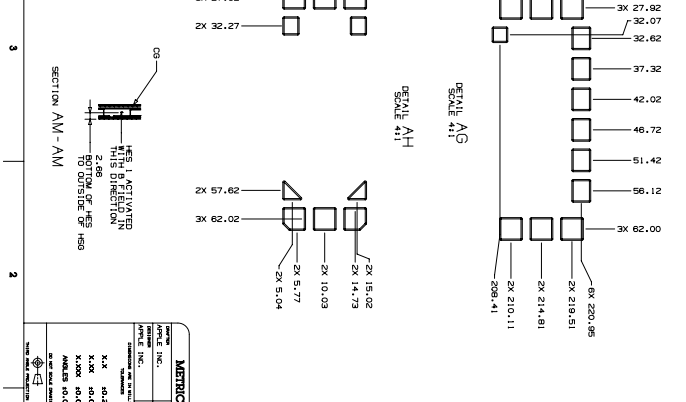
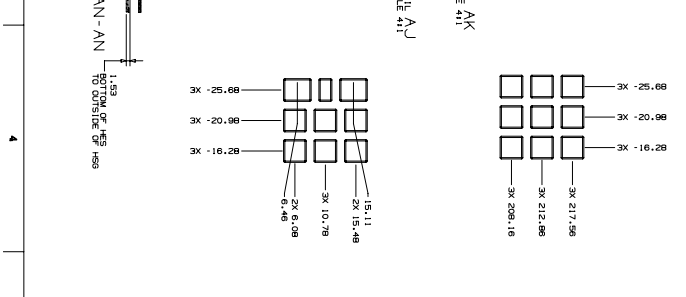
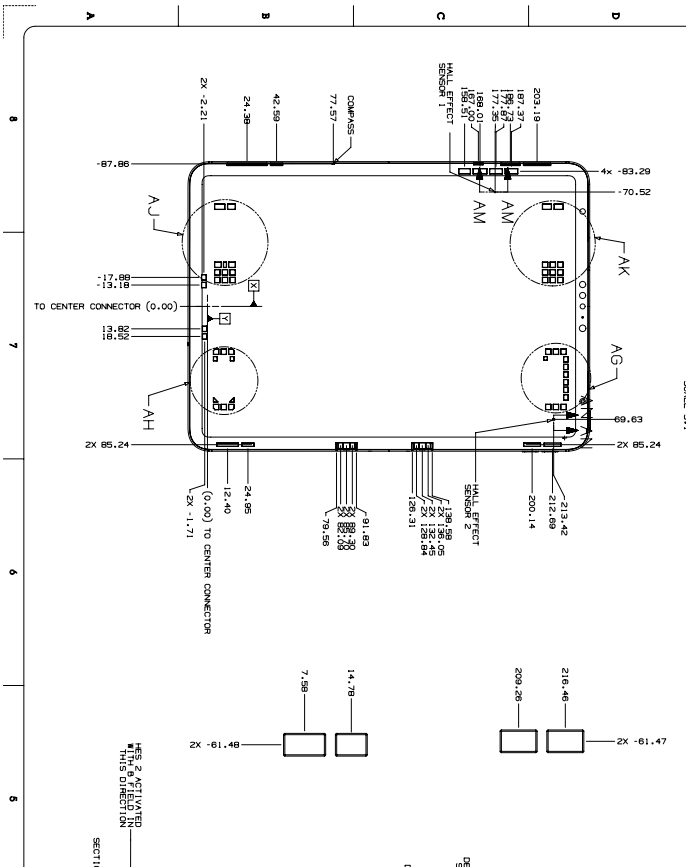


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DATE:	10/27/21	DATE:	10/27/21
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ASSEMBLY:	NONE		
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SCALE:	1:1	SCALE:	1:1
UNIT:	MILLIMETERS	UNIT:	MILLIMETERS
ASSEMBLY:	NONE		

- NOTES:** (UNLESS OTHERWISE SPECIFIED)
- 1 DO NOT OBSTRUCT ACOUSTIC OPENINGS: REAR MIC, SIDE MICS, FRONT MIC, SPEAKERS
 - 2 DO NOT OBSTRUCT REAR CAMERA & REAR FLASH
 - 3 DO NOT OBSTRUCT AMBIENT LIGHT SENSOR
 - 4 DO NOT OBSTRUCT IR CAMERA, FLUOR ILLUMINATION, FRONT CAMERA & DOT PROJECTOR
 - 5 DO NOT HAVE METAL CONTACT WITH DEVICE COVER GLASS



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Apple Inc.

Model: A2091

Part Number: 44.87

Version: 1.0

Revision: 05

DATE: 2021-09-28

BY: [Signature]

APPROVED: [Signature]

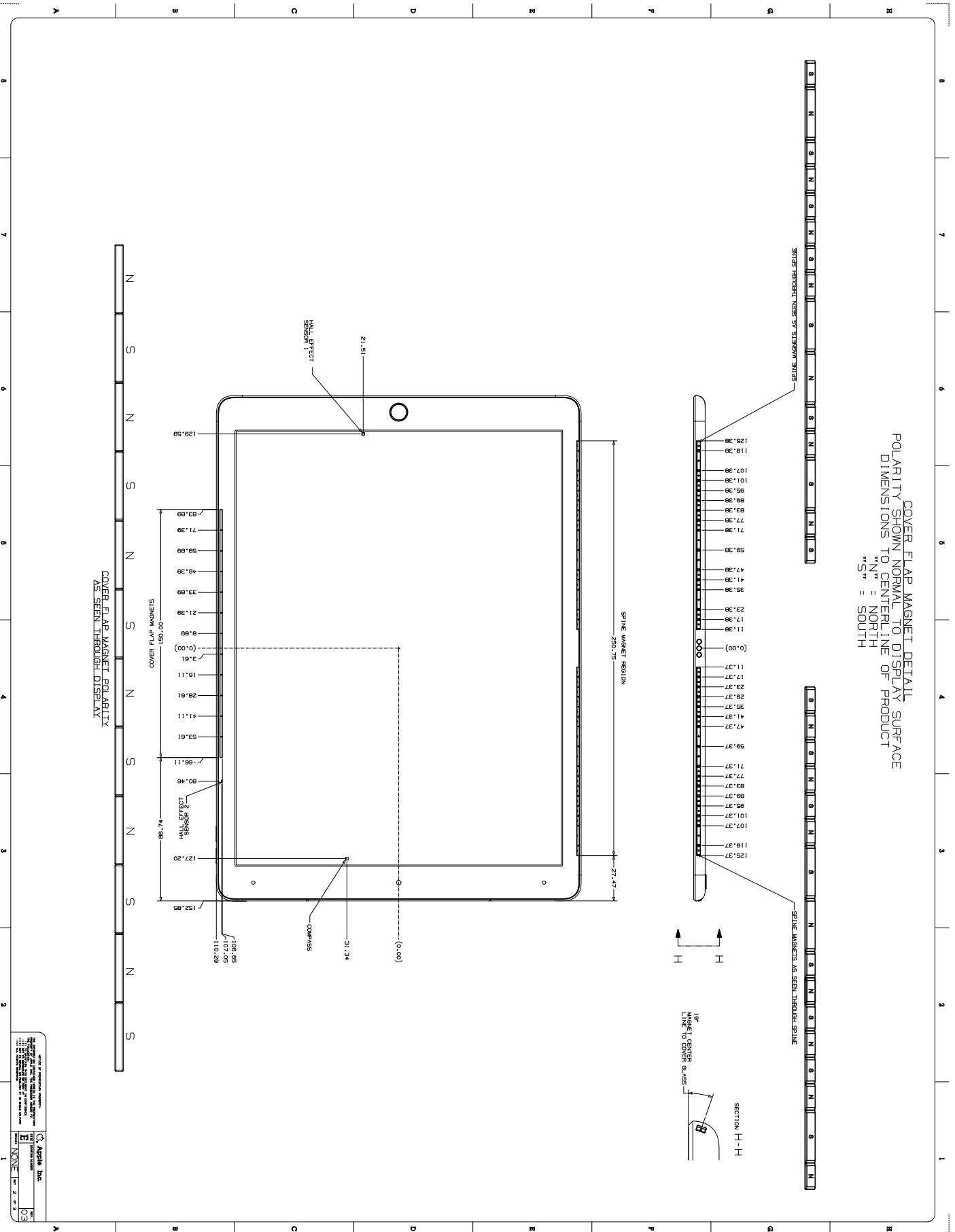
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UNIT: MM

ORIENTATION: NONE

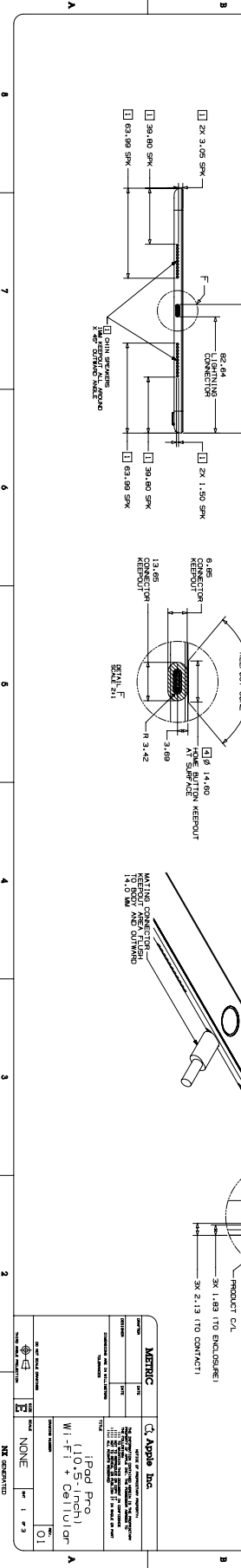
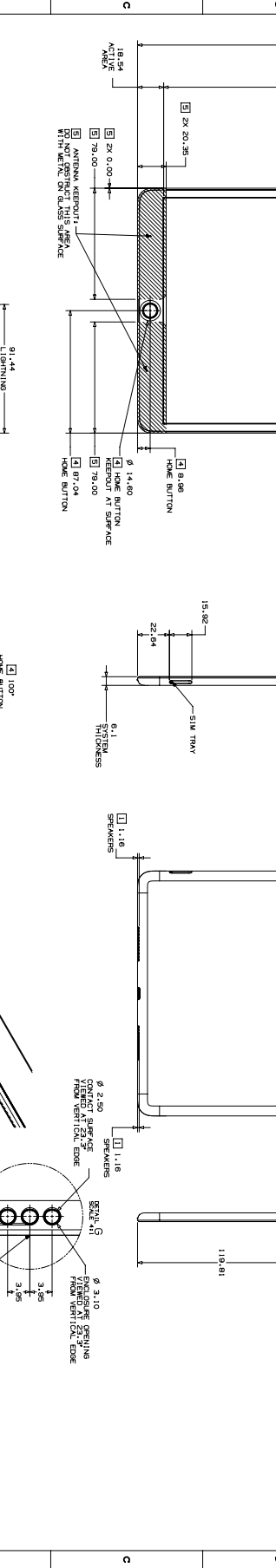
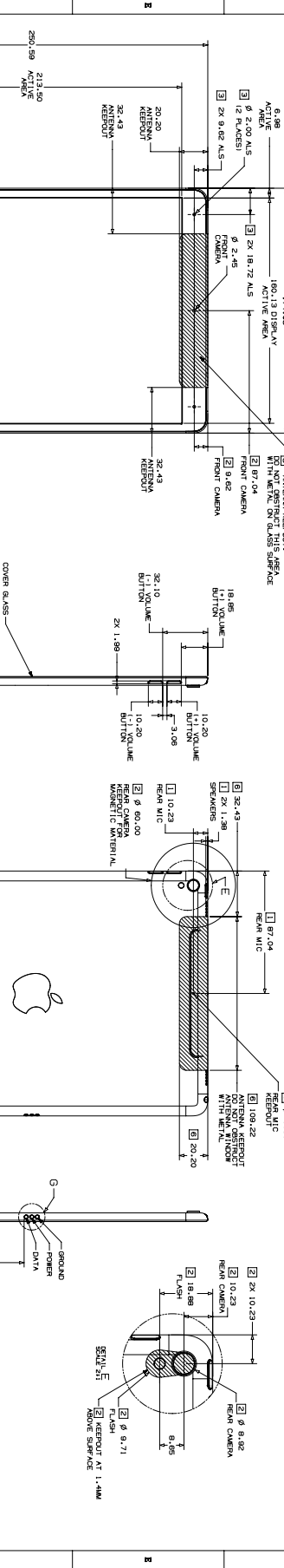
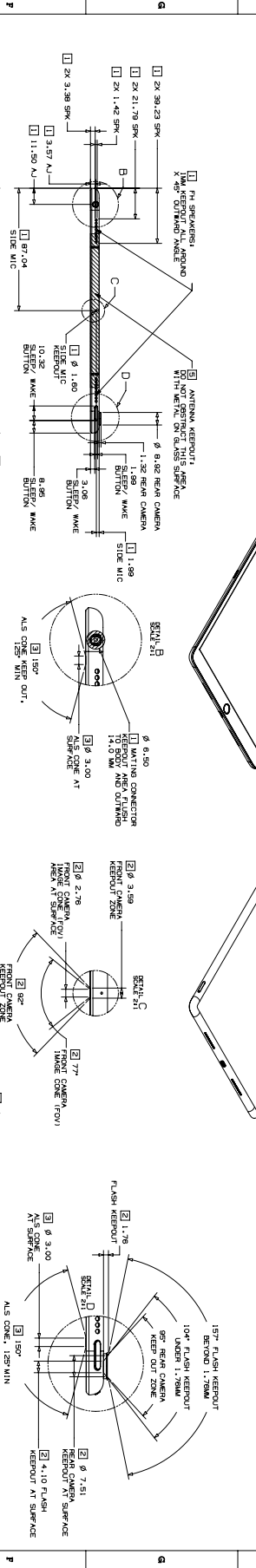
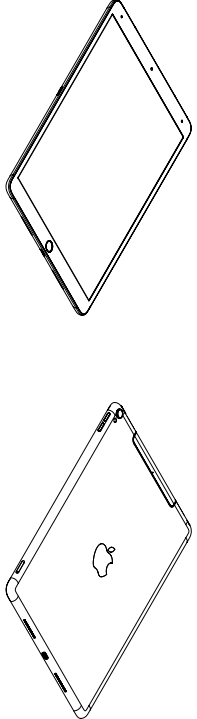
2 of 3

