



BSI Standards Publication

Universal serial bus interfaces for data and power

Part 1-3: Common components —
USB Type-C(r) Cable and Connector Specification

National foreword

This British Standard is the UK implementation of EN IEC 62680-1-3:2021. It is identical to IEC 62680-1-3:2021. It supersedes [BS EN IEC 62680-1-3:2018](#), which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/100, Audio-visual equipment.

A list of organizations represented on this committee can be obtained on request to its committee manager.

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

© The British Standards Institution 2021
Published by BSI Standards Limited 2021

ISBN 978 0 539 13262 5

ICS 33.120.20; 33.120.30; 35.200

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 April 2021.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

English Version

Universal serial bus interfaces for data and power - Part 1-3:
Common components - USB Type-C(r) Cable and Connector
Specification
(IEC 62680-1-3:2021)

Interfaces de bus universel en série pour les données et
l'alimentation électrique - Partie 1-3: Composants communs
- Spécification des câbles et connecteurs USB Type-C(r)
(IEC 62680-1-3:2021)

Schnittstellen des Universellen Seriellen Busses für Daten
und Energie - Teil 1-3: Gemeinsame Bauteile - Festlegung
für USB-Typ-CTM-Kabel und -Steckverbinder
(IEC 62680-1-3:2021)

This European Standard was approved by CENELEC on 2021-03-23. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document 100/3439/CDV, future edition 4 of IEC 62680-1-3, prepared by IEC/TC 100 "Audio, video and multimedia systems and equipment" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 62680-1-3:2021.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2021-12-23
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2024-03-23

This document supersedes EN IEC 62680-1-3:2018 and all of its amendments and corrigenda (if any).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 62680-1-3:2021 was approved by CENELEC as a European Standard without any modification.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



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

**Interfaces de bus universel en série pour les données et l'alimentation
électrique –
Partie 1-3: Composants communs – Spécification des câbles et connecteurs
USB Type-C®**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 33.120.20; 33.120.30; 35.200

ISBN 978-2-8322-9337-9

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

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 18: Multimedia home systems and applications for end-user networks, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

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
100/3439/CDV	100/3501/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.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

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 document 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 Universal Serial Bus Type-C Cable and Connector Specification Revision 2.0.

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:

<https://www.usb.org/documents>

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 2.0
August 2019

**Copyright © 2014-2019, 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®, USB-C®, USB 2.0 Type-C™ and USB4™ are trademarks of the Universal Serial Bus Implementers Forum (USB-IF). DisplayPort™ is a trademark of VESA. All product names are trademarks, registered trademarks, or service marks of their respective owners.

Thunderbolt™ is a trademark of Intel Corporation. You may only use the Thunderbolt™ trademark or logo in conjunction with products designed to this specification that complete proper certification and executing a Thunderbolt™ trademark license – see usb.org/compliance for further information.

CONTENTS

Specification Work Group Chairs / Specification Editors	19
Specification Work Group Contributors	19
Pre-Release Draft Industry Reviewing Companies That Provided Feedback.....	24
Revision History.....	25
1 Introduction	26
1.1 Purpose	26
1.2 Scope.....	26
1.3 Related Documents	27
1.4 Conventions.....	27
1.4.1 Precedence	27
1.4.2 Keywords	27
1.4.3 Numbering.....	28
1.5 Terms and Abbreviations	28
2 Overview	33
2.1 Introduction	33
2.2 USB Type-C Receptacles, Plugs and Cables	34
2.3 Configuration Process	35
2.3.1 Source-to-Sink Attach/Detach Detection.....	36
2.3.2 Plug Orientation/Cable Twist Detection.....	36
2.3.3 Initial Power (Source-to-Sink) Detection and Establishing the Data (Host-to-Device) Relationship.....	36
2.3.4 USB Type-C VBUS Current Detection and Usage	37
2.3.5 USB PD Communication.....	37
2.3.6 Functional Extensions.....	38
2.4 VBUS.....	38
2.5 VCONN.....	39
2.6 Hubs.....	39
3 Mechanical	40
3.1 Overview	40
3.1.1 Compliant Connectors.....	40
3.1.2 Compliant Cable Assemblies	40
3.1.3 Compliant USB Type-C to Legacy Cable Assemblies	40
3.1.4 Compliant USB Type-C to Legacy Adapter Assemblies	41
3.2 USB Type-C Connector Mating Interfaces	41
3.2.1 Interface Definition	42
3.2.2 Reference Designs	63
3.2.3 Pin Assignments and Descriptions.....	70
3.3 Cable Construction and Wire Assignments.....	71
3.3.1 Cable Construction (Informative)	71
3.3.2 Wire Assignments	73
3.3.3 Wire Gauges and Cable Diameters (Informative).....	74
3.4 Standard USB Type-C Cable Assemblies	76

3.4.1	USB Full-Featured Type-C Cable Assembly	76
3.4.2	USB 2.0 Type-C Cable Assembly	77
3.4.3	USB Type-C Captive Cable Assemblies	78
3.5	Legacy Cable Assemblies	78
3.5.1	USB Type-C to <i>USB 3.1</i> Standard-A Cable Assembly	79
3.5.2	USB Type-C to <i>USB 2.0</i> Standard-A Cable Assembly	80
3.5.3	USB Type-C to <i>USB 3.1</i> Standard-B Cable Assembly	81
3.5.4	USB Type-C to <i>USB 2.0</i> Standard-B Cable Assembly	82
3.5.5	USB Type-C to <i>USB 2.0</i> Mini-B Cable Assembly	83
3.5.6	USB Type-C to <i>USB 3.1</i> Micro-B Cable Assembly	84
3.5.7	USB Type-C to <i>USB 2.0</i> Micro-B Cable Assembly	86
3.6	Legacy Adapter Assemblies	87
3.6.1	USB Type-C to <i>USB 3.1</i> Standard-A Receptacle Adapter Assembly	87
3.6.2	USB Type-C to <i>USB 2.0</i> Micro-B Receptacle Adapter Assembly	89
3.7	Electrical Characteristics	90
3.7.1	Raw Cable (Informative)	90
3.7.2	USB Type-C to Type-C Passive Cable Assemblies (Normative)	91
3.7.3	Mated Connector (Informative – USB 3.2 Gen2 and USB4 Gen2)	109
3.7.4	Mated Connector (Normative – USB4 Gen3)	113
3.7.5	USB Type-C to Legacy Cable Assemblies (Normative)	114
3.7.6	USB Type-C to USB Legacy Adapter Assemblies (Normative)	118
3.7.7	Shielding Effectiveness Requirements (Normative)	120
3.7.8	DC Electrical Requirements (Normative)	122
3.8	Mechanical and Environmental Requirements (Normative)	125
3.8.1	Mechanical Requirements	125
3.8.2	Environmental Requirements	130
3.9	Docking Applications (Informative)	131
3.10	Implementation Notes and Design Guides	132
3.10.1	EMC Management (Informative)	132
3.10.2	Stacked and Side-by-Side Connector Physical Spacing (Informative)	134
3.10.3	Cable Mating Considerations (Informative)	135
4	Functional	136
4.1	Signal Summary	136
4.2	Signal Pin Descriptions	136
4.2.1	SuperSpeed USB Pins	136
4.2.2	USB 2.0 Pins	137
4.2.3	Auxiliary Signal Pins	137
4.2.4	Power and Ground Pins	137
4.2.5	Configuration Pins	137
4.3	Sideband Use (SBU)	137
4.4	Power and Ground	137
4.4.1	IR Drop	137
4.4.2	VBUS	138
4.4.3	VCONN	141

4.5	Configuration Channel (CC).....	145
4.5.1	Architectural Overview	145
4.5.2	CC Functional and Behavioral Requirements	159
4.5.3	USB Port Interoperability Behavior.....	194
4.6	Power	213
4.6.1	Power Requirements during USB Suspend.....	214
4.6.2	VBUS Power Provided Over a USB Type-C Cable	215
4.7	USB Hubs	220
4.8	Power Sourcing and Charging.....	220
4.8.1	DFP as a Power Source	221
4.8.2	Non-USB Charging Methods	223
4.8.3	Sinking Host	224
4.8.4	Sourcing Device.....	224
4.8.5	Charging a System with a Dead Battery	224
4.8.6	USB Type-C Multi-Port Chargers	224
4.9	Electronically Marked Cables.....	227
4.9.1	Parameter Values	228
4.9.2	Active Cables.....	229
4.10	VCONN-Powered Accessories (VPAs) and VCONN-Powered USB Devices (VPDs).....	229
4.10.1	VCONN-Powered Accessories (VPAs).....	229
4.10.2	VCONN-Powered USB Devices (VPDs)	229
4.11	Parameter Values.....	231
4.11.1	Termination Parameters	231
4.11.2	Timing Parameters.....	233
4.11.3	Voltage Parameters.....	236
5	USB4 Discovery and Entry	238
5.1	Overview of the Discovery and Entry Process.....	238
5.2	USB4 Functional Requirements.....	239
5.2.1	USB4 Host Functional Requirements	239
5.2.2	USB4 Device Functional Requirements	239
5.2.3	USB4 Alternate Mode Support.....	239
5.2.3.1	USB4 Alternate Mode Support on Hosts.....	239
5.2.3.2	USB4 Alternate Mode Support on Hubs and USB4-based Docks.....	239
5.3	USB4 Power Requirements.....	240
5.3.1	Source Power Requirements.....	240
5.3.2	Sink Power Requirements	240
5.3.3	Device Power Management Requirements	240
5.4	USB4 Discovery and Entry Flow Requirements	241
5.4.1	USB Type-C Initial Connection	241
5.4.2	USB Power Delivery Contract.....	241
5.4.3	USB4 Discovery and Entry Flow	241
5.4.3.1	USB4 Device Discovery (SOP).....	242
5.4.3.2	USB4 Cable Discovery (SOP')	243
5.4.3.3	USB4 Operational Entry	245

5.4.4	USB4 Post-Entry Operation	245
5.4.4.1	During USB4 Operation	245
5.4.4.2	Exiting USB4 Operation	245
5.5	USB4 Hub Connection Requirements	246
5.5.1	USB4 Hub Port Initial Connection Requirements	246
5.5.2	USB4 Hub UFP and Host Capabilities Discovery	246
5.5.3	Hub DFP Connection Requirements	247
5.5.3.1	Speculative Connections	247
5.5.3.2	Operational Connections	247
5.5.4	Hub Ports Connection Behavior Flow Model	247
5.5.5	Connecting to Downstream USB4 Hubs	253
5.5.6	Fallback Functional Requirements for USB4 Hubs	253
5.6	USB4 Device Connection Requirements	254
5.6.1	Fallback Mapping of USB4 Peripheral Functions to USB Device Class Types	254
5.7	Parameter Values	255
5.7.1	Timing Parameters	255
6	Active Cables	256
6.1	USB Type-C State Machine	257
6.2	USB PD Requirements	258
6.2.1	Active Cable USB PD Requirements	259
6.2.2	USB PD Messages for OIAC	259
6.2.3	Short Active Cable Behaviors in Response to Power Delivery Events	271
6.3	OIAC Connection Flow and State Diagrams	271
6.3.1	OIAC Connection Flow – Discovery – Phase 1	272
6.3.2	OIAC Connection Flow – Reboot – Phase 2	273
6.3.3	OIAC Connection Flow – Configuration – Phase 3	274
6.3.4	OIAC Connection State Diagram Master	277
6.3.5	OIAC Connection State Diagram Slave	285
6.4	Active Cable Power Requirements	290
6.4.1	VBUS Requirements	290
6.4.2	OIAC VBUS Requirements	290
6.4.3	USB PD Rules in Active State	291
6.4.4	VCONN Requirements	292
6.5	Mechanical	293
6.5.1	Thermal	293
6.5.2	Plug Spacing	293
6.6	Electrical Requirements	294
6.6.1	Shielding Effectiveness Requirement	294
6.6.2	Low Speed Signal Requirement	294
6.6.3	USB 2.0	294
6.6.4	USB 3.2	295
6.6.5	Return Loss	301
6.7	Active Cables That Support Alternate Modes	302
6.7.1	Discover SVIDs	302

6.7.2	Discover Modes	302
6.7.3	Enter/Exit Modes	302
6.7.4	Power in Alternate Modes	302
A	Audio Adapter Accessory Mode	303
A.1	Overview	303
A.2	Detail	303
A.3	Electrical Requirements	304
A.4	Example Implementations	306
A.4.1	Passive 3.5 mm to USB Type-C Adapter – Single Pole Detection Switch	306
A.4.2	3.5 mm to USB Type-C Adapter Supporting 500 mA Charge-Through	306
B	Debug Accessory Mode	308
B.1	Overview	308
B.2	Functional	308
B.2.1	Signal Summary	309
B.2.2	Port Interoperability	309
B.2.3	Debug Accessory Mode Entry	309
B.2.4	Connection State Diagrams	310
B.2.5	DTS Port Interoperability Behavior	318
B.2.6	Orientation Detection	327
B.3	Security/Privacy Requirements:	328
C	USB Type-C Digital Audio	329
C.1	Overview	329
C.2	USB Type-C Digital Audio Specifications	329
D	Thermal Design Considerations for Active Cables	331
D.1	Introduction	331
D.2	Model	331
D.2.1	Assumptions	331
D.2.2	Model Architecture	332
D.2.3	Heat Sources	333
D.2.4	Heat Flow	333
D.3	USB 3.2 Single Lane Active Cable	334
D.3.1	USB 3.2 Single-Lane Active Cable Design Considerations	334
D.4	Dual-Lane Active Cables	337
D.4.1	USB 3.2 Dual-Lane Active Cable Design Considerations	337
D.4.2	USB 3.2 Dual-Lane Active Cable in a Multi-Port Configuration	339
D.5	USB 3.2 Host and Device Design Considerations	341
D.5.1	Heat Spreading or Heat Sinking from Host or Device	341
D.5.2	Motherboard Temperature Control	342
D.5.3	Wider Port Spacing for Multi-Port Applications	342
D.5.4	Power Policies	342
E	Alternate Modes	343
E.1	Alternate Mode Architecture	343
E.2	Alternate Mode Requirements	343
E.2.1	Alternate Mode Pin Reassignment	344

