Universal Serial Bus Type-C Connectors and Cable Assemblies Compliance Document

Revision ~~2.1a~~2.1b

June ~~1, 2020~~2021

Please send comments via electronic mail to techadmin@usb.org

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FIGURES

TABLES

Revision History

Revision	Date	Filename	Comments
Rev 1.0	January 19, 2016	Rev 1.0	Initial release
Rev 1.1	May 28, 2016	Rev 1.1	Add Locking Connector
Rev 1.2	August 22, 2017	Rev 1.2	Updated to reflect Rev 1.3 and ECNs
Rev 2.0	April 29, 2020	Rev 2.0	Updated with USB Type-C Specification Rev 2.0
Rev 2.1	May 6, 2020	Rev 2.1	Added EMC spring requirements for USB Type-C receptacle in Annex B
Rev 2.1a	June 1, 2020	Rev 2.1a	Corrected locking connector protrusion tolerance and Table D1 title
Rev 2.1b	June 2021	Rev 2.1b	Updated with USB Type-C Specification 2.1

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1 Introduction

1.1 Purpose

This document describes mechanical, environmental, and electrical performance criteria and compliance requirements for USB Type-C connectors and passive cable assemblies, which include:

1. Type-C receptacles
2. Type-C plugs
3. Type-C to Type-C cables assemblies
4. Type-C to legacy USB cable assemblies
5. Type-C to legacy USB adapter assemblies

1.2 Scope

The information provided in this document governs the compliance testing of all USB Type-C connectors and passive cable assemblies. It defines how USB Type-C connectors and passive cable assemblies are to be tested and how the compliance program works.

1.3 Related Documents

ANSI/EIA 364-C	*Electrical Connector/Socket Test Procedures Including Environmental Classifications*, approved 1994. Available in hard copy – reference search site http://www.nssn.org/information.html
ASTM-D-4566	*Standard Test Methods for Electrical Performance Properties of Insulations and Jackets for Telecommunications Wire and Cable.* This specification is available through the World Wide Web site http://www.astm.org/
EIA-364-1000.01	*Environmental Test Methodology for Assessing the Performance of Electrical Connectors and Sockets Used in Business Office Applications*
UL STD-94	*Test procedures used to classify polymeric materials 94HB, 94V-1, 94V-2, 94-5VA, 94-5VB, 94VTM-0, 94VTM-1, 94VTM-2, 94HBF, 94HF-1, and 94HF-2.* This specification is available through the World Wide Web site http://www.comm-2000.com/
UL Subject-444	*Type CMP (plenum cable), Type CMR (riser cable), Type CM (commercial cable), and Type CMX (cable for restricted use.* This specification is available through the World Wide Web site http://www.comm-2000.com/
Universal Serial Bus 2.0	*Universal Serial Bus Specification*, Revision 2.0 (also referred to as the USB Specification). This specification is available on the World Wide Web site http://www.usb.org.
Universal Serial Bus 3.2	*Universal Serial Bus Specification*, Revision 3.2. This specification is available on the World Wide Web site http://www.usb.org.
Universal Serial Bus 4	*Universal Serial Bus Specification*, Revision 4. This specification is available on the World Wide Web site http://www.usb.org.
USB 3.1 Legacy Connector and Cable Specification	*USB 3.1 Legacy Connector and Cable Specification*, Revision 1.0. This specification is available on the World Wide Web site http://www.usb.org.
USB Type-C	*Universal Serial Bus Type-C Cable and Connector Specification*, Revision ~~2.0~~2.1 (also referred to as the USB Type-C Specification). This specification is available on the World Wide Web site http://www.usb.org.

1.4 Terms and Abbreviations

Term	Description
A2LA	The American Association for Laboratory Accreditation (A2LA) is a non-profit, professional membership society. A2LA coordinates and manages a broad-spectrum, nationwide laboratory accreditation system and offers training and continuing education in laboratory practices and management. A2LA offers accreditation to private, independent (for hirer), in-house and government testing laboratories in the following fields: acoustics and vibration; biological; chemical; construction materials; electrical; environmental; geotechnical; mechanical; calibration; and, non-destructive and thermal.
ANSI	American National Standards Institute
Approved Integrators List (AIL)	A listing available to USB-IF member companies at http://www.usb.org listing cable and connector products that have successfully completed a Voluntary Compliance Testing program conducted in accordance with the most current version of the USB Specification's Electrical, Mechanical and Environmental Performance Standards and this document.
ASTM	American Society for Testing and Materials
ASUPS	The acronym for Application Specific USB Product Specification. An ASUPS describes the unique characteristics of a special purpose nonstandard USB connector or cable assembly specification.
C of C	Certificate of Compliance
Characteristic	A physical, chemical, visual or any other measurable property of a product or material.
CNLA	Chinese National Laboratory Accreditation
Contact Point	One electrical contact of a multi-contact connector.
CTR	Conformance Test Report
Defect	Any nonconformance of the unit of product with specified requirements.
Defective Unit	A unit of product that contains one or more defects.
DWG	USB-IF Device Working Group
EIA	Electronic Industries Association
EMI/RFI	Electro-magnetic Interference/Radio Frequency Interference
NIST	National Institute of Standards and Technology
Power Pair	The non-twisted pair of electrical conductors in a USB cable used to carry power from the 'host controller' and/or a 'self-powered hub' to the device. It consists of Vbus and Ground.
SBU	Sideband Use
Signal Pair(s)	Two electrical conductors that carry differential signals.
SuperSpeed	The USB 'SuperSpeed' data rate is 5 Gb/s (USB 3.2 Gen 1) or 10 Gb/s (USB 3.2 Gen 2).
TID	Test Identification Number
Type-C Plug	A plug conforming to the mechanical and electrical requirements in this specification.

Term	Description
Type-C Port	The USB port associated to a USB Type-C receptacle. This includes the USB signalling, CC logic, multiplexers and other associated logic.
Type-C Receptacle	A receptacle conforming to the mechanical and electrical requirements of this specification.
UL	Underwriters Laboratories
Universal Serial Bus	Universal Serial Bus is a serial interconnect bus that supports transfer rates up to 10 Gbps for a maximum of 127 USB devices.
USB	Universal Serial Bus (see Universal Serial Bus).
USB 3.2 Gen 1	The USB data signalling rate is 5 Gb/s.
USB 3.2 Gen 2	The USB data signalling rate is 10 Gb/s.
USB Devices	USB devices may be: ‘Hubs’ that provide attachment points for USB; or, ‘Functions’ that provide capabilities to the system, such as an ISDN connection, a digital joystick, a printer, speakers, et cetera.
USB Host	The USB interface to the host computer system is referred to as the Host Controller. The Host Controller may be implemented in a combination of hardware, firmware or software. A ‘root hub’ is integrated within the host system to provide one or more attachment points. Additional information concerning the ‘USB host’ may be found in Section 4.9 and Chapter 10 of the USB Specification USB 2.0.
USB Topology	The USB connects USB devices with the USB host. The USB physical interconnection is a tiered star topology. A ‘hub’ is at the center of each star. Each wire segment is a point-to-point connection between the ‘host’ and a ‘hub’ or ‘function,’ or a ‘hub’ connected to another ‘hub’ or ‘function.’
USB-IF	USB Implementers Forum is a nonprofit industry organization made up of original equipment manufacturers (OEMs), component manufacturers and firmware/software developers who are actively involved in the advancement of USB technology. (Please see http://www.usb.org)
USB4 Gen 2	Refers to speeds of 10 Gbps per lane (USB4).
USB4 Gen 3	Refers to speeds of 20 Gbps per lane (USB4).

2 Overview

This section is an overview of the contents of this document and provides a brief summary of each of the subsequent sections. It does not establish any requirements or guidelines.

Section 3 describes USB Type-C Compliance Requirements.

Section 4 describes the acceptance testing criteria and test procedures for USB Type-C connectors and cable assemblies.

Section 5 describes the Certification, Acceptance and Submission processes.

Appendices provide necessary supporting information for this document.

3 USB Type-C Compliance Requirements

USB Type-C connectors and passive cable assemblies shall meet or exceed the requirements specified by the most current version of Chapter 3 of the *Universal Serial Bus Type-C Cable and Connector Specification* and applicable Supplements.

Table 3-1 to Table 3-9 summarize the USB Type-C connector (receptacle and plug) and passive cable assembly compliance requirements:

- Table 3-1 USB Type-C Connector DC Electrical Compliance Requirements.
- Table 3-2 USB Type-C Connector Mechanical and Environmental Compliance Standards.
- Table 3-3 USB Type-C Cable Assembly Mechanical and Voltage Drop Compliance Requirements.
- Table 3-4 USB Type-C to Type-C Cable Assembly Signal Integrity Compliance Requirements.
- Table 3-5 USB Type-C to Legacy USB Cable Assembly Signal Integrity Compliance Requirements.
- Table 3-6 USB Type-C to Legacy USB Adapter Assembly Signal Integrity Compliance Requirements.
- Table 3-7 USB Type-C Cable Assembly Shielding Effectiveness Compliance Requirements.
- Table 3-8 Special requirements for legacy USB plugs and receptacles used in Type-C to legacy USB cable assemblies and Type-C to legacy USB adapter assemblies.
- Table 3-9 USB Type-C Connector High-Speed Signal Integrity Compliance Requirements.

Table 3-1 USB Type-C Connector DC Electrical Compliance Requirements

Test Description	Test Procedure	Performance Requirement
Low Level Contact Resistance (LLCR)	EIA 364-23 The low level contact resistance (LLCR) measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. The test boards shall be provided with the connectors to be tested. • Measure at 20 mV (max) open circuit at 100 mA.	The following requirements apply to the power and signal contacts: • 40 mΩ (max) initial for VBUS, GND and all other contacts. • 50 mΩ maximum after initial measurement.
Dielectric Withstanding Voltage	EIA 364-20 Applicable to both receptacle and plug. • Measurement per Method B.	The dielectric shall withstand 100 VAC (RMS) for one minute at sea level after the environmental stress defined in Table 4-8, Test Group A-7.
Insulation Resistance	EIA 364-21 Applicable to both receptacle and plug. See Table 4-8 Test Group A-7.	A minimum of 100 MΩ insulation resistance is required between adjacent contacts of unmated and mated connectors.
Contact Current Rating	See Appendix C	When current is applied to the contacts, the temperature rise shall not exceed limit at the location defined in Appendix C.

Table 3-2 USB Type-C Connector Mechanical and Environmental Compliance Standards

Test Description	Test Procedure	Performance Requirement
Critical Dimension Inspection	See Appendix B.	Meet all critical dimension requirements defined in Appendix B.
Insertion Force	EIA 364-13 The insertion force test shall be done at a maximum speed of 12.5 mm (0.492") per minute.	Within the range from 5 N to 20 N. This requirement does not apply to the plugs that are used for direct docking without a cable.
Extraction Force	EIA 364-13 The extraction force test shall be done at a maximum speed of 12.5 mm (0.492") per minute.	Within the range of 8 N to 20 N, measured after a preconditioning of five insertion/extraction cycles (i.e., the sixth extraction). After an additional twenty-five insertion/extraction cycles, the extraction force shall be measured again (i.e., the thirty-second extraction) and the extraction force shall be within: a) 33 % of the initial reading, and b) within the range of 8 N to 20 N. The extraction force shall be within the range of 6 N to 20 N after 10,000 insertion/extraction cycles. This requirement does not apply to the plugs that are used for direct docking without a cable.

Test Description	Test Procedure	Performance Requirement
Durability or Insertion/Extraction Cycles	EIA 364-09	10,000 cycles minimum. Low level contact resistance and dielectric withstanding voltage shall be checked to be within spec after the 10,000 durability cycles according to Table 4-8, Test Group A-7.
Wrenching Strength (Plug-only)	Perpendicular forces are applied to the plug in four directions (i.e., left, right, up, and down). A metal fixture with opening and tongue representative of a receptacle shall be used. See Appendix E.	a) A single plug shall be used for this test. Some mechanical deformation may occur. The plug shall be mated with the continuity test fixture after the test forces have been applied to verify no damage has occurred that causes discontinuity or shorting. The Dielectric Withstanding Voltage test shall be conducted after the continuity test to verify plug compliance. b) A new plug is required for each of the four test directions. The plug shall disengage from the test fixture or demonstrate mechanical failure (i.e., the force applied during the test procedure peaks and drops off) when a moment of 2.0 Nm is applied to the plug in the up and down directions and a moment 3.5 Nm is applied to the plug in the left and right directions. See Appendix E.
4-Axes Continuity	See Appendix D for detailed test fixtures and procedures. Plug and Receptacle: Subject the mating interface to the moments defined in Appendix D for at least 10 seconds.	No discontinuities greater than 1 microsecond duration in any of the four orientations tested.
Temperature Life	EIA 364-17, Method A. 105° C without applied voltage for 120 hours. 105° C without applied voltage for 72 hours when used as preconditioning.	Low level contact resistance meets spec before and after the Temperature Life test.
Vibration	EIA 364-28 Test Condition VII, Test Letter D	No evidence of physical damages and no discontinuity longer than 1 microsecond. Low level contact resistance meets spec before and after the Vibration test.
Cyclic Temperature and Humidity	EIA 364-31	Low level contact resistance meets spec before and after the Cyclic Temperature and Humidity test.
Thermal Shock	EIA 364-32, Test Condition I 10 Cycles –55°C and +85°C.	No evidence of any physical damage. Low level contact resistance meets spec before and after the Thermal Shock test.

Test Description	Test Procedure	Performance Requirement
Mixed Flowing Gas	IA 364-65,Class II A Samples should be placed in an environmentally controlled 'test chamber' that is monitored by a gas analyzing system for controlled concentrations of the specified gas mixture. Test coupons shall also be used and the weight gain reported. Test duration is 7 days.	Low level contact resistance meets spec before and after the Mixed Flowing Gas test.
Notes: 1. Unless otherwise specified, all tests shall be done with mated connectors. 2. Legacy USB (mated) connectors mechanical and environmental compliance requirements are governed by the legacy USB connectors and cable assemblies compliance documents.		

Table 3-3 USB Type-C Cable Assembly Mechanical and Voltage Drop Compliance Requirements

Test Description	Test Procedure	Performance Requirement
Cable Flexing	EIA 364-41, Condition I with Dimension X = 3.7 times the cable diameter and 500 cycles in each of two planes 120 degree arc.	No physical damage and discontinuity over 1 microsecond during flexing shall occur to the cable assembly.
Cable Pull-Out	EIA 364-38 Test Condition A The cable assembly shall be subjected to a 40 N axial load for a minimum of 1 minute while clamping one end of the cable plug.	No visible physical damage and no electrical discontinuity over 1 microsecond to the cable assembly.
Cable Assembly Voltage Drop	The maximum rated VBUS current of the cable assembly shall be used. The measurement includes representative receptacles at both ends of the cable assembly, mounted on test fixtures. The voltage drop measurement is made at the receptacle contact solder tails and does not include fixture losses. The plug shell shall be DC connected to the applied GND through the receptacle shell and/or receptacle ground bar.	250 mV max for GND and 500 mV max for VBUS
Notes: 1. All tests are for the Type-C cable assemblies. The mating connectors needed for the testing are considered part of the fixture, either a representative spec-compliant receptacle or machined metal part. 2. Legacy USB cable assembly mechanical compliance requirements are governed by the legacy USB cable assembly compliance documents.		

Table 3-4 USB Type-C to Type-C Cable Assembly Signal Integrity Compliance Requirements

Test Description	Test Procedure	Performance Requirement
Insertion Loss Fit at Nyquist Frequencies (ILfitatNq)	See Appendix H.3.	For USB 3.2 Gen1 SuperSpeed for USB4 Gen 2 TX/RX pairs: ≥−7 dB at 2.5 GHz ≥ −11.5 dB at 5 GHz For USB 3.2 Gen 2 SuperSpeed and USB4 Gen 2 TX/RX pairs: ≥ −4 dB at 2.5 GHz ≥ −6 dB at 5 GHz ≥ −11 dB at 10 GHz For USB 4 Gen 3 pairs: ≥ −1 dB at 100 MHz, ≥ −4.2 dB at 2.5 GHz, ≥ −6 dB at 5 GHz, ≥ −7.5 dB at 10 GHz, ≥ −9.3 dB at 12.5 GHz, and ≥ −11 dB at 15 GHz.
Integrated Multi-Reflection (IMR)	See Appendix H.3.	For USB 3.2 Gen 1 SuperSpeed and USB4 Gen 2 TX/RX pairs: ≤ 0.126 · ILfitatNq^2+3.024 · ILfitatNq – 24.792, in dB. For USB 3.2 Gen 2 SuperSpeed and USB4 Gen 2 TX/RX pairs: ≤ 0.126 · ILfitatNq^2+3.024 · ILfitatNq – 23.392, in dB.
Integrated Crosstalk between SuperSpeed Pairs (INEXT and IFEXT)	See Appendix H.3.	For USB 3.2 SuperSpeed, USB4 Gen2 TX/RX pairs: Integrated near-end crosstalk: INEXT ≤ -40 dB. Integrated far-end crosstalk: IFEXT ≤ -40 dB. For USB4 Gen 3 TX/RX pairs: Integrated near-end crosstalk within a port: INEXT ≤ -43 dB. Integrated far-end crosstalk within a port: IFEXT ≤ -43 dB. Integrated port-to-port near-end crosstalk: INEXT_p2p ≤ -50 dB. Integrated port-to-port far-end crosstalk: IFEXT_p2p≤ -50 dB. The total crosstalk, IXT_DP and IXT_USB: IXT_DP/IXT_USB ≤ (ILfit_10Ghz+7.5) *2/3.5 -41, dB, -4 ≤ ILfit_10G ≤ -7.5 ≤ -39, dB, ILfit_10G ≥ -4 dB
Integrated Crosstalk between SuperSpeed Pairs and D+/D- (IDDXT_1NEXT+FEXT and, IDDXT_2NEXT)	See Appendix H.3.	Integrated near-end crosstalk to D+/D-: IDDXT_1NEXT+FEXT ≤ −34.5 dB Integrated near-end and far-end crosstalk to D+/D-: IDDXT_2NEXT ≤ −33 dB For all SuperSpeed pairs.

Test Description	Test Procedure	Performance Requirement
Integrated Return Loss (IRL)	See Appendix H.3.	For USB 3.2 Gen 1 SuperSpeed and USB4 Gen 2 TX/RX pairs: ≤ 0.046· ILfitatNq^2 + 1.812 · ILfitatNq – 9.784, in dB. For USB 3.2 Gen 2 SuperSpeed and USB4 Gen 2 TX/RX pairs: ≤ 0.046· ILfitatNq^2 + 1.812 · ILfitatNq – 10.784, in dB. For USB 4 Gen 3 TX/RX pairs: ≤ (ILfitat10Ghz+7.5) *3.5/3.5 -19.5 in dB, for -4 ≤ ILfitat10GHz ≤ -7.5 ≤ -16 in dB, for ILfitat10GHz ≥ -4 dB
Differential-to -Common-Mode Conversion (SCD12/SCD21)	See Appendix H.3.	For USB 3.2 Gen 1/Gen 2 SuperSpeed pairs and USB4 Gen 2 TX/RX pairs: ≤ -20 dB from 100 MHz to 10 GHz For USB4 Gen 3 TX/RX Pairs: ≤ -17 dB from 100 MHz to 10 GHz.
COM Requirement	See Appendix H.3.	For USB 4 Gen 3 TX/RX pairs: COM Threshold ≥ 3 dB
Differential coupling between CC and USB D+/D-	See Appendix H.5.	For cable assemblies the limit is defined with the vertices of (0.3 MHz, -60.5 dB), (1 MHz, −50 dB), (10 MHz, −30 dB), (16 MHz, −26 dB) and (100 MHz, −26 dB) on scale of log10(f).
Coupling between VBUS and differential USB D+/D-	See Appendix H.5.	≤ -40 dB for 0.3 MHz < f ≤ 30 MHz, and ≤ 19.12·log10(f/30)-40 (in dB) for 30 MHz< f ≤ 100 MHz.
Single-ended coupling between SBU_A and CC, SBU_B and CC	See Appendix H.5.	The limit is defined with the vertices of (0.3 MHz, -65 dB), (1 MHz, −55 dB), (18 MHz, −30 dB), and (100 MHz, −30 dB) on scale of log10(f).
Single-ended coupling between CC and D-	See Appendix H.5.	For USB 2.0 Type-C cables, the singled-ended coupling between the CC and D− shall be below the limit shown in Figure 3-49. The limit is defined with the vertices of (0.3 MHz, −48.5 dB), (1 MHz, −38 dB), (10 MHz, −18 dB) and (100 MHz, −18 dB) on scale of log10(f). For USB Full-Featured Type-C cables, the singled-ended coupling between the CC and D− shall be below the limit shown in Figure 3-50. The limit is defined with the vertices of (0.3 MHz, −58 dB), (10 MHz, −27.5 dB), (11.8 MHz, −26 dB) and (100 MHz, −26 dB) on scale of log10(f).
Single-ended coupling between SBU_A and SBU_B	See Appendix H.5.	The limit is defined with the vertices of (0.3 MHz, −56.5 dB), (1 MHz, −46 dB), (10 MHz, −26 dB), (11.2 MHz, −25 dB), and (100 MHz, −25 dB) on scale of log10(f).
Coupling between SBU_A/SBU_B and differential USB D+/D−	See Appendix H.5.	The limit is defined with the vertices of (0.3 MHz, -80 dB), (30 MHz, −40 dB), and (100 MHz, −40 dB) on scale of log10(f).
VBUS loop inductance	See Appendix H.5. Measure the 2-port S-parameters for the VBUS line and then convert to loop inductance.	≤ 900 nH

Test Description	Test Procedure	Performance Requirement
VBUS Capacitance	See Appendix H.5. Measure the 2-port S-parameters for the VBUS line and then convert to capacitances.	8 nF to 500 nF each side, not including the by-pass capacitor on the test fixture. Does not apply to USB 2.0-only cable assembly.
Mutual Inductance (M) between VBUS and Other Low Speed Signals (CC, SBU_A, SBU_B, D+ and D-)	See Appendix H.5. Extract from measured S-parameters.	See B-2-13 (Table 4 11) for values. The mutual inductance is defined as: $M = \frac{1}{2\pi f} imag\left(\frac{Y_{14}+Y_{41}+Y_{23}+Y_{32}}{(Y_{12}+Y_{21})(Y_{34}+Y_{43})}\right)$
D+/D- Pair Differential Impedance	EIA 364-108 and Appendix H.4. Measured with a 400 ps rise time (20%-80%).	75 ohms min and 105 ohms max.
D+/D- Pair Propagation Delay	EIA 364-103 and Appendix H.4. Measured with a 400 ps rise time (20%-80%) at 50% voltage crossing.	20 ns max
D+/D- Pair intra-pair Skew	EIA 364 – 103 and Appendix H.4. Measured with a 400 ps rise time (20%-80%) at 50% voltage crossing.	100 ps max
D+/D- Pair Attenuation	EIA 364 – 101 and Appendix H.4.	≥ −1.02 dB @ 50 MHz ≥ −1.43 dB @ 100 MHz ≥ −2.40 dB @ 200 MHz ≥ −4.35 dB @ 400 MHz
D+ and D- DC Resistance	Ohmmeter measurement from connector to connector of the D+ line and the D- line.	3.5 ohms max.

