

INTERNATIONAL STANDARD



**Universal serial bus interfaces for data and power –
Part 1-3: Common components – USB Type-C™ Cable and Connector
Specification**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2018 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 21 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

INTERNATIONAL STANDARD



**Universal serial bus interfaces for data and power –
Part 1-3: Common components – USB Type-C™ Cable and Connector
Specification**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.120.20; 33.120.30; 35.200

ISBN 978-2-8322-5749-4

Warning! Make sure that you obtained this publication from an authorized distributor.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

UNIVERSAL SERIAL BUS INTERFACES FOR DATA AND POWER –**Part 1-3: Common components –
USB Type-C™ Cable and Connector Specification**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 62680-1-3 has been prepared by technical area 14: Interfaces and methods of measurement for personal computing equipment, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

This third edition cancels and replaces the second edition published in 2017 and constitutes a technical revision.

The text of this standard was prepared by the USB Implementers Forum (USB-IF). The structure and editorial rules used in this publication reflect the practice of the organization which submitted it.

The text of this International Standard is based on the following documents:

CDV	Report on voting
100/3011/CDV	100/3099/RVC

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The IEC 62680 series is based on a series of specifications that were originally developed by the USB Implementers Forum (USB-IF). These specifications were submitted to the IEC under the auspices of a special agreement between the IEC and the USB-IF.

This standard is the USB-IF publication USB Type-C™ Cable and Connector Specification Revision 1.3 as of July 14, 2017.

The USB Implementers Forum, Inc.(USB-IF) is a non-profit corporation founded by the group of companies that developed the Universal Serial Bus specification. The USB-IF was formed to provide a support organization and forum for the advancement and adoption of Universal Serial Bus technology. The Forum facilitates the development of high-quality compatible USB peripherals (devices), and promotes the benefits of USB and the quality of products that have passed compliance testing.

ANY USB SPECIFICATIONS ARE PROVIDED TO YOU "AS IS, "WITH NO WARRANTIES WHATSOEVER, INCLUDING ANY WARRANTY OF MERCHANTABILITY, NON-INFRINGEMENT, OR FITNESS FOR ANY PARTICULAR PURPOSE. THE USB IMPLEMENTERS FORUM AND THE AUTHORS OF ANY USB SPECIFICATIONS DISCLAIM ALL LIABILITY, INCLUDING LIABILITY FOR INFRINGEMENT OF ANY PROPRIETARY RIGHTS, RELATING TO USE OR IMPLEMENTATION OR INFORMATION IN THIS SPECIFICATION.

THE PROVISION OF ANY USB SPECIFICATIONS TO YOU DOES NOT PROVIDE YOU WITH ANY LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS.

Entering into USB Adopters Agreements may, however, allow a signing company to participate in a reciprocal, RAND-Z licensing arrangement for compliant products. For more information, please see:

<http://www.usb.org/developers/docs/>

http://www.usb.org/developers/devclass_docs#approved

IEC DOES NOT TAKE ANY POSITION AS TO WHETHER IT IS ADVISABLE FOR YOU TO ENTER INTO ANY USB ADOPTERS AGREEMENTS OR TO PARTICIPATE IN THE USB IMPLEMENTERS FORUM.”

Universal Serial Bus Type-C Cable and Connector Specification

**Release 1.3
July 14, 2017**

**Copyright © 2014-2017, USB 3.0 Promoter Group:
Apple Inc., Hewlett-Packard Inc., Intel Corporation, Microsoft
Corporation, Renesas, STMicroelectronics, and Texas Instruments
All rights reserved.**

NOTE: Adopters may only use the USB Type-C™ cable and connector to implement USB or third party functionality as expressly described in this Specification; all other uses are prohibited.

LIMITED COPYRIGHT LICENSE: The USB 3.0 Promoters grant a conditional copyright license under the copyrights embodied in the USB Type-C Cable and Connector Specification to use and reproduce the Specification for the sole purpose of, and solely to the extent necessary for, evaluating whether to implement the Specification in products that would comply with the specification. Without limiting the foregoing, use of the Specification for the purpose of filing or modifying any patent application to target the Specification or USB compliant products is not authorized. Except for this express copyright license, no other rights or licenses are granted, including without limitation any patent licenses. In order to obtain any additional intellectual property licenses or licensing commitments associated with the Specification a party must execute the USB 3.0 Adopters Agreement. NOTE: By using the Specification, you accept these license terms on your own behalf and, in the case where you are doing this as an employee, on behalf of your employer.

INTELLECTUAL PROPERTY DISCLAIMER

THIS SPECIFICATION IS PROVIDED TO YOU “AS IS” WITH NO WARRANTIES WHATSOEVER, INCLUDING ANY WARRANTY OF MERCHANTABILITY, NON-INFRINGEMENT, OR FITNESS FOR ANY PARTICULAR PURPOSE. THE AUTHORS OF THIS SPECIFICATION DISCLAIM ALL LIABILITY, INCLUDING LIABILITY FOR INFRINGEMENT OF ANY PROPRIETARY RIGHTS, RELATING TO USE OR IMPLEMENTATION OF INFORMATION IN THIS SPECIFICATION. THE PROVISION OF THIS SPECIFICATION TO YOU DOES NOT PROVIDE YOU WITH ANY LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE, TO ANY INTELLECTUAL PROPERTY RIGHTS.

