

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 des connecteurs
USB Type-C®**



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2024 IEC, Geneva, Switzerland

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

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

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

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

About the IEC

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

About IEC publications

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

IEC publications search - webstore.iec.ch/advsearchform

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 It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

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

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

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

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC -

webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, ...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications, symboles graphiques et le glossaire. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 500 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 25 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

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 des connecteurs
USB Type-C®**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 33.120.20, 33.120.30, 35.200

ISBN 978-2-8327-0006-8

**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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <https://patents.iec.ch>. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62680-1-2 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. It is an International Standard.

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:

Draft	Report on voting
100/4139/CDV	100/4177/RVC

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

A list of all parts in the IEC 62680 series, published under the general title *Universal serial bus interfaces for data and power*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn, or
- revised.

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.

Universal Serial Bus Type-C Cable and Connector Specification

Release 2.3
October 2023

Copyright © 2014-2023, USB3.0 Promoter Group:

**Apple Inc., HP 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® 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 <https://www.usb.org/compliance> for further information.

Contents

FOREWORD..... 2

Specification Editor21

Specification Work Group Contributors.....21

Pre-Release Draft Industry Reviewing Companies That Provided Feedback.....29

Revision History.....29

1 Introduction.....30

 1.1 Purpose30

 1.2 Scope30

 1.3 Related Documents30

 1.4 Conventions.....31

 1.4.1 Precedence31

 1.4.2 Keywords31

 1.4.3 Numbering.....32

 1.5 Terms and Abbreviations32

2 Overview37

 2.1 Introduction37

 2.2 USB Type-C Receptacles, Plugs and Cables38

 2.3 Configuration Process.....39

 2.3.1 Source-to-Sink Attach/Detach Detection.....39

 2.3.2 Plug Orientation/Cable Twist Detection.....40

 2.3.3 Initial Power (Source-to-Sink) Detection and Establishing the Data (Host-to-Device) Relationship
40

 2.3.4 USB Type-C VBUS Current Detection and Usage.....41

 2.3.5 *USB PD* Communications.....41

 2.3.6 Functional Extensions42

 2.4 VBUS.....42

 2.5 VCONN.....42

 2.6 Hubs.....43

3 Mechanical.....44

 3.1 Overview.....44

 3.1.1 Compliant Connectors.....44

 3.1.2 Compliant Cable Assemblies44

 3.1.3 Compliant USB Type-C to Legacy Cable Assemblies.....45

 3.1.4 Compliant USB Type-C to Legacy Adapter Assemblies.....46

 3.2 USB Type-C Connector Mating Interfaces46

 3.2.1 Interface Definition.....46

3.2.2	Reference Designs	67
3.2.3	Pin Assignments and Descriptions	74
3.3	Cable Construction and Wire Assignments	75
3.3.1	Cable Construction (<i>Informative</i>).....	75
3.3.2	Wire Assignments	77
3.3.3	Wire Gauges and Cable Diameters (<i>Informative</i>).....	78
3.4	Standard USB Type-C Cable Assemblies.....	80
3.4.1	USB Full-Featured Type-C Cable Assembly.....	80
3.4.2	USB 2.0 Type-C Cable Assembly	82
3.4.3	USB Type-C Captive Cable Assembly	82
3.4.4	USB Type-C Thumb Drive Assembly	83
3.5	Legacy Cable Assemblies.....	83
3.5.1	USB Type-C to USB 3.1 Standard-A Cable Assembly	84
3.5.2	USB Type-C to USB 2.0 Standard-A Cable Assembly	85
3.5.3	USB Type-C to USB 3.1 Standard-B Cable Assembly	86
3.5.4	USB Type-C to USB 2.0 Standard-B Cable Assembly	87
3.5.5	USB Type-C to USB 2.0 Mini-B Cable Assembly.....	88
3.5.6	USB Type-C to USB 3.1 Micro-B Cable Assembly	89
3.5.7	USB Type-C to USB 2.0 Micro-B Cable Assembly	90
3.6	Legacy Adapter Assemblies.....	90
3.6.1	USB Type-C to USB 3.1 Standard-A Receptacle Adapter Assembly	90
3.6.2	USB Type-C to USB 2.0 Micro-B Receptacle Adapter Assembly	92
3.7	Electrical Characteristics.....	92
3.7.1	Raw Cable (<i>Informative</i>).....	93
3.7.2	USB Type-C to USB Type-C Passive Cable Assemblies	94
3.7.3	Mated Connector (<i>Informative – USB 3.2 Gen2 and USB4 Gen2</i>).....	116
3.7.4	Receptacle Connector SI Requirements and Testing (<i>Normative – USB4 Gen3/Gen4</i>).....	120
3.7.5	USB Type-C to USB Legacy Cable Assemblies (<i>Normative</i>)	122
3.7.6	USB Type-C to USB Legacy Adapter Assemblies (<i>Normative</i>)	126
3.7.7	Shielding Effectiveness Requirements (<i>Normative</i>)	129
3.7.8	DC Electrical Requirements (<i>Normative</i>).....	131
3.8	Mechanical and Environmental Requirements (<i>Normative</i>).....	133
3.8.1	Mechanical Requirements	134
3.8.2	Environmental Requirements.....	139
3.9	Docking Applications (<i>Informative</i>)	140
3.10	Implementation Notes and Design Guides	141
3.10.1	EMC Management (<i>Informative</i>)	141