E.2.2	Alternate Mode Electrical Requirements	344
E.3	Parameter Values.....	347
E.4	Example Alternate Mode – USB DisplayPort™ Dock	348
E.4.1	USB DisplayPort™ Dock Example	348
E.4.2	Functional Overview	349
E.4.3	Operational Summary	350
F	Thunderbolt 3 Compatibility Discovery and Entry	351
F.1	TBT3 Compatibility Mode Functional Requirements	351
F.1.1	TBT3-Compatible Power Requirements.....	351
F.1.2	TBT3-Compatible Host Requirements	351
F.1.3	TBT3-Compatible Device Upstream Requirements	351
F.1.4	TBT3-Compatible Device Downstream Requirements.....	351
F.1.5	TBT3-Compatible Self-Powered Device Without Predefined Upstream Port Rules.....	352
F.1.6	TBT3-Compatible Devices with a Captive Cable	352
F.2	TBT3 Discovery and Entry Flow	352
F.2.1	TBT3 Passive Cable Discover Identity Responses.....	354
F.2.2	TBT3 Active Cable Discover Identity Responses.....	356
F.2.3	TBT3 Device Discover Identity Responses	359
F.2.4	TBT3 Discover SVID Responses	360
F.2.5	TBT3 Device Discover Mode Responses.....	361
F.2.6	TBT3 Cable Discover Mode Responses	362
F.2.7	TBT3 Cable Enter Mode Command	363
F.2.8	TBT3 Device Enter Mode Command.....	364
F.2.9	TBT3 Cable Functional Difference Summary	365

FIGURES

Figure 2-1	USB Type-C Receptacle Interface (Front View).....	33
Figure 2-2	USB Full-Featured Type-C Plug Interface (Front View)	34
Figure 3-1	USB Type-C Receptacle Interface Dimensions.....	44
Figure 3-2	Reference Design USB Type-C Plug External EMC Spring Contact Zones.....	47
Figure 3-3	USB Full-Featured Type-C Plug Interface Dimensions.....	48
Figure 3-4	Reference Footprint for a USB Type-C Vertical Mount Receptacle (Informative).....	51
Figure 3-5	Reference Footprint for a USB Type-C Dual-Row SMT Right Angle Receptacle (Informative)	52
Figure 3-6	Reference Footprint for a USB Type-C Hybrid Right-Angle Receptacle (Informative).....	53
Figure 3-7	Reference Footprint for a USB Type-C Mid-Mount Dual-Row SMT Receptacle (Informative)	54
Figure 3-8	Reference Footprint for a USB Type-C Mid-Mount Hybrid Receptacle (Informative).....	55
Figure 3-9	Reference Footprint for a USB 2.0 Type-C Through Hole Right Angle Receptacle (Informative)	56
Figure 3-10	Reference Footprint for a USB 2.0 Type-C Single Row Right Angle Receptacle (Informative)	57
Figure 3-11	USB 2.0 Type-C Plug Interface Dimensions.....	59
Figure 3-12	USB Type-C Plug EMC Shielding Spring Tip Requirements.....	62
Figure 3-13	Reference Design of Receptacle Mid-Plate.....	63
Figure 3-14	Reference Design of the Retention Latch.....	64

Figure 3-15 Illustration of the Latch Soldered to the Paddle Card Ground.....	64
Figure 3-16 Reference Design of the USB Full-Featured Type-C Plug Internal EMC Spring.....	65
Figure 3-17 Reference Design of the <i>USB 2.0</i> Type-C Plug Internal EMC Spring	66
Figure 3-18 Reference Design of Internal EMC Pad	67
Figure 3-19 Reference Design of a USB Type-C Receptacle with External EMC Springs.....	68
Figure 3-20 Reference Design for a USB Full-Featured Type-C Plug Paddle Card	69
Figure 3-21 Illustration of a USB Full-Featured Type-C Cable Cross Section, a Coaxial Wire Example with VCONN.....	72
Figure 3-22 Illustration of a USB Full-Featured Type-C Cable Cross Section, a Coaxial Wire Example without VCONN.....	72
Figure 3-23 USB Full-Featured Type-C Standard Cable Assembly.....	76
Figure 3-24 USB Type-C to USB 3.1 Standard-A Cable Assembly	79
Figure 3-25 USB Type-C to <i>USB 2.0</i> Standard-A Cable Assembly.....	80
Figure 3-26 USB Type-C to <i>USB 3.1</i> Standard-B Cable Assembly.....	81
Figure 3-27 USB Type-C to <i>USB 2.0</i> Standard-B Cable Assembly.....	82
Figure 3-28 USB Type-C to <i>USB 2.0</i> Mini-B Cable Assembly.....	83
Figure 3-29 USB Type-C to <i>USB 3.1</i> Micro-B Cable Assembly.....	84
Figure 3-30 USB Type-C to <i>USB 2.0</i> Micro-B Cable Assembly.....	86
Figure 3-31 USB Type-C to <i>USB 3.1</i> Standard-A Receptacle Adapter Assembly.....	87
Figure 3-32 USB Type-C to <i>USB 2.0</i> Micro-B Receptacle Adapter Assembly.....	89
Figure 3-33 Illustration of Test Points for a Mated Cable Assembly	91
Figure 3-34 Recommended Differential Insertion Loss Requirement (USB 3.2 Gen2 and USB4 Gen2).....	92
Figure 3-35 Recommended Differential Return Loss Requirement	92
Figure 3-36 Recommended Differential Crosstalk Requirement.....	93
Figure 3-37 Recommended Differential Near-End and Far-End Crosstalk Requirement between USB D+/D- Pair and TX/RX Pair.....	94
Figure 3-38 Recommended Differential Insertion Loss Requirement (USB4 Gen3).....	94
Figure 3-39 Illustration of Insertion Loss Fit at Nyquist Frequency	95
Figure 3-40 Input Pulse Spectrum	96
Figure 3-41 IMR Limit as Function of ILfitatNq	97
Figure 3-42 IRL Limit as Function of ILfitatNq	99
Figure 3-43 Differential-to-Common-Mode Conversion Requirement	99
Figure 3-44 IMR Limit as Function of ILfit at 10 GHz (USB4 Gen3).....	100
Figure 3-45 Definition of Port, Victim, and Aggressor	101
Figure 3-46 IXT_DP and IXT_USB Limit as Function of ILfit at 10 GHz (USB4 Gen3).....	101
Figure 3-47 IRL Limit as Function of ILfitatNq (USB4 Gen3)	102
Figure 3-48 Differential-to-Common-Mode Conversion Requirement (USB4 Gen3).....	102
Figure 3-49 Cable Assembly in System.....	103
Figure 3-50 Requirement for Differential Coupling between CC and D+/D-	105
Figure 3-51 Requirement for Single-Ended Coupling between CC and D- in USB 2.0 Type-C Cables.....	105
Figure 3-52 Requirement for Single-Ended Coupling between CC and D- in USB Full-Featured Type-C Cables	106
Figure 3-53 Requirement for Differential Coupling between VBUS and D+/D-.....	106
Figure 3-54 Requirement for Single-Ended Coupling between SBU_A and SBU_B.....	107
Figure 3-55 Requirement for Single-Ended Coupling between SBU_A/SBU_B and CC.....	108
Figure 3-56 Requirement for Coupling between SBU_A and differential D+/D-, and SBU_B and differential D+/D-.....	108
Figure 3-57 Illustration of USB Type-C Mated Connector	109
Figure 3-58 Recommended Impedance Limits of a USB Type-C Mated Connector	110
Figure 3-59 Recommended Ground Void Dimensions for USB Type-C Receptacle.....	111
Figure 3-60 Recommended Differential Near-End and Far-End Crosstalk Limits between D+/D- Pair and TX/RX Pairs	112
Figure 3-61 Recommended Limits for Differential-to-Common-Mode Conversion.....	113
Figure 3-62 IMR Limit as Function of ILfitatNq for USB Type-C to Legacy Cable Assembly	117
Figure 3-63 IRL Limit as Function of ILfitatNq for USB Type-C to Legacy Cable Assembly.....	117
Figure 3-64 Cable Assembly Shielding Effectiveness Testing	122

Figure 3-65 Shielding Effectiveness Pass/Fail Criteria	121
Figure 3-66 LLCR Measurement Diagram	122
Figure 3-67 Temperature Measurement Point	123
Figure 3-68 Example Current Rating Test Fixture Trace Configuration.....	124
Figure 3-69 Example of 4-Axis Continuity Test Fixture	126
Figure 3-70 Example Wrenching Strength Test Fixture for Plugs without Overmold	128
Figure 3-71 Reference Wrenching Strength Continuity Test Fixture	129
Figure 3-72 Example of Wrenching Strength Test Mechanical Failure Point.....	129
Figure 3-73 Wrenching Strength Test with Cable in Fixture	130
Figure 3-74 USB Type-C Cable Receptacle Flange Example	132
Figure 3-75 EMC Guidelines for Side Latch and Mid-plate	133
Figure 3-76 EMC Finger Connections to Plug Shell	133
Figure 3-77 EMC Pad Connections to Receptacle Shell	134
Figure 3-78 Examples of Connector Apertures	134
Figure 3-79 Recommended Minimum Spacing between Connectors	135
Figure 3-80 Recommended Minimum Plug Overmold Clearance.....	135
Figure 3-81 Cable Plug Overmold and an Angled Surface	135
Figure 4-1 Cable IR Drop	138
Figure 4-2 Cable IR Drop for powered cables.....	138
Figure 4-3 Logical Model for Single-Lane Data Bus Routing across USB Type-C-based Ports	147
Figure 4-4 Logical Model for USB Type-C-based Ports for a Single-Lane Direct Connect Device	147
Figure 4-5 Pull-Up/Pull-Down CC Model.....	149
Figure 4-6 Current Source/Pull-Down CC Model.....	149
Figure 4-7 Source Functional Model for CC1 and CC2	152
Figure 4-8 Source Functional Model Supporting USB PD PR_Swap.....	153
Figure 4-9 Sink Functional Model for CC1 and CC2.....	153
Figure 4-10 Sink Functional Model Supporting USB PD PR_Swap and VCONN_Swap	154
Figure 4-11 DRP Functional Model for CC1 and CC2	155
Figure 4-12 Connection State Diagram: Source	160
Figure 4-13 Connection State Diagram: Sink	161
Figure 4-14 Connection State Diagram: Sink with Accessory Support.....	162
Figure 4-15 Connection State Diagram: DRP	163
Figure 4-16 Connection State Diagram: DRP with Accessory and Try.SRC Support.....	164
Figure 4-17 Connection State Diagram: DRP with Accessory and Try.SNK Support	165
Figure 4-18 Connection State Diagram: Charge-Through VPD	166
Figure 4-19 Sink Power Sub-States	189
Figure 4-20 Cable eMarker State Diagram	190
Figure 4-21 Source to Sink Functional Model.....	194
Figure 4-22 Source to DRP Functional Model.....	195
Figure 4-23 DRP to Sink Functional Model	196
Figure 4-24 DRP to DRP Functional Model – CASE 1.....	197
Figure 4-25 DRP to DRP Functional Model – CASE 2 & 3	198
Figure 4-26 Source to Source Functional Model.....	200
Figure 4-27 Sink to Sink Functional Model	201
Figure 4-28 DRP to VPD Model.....	201
Figure 4-29 Example DRP to Charge-Through VCONN-Powered USB Device Model.....	202
Figure 4-30 Source to Legacy Device Port Functional Model	210
Figure 4-31 Legacy Host Port to Sink Functional Model.....	211
Figure 4-32 DRP to Legacy Device Port Functional Model.....	212
Figure 4-33 Legacy Host Port to DRP Functional Model.....	213
Figure 4-34 Sink Monitoring for Current in Pull-Up/Pull-Down CC Model.....	216
Figure 4-35 Sink Monitoring for Current in Current Source/Pull-Down CC Model.....	217
Figure 4-36 USB PD over CC Pins	217
Figure 4-37 USB PD BMC Signaling over CC	218