All implementation examples and reference designs contained within this Specification are included as part of the limited patent license for those companies that execute the USB 3.0 Adopters Agreement.

USB Type-C™ and USB-C™ are trademarks of the Universal Serial Bus Implementers Forum (USB-IF). All product names are trademarks, registered trademarks, or service marks of their respective owners.

CONTENTS

FOREWORD.....	2
INTRODUCTION.....	4
1 Introduction	20
1.1 Purpose	20
1.2 Scope	20
1.3 Related Documents.....	21
1.4 Conventions.....	21
1.4.1 Precedence	21
1.4.2 Keywords	21
1.4.3 Numbering.....	22
1.5 Terms and Abbreviations	22
2 Overview	25
2.1 Introduction.....	25
2.2 USB Type-C Receptacles, Plugs and Cables	26
2.3 Configuration Process.....	28
2.3.1 Source-to-Sink Attach/Detach Detection	28
2.3.2 Plug Orientation/Cable Twist Detection.....	28
2.3.3 Initial Power (Source-to-Sink) Detection and Establishing the Data (Host-to-Device) Relationship.....	29
2.3.4 USB Type-C VBUS Current Detection and Usage	30
2.3.5 USB PD Communication	30
2.3.6 Functional Extensions.....	30
2.4 VBUS	31
2.5 VCONN.....	31
2.6 Hubs.....	32
3 Mechanical	32
3.1 Overview	32
3.1.1 Compliant Connectors	32
3.1.2 Compliant Cable Assemblies	32
3.1.3 Compliant USB Type-C to Legacy Cable Assemblies.....	32
3.1.4 Compliant USB Type-C to Legacy Adapter Assemblies.....	33
3.2 USB Type-C Connector Mating Interfaces.....	34
3.2.1 Interface Definition	34
3.2.2 Reference Designs	56
3.2.3 Pin Assignments and Descriptions.....	64
3.3 Cable Construction and Wire Assignments.....	65
3.3.1 Cable Construction (Informative)	65
3.3.2 Wire Assignments.....	67
3.3.3 Wire Gauges and Cable Diameters (Informative)	68
3.4 Standard USB Type-C Cable Assemblies.....	70
3.4.1 USB Full-Featured Type-C Cable Assembly.....	70
3.4.2 USB 2.0 Type-C Cable Assembly	71
3.4.3 USB Type-C Captive Cable Assemblies.....	72

- 3.5 Legacy Cable Assemblies 72
 - 3.5.1 USB Type-C to *USB 3.1* Standard-A Cable Assembly 73
 - 3.5.2 USB Type-C to *USB 2.0* Standard-A Cable Assembly 75
 - 3.5.3 USB Type-C to *USB 3.1* Standard-B Cable Assembly 76
 - 3.5.4 USB Type-C to *USB 2.0* Standard-B Cable Assembly 78
 - 3.5.5 USB Type-C to *USB 2.0* Mini-B Cable Assembly 79
 - 3.5.6 USB Type-C to *USB 3.1* Micro-B Cable Assembly 80
 - 3.5.7 USB Type-C to *USB 2.0* Micro-B Cable Assembly 82
- 3.6 Legacy Adapter Assemblies 83
 - 3.6.1 USB Type-C to *USB 3.1* Standard-A Receptacle Adapter Assembly 83
 - 3.6.2 USB Type-C to *USB 2.0* Micro-B Receptacle Adapter Assembly 85
- 3.7 Electrical Characteristics 86
 - 3.7.1 Raw Cable (Informative) 86
 - 3.7.2 USB Type-C to Type-C Passive Cable Assemblies (Normative) 87
 - 3.7.3 Mated Connector (Informative) 101
 - 3.7.4 USB Type-C to Legacy Cable Assemblies (Normative) 105
 - 3.7.5 USB Type-C to USB Legacy Adapter Assemblies (Normative) 109
 - 3.7.6 Shielding Effectiveness Requirements (Normative) 112
 - 3.7.7 DC Electrical Requirements (Normative) 114
- 3.8 Mechanical and Environmental Requirements (Normative) 117
 - 3.8.1 Mechanical Requirements 117
 - 3.8.2 Environmental Requirements 123
- 3.9 Docking Applications (Informative) 125
- 3.10 Implementation Notes and Design Guides 126
 - 3.10.1 EMC Management (Informative) 126
 - 3.10.2 Stacked and Side-by-Side Connector Physical Spacing (Informative) 128
 - 3.10.3 Cable Mating Considerations (Informative) 129
- 4 Functional 130
 - 4.1 Signal Summary 130
 - 4.2 Signal Pin Descriptions 131
 - 4.2.1 SuperSpeed USB Pins 131
 - 4.2.2 USB 2.0 Pins 131
 - 4.2.3 Auxiliary Signal Pins 131
 - 4.2.4 Power and Ground Pins 131
 - 4.2.5 Configuration Pins 131
 - 4.3 Sideband Use (SBU) 132
 - 4.4 Power and Ground 132
 - 4.4.1 IR Drop 132
 - 4.4.2 VBUS 133
 - 4.4.3 VCONN 134
 - 4.5 Configuration Channel (CC) 138
 - 4.5.1 Architectural Overview 138
 - 4.5.2 CC Functional and Behavioral Requirements 153
 - 4.5.3 USB Port Interoperability Behavior 182
 - 4.6 Power 195