- 3.10.2 Stacked and Side-by-Side Connector Physical Spacing (*Informative*) 144
- 3.10.3 Cable Mating Considerations (*Informative*) 144
- 3.11 Extended Power Range (EPR) Cables 145
 - 3.11.1 Electrical Requirements 145
 - 3.11.2 EPR Cable Identification Requirements 145
- 4 Functional 146
 - 4.1 Signal Summary 146
 - 4.2 Signal Pin Descriptions 146
 - 4.2.1 USB 3.2/USB4 Pins 146
 - 4.2.2 USB 2.0 Pins 147
 - 4.2.3 Auxiliary Signal Pins 147
 - 4.2.4 Power and Ground Pins 147
 - 4.2.5 Configuration Pins 147
 - 4.3 Sideband Use (SBU) 147
 - 4.4 Power and Ground 147
 - 4.4.1 IR Drop 147
 - 4.4.2 VBUS 148
 - 4.4.3 VCONN 150
 - 4.5 Configuration Channel (CC) 154
 - 4.5.1 Architectural Overview 154
 - 4.5.2 CC Functional and Behavioral Requirements 166
 - 4.5.3 USB Port Interoperability Behavior 202
 - 4.6 Power 219
 - 4.6.1 Power Requirements during USB Suspend 220
 - 4.6.2 VBUS Power Provided Over a USB Type-C Cable 221
 - 4.7 USB Hubs 226
 - 4.8 Power Sourcing and Charging 227
 - 4.8.1 DFP as a Power Source 227
 - 4.8.2 Non-USB Charging Methods 229
 - 4.8.3 Sinking Host 230
 - 4.8.4 Sourcing Device 230
 - 4.8.5 Charging a System with a Dead Battery 230
 - 4.8.6 USB Type-C Multi-Port Chargers 230
 - 4.9 Electronically Marked Cables 234
 - 4.9.1 Parameter Values 235
 - 4.9.2 Active Cables 235
 - 4.10 VCONN-Powered Accessories (VPAs) and VCONN-Powered USB Devices (VPDs) 236