Notes:

1. See the *USB Type-C Cable and Connector Specification* ~~Revision 2.0~~ for the integration method on frequency domain S-parameter data for each generation.
2. Tb is the unit interval. Tb=200 ps is for USB 3.2 Gen 1, Tb = 100 ps is for USB 3.2 Gen 2 and USB4 Gen2, and Tb = 50 ps is for USB4 Gen3.
3. USB 2.0-only Type-C to Type-C cable assembly includes only the D+/D- pair, VBUS and CC lines. Only the signal integrity requirement applicable to those signals shall be tested for such cable assemblies.

Table 3-5 USB Type-C to Legacy USB Cable Assembly Signal Integrity Compliance Requirements

Test Description	Test Procedure	Performance Requirement
D+/D- Pair Differential Impedance	EIA 364-108 and Appendix H.4. Measured with a 400 ps rise time (20%-80%).	75 ohms min and 105 ohms max.
D+/D- Pair Propagation Delay	EIA 364-103 and Appendix H.4. Use a 400 ps rise time (20%-80%) at 50% voltage crossing.	10 ns max for USB Type-C to Micro-B cable assembly; 20 ns max for all other USB Type-C to legacy USB cable assemblies.
D+/D- Pair Intra-pair Skew	EIA 364 – 103 and Appendix H.4. Measured with a 400 ps rise time (20%-80%) at 50% voltage crossing.	100 ps max.
D+/D− Pair Attenuation	EIA 364 – 101 and Appendix H.4.	≥ −1.02 dB @ 50 MHz ≥ −1.43 dB @ 100 MHz ≥ −2.40 dB @ 200 MHz ≥ −4.35 dB @ 400 MHz
D+ and D- DC Resistance	Ohmmeter measurement from connector to connector of the D+ line and the D- line.	3.5 ohms max.
VBUS Capacitance (Does not apply to USB 2.0-only cable assembly)	See Appendix H.5. Measure the 2-port S-parameters for the VBUS line and then convert to capacitances.	PD not supported: 8 nF to 12 nF located in the Type-C plug. PD supported: 80 pF to 120 pF located in the Type-C plug.
Rd resistor verification	Measure the resistance between pin A5 and Ground (pin A1, A12, B1, or B12).	Type-C pin A5 resistance to GND for cable assemblies with a USB B plug.
Rp resistor verification	Measure the resistance between pin A5 and VBUS (pin A4, A9, B4, or B9).	Type-C pin A5 to VBUS resistance for cable assemblies with a Standard-A plug.
Differential Insertion Loss Fit at Nyquist Frequencies (ILfitatNq)	See Appendix H.5.	≥ −4 dB @ 2.5 GHz, except for the USB Type-C plug to USB 3.1 Standard-A plug cable assembly which is specified as: ≥ −3.5 dB @ 2.5 GHz ≥ −6 dB @ 5.0 GHz For SuperSpeed pairs only.
Integrated Differential Multi-reflection (IMR)	See Appendix H.5.	≤ 0.126 · ILfitatNq^2+3.024 · ILfitatNq – 21.392 (in dB). For SuperSpeed pairs only.
Integrated Differential Crosstalk on SuperSpeed (ISSXT)	See Appendix H.5.	≤ −37 dB
Integrated Differential Crosstalk on D+/D- (IDDXT)	See Appendix H.5.	≤ −28.5 dB
Integrated Return Loss (IRL)	See Appendix H.5.	≤ 0.046· ILfitatNq^2 + 1.812 · ILfitatNq – 9.784 (in dB). For SuperSpeed pairs only.

Test Description	Test Procedure	Performance Requirement
Differential-to - Common-Mode Conversion (SCD12 and SCD21)	See Appendix H.5.	≤ -20 dB from 100 MHz to 10 GHz.
Notes: 1. The SuperSpeed pairs is only applicable to Type-C to legacy USB 3.2 Gen 2 cable assembly.		

Table 3-6 USB Type-C to Legacy USB Adapter Assembly Signal Integrity Compliance Requirements

Test Description	Test Procedure	Performance Requirement
D+/D- Pair Differential Impedance	EIA 364-108 Measured with a 400 ps rise time (20%-80%).	75 ohms min and 105 ohms max.
D+/D- Pair Intra-pair Skew	EIA 364 – 103 Measured with a 400 ps rise time (20%-80%) at 50% voltage crossing.	20 ps max.
D+/D− Pair Attenuation	EIA 364 – 101	≥ −0.7 dB @ 400 MHz
D+ and D- DC Resistance	Ohmmeter measurement from connector to connector of the D+ line and the D- line.	2.5 ohms max.
VBUS Capacitance	See Appendix H.5. Measure the 2-port S-parameters for the VBUS line and then convert to capacitances.	8 nF to 12 nF located in the Type-C plug. (Does not apply to USB 2.0-only adapter assemblies)
Rd resistor verification	Measure the resistance between pin A5 and Ground (pin A1, A12, B1, or B12).	Type-C pin A5 to GND resistance for adapters with a Standard-A receptacle.
Rp resistor verification	Measure the resistance between pin A5 and VBUS (pin A4, A9, B4, or B9).	Type-C pin A5 to VBUS resistance for adapters with a Micro-B receptacle.
Differential Insertion Loss Fit at Nyquist Frequency (ILfitatNq)	See Appendix H.3.	≥ −2.4 dB at 2.5 GHz and ≥ −3.5 dB at 5.0 GHz
Integrated Differential Multi-Reflection (IMR)	See Appendix H.3.	≤ −34 dB for Tb=200 ps and ≤ -27 dB for Tb=100 ps
Integrated Differential Crosstalk on SuperSpeed (ISSXT)	See Appendix H.3.	≤ −37 dB
Integrated Differential Crosstalk on D+/D- (IDDXT)	See Appendix H.3.	≤ −30 dB
Integrated Return Loss (IRL)	See Appendix H.3.	≤ −14.5 dB for Tb=200 ps and ≤ -12.0 dB for Tb=100 ps

Test Description	Test Procedure	Performance Requirement
Differential-to - Common-Mode Conversion (SCD12 and SCD21)	See Appendix H.3.	≤ -15 dB from 100 MHz to 7.5 GHz.
Notes: 1. SuperSpeed pair requirements are only applicable to the USB Type-C to USB Standard-A Receptacle adapter assembly. 2. Tb is the unit interval – Tb=200 ps is for USB 3.2 Gen 1 and Tb=100 ps is for USB 3.2 Gen 2.		

Table 3-7 USB Type-C Cable Assembly Shielding Effectiveness Compliance Requirements

Test Description	Test Procedure	Performance Requirement
USB Type-C to Type-C (USB 3.2) Cable Assembly Cable Shielding Effectiveness	See Appendix I.	Differential model: ≤ -55 dB for f ≤1.6 GHz ≤ -50 dB for 1.6 GHz ≤ f ≤ 4.0 GHz and 5 GHz ≤ f ≤ 6 GHz Common model: ≤ -40 dB for f ≤ 1.6 GHz ≤ -35 dB for 1.6 GHz ≤ f ≤ 4 GHz and 5 GHz ≤ f ≤ 6 GHz
USB Type-C to USB Legacy (USB 3.2) Cable Assembly Cable Shielding Effectiveness	See Appendix I.	Differential model: ≤ -49 dB for f ≤1.6 GHz ≤ -44 dB for 1.6 GHz ≤ f ≤4GHz and 5 GHz ≤ f ≤ 6 GHz Common model: ≤ -34 dB for f ≤1.6 GHz ≤ -29 dB for 1.6 GHz ≤ f ≤ 4 GHz and 5 GHz ≤ f ≤ 6 GHz
Type-C to Standard-A Receptacle Adapter Cable Shielding Effectiveness	See Appendix I.	Differential model: ≤ -44 dB for f ≤1.6 GHz ≤ -39 dB for 1.6 GHz ≤ f ≤4 GHz and for 5 GHz ≤ f ≤ 6 GHz Common model: ≤ -24dB for f ≤1.6 GHz ≤ -24 dB for 1.6 GHz ≤ f ≤ 4 GHz and for 5 GHz ≤ f ≤ 6 GHz

Table 3-8 Special requirements for legacy USB plugs and receptacles used in Type-C to legacy USB cable assemblies and Type-C to legacy USB adapter assemblies

Test Description	Test Procedure	Performance Requirement
Low Level Contact Resistance (LLCR)	EIA 364-23B The low level contact resistance (LLCR) measurement is made across the plug and receptacle as defined in the respective compliance specification for the legacy connector.	The following requirements apply to the power and signal contacts of the USB Micro-B mated pair: 20 mΩ (max) initial for VBUS and GND contacts. 30 mΩ maximum after initial measurement.
Contact Current Rating	EIA 364-70, Method 2	For USB Standard-A, USB Standard-B, and USB Micro-B connector mated pairs used in Type-C to legacy cables and adapter assemblies, when a current of 3 A is applied to the VBUS pin and its corresponding GND pin (i.e., pins 1 and 4 in a USB Standard-A or USB Standard-B connector or pins 1 and 5 in a USB Micro-B connector), the temperature rise shall not exceed 30ºC at any point on the connectors under test when measured at an ambient temperature of 25ºC. The manufacturer shall provide both the receptacle and plug for this test.

Table 3-9 USB Type-C Connector High-Speed Signal Integrity Compliance Requirements

Test Description	Test Procedure	Performance Requirement
Insertion Loss Fit at Nyquist Frequencies (ILfitatNq)	See Appendix G.	For USB4 Gen 3 TX/RX pairs: ≥ −0.6 dB @ 2.5 GHz ≥ −0.8 dB @ 5.0 GHz ≥ −1.0 dB @ 10 GHz ≥ −1.25 dB @ 12.5 GHz ≥ −1.5 dB @ 15 GHz
Integrated Multi-reflection (IMR)	See Appendix G.	For USB 4 Gen 3 TX/RX pairs: ≤ −39 dB
Integrated Differential Crosstalk	See Appendix G.	For USB4 Gen 3 TX/RX pairs, INEXT/IFEXT: ≤ −43 dB
Differential Crosstalk of TX/RX on D+/D−	See Appendix G.	Between D+/D- pair and USB4 Gen 3 TX/RX pairs: ≤ −50 dB
Integrated Return Loss (IRL)	See Appendix G.	For USB4 Gen 3 TX/RX pairs: ≤ −15 dB
Differential to Common Mode Conversion (SCD12 and SCD21)	See Appendix G.	For USB4 Gen 3 TX/RX pairs: ≤ −20 dB (100 Mhz ~ 10.0 Ghz)
Notes: 1. See the *USB Type-C Cable and Connector Specification* ~~*Revision* 2.0~~ for the USB4 Gen 3 integration method on frequency domain S-parameter data. 2. Tb is the unit interval. Tb = 50 ps for USB4 Gen3.		

4 Acceptance Criteria, Test Methods and Test Procedures

For a USB Type-C connector or cable assembly product to be listed on the USB-IF Integrators List, the manufacturer shall show satisfactory completion of all qualification tests specified in the most current version of the *USB Type-C Cable and Connector Specification* and the USB Type-C Connectors and Cable Assemblies Compliance Document.

Connector compliance testing includes dimensional inspection, mechanical, environmental and DC electrical tests, signal integrity for USB4 Gen 3 only, but it does not cover shielding effectiveness. A receptacle is considered part of the host/device from signal integrity and shielding effectiveness perspective.

USB Type-C cable assemblies and adapters are required to be constructed with certified USB Type-C connectors to be granted certification at the assembly level. USB 2.0 Type-C cable assemblies may be constructed with either USB 2.0 Type-C plug connectors or USB Full-Featured Type-C plug connectors. USB Type-C cable assemblies shall be electronically marked as specified in the most current version of the *USB Type-C Cable and Connector Specification* (not all cable assemblies require electronic marking). The cable assembly electronic marking test methodology may be found at: http://www.usb.org/developers/tools.

IMPORTANT NOTICE: USB Type-C connectors and cable assemblies shall successfully pass all inspection procedures and compliance testing at the intervals defined in this document before listing on the USB-IF Integrators List will be granted.

4.1 Integrators List (IL)

USB-IF maintains a current listing of "IL manufacturers and/or fabricators" who have been authorized to use the trademarked logo in conjunction with or on their connector and/or cable assembly products. The USB-IF's listing of approved manufacturers is periodically updated and is available to all USB-IF member companies.

4.2 USB Logo Usage

Only products that meet or exceed the compliance test requirements identified in this document at the time of testing are eligible to display the certified logo provided the product vendor has signed the USB IF logo trademark license agreement.

4.3 Compliance Test Report

The testing laboratory performing the compliance testing will issue a certified test report concisely detailing the tests performed. The certified test report shall contain complete test results (inclusive of the raw data). Upon completion of compliance testing, the certified laboratory shall be responsible for notifying the USB IF with the products test results. Upon acceptance of the test results confirming compliance to this document the product will be added to the integrators list.

4.4 Connector and Cable Assembly Physical Certification

In case of conflict between the requirements of this document and the *USB Type-C Cable and Connector Specification*, the most current revision of the *USB Type-C Cable and Connector Specification* & applicable USB Type-C Supplements shall take precedence.

Unless otherwise specified, all tests shall be performed at the standard test conditions defined in Table 4-1.

Table 4-1 Standard Test Conditions

Temperature	15° C to 35° C
Air Pressure	86 to 106 kPa
Relative Humidity	25% to 85%

4.5 General Information

This document shows minimum compliance tests to be performed, and the order in which they shall be performed and the performance requirements for each test.

4.5.1 Test Fixtures

Most test items for receptacle certification are done in the mated condition with a plug. The plug fixtures for USB4 Gen3 signal integrity (SI) testing require a "golden plug" and these fixtures shall be obtained through USB-IF or a source approved by USB-IF. The plugs used for other receptacle certification testing shall be provided by the connector vendor or by a USB certified lab. Similarly, the receptacles necessary to conduct plug certification shall come either from the connector vendor or from a USB certified lab. For cable assembly certification, all signal integrity and shielding effectiveness test fixtures shall come from the USB certified lab and be approved by USB-IF.

4.5.2 Mated Pairs

An example of a mated pair is one USB Type-C Receptacle and one USB Type-C Plug and they are tested as such unless otherwise specified. Typically the USB Type-C Receptacle is "fixed" and the USB Type-C Plug is "free". Each "receptacle" and "plug" shall be clearly and individually identified.

Note: "Mated connectors" shall remain together for the duration of the testing sequence. For example, when "un-mating" is required by a test, the same "receptacle and plug pair" as before shall be mated for the subsequent tests.

4.5.3 Before Testing

Before testing commences, the specimens shall have been stored for at least 24 hours in the non-inserted state under standard test conditions, unless otherwise specified.

4.5.4 EIA Test Procedures

Where an EIA test is specified the latest approved revision of that test shall be used.

4.5.5 Test Sequences

All the tests in Table 4-2 shall follow the sequences defined in Section 4.10.

4.6 Sample Selection

The samples to be tested for USB Type-C Certification shall be from a production-equivalent run of the product.

All acceptance tests shall be performed on the minimum number of samples specified in Table 4-2 unless otherwise specified.

IMPORTANT NOTE: Compliance testing shall be performed at the manufacturer's expense by a certified laboratory except for specific Test Groups that are to be performed by the manufacturer as noted in Table 4-2. The certified laboratory shall have direct traceability to a recognized standards organization (e.g., A2LA).

4.7 USB Type-C Compliance Testing Interval

Once a connector or cable assembly has been certified it remains certified for the life of the product. However, any change to the materials, including platings, configuration or dimensions will void certification of that product. Any modification of the manufacturing process that results to a change in the product will void the certification. The USB-IF offers a Qualification by Similarity (QbS) program for re-certification requirements.

4.8 Primary Qualification Approval Testing

The following number of specimens shall be subjected to the tests under the conditions as specified in Section 3 of this document.

Table 4-2 Primary Qualification Approval Testing

Test Group	Number of Samples						Performance Level1
	Connectors					Cable or Adapter Assembly	Number of Defects Permitted
	USB 2.0 or Power-Only		Full-Featured Plug	USB 3.2 Gen 2 Receptacle	USB4 Gen 3 Receptacle		
	Plug	Receptacle					
Inspection	43	43	43	43	43	25	0
A-1, A-2, A-3, and A-7	10 per group (40)	10 per group (40)	5 per group (20)	5 per group (20)	5 per group (20)	n/a	0
A-4	20	20	10	10	10	n/a	0
A-8	n/a	n/a	n/a	n/a	3	n/a	0
B-1	n/a	8 (B1-4 only)	n/a	8 (B1-4 only)	8 (B1-4 only)	8	0
B-2	n/a	n/a	n/a	n/a	n/a	3	0
B-3	n/a	n/a	n/a	n/a	n/a	3	0
B-4	n/a	n/a	n/a	n/a	n/a	3	0
B-5	3	3	3	3	3	3	0
B-6	3	3	3	3	3	n/a	0
B-7	15 (3 sets of 5)	n/a	15 (3 sets of 5)	n/a	n/a	15 (3 sets of 5)	0
B-8	n/a	n/a	n/a	n/a	n/a	10 (out of 50)	Distribution-Based Data
Total Samples	124	117	94	87	90	110	

Notes:

1. The connector manufacturer shall provide test results to the USB-IF for Test Groups A-1, A-2, A-4, A-5, and A-6. The certified lab shall perform Test Groups A-3, A-7 and the applicable B Test Groups.
2. Critical Dimension Inspection of some connectors may require destructive disassembly of the part for complete dimensional inspection.
3. Critical dimensions for cable or adapter assemblies is limited to overmold dimensions only.
4. The vendor is responsible for providing additional plugs (as specified by the test lab) with a cable of 200 mm (or greater length) properly terminated for the test lab's setup fixtures.
5. The vendor is responsible for providing additional receptacles (as specified by the test lab) properly mounted on a printed circuit board for the test lab's setup fixtures.
6. Legacy connectors used in cable assemblies and adapter assemblies shall comply with Table 3-8, as applicable.

4.9 Sustaining Qualification Approval Testing

USB IF does not require vendors to re-qualify certified products. See Section 4.7.

4.10 Compliance Test Sequences

The following tests shall be performed in the sequence shown.

4.10.1 Inspection (EIA 364-18) Visual and Dimensional Inspection and Test Group B-5 Critical Dimension Inspection

Because of the inspection criteria similarities between test groups and the fact that data may be collected during inspections that may halt the subsequent tests, it is recommended the inspection be conducted concurrently. Representative specimens should be subjected to the following tests to verify that a USB Type-C connector and/or cable assembly demonstrates sufficient product integrity to be processed through the remaining product acceptance test procedures/groups.

4.10.1.1 Visual Inspection

The laboratory conducting the compliance testing is required to 100% visually inspect each lot of sample parts for obvious mechanical defects. Prohibited cable assemblies or connectors are not eligible for certification. Vendors are to be informed of non-compliant configurations.

4.10.1.1.1 Connector Number of Contacts

The number of contacts required for certification of the USB Type-C connector:

USB Full-Featured Type-C receptacle:

24 contacts: A1 – A12 and B1 – B12.

USB 2.0 Type-C receptacle:

16 contacts: A1, A4, A5, A6, A7, A8, A9, A12, B1, B4, B5, B6, B7, B8, B9, and B12.

USB Full-Featured Type-C plug:

22 contacts: A1 – A12 and B1 – B12, with contacts B6 and B7 depopulated (preferred); or

24 contacts: A1 – A12 and B1 – B12 (not recommended).

USB 2.0 Type-C plug:

12 contacts A1, A4, A5, A6, A7, A9, A12, B1, B4, B5, B9, and B12 (preferred);

14 contacts A1, A4, A5, A6, A7, A8, A9, A12, B1, B4, B5, B8, B9, and B12 (also includes A8 and B8; SBU_A and SBU_B) (preferred);

14 contacts A1, A4, A5, A6, A7, A9, A12, B1, B4, B5, B6, B7, B9, and B12 (not recommended); or

16 contacts A1, A4, A5, A6, A7, A8, A9, A12, B1, B4, B5, B6, B7, B8, B9, and B12 (also includes A8 and B8; SBU_A and SBU_B) (not recommended).

USB Type-C Power-Only plug:

9 contacts (A1, A4, A5, A9, A12, B1, B4, B9, and B12).

The laboratory conducting the compliance testing is required to visually verify, where possible, the number of contacts implemented in the connector.

4.10.1.1.2 Cable Construction

The *USB Type-C Cable and Connector Specification* does not have normative requirements for raw or bulk cables. Bulk cable is not eligible for USB certification.

The cable construction for detachable USB Type-C cable assemblies shall be visually verified. The certification laboratory shall not conduct cable assembly compliance testing if the cable construction is not as follows:

- Cable construction should contain a braided outer shield.
- Cables shall contain at least a power pair and CC.
- The USB 2.0 D+/D- pair may be unshielded or shielded.
- The SuperSpeed conductors shall be shielded (micro-coaxial, shielded twisted pair, or shielded twin-ax pair).

4.10.1.2 Dimensional Inspection

The laboratory conducting the compliance testing shall measure and record critical dimensions per Appendix B.

4.10.2 Test Groups A

Test Groups A consists of all the test groups defined in this section. They are based on EIA-364-1000.01, with some modifications. For the test sequences in each of Test Groups A, unless otherwise stated, at least 100 separable contact interfaces from at least 5 connectors (i.e., plug/receptacle) should be evaluated for USB Full-Featured Type-C plugs or at least 10 connectors should be evaluated for USB 2.0 Type-C plugs. Test group A-4 requires twice this sample size due to the mixed flowing gas test methodology.

Except for Test Groups A-3, A-7, and A-8, which shall be performed by a USB-IF certified lab, all other tests in Test Groups A (A-1, A-2, A-4, A-5, and A-6) may be done by the connector manufacturer or at a testing lab and the test results shall be provided to USB-IF.

Test Group A-8 is for signal integrity testing of USB Full-Featured Type-C receptacle connectors intended for USB4 Gen 3 applications. Three test samples of the receptacle connector shall be provided to the testing lab, each mounted on a test fixture as defined in Annex H.

Table 4-3 Test Group A-1 (required for all connectors)

Test Order	Test	Test Procedure	Condition of Test Specimens	Test Criteria
1	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	40 milliohms max for all contacts. Baseline measurement.
2	Durability (preconditioning)	EIA-364-09 Perform 50 unplug/plug cycles.		No evidence of physical damage
3	Temperature life	EIA-364-17, method A 105^{o} C without applied voltage for 120 hours.	Mated	None
4	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	50 milliohms max.
5	Reseating	Manually unplug/plug the connector or socket. Perform 3 such cycles.		No evidence of physical damage
6	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	50 milliohms max.

