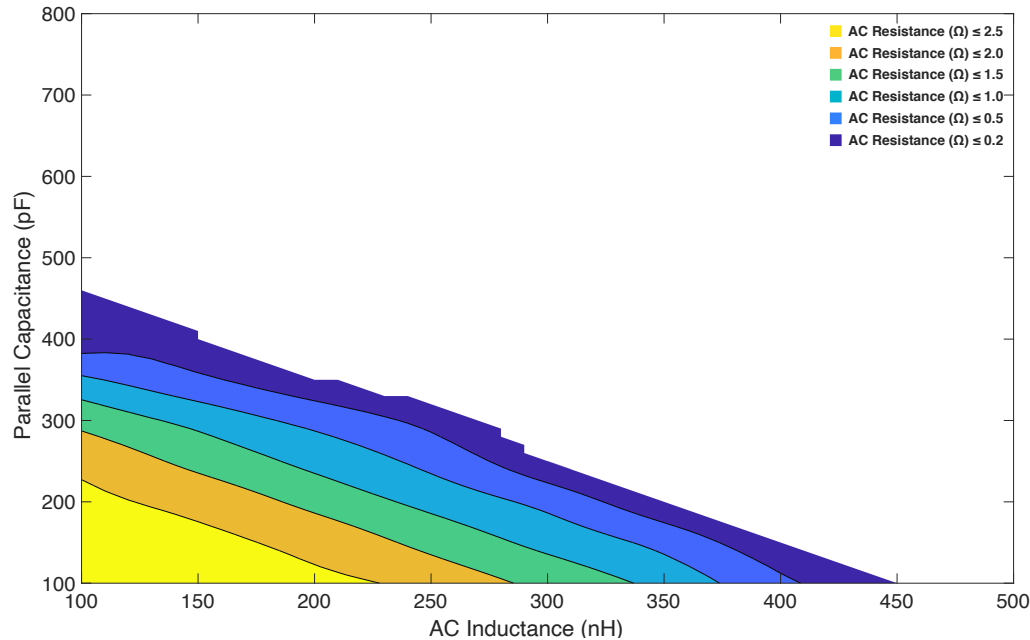


Figure 72-4 Watch Fast Charger Module cable requirements at 1.778 MHz



72.3.4.1 Measuring Cable Performance

AC resistance and AC inductance shall be measured between the COIL+ and COIL- signals at one end of the cable, shorting COIL+ / COIL- at the other end of the cable.

Parallel capacitance shall be measured between COIL+ and the COIL- signals at one end of the cable, leaving COIL+ / COIL- at the other end of the cable open.

Measurements should be taken when the cable is straight. Ground shielding should be left floating for all measurements.

Recommended equipment for measuring cable performance:

- VNA
- LCR meter
- Impedance analyzer

Recommended VNA settings:

- Set IF Bandwidth 10 kHz.
- Perform calibration from 100 kHz to 10 MHz.
- Max number of points.
- Markers set to the operating frequencies defined in [Operating Frequency](#) (page 658).

72.3.5 EMC

Accessories integrating the C962 should be designed for [Electromagnetic Compatibility \(EMC\)](#) (page 328).

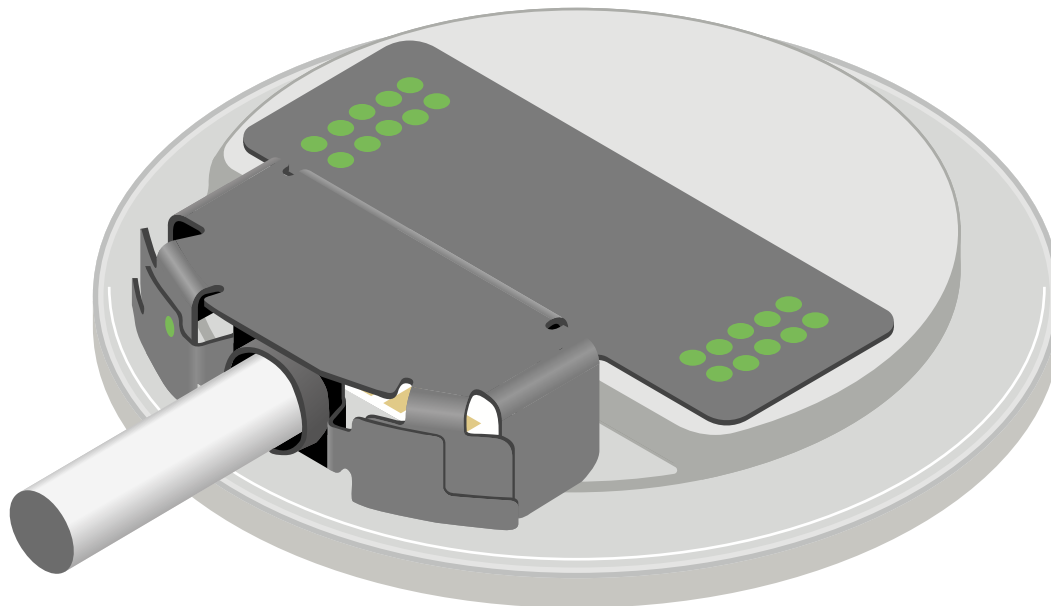
A variety of Apple Watch models and wristband combinations should be tested with the C962 accessory for EMC performance.