4.4.91 iPad Pro (12.9-inch) 2nd Generation Magnet/Hall Effect Sensors 1 of 2



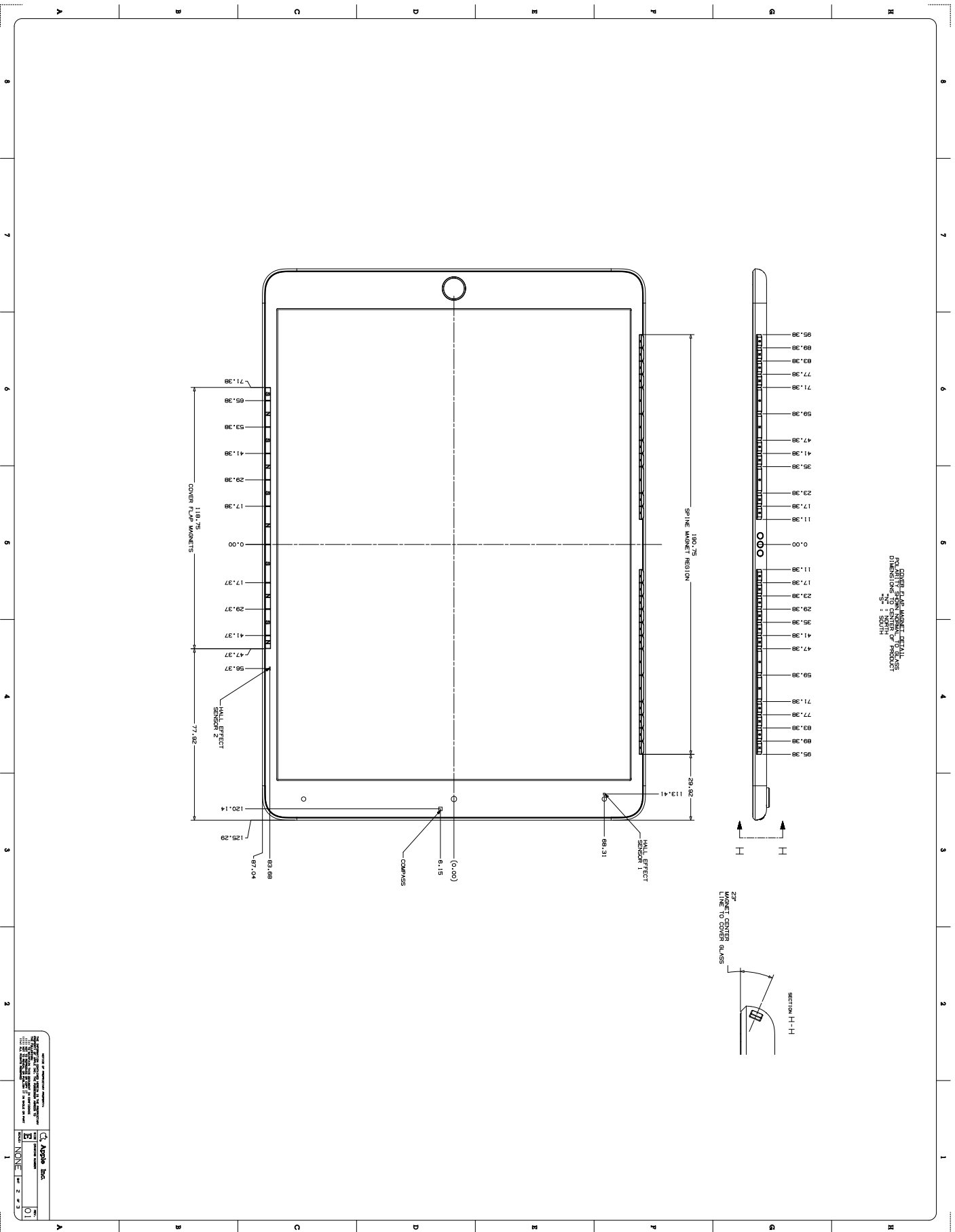
4.4.94 iPad Pro (10.5-inch) with Wi-Fi + Cellular

- NOTES**
- 1 DO NOT DISTRIBUTE ACOUSTIC OPENINGS. SILE MIC, REAR MIC, AUDIO JACK, SPEAKERS
 - 2 DO NOT DISTRIBUTE THE IMAGING FEATURES FRONT CAMERA, REAR CAMERA, REAR FLASH
 - 3 DO NOT DISTRIBUTE AMBIENT LIGHT SENSOR (ALS)
 - 4 DO NOT DISTRIBUTE THE HOME BUTTON
 - 5 DO NOT HAVE METAL CONTACT WITH DEVICE COVER GLASS
 - 6 DO NOT HAVE METAL CONTACT WITH DEVICE ENCLOSURE



METRIC		Apple Inc.	
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MM	50.8	MM	50.8
MM	76.2	MM	76.2
MM	101.6	MM	101.6
MM	127.0	MM	127.0
MM	152.4	MM	152.4
MM	177.8	MM	177.8
MM	203.2	MM	203.2
MM	228.6	MM	228.6
MM	254.0	MM	254.0
MM	279.4	MM	279.4
MM	304.8	MM	304.8
MM	330.2	MM	330.2
MM	355.6	MM	355.6
MM	381.0	MM	381.0
MM	406.4	MM	406.4
MM	431.8	MM	431.8
MM	457.2	MM	457.2
MM	482.6	MM	482.6
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MM	533.4	MM	533.4
MM	558.8	MM	558.8
MM	584.2	MM	584.2
MM	609.6	MM	609.6
MM	635.0	MM	635.0
MM	660.4	MM	660.4
MM	685.8	MM	685.8
MM	711.2	MM	711.2
MM	736.6	MM	736.6
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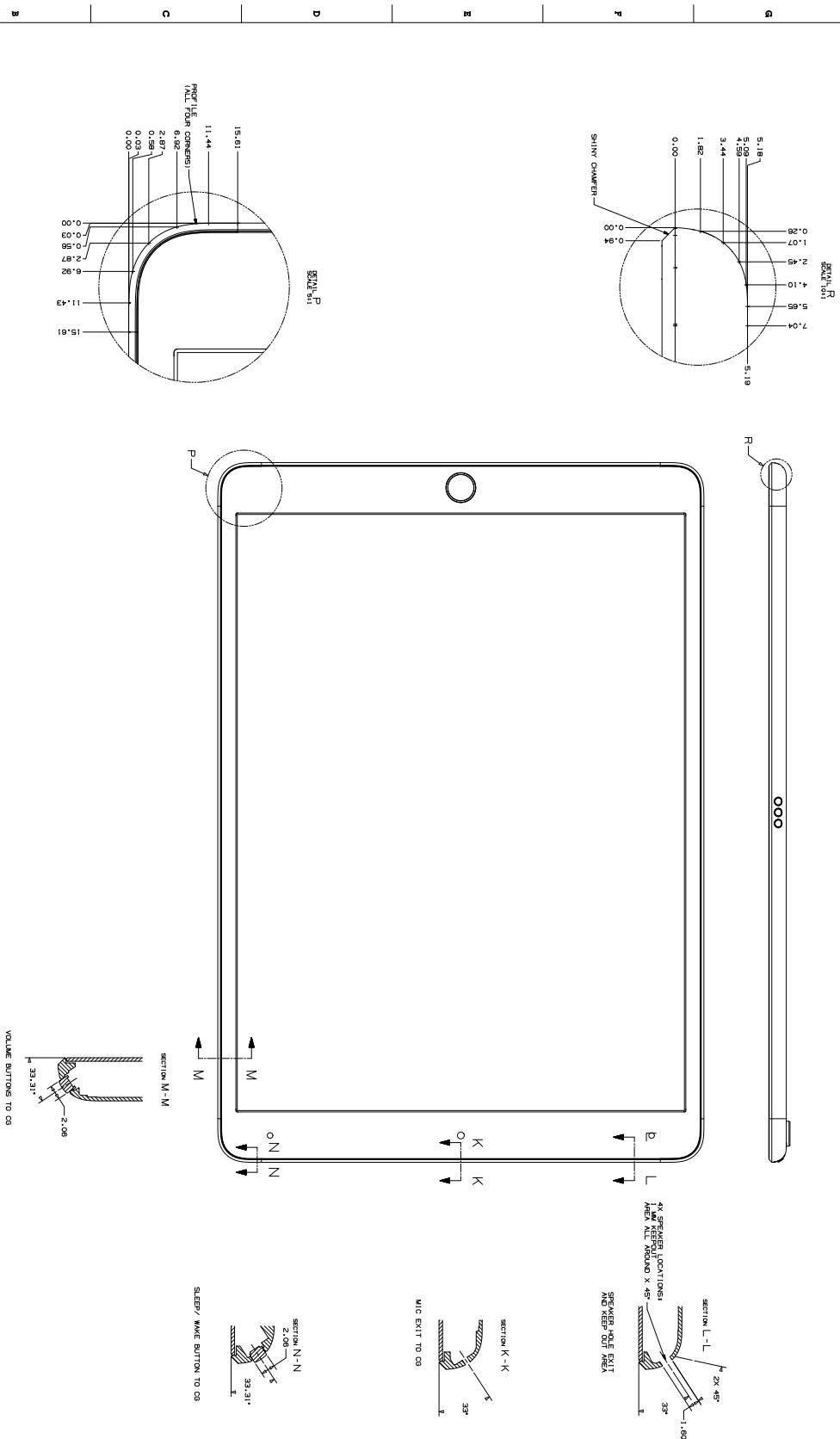
44.95 iPad Pro (10.5-inch) Magnet/Hall Effect Sensors 1 of 2



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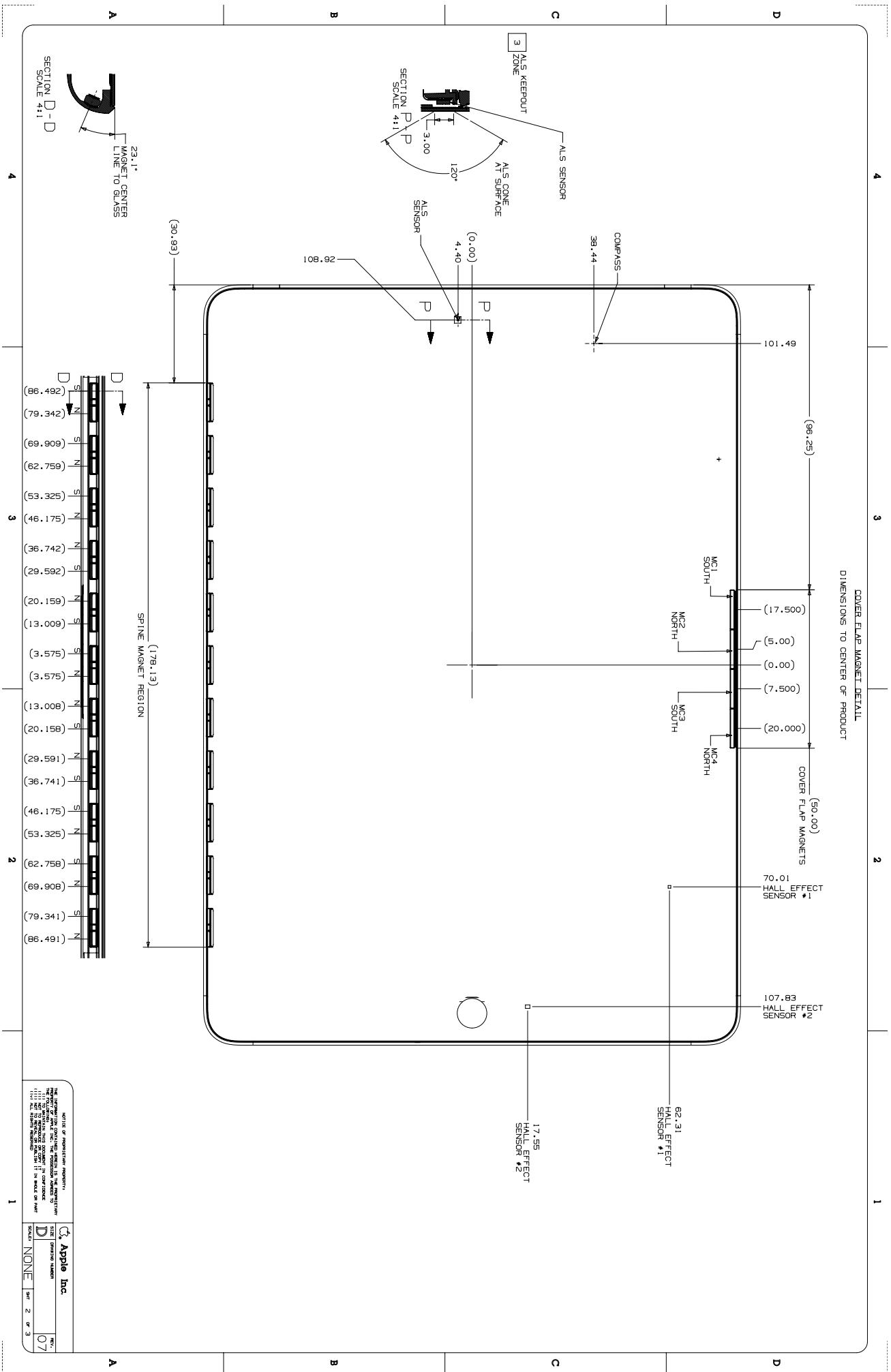
44.96 iPad Pro (10.5-inch) Magnet/Hall Effect Sensors 2 of 2

SECTION AND DETAIL INFORMATION



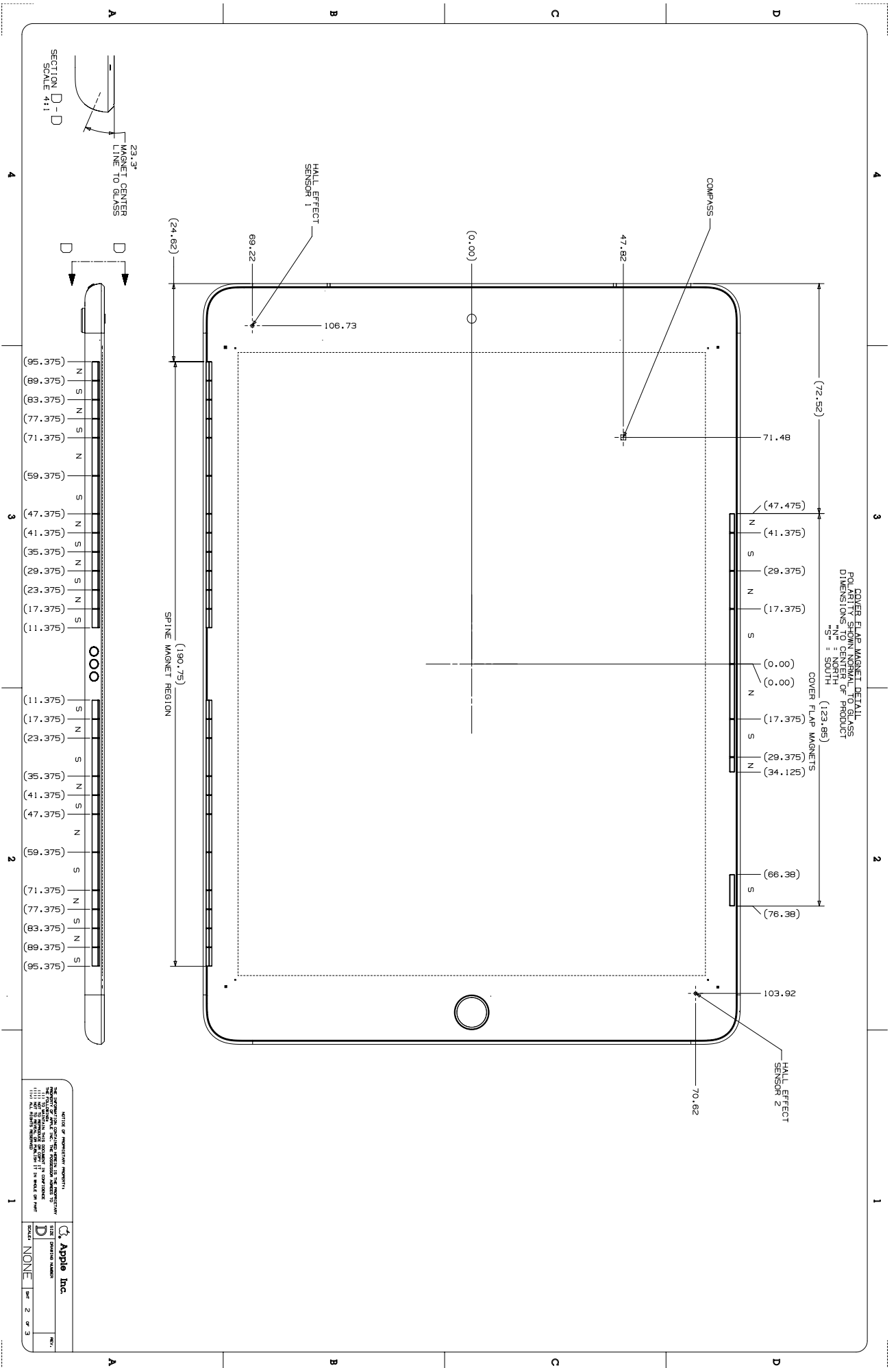
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Revision	1
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44.98 iPad (5th and 6th generation) Magnet/Hall Effect Sensors 1 of 2