4.6.1	Power Requirements during USB Suspend	196
4.6.2	VBUS Power Provided Over a USB Type-C Cable.....	197
4.7	USB Hubs	201
4.8	Power Sourcing and Charging.....	201
4.8.1	DFP as a Power Source.....	202
4.8.2	Non-USB Charging Methods	205
4.8.3	Sinking Host	205
4.8.4	Sourcing Device	205
4.8.5	Charging a System with a Dead Battery.....	205
4.8.6	USB Type-C Multi-Port Chargers	205
4.9	Electronically Marked Cables	208
4.9.1	Parameter Values	209
4.9.2	Active Cables	209
4.10	VCONN-Powered Accessories (VPAs) and VCONN-Powered USB Devices (VPDs)	209
4.10.1	VCONN-Powered Accessories (VPAs)	210
4.10.2	VCONN-Powered USB Devices (VPDs)	210
4.11	Parameter Values	210
4.11.1	Termination Parameters	210
4.11.2	Timing Parameters	213
4.11.3	Voltage Parameters	216
5	Functional Extensions	217
5.1	Alternate Modes.....	217
5.1.1	Alternate Mode Architecture	217
5.1.2	Alternate Mode Requirements.....	218
5.1.3	Parameter Values	222
5.1.4	Example Alternate Mode – USB DisplayPort™ Dock.....	223
5.2	Managed Active Cables	225
5.2.1	Requirements for Managed Active Cables that respond to SOP' and SOP" ..	225
5.2.2	Cable Message Structure	226
5.2.3	Modal Cable Management	226
A	Audio Adapter Accessory Mode	228
A.1.	Overview	228
A.2.	Detail	228
A.3.	Electrical Requirements	230
A.4.	Example Implementations	231
A.4.1.	Passive 3.5 mm to USB Type-C Adapter – Single Pole Detection Switch	231
A.4.2.	3.5 mm to USB Type-C Adapter Supporting 500 mA Charge-Through.....	231
B	Debug Accessory Mode	233
B.1.	Overview	233
B.2.	Functional.....	233
B.2.1.	Signal Summary	235
B.2.2.	Port Interoperability	235
B.2.3.	Debug Accessory Mode Entry	235
B.2.4.	Connection State Diagrams	236
B.2.5.	DTS Port Interoperability Behavior.....	246

B.2.6. Orientation Detection 257

B.3. Security/Privacy Requirements: 257

C USB Type-C Digital Audio..... 258

C.1. Overview 258

C.2. USB Type-C Digital Audio Specifications 258

FIGURES

Figure 2-1 USB Type-C Receptacle Interface (Front View)..... 26

Figure 2-2 USB Full-Featured Type-C Plug Interface (Front View) 26

Figure 3-1 USB Type-C Receptacle Interface Dimensions..... 37

Figure 3-2 Reference Design USB Type-C Plug External EMC Spring Contact Zones 40

Figure 3-3 USB Full-Featured Type-C Plug Interface Dimensions 41

Figure 3-4 Reference Footprint for a USB Type-C Vertical Mount Receptacle (Informative) . 44

Figure 3-5 Reference Footprint for a USB Type-C Dual-Row SMT Right Angle Receptacle (Informative) 45

Figure 3-6 Reference Footprint for a USB Type-C Hybrid Right-Angle Receptacle (Informative) 46

Figure 3-7 Reference Footprint for a USB Type-C Mid-Mount Dual-Row SMT Receptacle (Informative) 47

Figure 3-8 Reference Footprint for a USB Type-C Mid-Mount Hybrid Receptacle (Informative) 48

Figure 3-9 Reference Footprint for a USB 2.0 Type-C Through Hole Right Angle Receptacle (Informative)..... 49

Figure 3-10 Reference Footprint for a USB 2.0 Type-C Single Row Right Angle Receptacle (Informative)..... 50

Figure 3-11 *USB 2.0* Type-C Plug Interface Dimensions 52

Figure 3-12 USB Type-C Plug EMC Shielding Spring Tip Requirements 55

Figure 3-13 Reference Design of Receptacle Mid-Plate 56

Figure 3-14 Reference Design of the Retention Latch 57

Figure 3-15 Illustration of the Latch Soldered to the Paddle Card Ground 57

Figure 3-16 Reference Design of the USB Full-Featured Type-C Plug Internal EMC Spring . 58

Figure 3-17 Reference Design of the *USB 2.0* Type-C Plug Internal EMC Spring 59

Figure 3-18 Reference Design of Internal EMC Pad 61

Figure 3-19 Reference Design of a USB Type-C Receptacle with External EMC Springs 62

Figure 3-20 Reference Design for a USB Full-Featured Type-C Plug Paddle Card 63

Figure 3-21 Illustration of a USB Full-Featured Type-C Cable Cross Section, a Coaxial Wire Example with VCONN..... 66

Figure 3-22 Illustration of a USB Full-Featured Type-C Cable Cross Section, a Coaxial Wire Example without VCONN 66