Figure 4-38 USB Type-C Cable's Output as a Function of Load for Non-PD-based USB Type-C Charging	222
Figure 4-39 0 – 3 A USB PD-based Charger USB Type-C Cable's Output as a Function of Load	223
Figure 4-40 3 – 5 A USB PD-based Charger USB Type-C Cable's Output as a Function of Load	223
Figure 4-41 Electronically Marked Cable with VCONN connected through the cable	228
Figure 4-42 Electronically Marked Cable with SOP' at both ends	228
Figure 4-43 Example Charge-Through VCONN-Power USB Device Use Case	231
Figure 4-44 DRP Timing	234
Figure 5-1 USB4 Discovery and Entry Flow Model	242
Figure 5-2 USB4 Hub with USB4 Host and Device Connection Flow Alignment	248
Figure 5-3 USB4 Hub with USB 3.2 Host and USB4 Device Host Connection Flow Model	249
Figure 5-4 USB4 Hub with USB4 Host and USB 3.2 Device Connection Flow Model	250
Figure 5-5 USB4 Hub with USB 3.2 Host and Device Connection Flow Model	251
Figure 5-6 USB4 Hub with USB4 Host and DP Alt Mode Device Connection Flow Model	252
Figure 5-7 USB4 Hub with USB 3.2 Host and DP Alt Mode Device Connection Flow Model	253
Figure 6-1 Electronically Marked Short Active Cable with SOP' Only	258
Figure 6-2 Electronically Marked Short Active Cable with SOP' and SOP"	258
Figure 6-3 Electronically Marked Optically Isolated Active Cable	259
Figure 6-4 OIAC USB PD Message Forwarding	265
Figure 6-5 OIAC Successful Data Role Swap	268
Figure 6-6 OIAC Rejected Data Role Swap	269
Figure 6-7 OIAC Wait Data Role Swap	269
Figure 6-8 OIAC Initiator Reject Data Role Swap	270
Figure 6-9 OIAC Initiator Wait Data Role Swap	271
Figure 6-10 OIAC Discovery – Phase 1	273
Figure 6-11 OIAC Reboot – Phase 2	274
Figure 6-12 OIAC Master Plug Configure as DFP – Phase 3	275
Figure 6-13 OIAC Master Plug Configure as UFP – Phase 3	276
Figure 6-14 OIAC Master Plug No Connection Possible Billboard – Phase 3	277
Figure 6-15 OIAC Master Plug State Diagram Part 1 (Phase 1 and 2)	278
Figure 6-16 OIAC Master Plug State Diagram Part 2 (Phase 3)	279
Figure 6-17 OIAC Slave Plug State Diagram	286
Figure 6-18 Active Cable Topologies	295
Figure 6-19 Illustrations of Usages for OIAC That Require an Adapter or Hub	298
Figure 6-20 SuperSpeed USB Electrical Test Points	299
Figure 6-21 SuperSpeed USB Compliance Test Setup	299
Figure A-1 Example Passive 3.5 mm to USB Type-C Adapter	306
Figure A-2 Example 3.5 mm to USB Type-C Adapter Supporting 500 mA Charge-Through	307
Figure B-1 USB Type-C Debug Accessory Layered Behavior	308
Figure B-2 DTS Plug Interface	309
Figure B-3 Connection State Diagram: DTS Source	310
Figure B-4 Connection State Diagram: DTS Sink	311
Figure B-5 Connection State Diagram: DTS DRP	312
Figure B-6 TS Sink Power Sub-States	316
Figure D-1 Active Cable Model (Single Port, Top Mount Receptacle)	332
Figure D-2 Model Architecture	332
Figure D-3 Heat Sources and Heat Flow Paths	333
Figure D-4 Vertically Stacked Horizontal Connectors 3x1 Configuration (VERT)	335
Figure D-5 Horizontally Stacked Vertical Connectors 1x3 Configuration (HZ90)	335
Figure D-6 Horizontally Stacked Horizontal Connector 1x3 Configuration (HORZ)	335
Figure D-7 USB 3.2 Single-Lane 3A Active Cable in a 3-Port Configuration	336
Figure D-8 USB 3.2 Single-Lane 5A Active Cable in a 3-Port Configuration	337
Figure D-9 Impact of Over-mold Power P_0 and Thermal Boundary Temperature T_{MB} at 3 A V_{BUS} in a Single Port Configuration	338
Figure D-10 Impact of Over-mold Power P_0 and Thermal Boundary Temperature T_{MB} at 5 A V_{BUS} in a Single Port Configuration	338

Figure D-11 USB 3.2 Active Cable Dongle Design (One End Shown).....	339
Figure D-12 USB 3.2 Dual-Lane 3A Active Cable in a 3-Port Configuration	340
Figure D-13 USB 3.2 Dual-Lane 5A Active Cable in a 3-Port Configuration	341
Figure D-14 Example: Additional Heat Spreader on Receptacle in Host or Device	342
Figure D-15 Example: Heat Sinking by Chassis of Host or Device	342
Figure E-1 Pins Available for Reconfiguration over the Full-Featured Cable.....	344
Figure E-2 Pins Available for Reconfiguration for Direct Connect Applications.....	344
Figure E-3 Alternate Mode Implementation using a USB Type-C to USB Type-C Cable	346
Figure E-4 Alternate Mode Implementation using a USB Type-C to Alternate Mode Cable or Device.....	347
Figure E-5 USB DisplayPort Dock Example.....	349
Figure F-1 TBT3 Discovery Flow	353

TABLES

Table 2-1 Summary of power supply options.....	38
Table 3-1 USB Type-C Standard Cable Assemblies.....	40
Table 3-2 USB Type-C Legacy Cable Assemblies	41
Table 3-3 USB Type-C Legacy Adapter Assemblies.....	41
Table 3-4 USB Type-C Receptacle Interface Pin Assignments.....	70
Table 3-5 USB Type-C Receptacle Interface Pin Assignments for USB 2.0-only Support.....	71
Table 3-6 USB Type-C Standard Cable Wire Assignments	73
Table 3-7 USB Type-C Cable Wire Assignments for Legacy Cables/Adapters	74
Table 3-8 Reference Wire Gauges for standard USB Type-C Cable Assemblies	75
Table 3-9 Reference Wire Gauges for USB Type-C to Legacy Cable Assemblies	75
Table 3-10 USB Full-Featured Type-C Standard Cable Assembly Wiring.....	77
Table 3-11 USB 2.0 Type-C Standard Cable Assembly Wiring.....	78
Table 3-12 USB Type-C to USB 3.1 Standard-A Cable Assembly Wiring.....	79
Table 3-13 USB Type-C to USB 2.0 Standard-A Cable Assembly Wiring.....	80
Table 3-14 USB Type-C to USB 3.1 Standard-B Cable Assembly Wiring.....	81
Table 3-15 USB Type-C to USB 2.0 Standard-B Cable Assembly Wiring.....	82
Table 3-16 USB Type-C to USB 2.0 Mini-B Cable Assembly Wiring.....	83
Table 3-17 USB Type-C to USB 3.1 Micro-B Cable Assembly Wiring	85
Table 3-18 USB Type-C to USB 2.0 Micro-B Cable Assembly Wiring	86
Table 3-19 USB Type-C to USB 3.1 Standard-A Receptacle Adapter Assembly Wiring.....	88
Table 3-20 USB Type-C to USB 2.0 Micro-B Receptacle Adapter Assembly Wiring	89
Table 3-21 Differential Insertion Loss Examples for TX/RX with Twisted Pair Construction	90
Table 3-22 Differential Insertion Loss Examples for USB TX/RX with Coaxial Construction.....	91
Table 3-23 Key Parameters in COM Configuration File.....	103
Table 3-24 Electrical Requirements for CC and SBU wires.....	104
Table 3-25 Coupling Matrix for Low Speed Signals.....	104
Table 3-26 Maximum Mutual Inductance (M) between VBUS and Low Speed Signal Lines	107
Table 3-27 USB D+/D- Signal Integrity Requirements for USB Type-C to USB Type-C Passive Cable Assemblies	109
Table 3-28 USB Type-C Mated Connector Recommended Signal Integrity Characteristics (Informative)	111
Table 3-29 USB Type-C Mated Connector Signal Integrity Characteristics for USB4 Gen3 (Normative).....	113
Table 3-30 USB D+/D- Signal Integrity Requirements for USB Type-C to Legacy USB Cable Assemblies	115
Table 3-31 Design Targets for USB Type-C to USB 3.1 Gen2 Legacy Cable Assemblies (Informative).....	115
Table 3-32 USB Type-C to USB 3.1 Gen2 Legacy Cable Assembly Signal Integrity Requirements (Normative)	116
Table 3-33 USB D+/D- Signal Integrity Requirements for USB Type-C to Legacy USB Adapter Assemblies (Normative).....	118
Table 3-34 Design Targets for USB Type-C to USB 3.1 Standard-A Adapter Assemblies (Informative).....	119

Table 3-35 USB Type-C to USB 3.1 Standard-A Receptacle Adapter Assembly Signal Integrity Requirements (Normative).....	119
Table 3-36 Current Rating Test PCB.....	124
Table 3-37 Maximum DC Resistance Requirement (Normative).....	124
Table 3-38 Force and Moment Requirements.....	127
Table 3-39 Environmental Test Conditions.....	130
Table 3-40 Reference Materials.....	131
Table 4-1 USB Type-C List of Signals.....	136
Table 4-2 VBUS Source Characteristics.....	139
Table 4-3 VBUS Sink Characteristics.....	140
Table 4-4 USB Type-C Source Port's VCONN Requirements Summary.....	141
Table 4-5 VCONN Source Characteristics.....	142
Table 4-6 Cable VCONN Sink Characteristics.....	143
Table 4-7 VCONN-Powered Accessory (VPA) Sink Characteristics.....	144
Table 4-8 VCONN-Powered USB Device (VPD) Sink Characteristics.....	145
Table 4-9 USB Type-C-based Port Interoperability.....	148
Table 4-10 Source Perspective.....	150
Table 4-11 Source (Host) and Sink (Device) Behaviors by State.....	151
Table 4-12 USB PD Swapping Port Behavior Summary.....	157
Table 4-13 Power Role Behavioral Model Summary.....	158
Table 4-14 Source Port CC Pin State.....	167
Table 4-15 Sink Port CC Pin State.....	167
Table 4-16 Mandatory and Optional States.....	192
Table 4-17 Precedence of power source usage.....	214
Table 4-18 USB Type-C Current Advertisement and PDP Equivalent.....	216
Table 4-19 Precedence of power source usage.....	219
Table 4-20 Example Charge-Through VPD Sink Maximum Currents based on VBUS Impedance and GND Impedance.....	220
Table 4-21 SOP' and SOP" Timing.....	228
Table 4-22 Charge-Through VPD CC Impedance (RccCON) Requirements.....	230
Table 4-23 CTVPD Charge-Through Port VBUS Bypass Requirements.....	230
Table 4-24 Source CC Termination (Rp) Requirements.....	231
Table 4-25 Sink CC Termination (Rd) Requirements.....	232
Table 4-26 Powered Cable Termination Requirements.....	232
Table 4-27 CC Termination Requirements for Disabled state, ErrorRecovery state, and Unpowered Source.....	232
Table 4-28 SBU Termination Requirements.....	232
Table 4-29 VBUS and VCONN Timing Parameters.....	233
Table 4-30 DRP Timing Parameters.....	234
Table 4-31 CC Timing.....	235
Table 4-32 CC Voltages on Source Side – Default USB.....	236
Table 4-33 CC Voltages on Source Side – 1.5 A @ 5 V.....	236
Table 4-34 CC Voltages on Source Side – 3.0 A @ 5 V.....	237
Table 4-35 Voltage on Sink CC Pins (Default USB Type-C Current only).....	237
Table 4-36 Voltage on Sink CC pins (Multiple Source Current Advertisements).....	237
Table 5-1 Certified Cables Where USB4-compatible Operation is Expected.....	243
Table 5-2 Fallback Mapping USB4 Peripheral Functions to USB Device Class Types.....	254
Table 5-3 USB Billboard Device Class Availability Following USB4 Device Entry Failure.....	255
Table 6-1 Comparison of Active Cables.....	257
Table 6-2 Summary of Active Cable Features.....	257
Table 6-3 OIAC USB PD Message Behavior on Initial Connection.....	260
Table 6-4 OIAC USB PD Messages Which Do Not Traverse in Active State.....	262
Table 6-5 OIAC USB PD Messages Addressed to SOP Which Traverse the OIAC in the Active State.....	264
Table 6-6 OIAC USB PD Message Timing.....	265
Table 6-7 OIAC SOP Messages Which Terminate at the Cable Plug.....	266
Table 6-8 Port and Plug Capabilities.....	270