4.10.1	VCONN-Powered Accessories (VPAs).....	236
4.10.2	VCONN-Powered Devices (VPDs).....	236
4.11	Parameter Values.....	238
4.11.1	Termination Parameters.....	238
4.11.2	Timing Parameters.....	240
4.11.3	Voltage Parameters.....	243
5	<i>USB4</i> Discovery and Entry.....	245
5.1	Overview of the Discovery and Entry Process.....	245
5.2	<i>USB4</i> Functional Requirements.....	246
5.2.1	<i>USB4</i> Host Functional Requirements.....	246
5.2.2	USB Device Functional Requirements.....	246
5.2.3	<i>USB4</i> Alternate Mode Support.....	246
5.3	<i>USB4</i> Power Requirements.....	247
5.3.1	Source Power Requirements.....	247
5.3.2	Sink Power Requirements.....	247
5.3.3	Device Power Management Requirements.....	247
5.4	<i>USB4</i> Discovery and Entry Flow Requirements.....	248
5.4.1	USB Type-C Initial Connection.....	248
5.4.2	USB Power Delivery Contract.....	248
5.4.3	<i>USB4</i> Discovery and Entry Flow.....	248
5.4.4	<i>USB4</i> Post-Entry Operation.....	253
5.5	<i>USB4</i> Hub Connection Requirements.....	254
5.5.1	<i>USB4</i> Hub Port Initial Connection Requirements.....	254
5.5.2	<i>USB4</i> Hub UFP and Host Capabilities Discovery.....	254
5.5.3	Hub DFP Connection Requirements.....	255
5.5.4	Hub Ports Connection Behavior Flow Examples.....	255
5.5.5	Connecting to Downstream <i>USB4</i> Hubs.....	261
5.5.6	Fallback Functional Requirements for <i>USB4</i> Hubs.....	261
5.6	<i>USB4</i> Device Connection Requirements.....	261
5.6.1	Fallback Mapping of <i>USB4</i> Peripheral Functions of USB Device Class Types.....	261
5.7	Parameter Values.....	263
5.7.1	Timing Parameters.....	263
6	Active Cables.....	264
6.1	General Specifications for All Active Cables.....	264
6.1.1	Discovering Active Cable Characteristics.....	264
6.1.2	Electrical Requirements.....	266
6.1.3	Mechanical Requirements.....	298

- 6.2 Additional Specifications for Copper and Hybrid-Optical Active Cables.....299
 - 6.2.1 Active Cable Block Diagram300
 - 6.2.2 *USB4* Asymmetric Mode Support300
 - 6.2.3 Active Cable *USB PD* Requirements.....300
 - 6.2.4 Active Cable Behaviors in Response to *USB PD* Events.....300
 - 6.2.5 Active Cable Power Requirements.....301
- 6.3 Additional Specifications for Optically Isolated Active Cables301
 - 6.3.1 OIAC Block Diagrams302
 - 6.3.2 OIAC Limitations and General Requirements304
 - 6.3.3 OIAC Cable Power Requirements305
 - 6.3.4 OIAC *USB PD* Requirements.....305
 - 6.3.5 OIAC Connection Flow and State Diagrams315
 - 6.3.6 Additional Electrical Requirements for OIAC333
 - 6.3.7 Additional Mechanical Requirements for OIAC336
- A Liquid Corrosion Mitigation Mode.....337
 - A.1 Overview.....337
 - A.2 Detail337
 - A.3 Liquid Detection Methods.....339
 - A.3.1 Liquid Measurement Method339
 - A.3.2 Pulsed Measurement Method.....339
 - A.3.3 Impedance Measurement Method.....340
 - A.4 Liquid Detection Pins in the Connector343
- B Debug Accessory Mode346
 - B.1 Overview.....346
 - B.2 Functional346
 - B.2.1 Signal Summary346
 - B.2.2 Port Interoperability.....347
 - B.2.3 Debug Accessory Mode Entry.....347
 - B.2.4 Connection State Diagrams.....347
 - B.2.5 DTS Port Interoperability Behaviors.....356
 - B.2.6 Orientation Detection.....365
 - B.3 Security/Privacy Requirements365
- C USB Type-C Digital Audio.....366
 - C.1 Overview.....366
 - C.2 USB Type-C Digital Audio Specifications.....366
- D Thermal Design Considerations for Active Cables.....367
 - D.1 Introduction367