Table 4-4 Test Group A-2 (required for all connectors)

Test Order	Test	Test Procedure	Condition of Test Specimens	Test Criteria
1	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	40 milliohms max for all contacts. Baseline measurement.
2	Durability (preconditioning)	EIA-364-09 Perform 50 unplug/plug cycles.		No evidence of physical damage.
3	Thermal shock	EIA-364-32, test condition I 10 cycles with the exception of exposure times. Place a thermocouple in the center of the largest mass component of the connector that is in the center of the test chamber to insure that the contacts reach the temperature extremes before ramping to the other temperature.	Mated	None.
4	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	50 milliohms max.
5	Cyclic temperature and humidity	EIA-364-31 Cycle the connector between 25 °C ±3 °C at 80 % ±3% RH and 65 °C ±3 °C at 50 % ±3% RH. Ramp times should be 0.5 hour and dwell times should be 1.0 hour. Dwell times start when the temperature and humidity have stabilized within the specified levels. Perform 24 such cycles.	Mated	None.
6	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	50 milliohms max.
7	Reseating	Manually unplug/plug the connector or socket. Perform 3 such cycles.		No evidence of physical damage.
8	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	50 milliohms max.

Table 4-5 Test Group A-3 (required for all connectors)

Test Order	Test	Test Procedure	Condition of Test Specimens	Test Criteria
1	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	40 milliohms max for all contacts. Baseline measurement.
2	Durability (preconditioning)	EIA-364-09 Perform 50 unplug/plug cycles.		No evidence of physical damage.
3	Temperature life (preconditioning)	EIA-364-17, method A 105° C without applied voltage for 72 hours when used as preconditioning.	Mated	None.
4	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	50 milliohms max for all contacts.
5	Vibration	EIA-364-28, test condition VII, test condition letter D 15 minutes in each of 3 mutually perpendicular directions. Both mating halves should be rigidly fixed so as not to contribute to the relative motion of one contact against another. The method of fixturing should be detailed in the test report.	Mated	No evidence of physical damage. No discontinuities of 1 microsecond or longer duration when mated connector during test.
6	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	50 milliohms max for all contacts.

Table 4-6 Test Group A-4 (required for all connectors)

Test Order	Test	Test Procedure	Condition of Test Specimens	Test Criteria
1	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	40 milliohms max for all contacts. Baseline measurement.
2	Durability (preconditioning)	EIA-364-09 Perform 50 unplug/plug cycles.		No evidence of physical damage.
3	Temperature life (preconditioning)	EIA-364-17, method A 105º C without applied voltage for 72 hours when used as preconditioning.	Mated	None.
4	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	50 milliohms max for all contacts.
5	Mixed flowing gas	EIA 364-65,Class II A Samples should be placed in an environmentally controlled 'test chamber' that is monitored by a gas analyzing system for controlled concentrations of the specified gas mixture. Test coupons shall also be used and the weight gain reported. Test duration is 7 days.	Mated	Low level contact resistance meets spec before and after the mixed flowing gas test.
6	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	50 milliohms max for all contacts.
7	Thermal disturbance	Cycle the connector or socket between 15 °C ±3 °C and 85 °C ± 3 °C, as measured on the part. Ramps should be a minimum of 2 °C per minute, and dwell times should insure that the contacts reach the temperature extremes (a minimum of 5 minutes). Humidity is not controlled. Perform 10 such cycles.	Mated	None.
8	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	50 milliohms max for all contacts.
9	Reseating	Manually unplug/plug the connector or socket. Perform 3 such cycles.		No evidence of physical damage.

Test Order	Test	Test Procedure	Condition of Test Specimens	Test Criteria
10	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	50 milliohms max for all contacts.
NOTES 1. Plugs: 1) expose 1/2 of the specimens unmated for 2/3 of the test duration; 2) mate each specimen to the same receptacle that it was mated to during temperature life (preconditioning); and, 3) expose for the remainder of the test duration. 2. Receptacles: 1) expose 1/2 of the specimens unmated for 2/3 of the test duration; 2) mate each specimen to the same plug that it was mated to during temperature life (preconditioning); and, 3) expose for the remainder of the test duration.				

Table 4-7 Test Group A-7 (EIA test groups A-5 and A-6 do not apply to this connector)

Test Order	Test	Test Procedure	Condition of Test Specimens	Test Criteria
1	Dielectric withstanding voltage	EIA-364-20, 100 VAC (rms)	Mated	No disruptive discharge.
2	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	40 milliohms max for all contacts. Baseline measurement.
3	Durability (preconditioning)	EIA-364-09 Perform 4 unplug/plug cycles, followed by an unplug.		No evidence of physical damage.
4	Insertion force	EIA 364-13 Perform the measurement at a maximum speed of 12.5 mm (0.492”) per minute.		Within the range of 5 N to 20 N.
5	Extraction force	EIA 364-13 Perform the measurement at a maximum speed of 12.5mm (0.492") per minute.		Within the range of 8 N to 20 N. Initial reading.
6	Durability	EIA 364-9 Perform 25 plug/unplug cycles. Cycle rate of 500 ± 50 cycles per hour followed by a plug.		No evidence of physical damage.
7	Extraction force	EIA 364-13 Perform the measurement at a maximum speed of 12.5mm (0.492") per minute		Within: a) 33% of the initial reading, and b) 8 N to 20 N.

Test Order	Test	Test Procedure	Condition of Test Specimens	Test Criteria
8	Durability	EIA 364-9 Perform 2,468 plug/unplug cycles. Rotate the receptacle or plug 180º and perform 2,500 plug/unplug cycles. Rotate the receptacle or plug 180º and perform 2,500 plug/unplug cycles. Rotate the receptacle or plug 180º and perform 2,500 plug/unplug cycles. Cycle rate of 500 ± 50 cycles per hour (total of 10,000 plug/unplug cycles, flipping every 2,500 cycles).		No evidence of physical damage.
9	Extraction force	EIA 364-13 Perform the measurement at a maximum rate of 12.5mm (0.492") per minute.		Within 6 N to 20 N.
10	Low level contact resistance	EIA-364-23 The measurement is made across the plug and receptacle mated contacts and does not include any internal paddle cards or substrates of the plug or receptacle. See Figure 4-1.	Mated	50 milliohms max for all contacts.
11	Dielectric withstanding voltage	EIA-364-20, 100 VAC (RMS)	Mated	No disruptive discharge
12	Insulation Resistance	EIA 364-21. Applicable to both receptacle and plug.	Both unmated and mated	A minimum of 100 MΩ insulation resistance is required between adjacent contacts of unmated and mated connectors.

NOTES

1. Separate sets of test specimens may be used to assess dielectric withstanding voltage and the change in low level contact resistance.
2. Dielectric withstanding voltage testing should involve different contacts than low level contact resistance testing.
3. The durability test requires that the plug be fully dis-engaged or separated from the receptacle during the cycling.

Table 4-8 Test Group A-8 (required for USB4 Gen 3 receptacles only)

Test Order	Test	Test Procedure	Condition of Test Specimens	Test Criteria
1	Insertion Loss Fit at Nyquist Frequencies (ILfitatNq)	See Appendix H.	Mated	≥ −0.6 dB @ 2.5 GHz ≥ −0.8 dB @ 5.0 GHz ≥ −1.0 dB @ 10 GHz ≥ −1.25 dB @ 12.5 GHz ≥ −1.5 dB @ 15 GHz
~~2~~	~~Integrated Multi-reflection (IMR)~~	~~See Appendix H.~~	~~Mated~~	~~≤ −39 dB~~
~~3~~2	Integrated Differential Crosstalk	See Appendix H.	Mated	INEXT/IFEXT:≤ −43 dB
~~4~~3	Differential Crosstalk of TX/RX on D+/D−	See Appendix H.	Mated	≤ −50 dB
~~5~~4	Integrated Return Loss (IRL)	See Appendix H.	Mated	≤ −15 dB
~~6~~5	Differential to Common Mode Conversion (SCD12 and SCD21)	See Appendix H.	Mated	≤ −20 dB (100 Mhz to 10.0 Ghz)

NOTES

1. See the *USB Type-C Cable and Connector Specification* ~~Revision 2.0~~ for the USB4 Gen 3 integration method on frequency domain S-parameter data.

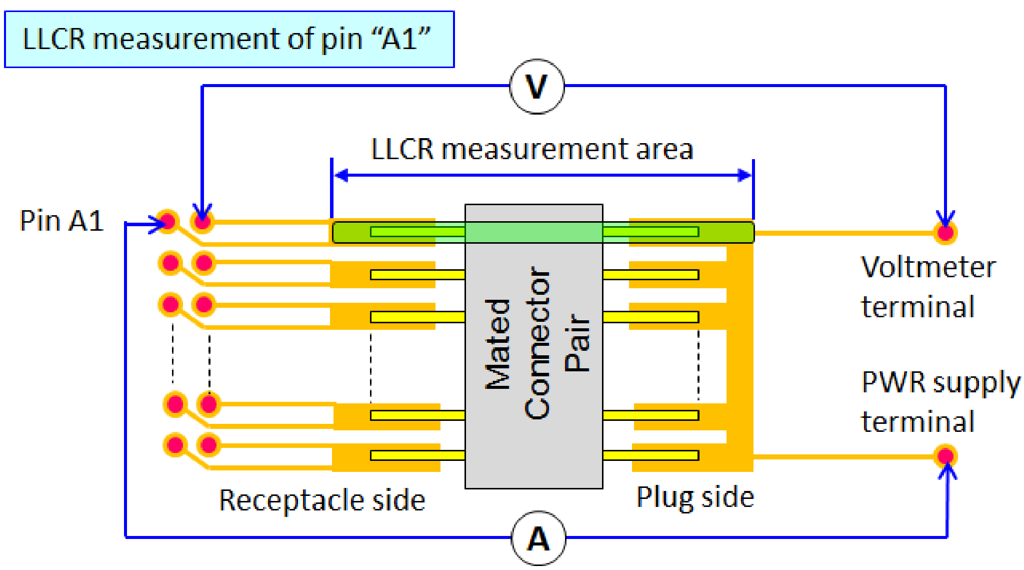


Figure 4-1 Typical Contact Resistance Measurement

4.10.3 Test Groups B

Test Groups B cover tests not included in 4.10.2. There are a total of eight test groups in Test Groups B, as defined in the tables of this section.

Cable assemblies shall be identified by the manufacturer regarding their configuration as specified by the most current version of Chapter 3 of the *Universal Serial Bus Type-C Cable and Connector Specification* and applicable Supplements. Verification of compliance with electronic marking, as required (see Chapter 3 of the *Type-C Cable and Connector Specification*), shall also be performed. This information is used to determine the maximum rated currents and signal capability as applicable to various test procedures (e.g., voltage drop and insertion loss fit at Nyquist).

Table 4-9 Test Group B-1: USB Type-C Connector and Cable Assembly Electronic Marking and Mechanical Tests

Test Phase	Test			Requirements
	Title	**EIA 364 Test**	**Severity or Condition of Test**	
B-1-1	Electronic Marking	n/a	See section 4.9 of the *USB Type-C Cables and Connectors Specification*.	Electronic marking, as required, matches the cable assembly capabilities.
B-1-2	Cable Pull Out	38b	Apply steady state axial load to the cable for one minute.	40 N minimum. The cable assembly shall have no electrical discontinuity and cable shall have no mechanical separation from connector. For cable assembly only.
B-1-3	Cable Flex	41	X=3.7 x cable diameter 500 cycles 2 planes 120 degree arc.	No loss of continuity during cycling. For cable assembly only.
B-1-4	4-Axis Continuity	n/a	See Appendix D for detailed test fixture and procedures.	No discontinuities greater than 1 microsecond duration in any of the four orientations tested.
B-1-5	Voltage drop	n/a	Use the highest rated current for the cable assembly.	250 mV for GND and 500 mV for VBUS.

Notes:

2. All tests in this group shall be performed for cable assembly certification.
3. All tests in this group except for B-1-1 and B-1-5 shall be performed for certification of plugs or receptacles attached to cables. The connector manufacturer is responsible for providing sample connectors with attached cables for testing.
4. Only the test B-1-4 is required for certification receptacles and plugs not attached to cables. The connector manufacturer is responsible for providing receptacles mounted on 4-axis continuity test fixtures. See Appendix D.
5. Tests do not have to be performed according to the sequence listed in the table. Concurrent testing using virgin parts for each test is allowed.
6. The voltage drop measurement is made at the receptacle contact solder tails and does not include fixture losses. The plug shell shall be DC connected to the applied GND through the receptacle shell and/or receptacle ground bar.

Table 4-10 Test Group B-2: USB 2.0 and Low Speed Signal Tests of Type-C Cable and Adapter Assemblies

Test Phase	Test			Requirements		
	Title	EIA 364 Test	Severity or Condition of Test	Type-C to Type-C	Type-C to Legacy	Type-C to Legacy Adapter
B-2-1	D+/D-Pair Attenuation	101	AppendixH.4.	≥−1.02 dB @ 50 MHz ≥−1.43 dB @100 MHz ≥−2.40 dB @200 MHz ≥−4.35 dB @400 MHz	≥−1.02 dB @ 50 MHz ≥−1.43 dB @100 MHz −2.40 dB @200 MHz ≥−4.35 dB @400 MHz	≥ −0.7 dB @400 MHz
B-2-2	D+/D- Pair Differential Impedance	n/a	Appendix H.4. 400 ps (20%-80%) rise time	75 ohms to 105 ohms	75 ohms to 105 ohms	75 ohms to 105 ohms
B-2-3	D+/D- Pair Propagation Delay	103	Appendix H.4. 400 ps (20%-80%) rise time at 50% voltage crossing	20 ns max	10 ns max for Type-C to Micro-B cable assembly; 20 ns max for all other Type-C to legacy USB cable assemblies.	n/a
B-2-4	D+/D- Intra-Pair Skew	103	Appendix H.4. 400 ps (20%-80%) rise time at 50% voltage crossing	100 ps max	100 ps max	20 ps max
B-2-5	Coupling between CC and differential USB D+/D-	90	Appendix H.5.	For cables the limit is defined with the vertices of (0.3 MHz, -60.5 dB), (1 MHz, −50 dB), (10 MHz, −30 dB), (16 MHz, −26 dB) and (100 MHz, −26 dB) in scale of log10(f).	n/a	n/a
B-2-6	Coupling between VBUS and differential USB D+/D-	90	Appendix H.5.	≤ -40 dB for 0.3 MHz<f≤30 MHz, and ≤ 19.12·log10(f/30)-40 (in dB) for 30 MHz< f ≤ 100 MHz.	n/a	n/a
B-2-7	Single- ended Coupling between SBU_A and CC, SBU_B and CC	90	Appendix H.5.	The limit is defined with the vertices of (0.3 MHz, -65 dB), (1 MHz, −55 dB), (18 MHz, −30 dB), and (100 MHz, −30 dB) in scale of log10(f).	n/a	n/a

Test Phase	Test			Requirements		
	Title	EIA 364 Test	Severity or Condition of Test	Type-C to Type-C	Type-C to Legacy	Type-C to Legacy Adapter
B-2-8	Single- ended Coupling between CC and D-	90	Appendix H.5.	For USB 2.0 Type-C cables, the singled-ended coupling between the CC and D− shall be below the limits defined with the vertices of (0.3 MHz, −48.5 dB), (1 MHz, −38 dB), (10 MHz, −18 dB) and (100 MHz, −18 dB) in scale of log10(f). For USB Full-Featured Type-C cables, the singled-ended coupling between the CC and D− shall be below the limits defined with the vertices of (0.3 MHz, −58 dB), (10 MHz, −27.5 dB), (11.8 MHz, −26 dB) and (100 MHz, −26 dB) in scale of log10(f).		
B-2-9	Single-ended Coupling between SBU_A and SBU_B	90	Appendix H.5.	The limit is defined with the vertices of (0.3 MHz, −56.5 dB), (1 MHz, −46 dB), (10 MHz, −26 dB), (11.2 MHz, −25 dB), and (100 MHz, −25 dB) in scale of log10(f).	n/a	n/a
B-2-10	Coupling between SBU_A /SBU_B and differential USB D+/D−	90	Appendix H.5.	The limit is defined with the vertices of (0.3 MHz, -80 dB), (30 MHz, −40 dB), and (100 MHz, −40 dB) in scale of log10(f).	n/a	n/a
B-2-11	VBUS loop inductance	n/a	Appendix H.5.	≤ 900 nH.	n/a	n/a
B-2-12	VBUS Capacitance (Does not apply to USB 2.0-only cable assemblies or USB 2.0 adapter assemblies.)	n/a	Appendix H.5.	8 nF to 500 nF in each Type-C plug.	Do not support PD: 8 nF to 12 nF located in the Type-C plug. Support PD: 80 pF to 120 pF located in the Type-C plug.	8 nF to 12 nF located in the Type-C plug.

Test Phase	Test			Requirements		
	Title	EIA 364 Test	Severity or Condition of Test	Type-C to Type-C	Type-C to Legacy	Type-C to Legacy Adapter
B-2-13	Mutual Inductance between VBUS and Other Low Speed Signals (CC, SBU_A, SBU_B, D+, and D-)	n/a	Appendix H.5.	Maximum: VBUS to CC = ~~443~~350 VBUS to D+ = ~~333~~330 VBUS to D- = ~~333~~330 VBUS to SBU_A = ~~334~~330 VBUS to SBU_B = ~~334~~330	n/a	n/a
B-2-14	Rd resistor verification	n/a	Measure the resistance between pin A5 and Ground (pin A1, A12, B1, or B12).	n/a	Type-C pin A5 resistance to GND for cable assemblies with a USB B plug:	Type-C pin A5 to GND resistance for adapters with a Standard-A receptacle: 5.1kΩ ± 20%
B-2-15	Rp resistor verification	n/a	Measure the resistance between pin A5 and VBUS (pin A4, A9, B4, or B9).	n/a	Type-C pin A5 to VBUS resistance for cable assemblies with a Standard-A plug:	Type-C pin A5 to VBUS resistance for adapters with a Micro-B receptacle: 56kΩ ± 5%
B-2-16	D+ and D- DC Resistance	n/a	Ohmmeter measurement from connector to connector of the D+ line and the D- line.	3.5 ohms max.	3.5 ohms max.	2.5 ohms max.

Table 4-11 Test Group B-3: USB SuperSpeed Signal Tests of Type-C Cable and Adapter Assemblies

Test Phase	Test			Requirements		
	Title	EIA 364 Test	Severity or Condition of Test	Type-C to Type-C	Type-C to Legacy	Type-C to Legacy Adapter
B-3-1	Insertion Loss Fit at Nyquist Frequencies (ILfitatNq)	n/a	Appendix H.3.	For USB 3.2 Gen 1 SuperSpeed pairs and USB4 Gen2 TX/RX pairs: ≥−7.0 dB at 2.5 GHz ≥ −11.5 dB at 5 GHz. For all USB 3.2 Gen 2 SuperSpeed pairs: ≥ −4 dB at 2.5 GHz ≥ −6 dB at 5 GHz ≥ −11 dB at 10 GHz	≥ −4 dB @ 2.5 GHz, except for the USB Type-C plug to USB 3.1 Standard-A plug cable assembly which is: ≥ −3.5 dB @ 2.5 GHz ≥ −6 dB at 5 GHz	≥ −2.4 dB at 2.5 GHz and ≥ −3.5 dB at 5.0 GHz
B-3-2	Integrated Multi-reflection (IMR)	n/a	Appendix H.3.	For USB 3.2 Gen1 SuperSpeed and USB4 Gen2 TX/RX pairs: ≤ 0.126 · ILfitatNq^2+ 3.024 · ILfitatNq – 24.792, in dB. For USB 3.2 Gen 2 SuperSpeed and USB4 Gen2 TX/RX pairs: ≤ 0.126 · ILfitatNq^2+ 3.024 · ILfitatNq – 23.392, in dB.	≤ 0.126 · ILfitatNq^2+ 3.024 · ILfitatNq – 21.392, in dB	≤ −~~34~~ 38 dB for Tb=200 ps and ≤ −27 dB for Tb=100 ps
B-3-3	Integrated Crosstalk b SuperSpeed Pairs (INEXT and ISSXT)	n/a	Appendix H.3.	For USB 3.2 SuperSpeed pairs and USB4 Gen2 TX/RX pairs: Integrated near-end crosstalk: INEXT ≤ −40 dB to 12.5GHz, for Tx1 to Rx1, Tx2 to Rx2, TX1 to RX2, TX2 to RX1, TX1 to TX2, and RX1 to RX2	ISSXT ≤ −38 dB	ISSXT ≤ −37 dB

Test Phase	Test			Requirements		
	Title	EIA 364 Test	Severity or Condition of Test	Type-C to Type-C	Type-C to Legacy	Type-C to Legacy Adapter
B-3-4	Integrated Crosstalk between SuperSpeed Pairs and D+/D- (IDDXT_1NEXT +FEXT and, IDDXT_2NEXT)	n/a	Appendix H.3.	For USB 3.2 SuperSpeed pairs and USB4 Gen2 TX/RX pairs: Integrated near-end crosstalk to D+/D-: IDDXT_2NEXT ≤ −33 dB Integrated near-end and far-end crosstalk to D+/D-: IDDXT_1NEXT+FEXT ≤ −34.5 dB	n/a	n/a
B-3-5	Integrated Differential Crosstalk on D+/D- (IDDXT)	n/a	Appendix H.3.	n/a	≤ −28.5 dB	≤ -30 dB
B-3-6	Integrated Return Loss (IRL)	n/a	Appendix H.3.	For USB 3.2 Gen2 SuperSpeed and USB4 Gen2 TX/RX pairs: ≤ 0.046· ILfitatNq^2 + 1.812 · ILfitatNq – 10.784 in dB For USB 3.2 Gen1 SuperSpeed and USB4 Gen2 TX/RX pairs: ≤ 0.046· ILfitatNq^2 + 1.812 · ILfitatNq – 9.784 in dB	≤ 0.046· ILfitatNq^2 + 1.812 · ILfitatNq – 9.784 in dB	≤ −14.5 dB for Tb=200 ps and ≤ -12.0 dB for Tb=100 ps
B-3-7	Differential-to - Common-Mode Conversion (SCD12/SCD21)	n/a	Appendix H.3.	For USB 3.2 ~~Gen1/~~Gen2 SuperSpeed and USB4 Gen2 pairs: ≤ -20 dB from 100 MHz to 10 GHz For USB 3.2 Gen1 SuperSpeed and USB4 Gen2 TX/RX pairs: ≤ -17 dB from 100 MHz to 10 GHz	≤ -20 dB from 100 MHz to 10 GHz	≤ -15 dB from 100 MHz to 7.5 GHz

Table 4-12 Test Group B-4: USB Type-C Cable Assembly Shielding Effectiveness

Test Phase	Test			Requirements		
	Title	EIA 364 Test	Severity or Condition of Test	Type-C to Type-C	Type-C to Legacy	Type-C to Standard-A Receptacle Adapter
B-4-1	Cable Shielding Effectiveness	n/a	Appendix J.	Differential model: ≤-55 dB for f ≤1.6 GHz ≤ -50dB for 1.6 GHz ≤ f ≤ 4.0 GHz and for 5 GHz ≤ f ≤ 6 GHz Common model: ≤-40 dB for f≤1.6 GHz ≤ -35 dB for 1.6 GHz ≤ f ≤ 4 GHz and for 5 GHz ≤ f ≤ 6 GHz	Differential model: ≤ -49 dB for f ≤1.6 GHz ≤ -44 dB for 1.6 GHz ≤ f ≤4 GHz and for 5 GHz ≤ f ≤ 6 GHz Common model: ≤ -34 dB for f ≤1.6 GHz ≤ -29 dB for 1.6 GHz ≤ f ≤ 4 GHz and for 5 GHz ≤ f ≤ 6 GHz	Differential model: ≤ -44 dB for f ≤1.6 GHz ≤ -39 dB for 1.6 GHz ≤ f ≤4 GHz and for 5 GHz ≤ f ≤ 6 GHz Common model: ≤ -~~24dB~~ 29dB for f ≤1.6 GHz ≤ -24 dB for 1.6 GHz ≤ f ≤ 4 GHz and for 5 GHz ≤ f ≤ 6 GHz

Table 4-13 Test Group B-5: USB Type-C Connector and Cable Assembly Electronic Marking and Mechanical Tests

Test Phase	Test			Common Requirements
	Title	EIA 364 Test	Severity or Condition of Test	
B-5-1	Critical Dimensions	18	See Appendix B.	All dimensions for component level qualification and overmold only for cable and adapter assemblies.
B-5-2	EMC Shielding Spring Inspection	n/a	Visual inspection for compliance with Figure 4-2.	No EMC shielding spring finger tip of the USB Full-Featured Type-C plug or USB 2.0 Type-C plug shall be exposed in the plug housing opening of the unmated Type-C plug.