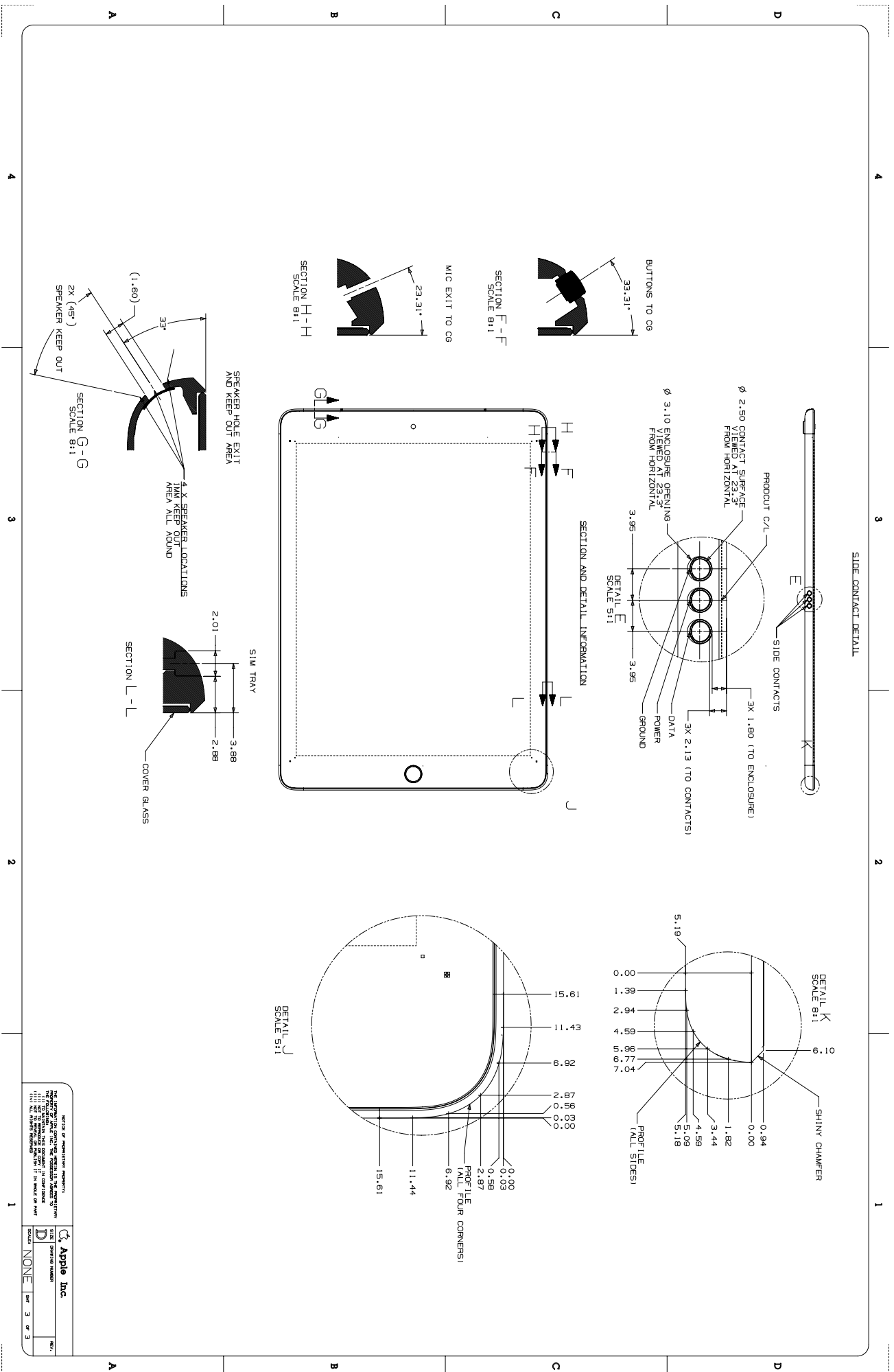


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 Apple Inc.
 TYPE: Revision Number
 D
 NONE
 07
 Rev. 07

44.102 iPad Pro (9.7-inch) Magnet/Hall Effect Sensors 1 of 2



44.103 iPad Pro (9.7-inch) Magnet/Hall Effect Sensors 2 of 2

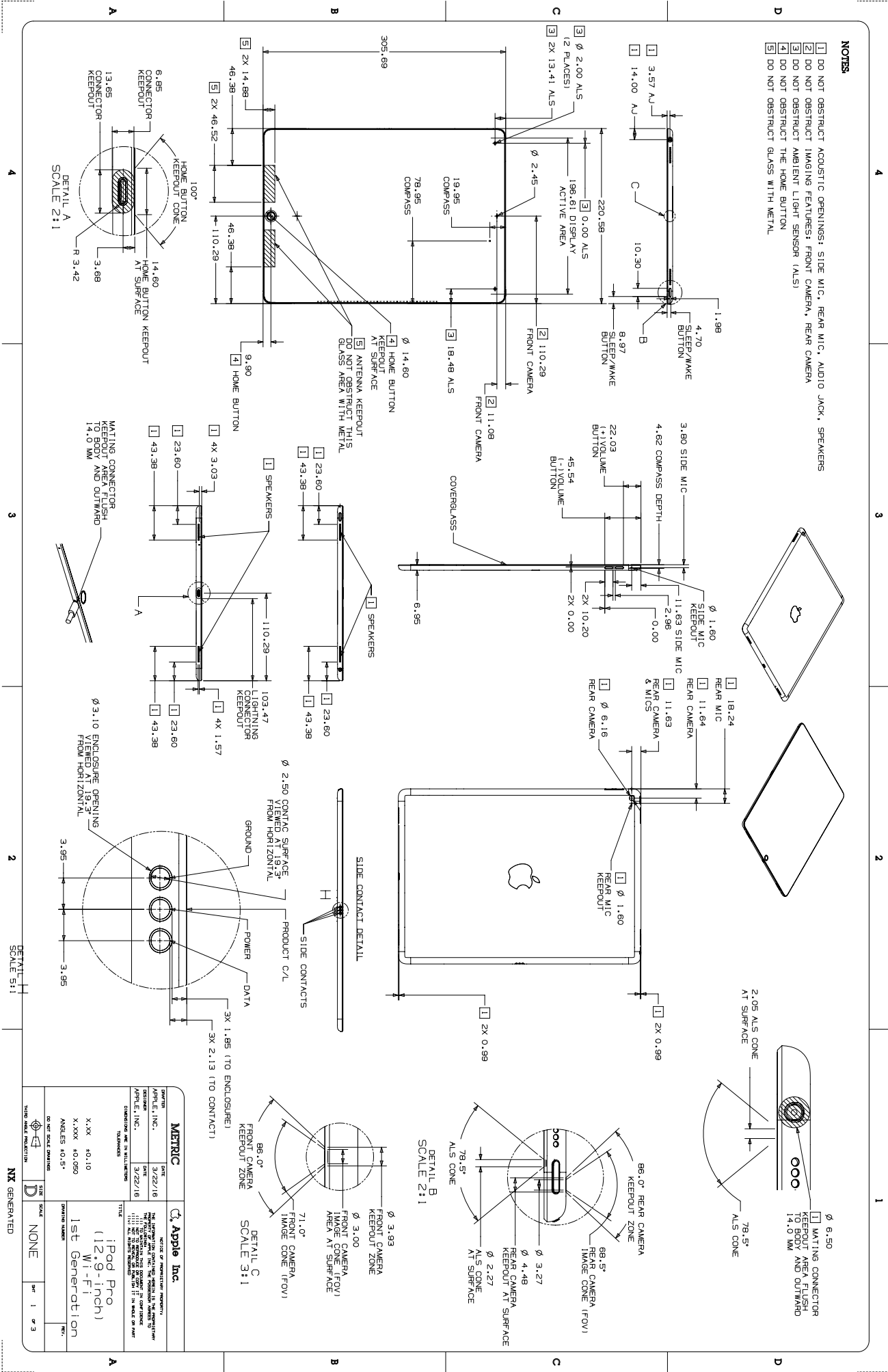


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Apple Inc.	REV. 1
Apple Inc.	REV. 2
Apple Inc.	REV. 3
Apple Inc.	REV. 4
Apple Inc.	REV. 5

44.104 iPad Pro (12.9-inch) 1st Generation with Wi-Fi

NOTES

- 1 DO NOT OBSTRUCT ACOUSTIC OPENINGS: SIDE MIC, REAR MIC, AUDIO JACK, SPEAKERS
- 2 DO NOT OBSTRUCT IMAGING FEATURES: FRONT CAMERA, REAR CAMERA
- 3 DO NOT OBSTRUCT AMBIENT LIGHT SENSOR (ALS)
- 4 DO NOT OBSTRUCT THE HOME BUTTON
- 5 DO NOT OBSTRUCT GLASS WITH METAL

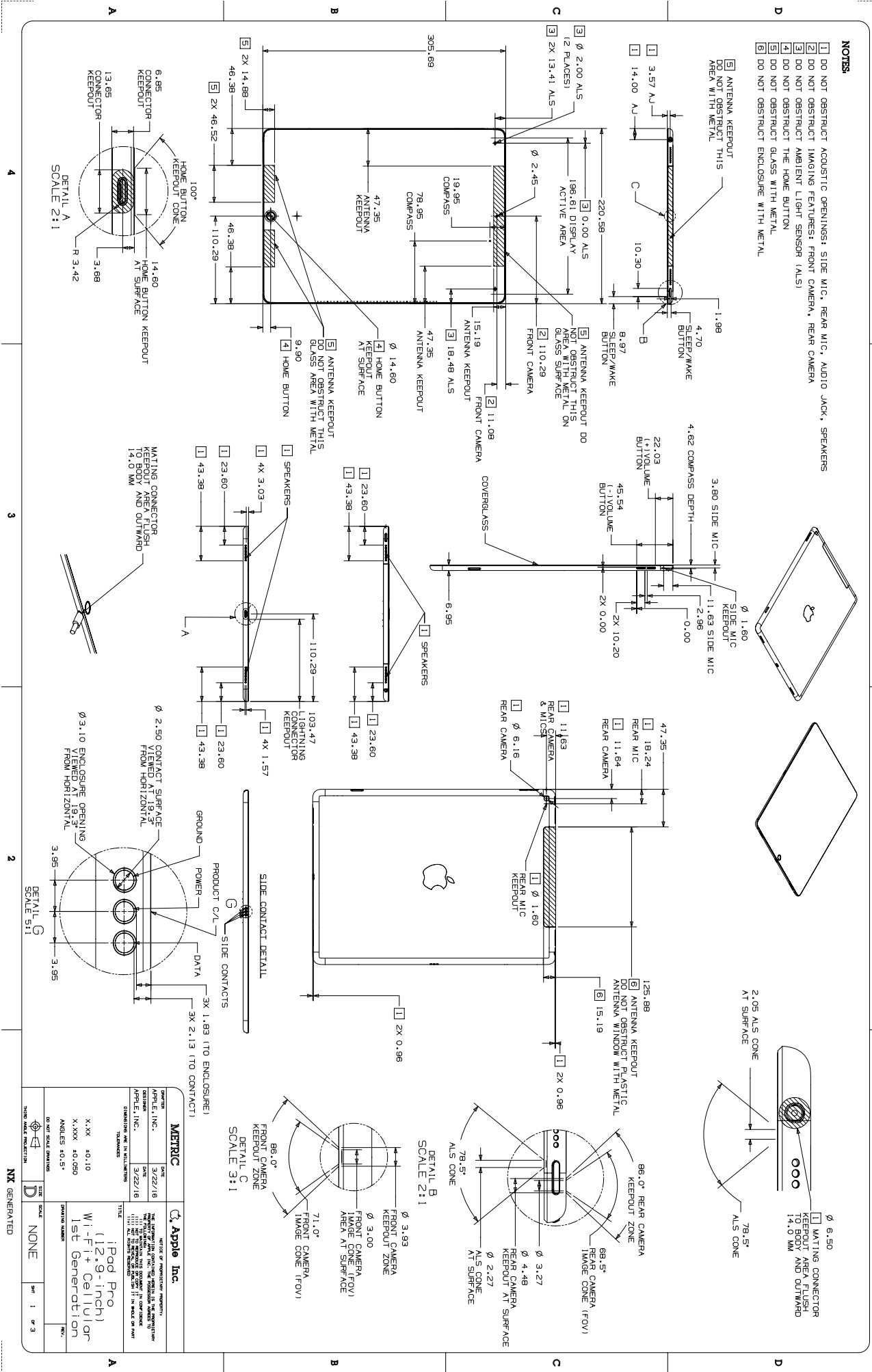


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DATE	3/22/16	DATE	3/22/16
DESIGNED BY	Apple Inc.	DESIGNED BY	Apple Inc.
APPROVED BY	Apple Inc.	APPROVED BY	Apple Inc.
TITLE	1st Generation	TITLE	1st Generation
SCALE	2:1	SCALE	2:1
ANGLES	10, 15, 30, 45, 60, 75, 90, 105, 120, 135, 150, 165, 180	ANGLES	10, 15, 30, 45, 60, 75, 90, 105, 120, 135, 150, 165, 180
DO NOT SCALE DIMENSIONS		DO NOT SCALE DIMENSIONS	
NO DIM LINE PROJECTION		NO DIM LINE PROJECTION	
DATE	3/22/16	DATE	3/22/16
DESIGNED BY	Apple Inc.	DESIGNED BY	Apple Inc.
APPROVED BY	Apple Inc.	APPROVED BY	Apple Inc.
TITLE	1st Generation	TITLE	1st Generation
SCALE	2:1	SCALE	2:1
ANGLES	10, 15, 30, 45, 60, 75, 90, 105, 120, 135, 150, 165, 180	ANGLES	10, 15, 30, 45, 60, 75, 90, 105, 120, 135, 150, 165, 180
DO NOT SCALE DIMENSIONS		DO NOT SCALE DIMENSIONS	
NO DIM LINE PROJECTION		NO DIM LINE PROJECTION	
DATE	3/22/16	DATE	3/22/16
DESIGNED BY	Apple Inc.	DESIGNED BY	Apple Inc.
APPROVED BY	Apple Inc.	APPROVED BY	Apple Inc.
TITLE	1st Generation	TITLE	1st Generation
SCALE	2:1	SCALE	2:1
ANGLES	10, 15, 30, 45, 60, 75, 90, 105, 120, 135, 150, 165, 180	ANGLES	10, 15, 30, 45, 60, 75, 90, 105, 120, 135, 150, 165, 180
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NO DIM LINE PROJECTION		NO DIM LINE PROJECTION	