D.2	Model.....	367
D.2.1	Assumptions.....	367
D.2.2	Model Architecture.....	368
D.2.3	Heat Sources.....	368
D.2.4	Heat Flow.....	369
D.3	USB 3.2 Single-Lane Active Cable.....	370
D.3.1	USB 3.2 Single-Lane Active Cable Design Considerations	370
D.4	Dual-Lane Active Cables.....	373
D.4.1	USB 3.2 Dual-Lane Active Cable Design Considerations	373
D.4.2	USB 3.2 Dual-Lane Active Cable in a Multiple Port Configuration.....	375
D.5	USB 3.2 Host and Device Design Considerations	376
D.5.1	Heat Spreading or Heat Sinking from Host or Device.....	376
D.5.2	Motherboard Temperature Control	377
D.5.3	Wider Port Spacing for Multi-Port Applications	377
D.5.4	Power Policies	377
E	Alternate Modes.....	378
E.1	Alternate Mode Architecture.....	378
E.2	Alternate Mode Requirements.....	378
E.2.1	Alternate Mode Pin Reassignment.....	379
E.2.2	Alternate Mode Electrical Requirements.....	379
E.3	Parameter Values	382
E.4	Example Alternate Mode – USB DisplayPort™ Dock	383
E.4.1	USB DisplayPort™ Dock Example.....	383
E.4.2	Functional Overview	383
E.4.3	Operational Summary	384
E.5	Example Alternate Mode Entry Flow with Cable Warnings.....	385
E.5.1	Operational Summary	386
F	Thunderbolt™ 3 Compatibility Discovery and Entry.....	387
F.1	TBT3 Compatibility Mode Functional Requirements	387
F.1.1	TBT3-Compatible Power Requirements.....	387
F.1.2	TBT3-Compatible Host Requirements	387
F.1.3	TBT3-Compatible Device Upstream Requirements.....	387
F.1.4	TBT3-Compatible Device Downstream Requirements.....	387
F.1.5	TBT3-Compatible Self-Powered Device Without Predefined Upstream Port Rules	388
F.1.6	TBT3-Compatible Devices with a Captive Cable	388
F.2	TBT3 Discovery and Entry Flow.....	388
F.2.1	TBT3 Passive Cable Discover Identity Responses	389

F.2.2 *TBT3* Active Cable Discover Identity Responses.....392

F.2.3 *TBT3* Device Discover Identity Responses.....395

F.2.4 *TBT3* Discover SVID Responses.....396

F.2.5 *TBT3* Device Discover Mode Responses.....397

F.2.6 *TBT3* Cable Discover Mode Responses398

F.2.7 *TBT3* Cable Enter Mode Command.....399

F.2.8 *TBT3* Device Enter Mode Command400

F.2.9 *TBT3* Cable Functional Difference Summary402

G Extracting Pulse Response from Sampled Data and Calculating Non-Linearity Noise.....403

H *USB PD* High-Voltage Design Considerations405

H.1 Potential for Arcing Damage During Cable Withdrawal.....405

H.2 Arcing During USB Type-C Cable Withdrawal405

H.3 Mitigating Arcing Damage During Cable Withdrawal Due to Sink Discharge.....407

H.3.1 Limiting Sink Discharge Rate.....408

H.3.2 Load Removal409

H.3.3 Limiting Source Current Capability412

I *USB PD* Encoding Guidelines for USB Type-C Product Types413

I.1 USB Type-C Product Type Definitions and *USB PD* Encodings.....413

I.2 *USB PD* Encoding Guidelines Tables.....414

I.3 Detailed Examples.....421

I.3.1 *USB 3.2* Host – no DC – Power Consumer : DRP (Source or Sink) / Not DRD (DFP).....421

I.3.2 *USB 3.2* Peripheral – Power Provider : DRP (Source or Sink) / Not DRD (UFP).....421

I.3.3 *USB4* Host – Power Consumer : DRP (Source or Sink) / Not DRD (DFP)422

I.3.4 *USB4* Host – *USB4* DC – Partial or no USB Equivalent : DRP (Source or Sink) / DRD.....422

I.3.5 *USB4* Peripheral : UFP (Sink)423

I.3.6 *USB4* Dock (Upstream) – Power Provider : DRP (Source or Sink) / Not DRD (UFP)424

I.3.7 *USB4* Hub (Downstream) – DFP (Source)424

J Design Assumptions for the *USB4* Gen4 LRD Cable Specification426

Figures

Figure 2-1 USB Type-C Receptacle Interface (Front View).....37

Figure 2-2 USB Full-Featured Type-C Plug Interface (Front View).....38

Figure 3-1 USB Type-C Receptacle Interface Dimensions.....49

Figure 3-2 Reference Design USB Type-C Plug External EMC Spring Contact Zones.....52

Figure 3-3 USB Full-Featured Type-C Plug Interface Dimensions.....53

Figure 3-4 Reference Footprint for a USB Type-C Vertical Mount Receptacle (*Informative*)56

Figure 3-5 Reference Footprint for a USB Type-C Dual-Row SMT Right-Angle Receptacle (*Informative*)57

Figure 3-6 Reference Footprint for a USB Type-C Hybrid Right-Angle Receptacle (*Informative*).....58

Figure 3-7 Reference Footprint for a USB Type-C Mid-Mount Dual-Row SMT Receptacle (*Informative*)59