Table 6-9	OIAC Sink_Capabilities PDO (SOP) on Initial Connection	290
Table 6-10	OIAC Sink_Capabilities_Extended PDO (SOP) on Initial Connection	291
Table 6-11	OIAC Sink RDO (SOP) on Initial Connection.....	291
Table 6-12	OIAC Active Sink RDO (SOP)	292
Table 6-13	OIAC Sink_Capabilities PDO (SOP) in Active	292
Table 6-14	Cable Temperature Requirements	293
Table 6-15	Summary of Active Cable Features	294
Table 6-16	Active Cable Power-on Requirements	296
Table 6-17	OIAC Maximum USB 3.2 U0 Delay	297
Table 6-18	Usages for OIAC That Require an Adapter or Hub	297
Table 6-19	USB 3.2 U-State Requirements.....	298
Table 6-20	Active Cable USB 3.2 Stressed Source Swing, TP1	300
Table 6-21	Active Cable USB 3.2 Stressed Source Jitter, TP1.....	300
Table 6-22	Active Cable USB 3.2 Input Swing at TP2 (Informative).....	301
Table 6-23	Active Cable USB 3.2 Output Swing at TP3 (Informative)	301
Table A-1	USB Type-C Analog Audio Pin Assignments.....	304
Table A-2	USB Type-C Analog Audio Pin Electrical Parameter Ratings.....	305
Table B-1	DTS to TS Port Interoperability.....	309
Table B-2	Rp/Rp Charging Current Values for a DTS Source.....	316
Table B-3	Mandatory and Optional States.....	318
Table D-1	Heat Sources and Heat Dissipation Example (1.5 W cable and 5 A)	334
Table D-2	USB 3.2 Active Cable Design Single Port Case Study at 35 °C Ambient and 60 °C Thermal Boundary (Single Lane)	334
Table D-3	USB 3.2 Active Cable Design Single Port Case Study at 35 °C Ambient and 60 °C Thermal Boundary (Dual Lane)	338
Table E-1	USB Safe State Electrical Requirements	347
Table E-2	USB Billboard Device Class Availability Following Alternate Mode Entry Failure.....	348
Table E-3	Alternate Mode Signal Noise Ingression Requirements.....	348
Table F-1	TBT3 Passive Cable Discover Identity VDO Responses	354
Table F-2	TBT3 Passive Cable VDO for USB PD Revision 2.0, Version 1.3	355
Table F-3	TBT3 Passive Cable VDO for USB PD Revision 3.0, Version 1.2	355
Table F-4	TBT3 Active Cable Discover Identity VDO Responses.....	356
Table F-5	TBT3 Active Cable VDO for USB PD Revision 2.0, Version 1.3.....	357
Table F-6	TBT3 Active Cable VDO 1 for USB PD Revision 3.0, Version 1.2	357
Table F-7	TBT3 Active Cable VDO 2 for USB PD Revision 3.0, Version 1.2	358
Table F-8	TBT3 Device Discover Identity VDO Responses	359
Table F-9	TBT3 Discover SVID VDO Responses.....	360
Table F-10	TBT3 Device Discover Mode VDO Responses	361
Table F-11	TBT3 Cable Discover Mode VDO Responses.....	362
Table F-12	TBT3 Cable Enter Mode Command	363
Table F-13	TBT3 Device Enter Mode Command.....	364
Table F-14	TBT3 Cable Functional Difference Summary.....	365

Specification Work Group Chairs / Specification Editors

Intel Corporation (USB 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 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

Note: For historical reasons, the following list also includes individual contributors that were members of the work group and associated with their company affiliations at the time of the original Release 1.0 and Release 2.0.

Advanced-Connectek, Inc. (ACON)	Victory Chen	Conrad Choy	Alan Tsai
	Glen Chandler	Vicky Chuang	Wayne Wang
	Dennis Cheung	Jessica Feng	Stephen Yang
	Jeff Chien	Aven Kao	Sunney Yang
	Lee (Dick Lee) Ching	Danny Liao	
Advanced Micro Devices	Steve Capezza	Jason Hawken	Joseph Scanlon
	Walter Fry	Tim Perley	Peter Teng
	Will Harris		
Allion Labs, Inc.	Howard Chang	Brian Shih	Chester Tsai
	Minoru Ohara		
Amphenol AssembleTech (Xiamen) Co., Ltd.	Louis Chan	Martin Li	Alan Yang
	Jesse Jaramillo	Lino Liu	
	Terry Ke	Shawn Wei	
Amphenol Corporation	Zhineng Fan		
Agilent Technologies, Inc.	James Choate		
Analogix Semiconductor, Inc.	Mehran Badii	Haijian Sui	Yueke Tang
	Greg Stewart		
Apple Inc. (USB Promoter company)	Colin Abraham	Zheng Gao	James Orr
	Mahmoud Amini	Derek Iwamoto	Keith Porthouse
	Sree Anantharaman	Scott Jackson	Breton Saunders
	Brian Baek	Girault Jones	Reese Schreiber
	Paul Baker	Keong Kam	Sascha Tietz
	Michael Bonham	Kevin Keeler	Jennifer Tsai
	Carlos Calderon	Min Kim	Colin Whitby-Strevens
	Jason Chung	Woopoung Kim	Jeff Wilcox
	David Conroy	Alexei Kosut	Eric Wiles
	Bill Cornelius	Christine Krause	Dan Wilson
	Christophe Daniel	Chris Ligtenberg	Dennis Yarak
	William Ferry	Matthew Mora	
	Brian Follis	Nathan Ng	
	Alex Chou	Morphy Hsieh	
Bizlink Technology, Inc.			

Cadence Design Systems, Inc.	Marcin Behrendt Huzaifa Dalal Pawel Eichler Sathish Kumar Ganesan	Dariusz Kaczmarczyk Tomasz Klimek Jie Min Asila Nahas Uyen Nguyen	Neelabh Singh Michal Staworko Fred Stivers Mark Summers Claire Ying
Canova Tech	Piergiorgio Beruto Andrea Maniero	Michael Marioli Antonio Orzelli	Paola Pilla Nicola Scantamburlo
Cirrus Logic Inc.	Sean Davis	Darren Holding	Brad Lambert
Corning Optical Communication LLC	Wojciech Giziewicz	Ian McKay	Jamie Silva
Cosemi Technologies Inc.	Samir Desai	Devang Parekh	
Cypress Semiconductor	Mark Fu Naman Jain Rushil Kadakia	Benjamin Kropf Venkat Mandagulathur Anup Nayak	Jagadeesan Raj Sanjay Sancheti Subu Sankaran
Dell	Mohammed Hijazi David Meyers Sean O'Neal	Ernesto Ramirez Siddhartha Reddy	Thomas Voor Merle Wood
Dialog Semiconductor (UK) Ltd.	Yimin Chen		
Diodes Incorporated	Kay Annamalai Justin Lee Paul Li	Bob Lo Jaya Shukla	Qun Song Ada Yip
DisplayLink (UK) Ltd.	Pete Burgers		
DJI Technology Co., Ltd.	Steve Huang		
Electronics Testing Center, Taiwan	Sophia Liu		
Elka International Ltd.	Roy Ting		
Ellisys	Abel Astley Rick Bogart	Mario Pasquali Chuck Trefts	Tim Wei
Etron Technology, Inc.	Chien-Cheng Kuo		
Feature Integration Technologies Inc.	Jacky Chan Chen Kris Yulin Lan	KungAn Lin Yuchi Tsao	Paul Yang Amanda Ying
Foxconn / Hon Hai	Patrick Casher Asroc Chen Joe Chen Allen Cheng Jason Chou Edmond Choy Fred Fons	Bob Hall Chien-Ping Kao Ji Li Ann Liu Terry Little Steve Sedio Christine Tran	Pei Tsao AJ Yang Yuan Zhang Jessica Zheng Jie Zheng Andy Yao
Foxlink/Cheng Uei Precision Industry Co., Ltd.	Robert Chen Sunny Chou Carrie Chuang Wen-Chuan Hsu Alex Hsue	Armando Lee Dennis Lee Justin Lin Robert Lu Tse Wu Ting	Steve Tsai Wen Yang Wiley Yang Junjie Yu
Fresco Logic Inc.	Bob McVay	Christopher Meyers	

Google	Alec Berg	Nithya Jagannathan	Adam Rodriguez
	Joshua Boilard	Lawrence Lam	David Schneider
	Alec Berg	Adam Langley	Stephan Schooley
	Todd Broch	Ingrid Lin	Toshak Singhal
	Jim Guerin	Richard Palatin	Ken Wu
	Jeffrey Hayashida	Vincent Palatin	
	Mark Hayter	Dylan Reid	
Granite River Labs	Yung Han Ang	Alan Chuang	Krishna Murthy
	Sandy Chang	Mike Engbretson	Johnson Tan
	Allen Chen	Caspar Lin	Chin Hun Yaep
	Swee Guan Chua		
Hewlett Packard Inc. (USB Promoter company)	Lee Atkinson	Robin Castell	Jim Mann
	Srinath Balaraman	Steve Chen	Linden McClure
	Roger Benson	Michael Krause	Mike Pescetto
	Alan Berkema	Rahul Lakdawala	Asjad Shamim
Hirose Electric Co., Ltd.	Jeremy Buan	William MacKillop	Eungsoo Shin
	William Kysiak	Gourgen Oganessyan	Sid Tono
	Sang-Muk Lim		
Hosiden Corporation	Takahisa Otsuji	Fumitake Tamaki	
I-PEX (Dai-ichi Seiko)	Alan Kinningham	Ro Richard	Tetsuya Tagawa
Infineon Technologies	Tue Fatt David Wee		
Intel Corporation (USB Promoter company)	Dave Ackelson	Ziv Kabiry	Sridharan
	Mike Bell	Vijaykumar Kadgi	Ranganathan
	Brad Berlin	Luke Johnson	Rajaram Regupathy
	Pierre Bossart	Jerzy Kolinski	Brad Saunders
	Kuan-Yu Chen	Rolf Kuhn	Ehud Shoor
	Hengju Cheng	Henrik Leegaard	Amit Srivastava
	Jhuda Dayan	Edmond Lau	Einat Suriyan
	Paul Durley	Xiang Li	Ron Swartz
	Saranya Gopal	Yun Ling	David Thompson
	Howard Heck	Guobin Liu	Karthi Vadivelu
	Hao-Han Hsu	Steve McGowan	Tsion Vidal
	Seppo Ingalsuo	Sankaran Menon	Stephanie Wallick
	Abdul (Rahman)	Chee Lim Nge	Rafal Wielicki
	Ismail	Sagar Pawar	Devon Worrell
	James Jaussi		Li Yuan
Japan Aviation Electronics Industry Ltd. (JAE)	Kenji Hagiwara	Tadashi Okubo	Masaaki Takaku
	Hiroaki Ikeda	Kazuhiro Saito	Jussi Takaneva
	Masaki Kimura	Kimiaki Saito	Tomohiko Tamada
	Toshio Masumoto	Yuichi Saito	Kentaro Toda
	Kenta Minejima	Mark Saubert	Kouhei Ueda
	Toshiyuki Moritake	Toshio Shimoyama	Takakazu Usami
	Joe Motojima	Tatsuya Shioda	Masahide Watanabe
	Ron Muir	Atsuo Tago	Youhei Yokoyama
JPC/Main Super Inc.	Sam Tseng	Ray Yang	
LeCroy Corporation	Daniel H. Jacobs	Tyler Joe	
Lenovo	Rob Bowser	Jianye Li	Howard Locker
	Tomoki Harada	Wei Liu	

LG Electronics Inc.	Do Kyun Kim		
Lintes Technology Co., Ltd.	Tammy Huang	Max Lo	JinYi Tu
	Charles Kaun	CT Pien	Jason Yang
	RD Lintes		
Lotes Co., Ltd.	Ariel Delos Reyes	Charles Kaun	John Lynch
	Ernest Han	Chi-Chang Lin	JinYi Tu
	Mark Ho	Max Lo	Jason Yang
	Regina Liu-Hwang		
LSI Corporation	Dave Thompson		
Luxshare-ICT	Josue Castillo	Alan Kinningham	Sean O'Neal
	Daniel Chen	Gorden Lin	Scott Shuey
	Lisen Chen	John Lin	James Stevens
	Sally Chiu	Stone Lin	Pat Young
	CY Hsu	Alan Liu	
Maxim Integrated Products	Forrest Christo	Sang Kim	Michael Miskho
	Ken Helfrich	Jeff Lo	Jacob Scott
MCCI Corporation	Terry Moore		
MediaTek Inc.	Alex YC Lin		
MegaChips Corporation	Alan Kobayashi	Satoru Kumashiro	
Microchip (SMSC)	Josh Averyt	Matthew Kalibat	John Sisto
	Mark Bohm	Donald Perkins	Anthony Tarascio
	Shannon Cash	Richard Petrie	Kiet Tran
	Thomas Farkas	Mohammed Rahman	Christopher Twigg
	Fernando Gonzalez	Andrew Rogers	Prasanna Vengateshan
Microsoft Corporation (USB Promoter company)	Randy Aull	Teemu Helenius	Toby Nixon
	Jim Belesiu	Dan Iatco	Rahul Ramadas
	Michelle Bergeron	Kai Inha	Srivatsan Ravindran
	Fred Bhesania	Jayson Kastens	Nathan Sherman
	Anthony Chen	Andrea Keating	Bala Sivakumar
	Philip Froese	Shoaib Khan	Timo Toivola
	Vivek Gupta	Eric Lee	David Voth
	David Hargrove	Ivan McCracken	Andrew Yang
	Robbie Harris	Arvind Murching	Panu Ylihaavisto
	Robert Hollyer	Gene Obie	
Molex LLC	Adib Al Abaji	Alan MacDougall	
Monolithic Power Systems	Di Han	Chris Sporck	
MQP Electronics Ltd.	Sten Carlsen	Pat Crowe	
NEC Corporation	Kenji Oguma		
Newnex Technology Corp.	Sam Liu	Nimrod Peled	
Nokia Corporation	Daniel Gratiot	Samuli Makinen	Timo Toivola
	Pekka Leinonen	Pekka Talmola	Panu Ylihaavisto
NXP Semiconductors	Mahmoud EL Sabbagh	Ken Jaramillo	Guru Prasad
	Dennis Ha	Vijendra Kuroodi	Krishnan TN
Oculus VR LLC	Amish Babu	Marty Evans	Joaquin Fierro
ON Semiconductor	Eduardo De Reza	Christian Klein	Michael Smith
	Oscar Freitas	Amir Lahooti	