Figure 3-23 USB Full-Featured Type-C Standard Cable Assembly 70

Figure 3-24 USB Type-C to USB 3.1 Standard-A Cable Assembly 73

Figure 3-25 USB Type-C to *USB 2.0* Standard-A Cable Assembly 75

Figure 3-26	USB Type-C to <i>USB 3.1</i> Standard-B Cable Assembly	76
Figure 3-27	USB Type-C to <i>USB 2.0</i> Standard-B Cable Assembly	78
Figure 3-28	USB Type-C to <i>USB 2.0</i> Mini-B Cable Assembly	79
Figure 3-29	USB Type-C to <i>USB 3.1</i> Micro-B Cable Assembly	80
Figure 3-30	USB Type-C to <i>USB 2.0</i> Micro-B Cable Assembly	82
Figure 3-31	USB Type-C to <i>USB 3.1</i> Standard-A Receptacle Adapter Assembly	83
Figure 3-32	USB Type-C to <i>USB 2.0</i> Micro-B Receptacle Adapter Assembly.....	85
Figure 3-33	Illustration of Test Points for a Mated Cable Assembly.....	87
Figure 3-34	Recommended Differential Insertion Loss Requirement	88
Figure 3-35	Recommended Differential Return Loss Requirement	88
Figure 3-36	Recommended Differential Crosstalk Requirement.....	89
Figure 3-37	Recommended Differential Near-End and Far-End Crosstalk Requirement between USB D+/D- Pair and USB SuperSpeed Pair.....	89
Figure 3-38	Illustration of Insertion Loss Fit at Nyquist Frequency	90
Figure 3-39	Input Pulse Spectrum.....	91
Figure 3-40	IMR Limit as Function of $IL_{fitatNq}$	92
Figure 3-41	IRL Limit as Function of $IL_{fitatNq}$	94
Figure 3-42	Differential-to-Common-Mode Conversion Requirement	95
Figure 3-43	Requirement for Differential Coupling between CC and D+/D-	96
Figure 3-44	Requirement for Single-Ended Coupling between CC and D- in USB 2.0 Type-C Cables.....	97
Figure 3-45	Requirement for Single-Ended Coupling between CC and D- in USB Full- Featured Type-C Cables.....	97
Figure 3-46	Requirement for Differential Coupling between VBUS and D+/D-	98
Figure 3-47	Requirement for Single-Ended Coupling between SBU_A and SBU_B	99
Figure 3-48	Requirement for Single-Ended Coupling between SBU_A/SBU_B and CC	99
Figure 3-49	Requirement for Coupling between SBU_A and differential D+/D-, and SBU_B and differential D+/D-.....	100
Figure 3-50	Illustration of USB Type-C Mated Connector	101
Figure 3-51	Recommended Impedance Limits of a USB Type-C Mated Connector	102
Figure 3-52	Recommended Ground Void Dimensions for USB Type-C Receptacle.....	103
Figure 3-53	Recommended Differential Near-End and Far-End Crosstalk Limits between D+/D- Pair and SuperSpeed Pairs.....	105
Figure 3-54	Recommended Limits for Differential-to-Common-Mode Conversion	105
Figure 3-55	IMR Limit as Function of $IL_{fitatNq}$ for USB Type-C to Legacy Cable Assembly	108
Figure 3-56	IRL Limit as Function of $IL_{fitatNq}$ for USB Type-C to Legacy Cable Assembly.	109
Figure 3-57	Cable Assembly Shielding Effectiveness Testing	112
Figure 3-58	Shielding Effectiveness Pass/Fail Criteria	113
Figure 3-59	LLCR Measurement Diagram	114
Figure 3-60	Temperature Measurement Point	116
Figure 3-61	Example Current Rating Test Fixture Trace Configuration.....	117

Figure 3-62 Example of 4-Axis Continuity Test Fixture 119

Figure 3-63 Example Wrenching Strength Test Fixture for Plugs without Overmold..... 121

Figure 3-64 Reference Wrenching Strength Continuity Test Fixture 122

Figure 3-65 Example of Wrenching Strength Test Mechanical Failure Point 123

Figure 3-66 Wrenching Strength Test with Cable in Fixture 123

Figure 3-67 USB Type-C Cable Receptacle Flange Example 126

Figure 3-68 EMC Guidelines for Side Latch and Mid-plate 127

Figure 3-69 EMC Finger Connections to Plug Shell..... 127

Figure 3-70 EMC Pad Connections to Receptacle Shell 128

Figure 3-71 Examples of Connector Apertures 128

Figure 3-72 Recommended Minimum Spacing between Connectors..... 129

Figure 3-73 Recommended Minimum Plug Overmold Clearance 129

Figure 3-74 Cable Plug Overmold and an Angled Surface..... 130

Figure 4-1 Cable IR Drop 132

Figure 4-2 Cable IR Drop for powered cables 133

Figure 4-3 Logical Model for Data Bus Routing across USB Type-C-based Ports..... 140

Figure 4-4 Logical Model for USB Type-C-based Ports for the Direct Connect Device..... 140

Figure 4-5 Pull-Up/Pull-Down CC Model 142

Figure 4-6 Current Source/Pull-Down CC Model 142

Figure 4-7 Source Functional Model for CC1 and CC2 145

Figure 4-8 Source Functional Model Supporting USB PD PR_Swap..... 146

Figure 4-9 Sink Functional Model for CC1 and CC2 147

Figure 4-10 Sink Functional Model Supporting USB PD PR_Swap and VCONN_Swap..... 148