Accessories with metal enclosures should ensure a reliable electrical and mechanical connection between the accessory enclosure and the C962 inductive coil module to avoid a secondary discharge to the C962 inductive coil.

The cable shield connecting the C962 inductive coil module should be connected as in [Figure 72-5](#) (page 661) by:

1. Twisting one half and soldering it onto the C962 inductive coil module ground.
2. Folding back one half and laser welding to the shell.

Figure 72-5 Cable and C962 Inductive Coil Module

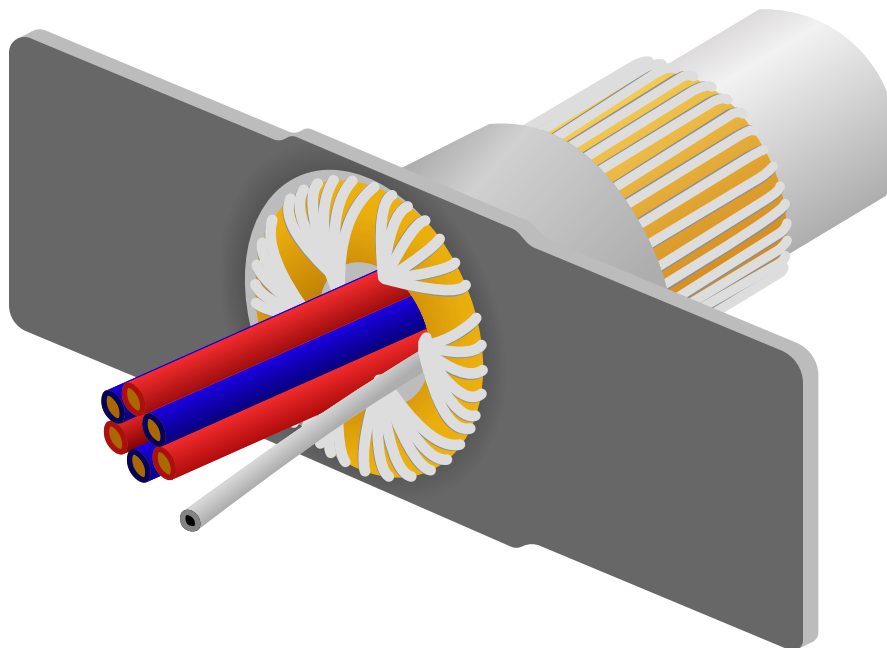


The cable shield connecting the C962 control module should be connected as in [Figure 72-6](#) (page 662) by:

1. Twisting one half and soldering it onto the C962 control module ground.
2. Folding back one half and laser welding to the crimp.

Accessories with a USB connector and longer USB D+/D- signal wires should consider additional ESD protection such as differential TVS diodes.

Figure Cable Crimp
72-6



An EMI shell for the C962 control module should be used. The EMI shell should be connected to the system ground.

C962 control module ground DC resistance should be $<1\ \Omega$.

RF absorber material may be wrapped around the cable core to further attenuate EMI noise and reduce emissions. Wrap the absorber material around the shield before applying the jacket. The absorber should be $>35\ \mu\text{m}$ thick and should have:

- $\mu' > 90$, $\mu'' > 35$ @ 30 MHz.
- $\mu' > 60$, $\mu'' > 40$ @ 100 MHz.

Note:

Accessories with cables $>30\ \text{cm}$ may benefit the most from added RF absorbers.