Parade Technologies, Inc.	Jian Chen Craig Wiley	Paul Xu	Alan Yuen
Power Integrations	Shruti Anand Rahul Joshi	Aditya Kulkarni Akshay Nayaknur	Amruta Patra
Qualcomm, Inc.	Lior Amarilio Aris Balatsos Tomer Ben Chen Richard Burrows Amit Gil James Goel Amit Gupta	Philip Hardy Will Kun Jonathan Luty Lalan Mishra George Paparrizos Vatsal Patel	Jack Pham Vamsi Samavedam Matthew Sienko Dmitrii Vasilchenko Joshua Warner Chris Wiesner
Realtek Semiconductor Corp.	Marco Chiu Tsung-Peng Chuang Charlie Hsu Fan-Hau Hsu	Ty Kingsmore Ray Lee Jay Lin Ryan Lin	Terry Lin Chuting Su Changhung Wu
Renesas Electronics Corp. (USB Promoter company)	Kai Bao Bob Dunstan Nobuo Furuya	Philip Leung Kiichi Muto Ziba Nami	Hajime Nozaki Yosuke Sasaki Toshifumi Yamaoka
Richtek Technology Corp.	Roger Lo		
Rohm Co., Ltd.	Mark Aaldering Kris Bahar Ruben Balbuena Nobutaka Itakura	Yusuke Kondo Arun Kumar Chris Lin Kazuomi Nagai	Yoshinori Ohwaki Takashi Sato Hiroshi Yoshimura
Samsung Electronics Co., Ltd.	Jaedeok Cha KangSeok Cho Woojin Choi Yeongbok Choi Cheolyoon Chung JaeRyong Han Jaehyeok Jang Wonseok Jang	Sangju Kim Soondo Kim Woonki Kim Jagoun Koo Termi Kwon Cheolho Lee Edward Lee	Jun Bum Lee Jinyoung Oh Chahoon Park Chulwoo Park Youngjin Park Jung Waneui Sunggeun Yoon
Seagate	Alvin Cox Emmanuel Lemay	Tony Priborsky Tom Skaar	Dan Smith
Shenzhen Deren Electronic Co., Ltd.	Smarm (Zhudong) Huo Wen Fa Lei	Yang Lirong	Lucy Zhang
Silicon Line GmbH	Ian Jackson		
SiliConch Systems Private Limited	Jaswanth Ammineni Pavitra Balasubramanian Kaustubh Kumar Aniket Mathad	Shubham Paliwal Jinisha Patel Vinay Patel Rakesh Polasa	Vishnu Pusuluri Abhishek Sardeshpande Satish Anand Verkila
Simula Technology Inc.	John Chang Voss Cheng Thomas Li	Jung Lin Jyunming Lin Doris Liu	CK Wang Alice Yu
Softnautics LLP	Bhaves Desai Hetali Jariwala	Dipakkumar Modi Ishita Shah	Ujjwal Talati
Sony Corporation	Shinichi Hirata	Shigenori Tagami	
Spectra7 Microsystems Corp.	Andrew Kim	James McGrath	John Mitchell
Specwerkz	Amanda Hosler	Diane Lenox	

STMicroelectronics (USB Promoter company)	Jerome Bach Nathalie Ballot Filippo Bonaccorso Christophe Cochard Nicolas Florenchie Cedric Force	Gregory Cosciniak Chekib Hammami Joel Huloux Christophe Lorin Patrizia Milazzo Federico Musarra	Pascal Legrand Richard O'Connor Massimo Panzica Legrand Pascal Nicolas Perrin
Sumitomo Electric Ind., Ltd.	Takeshi Inoue Yasuhiro Maeda	Wataru Sakurai Sainer Siagian	Masaki Suzuki Mitsuaki Tamura
Synaptics Inc.	Daniel Bogard	Jeff Lukanc	Prashant Shamarao
Synopsys, Inc.	Subramaniam Aravindhan	Morten Christiansen Nivin George	Satya Patnala
Tektronix, Inc.	Randy White		
Texas Instruments (USB Promoter company)	Jawaid Ahmad Mike Campbell Greg Collins Gary Cooper GP Gopalakrishnan Craig Greenberg Richard Hubbard Nate Johnson Michael Koltun IV Yoon Lee Grant Ley	Win Maung Shafiuddin Mohammed Lauren Moore Brian Parten Martin Patoka Jason Peck John Perry Louis Peryea Brian Quach	Sai Karthik Rajaraman Wes Ray Dafydd Roche Anwar Sadat Cory Stewart Sue Vining Bill Waters Deric Waters Gregory Watkins Roy Wojciechowski
Total Phase	Chris Yokum		
Tyco Electronics Corp. (TE Connectivity Ltd.)	Max Chao Robert E. Cid Calvin Feng Kengo Ijio Eiji Ikematsu Joan Leu Clark Li	Mike Lockyer Jeff Mason Takeshi Nakashima Luis A. Navarro Masako Saito Yoshiaki Sakuma Gavin Shih	Hiroshi Shirai Hidenori Taguchi Nathan Tracy Bernard Vetten Ryan Yu Noah Zhang Sjoerd Zwartkruis
UL LLC	Michael Hu		
Varjo Technologies	Kai Inha		
Ventev Mobile	Brad Cox	Colin Vose	
VIA Technologies Inc.	Terrance Shih	Jay Tseng	Fong-Jim Wang
Weltrend Semiconductor	Hung Chiang Jeng Cheng	Wayne Lo Ho Wen Tsai	Eric Wu
Xiaomi Communications Co., Ltd.	Xiaoxing Yang	Juejia Zhou	

Pre-Release Draft Industry Reviewing Companies That Provided Feedback

Aces	JST Mfg. Co., Ltd.	Pericom
Fairchild Semiconductor	Korea Electric Terminal	Semtech Corporation
Fujitsu Ltd.	Marvell Semiconductor	Silicon Image
Industrial Technology Research Institute (ITRI)	Motorola Mobility LLC PalCONN/PalNova (Palpilot International Corp.)	SMK Corporation Toshiba Corporation

Joinsoon Electronics Mfg. Co.
Ltd.

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.
1.4	March 29, 2019	Reprint release including incorporation of all approved ECNs as of the revision date plus editorial clean-up.
2.0	August 2019	New release primarily for enabling USB4 over USB Type-C connectors and cables. Also includes 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 3.2](#), [USB4™](#) and [USB Power Delivery](#) specifications. It addresses only the elements required to implement and support the USB Type-C receptacles, plugs and cables.

Normative information is provided to allow interoperability of components designed to this specification. Informative information, when provided, may illustrate possible design implementations.

1.3 Related Documents

- USB 2.0** *Universal Serial Bus Revision 2.0 Specification*
This includes the entire document release package.
- USB 3.2** *Universal Serial Bus Revision 3.2 Specification*
This includes the entire document release package.
USB 3.1 Legacy Cable and Connector Specification, Revision 1.0
- USB4** *USB4™ Specification, Version 1.0, August 2019*
(including posted errata and ECNs)
- TBT3** Chapter 13 of *USB4 Specification, Version 1.0, August 2019*
- USB PD** *USB Power Delivery Specification, Revision 2.0, Version 1.3, January 12, 2017*
USB Power Delivery Specification, Revision 3.0, Version 2.0, August 2019
(including posted errata and ECNs)
- USB BB** *USB Billboard Device Class Specification, Revision 1.21, September 8, 2016*
- USB BC** *Battery Charging Specification, Revision 1.2 (including errata and ECNs through March 15, 2012), March 15, 2012*
- DP AM** *DisplayPort™ Alt Mode on USB Type-C Standard, Version 1.0b, 03 November 2017*

All USB-specific documents are available for download at <http://www.usb.org/documents>. The DisplayPort Alt Mode specification is available from VESA (<http://www.vesa.org>).

1.4 Conventions

1.4.1 Precedence

If there is a conflict between text, figures, and tables, the precedence shall be tables, figures, and then text.

1.4.2 Keywords

The following keywords differentiate between the levels of requirements and options.

1.4.2.1 Informative

Informative is a keyword that describes information with this specification that intends to discuss and clarify requirements and features as opposed to mandating them.

1.4.2.2 May

May is a keyword that indicates a choice with no implied preference.

1.4.2.3 N/A

N/A is a keyword that indicates that a field or value is not applicable and has no defined value and shall not be checked or used by the recipient.

1.4.2.4 Normative

Normative is a keyword that describes features that are mandated by this specification.

1.4.2.5 Optional

Optional is a keyword that describes features not mandated by this specification. However, if an optional feature is implemented, the feature shall be implemented as defined by this specification (optional normative).

1.4.2.6 Reserved

Reserved is a keyword indicating reserved bits, bytes, words, fields, and code values that are set-aside for future standardization. Their use and interpretation may be specified by future extensions to this specification and, unless otherwise stated, shall not be utilized or adapted by vendor implementation. A reserved bit, byte, word, or field shall be set to zero by the sender and shall be ignored by the receiver. Reserved field values shall not be sent by the sender and, if received, shall be ignored by the receiver.

1.4.2.7 Shall

Shall is a keyword indicating a mandatory (normative) requirement. Designers are mandated to implement all such requirements to ensure interoperability with other compliant Devices.

1.4.2.8 Should

Should is a keyword indicating flexibility of choice with a preferred alternative. Equivalent to the phrase “it is recommended that”.

1.4.3 Numbering

Numbers that are immediately followed by a lowercase “b” (e.g., 01b) are binary values. Numbers that are immediately followed by an uppercase “B” are byte values. Numbers that are immediately followed by a lowercase “h” (e.g., 3Ah) are hexadecimal values. Numbers not immediately followed by either a “b”, “B”, or “h” are decimal values.

1.5 Terms and Abbreviations

Term	Description
Accessory Mode	A reconfiguration of the connector based on the presence of Rd/Rd or Ra/Ra on CC1/CC2, respectively.
Active cable	Active cables are USB 3.2 Full-Featured Type-C Cables that incorporate repeaters in the USB 3.2 data path. All active cables, regardless of length, are expected to comply with this specification, the USB 3.2 Appendix E, and the USB 3.2 active cable CTS. Active cables may incorporate repeaters in both ends of the cable, one end, or anywhere in the cable.
Alternate Mode	Operation defined by a vendor or standards organization that is associated with a SVID assigned by the USB-IF. Entry and exit into and from an Alternate Mode is controlled by the USB PD Structured VDM Enter Mode and Exit Mode commands.
Alternate Mode Adapter (AMA)	A USB PD Device which supports Alternate Modes and acts as a UFP.
Audio Adapter Accessory Mode	The Accessory Mode defined by the presence of Ra/Ra on CC1/CC2, respectively. See Appendix A .
BMC	Biphase Mark Coding used for USB PD communication over the CC wire.
Cable Port Partner	The USB Type-C DRP, Source, or Sink connected to the cable plug.
Captive cable	A cable that is terminated on one end with a USB Type-C plug and has a vendor-specific connect means (hardwired or custom detachable) on the opposite end.

Term	Description
CC	Configuration Channel (CC) used in the discovery, configuration and management of connections across a USB Type-C cable.
Charge-Through VPD (CTVPD)	A VCONN-Powered USB Device that has the mechanism to pass power and CC communication from one port to the other without any reregulation.
Configuration Lane	The USB 3.2 Configuration Lane is used to establish and manage dual-lane SuperSpeed USB operation. The Configuration Lane is specifically the SuperSpeed USB TX1/RX1 differential signal set in the cable/plug.
Debug Accessory Mode (DAM)	The Accessory Mode defined by the presence of Rd/Rd or Rp/Rp on CC1/CC2, respectively. See Appendix B .
Debug and Test System (DTS)	The combined hardware and software system that provides a system developer debug visibility and control when connected to a Target System in Debug Accessory Mode.
Default VBUS	VBUS voltage as defined by the USB 2.0 and USB 3.2 specifications. Note: where used, 5 V connotes the same meaning.
DFP	Downstream Facing Port, specifically associated with the flow of data in a USB connection. Typically the ports on a host or the ports on a hub to which devices are connected. In its initial state, the DFP sources VBUS and VCONN, and supports data. A charge-only DFP port only sources VBUS.
Direct connect device	A device with either a captive cable or just a USB Type-C plug (e.g., thumb drive).
DRD (Dual-Role-Data)	The acronym used in this specification to refer to a USB port that can operate as either a DFP (Host) or UFP (Device). The role that the port initially takes is determined by the port's power role at attach. A Source port takes on the data role of a DFP and a Sink port takes on the data role of a UFP. The port's data role may be changed dynamically using USB PD Data Role Swap.
DRP (Dual-Role-Power)	The acronym used in this specification to refer to a USB port that can operate as either a Source or a Sink. The role that the port offers may be fixed to either a Source or Sink or may alternate between the two port states. Initially when operating as a Source, the port will also take on the data role of a DFP and when operating as a Sink, the port will also take on the data role of a UFP. The port's power role may be changed dynamically using USB PD Power Role Swap.
DR_Swap	USB PD Data Role Swap.
Dual-lane (x2)	USB 3.2 dual-lane operation is defined as simultaneously signaling on both sets of SuperSpeed USB transmit and receive differential pairs (TX1/RX1 and TX2/RX2 in the cable/plug).
Electronically Marked Cable	A USB Type-C cable that uses USB PD to provide the cable's characteristics.
eMarker	The element in an Electronically Marked Cable that returns information about the cable in response to a USB PD Discover Identity command.