44.105 iPad Pro (12.9-inch) 1st Generation with Wi-Fi + Cellular

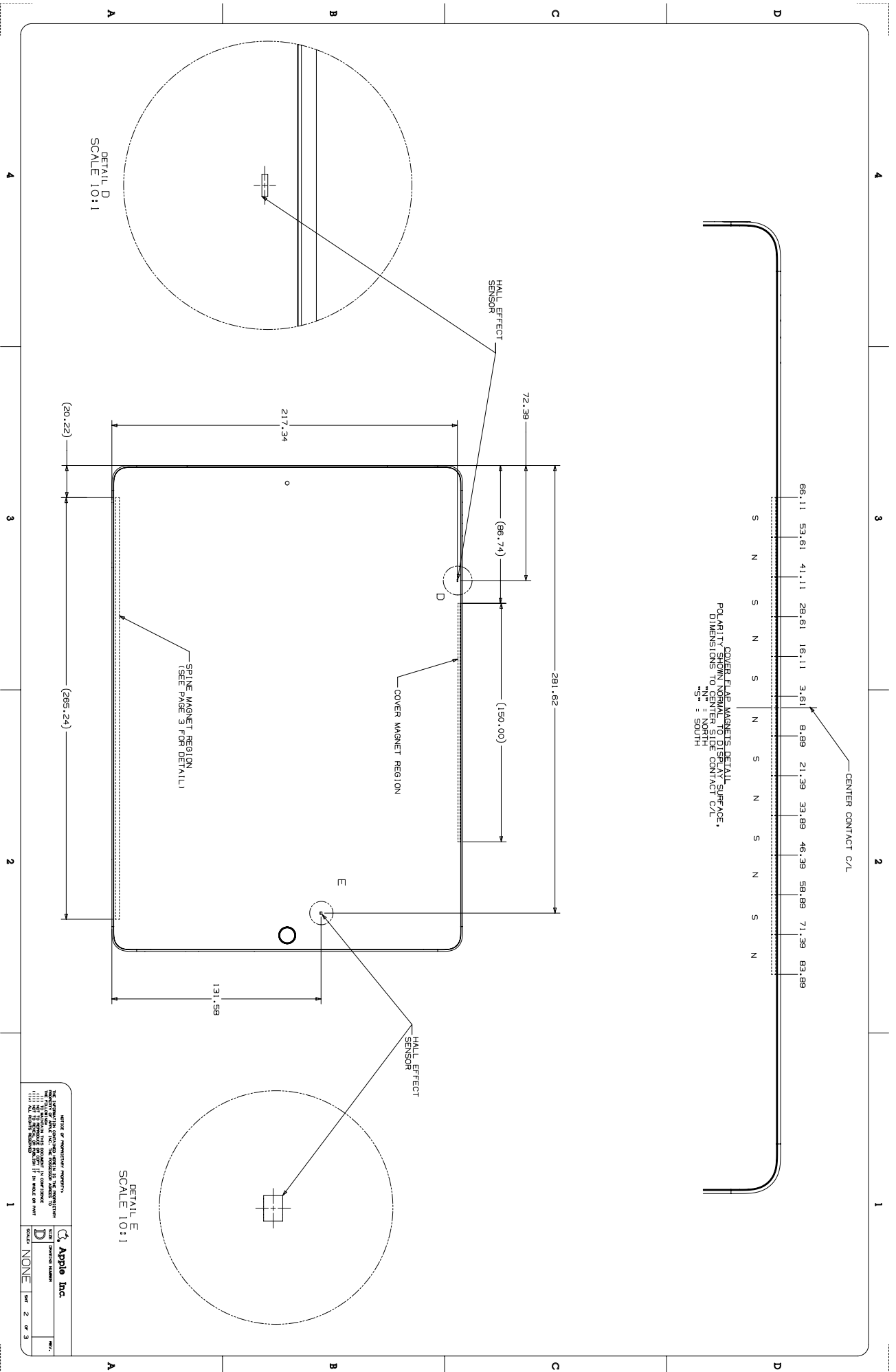
NOTES

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- 3 DO NOT OBSTRUCT AMBIENT LIGHT SENSOR (ALS)
- 4 DO NOT OBSTRUCT THE HOME BUTTON
- 5 DO NOT OBSTRUCT GLASS WITH METAL
- 6 DO NOT OBSTRUCT ENCLOSURE WITH METAL



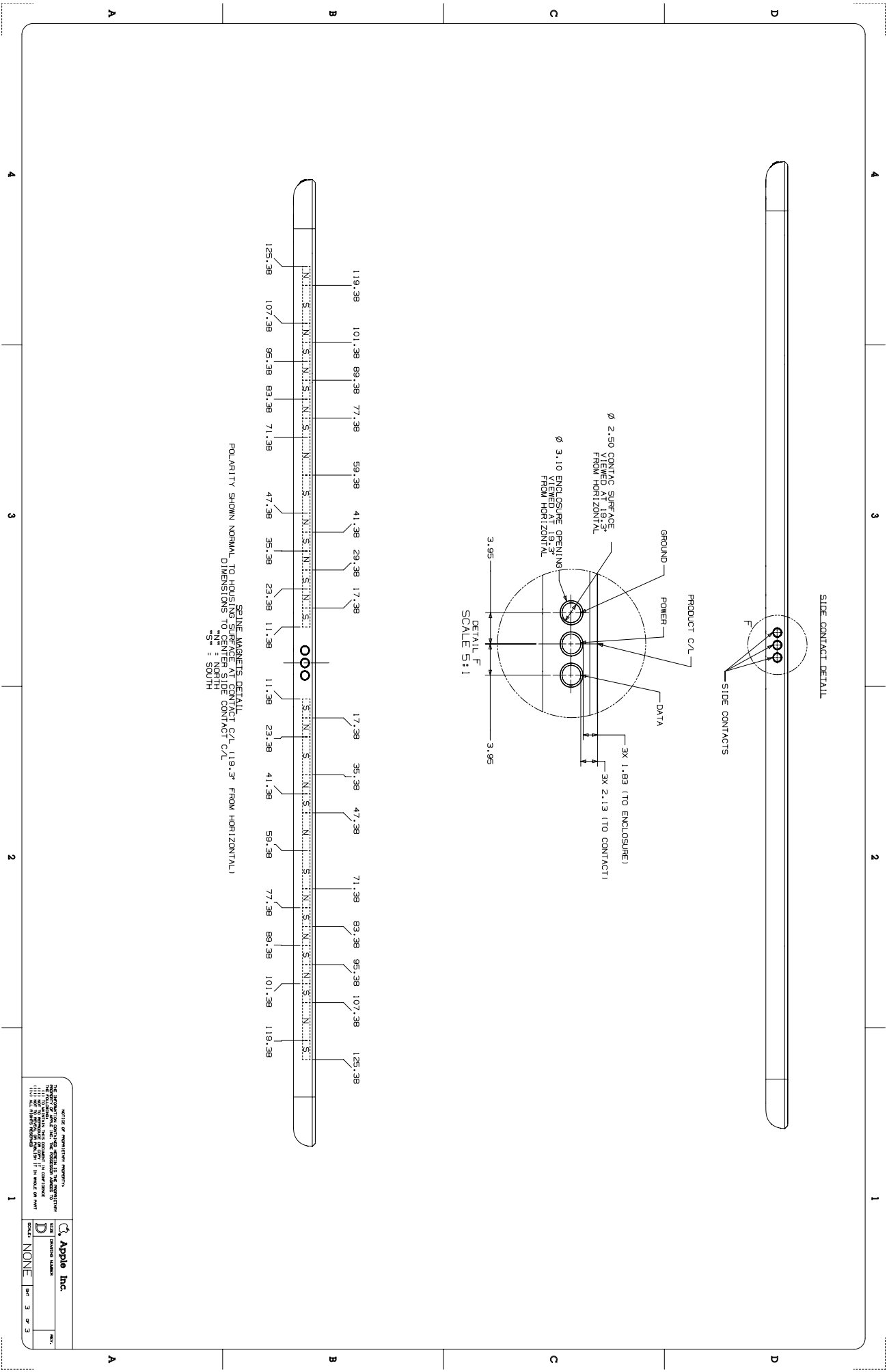
METRIC		Apple Inc.	
DATE	3/22/16	VERSION	1.0
DESIGNED BY	X.XXX	APPROVED BY	X.XXX
CHECKED BY	X.XXX	DATE	3/22/16
DATE	3/22/16	SCALE	1:1
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<p>Apple Inc. 12.9-inch iPad Pro Wi-Fi + Cellular 1st Generation</p>			
DATE	3/22/16	SCALE	NONE
VERSION	1	REV	3

44.106 iPad Pro (12.9-inch) 1st Generation Magnet/Hall Effect Sensors 1 of 2



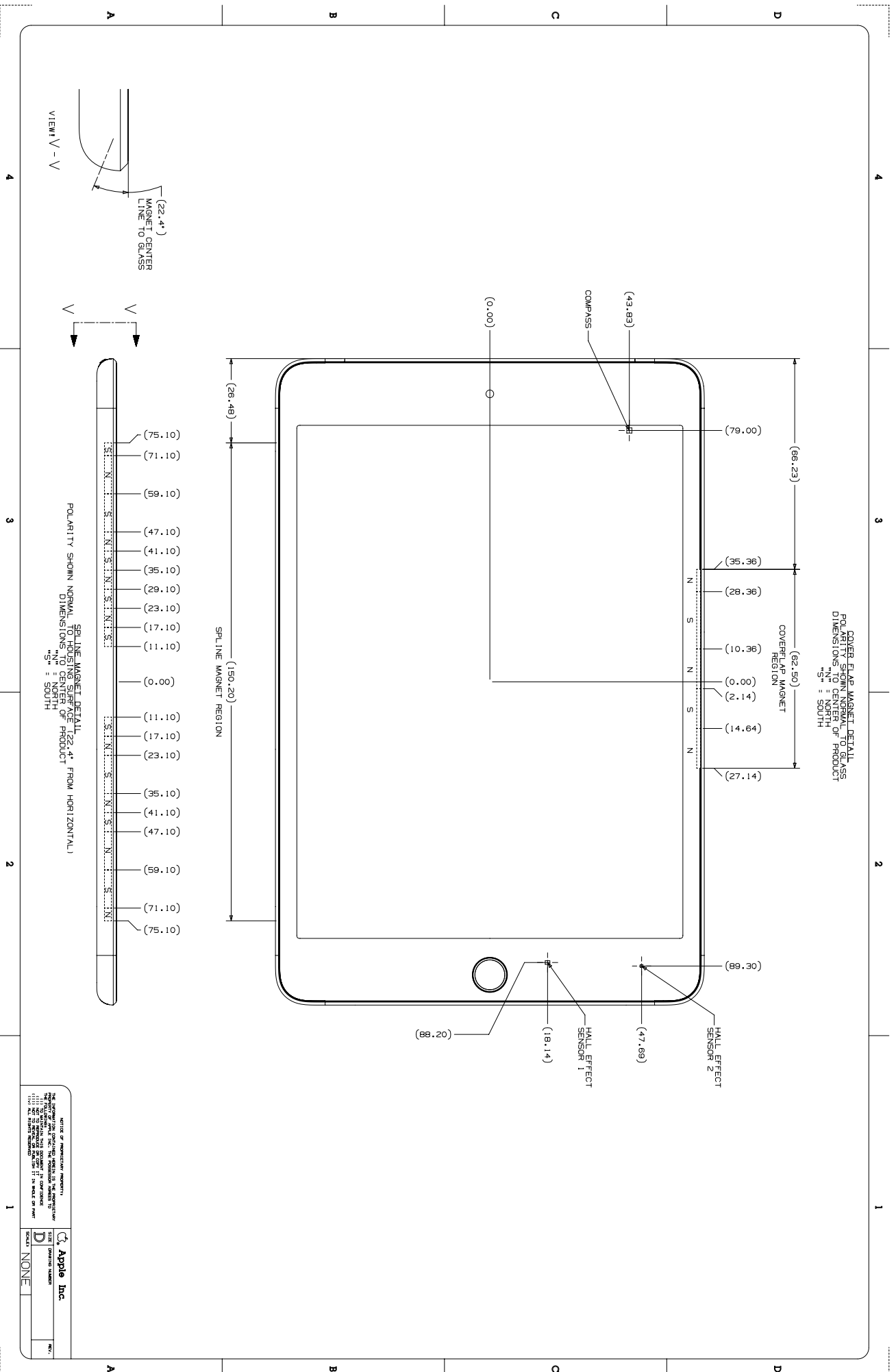
Apple Inc.
 Apple logo
 Apple Inc.
 Apple logo
 Apple Inc.
 Apple logo

44.107 iPad Pro (12.9-inch) 1st Generation Magnet/Hall Effect Sensors 2 of 2



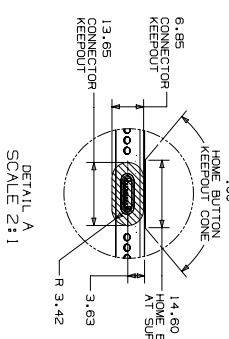
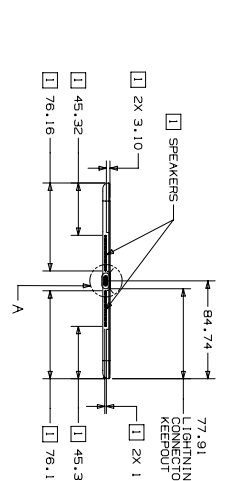
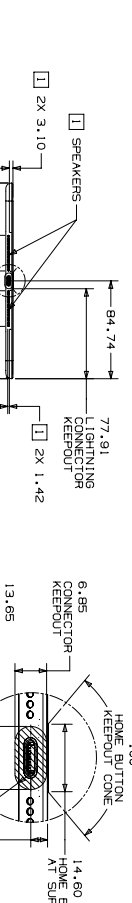
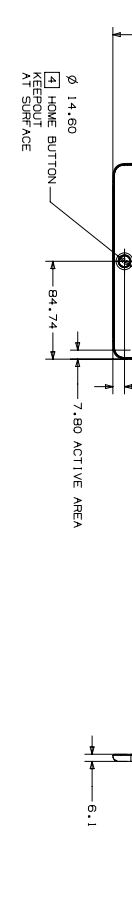
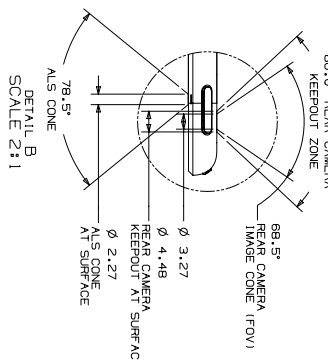
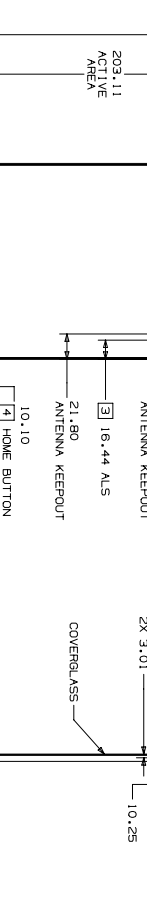
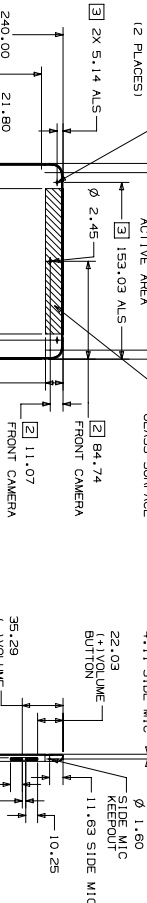
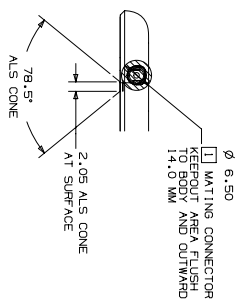
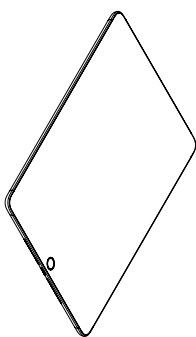
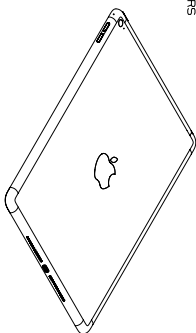
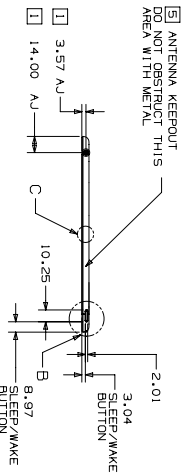
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44.110 iPad mini 4 Magnet/Hall Effect Sensors