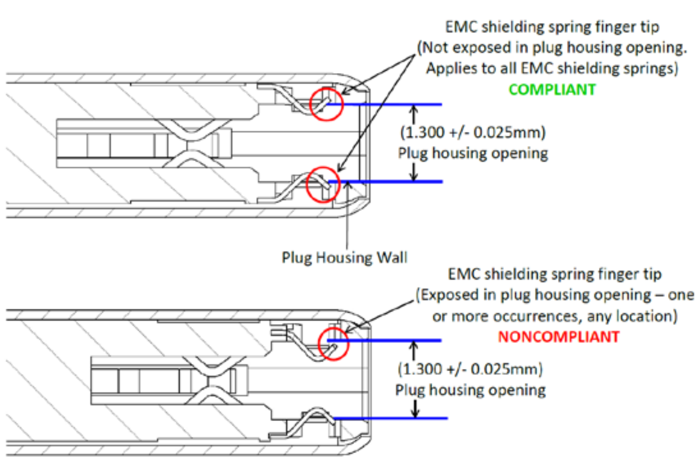


Figure 4-2 Typical Contact Resistance Measurement

Table 4-14 Test Group B-6: Connector Pair Current Rating

Test Phase	Test			Common Requirements
	Title	EIA 364 Test	Severity or Condition of Test	
B-6-1	Contact Current Rating	n/a	See Appendix C.	When current is applied to the contacts, the temperature rise shall not exceed 30°C at the outside surface of the shell. This requirement applies to the USB Type-C connector mated pair only.

Table 4-15 Test Group B-7: Plug Connector Wrenching Test

Test Phase	Test			Common Requirements
	Title	EIA 364 Test	Severity or Condition of Test	
B-7-1	Wrenching Strength	n/a	Perpendicular forces are applied to the plug in four directions (i.e., left, right, up, and down). A metal fixture with opening and tongue representative of a receptacle shall be used. See Appendix E.	The plug shall be mated with the continuity test fixture after the test forces have been applied to verify no damage has occurred that causes discontinuity or shorting.
B-7-2	Continuity	n/a	See Appendix E.	No discontinuities or shorts allowed.
B-7-3	Dielectric withstanding voltage	20	Mated, 100 VAC (RMS)	No disruptive discharge
B-7-4	Wrenching Strength	n/a	Perpendicular forces are applied to the plug in four directions (i.e., left, right, up, and down). A metal fixture with opening and tongue representative of a receptacle shall be used. See Appendix E.	The plug shall disengage from the test fixture or mechanically fail (as defined in Appendix E) when a moment of 2.0 Nm is applied in the up and down directions and a moment 3.5 Nm is applied in the left and right directions.

Table 4-16 Test Group B-8: USB4 Gen3 Signal Tests of Type-C Cable Assemblies

Test Phase	Test			Type-C to Type-C Requirements
	Title	EIA 364 Test	Severity or Condition of Test	
B-8-1	Insertion Loss Fit at Nyquist Frequencies (ILfitatNq)	n/a	Appendix H.3.	For USB 4 Gen 3 TX/RX pairs: ≥ −1 dB at 100 MHz, ≥ −4.2 dB at 2.5 GHz, ≥ −6 dB at 5 GHz, ≥ −7.5 dB at 10 GHz, ≥ −9.3 dB at 12.5 GHz, and ≥ −11 dB at 15 GHz.
B-8-2	Integrated Crosstalk on TX/RX Pairs (INEXT and IFEXT)	n/a	Appendix H.3.	For USB4 Gen 3 TX/RX pairs: Integrated near-end crosstalk within a port: INEXT ≤ -43 dB. Integrated far-end crosstalk within a port: IFEXT ≤ -43 dB. Integrated port-to-port near-end crosstalk: INEXT_p2p ≤ -50 dB. Integrated port-to-port far-end crosstalk: IFEXT_p2p≤ -50 dB. The total crosstalk, IXT_DP and IXT_USB: IXT_DP/IXT_USB ≤ (ILfit_10Ghz+7.5) *2/3.5 -41, dB, -4 ≤ ILfit_10G ≤ -7.5 ≤ -39, dB, ILfit_10G ≥ -4 dB
B-8-3	Integrated Crosstalk between TX/RX Pairs and D+/D- (IDDXT_1NEXT+FEXT, and IDDXT_2NEXT)	n/a	Appendix H.3.	For all USB4 Gen3 TX/RX pairs: Integrated near-end crosstalk to D+/D-: IDDXT_1NEXT+FEXT ≤ −34.5 dB Integrated near-end and far-end crosstalk to D+/D-: IDDXT_2NEXT ≤ −33 dB
B-8-4	Integrated Return Loss (IRL)	n/a	Appendix H.3.	For USB 4 Gen 3 pairs: ≤ (ILfit_10Ghz+7.5) *3.5/3.5 -19.5, dB, -4 ≤ ILfit_10G ≤ -7.5 ≤ -16, dB, ILfit_10G ≥ -4 dB
B-8-5	Differential-to - Common-Mode Conversion (SCD12/SCD21)	n/a	Appendix H.3.	For all USB4 Gen3 Pairs: ≤ -17 dB from 100 MHz to 10 GHz
B-8-6	COM Threshold	n/a	Appendix H.3.	For USB 4 Gen 3 pairs: ≥ 3 dB

5 Certification Acceptance and Submission

Manufacturers of USB Type-C connectors and/or cable/adapter assemblies desiring to have a product or products listed on the USB Implementers' Forum (USB-IF) Integrators List (IL) are required to submit "certified proof" that their USB Type-C product meets or exceeds the performance requirements specified in the most current version of the *USB Type-C Specification* and this document. Certified proof of compliance shall be in the form of a Compliance Test Report (CTR) completed by an A2LA /CNLA or equivalent certified testing laboratory per IEC/ISO 17025.

5.1 Compliance Test Report

Upon successful completion of the compliance testing, the certified laboratory performing the specified tests will issue formal compliance test report. This confidential report will only be available to the manufacturer, test laboratory submitting the report and USB-IF Administration.

5.2 Listing, Authorization and Notification

5.2.1 Listing

Upon successful completion of the compliance testing, the certified laboratory performing the specified tests will provide the USB IF Administration the test results. Upon approval by the USB IF Administration of the test results, the product (s) will be added to the integrators list. The manufacturer has the option whether to display their certified products via the integrators list to the USB IF membership.

5.2.2 Authorization to use Certified USB Logo(s) and USB Trident Logo(s)

Products that are listed on the USB IF Integrators List may use the Certified USB Logo(s) and USB Trident Logo(s) provided that the manufacturer has executed the USB IF Trademark License Agreement and it is on file with USB-IF. Possession of a TID does not indicate that a product is certified. Only products that are listed on the integrators list are certified.

If a manufacturer wishes to use the trademarked Certified USB Logo(s) or USB Trident Logo(s) on more than one USB Type-C product, each product displaying the Certified USB Logo(s) or USB Trident Logo(s) shall have successfully completed the Compliance Testing Program, shall have a TID assigned by USB-IF, and have each product listed on the integrators list.

Only upon receiving official USB-IF Notification and executing the USB-IF Trademark License Agreement is the product authorized to bear the Certified USB Logo(s) or USB Trident Logo(s) on the listed product.

5.2.3 Notification

The manufacturer of record will be notified by E-mail that their product has been listed.

Appendicies

This document is developed as a "living document". In order to provide system engineers and designers the most current USB Type-C cable and connector information, USB-IF Device Working Group members may from time to time choose to add additional useful information to this document, e.g., listings of international laboratories capable of performing approval testing, et cetera.

A Testing by Similarity – General Guidelines

Not all USB Type-C connector and cable assembly products have to go through the full compliance tests. Certain tests may be exempted if a similar USB Type-C product is already certified. Below are some general guidelines for Testing by Similarity:

1) If a new USB Type-C connector product has an identical mating interface (both design and material) to another USB Type-C connector that has already been certified, then all the tests associated to the mating interface may be exempted. For example, if a company A has a certified through-hole USB Type-C connector and it then adds a SMT part into the product line with the only difference being the soldering feature, then no new certification is required, provided that the connector vendor has verified the performance of the soldering features and signal integrity.

2) If a new Type-C cable assembly has the same mating interface and wire termination (both design and material) as another USB Type-C cable assembly that has been already fully tested and certified, then it is not necessary to do the full compliance testing:

    a) All the tests from the Group A are waived since the new cable assembly has the identical mating interface and material from the certified cable assembly.

    b) Tests in test groups B-1, B-4, B-5 and B-6 are waived.

    c) Only the Test Groups B-2 and B-3 are required for the new cable assembly, if the new cable assembly is longer than the certified cable assembly.

B Critical Dimensions

The critical dimensions and tolerances for the Type-C connectors are defined in this section with the circles marked near them.

B.1 USB Full-Featured Type-C Plug

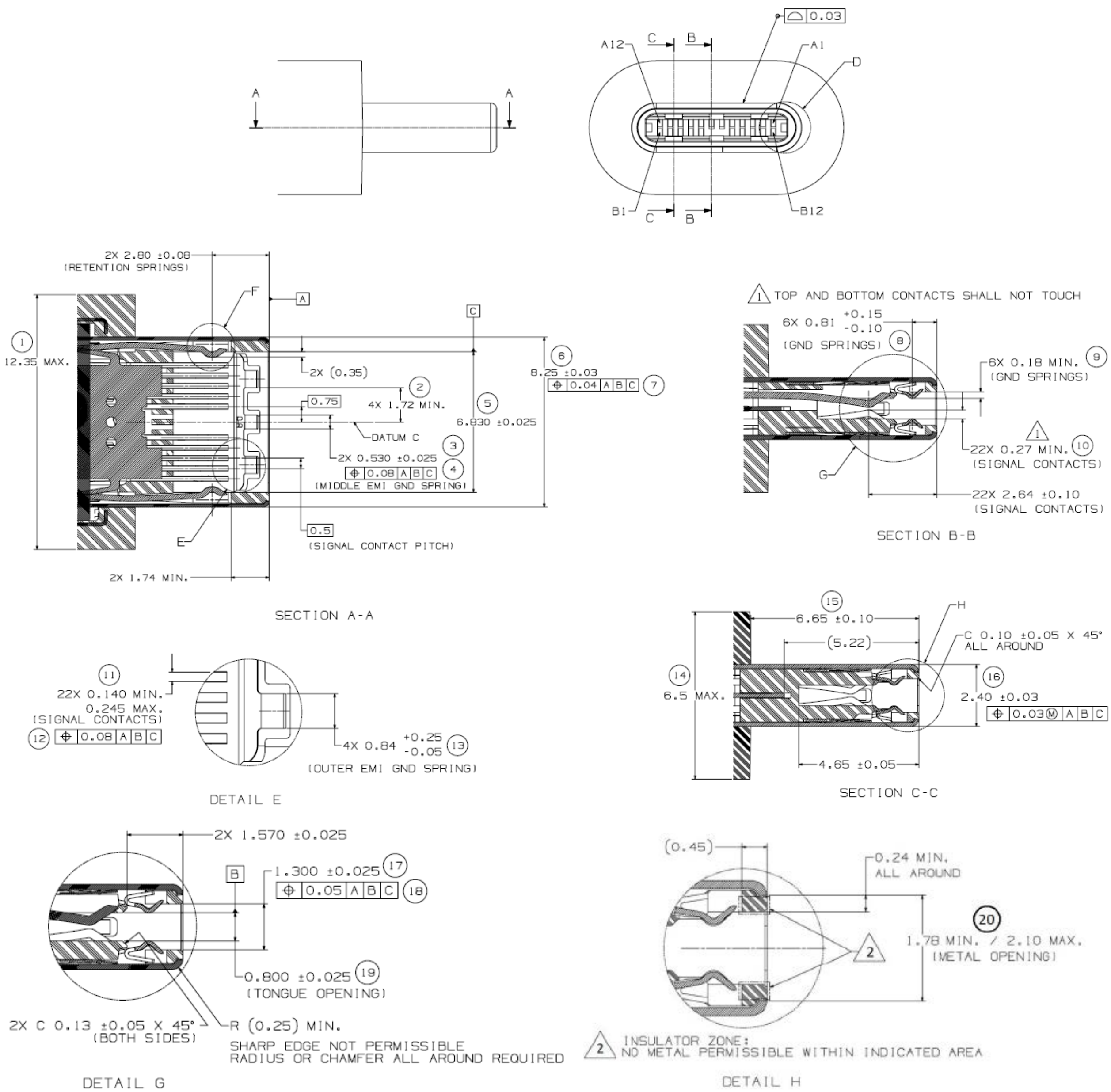


Figure B-1 USB Full-Featured Type-C Plug

Table B-1 USB Full-Featured Type-C Plug

Description	Dimension	+ Tol.	- Tol.
1. Plug overmold/insulator width	12.35 max	n/a	n/a
2. EMC finger location	1.72 min	n/a	n/a
3. EMC middle finger width	0.530	0.025	0.025
4. EMC finger position tolerance	0.08 with datum A/B/C	n/a	n/a
5. Plug opening in y-direction	6.830	0.025	0.025
6. Plug width	8.25	0.03	0.03
7. Plug width (centerline) position tolerance	0.04 with datum A/B/C	n/a	n/a
8. Contact point of EMC finger	0.81	0.15	0.10
9. EMC finger contact height	0.18 min	n/a	n/a
10. Signal contact height (top and bottom contacts shall not touch)	0.27 min	n/a	n/a
11. Signal contact width	0.140 min and 0.245 max	n/a	n/a
12. Signal contact width position tolerance	0.08 with datum A/B/C	n/a	n/a
13. Outer EMC finger width	0.84	0.25	0.05
14. Plug overmold/insulator height	6.5 max	n/a	n/a
15. Plug length	6.65	0.10	0.10
16. Plug thickness	2.40	0.03	0.03
17. Plug thickness opening	1.300	0.025	0.025
18. Plug thickness opening position tolerance	0.05 with datum A/B/C	n/a	n/a
19. Plug tongue opening	0.800	0.025	0.025
20. Metal opening	1.78 min and 2.10 max	n/a	n/a

Notes:

1. All dimensions are in millimeters.
2. For cable and adapter assemblies, only verify overmold/insulator dimensions 1, 14, and 15.
3. Dimensions 1, 14, and 15 only apply if the overmold/insulator is present.
4. All dimensions except 1 and 14 apply to the USB Type-C locking plug. See Figure B-3 and Figure B-4 for additional USB Type-C locking plug requirements.

B.2 USB 2.0 Type-C Plug and USB Type-C Power-Only Plug

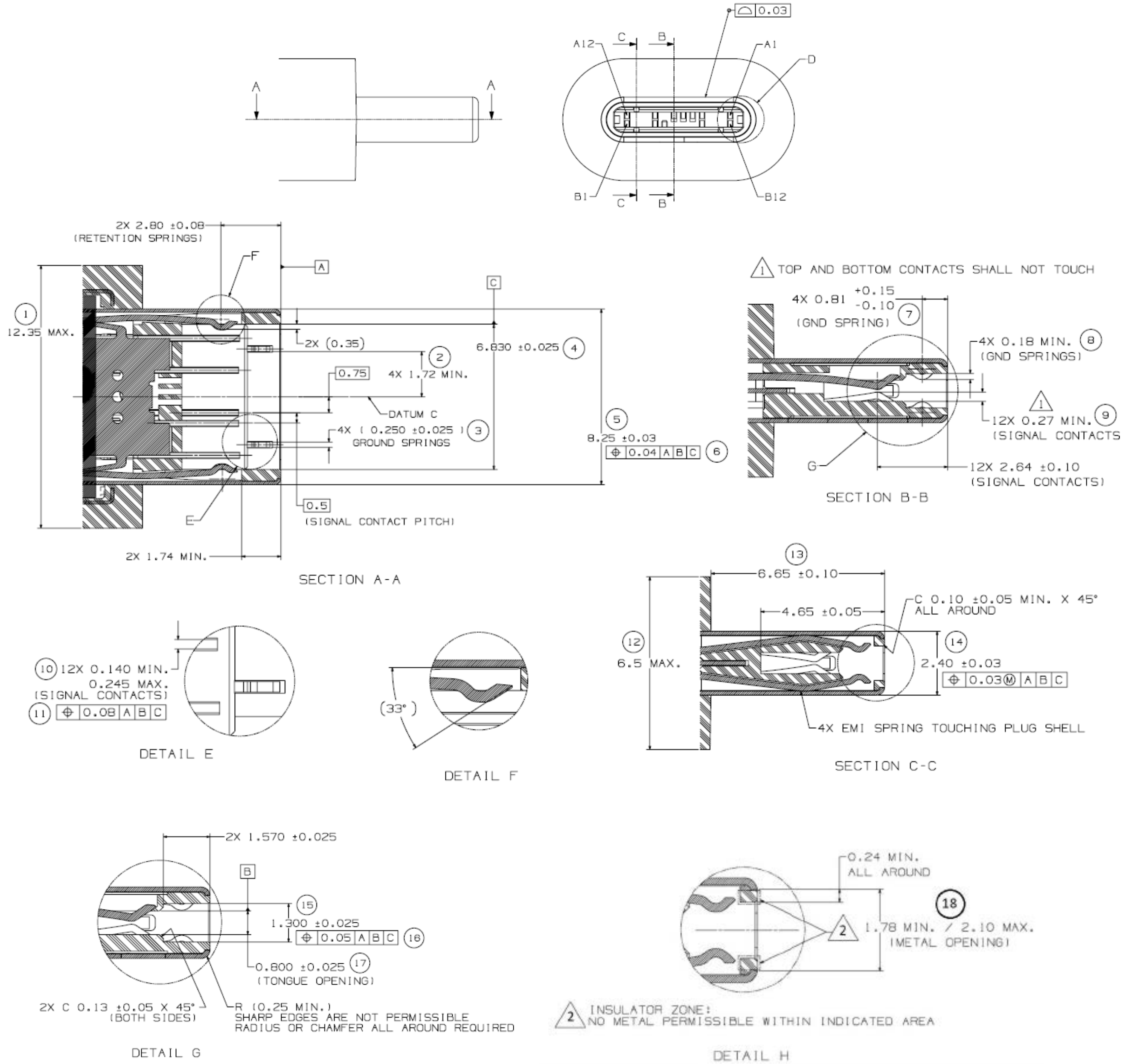


Figure B-2 USB 2.0 Type-C Plug and USB Type-C Power-Only Plug

Table B-2 USB 2.0 Type-C Plug and USB Type-C Power-Only Plug

Description	Dimension	+ Tol.	- Tol.
1. Plug overmold/insulator width	12.35 max	n/a	n/a
2. EMC finger location	1.72 min	n/a	n/a
3. EMC finger width	0.250	0.025	0.025
4. Plug opening in width direction	6.830	0.025	0.025
5. Plug width	8.25	0.03	0.03
6. Plug width (centerline) position tolerance	0.04 with datum A/B/C	n/a	n/a
7. Contact point of EMC finger[2]	0.81	0.15	0.10
8. EMC finger contact height[2]	0.18 min	n/a	n/a
9. Signal contact height (Top and bottom contacts shall not touch)	0.27 min	n/a	n/a
10. Signal contact width	0.140 min and 0.245 max	n/a	n/a
11. Signal contact width position tolerance	0.08 with datum A/B/C	n/a	n/a
12. Plug overmold/insulator height	6.5 max	n/a	n/a
13. Plug length	6.65	0.10	0.10
14. Plug thickness	2.40	0.03	0.03
15. Plug opening in thickness direction	1.300	0.025	0.025
16. Plug opening position tolerance	0.05 with datum A/B/C	n/a	n/a
17. Plug tongue opening	0.800	0.025	0.025
18. Metal opening	1.78 min and 2.10 max	n/a	n/a

Notes:

1. All values are in millimeters.
2. Full-featured plug EMC fingers may be used in the USB 2.0 Type-C plug or USB Type-C power-only plug. If the full-feature EMC fingers are present, substitute critical dimensions 2, 3, 4, 8, and 9 from the full-featured plug for critical dimensions 2, 3, 7, and 8.
3. For cable and adapter assemblies, only verify overmold/insulator dimensions 1, 12, and 13.
4. Dimensions 1, 12, and 13 only apply if the overmold/insulator is present.
5. All dimensions except 1 and 12 apply to the USB Type-C locking plug. See Figure B-3 and Figure B-4 for additional USB Type-C locking plug requirements.

B.3 Single Screw USB Type-C Locking Plug Additional Dimensional Requirements

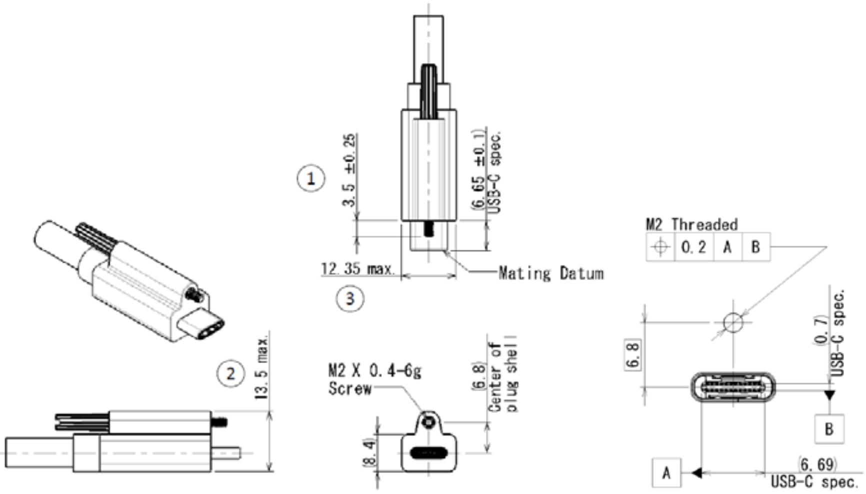


Figure B-3 Single Screw USB Type-C Locking Plug and Mating Capability Requirement

Table B-3 Single Screw USB Type-C Locking Plug Additional Dimensional Requirements

Description	Dimension	+ Tol.	- Tol.
1. Screw protrusion	3.5	0.25	0.25
2. Plug overmold/insulator height	13.5 max	n/a	n/a
3. Plug overmold/insulator width	12.35 min	n/a	n/a

Notes:

1. All values are in millimeters.
2. Dimensions apply to both full-featured and USB 2.0 Type-C locking plugs.
3. Dimension 1 is the maximum screw protrusion. The screw threads shall also retract to flush or below the overmold/insulator surface.
4. The connector shall mount to receptacle and the screw shall properly engage with the threaded hole when the receptacle and hole comply with the dimensions shown in the figure and the screw is oriented on the same side of the receptacle as the threaded hole.