Term	Description
Initiator	The port initiating a Vendor Defined Message. It is independent of the port's PD role (e.g., Provider, Consumer, Provider/Consumer, or Consumer/Provider). In most cases, the Initiator will be a host.
Internal Temperature	In reference to an active cable, the temperature measured inside a plug. It is not the skin temperature. There is a relationship between the plug's internal temperature and the skin temperature, but that relationship is design dependent.
Local Plug	The cable plug being referred to.
Optically Isolated Active Cable (OIAC)	A cable with a USB Type-C Plug on each end with one Cable Plug supporting SOP' and the other supporting SOP". This cable is electrically isolated between the two plugs.
Passive cable	A cable that does not incorporate any electronics to condition the data path signals. A passive cable may or may not be electronically marked.
Port Partner	Refers to the port (device or host) a port is attached to.
Power Bank	A device with a battery whose primary function is to charge or otherwise extend the runtime of other USB Type-C devices.
Power Sinking Devices (PSD)	Sink which draws power but has no other USB or Alternate Mode communication function, e.g. a USB-powered light.
Powered cable	A cable with electronics in the plug that requires VCONN indicated by the presence of Ra between the VCONN pin and ground.
PR_Swap	USB PD Power Role Swap.
Re-driver	Re-driver refers to an analog component that operates on the signal without re-timing it. This may include equalization, amplification, and transmitter. The re-driver does not include a clock-data recovery (CDR) circuit. Re-drivers are beyond the scope of this document.
Remote Plug	A remote cable plug in the context of OIAC plugs is the plug at the other end of the Optically Isolated Active Cable.
Repeater	Repeater refers to any active component that acts on a signal in order to increase the physical lengths and/or interconnect loss over which the signal can be transmitted successfully. The category of repeaters includes both re-timers and re-drivers.
Responder	The port responding to the Initiator of a Vendor Defined Message (VDM). It is independent of the port's PD role (e.g., Provider, Consumer, Provider/Consumer, or Consumer/Provider). In most cases, the Responder will be a device.
Re-timer	Re-timer refers to a component that contains a clock-data recovery (CDR) circuit that "retimes" the signal. The re-timer latches the signal into a synchronous memory element before re-transmitting it. It is used to extend the physical length of the system without accumulating high frequency jitter by creating separate clock domains on either side of the re-timer. Re-timers are defined in USB 3.2 Appendix E and USB4 .

Term	Description
SBU	Sideband Use.
Short Active Cable (SAC)	A cable with a USB Type-C Plug on each end at least one of which is a Cable Plug supporting SOP'. Cable length up to 5 meters.
SID	A Standard ID (SID) is a unique 16-bit value assigned by the USB-IF to identify an industry standard.
Single-lane (x1)	USB 3.2 single-lane operation is defined as signaling on only one set of SuperSpeed USB transmit and receive differential pairs (TX1/RX1 in the cable/plug).
Sink	Port asserting Rd on CC and when attached is consuming power from VBUS; most commonly a Device.
Skin Temperature	In reference to an active cable, the temperature of a plug's over-mold.
Source	Port asserting Rp on CC and when attached is providing power over VBUS; most commonly a Host or Hub DFP.
SVID	General reference to either a SID or a VID. Used by USB PD Structured VDMs when requesting SIDs and VIDs from a device.
Target System (TS)	The system being debugged in Debug Accessory Mode.
Type-A	A general reference to all versions of USB "A" plugs and receptacles.
Type-B	A general reference to all versions of USB "B" plugs and receptacles.
Type-C Plug	A USB plug conforming to the mechanical and electrical requirements in this specification.
Type-C Port	The USB port associated to a USB Type-C receptacle. This includes the USB signaling, CC logic, multiplexers and other associated logic.
Type-C Receptacle	A USB receptacle conforming to the mechanical and electrical requirements of this specification.
UFP	Upstream Facing Port, specifically associated with the flow of data in a USB connection. The port on a device or a hub that connects to a host or the DFP of a hub. In its initial state, the UFP sinks VBUS and supports data.
USB 2.0 Type-C Cable	A USB Type-C to Type-C cable that only supports USB 2.0 data operation. This cable does not include USB 3.2 or SBU wires.
USB 2.0 Type-C Plug	A USB Type-C plug specifically designed to implement the USB 2.0 Type-C cable.
USB Full-Featured Type-C Cable	A USB Type-C to Type-C cable that supports USB 2.0 , USB 3.2 and USB4 data operation. This cable includes SBU wires and is an Electronically Marked Cable.
USB Full-Featured Type-C Plug	A USB Type-C plug specifically designed to implement the USB Full-Featured Type-C cable.
USB4 Hub	A USB4 hub product is used for USB port expansion, includes only USB upstream and downstream ports, and does not include any additional capability that exposes other connector types or functions except as defined in Section 5.2.3 (Alternate Modes).

Term	Description
USB4-based Dock	A USB4-based dock product combines a USB4 hub (including at least one exposed USB Type-C downstream port) with additional capabilities that either exposes other connector types and/or includes other user-visible functions, e.g. storage, networking, etc. Examples of functions that are not considered user-visible include firmware update and device authentication.
USB Safe State	The USB Safe State as defined by the USB PD specification.
VCONN-Powered Accessory (VPA)	An accessory that is powered from VCONN to operate in an Alternate Mode . VPAs cannot implement the charge-through mechanism described for VPDs, and instead must intermediate by negotiating USB Power Delivery with both the connected host and source in order to enable similar functionality.
VCONN-Powered USB Device (VPD)	A USB direct-connect or captive-cable device that can be powered solely from either VCONN or VBUS. VPDs may optionally support the VPD charge-through capability.
VCONN_Swap	USB PD VCONN Swap.
VDM	Vendor Defined Message as defined by the USB PD specification.
VID	A Vendor ID (VID) is a unique 16-bit value assigned by the USB-IF to identify a vendor.
vSafe0V	VBUS “0 volts” as defined by the USB PD specification.
vSafe5V	VBUS “5 volts” as defined by the USB PD specification.
x1	See Single-lane.
x2	See Dual-lane.

2 Overview

2.1 Introduction

The USB Type-C® receptacle, plug and cable provide a smaller, thinner and more robust alternative to legacy USB interconnect (Standard and Micro USB cables and connectors). This solution targets use in very thin platforms, ranging from ultra-thin notebook PCs down to smart phones where existing Standard-A and Micro-AB receptacles are deemed too large, difficult to use, or inadequately robust. Some key specific enhancements include:

- The USB Type-C receptacle may be used in very thin platforms as its total system height for the mounted receptacle is under 3 mm
- The USB Type-C plug enhances ease of use by being plug-able in either upside-up or upside-down directions
- The USB Type-C cable enhances ease of use by being plug-able in either direction between host and devices

While the USB Type-C interconnect no longer physically differentiates plugs on a cable by being an A-type or B-type, the USB interface still maintains such a host-to-device logical relationship. Determination of this host-to-device relationship is accomplished through a [Configuration Channel](#) (CC) that is connected through the cable. In addition, the [Configuration Channel](#) is used to set up and manage power and Alternate/Accessory Modes.

Using the [Configuration Channel](#), the USB Type-C interconnect defines a simplified 5 volt VBUS-based power delivery and charging solution that supplements what is already defined in the [USB 3.2 Specification](#). More advanced power delivery and battery charging features over the USB Type-C interconnect are based on the [USB Power Delivery Specification](#). As a product implementation improvement, the USB Type-C interconnect shifts the [USB PD](#) communication protocol from being communicated over VBUS to being delivered across the USB Type-C [Configuration Channel](#).

The USB Type-C receptacle, plug and cable designs are intended to support future USB functional extensions. As such, consideration was given to frequency scaling performance, pin-out arrangement and the configuration mechanisms when developing this solution. The definition of future USB functional extensions is not in the scope of this specification but rather will be provided in future releases of the base USB Specification, i.e., beyond the existing [USB4™ Specification](#).

Figure 2-1 illustrates the comprehensive functional signal plan for the USB Full-Featured Type-C receptacle, not all signals shown are required in all platforms or devices. As shown, the receptacle signal list functionally delivers both [USB 2.0](#) (D+ and D-) and either [USB 3.2](#) or [USB4](#) (TX and RX pairs) data buses, USB power (VBUS) and ground (GND), [Configuration Channel](#) signals (CC1 and CC2), and two Sideband Use (SBU) signal pins. Multiple sets of USB data bus signal locations in this layout facilitate being able to functionally map the USB signals independent of plug orientation in the receptacle. For reference, the signal pins are labeled. For the [USB 2.0](#) Type-C receptacle, neither the [USB 3.2](#) nor [USB4](#) signals are implemented.

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

A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
GND	TX1+	TX1-	VBUS	CC1	D+	D-	SBU1	VBUS	RX2-	RX2+	GND
GND	RX1+	RX1-	VBUS	SBU2	D-	D+	CC2	VBUS	TX2-	TX2+	GND
B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1

Figure 2-2 illustrates the comprehensive functional signal plan for the USB Type-C plug. Only one CC pin is connected through the cable to establish signal orientation and the other CC pin is repurposed as VCONN for powering electronics in the USB Type-C plug. Also, only one set of [USB 2.0](#) D+/D- wires are implemented in a USB Type-C cable. For USB Type-C cables that only intend to support [USB 2.0](#) functionality, the TX/RX and SBU signals are not implemented. For the USB Type-C Power-Only plug (intended only for USB Type-C Sink applications), only nine contacts are implemented to support CC, VBUS, and GND.

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

A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1
GND	RX2+	RX2-	VBUS	SBU1	D-	D+	CC	VBUS	TX1-	TX1+	GND
GND	TX2+	TX2-	VBUS	VCONN			SBU2	VBUS	RX1-	RX1+	GND
B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12

2.2 USB Type-C Receptacles, Plugs and Cables

Cables and connectors, including USB Type-C to USB legacy cables and adapters, are explicitly defined within this specification. These are the only connectors and cables that are authorized by the licensing terms of this specification. All licensed cables and connectors are required to comply with the compliance and certification requirements that are developed and maintained by the [USB-IF](#).

The following USB Type-C receptacles and plugs are defined.

- USB Full-Featured Type-C receptacle for [USB 2.0](#), [USB 3.2](#), [USB4](#) and full-featured platforms and devices
- [USB 2.0](#) Type-C receptacle for [USB 2.0](#) platforms and devices
- USB Full-Featured Type-C plug
- [USB 2.0](#) Type-C plug
- USB Type-C Power-Only plug

The following USB Type-C cables are defined.

- USB Full-Featured Type-C cable with a USB Full-Featured Type-C plug at both ends for [USB 3.2](#), [USB4](#) and full-featured applications
- [USB 2.0](#) Type-C cable with a [USB 2.0](#) Type-C plug at both ends for [USB 2.0](#) applications
- Captive cable with either a USB Full-Featured Type-C plug or [USB 2.0](#) Type-C plug at one end
- Active cables as defined in [Chapter 6](#)

All of the defined USB Type-C receptacles, plugs and cables (except OIAC) support USB charging applications, including support for the optional USB Type-C-specific implementation of the [USB Power Delivery Specification](#) (See Section 4.6.2.4).

All USB Full-Featured Type-C cables are electronically marked. [USB 2.0](#) Type-C cables may be electronically marked. See Section 4.9 for the requirements of [Electronically Marked Cables](#).

The following USB Type-C to USB legacy cables and adapters are defined.