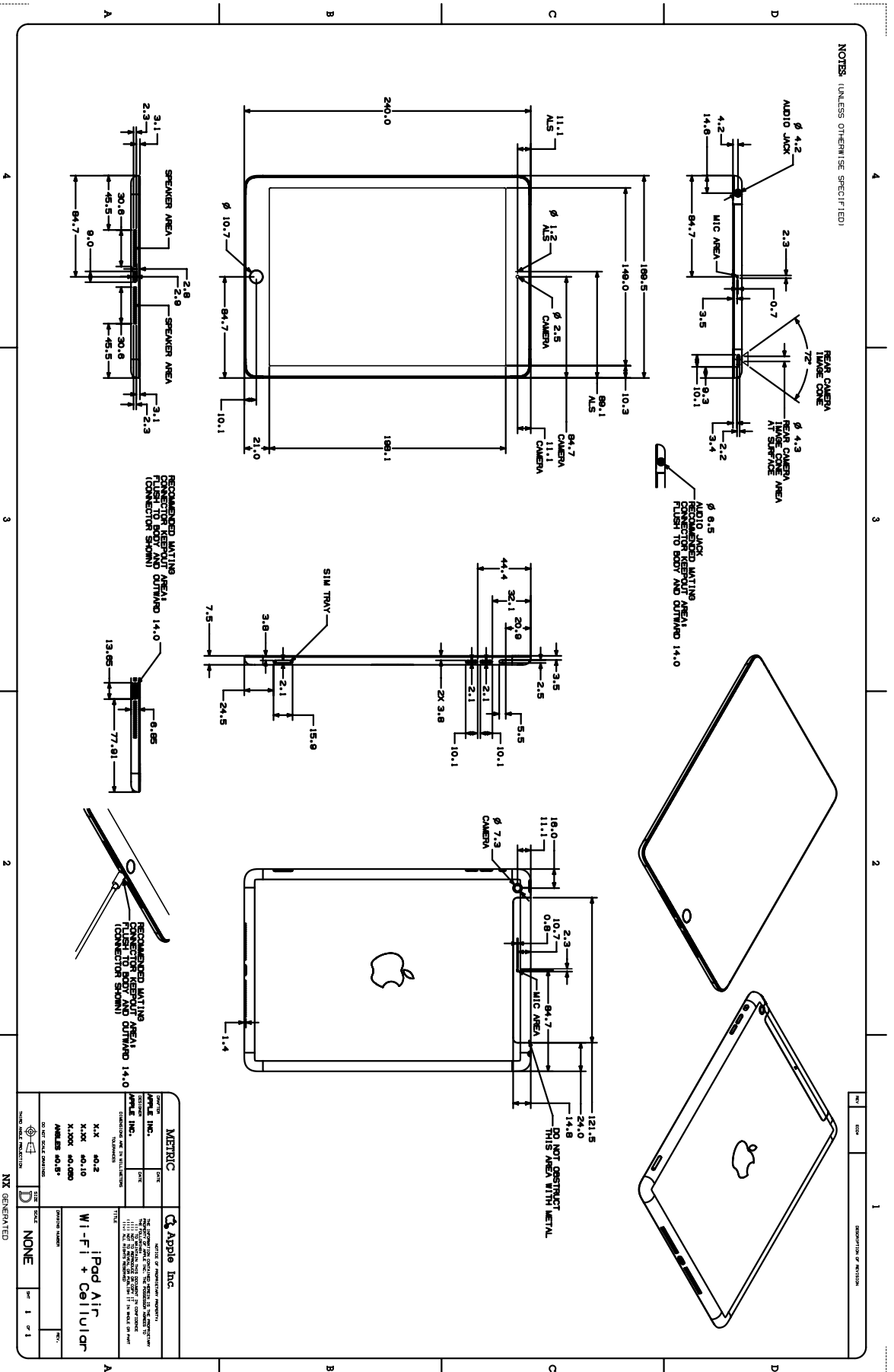
NOTES:

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- 5 DO NOT OBSTRUCT GLASS WITH METAL
- 6 DO NOT OBSTRUCT ENCLOSURE WITH METAL

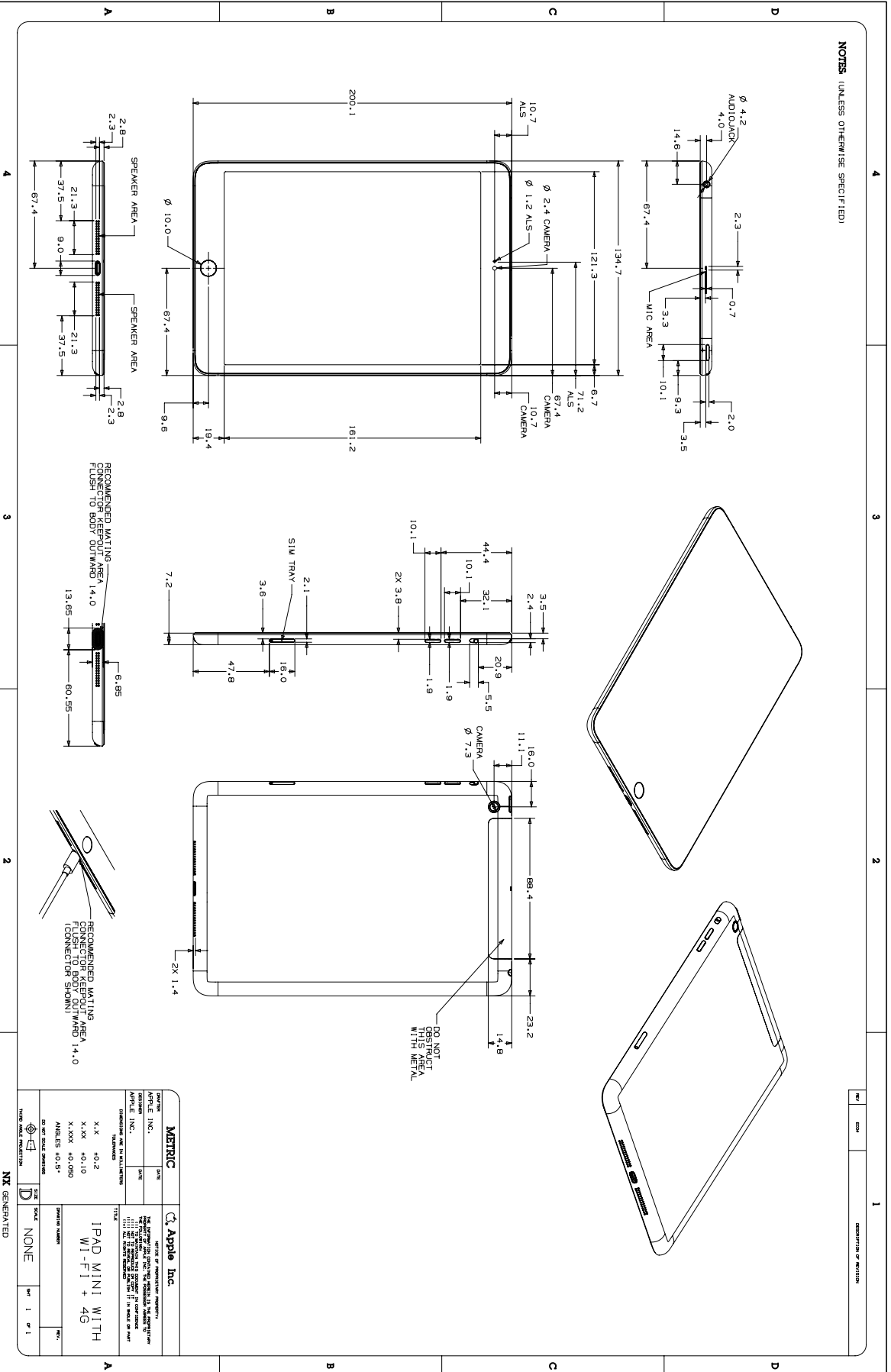


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APPROVED	DATE	DATE	DATE
CONSTRUCTION		TITLE	
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SIZE		SCALE	
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SHEET		OF 1	
NX GENERATED		REV.	