Figure 4-11 DRP Functional Model for CC1 and CC2..... 149

Figure 4-12 Connection State Diagram: Source 154

Figure 4-13 Connection State Diagram: Sink..... 155

Figure 4-14 Connection State Diagram: Sink with Accessory Support 156

Figure 4-15 Connection State Diagram: DRP 157

Figure 4-16 Connection State Diagram: DRP with Accessory and Try.SRC Support..... 158

Figure 4-17 Connection State Diagram: DRP with Accessory and Try.SNK Support 159

Figure 4-18 Sink Power Sub-States 175

Figure 4-19 Passive Cable eMarker State Diagram 177

Figure 4-20 Active Cable eMarker State Diagram..... 177

Figure 4-21 Source to Sink Functional Model 182

Figure 4-22 Source to DRP Functional Model 183

Figure 4-23 DRP to Sink Functional Model..... 185

Figure 4-24 DRP to DRP Functional Model – CASE 1 186

Figure 4-25 DRP to DRP Functional Model – CASE 2 & 3..... 187

Figure 4-26 Source to Source Functional Model..... 190

Figure 4-27 Sink to Sink Functional Model 190

Figure 4-28	DRP to VPD Model	191
Figure 4-29	Source to Legacy Device Port Functional Model	192
Figure 4-30	Legacy Host Port to Sink Functional Model	193
Figure 4-31	DRP to Legacy Device Port Functional Model	194
Figure 4-32	Legacy Host Port to DRP Functional Model.....	195
Figure 4-33	Sink Monitoring for Current in Pull-Up/Pull-Down CC Model.....	198
Figure 4-34	Sink Monitoring for Current in Current Source/Pull-Down CC Model.....	199
Figure 4-35	USB PD over CC Pins.....	200
Figure 4-36	USB PD BMC Signaling over CC.....	200
Figure 4-37	USB Type-C Cable's Output as a Function of Load for Non-PD-based USB Type-C Charging	203
Figure 4-38	0 – 3 A USB PD-based Charger USB Type-C Cable's Output as a Function of Load	204
Figure 4-39	3 – 5 A USB PD-based Charger USB Type-C Cable's Output as a Function of Load	204
Figure 4-40	Electronically Marked Cable with VCONN connected through the cable	208
Figure 4-41	Electronically Marked Cable with SOP' at both ends	209
Figure 4-42	DRP Timing	214
Figure 5-1	Pins Available for Reconfiguration over the Full-Featured Cable	219
Figure 5-2	Pins Available for Reconfiguration for Direct Connect Applications	219
Figure 5-3	Alternate Mode Implementation using a USB Type-C to USB Type-C Cable.....	220
Figure 5-4	Alternate Mode Implementation using a USB Type-C to Alternate Mode Cable or Device	221
Figure 5-5	USB DisplayPort Dock Example	223
Figure 5-6	Managed Active Cable	226
Figure A-1	Example Passive 3.5 mm to USB Type-C Adapter	231
Figure A-2	Example 3.5 mm to USB Type-C Adapter Supporting 500 mA Charge-Through	233
Figure B-1	USB Type-C Debug Accessory Layered Behavior	234
Figure B-2	DTS Plug Interface	235
Figure B-3	Connection State Diagram: DTS Source	237
Figure B-4	Connection State Diagram: DTS Sink	238
Figure B-5	Connection State Diagram: DTS DRP	239
Figure B-6	TS Sink Power Sub-States	244

TABLES

Table 2-1	Summary of power supply options.....	31
Table 3-1	USB Type-C Standard Cable Assemblies	32
Table 3-2	USB Type-C Legacy Cable Assemblies	33
Table 3-3	USB Type-C Legacy Adapter Assemblies.....	34
Table 3-4	USB Type-C Receptacle Interface Pin Assignments	64
Table 3-5	USB Type-C Receptacle Interface Pin Assignments for USB 2.0-only Support	65

Table 3-6 USB Type-C Standard Cable Wire Assignments 67

Table 3-7 USB Type-C Cable Wire Assignments for Legacy Cables/Adapters 68

Table 3-8 Reference Wire Gauges for standard USB Type-C Cable Assemblies 69

Table 3-9 Reference Wire Gauges for USB Type-C to Legacy Cable Assemblies 69

Table 3-10 USB Full-Featured Type-C Standard Cable Assembly Wiring 71

Table 3-11 *USB 2.0* Type-C Standard Cable Assembly Wiring 72

Table 3-12 USB Type-C to *USB 3.1* Standard-A Cable Assembly Wiring 74

Table 3-13 USB Type-C to *USB 2.0* Standard-A Cable Assembly Wiring 75

Table 3-14 USB Type-C to *USB 3.1* Standard-B Cable Assembly Wiring 77

Table 3-15 USB Type-C to *USB 2.0* Standard-B Cable Assembly Wiring 78

Table 3-16 USB Type-C to *USB 2.0* Mini-B Cable Assembly Wiring 79

Table 3-17 USB Type-C to *USB 3.1* Micro-B Cable Assembly Wiring 81

Table 3-18 USB Type-C to *USB 2.0* Micro-B Cable Assembly Wiring 82

Table 3-19 USB Type-C to *USB 3.1* Standard-A Receptacle Adapter Assembly Wiring 84

Table 3-20 USB Type-C to *USB 2.0* Micro-B Receptacle Adapter Assembly Wiring 85

Table 3-21 Differential Insertion Loss Examples for USB SuperSpeed with Twisted Pair Construction 86