- [USB 3.2](#) Type-C to Legacy Host cable with a USB Full-Featured Type-C plug at one end and a [USB 3.1](#) Standard-A plug at the other end – *this cable supports use of a USB Type-C-based device with a legacy USB host*
- [USB 2.0](#) Type-C to Legacy Host cable with a [USB 2.0](#) Type-C plug at one end and a [USB 2.0](#) Standard-A plug at the other end – *this cable supports use of a USB Type-C-based device with a legacy [USB 2.0](#) host (primarily for mobile charging and sync applications)*
- [USB 3.2](#) Type-C to Legacy Device cable with a USB Full-Featured Type-C plug at one end and a [USB 3.1](#) Standard-B plug at the other end – *this cable supports use of legacy [USB 3.1](#) hubs and devices with a USB Type-C-based host*
- [USB 2.0](#) Type-C to Legacy Device cable with a [USB 2.0](#) Type-C plug at one end and a [USB 2.0](#) Standard-B plug at the other end – *this cable supports use of legacy [USB 2.0](#) hubs and devices with a USB Type-C-based host*
- [USB 2.0](#) Type-C to Legacy Mini Device cable with a [USB 2.0](#) Type-C plug at one end and a [USB 2.0](#) Mini-B plug at the other end – *this cable supports use of legacy devices with a [USB 2.0](#) Type-C-based host*
- [USB 3.2](#) Type-C to Legacy Micro Device cable with a USB Full-Featured Type-C plug at one end and a [USB 3.1](#) Micro-B plug at the other end – *this cable supports use of legacy [USB 3.1](#) hubs and devices with a USB Type-C-based host*
- [USB 2.0](#) Type-C to Legacy Micro Device cable with a [USB 2.0](#) Type-C plug at one end and a [USB 2.0](#) Micro-B plug at the other end – *this cable supports use of legacy [USB 2.0](#) hubs and devices with a USB Type-C-based host*
- [USB 3.2](#) Type-C to Legacy Standard-A adapter with a USB Full-Featured Type-C plug at one end and a [USB 3.1](#) Standard-A receptacle at the other end – *this adapter supports use of a legacy USB “thumb drive” style device or a legacy USB ThinCard device with a [USB 3.2](#) Type-C-based host*
- [USB 2.0](#) Type-C to Legacy Micro-B adapter with a [USB 2.0](#) Type-C plug at one end and a [USB 2.0](#) Micro-B receptacle at the other end – *this adapter supports charging a USB Type-C-based mobile device using a legacy USB Micro-B-based chargers, either captive cable-based or used in conjunction with a legacy [USB 2.0](#) Standard-A to Micro-B cable*

USB Type-C receptacle to USB legacy adapters are explicitly not defined or allowed. Such adapters would allow many invalid and potentially unsafe cable connections to be constructed by users.

2.3 Configuration Process

The USB Type-C receptacle, plug and cable solution incorporates a configuration process to detect a downstream facing port to upstream facing port (Source-to-Sink) connection for VBUS management and host-to-device connected relationship determination.

The USB Type-C port configuration process is used for the following:

- Source-to-Sink attach/detach detection
- Plug orientation/cable twist detection
- Initial power (Source-to-Sink) detection and establishing the data (Host-to-Device) relationship
- Detect if cable requires VCONN
- USB Type-C VBUS current detection and usage
- [USB PD](#) communication
- Discovery and configuration of functional extensions

Two pins on the USB Type-C receptacle, CC1 and CC2, are used for this purpose. Within a standard USB Type-C cable, only a single CC pin position within each plug of the cable is connected through the cable.

2.3.1 Source-to-Sink Attach/Detach Detection

Initially, Source-to-Sink attach is detected by a host or hub port (Source) when one of the CC pins at its USB Type-C receptacle senses a specified resistance to GND. Subsequently, Source-to-Sink detach is detected when the CC pin that was terminated at its USB Type-C receptacle is no longer terminated to GND.

Power is not applied to the USB Type-C host or hub receptacle (VBUS or VCONN) until the Source detects the presence of an attached device (Sink) port. When a Source-to-Sink attach is detected, the Source is expected to enable power to the receptacle and proceed to normal USB operation with the attached device. When a Source-to-Sink detach is detected, the port sourcing VBUS removes power.

2.3.2 Plug Orientation/Cable Twist Detection

The USB Type-C plug can be inserted into a receptacle in either one of two orientations, therefore the CC pins enable a method for detecting plug orientation in order to determine the lane ordering of the SuperSpeed USB data signal pairs functionally connected through the cable and identify the Configuration Lane for dual-lane operation when supported. This allows for signal routing, if needed, within a host or device to be established for a successful connection.

2.3.3 Initial Power (Source-to-Sink) Detection and Establishing the Data (Host-to-Device) Relationship

Unlike existing USB Type-A and USB Type-B receptacles and plugs, the mechanical characteristics of the USB Type-C receptacle and plug do not inherently establish the relationship of USB host and device ports. The CC pins on the receptacle also serve to establish an initial power (Source-to-Sink) and data (Host-to-Device) relationships prior to the normal USB enumeration process.

For the purpose of defining how the CC pins are used to establish the initial power relationship, the following port power behavior modes are defined.

1. Source-only – for this mode, the port exclusively behaves as a Source
2. Sink-only – for this mode, the port exclusively behaves as a Sink
3. Dual-Role-Power (DRP) – for this mode, the port can behave either as a Source or Sink

Additionally, when a port supports USB data operation, a port's data behavior modes are defined.

1. DFP-only – for this mode, the port exclusively behaves as a DFP
2. UFP-only – for this mode, the port exclusively behaves as a UFP
3. Dual-Role-Data (DRD) – for this mode, the port can behave either as a DFP or UFP

The DFP-only and UFP-only ports behaviorally map to traditional USB host ports and USB device ports, respectively but may not necessarily do USB data communication. When a host-only port is attached to a device-only port, the behavior from the user's perspective follows the traditional USB host-to-device port model. However, the USB Type-C connector solution does not physically prevent host-to-host or device-to-device connections. In this case, the resulting host-to-host or device-to-device connection results in a safe but non-functional situation.

Once initially established, the Source supplies VBUS and behaves as a DFP, and the Sink consumes VBUS and behaves as a UFP. [USB PD](#), when supported by both ports, may then be used to independently swap both the power and data roles of the ports.

A port that supports dual-role operation by being able to shift to the appropriate connected mode when attached to either a Source-only or Sink-only port is a DRP. In the special case of a DRP being attached to another DRP, an initialization protocol across the CC pins is used to establish the initial host-to-device relationship. Given no role-swapping intervention, the determination of which is DFP or UFP is random from the user's perspective.

Two independent set of mechanisms are defined to allow a USB Type-C DRP to functionally swap power and data roles. When [USB PD](#) is supported, power and data role swapping is performed as a subsequent step following the initial connection process. For non-PD implementations, power/data role swapping can optionally be dealt with as part of the initial connection process. To improve the user's experience when connecting devices that are of categorically different types, products may be implemented to strongly prefer being a DFP or a UFP, such that the DFP/UFP determination becomes predictable when connecting two DRPs of differing categories. See Section 4.5.1.4 for more on available swapping mechanisms.

As an alternative to role swapping, a USB Type-C DRP may provide useful functionality by when operating as a host, exposing a CDC/network (preferably TCP/IP) stack or when operating as a device, exposing a CDC/network interface.

USB hubs have two types of ports, a UFP that is connected to a DFP (host or another hub) that initially functions as a Sink, and one or more DFPs for connecting other devices that initially function as Sources.

2.3.4 USB Type-C Vbus Current Detection and Usage

With the USB Type-C connector solution, a Source (host or downstream hub port) may implement higher source current over VBUS to enable faster charging of mobile devices or higher-power devices. All USB host and hub ports advertise via the CC pins the level of current that is presently available. The USB device port is required to manage its load to stay within the current level offered by the host or hub, including dynamically scaling back the load if the host or hub port changes its advertisement to a lower level as indicated over the CC pins.

Three current level advertisements at 5V VBUS are defined by [USB Type-C Current](#):

- Default is the as-configured for high-power operation current value as defined by a USB Specification (500 mA for USB 2.0 ports; 900 mA or 1,500 mA for USB 3.2 ports operating in single-lane or dual-lane, respectively)
- USB Type-C Current @ 1.5 A
- USB Type-C Current @ 3.0 A

There is a clear functional distinction between advertising Default versus the USB Type-C Current at either 1.5 A or 3.0 A.

- Default is intended for host operation in providing bus power to a connected device where the host manages the device's current consumption for the low-power, high-power and suspend states as defined in the USB base specifications.
- USB Type-C Current at either 1.5 A or 3.0 A is primarily intended for charging applications. The Sink can vary its current draw up to the advertised limit. Offering USB Type-C Current at either 1.5 A or 3.0 A is allowed for a host providing bus power to a device. The host needs to assume that the device will continuously draw up to the offered limit.

The higher [USB Type-C Current](#) levels that can be advertised allows hosts and devices that do not implement [USB PD](#) to take advantage of higher charging current.

2.3.5 USB PD Communication

[USB Power Delivery](#) is a feature on products (hosts, hubs and devices). [USB PD](#) communications is used to:

- Establish power contracts that allow voltage and current beyond existing USB data bus specifications.
- Change the port sourcing VBUS.
- Change the port sourcing VCONN.
- Swap DFP and UFP roles.
- Communicate with cables.

The [USB PD](#) Bi-phase Mark Coded (BMC) communications are carried on the CC wire of the USB Type-C cable.

2.3.6 Functional Extensions

Functional extensions (see Chapter E) are enabled via a communications channel across CC using methods defined by the [USB Power Delivery Specification](#).

2.4 VBUS

VBUS provides a path to deliver power between a host and a device, and between a USB power charger and a host/device. A simplified high-current supply capability is defined for hosts and chargers that optionally support current levels beyond the [USB 2.0](#), [USB 3.2](#), and [USB4](#) specifications. The [USB Power Delivery Specification](#) is supported.

Table 2-1 summarizes the power supply options available from the perspective of a device with the USB Type-C connector. Not all options will be available to the device from all host or hub ports – only the first two listed options are mandated by the base USB specifications and form the basis of [USB Type-C Current](#) at the Default USB Power level.

Table 2-1 Summary of power supply options

Mode of Operation	Voltage	Current	Notes
USB 2.0	5 V	See USB 2.0	
USB 3.2	5 V	See USB 3.2	
USB4	5 V	1.5 A	See Section 5.3.
USB BC 1.2	5 V	1.5 A ¹	Legacy charging
USB Type-C Current @ 1.5 A	5 V	1.5 A	Supports higher power devices
USB Type-C Current @ 3.0 A	5 V	3 A	Supports higher power devices
USB PD	Configurable up to 20 V	Configurable up to 5 A	Directional control and power level management

Notes:

1. Whereas [USB BC 1.2](#) specification permits a power provider to be designed to support a level of power between 0.5 A and 1.5 A, the USB Type-C specification requires that a Source port that supports [USB BC 1.2](#) be at a minimum capable of supplying 1.5 A and advertise USB Type-C Current @ 1.5 A in addition to supporting the [USB BC 1.2](#) power provider termination.

The USB Type-C receptacle is specified for current capability of 5 A whereas standard USB Type-C cable assemblies are rated for 3 A. The higher rating of the receptacle enables systems to deliver more power over directly attached docking solutions or using appropriately designed chargers with

captive cables when implementing [USB PD](#). Also, USB Type-C cable assemblies designed for [USB PD](#) and appropriately identified via electronic marking are allowed to support up to 5 A.

2.5 VCONN

Once the connection between host and device is established, the CC pin (CC1 or CC2) in the receptacle that is not connected via the CC wire through the standard cable is repurposed to source VCONN to power circuits in the plug needed to implement [Electronically Marked Cables](#) (see Section 4.9), [VCONN-Powered Accessories](#) and [VCONN-Powered USB Devices](#). Initially, the source supplies VCONN and the source of VCONN may be swapped using [USB PD](#) VCONN_Swap.

Electronically marked cables may use VBUS instead of VCONN as VBUS is available across the cable. VCONN functionally differs from VBUS in that it is isolated from the other end of the cable. VCONN is independent of VBUS and, unlike VBUS which can use [USB PD](#) to support higher voltages, VCONN voltage stays within the range of 3.0 to 5.5 V ([vVCONNValid](#)).

2.6 Hubs

USB hubs implemented with USB Type-C receptacles are required to clearly identify the upstream facing port. This requirement is needed because a user can no longer know which port on a hub is the upstream facing port and which ports are the downstream facing ports by the type of receptacles that are exposed, i.e., USB Type-B is the upstream facing port and USB Type-A is a downstream facing port.

3 Mechanical

3.1 Overview

This chapter defines the USB Type-C® connectors and wired cable assemblies. Cables which include active elements in the data path are defined in [Chapter 6 \(Active Cables\)](#).

3.1.1 Compliant Connectors

The USB Type-C specification defines the following standard connectors:

- USB Full-Featured Type-C receptacle
- [USB 2.0](#) Type-C receptacle
- USB Full-Featured Type-C plug
- [USB 2.0](#) Type-C plug
- USB Type-C Power-Only plug

3.1.2 Compliant Cable Assemblies

Table 3-1 summarizes the USB Type-C standard cable assemblies along with the primary differentiating characteristics. All USB Full-Featured Type-C cables shall support simultaneous, independent signal transmission on both [USB 3.2](#) and [USB4™](#) (TX and RX pairs) data buses. The cable lengths listed in the table are informative and represents the practical length based on cable performance requirements. All cables that are either full-featured and/or are rated at more than 3 A current are [Electronically Marked Cables](#).

Table 3-1 USB Type-C Standard Cable Assemblies

Cable Ref	Plug 1	Plug 2	USB Version	Cable Length	Current Rating	USB Power Delivery	USB Type-C Electronically Marked
CC2-3	C	C	USB 2.0	≤ 4 m	3 A	Supported	Optional
CC2-5					5 A		Required
CC3G1-3	C	C	USB 3.2 Gen1 and USB4 Gen2	≤ 2 m	3 A	Supported	Required
CC3G1-5					5 A		
CC3G2-3	C	C	USB 3.2 Gen2 and USB4 Gen2	≤ 1 m	3 A	Supported	Required
CC3G2-5					5 A		
CC4G3-3	C	C	USB4 Gen3	≤ 0.8 m	3 A	Supported	Required
CC4G3-5					5 A		

USB Type-C products are also allowed to have a captive cable. See Section 3.4.3.