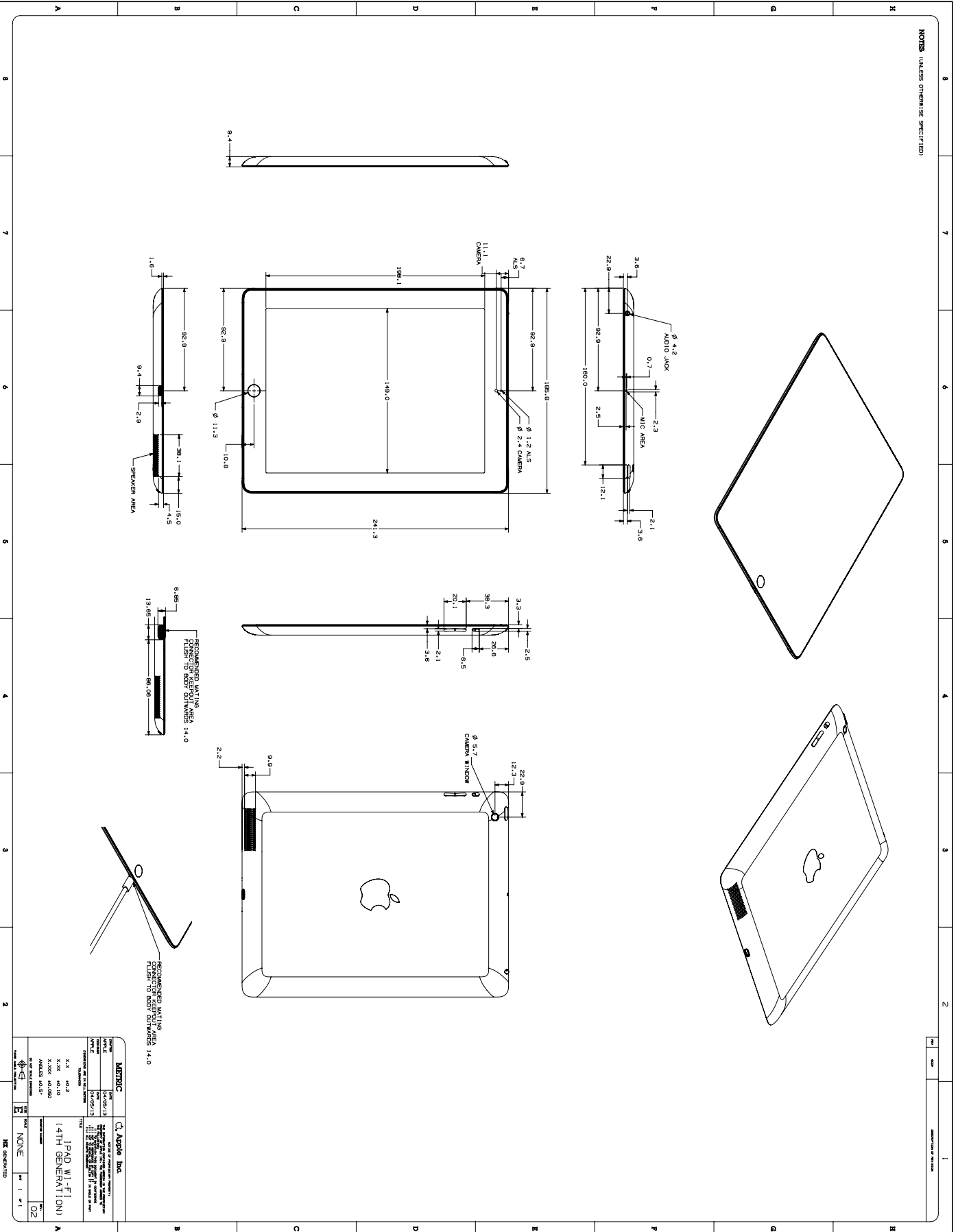
44.116 iPad Air with Wi-Fi + Cellular



44.118 iPad mini with Wi-Fi + Cellular

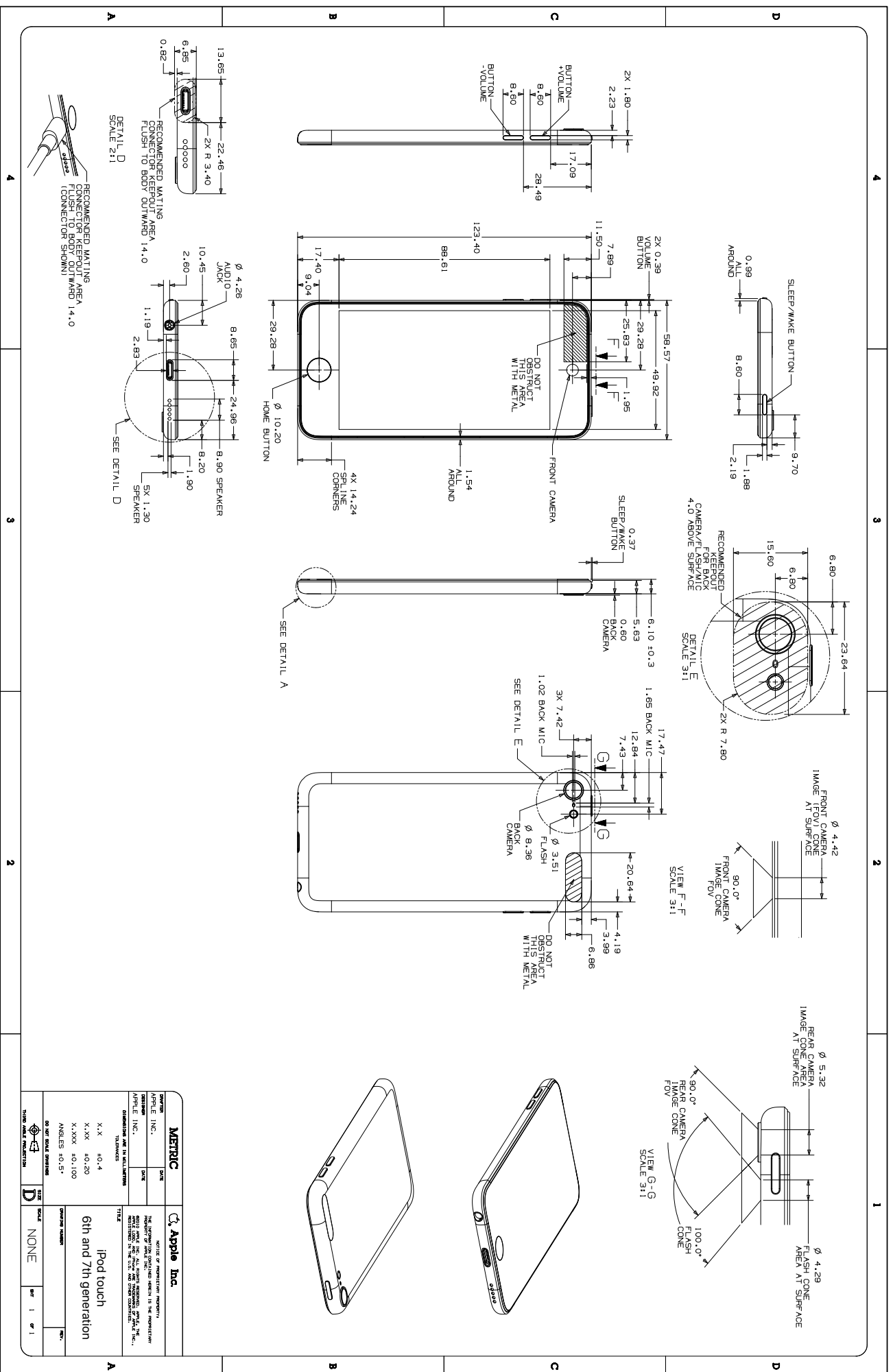


44.119 iPad (4th generation) with Wi-Fi

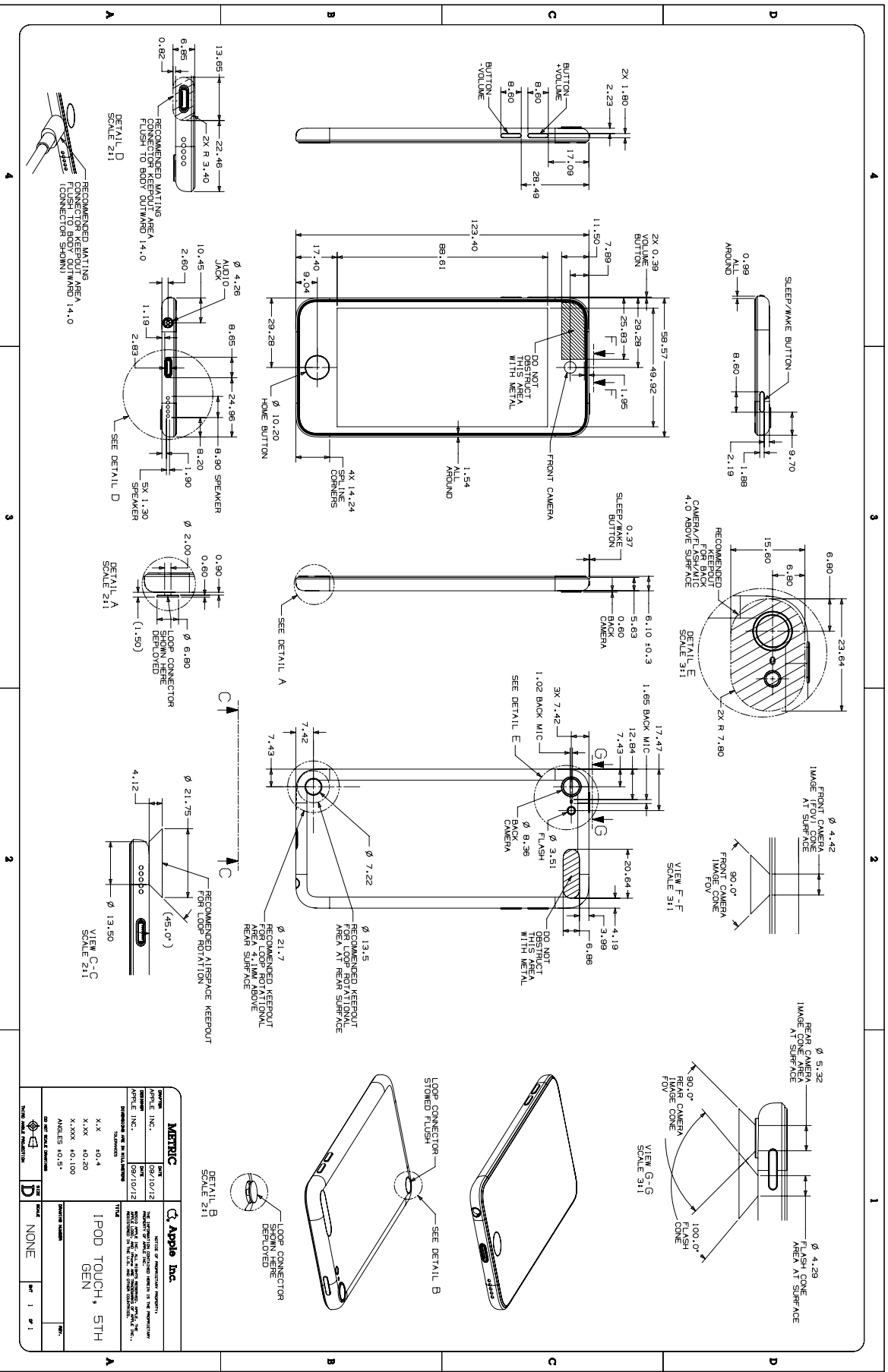


METRIC		Apple Inc.	
DATE	REV	DESCRIPTION	BY
2011/07/19	1	44.119 iPad (4th generation) with Wi-Fi	Apple Inc.
2011/07/19	1	44.119 iPad (4th generation) with Wi-Fi	Apple Inc.
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN MILLIMETERS			
TOLERANCES UNLESS OTHERWISE SPECIFIED:			
3.X	±0.2		
3.XX	±0.05		
3.XXX	±0.02		
ANGLES	±0.5°		
DIMENSIONS IN BRACKET ARE NONE			
NONE			
1			
02			

4.4.121 iPod touch (6th generation) & iPod touch (7th generation)

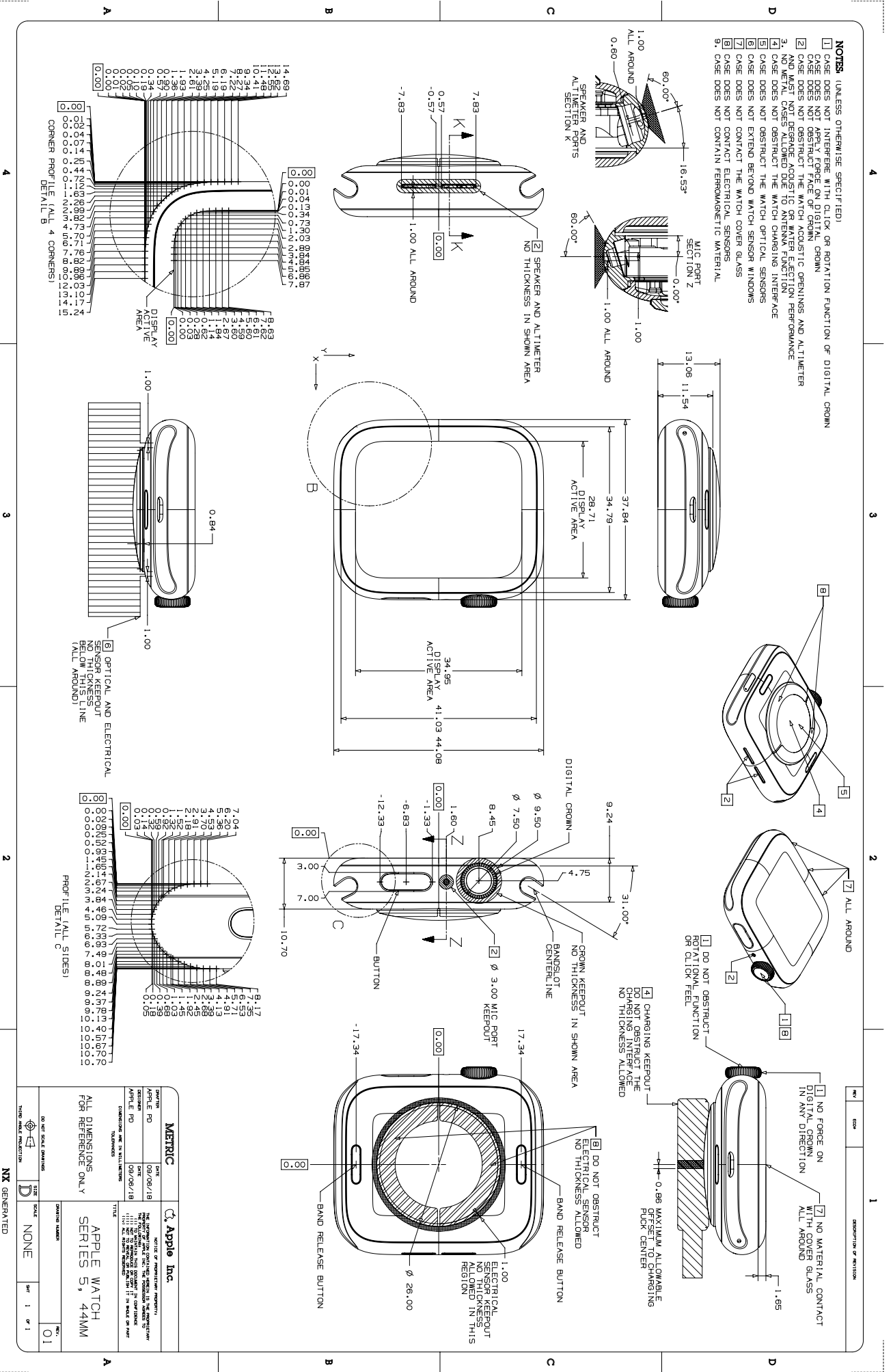


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DATE	DATE	DATE OF REVISION	REVISION
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REVISION	DATE	DESCRIPTION	DATE
APPLE INC.		DESCRIPTION AND DATE OF REVISION	
		X.XX ±0.4	
		X.XXX ±0.20	
		X.XXXX ±0.100	
		ANGLES ±0.5°	
		DO NOT SCALE DRAWING	
		THIS DRAWING IS UNCONTROLLED	
		DATE	SCALE
		NONE	
		SHEET	1 OF 1
TITLE		iPod touch 6th and 7th generation	
DRAWING NUMBER			
REV.			



44.127 Apple Watch Series 5, 44 mm

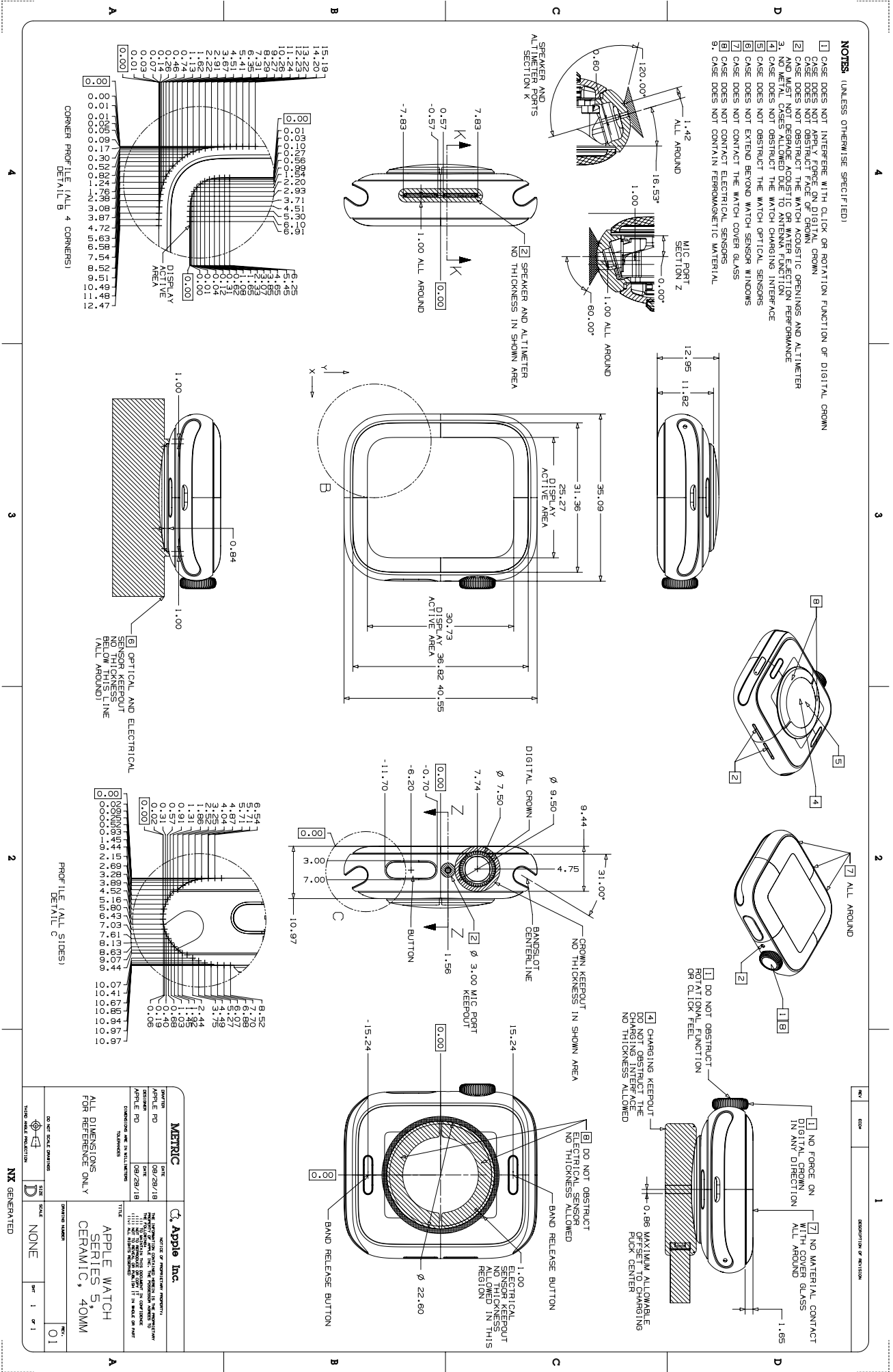
- NOTES** (UNLESS OTHERWISE SPECIFIED):
- 1 CASE DOES NOT INTERFERE WITH CLICK OR ROTATION FUNCTION OF DIGITAL CROWN
 - 2 CASE DOES NOT APPLY FORCE ON DIGITAL CROWN
 - 3 CASE DOES NOT OBSTRUCT FACE OF CROWN
 - 4 CASE DOES NOT OBSTRUCT THE WATCH ADJUSTIC OPENINGS AND ALTIMETER
 - 5 CASE DOES NOT OBSTRUCT THE WATCH CHARGING INTERFERENCE PERFORMANCE
 - 6 NO METAL CASES ALLOWED DUE TO ANTENNA FUNCTION
 - 7 CASE DOES NOT OBSTRUCT THE WATCH CHARGING INTERFACE
 - 8 CASE DOES NOT OBSTRUCT THE WATCH OPTICAL SENSORS
 - 9 CASE DOES NOT EXTEND BEYOND WATCH SENSOR WINDOWS
 - 10 CASE DOES NOT CONTACT BEYOND WATCH SENSOR GLASS
 - 11 CASE DOES NOT CONTACT ELECTRICAL SENSORS
 - 12 CASE DOES NOT CONTAIN FERROMAGNETIC MATERIAL



METRIC		DATE		SCALE	REV
DATE	09/08/18	DATE	09/08/18	NONE	1 of 1
DESIGNED BY	APPLE PD	DRAWN BY	APPLE PD		
CHECKED BY: [REDACTED]		DATE: [REDACTED]			
APPLE WATCH SERIES 5, 44MM					
ALL DIMENSIONS FOR REFERENCE ONLY					
DRAWING NUMBER: 01					

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44.130 Apple Watch Series 5 Ceramic, 40 mm



NOTES (UNLESS OTHERWISE SPECIFIED)

- CASE DOES NOT INTERFERE WITH CLICK OR ROTATION FUNCTION OF DIGITAL CROWN
- CASE DOES NOT APPLY FORCE ON DIGITAL CROWN
- CASE DOES NOT OBSTRUCT THE WATCH ACQUISITION OPENINGS AND ATTINETER
- NO METAL CASES ALLOWED DUE TO ANTENNA FUNCTION
- CASE DOES NOT OBSTRUCT THE WATCH CHARGING INTERFACE
- CASE DOES NOT EXTEND BEYOND WATCH SENSOR WINDOWS
- CASE DOES NOT CONTACT THE WATCH COVER GLASS
- CASE DOES NOT CONTACT ELECTRICAL SENSORS
- CASE DOES NOT CONTAIN FERROMAGNETIC MATERIAL