Figure 3-8 Reference Footprint for a USB Type-C Mid-Mount Hybrid Receptacle (*Informative*).....60

Figure 3-9 Reference Footprint for a <i>USB 2.0</i> Type-C Through Hole Right Angle Receptacle (<i>Informative</i>)	61
Figure 3-10 Reference Footprint for a <i>USB 2.0</i> Type-C Single Row Right Angle Receptacle (<i>Informative</i>)	62
Figure 3-11 <i>USB 2.0</i> Type-C Plug Interface Dimensions	63
Figure 3-12 USB Type-C Plug EMC Shielding Spring Tip Requirements	66
Figure 3-13 Reference Design of Receptacle Mid-Plate	67
Figure 3-14 Reference Design of Retention Latch	68
Figure 3-15 Illustration of the Latch Soldered to the Paddle Card Ground	68
Figure 3-16 Reference Design of the USB Full-Featured Type-C Plug Internal EMC Spring	69
Figure 3-17 Reference Design of the <i>USB 2.0</i> Type-C Plug Internal EMC Spring	70
Figure 3-18 Reference Design of Internal EMC Pad	71
Figure 3-19 Reference Design of a USB Type-C Receptacle with External EMC Springs	72
Figure 3-20 Reference Design of a USB Full-Featured Type-C Plug Paddle Card	73
Figure 3-21 Illustration of a USB Full-Featured Type-C Cable Cross Section, a Coaxial Wire Example with VCONN	76
Figure 3-22 Illustration of a USB Full-Featured Type-C Cable Cross Section, a Coaxial Wire Example without VCONN	76
Figure 3-23 USB Full-Featured Type-C Standard Cable Assembly	80
Figure 3-24 USB Type-C to <i>USB 3.1</i> Standard-A Cable Assembly	84
Figure 3-25 USB Type-C to <i>USB 2.0</i> Standard-A Cable Assembly	85
Figure 3-26 USB Type-C to <i>USB 3.1</i> Standard-B Cable Assembly	86
Figure 3-27 USB Type-C to <i>USB 2.0</i> Standard-B Cable Assembly	87
Figure 3-28 USB Type-C to <i>USB 2.0</i> Mini-B Cable Assembly	88
Figure 3-29 USB Type-C to <i>USB 3.1</i> Micro-B Cable Assembly	89
Figure 3-30 USB Type-C to <i>USB 2.0</i> Micro-B Cable Assembly	90
Figure 3-31 USB Type-C to <i>USB 3.1</i> Standard-A Receptacle Adapter Assembly	91
Figure 3-32 USB Type-C to <i>USB 2.0</i> Micro-B Receptacle Adapter Assembly	92
Figure 3-33 Illustration of Test Points for a Mated Cable Assembly	94
Figure 3-34 Recommended Differential Insertion Loss Requirement (<i>USB 3.2</i> Gen2 and <i>USB4</i> Gen2)	95
Figure 3-35 Recommended Differential Return Loss Requirement	95
Figure 3-36 Recommended Differential Crosstalk Requirement	96
Figure 3-37 Recommended Differential Near-End and Far-End Crosstalk Requirement between USB D+/D- Pair and TX/RX Pair	97
Figure 3-38 Recommended Differential Insertion Loss Requirement (<i>USB4</i> Gen3/Gen4)	97
Figure 3-39 Illustration of Insertion Loss Fit at Nyquist Frequency	98
Figure 3-40 Input Pulse Spectrum	99
Figure 3-41 IMR Limit as Function of ILfitatNq	100
Figure 3-42 IRL Limit as Function of ILfitatNq	102
Figure 3-43 Differential-to-Common Mode Conversion Requirement	102
Figure 3-44 IMR Limit as Function of ILfit at 10 GHz (<i>USB4</i> Gen3/Gen4)	106
Figure 3-45 Definition of Port, Victim, and Aggressor	107
Figure 3-46 IXT_DP and IXT_USB Limit as Function of ILfit at 10 GHz (<i>USB4</i> Gen3/Gen4)	107
Figure 3-47 IRL Limit as Function of ILfit at 10 GHz (<i>USB4</i> Gen3/Gen4)	108
Figure 3-48 Differential-to-Common Mode Conversion Requirement (<i>USB4</i> Gen3/Gen4)	108
Figure 3-49 Cable Assembly in System	109
Figure 3-50 Requirement for Differential Coupling between CC and D+/D-	112
Figure 3-51 Requirement for Single-Ended Coupling between CC and D- in <i>USB 2.0</i> Type-C Cables	112
Figure 3-52 Requirement for Single-Ended Coupling between CC and D- in USB Full-Featured Type-C Cables	113
Figure 3-53 Requirement for Differential Coupling between VBUS and D+/D-	113
Figure 3-54 Requirement for Single-Ended Coupling between SBU_A and SBU_B	114
Figure 3-55 Requirement for Single-Ended Coupling between SBU_A/SBU_B and CC	115