B.4 Dual Screw USB Type-C Locking Plug Additional Dimensional Requirements

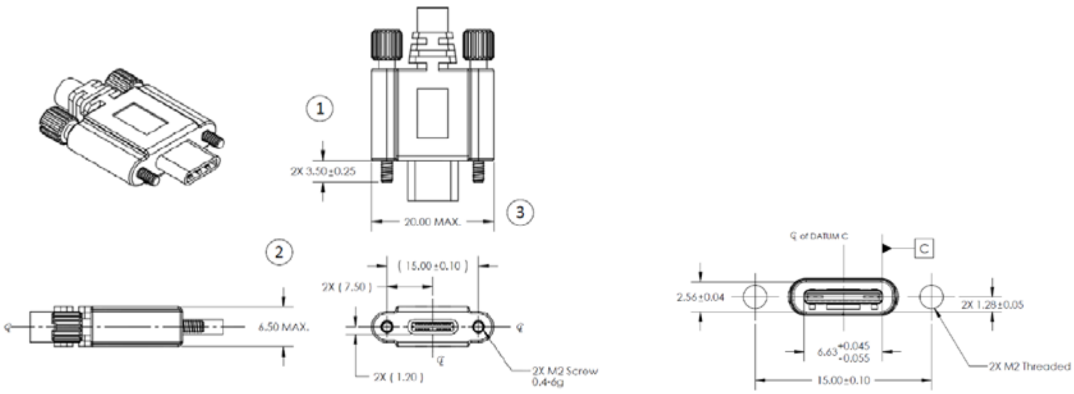


Figure B-4 Dual Screw USB Type-C Locking Plug and Mating Capability Requirement

Table B-4 Dual Screw USB Type-C Locking Plug Additional Dimensional Requirements

Description	Dimension	+ Tol.	- Tol.
1. Screw protrusion	3.5	0.25	0.25
2. Plug overmold/insulator height	6.5 max	n/a	n/a
3. Plug overmold/insulator width	20.00 min	n/a	n/a

Notes:

1. All values are in millimeters.
2. Dimensions apply to both full-featured and USB 2.0 Type-C locking plugs.
3. Dimension 1 is the maximum screw protrusion. The screw threads shall also retract to flush or below the overmold/insulator surface.
4. The connector shall mount to receptacle and the screw shall properly engage with the threaded hole when the receptacle and hole comply with the dimensions shown in the figure.

B.5 USB Type-C Receptacle

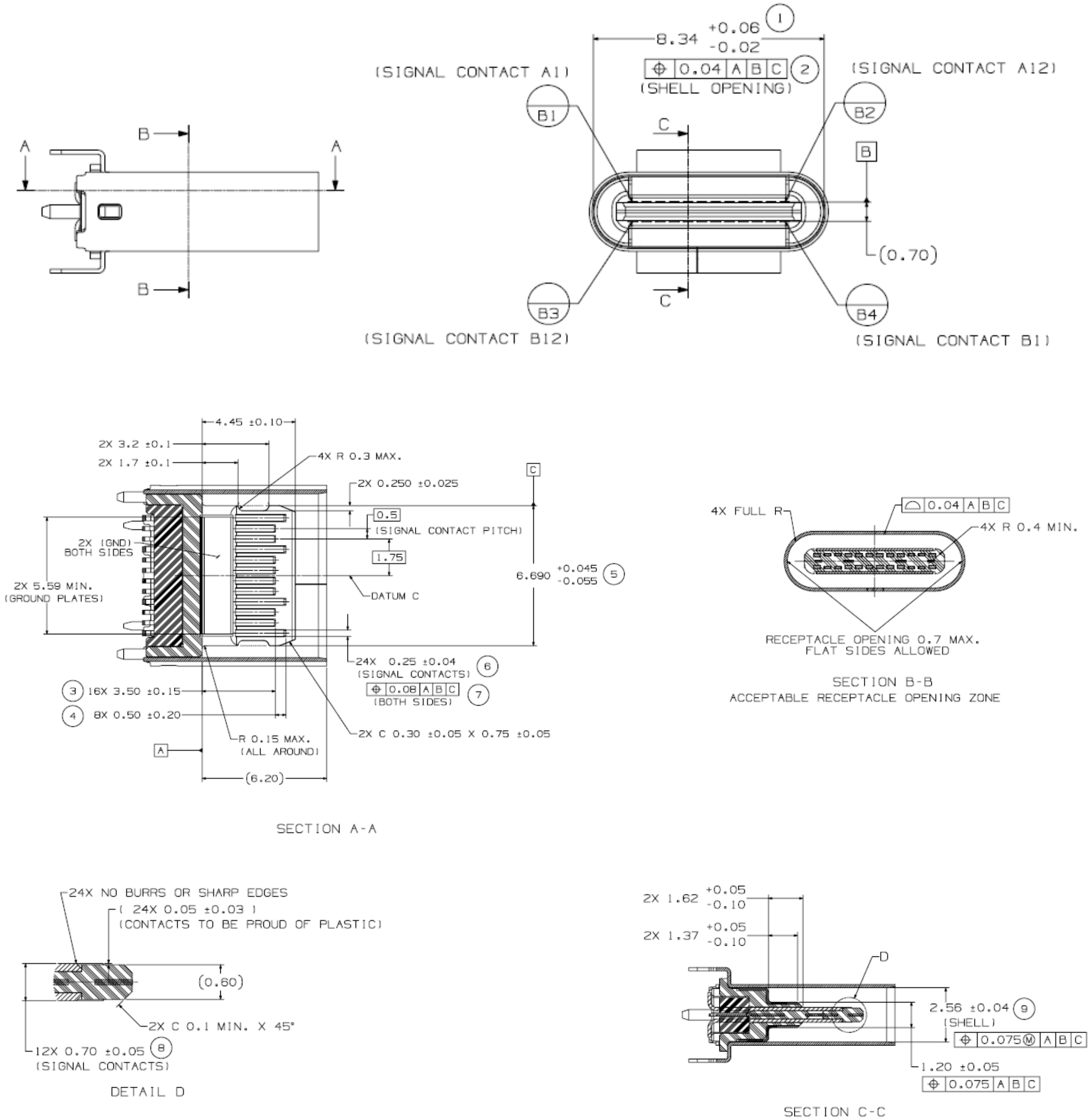


Figure B-5 USB Type-C Receptacle Using SECTION A-A

The USB Type-C specification allows receptacle configurations with a conductive shell, a non-conductive shell, or no shell. The following requirements apply to the receptacle contact dimensions shown in SECTION A-A and ALTERNATE SECTION A-A shown in Figure B-5 and Figure B-6.

- If the receptacle shell is conductive or there is no receptacle shell, then the receptacle contact dimensions of SECTION A-A shown in Figure B-5 or ALTERNATE SECTION A-A shown in Figure B-6 may be used.
- If the receptacle shell is non-conductive, then the receptacle contact dimensions of ALTERNATE SECTION A-A shown in Figure B-6 shall be used. The contact dimensions of SECTION A-A in Figure B-5 are not allowed.

Table B-5 Receptacle Critical Dimensions for Receptacles Using SECTION A-A in Figure B-5

Description	Dimension	+ Tol.	- Tol.
1. Receptacle inside opening	8.34	0.06	0.02
2. Receptacle insider opening position tolerance	0.04 with datum A/B/C	n/a	n/a
3. Receptacle signal pin length	3.50	0.15	0.15
4. Pin length delta	0.50	0.20	0.20
5. Tongue width	6.690	0.045	0.055
6. Contact width	0.25	0.04	0.04
7. Contact width position tolerance	0.08 with datum A/B/C	n/a	n/a
8. Tongue thickness	0.70	0.05	0.05
9. Receptacle inside thickness	2.56	0.04	0.04
Notes: 1. All values are in millimeters.			

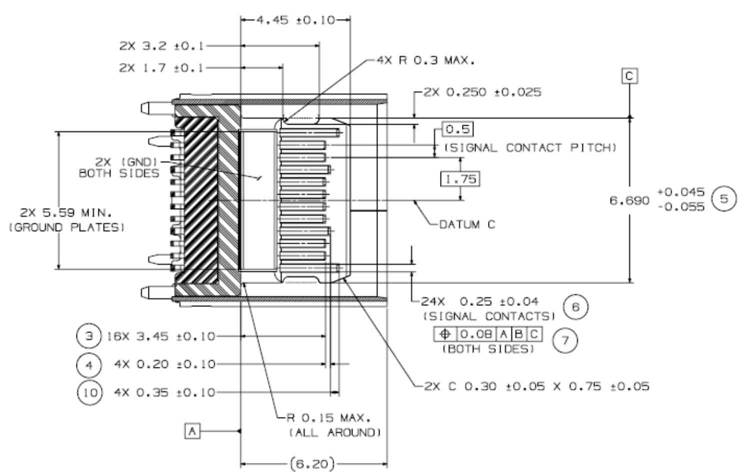


Figure B-6 USB Type-C Receptacle ALTERNATE SECTION A-A

Table B-6 Receptacle Critical Dimensions for Receptacles Using ALTERNATE SECTION A-A in Figure B-6

Description		Dimension	+ Tol.	- Tol.
1.	Receptacle inside opening	8.34	0.06	0.02
2.	Receptacle insider opening position tolerance	0.04 with datum A/B/C	n/a	n/a
3.	Receptacle signal pin length	3.45	0.10	0.10
4.	Pin length delta	0.20	0.10	0.10
5.	Tongue width	6.690	0.045	0.055
6.	Contact width	0.25	0.04	0.04
7.	Contact width position tolerance	0.08 with datum A/B/C	n/a	n/a
8.	Tongue thickness	0.70	0.05	0.05
9.	Receptacle inside thickness	2.56	0.04	0.04
10.	Pin length delta	0.35	0.10	0.10

Notes:

1. All values are in millimeters.
2. These dimension are defined in Figure B-5 except for substitution of ALTERNATE SECTION A-A in Figure B-6 for SECTION A-A in Figure B-5.

The USB Type-C receptacle shall provide an EMC ground return path through one of the following options:

- a system of specific points of contact on the receptacle outer shell (e.g., spring fingers or spring fingers and formed solid bumps),
- internal EMC pads, or
- a combination of both points of contact on the receptacle outer shell and internal EMC pads.

If points of contacts are used on the receptacle, then the receptacle points of contact shall make connection with the mated plug within the contact zones defined in Figure B-7. A minimum of four separate points of contact are required. Additional points of contact are allowed. Alternate configurations may include spring fingers on the A contact side or B contact side and formed solid bumps (e.g., dimples) on the B contact side or A contact side, respectively. Spring fingers are required on a minimum of one side to provide a pressure fit on opposing sides of the plug shell. Additional bumps may be used, but if bumps are on opposing sides of the receptacle shell, the minimum distance between the bumps shall be greater than the maximum plug shell defined dimension.

If internal EMC pads are present in the receptacle, then they shall comply with the requirements defined in Figure B-5 or Figure B-6 as applicable. The shielding pads shall be connected to the receptacle shell. If no receptacle shell is present, then the receptacle shall provide a means to connect the shielding pad to ground.

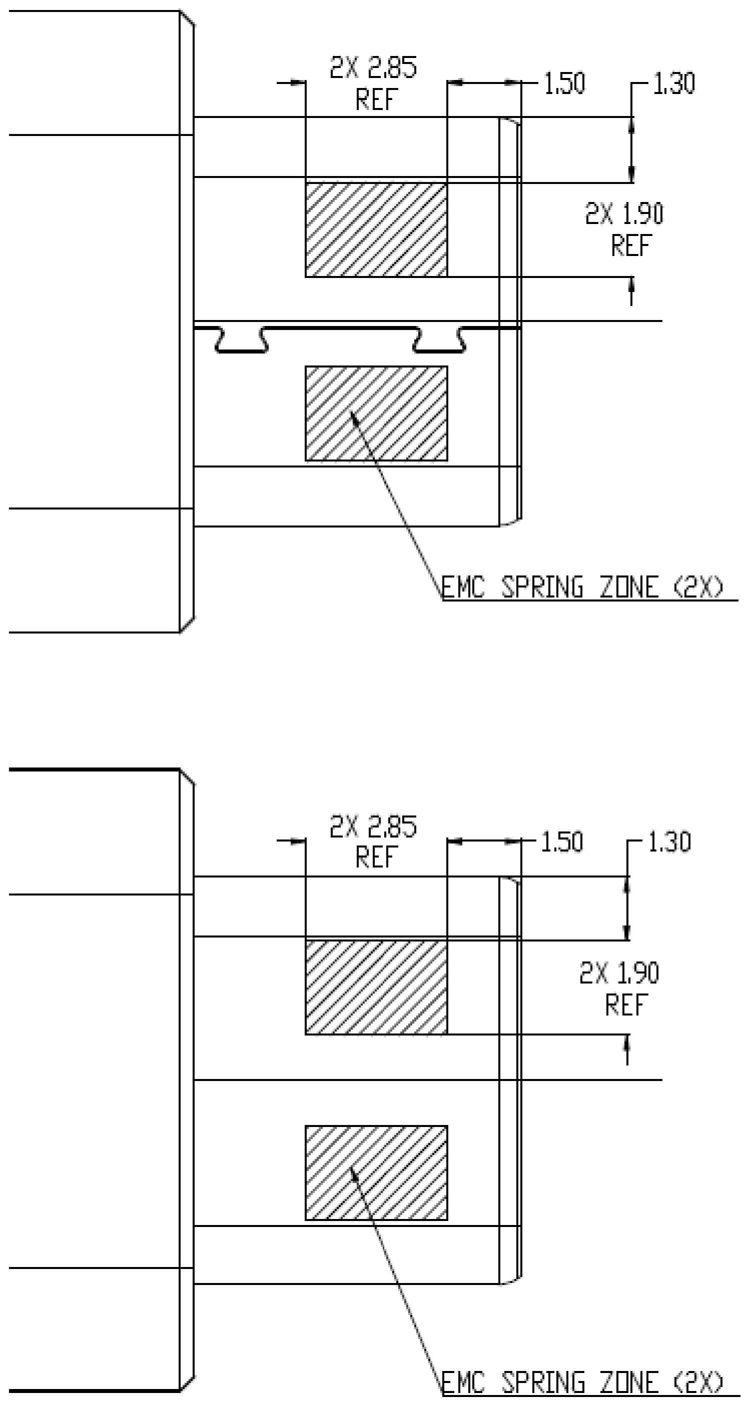


Figure B-7 USB Type-C Plug External EMC Spring Contact Zones

C Current Rating Test

The current rating testing for the Type-C connector (plug and receptacle) shall be conducted per the following set up and procedures:

A current of 5 A shall be applied collectively to VBUS pins (i.e., pins A4, A9, B4, and B9) and 1.25 A shall be applied to the VCONN pin (i.e., B5) as applicable, terminated through the corresponding GND pins (i.e., pins A1, A12, B1, and B12). A minimum current of 0.25 A shall also be applied individually to all the other contacts, as applicable. When current is applied to the contacts, the temperature of the connector pair shall be allowed to stabilize. The temperature rise of the outside shell surface of the mated pair above the VBUS and GND contacts shall not exceed 30ºC above the ambient temperature.

- Figure C-1 provides an illustration of the measurement locations.
- The measurement shall be done in still air.
- The connectors shall be oriented such that the accessible outer shell surface is on top and horizontal to the ground.
- The plug and receptacle may require modification to access solder tails or cable attachment points.
- Either thermocouple or thermo-imaging (preferred) method may be used for temperature measurement.
- For certification, the connector manufacturer shall provide the receptacle and plug samples under test mounted on a current rating test PCB with no copper planes. A cable plug may use short wires to attach the cable attachment points together rather than using a current rating test PCB.
    - The current rating test PCBs should be of 2-layer construction. If 2-layer construction is not possible due to the solder tail configuration, VBUS and ground traces shall be located on the outer layers with the inner layers reserved for signal traces, as required; VCONN traces may be routed either on internal or external layers. Table C-1 defines the requirements for the test PCB thickness and traces. The trace length applies to each PCB (receptacle PCB and plug PCB) and is from the contact terminal to the current source tie point. Figure C-2 provides an informative partial trace illustration of the current rating test PCB.
    - If short wires are used instead of a current rating test PCB, the wire length shall not exceed 70 mm, measured from the plug contact solder point to the other end of the wire. There shall be no paddle card or overmold included in the test set-up. Each plug solder tail shall be attached with a wire with the wire gauge of AWG 36 for signals, AWG 32 for power (VBUS and VCONN), and AWG 30 for ground.

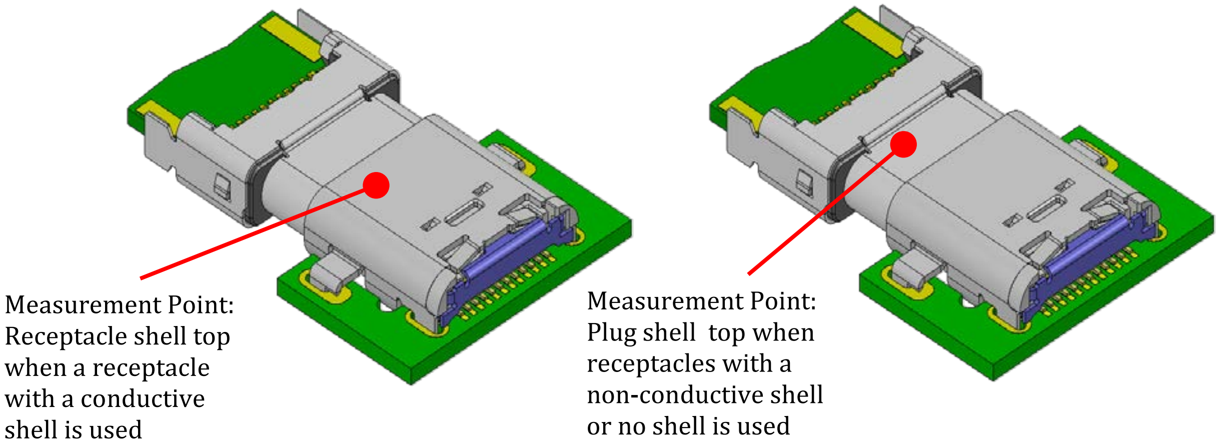


Figure C-1 Temperature Measurement Points

Table C-1 Current Rating Test PCB

Item	Trace Width (mm)	Trace length (mm) on each PCB	Thickness
Signal trace	0.25 max.	13 max.	35 µm (1 oz. copper)
Ground trace	1.57 max.	38 max.	35 µm (1 oz. copper)
VBUS and VCONN	1.25 max.	30 max.	35 µm (1 oz. copper)
PCB	N/A	N/A	0.80 – 1.20 mm

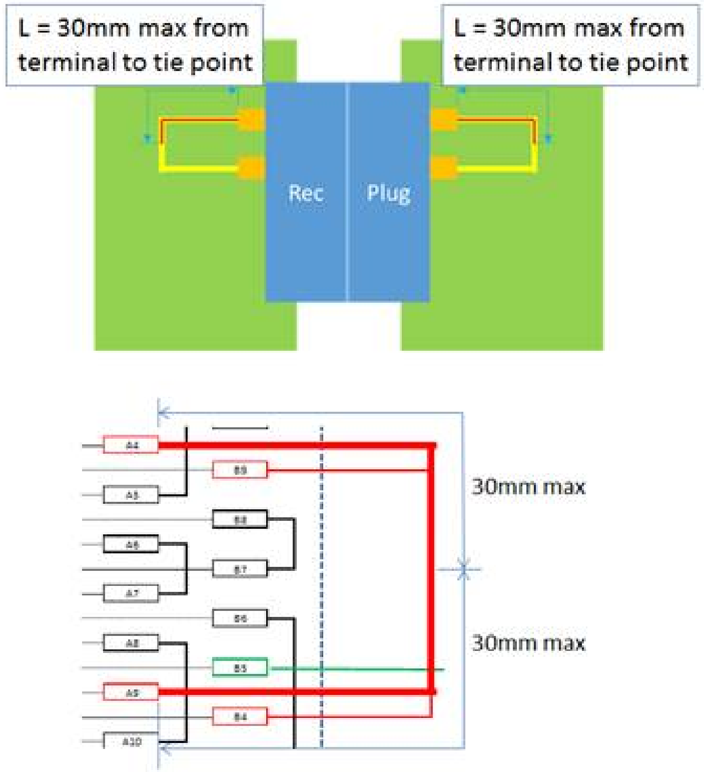
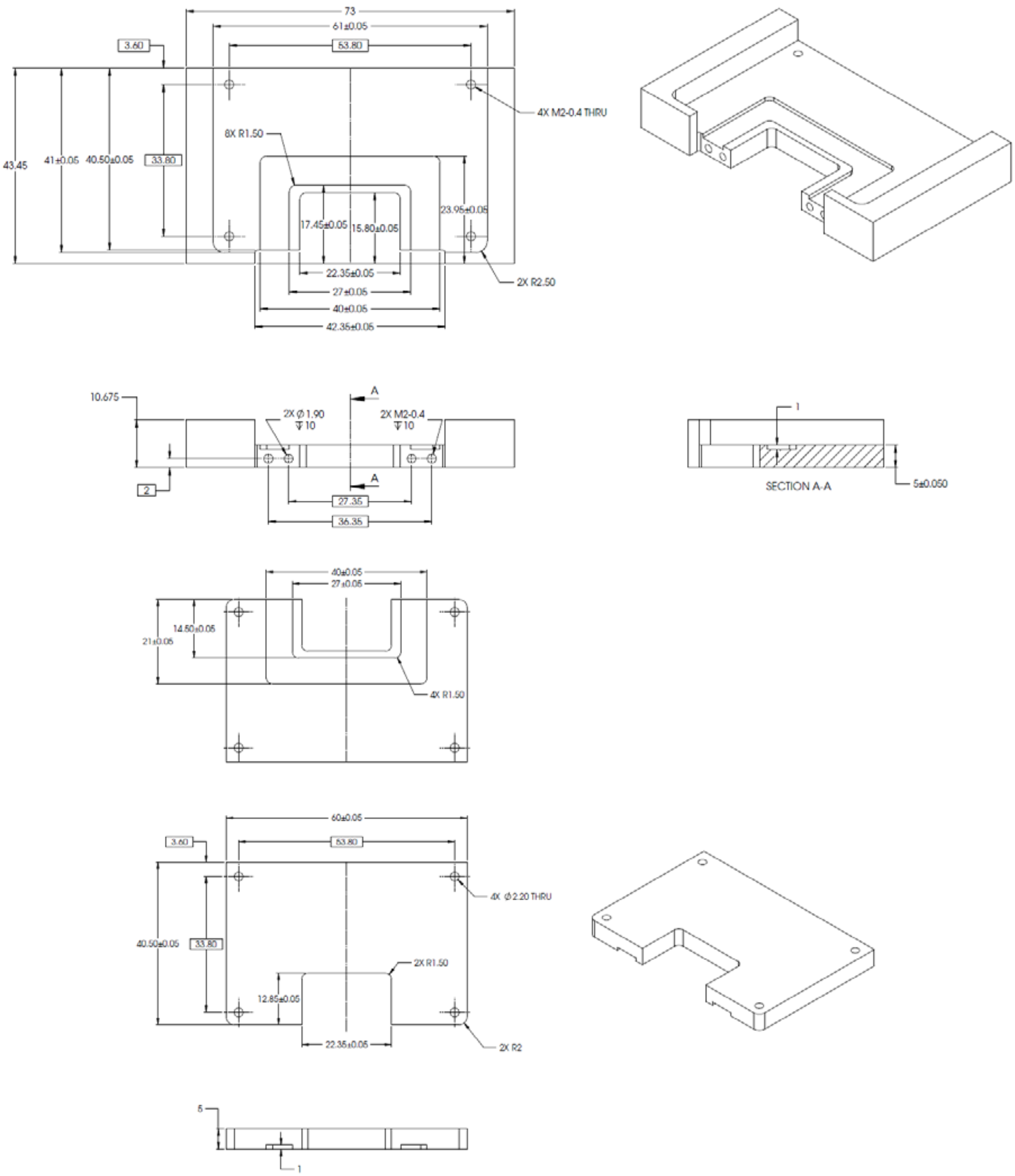


Figure C-2 Example Current Rating Test Fixture Trace Configuration- VBUS Trace Length is limited to 30 mm Max

D 4-Axis Continuity Test

The USB Type-C connector family shall be tested for continuity under stress using a test fixture shown in Figure D-1 or equivalent.