Table 3-22 Differential Insertion Loss Examples for USB SuperSpeed with Coaxial Construction 87

Table 3-23 Electrical Requirements for CC and SBU wires 95

Table 3-24 Coupling Matrix for Low Speed Signals 96

Table 3-25 Maximum Mutual Inductance (M) between VBUS and Low Speed Signal Lines 98

Table 3-26 USB D+/D- Signal Integrity Requirements for USB Type-C to USB Type-C Passive Cable Assemblies 100

Table 3-27 USB Type-C Mated Connector Recommended Signal Integrity Characteristics (Informative) 104

Table 3-28 USB D+/D- Signal Integrity Requirements for USB Type-C to Legacy USB Cable Assemblies 106

Table 3-29 Design Targets for USB Type-C to *USB 3.1* Gen 2 Legacy Cable Assemblies (Informative) 107

Table 3-30 USB Type-C to *USB 3.1* Gen 2 Legacy Cable Assembly Signal Integrity Requirements (Normative) 107

Table 3-31 USB D+/D- Signal Integrity Requirements for USB Type-C to Legacy USB Adapter Assemblies (Normative) 110

Table 3-32 Design Targets for USB Type-C to *USB 3.1* Standard-A Adapter Assemblies (Informative) 110

Table 3-33 USB Type-C to *USB 3.1* Standard-A Receptacle Adapter Assembly Signal Integrity Requirements (Normative) 111

Table 3-34 Current Rating Test PCB 116

Table 3-35 Force and Moment Requirements 120

Table 3-36 Environmental Test Conditions 124

Table 3-37 Reference Materials 125

Table 4-1 USB Type-C List of Signals 130

Table 4-2	VBUS Source Characteristics	133
Table 4-3	VBUS Sink Characteristics	134
Table 4-4	USB Type-C Source Port's VCONN Requirements Summary	135
Table 4-5	VCONN Source Characteristics.....	135
Table 4-6	Cable VCONN Sink Characteristics.....	136
Table 4-7	VCONN-Powered Accessory (VPA) Sink Characteristics	137
Table 4-8	VCONN-Powered USB Device (VPD) Sink Characteristics	138
Table 4-9	USB Type-C-based Port Interoperability.....	141
Table 4-10	Source Perspective	143
Table 4-11	Source (Host) and Sink (Device) Behaviors by State	144
Table 4-12	USB PD Swapping Port Behavior Summary.....	151
Table 4-13	Power Role Behavioral Model Summary.....	152
Table 4-14	Source Port CC Pin State.....	160
Table 4-15	Sink Port CC Pin State	160
Table 4-16	Mandatory and Optional States	180
Table 4-17	Precedence of power source usage.....	196
Table 4-18	USB Type-C Current Advertisement and PDP Labeling	198
Table 4-19	SOP' and SOP'' Timing.....	209
Table 4-20	Source CC Termination (Rp) Requirements.....	211
Table 4-21	Sink CC Termination (Rd) Requirements.....	211
Table 4-22	Powered Cable Termination Requirements.....	211
Table 4-23	Sink CC Termination Requirements.....	212
Table 4-24	SBU Termination Requirements	212
Table 4-25	VBUS and VCONN Timing Parameters	213
Table 4-26	DRP Timing Parameters.....	214
Table 4-27	CC Timing.....	215
Table 4-28	CC Voltages on Source Side – Default USB	216
Table 4-29	CC Voltages on Source Side – 1.5 A @ 5 V	216
Table 4-30	CC Voltages on Source Side – 3.0 A @ 5 V	216
Table 4-31	Voltage on Sink CC Pins (Default USB Type-C Current only)	216
Table 4-32	Voltage on Sink CC pins (Multiple Source Current Advertisements).....	217
Table 5-1	USB Safe State Electrical Requirements	222
Table 5-2	USB Billboard Device Class Availability Following Alternate Mode Entry Failure	222
Table 5-3	Alternate Mode Signal Noise Ingression Requirements	222
Table A-1	USB Type-C Analog Audio Pin Assignments	229
Table A-2	USB Type-C Analog Audio Pin Electrical Parameter Ratings.....	230
Table B-1	DTS to TS Port Interoperability	235
Table B-2	Rp/Rp Charging Current Values for a DTS Source	244
Table B-3	Mandatory and Optional States.....	246

Specification Work Group Chairs / Specification Editors

Intel Corporation (USB 3.0 Promoter company)	Yun Ling – Mechanical WG co-chair, Mechanical Chapter Co-editor Brad Saunders – Plenary/Functional WG chair, Specification Co-author
Renesas Electronics Corp. (USB 3.0 Promoter company)	Bob Dunstan – Functional WG co-chair, Specification Co-author
Seagate	Alvin Cox, Mechanical WG co-chair, Mechanical Chapter Co-editor