3.1.3 Compliant USB Type-C to Legacy Cable Assemblies

Table 3-2 summarizes the USB Type-C legacy cable assemblies along with the primary differentiating characteristics. The cable lengths listed in the table are informative and represents the practical length based on cable performance requirements. [USB 3.2](#) Type-C legacy cables assemblies that only offer performance up to [USB 3.1](#) Gen1 are not allowed by this specification. All USB Type-C to legacy cable assemblies are only defined specific to [USB 2.0](#) and [USB 3.2](#) as there are no USB Type-C to legacy cables that are uniquely applicable to [USB4](#).

For USB Type-C legacy cable assemblies that incorporate [Rp](#) termination, the value of this termination is required to be specified to the Default setting of [USB Type-C Current](#) even though the

cable assemblies are rated for 3 A. The [Rp](#) termination in these cables is intended to represent the maximum current of a compliant legacy USB host port, not the current rating of the cable itself. The cable current rating is intentionally set to a higher level given that there are numerous non-standard power chargers that offer more than the Default levels established by the [USB 2.0](#) and [USB 3.1](#) specifications.

Table 3-2 USB Type-C Legacy Cable Assemblies

Cable Ref	Plug 1 ³	Plug 2 ³	USB Version	Cable Length	Current Rating
AC2-3	USB 2.0 Standard-A	USB 2.0 Type-C ¹	USB 2.0	≤ 4 m	3 A
AC3G2-3	USB 3.1 Standard-A	USB Full-Featured Type-C ¹	USB 3.1 Gen2	≤ 1 m	3 A
CB2-3	USB 2.0 Type-C ²	USB 2.0 Standard-B	USB 2.0	≤ 4 m	3 A
CB3G2-3	USB Full-Featured Type-C ²	USB 3.1 Standard-B	USB 3.1 Gen2	≤ 1 m	3 A
CmB2	USB 2.0 Type-C ²	USB 2.0 Mini-B	USB 2.0	≤ 4 m	500 mA
CuB2-3	USB 2.0 Type-C ²	USB 2.0 Micro-B	USB 2.0	≤ 2 m	3 A
CuB3G2-3	USB Full-Featured Type-C ²	USB 3.1 Micro-B	USB 3.1 Gen2	≤ 1 m	3 A

Notes:

1. USB Type-C plugs associated with the “B” end of a legacy adapter cable are required to have R_p ($56 \text{ k}\Omega \pm 5\%$) termination incorporated into the plug assembly – see Section 4.5.3.2.2.
2. USB Type-C plugs associated with the “A” end of a legacy adapter cable are required to have R_d ($5.1 \text{ k}\Omega \pm 20\%$) termination incorporated into the plug assembly – see Section 4.5.3.2.1.
3. Refer to Section 3.7.5.3 for the mated resistance and temperature rise required for the legacy plugs.

3.1.4 Compliant USB Type-C to Legacy Adapter Assemblies

Table 3-3 summarizes the USB Type-C legacy adapter assemblies along with the primary differentiating characteristics. The cable lengths listed in the table are informative and represents the practical length based on cable performance requirements. All USB Type-C to legacy adapter assemblies are only defined specific to [USB 2.0](#) and [USB 3.2](#) as there are no USB Type-C to legacy adapters that are uniquely applicable to [USB4](#).

Table 3-3 USB Type-C Legacy Adapter Assemblies

Adapter Ref	Plug	Receptacle ³	USB Version	Cable Length	Current Rating
CuBR2-3	USB 2.0 Type-C ¹	USB 2.0 Micro-B	USB 2.0	≤ 0.15 m	3 A
CAR3G1-3	USB Full-Featured Type-C ²	USB 3.1 Standard-A	USB 3.1 Gen1	≤ 0.15 m	3 A

Notes:

1. USB Type-C plugs associated with the “B” end of a legacy adapter are required to have R_p ($56 \text{ k}\Omega \pm 5\%$) termination incorporated into the plug assembly – see Section 4.5.3.2.2.
2. USB Type-C plugs associated with the “A” end of a legacy adapter are required to have R_d ($5.1 \text{ k}\Omega \pm 20\%$) termination incorporated into the plug assembly – see Section 4.5.3.2.1.
3. Refer to Section 3.7.6.3 for the mated resistance and temperature rise required for the legacy receptacles.

3.2 USB Type-C Connector Mating Interfaces

This section defines the connector mating interfaces, including the connector interface drawings, pin assignments, and descriptions. All dimensions in figures are in millimeters

3.2.1 Interface Definition

Figure 3-1 and Figure 3-3 show, respectively, the USB Type-C receptacle and USB Full-Featured Type-C plug interface dimensions.

Figure 3-11 shows the [USB 2.0](#) Type-C plug interface dimensions. The dimensions that govern the mating interoperability are specified. All the REF dimensions are provided for reference only, not hard requirements.

Key features, configuration options, and design areas that need attention:

1. Figure 3-1 shows a vertical-mount receptacle. Other PCB mounting types such as right-angle mount and mid-mount are allowed.
2. A mid-plate is required between the top and bottom signals inside the receptacle tongue to manage crosstalk in full-featured applications. The mid-plate shall be connected to the PCB ground with at least two grounding points. A reference design of the mid-plate is provided in Section 3.2.2.1.
3. Retention of the cable assembly in the receptacle is achieved by the side-latches in the plug and features on the sides of the receptacle tongue. Side latches are required for all plugs except plugs used for docking with no cable attached. Side latches shall be connected to ground inside the plug. A reference design of the side latches is provided in Section 3.2.2.2 along with its grounding scheme. Docking applications may not have side latches, requiring special consideration regarding EMC (Electromagnetic Compatibility).
4. The EMC shielding springs are required inside the cable plug. The shielding spring shall be connected to the plug shell. 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 USB Type-C plug (see Figure 3-12). Section 3.2.2.3 shows reference designs of the EMC spring.
5. Shorting of any signal or power contact spring to the plug metal shell is not allowed. The spring in the deflected state should not touch the plug shell. An isolation layer (e.g., Kapton tape placed on the plug shell) is recommended to prevent accidental shorting due to plug shell deformation.
6. 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 3-2. A minimum of four separate points of contact are required. Additional points of contact are allowed. See Section 3.2.2.4 for a reference design of receptacle outer shell. The reference design includes four spring fingers as points of contact. 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 3-1. 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. See Section 3.2.2.3 for a reference design of the shielding pad and ground connection.

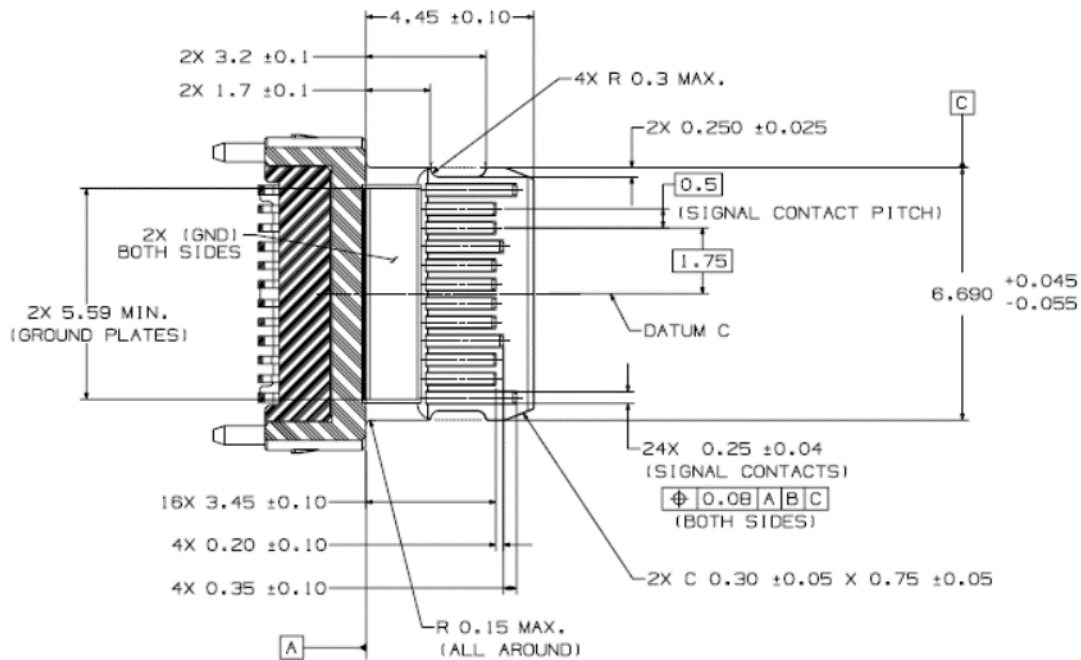
7. This specification defines the USB Type-C receptacle shell length of 6.20 mm as a reference dimension. The USB Type-C receptacle is designed to have shell length of 6.20 ± 0.20 mm to provide proper mechanical and electrical mating of the plug to the receptacle (e.g., full seating of the plug in the receptacle and protection of the receptacle tongue during insertion/withdrawal). The USB Type-C receptacle at the system level should be implemented such that the USB Type-C receptacle connector mounted in the associated system hardware has an effective shell length equal to 6.20 ± 0.20 mm.
8. The USB Type-C connector mating interface is defined so that the electrical connection may be established without the receptacle shell. To prevent excessive misalignment of the plug when it enters or exits the receptacle, the enclosure should have features to guide the plug for insertion and withdrawal when a modified receptacle shell is present. If the USB Type-C receptacle shell is modified from the specified dimension, then the recommended lead in from the receptacle tongue to the plug point of entry is 1.5 mm minimum when mounted in the system.

This 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 3-1:

- If the receptacle shell is conductive, then the receptacle contact dimensions of SECTION A-A or ALTERNATE SECTION A-A shown in Figure 3-1 shall be used.
 - If the receptacle shell is non-conductive, then the receptacle contact dimensions of ALTERNATE SECTION A-A shown in Figure 3-1 shall be used. The contact dimensions of SECTION A-A are not allowed.
 - If there is no receptacle shell, then the receptacle contact dimensions of either SECTION A-A or ALTERNATE SECTION A-A shown in Figure 3-1 shall be used. If there is no receptacle shell and the receptacle is used in an implementation that does not effectively provide a conductive shell, then a receptacle with the contact dimensions of ALTERNATE SECTION A-A shown in Figure 3-1 should be used.
9. A paddle card (e.g., PCB) may be used in the USB Type-C plug to manage wire termination and electrical performance. Section 3.2.2.5 includes the guidelines and a design example for a paddle card.
 10. This specification does not define standard footprints. Figure 3-4 shows an example SMT (surface mount) footprint for the vertical receptacle shown in Figure 3-1. Additional reference footprints and mounting configurations are shown in Figure 3-5, Figure 3-6, Figure 3-7, Figure 3-8, Figure 3-9 and Figure 3-10.
 11. The receptacle shell shall be connected to the PCB ground plane.
 12. All VBUS pins shall be connected together in the USB Type-C plug.
 13. All Ground return pins shall be connected together in the USB Type-C plug.
 14. All VBUS pins shall be connected together at the USB Type-C receptacle when it is in its mounted condition (e.g., all VBUS pins bussed together in the PCB).
 15. All Ground return pins shall be connected together at the USB Type-C receptacle when it is in its mounted condition (e.g., all Ground return pins bussed together in the PCB).
 16. The USB Type-C Power-Only plug is a depopulated version of the USB Full-Featured Type-C plug or the [USB 2.0](#) Type-C plug. The interface dimensions shall conform to Figure 3-3 or Figure 3-11. Contacts for CC, VBUS, and GND (i.e., A1, A4, A5, A9, A12, B1, B4, B9, and B12) shall be present. Physical presence of contacts in the other 15 contact locations is optional. The USB Type-C Power-Only plug shall only be used on a non-charger captive cable application. Implementation of [Rd](#) or CC communication on pin A5 is required in the application.

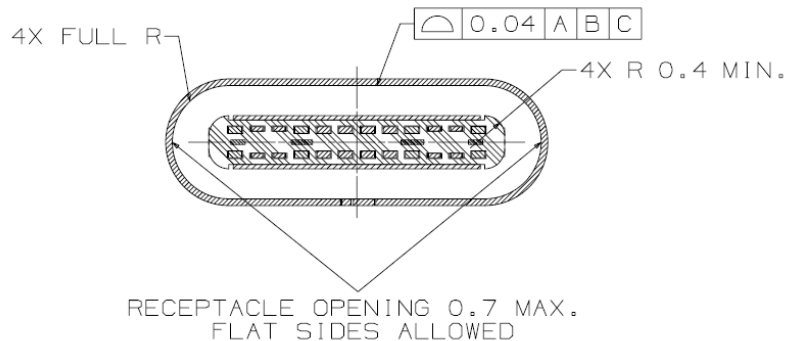
[illegible]

Figure 3-1 USB Type-C Receptacle Interface Dimensions, cont.



ALTERNATE SECTION A-A dimensions for use if the receptacle shell is non-conductive or there is no receptacle shell. This configuration is also allowed for receptacles with a conductive shell. See text for full requirements.

ALTERNATE SECTION A-A



SECTION B-B

Figure 3-1 USB Type-C Receptacle Interface Dimensions, cont.