Figure 72-7 Cable Absorber

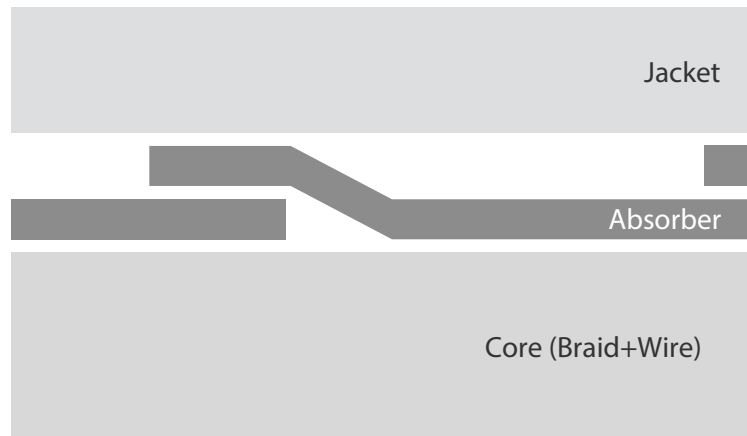
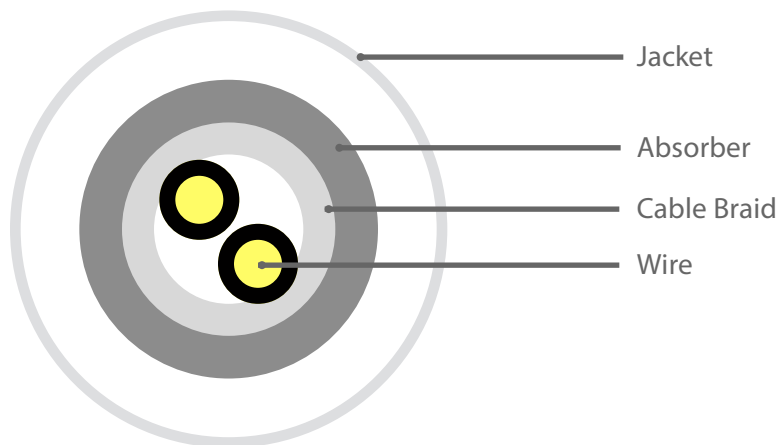


Figure 72-8 Cable Core



A common mode choke effective at 30–100 MHz should be included in the accessory's internal power supply or in any bundled power adapters. The common mode choke should have:

- $Z > 200 \, \Omega$ @ 30 MHz.
- $Z > 500 \, \Omega$ @ 100 MHz.

If the accessory includes a bundled power adapter, a ferrite core with high impedance in 30–100 MHz frequency range may be added to the power cord to reduce emissions. The ferrite core should have:

- $Z > 130 \, \Omega$ @ 25 MHz.
- $Z > 260 \, \Omega$ @ 100 MHz.

To reduce common mode noise potential, the accessory may include grounded metal outside of the module area to increase capacitance between the accessory and the device.

72.3.6 Inductive Coil

The C962 inductive coil has 9 turns with an outer diameter of ≈ 21.34 mm.

When an Apple Watch is attached, the C962 inductive coil module has an effective temperature limit of 45 °C.

72.4 Control Module

The C962 control module has a 60 °C temperature limit.

72.4.1 Firmware Update Over USB

C962 control module supports firmware updates over USB-C from Mac computers. To register an accessory for this support, email a request to `mfi-uarp-adopters@group.apple.com` with the following:

- Email subject containing the:
 - Module name ("C962").
 - Accessory's USB VID/PID in hex (for example, "XXXX/XXXX").
- Email body containing:
 - Requesting company's name.
 - MFi Product Plan UID (PPUID) from the MFi portal (for example, "XXXXXXXXXXXXXXXXXX").
 - MFi Product Plan ID (PPID) from the MFi portal (for example, "XXXXXX-XXXXXX").
 - Enable after date (optional).

72.5 Factory Configuration

The C962 exposes a USB HID interface to use for factory configuration. Connect the pads to a cable terminating in a USB-A plug or USB-C plug to access the interface.

The C962 factory configuration reference app available in the MFi Portal provides commands to set and read each configuration parameter.

72.5.1 Parameters

The following parameters shall be configured at the time of accessory manufacturing:

- [Vendor ID](#) (page 665)
- [Product ID](#) (page 665)
- [Product Plan UID](#) (page 665)
- [Vendor Name](#) (page 666)
- [Product Name](#) (page 666)
- [Model Number](#) (page 666)
- [Serial Number](#) (page 666)
- [Power Mode](#) (page 666)
- [AC Resistance](#) (page 666)
- [Vendor Lock](#) (page 666)

Every C962:

- Shall set the Vendor ID (VID) as assigned by the USB-IF and a unique Product ID (PID) assigned by the accessory developer. The VID shall correspond to the brand name appearing on the accessory or its packaging. See [USB Host Mode](#) (page 491).
- Shall set the Vendor Name, Product Name, and Model Number to human-readable strings matching names appearing on the accessory or its packaging.
- Shall not be configured with empty strings or generic string values.
- Shall be configured with a unique serialized Serial Number.