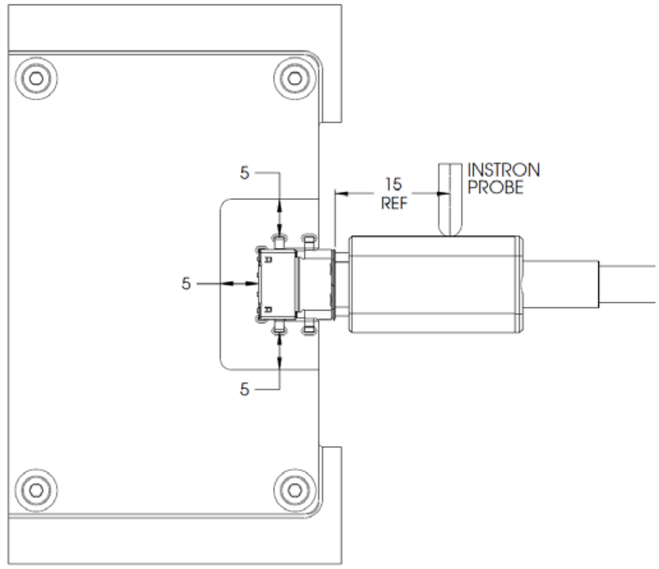


Figure D-1 Example of 4-AxIs Continuity Test Fixture

Plugs shall be supplied with a representative overmold or mounted on a 2 layer printed circuit board (PCB) between 0.8 mm and 1.0 mm thickness as applicable. A USB Type-C receptacle shall be mounted on a 2 layer PCB between 0.8 mm and 1.0 mm thickness. The PCB shall be clamped on three sides of the receptacle no further than 5 mm away from the receptacle outline. The receptacle PCB shall initially be placed in a horizontal plane, and a perpendicular moment shall be applied to the plug with a 5 mm ball tipped probe for a period of at least 10 seconds at a distance of 15 mm from the mating edge of the receptacle shell in a downward direction, perpendicular to the axis of insertion. See Table D-1 for the force and moment to be applied.

Table D-1 Force and Moment Requirements

Receptacle configuration with respect to mounting surface	Force at 15 mm from receptacle shell mating edge (N)	Moment with respect to receptacle shell mating edge (Nm)
Right angle	20	0.30
Vertical	8	0.12

The continuity across each contact shall be measured throughout the application of the tensile force. Each non-ground contact shall also be tested to confirm that it does not short to the shell during the stresses. The PCB shall then be rotated 90 degrees such that the cable is still inserted horizontally and the tensile force in Table D-1 shall be applied again in the downward direction and continuity measured as before. This test is repeated for 180 degree and 270 degree rotations. Passing parts shall not exhibit any discontinuities or shorting to the shell greater than 1 microsecond duration in any of the four orientations.

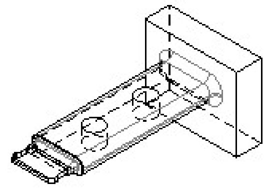
One method for measuring the continuity through the contacts is to short all the wires at the end of the cable pigtail and apply a voltage through a pull-up to each of VBUS, USB D+, USB D−, SBU, CC, and USB SuperSpeed pins, with the GND pins connected to ground. Alternate methods are allowed to verify continuity through all pins.

E Wrenching Strength Test

Type-C plugs on cable assemblies and fixtured plug component parts without overmold shall be tested using the mechanical wrenching test fixture, as illustrated in Figure E-1. The fixture substitutes machined metal parts for the receptacle. For plug component part testing, the supplier shall provide a plug test fixture that conforms to the specified plug overmold dimensions for the Type-C plug. See Figure E-2. The fixture may be metal or other suitable material. Perpendicular moments are applied to the plug with a 5 mm ball tipped probe for a period of at least 10 seconds when inserted in the test fixture to achieve the defined moments in four directions of up or down (i.e., perpendicular to the long axis of the plug opening) and left or right (i.e., in the plane of the plug opening). Compliant connectors shall meet the following force thresholds:

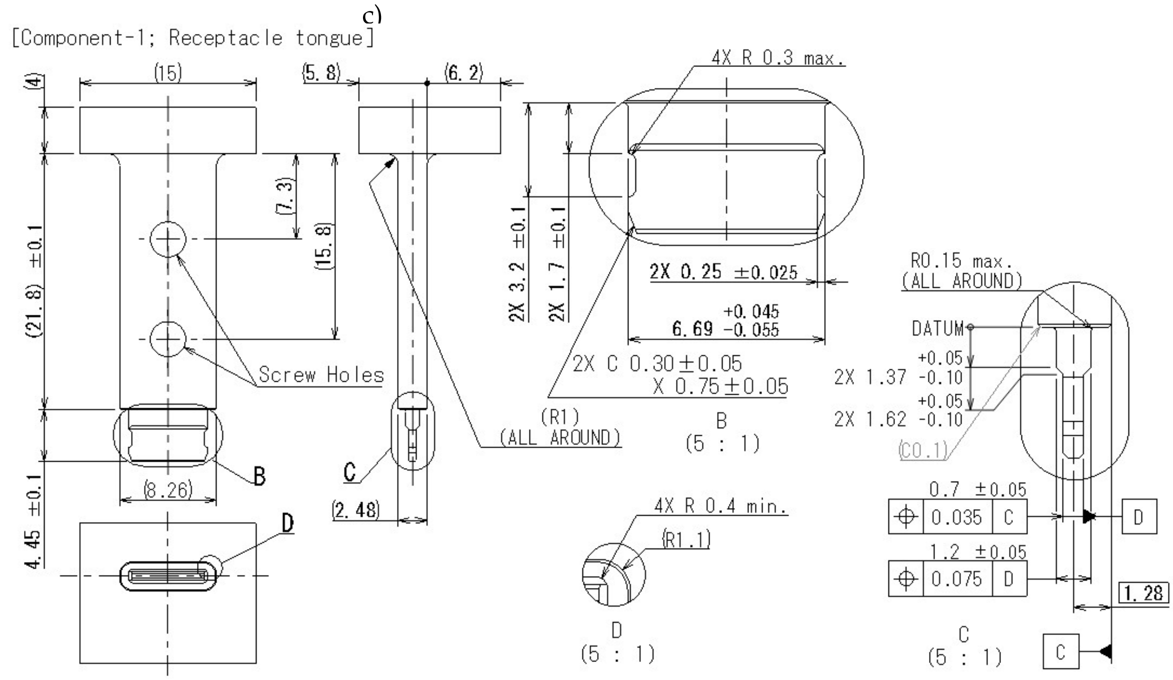
a) A moment of 0-0.75 Nm (e.g., 50 N at 15 mm from the edge of the receptacle) is applied to a plug inserted in the test fixture in each of the four directions. A single plug shall be used for this test. Some mechanical deformation may occur. The plug shall be mated with the continuity test fixture after the test forces have been applied to verify no damage has occurred that causes discontinuity or shorting. The continuity test fixture shall provide a planar surface on the mating side located 6.20 ± 0.20 mm from the receptacle Datum A, perpendicular to the direction of insertion. No moment forces are applied to the plug during this continuity test. Figure E-3 illustrates an example continuity test fixture to perform the continuity test. The Dielectric Withstanding Voltage test shall be conducted after the continuity test to verify plug compliance.

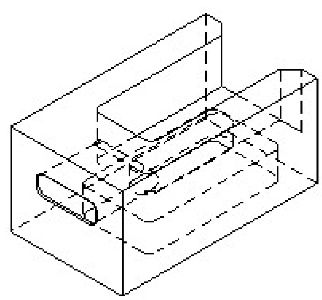
b) The plug shall disengage from the test fixture or demonstrate mechanical failure (i.e., the force applied during the test procedure peaks and drops off) when a moment of 2.0 Nm is applied to the plug in the up and down directions and a moment 3.5 Nm is applied to the plug in the left and right directions. A new plug is required for each of the four test directions. An example of the mechanical failure point is shown in Figure E-4.



Receptacle tongue

c)





Receptacle body

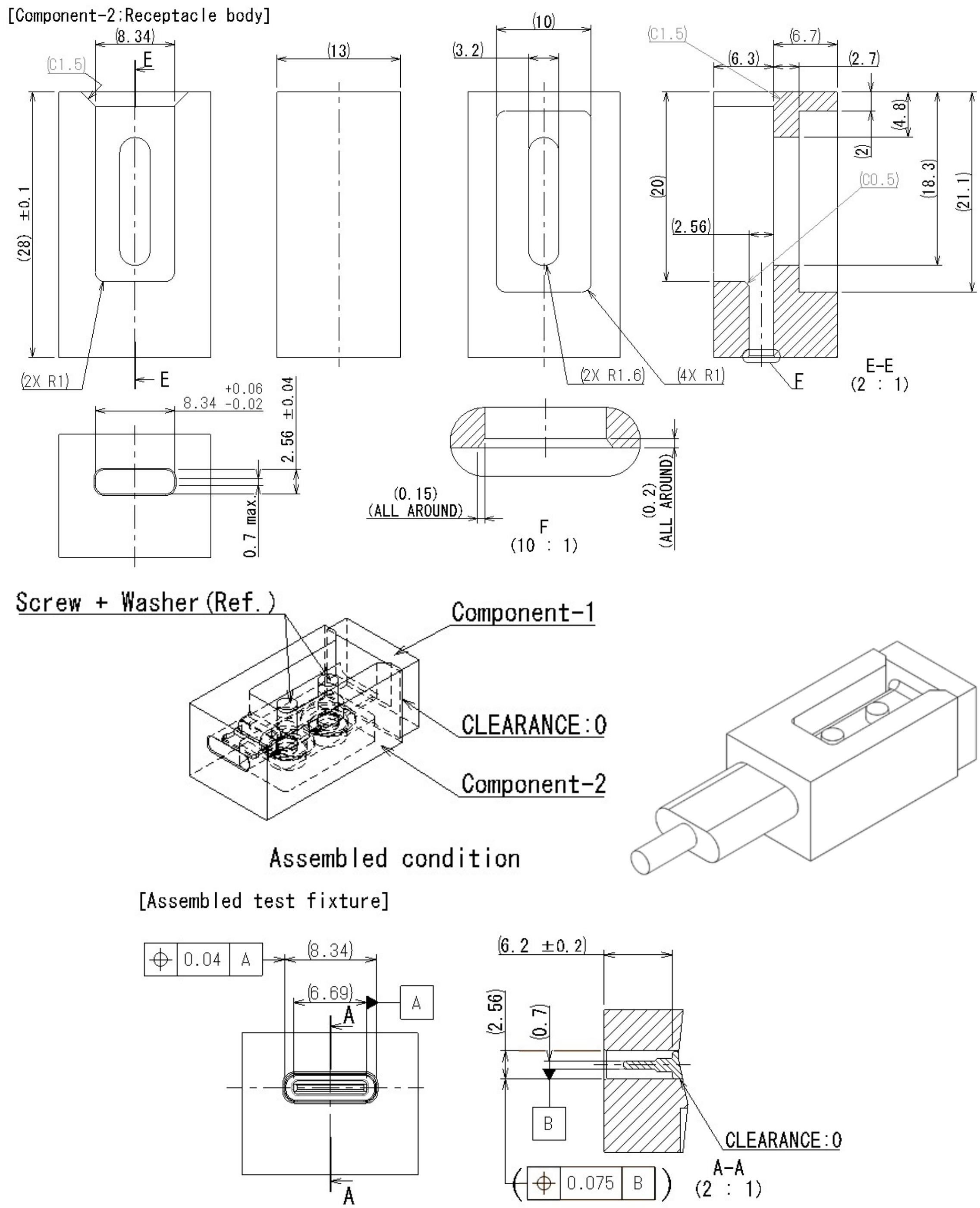


Figure E-1 Reference Wrenching Strength Plug Component Part Test Fixture

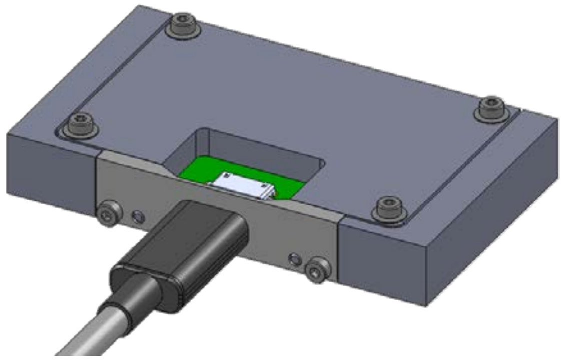


Figure E-2 Reference Wrenching Strength Plug Commponent Part Test Fixture

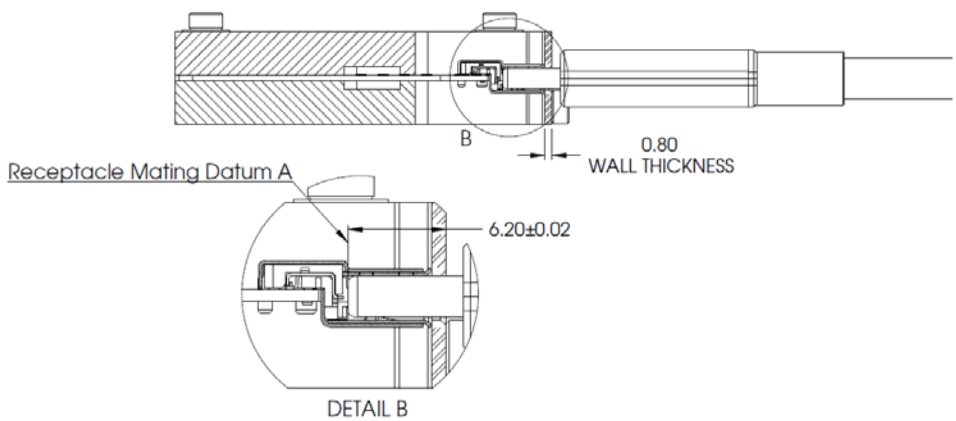


Figure E-3 Reference Wrenching Strength Continuity Test Fixture

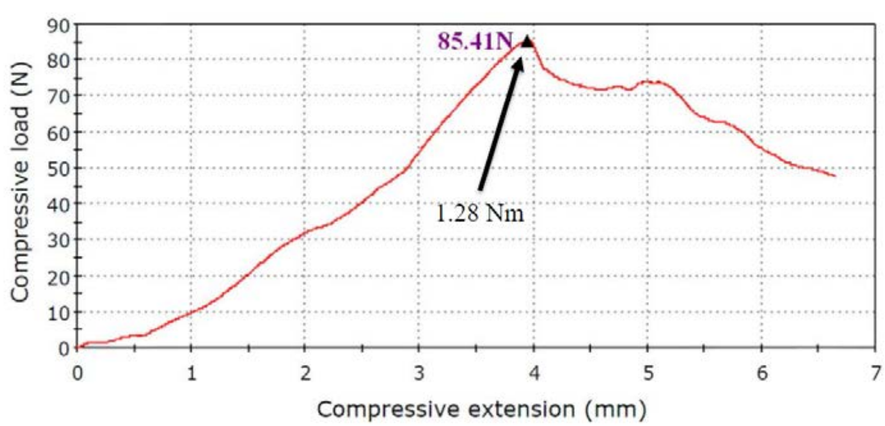


Figure E-4 Example of Wrenching Strength Test Mechanical Failure Point

F Type-C Cable Assemblies Signal Integrity Test Fixtures

USB Type-C cable assembly signal integrity testing shall use USB-IF approved test fixtures. The following test cards are needed to conduct the signal integrity testing for Type-C cable assemblies:

- High speed Type-C test card
- Low speed Type-C test card
- Legacy USB connector test cards
- Calibration card

For consistency, the test cards shall be designed and fabricated on the same PCB panel.

The USB-IF approved cable assembly signal integrity test fixture sets may be purchased from a designated test fixture vendor(s). USB-IF also provides a reference fixture design. Use the following link to download the Type-C cable assembly signal integrity test fixture Gerber files: http://www.usb.org/developers/tools/

F.1 Type-C High Speed Test Card

The Type-C high speed test fixture is used to test the SuperSpeed pair performance as well as the crosstalk between the SuperSpeed pairs and the USB 2.0 D+/D- pair. Figure F-1 shows the signal connections for the fixture. Only the SuperSpeed pairs and D+/D- pair are routed out to 3.5mm or 2.92 mm connectors. Note that Pins B6 and B7 are shorted to pins A6 and A7, respectively, in the fixture.

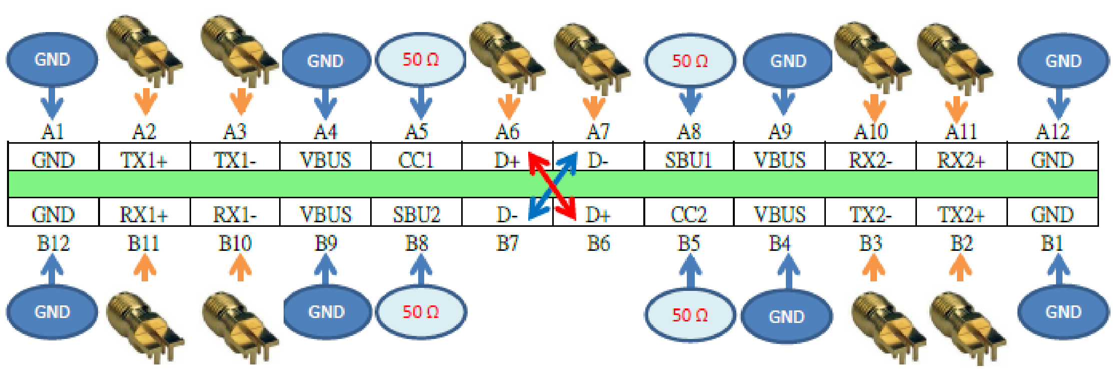


Figure F-1 Signal connections for high speed signal integrity test fixture

The most important feature of the high speed test card is that there is no actual Type-C receptacle mounted in the test card; a PCB tongue is fabricated on the test card as part of the mating interface, as illustrated in Figure F-2.

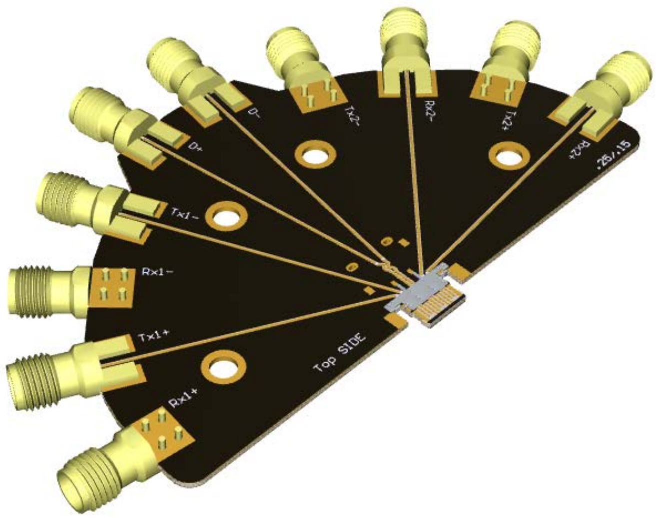


Figure F-2 Test fixture with PCB tongue as mating interface

There shall be a pad on each side of the test card to lift the internal EMC/RFI finger of the Type-C plug off the PCB. The pad is designed with air gap above the PCB, thus ensuring no contact with the PCB traces to avoid any impedance impact that may be introduced by the internal RFI finger. An example design is illustrated in Figure F-3.

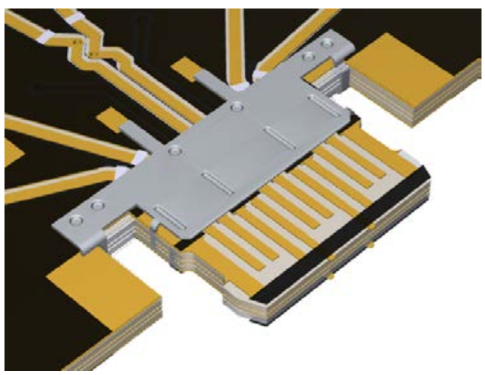


Figure F-3 Example of a pad design to lift the plug RFI finger off PCB

There shall be a metal shell mounted on the test card and connected to test card GND plane, enclosing the PCB tongue, as shown in Figure F-4. The metal shell emulates the receptacle shell GND and provides mechanical support for the plug.