Specification Work Group Contributors

Advanced-Connectek, Inc. (ACON)	Glen Chandler	Vicky Chuang	Alan Tsai
	Jeff Chien	Aven Kao	Stephen Yang
	Lee (Dick Lee) Ching	Danny Liao	
	Conrad Choy	Alan MacDougall	
Advanced Micro Devices	Steve Capezza	Walter Fry	Will Harris
Agilent Technologies, Inc.	James Choate		
Analogix Semiconductor, Inc.	Mehran Badii	Greg Stewart	
Apple Inc. (USB 3.0 Promoter company)	Mahmoud Amini	Zheng Gao	Keith Porthouse
	Sree Anantharaman	Girault Jones	Sascha Tietz
	Paul Baker	Keong Kam	Jennifer Tsai
	Jason Chung	Min Kim	Colin Whitby- Stevens
	David Conroy	Chris Ligtenberg	Dennis Yarak
	Bill Cornelius	Nathan Ng	
	William Ferry	James Orr	
Cypress Semiconductor	Mark Fu	Anup Nayak	Sanjay Sancheti
	Rushil Kadakia	Jagadeesan Raj	Subu Sankaran
Dell	Mohammed Hijazi	Sean O’Neal	Thomas Voor
	David Meyers	Ernesto Ramirez	
DisplayLink (UK) Ltd.	Pete Burgers		
Electronics Testing Center, Taiwan	Sophia Liu		
Foxconn	Asroc Chen	Chien-Ping Kao	Pei Tsao
	Allen Cheng	Ji Li	AJ Yang
	Jason Chou	Ann Liu	Yuan Zhang
	Edmond Choy	Terry Little	Jessica Zheng
	Fred Fons	Steve Sedio	Andy Yao
	Bob Hall		
Foxlink/Cheng Uei Precision Industry Co., Ltd.	Robert Chen	Armando Lee	Steve Tsai
	Sunny Chou	Dennis Lee	Wen Yang
	Carrie Chuang	Justin Lin	Wiley Yang
	Wen-Chuan Hsu	Tse Wu Ting	Junjie Yu
	Alex Hsue		

Google	Joshua Boilard	Mark Hayter	Adam Rodriguez
	Alec Berg	Nithya Jagannathan	David Schneider
	Todd Broch	Lawrence Lam	Ken Wu
	Jim Guerin	Ingrid Lin	
	Jeffrey Hayashida	Richard Palatin	
Granite River Labs	Mike Engbretson	Johnson Tan	
Hewlett Packard Inc. (USB 3.0 Promoter company)	Alan Berkema	Michael Krause	Linden McClure
	Robin Castell	Jim Mann	Mike Pescetto
Hirose Electric Co., Ltd.	Jeremy Buan	Gourgen Oganessyan	Sid Tono
	William MacKillop		
Intel Corporation (USB 3.0 Promoter company)	Dave Ackelson	Luke Johnson	Chee Lim Nge
	Mike Bell	Jerzy Kolinski	Sridharan Ranganathan
	Kuan-Yu Chen	Rolf Kuhnis	Brad Saunders
	Hengju Cheng	Christine Krause	Amit Srivastava
	Paul Durley	Henrik Leegaard	Ron Swartz
	Howard Heck	Yun Ling	Karthi Vadivelu
	Hao-Han Hsu	Xiang Li	Rafal Wielicki
	Abdul (Rahman) Ismail	Guobin Liu	
	James Jaussi	Steve McGowan	
		Sankaran Menon	
Japan Aviation Electronics Industry Ltd. (JAE)	Kenji Hagiwara	Kimiaki Saito	Jussi Takaneva
	Masaki Kimura	Yuichi Saito	Tomohiko Tamada
	Toshio Masumoto	Mark Saubert	Kentaro Toda
	Joe Motojima	Toshio Shimoyama	Kouhei Ueda
	Ron Muir	Tatsuya Shioda	Takakazu Usami
	Tadashi Okubo	Atsuo Tago	Masahide Watanabe
	Kazuhiro Saito	Masaaki Takaku	Youhei Yokoyama
JPC/Main Super Inc.	Sam Tseng	Ray Yang	
LeCroy Corporation	Daniel H. Jacobs		
Lenovo	Rob Bowser	Wei Liu	Howard Locker
	Tomoki Harada		
Lotes Co., Ltd.	Ariel Delos Reyes	Regina Liu-Hwang	John Lynch
	Ernest Han	Charles Kaun	JinYi Tu
	Mark Ho	Max Lo	Jason Yang
LSI Corporation	Dave Thompson		
Luxshare-ICT	Josue Castillo	CY Hsu	Stone Lin
	Daniel Chen	Alan Kinningham	Pat Young
	Lisen Chen	John Lin	
MegaChips Corporation	Alan Kobayashi		
Microchip (SMSC)	Josh Averyt	Donald Perkins	Mohammed Rahman
	Mark Bohm	Richard Petrie	