72.5.1.1 Vendor ID

The vendor ID (VID) from the manufacturer.

72.5.1.2 Product ID

The product ID (PID) from the manufacturer.

72.5.1.3 Product Plan UID

The Product Plan's UID (PPUID) from the MFi portal (up to 36 UTF8 characters). Note: the Product Plan UID is different from the Product Plan ID.

72. Apple Watch Fast Charger Module

72.5 Factory Configuration

72.5.1.4 Vendor Name

The vendor name from the manufacturer (up to 64 UTF8 characters).

72.5.1.5 Product Name

The product name from the manufacturer (up to 64 UTF8 characters).

72.5.1.6 Model Number

The model number from the manufacturer (up to 32 UTF8 characters).

72.5.1.7 Serial Number

The serial number from the manufacturer (up to 32 UTF8 characters).

72.5.1.8 Power Mode

A number indicating the power mode:

- 1 = USB-A mode.
- 2 = USB-C / USB-PD mode.
- 3 = 5 V mode. Input voltage and operating current range is fixed.
- All other values are reserved.

72.5.1.9 AC Resistance

The AC resistance (in mΩ) measured at 326.5 kHz of the [Cable](#) (page 658) connecting the C962 control module and C962 inductive coil module (for example, 500 for 500 mΩ).

72.5.1.10 Vendor Lock

A number indicating the configuration lock mode:

- 0 = Unlocked.
- 1 = Temporarily use the configured parameters to enumerate over USB on the next boot, then return to factory configuration mode on the following boot. This setting may be used to verify the parameters have been set correctly. This setting does not enable inductive charging.
- 2 = Permanently lock configuration on the next boot. This setting shall be used for all production units.
- All other values are reserved.

72.5.2 Examples

72.5.2.1 Configure, Verify, and Lock

The following is an example factory configuration sequence which permanently locks the C962 immediately after configuration:

1. Apply power to the C962 and connect to the USB HID interface.
2. Issues all commands to configure the C962 control module.
3. Verify all parameters are set to the expected values.
4. Set the [Vendor Lock](#) (page 666) to 2 (permanently lock firmware configuration).
5. Cycle power, the C962 permanently boots in production mode.