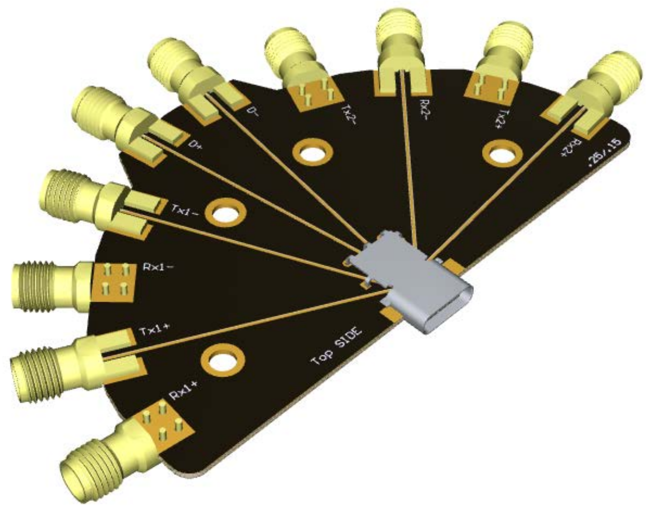


Figure F-4 Metal shell to enclose the PCB tongue

Note that pins B6 and B7 are shorted with pins A6 and A7, respectively, on the test card. The shorting traces should create a 6.5 mm stub length representing the typical stub length from the receptacle pins.

For USB4 Gen3 cable assembly compliance testing, the board RF connectors shall be replaced with a 3.5 mm or a 2.92 mm connector to cover a frequency range up to and above 20 Ghz.

F.2 Type-C Low Speed Test Card

The Type-C low speed test fixture is to test the performance of USB 2.0 D+/D- and other low speed signals such as VBUS, CC and SBU_A/SBU_B. Figure F-5 shows the signal connections for the fixture.

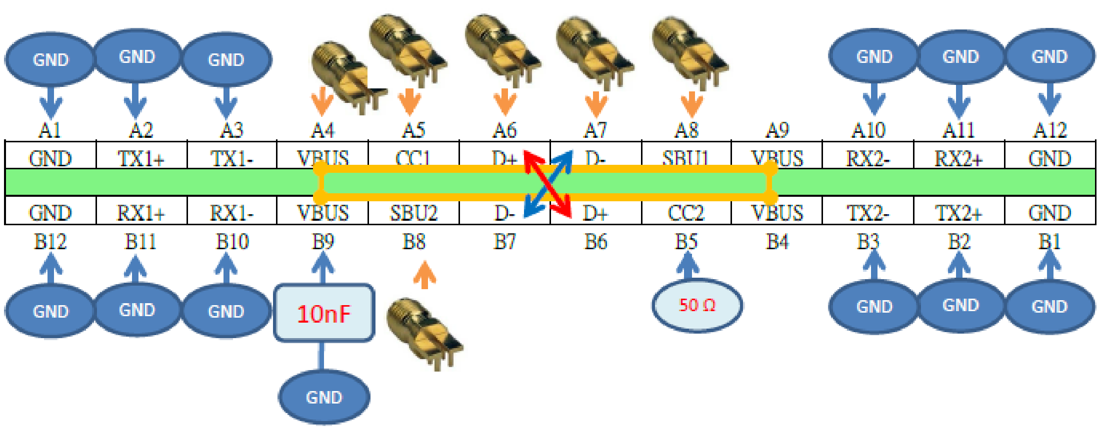


Figure F-5 Signal connections for low speed signal integrity test fixture

All the discussions for the Type-C high speed test card apply to the low speed test card. The additional discussion is for the VBUS pins. They shall be shorted together and connected to the fixture GND plane through a 10 nF 0402 bypass capacitor.

F.3 Legacy USB Test Cards

The legacy USB test cards are used to evaluate signal performance of the Type-C to legacy USB connector cable assemblies and adapter assemblies. A complete list of the legacy USB test cards includes:

- USB 3.1 Standard-A receptacle card to test the Type-C to USB 3.1 Standard-A cable assembly
- USB 2.0 Standard-A receptacle card to test the Type-C to USB 2.0 Standard-A cable assembly
- USB 3.1 Standard-B receptacle card to test the Type-C to USB 3.1 Standard-B cable assembly
- USB 2.0 Standard-B receptacle card to test the Type-C to USB 2.0 Standard-B cable assembly
- USB 3.1 Micro-B receptacle card to test the Type-C to USB 3.1 Micro-B cable assembly
- USB 2.0 Micro-B receptacle card to test the Type-C to USB 2.0 Micro-B cable assembly
- USB 2.0 Mini-B receptacle card to test the Type-C to USB 2.0 Mini-B cable assembly
- USB 3.1 Standard-A plug card to test the Type-C to USB 3.1 Standard-A receptacle adapter assembly

• USB 2.0 Micro-B plug card to test the Type-C to USB 2.0 Micro-B receptacle adapter assembly

Figure F-6, Figure F-7, and Figure F-8 show examples of such cards.

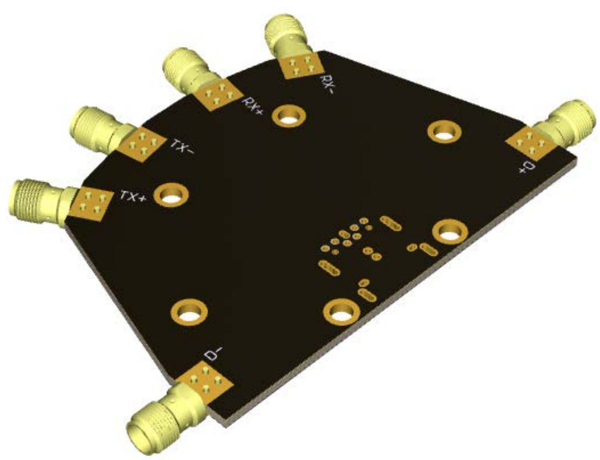


Figure F-6 USB 3.1 standard-A receptacle card

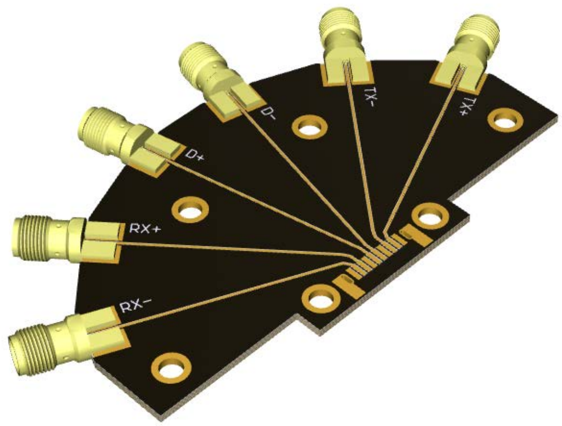


Figure F-7 USB 3.1 standard-A plug card

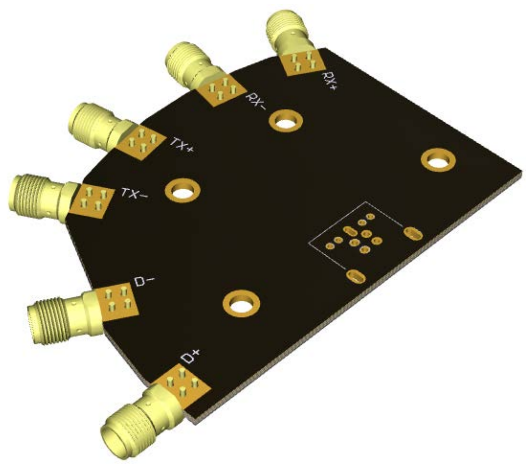


Figure F-8 USB 3.1 Standard B receptacle card

Actual receptacles or plugs are mounted to those test cards. Those receptacle or plugs are considered the “golden” receptacles or plugs. The golden receptacle or plug should be a USB-IF certified part with reasonable signal integrity performance, not compromising the measurement quality of the Type-C to legacy USB cable assemblies or adapter assemblies. The USB-IF test labs may choose the golden receptacle or plug, subject to USB-IF approval.

F.4 Calibration Card

The calibration card has the structures required for TRL calibration, including THRU, OPEN, SHORT, LOAD, and LINES. The LINES of different lengths cover the frequency range from 0.1 GHz to 20 GHz. There are also 1X THRUs on the calibration card to achieve the required rise time at the connector reference plans. Other calibration methods are allowed. For example, the Agilent automatic fixture removal or AFR; the 2X THRU structure may be used for AFR.

Figure F-9 shows a picture of the 2X through calibration card.

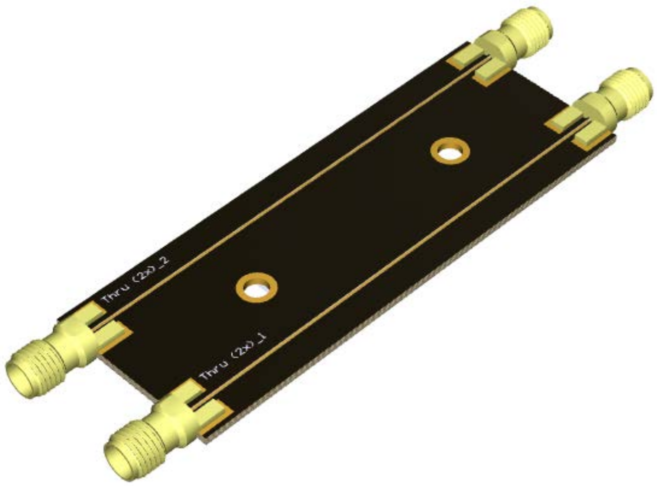


Figure F-9 Calibration card

F.5 Fixture Design Guidelines

To prevent the impact of the test fixture on cable assembly measurement quality, the following guidelines should be followed:

- The test fixture PCB nominal thickness is 0.7 mm. This is dictated by the use of the PCB as the tongue to mate with the Type-C plug. The PCB thickness tolerance is recommended to be ± 0.05 mm. Exceeding this tolerance may result in the plug not mating with the fixture.
- The PCB dielectric material is recommended to be Rogers. This minimizes the fixture impedance variation and trace losses. Other PCB materials such as FR4 may be used as long as the fixture electrical performance is achieved.
- All of the traces on the test fixture shall be single-ended with a characteristic impedance of 50 ohms ± 5% (47.5 to 52.5 Ω).
- Each trace length between the measurement reference plane and the 3.50 or 2.92 mm connectors should be less than 40 mm and equal length within a tolerance of ± 0.025mm.
- Traces between the reference plane and SMAs should be uncoupled from each other. They should be routed in such a way that traces diverge from each other exiting from the reference plane.
- Ground vias should be placed near the GND pins to ensure short ground return path.
- Co-planar wave guide (CPWG) structure should be used for trace isolation. Add plenty of stitching vias to connect the CPWG and the GND planes.
- All non-ground pins that are adjacent but not connected to measurement ports shall be terminated with 50 Ω loads.
- For through-hole connectors, traces should be routed on the opposite side of the PCB from the side the lead is inserted into. For SMT connectors, traces should be routed on the on the same side as the solder pads.

- The 3.50 or 2.92 mm connector impedance should be 50 Ω and the impedance variation should be controlled within ± 5% as seen from a TDR of 40 ps (20%-80%).
- The frequency range of the 3.50 or 2.92 mm connector should be ≥ 20 GHz and its durability cycle life ≥ 500 cycles.
- The test fixture should include the structures necessary to do a TRL cal, and in addition, a 1X THRU for rise time calibration.
- All fixture cards and calibration structures should be designed and fabricated from the same PCB panel.

G Type-C Mated Connector Signal Integrity Compliance Test Card Design

The Type-C mated connector test fixture is used to test the TX/RX pair performance as well as the crosstalk between the TX/RX pairs and the USB 2.0 D+/D- pair.

The following test cards are needed to conduct the signal integrity testing for Type-C mated connector:

- High speed Type-C plug test card: The test card with a USB-IF selected plug
- High speed Type-C receptacle test card.: The test card with a Type-C receptacle

The USB-IF approved high speed Type-C plug test card is available for purchase from USB-IF certificate lab(s). The high speed Type-C receptacle test card should be designed and built by designated test fixture vendor(s) or USB4 receptacle vendor(s), following USB-IF design guides.

USB-IF also provides reference fixture designs. The Type-C mated connector test fixture Gerber files are available to download from the following: http://www.usb.org/developers/tools/

2X through lines for fixture calibration are included in both the high speed Type-C plug test card and the high speed Type-C receptacle test card. The device under test (DUT) includes:

- Dual row SMT receptacle
  - Top contact: 30 mil microstrip, gold finger on paddle card, plug pin, receptacle pin, SMT pad + 30 mil microstrip
  - Bottom contact: 30 mil microstrip, gold finger on pad card, plug pin , receptacle pin + SMT pad + transition via + 30 mil microstrip
- DUT of hybrid receptacle
  - Top contact: 30 mil microstrip, gold finger on paddle card, plug, receptacle pin, SMT pad + 30 mil microstrip
  - Bottom contact: 30 mil microstrip, gold finger on paddle card, plug pin, receptacle pin, PTH via, 30 mil microstrip

G.1 Type-C High Speed Plug Test Card

The USB4 Type-C high speed plug test card reference design is shown in Figure G-1. 2X through calibration is located on the top and the bottom layers. The trace length from the gold finger edge to the SMA is 40 mm and the 2X through calibration trace is 78.48 mm. The plug locates at the center of the test card edge. Only the TX/RX pairs and one D+/D- pair are routed out to SMA connectors. Unused pins are terminated with 50 Ω resistors. The VBUS pins are designed as GND pins and connected to the GND plane.

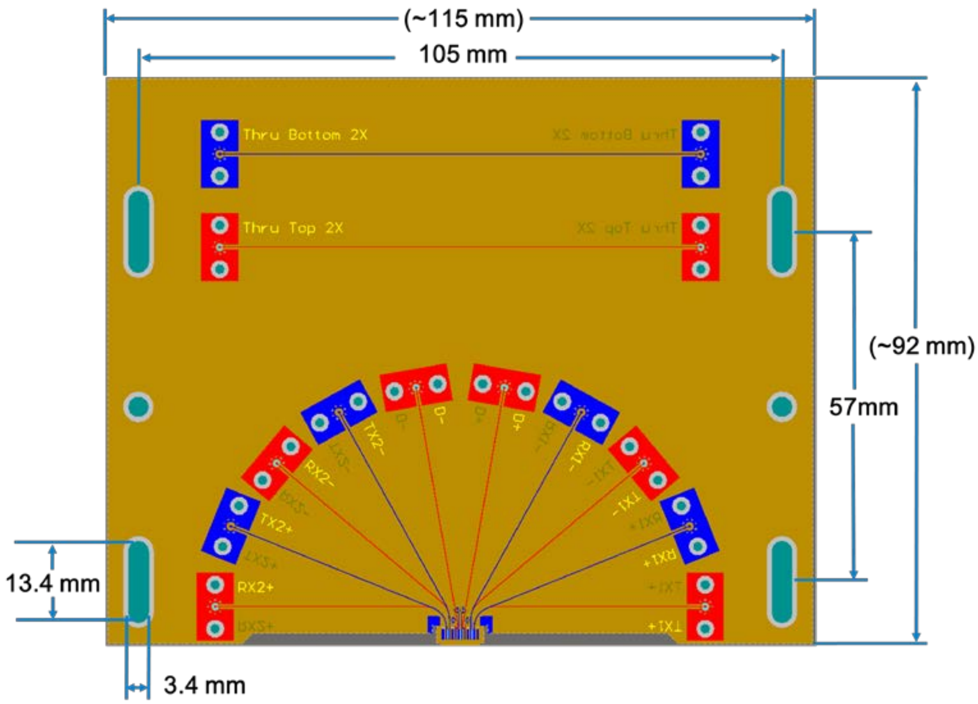


Figure G-1 Plug test card reference design

G.2 USB4 Type-C High Speed Receptacle Test Card

The USB4 Type-C high speed receptacle test card is designed and built by USB4 Type-C receptacle vendor(s) or designated test fixture vendor(s), by following the design rules:

- PCB stackup

  At least a 4-layer PCB is used for the USB4 Type-C high speed receptacle test card. Top and bottom layers are used for signal routing and inner layers are used for GND plane. The dielectric thickness between the top or bottom layer to the adjacent reference plane is 0.1mm (0.004 inch). Rogers or equivalent PCB dielectric material is recommended to minimize the fixture impedance variation and trace loss.

- Signal connection and footprint

  Figure G-2 shows the signal connections for the fixture. Only the TX/RX pairs and D+/D- pair are routed to SMA connectors. Note that Pins B6 and B7 are shorted to pins A6 and A7, respectively, in the fixture. Unused pins are terminated with 50 Ω resistors. The VBUS pins are designed as GND pins and connected to the GND plane. The two pairs of USB 2.0 signals are shorted on the PCB with traces and vias.

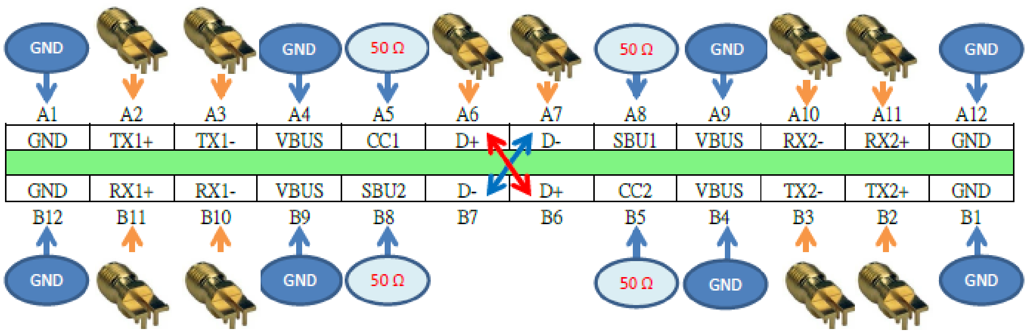


Figure G-2 Signal connections for receptacle test card

a. Dual SMT receptacle

As shown in the Figure G-3, TX1, RX2, and USB 2.0 signals are routed on the top layer. RX1 and TX2 signals are routed on the bottom layer. Transition vias are used to connect the RX1/TX2 signals to the bottom layer and USB 2.0 D+/D- pairs. The transition vias and ground vias have the same size. The via size is 0.2 mm, pad size is 0.4 mm and antipad size is 0.6 mm. The via to SMT pad edge distance is 0.3 mm. A PCB thickness of 0.8 mm is recommended.

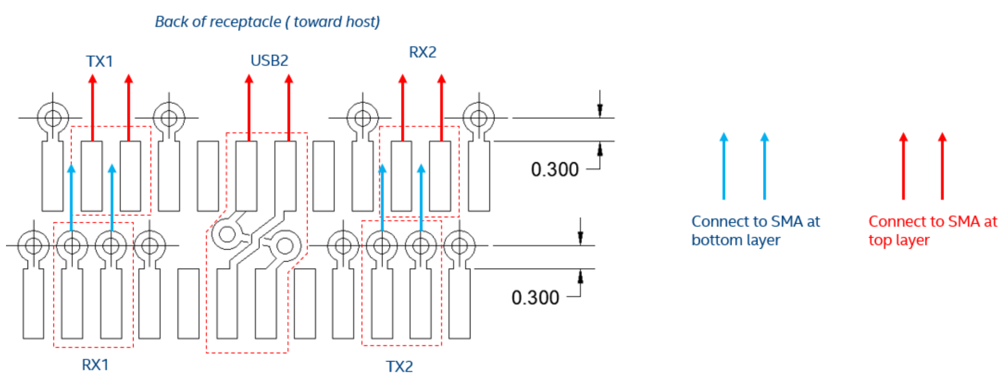


Figure G-3 Dual-row SMT receptacle footprint and via placement

b. Hybrid receptacle

As shown in the Figure G-4, TX1, RX2, and USB2 signals are routed on the top layer. RX1/TX2 signals are routed on the bottom layer, directly from PTH vias. A transition via is used to connect USB 2.0 D+/D- pairs. The transition via and ground vias have the same size. The via size is 0.2 mm, pad size is 0.4 mm and antipad size is 0.6 mm. The via to SMT pad edge distance is 0.3 mm. The PCB thickness is selected based on the compatibility of the hybrid receptacle. If no PCB thickness is specified for the hybrid receptacle, a PCB thickness of 0.8 mm is recommended.

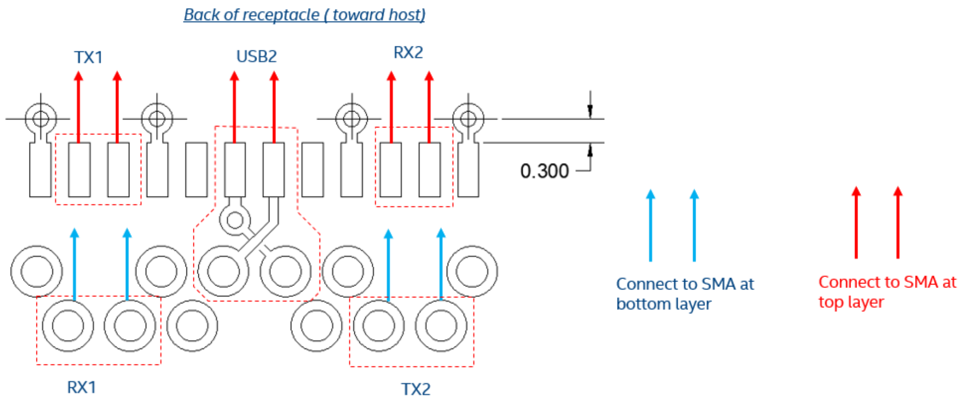


Figure G-4 Hybrid receptacle footprint and via placement

- Receptacle footprint

  It is recommended to optimize the receptacle footprint and related ground void underneath the SMT pad. For a hybrid receptacle, the antipad size of PTH via is also recommended to be optimized.

- Calibration fixture

  2X through calibration traces should be included on the receptacle test card. One is on the top layer and one on the bottom layer.

- Routing traces

  All the traces on the test card should be single-ended with a characteristic impedance of 50 Ω ± 5% (47.5 Ω to 52.5 Ω). Traces between the reference plane and SMAs should be uncoupled from each other. Each trace length between the measurement reference plane and SMA connectors should be less than 40 mm and equal length within a tolerance of ± 0.025mm. To reduce the fiber-weave effect, the routing trace is recommended to be 10 ~ 80 degree angle to weaver direction

- 2.92mm or 3.5mm connector

  2.92mm or 3.5mm vertical connectors are used on the test card, such as Molex 732520160 connector or equivalent. The 2.92mm or 3.5mm connector impedance should be 50 Ω and the impedance variation should be controlled within ± 5% as seen from a TDR of 40 ps (20%-80%).

- Test card size and mounting holes

  The USB4 mated connector test card is fragile once the VNA cables are connected. It is recommended to mount both plug test card and receptacle test card on a bracket for testing, as shown in Figure G-5.