REV	DATE	DESCRIPTION OF REVISION
1		

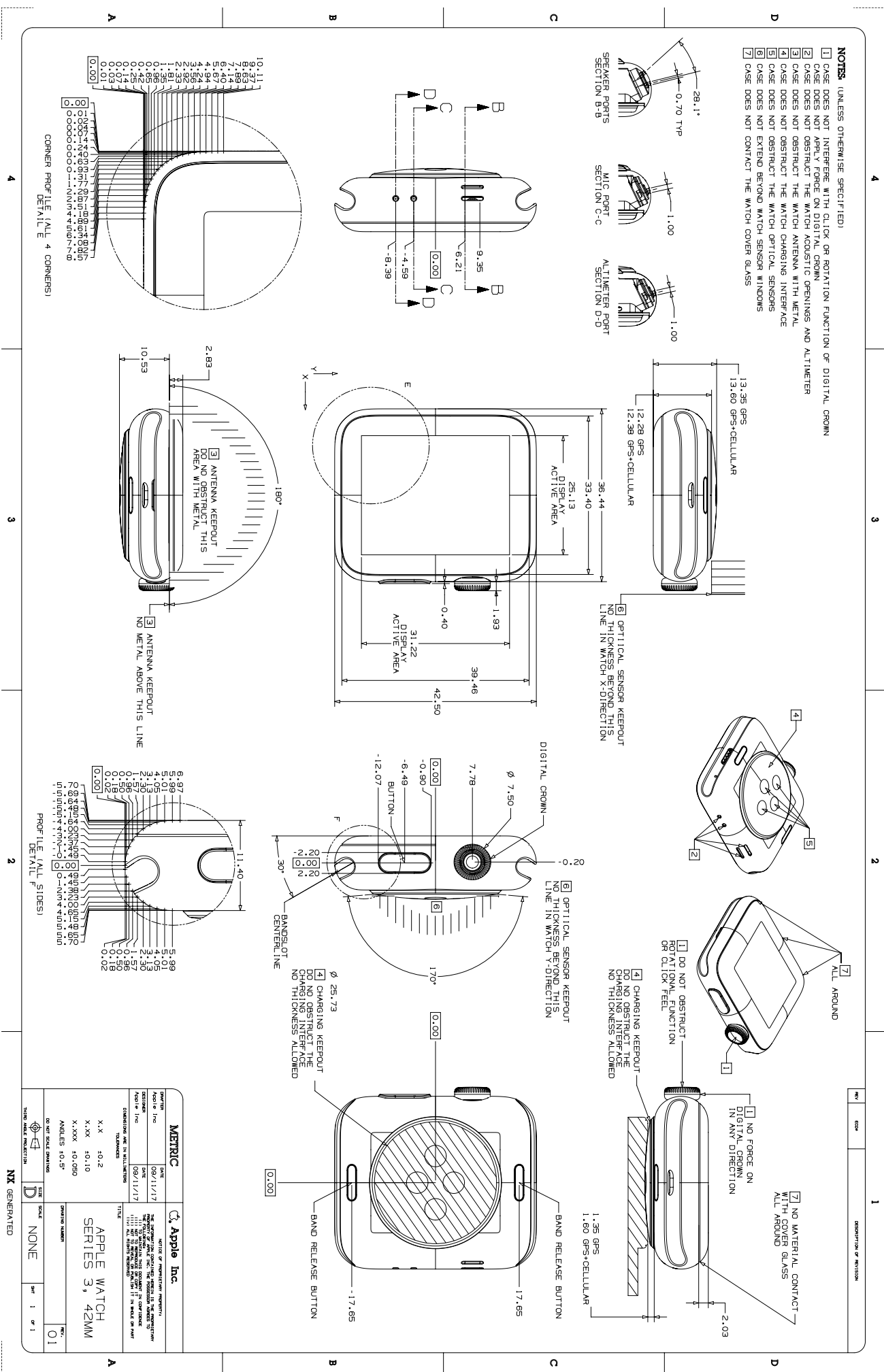
METRIC		DATE	
APPLE ID	09/28/18	DATE	09/28/18
APPLE PD	09/28/18	DATE	09/28/18

ALL DIMENSIONS FOR REFERENCE ONLY

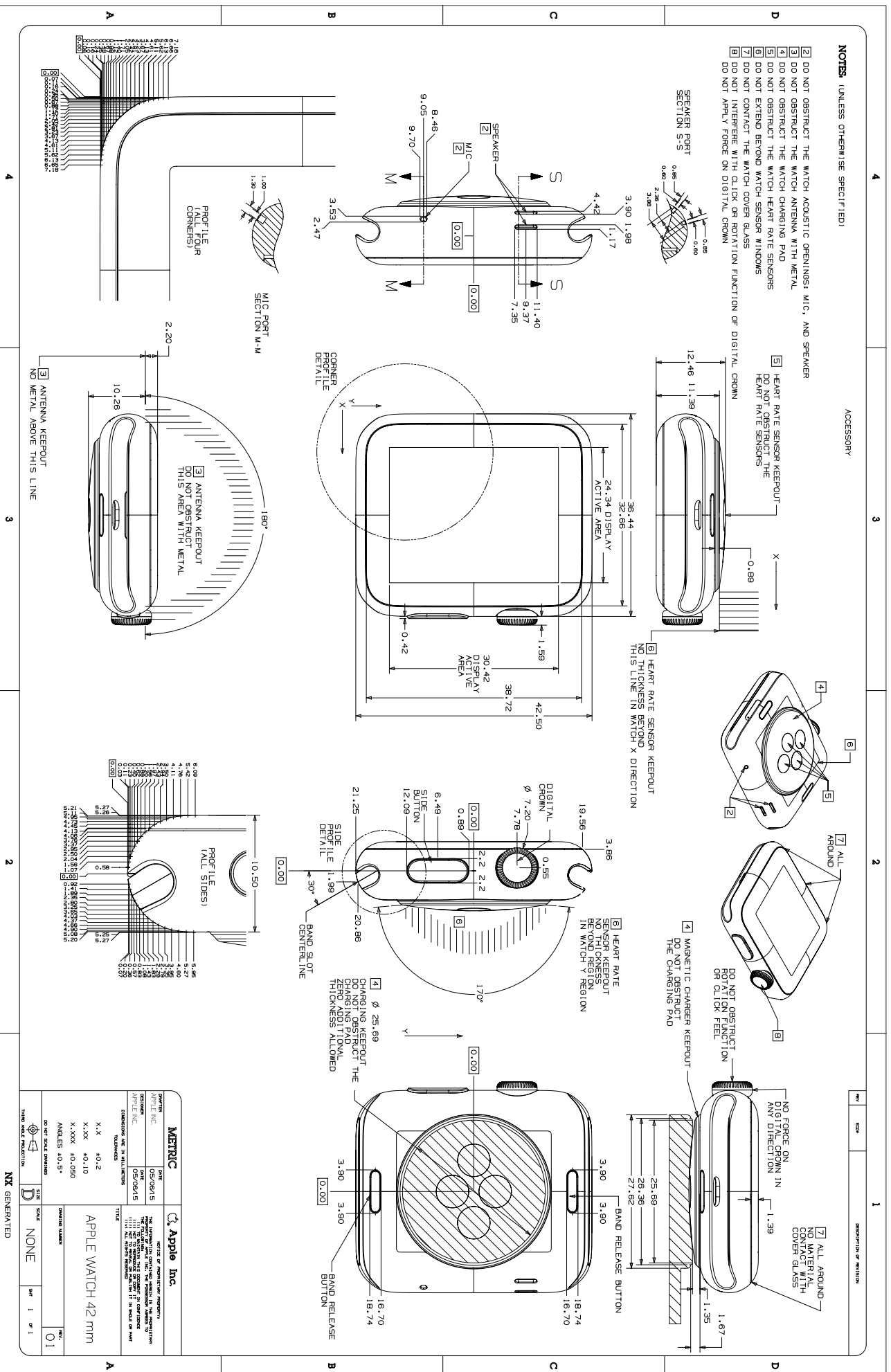
Apple Inc.
Apple Watch Series 5, 40mm Ceramic

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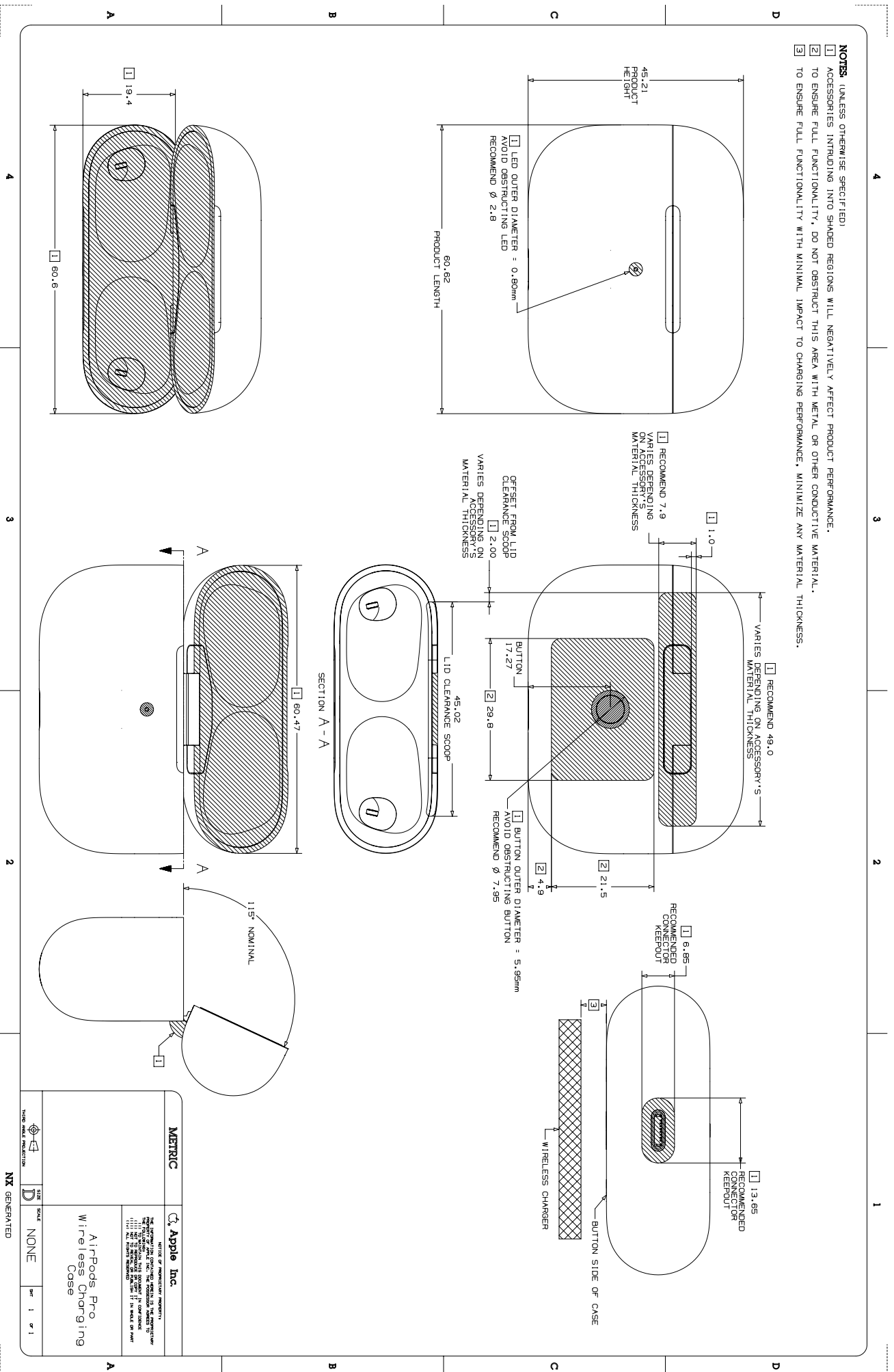
44.135 Apple Watch Series 3 Metal, 42 mm



44.141 Apple Watch (1st generation) & Apple Watch Series 1, 42 mm



44.143 AirPods Pro Wireless Charging Case

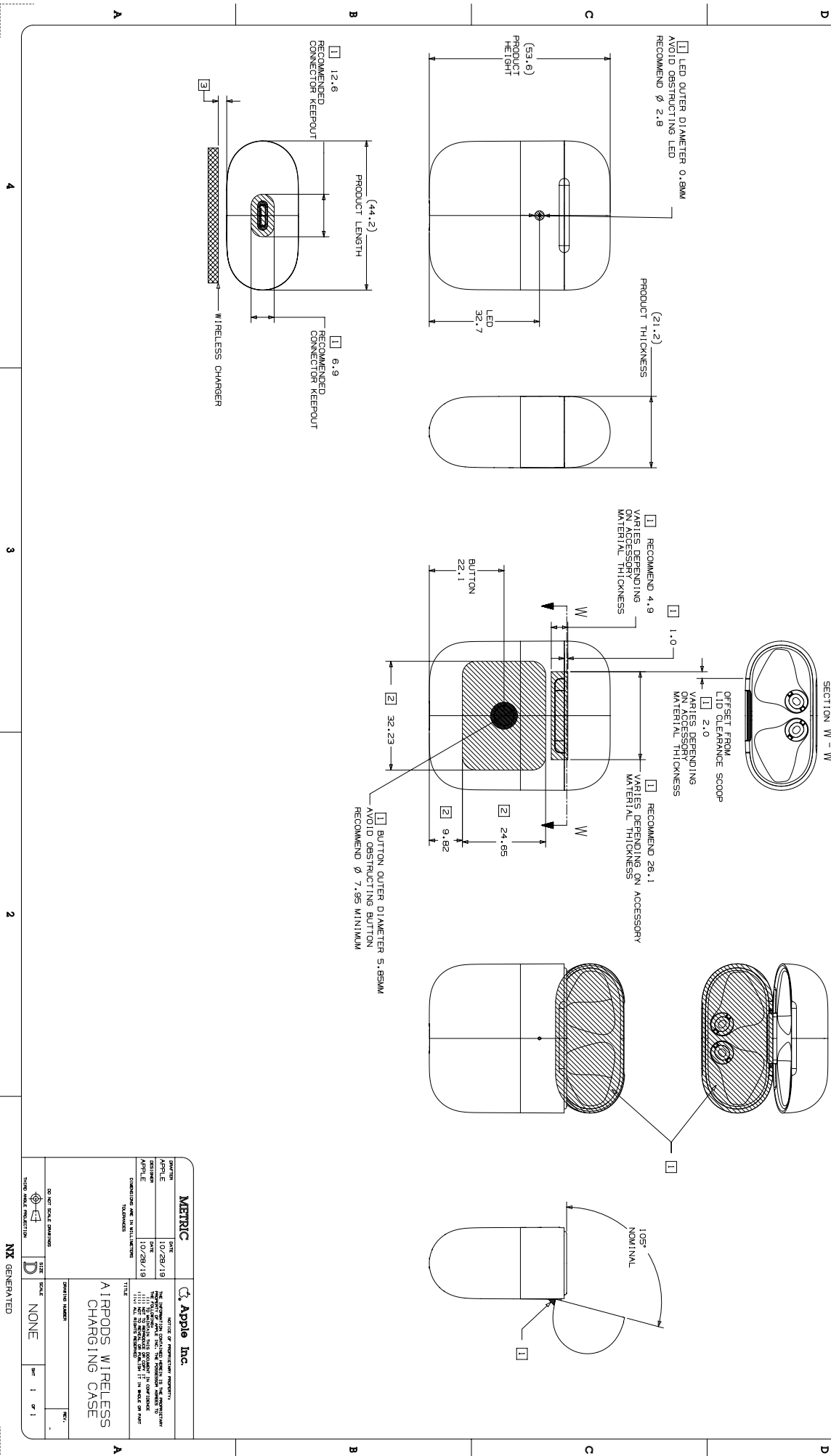


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THIRD ANGLE PROJECTION	THE SCALE	NONE	SHEET 1 OF 1
NX GENERATED			

44.144 AirPods Wireless Charging Case

NOTES (UNLESS OTHERWISE SPECIFIED)

- 1 ACCESSORIES INTRUDING INTO SHADED REGIONS WILL NEGATIVELY AFFECT PRODUCT PERFORMANCE.
- 2 TO ENSURE FULL FUNCTIONALITY, DO NOT OBSTRUCT INDICATED AREA WITH METAL OR OTHER CONDUCTIVE MATERIAL.
- 3 TO ENSURE FULL FUNCTIONALITY WITH MINIMAL IMPACT TO CHARGING PERFORMANCE, MINIMIZE ANY MATERIAL THICKNESS.