72.5.2.2 Configure and Test

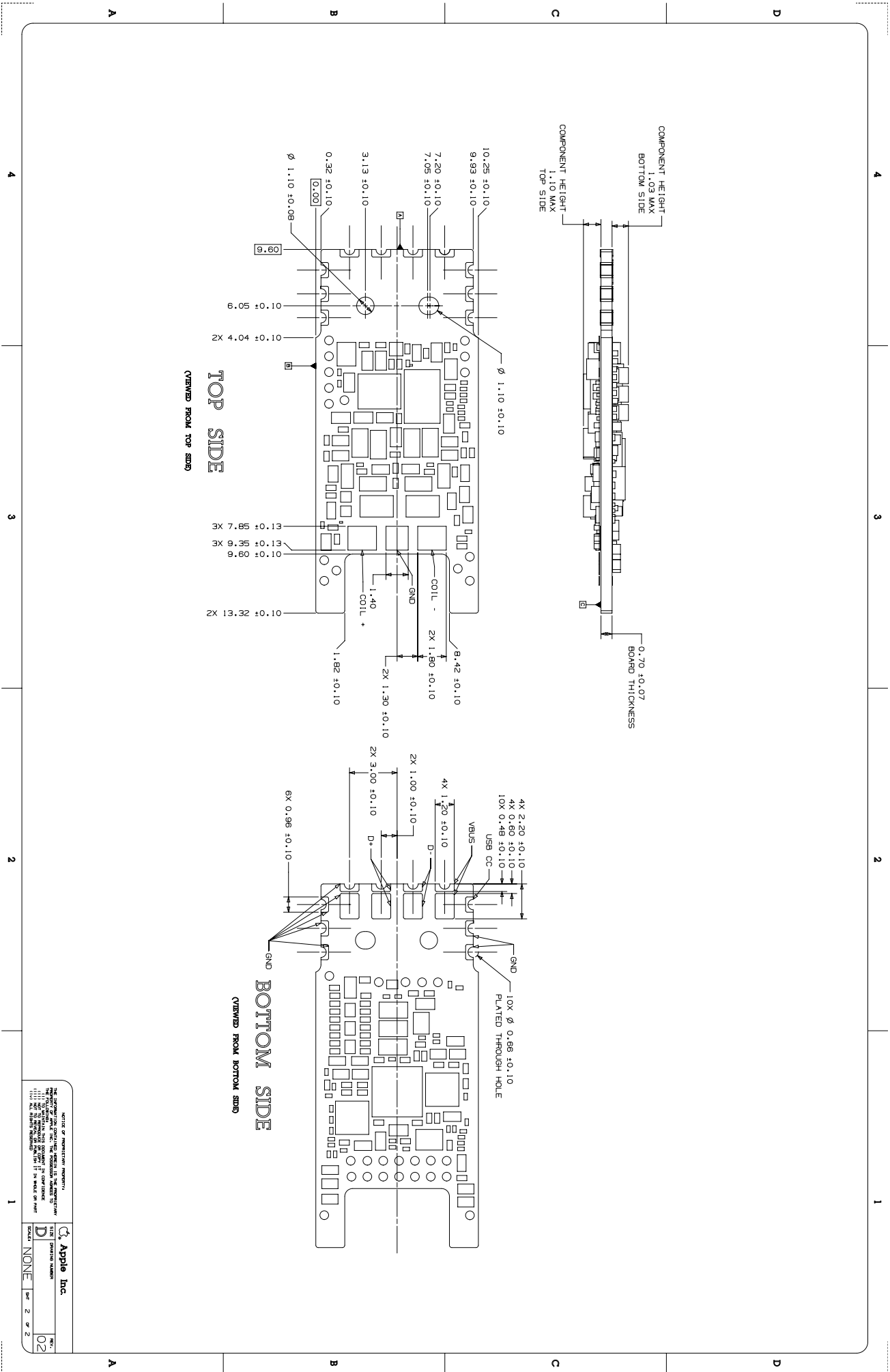
The following is an example manual configuration sequence to tests the configuration, but does not permanently lock the C962:

1. Apply power to the C962 and connect to the USB HID interface.
2. Issues all commands to configure the C962 control module.
3. Set the [Vendor Lock](#) (page 666) to 1 (next boot will use configured parameter values for testing).
4. Cycle power.
5. The C962 boots, enumerating using the configured parameters.
6. Verify the C962 has been correctly configured using the following procedure on a Mac (or its equivalent for another computer/operating system combination):
 - a. Open *System Information* on the Mac.
 - b. Select *USB* under the *Hardware* category on the left pane.
 - c. Verify the "Example Product" is listed in the USB device tree.
 - d. Select the "Example Product" and verify all displayed values, for example, Product Name, Product ID, Vendor ID, Serial Number, Manufacturer (Vendor Name).
7. Cycle power and connect to the USB HID interface to continue configuration.

72.6 Watch Fast Charger Inductive Coil Module Dimensions

[illegible]

72.7 Watch Fast Charger Control Module Dimensions



72.8 Test Procedures

Test procedures for accessories integrating the C962 are contained in this section. Tests should be performed with an Apple Watch 44 mm Stainless Steel Case with Link Bracelet.

72.8.1 Mechanical

This section contains mechanical test procedures for accessories integrating the C962.

72.8.1.1 Product Design

1. Verify the accessory:
 - a. Is intended for stationary use.
 - b. Does not require the watch band to be removed or detached.
 - c. Does not scratch or damage the body of the Apple Watch or watch band when connected.
2. Verify the accessory does not have ferromagnetic steel in proximity to the C962.
3. Use calipers to verify the C962 is 0.40 mm $\pm$ 0.25 mm proud of the accessory surface.

When mounted horizontally:

1. Use a protractor to verify the C962 is not mounted at an angle greater than 45° from horizontal.

When mounted vertically:

1. Verify the accessory's mounting angle is not adjustable.
2. Verify all Apple Watch model and band configurations are supported with the watch on its side (crown up).
3. Verify the accessory has an alignment feature ensuring the center of the Apple Watch aligns with the center of the C962 within $\pm$ 1.0 mm.

72.8.1.2 Drop Test

1. Drop the accessory onto a plywood surface from a height of 32 inches.
2. Verify the C962 has not been dislodged from the dropped accessory.
3. Verify the dropped accessory continues to charge the Apple Watch.