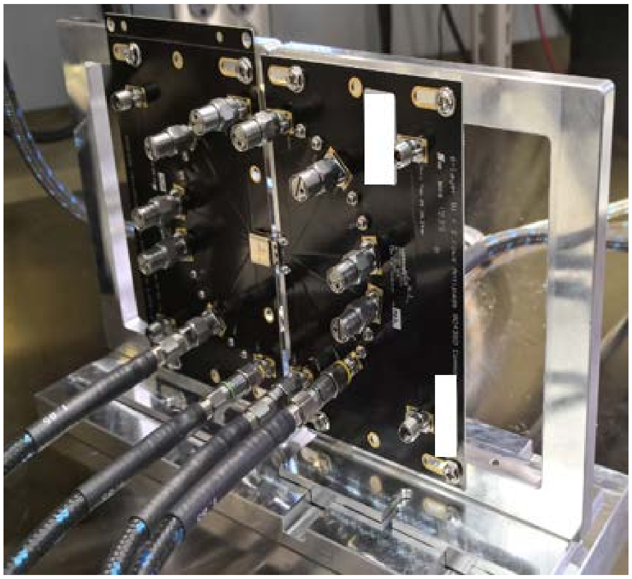


Figure G-5 Bracket for USB4 mated connector test board

The plated through slot holes on the receptacle test card are reserved to mount the card on the bracket. The USB4 receptacle should be placed at the center of test card edge. The dimensioning of holes on the receptacle test card is shown in Figure G-6.

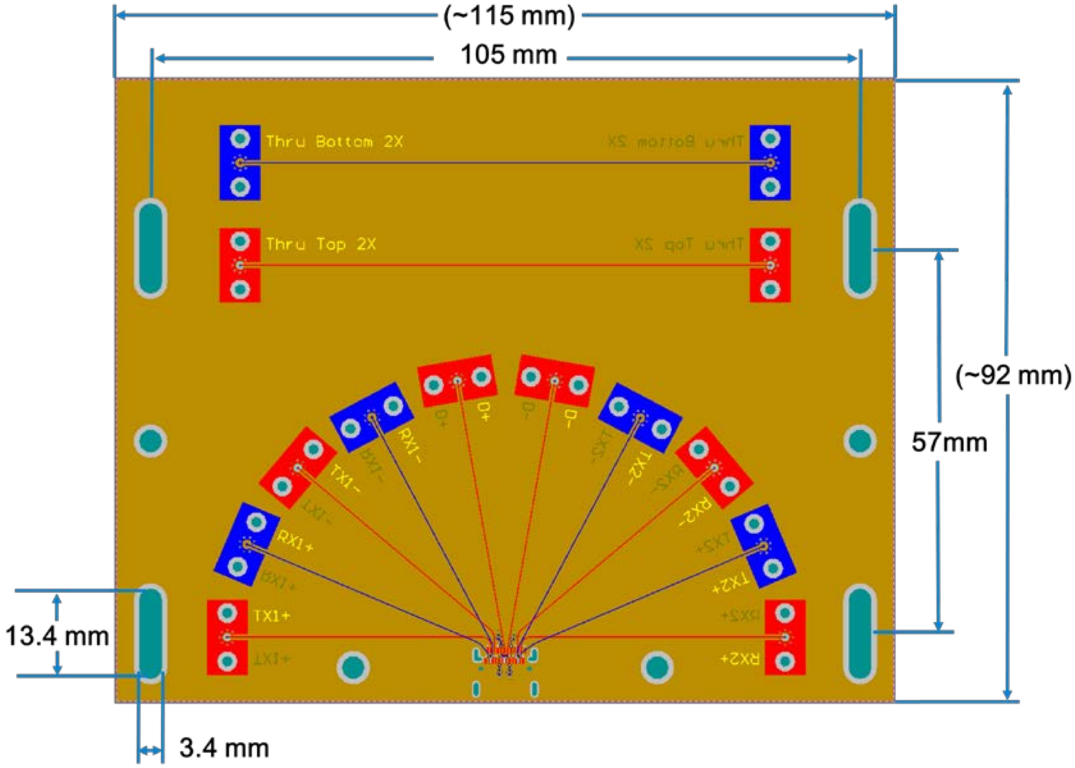


Figure G-6 USB4 receptacle test card reference design and mounting holes dimensions

H USB Type-C Cable Assemblies and Mated Connector Signal Integrity Compliance Test Procedures

This section describes all the USB Type-C cable assembly signal integrity compliance testing equipment and procedures.

H.1 Reference Equipment

Most USB Type-C cable assembly signal integrity items are specified in frequency domain. VNAs or equivalent equipment may be used for measurement. If a VNA is used, its frequency range should be to at least 20 GHz for the SuperSpeed pairs and TX/RX pairs (e.g., the Agilent 50 GHz PNA). Micro-coax precision 3.5 mm (e.g., UFB197C-1-0393) or 2.92 mm cables should be used to connect VNA and test fixtures.

A few D+/D- signal integrity compliance items are specified in the time-domain. TDR/TDT or its equivalent equipment should be used for time domain measurement.

H.2 Reference Equipment Setup

The reference equipment setup is described below, if a VNA is chosen.

- The VNA should be powered on and allowed to warm up – recommendation is for 24 hours prior to measurement.
- For VNA bandwidth setup, it is recommended to limit the frequency sweep range to slightly higher than the limit required in the specification (e.g. a 20 GHz sweep range for the USB Type-C SuperSpeed pairs and TX/RX pairs as required by the spec). A sufficient number of points should also be included in the frequency sweep (for instant, a 10 MHz step for SuperSpeed pairs and TX/RX pairs).
- The IF Bandwidth should be low enough to help reduce noise effects (e.g. < 300 Hz).

For time-domain measurements (for D+/D- pair), TDR/TDT may be used.

H.3 SuperSpeed and USB4 Gen3 Signal Measurements

All SuperSpeed and TX/RX measurements are done in frequency-domain with S-parameters. A VNA is typically used for such measurements, but other equivalent methods are allowed as long as the accuracy of the measured S-parameters is demonstrated. The following procedures apply for SuperSpeed and TX/RX signal measurements when using a VNA:

1. The Type-C High Speed Test Cards discussed in Appendix F.1 and Appendix F.3 (for legacy USB connectors) should be used for the measurements.
2. The fixture effects should be removed from the measurements, using the calibration structures defined in Appendix F.4. Allowed calibration methods include TRL, AFR, and other equivalent methods with demonstrated accuracy and consistency.
3. All measured S-parameters from a VNA are single-ended and they are converted to mixed mode through post process.
4. The measured frequency range shall be from 10 MHz to 20 GHz with a frequency step of 10 MHz.
5. Insertion losses and return losses of every SuperSpeed pair or TX/RX pair shall be measured.

6. All crosstalk terms are required to be measured. For example, if the DP2 (Differential Pair 2) in Figure H-1 is chosen as the victim, the crosstalk from DP1, DP3, DP4, and DP5 shall be measured.

7. The measured S-parameters are processed by a Type-C compliance tool to do insertion loss fit and to calculate ILfitatNq, IMR, IRL, INEXT, IFEXT and other integrated parameters, using the equations defined in Section 3.7 of the *USB Type-C Specification*. The USB Type-C compliance tool may be down-loaded from the following link: http://compliance.usb.org/files/.

8.

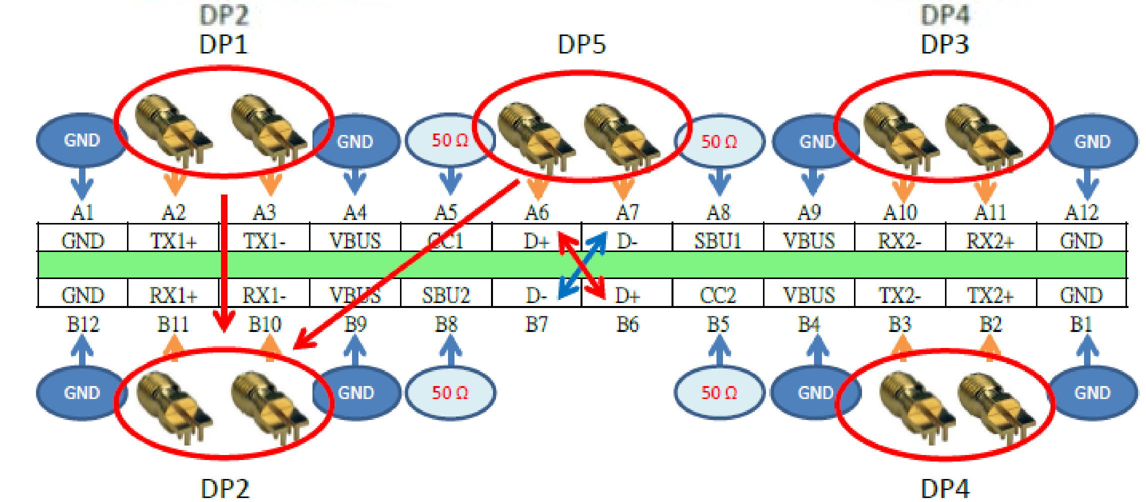


Figure H-1 Type-C connector crosstalk pairs

H.4 USB 2.0 D+/D- Signal Measurements

The USB 2.0 D+/D- signal integrity requirements are defined in both frequency-domain and time domain. The test methodology is essentially the same as what has been practiced for USB 2.0 cable assembly compliance testing. Brief discussions about USB 2.0 D+/D- signal measurements:

1. The Test Cards in Appendix F.1 or Appendix F.3 should be used for the measurements.

2. The D+/D- pair attenuation is the only S-parameter to be measured, typically with a VNA. The fixture loss shall be removed from the measurement and the simple AFR method is recommended. The measured frequency range should be from 50 MHz to 400 MHz with a frequency step of 10 MHz.

3. The D+/D- pair impedance is typically measured with a TDR. The 1X THRU in the calibration card should be used to calibrate the rise time to be 400 ps (20%-80%) entering the reference plane.

4. The D+/D- pair propagation delay and intra-pair skew are measured typically with a TDT. The 1X THRU in the calibration card should be used to calibrate the rise time to be 400 ps (20%-80%) entering the reference plane. The propagation delay and intra-pair skew are measured at the 50% voltage crossing of the received step response.

H.5 Low Speed Signal Measurements

Low speed signal compliance tests are all done in frequency domain, measuring coupling or crosstalk among the low speed signals, except for the VBUS line loop inductance. Descriptions regarding the crosstalk measurements:

1. A VNA is typically used to measure the coupling or crosstalk. The frequency range is from 300 KHz to 100 MHz.

2. The low speed test card defined in Appendix F.2 should be used to test the low speed signals.

3. All the measured S-parameters are single-ended with a 50 ohm reference impedance.

4. Both near-end and far-end crosstalk shall be measured.

5. If differential coupling is specified, then the single-ended S-parameters should be post-processed to get the differential coupling. For example, if the single-ended near-end crosstalk between the CC line and the D+ line is S_{CC2D+} and the single-ended near-end crosstalk between the CC line and the D- line is S_{CC2D-}, the differential near-end crosstalk between the CC line and the D+/D- pair is simply:

   $SDD_{CC2D+}/D-=(S_{CC2D+}-S_{CC2D-})/sqrt(2)$. All other differential crosstalk is similarly calculated from the single-ended measurements.

The VBUS loop inductance and capacitance may be obtained from the S-parameter measurement also. A 2-port S-parameter measurement is done to the VBUS line; the S-parameters are represented as S_{ij} (i, j=1 and 2). At low frequency (e.g., ~1 MHz range) the VBUS line may be modeled as a simple RLC circuit, as illustrated in Figure H-2.

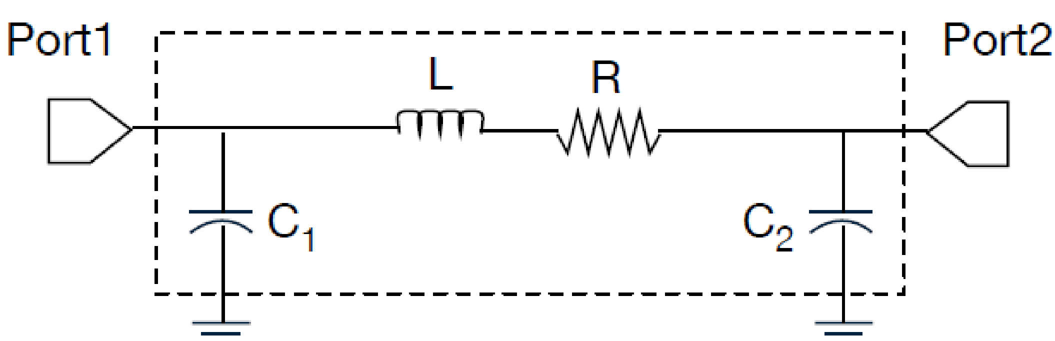


Figure H-2 Lumped RLC circuit model for VBUS line

This 2-port RLC circuit S-parameters may be analytically derived, and the VBUS loop inductance and capacitance may then be obtained as:

$$L = \frac{1}{2\pi f} imag\left(Z_0 \frac{(1+S_{11})(1+S_{22})-S_{12}S_{21}}{2S_{12}}\right),$$

$$C_1 = \frac{1}{2\pi f} imag\left(\frac{(1-S_{11})(1+S_{22})-S_{12}(2-S_{12})}{Z_0[(1+S_{11})(1+S_{22})-S_{12}S_{21}]}\right),$$

$$C_2 = \frac{1}{2\pi f} imag\left(\frac{(1+S_{11})(1-S_{22})-S_{12}(2-S_{12})}{Z_0[(1+S_{11})(1+S_{22})-S_{12}S_{21}]}\right),$$

where Z0 (=50 □) is the reference impedance of the S-parameter. The so extracted loop inductance is approximately independent of frequency from kHz to a few MHz range; a frequency range from 300 kHz to 2 MHz is recommended.

To extract the inductance coupling factor, a coupled line model is assumed, as illustrated in Figure H-3.

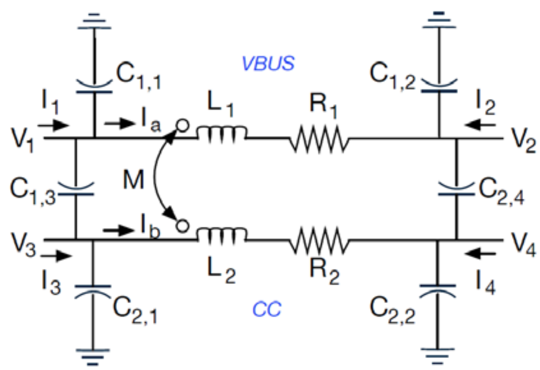


Figure H-3 Lumped RLC circuit model for VBUS line coupled with a low speed line (e.g., CC)

The 4-port S-parameters of the coupled lines are measured first and then converted to the Y-parameters:

$$\boldsymbol{Y} = Z_0^{-1}(\boldsymbol{I}+\boldsymbol{S})^{-1}(\boldsymbol{I}-\boldsymbol{S})$$

The mutual and loop inductances can be derived as:

$$M = \frac{1}{2\pi f} imag\left(\frac{Y_{14}+Y_{41}+Y_{23}+Y_{32}}{(Y_{12}+Y_{21})(Y_{34}+Y_{43})}\right)$$

$$L_1 = \frac{1}{2\pi f} imag\left(-\frac{2}{(Y_{12}+Y_{21})}\right)$$

$$L_2 = \frac{1}{2\pi f} imag\left(-\frac{2}{(Y_{34}+Y_{43})}\right)$$

And the inductance coupling factor k is defined as:

$$k = \frac{M}{\sqrt{L_1 L_2}}$$

The Type-C cable assembly compliance tool converts S-parameters to the VBUS loop inductance and capacitances as well as the inductance coupling factor between VBUS and other low speed signals.

H.6 Test Fixture Calibration

2X through calibration is used to remove the fixture effect of the measurement.

1. For the Type-C cable assembly test card, the traces from 2.92 mm or 3.5 mm connector to reference plane are identical. It is allowed to use the same 2X through trace at both ends when conduct the calibration.

2. For the Type-C mated connector test card the traces from 2.92 mm or 3.5 mm connector to reference plane on the plug test card and receptacle test card are very likely different. Both 2X through traces on plug test card and receptacle test card should be used for calibration. Consult the VNA supplier(s) or certified test lab(s) for the right procedure of test fixture calibration.

I Type-C Cable Assemblies Shielding Effectiveness Fixture

The cable assembly shielding effectiveness test setup and fixture are illustrated in Figure I-1.

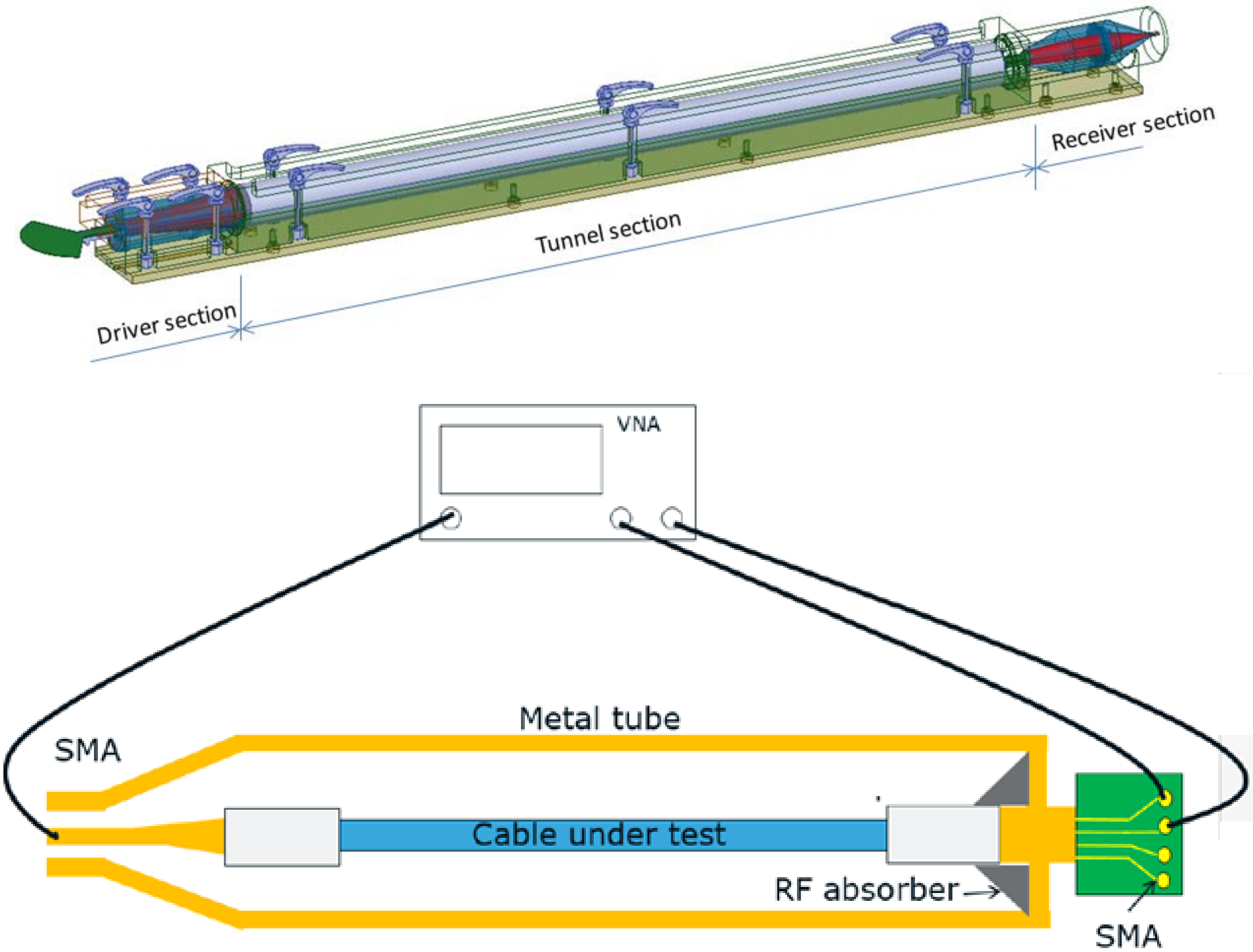


Figure I-1 Cable Shielding Effectiveness Measurement Setup

The fixture includes three sections: driver section, tunnel section and receiver section.

- Driver section: There is a PCB in this section, a top mounted Type C receptacle is mounted on the end of PCB, TX/RX and USB2.0 signals are routed on the PCB on the top layer to the SMA connectors on the other end. A metal shield is used to cover the traces and receptacle. An absorber is used in this section to avoid reflection of cable radiation.

- Tunnel section: Type C to type C cable under test is placed in this section. Supports made of Styrofoam are used to keep the cable straight. Outside of the supports in this section is a metal cover, which is used for prefect shielding to avoid any radiation leakage.

- Receiver section: A top mounted Type C receptacle is mounted on the edge of the PCB, TX/RX and USB2.0 signals are terminated and the trace are covered by a metal shield. The aperture between the outside shield and the metal cover is used to collect the cable radiation. The radiation is transferred to a built-in SMA at the other end of this section.

I.1.1 General Board Design Guideline

- Top mounted type C receptacle is used for both boards. All traces are routed on the top layer and no signal via is used.
- All of the traces on the driver board should be differential traces and shall be held to a characteristic impedance of 85 ohms with a tolerance of ± 7.5%.
- All of the traces on the terminated board should be differential traces and shall be held to a characteristic impedance of 100 ohms with a tolerance of ± 7.5%. TX/RX and USB 2.0 signals are connected to 50 Ω resistors. VBUS signals are connected to a 470 pf by-pass capacitor.

I.1.2 SMA (Launch Point) Design Guideline

- Recommend using 50 Ω edge-launch SMA connector.
- Working frequency range of the SMA should be ≥ 20 GHz.
- Mating cycle life of the SMA should be ≥ 500 cycles.
- SMA spacing: Pitch of side-by-side SMA should be greater than or equal to 15 mm.

I.1.3 Miscellaneous Design Guidelines

- All metal covers used are soldered on the PCB. The metal cover fully shields the PCB trace and receptacle shell to avoid any radiation.
- CC and SBU pins of the type C receptacle are grounded to save routing space.
- Ground stitch vias are placed along the edges of both boards.
- The plastic pegs of the type C receptacle are removed so that there is no non-plated through hole on the PCB.

J Type-C Cable Assemblies Shielding Effectiveness Measurement

Measurement of the shielding effectiveness:

1. The length of the cable assembly sample used for shielding effectiveness testing shall be 1 m ± 15 mm, regardless of the actual cable length to be certified. For example, if a cable assembly vendor wishes to certify a 0.5 m Type-C cable, the vendor shall prepare a 1 m ± 15 mm cable assembly for shielding effectiveness testing.
2. The cable shielding effectiveness test fixture has SMA connectors connected to the USB SuperSpeed TX pairs, RX pairs, and the cable shield.
3. Follow the VNA calibration procedures and calibrate to the end of the coaxial cable using the SOLT standards.
4. Install the cable under test into the fixture. Connect 1 port to the cable shield and 2 ports to a TX pair. Terminate the RX pairs with 50 ohm loads.
5. Perform measurement. Calculate the coupling factor from TX differential mode to cable shield. Calculate the coupling factor from TX common mode to cable shield.
6. Connect 1 port to the cable shield and 2 ports to the RX pair. Terminate the TX pair with 50 ohm loads. Repeat the steps until all the SuperSpeed pairs (i.e., TX and RX) have been used as the stimulus.