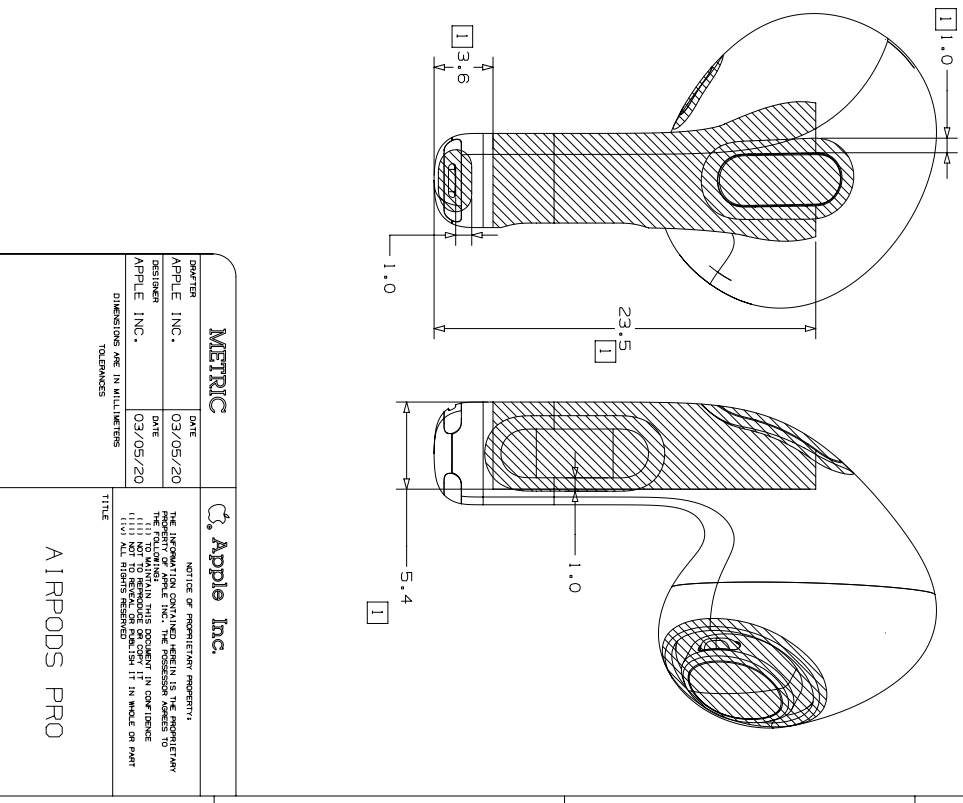
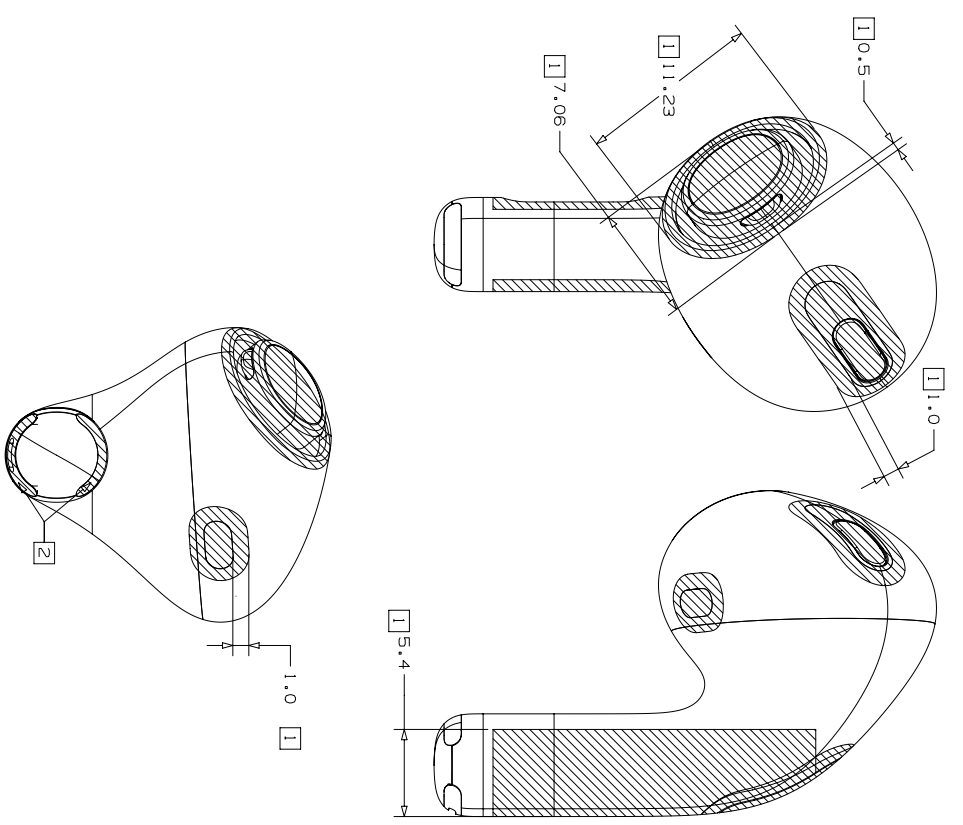


METRIC		Apple Inc.	
DATE	10/28/18	DATE	10/28/18
DESIGNED BY	APPLE	DESIGNED BY	APPLE
CHANGING NAME TO BULK/UNIT		CHANGING NAME TO BULK/UNIT	
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DRAWING NUMBER		SCALE	
NONE		NONE	
SHEET 1 OF 1		SHEET 1 OF 1	
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44.145 AirPods Pro

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1		

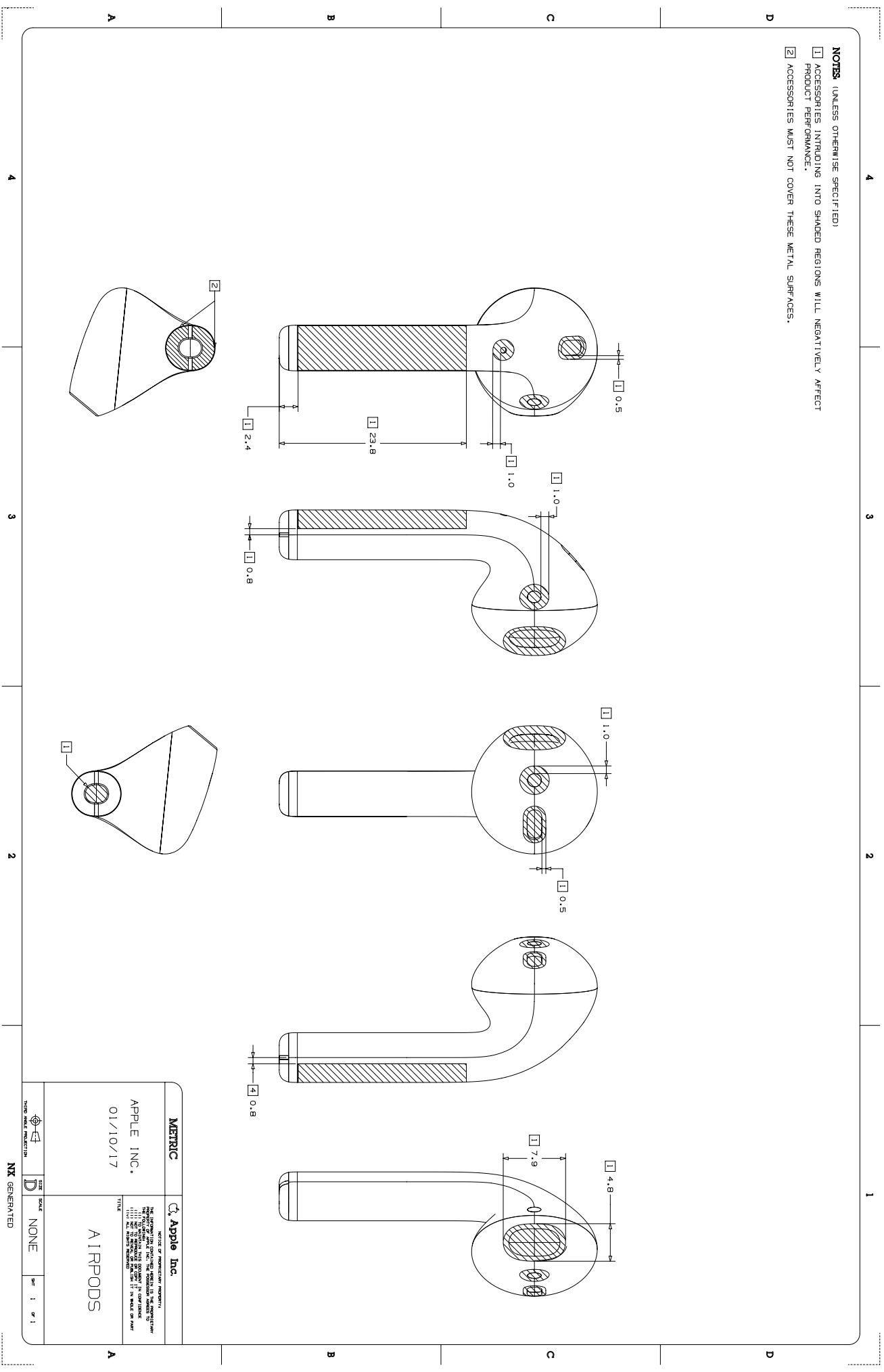
NOTES: (UNLESS OTHERWISE SPECIFIED)
 [1] ACCESSORIES INTRUDING INTO SHADED REGIONS WILL NEGATIVELY AFFECT PRODUCT PERFORMANCE
 [2] ACCESSORIES MUST NOT COVER THESE METAL SURFACES



METRIC		DATE		DRAWING NUMBER		REV.	
DRAWER	APPLE INC.	DATE	03/05/20	DRAWING NUMBER			REV.
DESIGNER	APPLE INC.	DATE	03/05/20	TITLE	AIRPODS PRO		01
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DO NOT SCALE DRAWINGS				THIRD ANGLE PROJECTION			
NX GENERATED							

44.146 AirPods

NOTES (UNLESS OTHERWISE SPECIFIED)
 [1] ACCESSORIES INTRUDING INTO SHADED REGIONS WILL NEGATIVELY AFFECT PRODUCT PERFORMANCE.
 [2] ACCESSORIES MUST NOT COVER THESE METAL SURFACES.



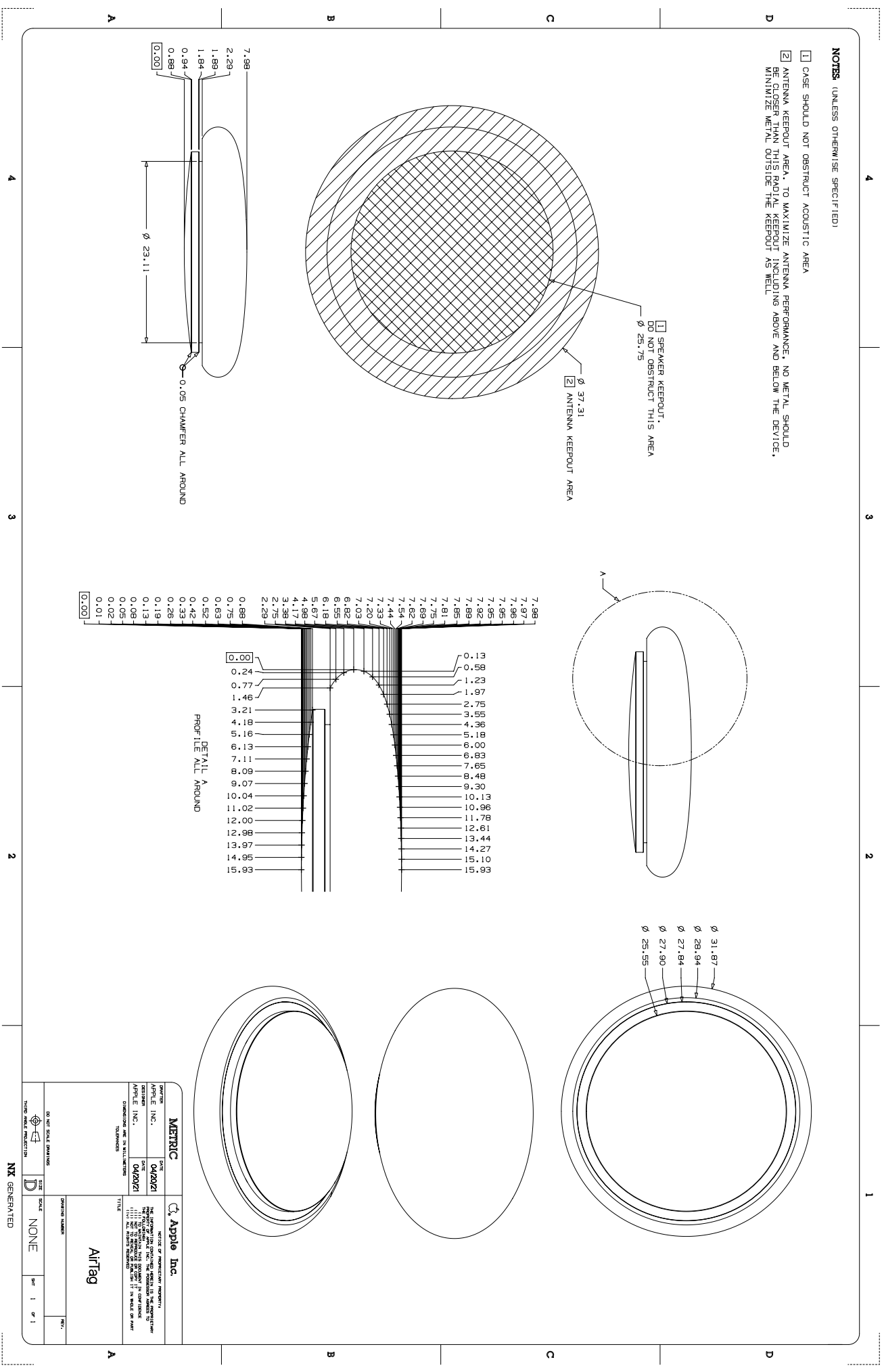
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TITLE AIRPODS	
THE DATE PUBLISHED NONE	THE SCALE NONE
THE DATE REVISION NONE	SHEET 1 OF 1

NX GENERATED

44.147 AirTag

NOTES (UNLESS OTHERWISE SPECIFIED)

- 1 CASE SHOULD NOT OBSTRUCT ACOUSTIC AREA
- 2 ANTENNA KEEP-OUT AREA. TO MAXIMIZE ANTENNA PERFORMANCE, NO METAL SHOULD BE CLOSER THAN THIS RADIAL KEEP-OUT INCLUDING ABOVE AND BELOW THE DEVICE, MINIMIZE METAL OUTSIDE THE KEEP-OUT AS WELL
- 3 SPEAKER KEEP-OUT. DO NOT OBSTRUCT THIS AREA. ϕ 25.75
- 4 ANTENNA KEEP-OUT AREA. ϕ 37.31



METRIC		Apple Inc.	
DATE	04/20/21	DESIGNER	Apple Inc.
APPROVED	Apple Inc.	DATE	04/20/21
DIMENSIONS ARE IN MILLIMETERS		TITLE: AirTag	
DO NOT SCALE DRAWINGS		DRAWING NUMBER	
HIDDEN LINE PROJECTION		SCALE: NONE	
NX GENERATED		SHEET: 1 OF 1	

45. Revision History

This chapter describes changes to the Accessory Design Guidelines for Apple Devices from the previous revision.

Added Content

- [Control Surface](#) (page 17)
- [Direct User Action](#) (page 18)
- [Apple MFi Licensing Program](#) (page 19)
- [Optical Transmission](#) (page 57)
- [Transmission Haze](#) (page 58)
- [Keyboards](#) (page 68)
- [Trackpads](#) (page 74)
- [MagSafe Attach](#) (page 108)
 - [Accessory Clearance](#) (page 124)
- [Human Interface Device \(HID\)](#) (page 161)
- [iPhone 13 Pro Max 1 of 2](#) (page 196)
- [iPhone 13 Pro Max 2 of 2](#) (page 197)
- [iPhone 13 Pro 1 of 2](#) (page 198)
- [iPhone 13 Pro 2 of 2](#) (page 199)
- [iPhone 13 1 of 2](#) (page 200)
- [iPhone 13 2 of 2](#) (page 201)
- [iPhone 13 mini 1 of 2](#) (page 202)
- [iPhone 13 mini 2 of 2](#) (page 203)
- [iPad mini \(6th generation\) 1 of 6](#) (page 231)
- [iPad mini \(6th generation\) 2 of 6](#) (page 232)
- [iPad mini \(6th generation\) 3 of 6](#) (page 233)
- [iPad mini \(6th generation\) 4 of 6](#) (page 234)
- [iPad mini \(6th generation\) 5 of 6](#) (page 235)
- [iPad mini \(6th generation\) 6 of 6](#) (page 236)
- [iPad \(9th generation\), iPad \(8th generation\) and iPad \(7th generation\) 1 of 4](#) (page 237)
- [iPad \(9th generation\), iPad \(8th generation\) and iPad \(7th generation\) 2 of 4](#) (page 238)
- [iPad \(9th generation\), iPad \(8th generation\) and iPad \(7th generation\) 3 of 4](#) (page 239)
- [iPad \(9th generation\), iPad \(8th generation\) and iPad \(7th generation\) 4 of 4](#) (page 240)

- [Siri Remote \(2nd generation\)](#) (page 343)

Updated Content

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- [Near Field Communication \(NFC\)](#) (page 24)
- [Edge Swipe Gestures](#) (page 29)
- [Cover Glass Contact](#) (page 30)
- [Taptic Engine](#) (page 34)
- [Device Models](#) (page 38)
- [Smart Covers](#) (page 55)
- [Strobes](#) (page 66)
- [Fast Charge for iPhone \(20 W\)](#) (page 101)
- [Device Power \(Inductive\)](#) (page 104)
- [MagSafe Attach](#) (page 108)



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