72.8.2 Electrical

This section contains electrical test procedures for accessories integrating the C962.

72.8.2.1 Internal Power Supplies

This section contains electrical test procedures for accessories containing internal power supplies.

72.8.2.1.1 Equipment

The following equipment is needed to perform the electrical test procedures:

- An electronic load rated at 10 W or higher, capable of constant current (CC) mode.
- An oscilloscope with a 100 MHz or higher bandwidth.

72.8.2.1.2 Test Setup

1. Disconnect the C962 from the accessory's power source.
2. Connect the electronic load and the oscilloscope channel to VBUS and GND signals in the accessory.
3. Reconnect the C962 to the power source.

72.8.2.1.3 Supply Voltage (DC)

1. Configure the oscilloscope with:
 - Horizontal scale: 1 ms/div
 - Vertical scale: 1 V/div
 - Channel coupling: DC
2. With the electronic load set to CC mode, record the average VBUS voltage on the scope for each load from 0 A to 1 A in 200 mA steps.
3. Verify all the recorded values are within 4.75 V and 5.50 V.

72.8.2.1.4 Supply Voltage Ripple

1. Configure the oscilloscope with:
 - Horizontal scale: 1 ms/div
 - Vertical scale: 10 mV/div
 - Channel coupling: AC
2. With electronic load set to CC mode, record the peak-peak VBUS voltage on the scope using cursors for each load from 0 A to 1 A in 200 mA steps. Capture at least 10 cycles and measure the worst-case peak-peak voltage, adjusting the horizontal scale if necessary based on the frequency of the ripple.
3. Verify all recorded values are below 20 mV.

72.8.2.2 External USB Power Sources

This section contains electrical test procedures for accessories using external USB power sources.

72.8.2.2.1 Equipment

The following equipment is needed:

- DMM with 4-wire Kelvin sense capability
- [USB Breakout Board](#) (page 853) (if accessory uses a USB-A plug)

- USB-IF certified USB-C receptacle breakout board (if accessory uses a USB-C plug), see https://www.usb.org/compliancetools#anchor_electricaltools
- USB-C PD power source (if accessory uses a USB-C plug)

72.8.2.2.2 Test Setup

1. Disconnect the C962 from the accessory.

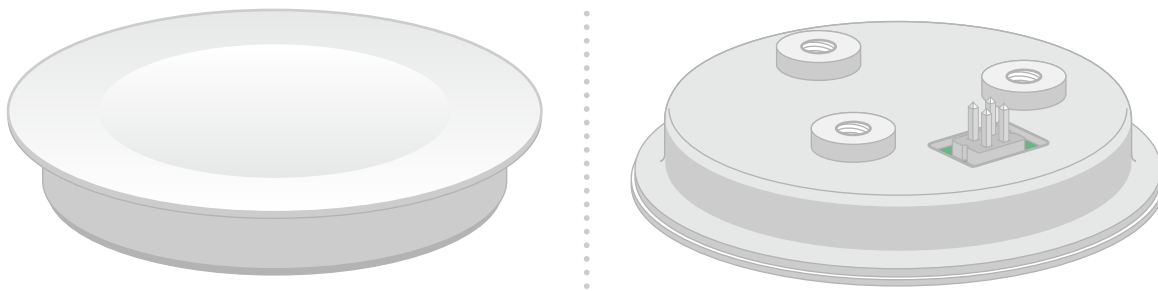
72.8.2.2.3 Round-Trip DC Resistance (DCR)

1. Connect the "Force" and "Sense" leads of the DMM to the VBUS and GND signals in the accessory.
2. Short the VBUS and GND signals at the USB plug using a USB breakout board.
3. Configure the DMM to perform a 4-wire Kelvin sense resistance measurement.

73. Apple Watch Charger Module

The Watch Charger Module (C162) enables accessories to charge the Apple Watch.

Figure 73-1 Watch Charger Module



73.1 Accessory Integration

Note:

Charging accessories claiming compatibility with Apple Watch Ultra shall integrate the [Apple Watch Fast Charger Module](#) (page 652).

All C162 accessories shall:

- Provide power to Apple Watch. See [Electrical](#) (page 676).
- Hold the Apple Watch when it is magnetically connected to the C162.
- Permit the Apple Watch to move relative to the C162.
- Be intended for stationary use.

Accessories shall not integrate the C162 into wearable accessories such as wrist straps or watch bands.

73.2 Mechanical

See [Watch Charger Module Dimensions](#) (page 684) for dimensional drawing.

73.5 Watch Charger Module Dimensions