Microsoft Corporation (USB 3.0 Promoter company)	Randy Aull	Robert Hollyer	Ivan McCracken
	Fred Bhesania	Kai Inha	Toby Nixon
	Anthony Chen	Jayson Kastens	Gene Obie
	Marty Evans	Andrea Keating	Srivatsan Ravindran
	Vivek Gupta	Eric Lee	David Voth
	Robbie Harris		
Monolithic Power Systems	Chris Sporck		
MQP Electronics Ltd.	Sten Carlsen	Pat Crowe	
Nokia Corporation	Daniel Gratiot	Samuli Makinen	Timo Toivola
	Pekka Leinonen	Pekka Talmola	Panu Ylihaavisto
NXP Semiconductors	Vijendra Kuroodi	Guru Prasad	
Renesas Electronics Corp. (USB 3.0 Promoter company)	Bob Dunstan	Philip Leung	Kiichi Muto
	Nobuo Furuya		
Rohm Co., Ltd.	Mark Aaldering	Arun Kumar	Takashi Sato
	Kris Bahar	Chris Lin	Hiroshi Yoshimura
	Yusuke Kondo		
Samsung Electronics Co., Ltd.	Cheolyoon Chung	Woonki Kim	Cheolho Lee
	Soondo Kim	Jagoun Koo	Jun Bum Lee
Seagate	Alvin Cox	Tom Skaar	Dan Smith
	Tony Priborsky		
SiliConch Systems Private Limited	Jaswanth Ammineni	Aniket Mathad	Rakesh Polasa
	Pavitra Balasubramanian	Shubham Paliwal	Abhishek Sardeshpande
	Kaustubh K		
STMicroelectronics (USB 3.0 Promoter company)	Nathalie Ballot	Christophe Lorin	Federico Musarra
	Nicolas Florenchie	Patrizia Milazzo	Pascal Legrand
	Joel Huloux		
Tektronix, Inc.	Randy White		
Texas Instruments (USB 3.0 Promoter company)	Jawaid Ahmad	Win Maung	Anwar Sadat
	Richard Hubbard	Lauren Moore	Sue Vining
	Scott Jackson	Martin Patoka	Deric Waters
	Yoon Lee	Brian Quach	
	Grant Ley	Wes Ray	
Tyco Electronics Corp. (TE Connectivity Ltd.)	Max Chao	Jim McGrath	Scott Shuey
	Robert E. Cid	Takeshi Nakashima	Hidenori Taguchi
	Kengo Ijiri	Luis A. Navarro	Bernard Vetten
	Eiji Ikematsu	Masako Saito	Ryan Yu
	Joan Leu	Yoshiaki Sakuma	Sjoerd Zwartkruis
	Clark Li	Gavin Shih	
	Mike Lockyer	Hiroshi Shirai	
VIA Technologies Inc.	Terrance Shih	Jay Tseng	Fong-Jim Wang

Pre-Release Draft Industry Reviewing Companies That Provided Feedback

Aces	Joinsoon Electronics Mfg. Co. Ltd.	Parade Technology
Allion Labs, Inc.	JST Mfg. Co., Ltd.	Pericom
BizLink International Corp.	Korea Electric Terminal	Qualcomm
Corning Optical Communications LLC	Marvell Semiconductor	Semtech Corporation
Cypress Semiconductor	Motorola Mobility LLC	Shenzhen Deren Electronic Co., Ltd.
Etron Technology Inc.	NEC	Silicon Image
Fairchild Semiconductor	Newnex Technology Corp.	Simula Technology Corp.
Fujitsu Ltd.	NXP Semiconductors	SMK Corporation
Industrial Technology Research Institute (ITRI)	PalCONN/PalNova (Palpilot International Corp.)	Sony Corporation
		Sumitomo Electric Industries
		Toshiba Corporation

Revision History

Revision	Date	Description
1.0	August 11, 2014	Initial Release
1.1	April 3, 2015	Reprint release including incorporation of all approved ECNs as of the revision date plus editorial clean-up.
1.2	March 25, 2016	Reprint release including incorporation of all approved ECNs as of the revision date plus editorial clean-up.
1.3	July 14, 2017	Reprint release including incorporation of all approved ECNs as of the revision date plus editorial clean-up.

1 Introduction

With the continued success of the USB interface, there exists a need to adapt USB technology to serve newer computing platforms and devices as they trend toward smaller, thinner and lighter form-factors. Many of these newer platforms and devices are reaching a point where existing USB receptacles and plugs are inhibiting innovation, especially given the relatively large size and internal volume constraints of the Standard-A and Standard-B versions of USB connectors. Additionally, as platform usage models have evolved, usability and robustness requirements have advanced and the existing set of USB connectors were not originally designed for some of these newer requirements. This specification is to establish a new USB connector ecosystem that addresses the evolving needs of platforms and devices while retaining all of the functional benefits of USB that form the basis for this most popular of computing device interconnects.

1.1 Purpose

This specification defines the USB Type-C™ receptacles, plug and cables.

The USB Type-C Cable and Connector Specification is guided by the following principles:

- Enable new and exciting host and device form-factors where size, industrial design and style are important parameters
- Work seamlessly with existing USB host and device silicon solutions
- Enhance ease of use for connecting USB devices with a focus on minimizing user confusion for plug and cable orientation

The USB Type-C Cable and Connector Specification defines a new receptacle, plug, cable and detection mechanisms that are compatible with existing USB interface electrical and functional specifications. This specification covers the following aspects that are needed to produce and use this new USB cable/connector solution in newer platforms and devices, and that interoperate with existing platforms and devices:

- USB Type-C receptacles, including electro-mechanical definition and performance requirements
- USB Type-C plugs and cable assemblies, including electro-mechanical definition and performance requirements
- USB Type-C to legacy cable assemblies and adapters
- USB Type-C-based device detection and interface configuration, including support for legacy connections
- USB Power Delivery optimized for the USB Type-C connector

The USB Type-C Cable and Connector Specification defines a standardized mechanism that supports Alternate Modes, such as repurposing the connector for docking-specific applications.

1.2 Scope

This specification is intended as a supplement to the existing *USB 2.0*, *USB 3.1* and *USB Power Delivery* specifications. It addresses only the elements required to implement and support the USB Type-C receptacles, plugs and cables.