Figure 3-56 Requirement for Coupling between SBU_A and differential D+/D-, and SBU_B and differential D+/D- 115

Figure 3-57 Illustration of USB Type-C Mated Connector 116

Figure 3-58 Recommended Impedance Limits of a USB Type-C Mated Connector 117

Figure 3-59 Recommended Ground Void Dimensions for USB Type-C Receptacle 117

Figure 3-60 Recommended Differential Near-End and Far-End Crosstalk Limits between D+/D- Pair and TX/RX Pairs..... 119

Figure 3-61 Recommended Limits for Differential-to-Common-Mode Conversion 120

Figure 3-62 IMR Limit as Function of ILfitatNq for USB Type-C to Legacy Cable Assembly 125

Figure 3-63 IRL Limit as Function of ILfitatNq for USB Type-C to Legacy Cable Assembly 125

Figure 3-64 Cable Assembly Shielding Effectiveness Testing..... 129

Figure 3-65 Shielding Effectiveness Pass/Fail Criteria..... 130

Figure 3-66 LLCR Measurement Diagram 131

Figure 3-67 Temperature Measurement Point..... 132

Figure 3-68 Example Current Rating Test Fixture Trace Configuration 133

Figure 3-69 Example of 4-Axis Continuity Test Fixture 135

Figure 3-70 Example Wrenching Strength Test Fixture for Plugs without Overmold..... 137

Figure 3-71 Reference Wrenching Strength Continuity Test Fixture 138

Figure 3-72 Example of Wrenching Strength Test Mechanical Failure Point 138

Figure 3-73 Wrenching Strength Test with Cable in Fixture..... 139

Figure 3-74 USB Type-C Cable Receptacle Flange Example 141

Figure 3-75 EMC Guidelines for Side Latch and Mid-Plate..... 142

Figure 3-76 EMC Finger Connections to Plug Shell..... 142

Figure 3-77 EMC Pad Connections to Receptacle Shell 143

Figure 3-78 Examples of Connector Apertures..... 143

Figure 3-79 Recommended Minimum Spacing between Connectors..... 144

Figure 3-80 Recommended Minimum Plug Overmold Clearance 144

Figure 3-81 Cable Plug Overmold and an Angled Surface..... 145

Figure 4-1 Cable IR Drop..... 148

Figure 4-2 Cable IR Drop for powered cables..... 148

Figure 4-3 Logical Model for Single-Lane Data Bus Routing across USB Type-C-based Ports..... 155

Figure 4-4 Logical Model for USB Type-C-based Ports for a Single-Lane Direct Connect Device..... 155

Figure 4-5 Pull-Up/Pull-Down CC Model..... 157

Figure 4-6 Current Source/Pull-Down CC Model..... 157

Figure 4-7 Source Functional Model for CC1 and CC2 160

Figure 4-8 Source Functional Model Supporting *USB PD PR_Swap*..... 161

Figure 4-9 Sink Functional Model for CC1 and CC2 161

Figure 4-10 Sink Functional Model Supporting *USB PD PR_Swap* and *VCONN_Swap* 162

Figure 4-11 DRP Functional Model for CC1 and CC2..... 163

Figure 4-12 Connection State Diagram: Source 168

Figure 4-13 Connection State Diagram: Sink 169

Figure 4-14 Connection State Diagram: Sink with Accessory Support 170

Figure 4-15 Connection State Diagram: DRP 171

Figure 4-16 Connection State Diagram: DRP with Accessory and Try.SRC Support 172

Figure 4-17 Connection State Diagram: DRP with Accessory and Try.SNK Support..... 173

Figure 4-18 Connection State Diagram: Charge-Through VPD 174

Figure 4-19 Sink Power Sub-States 196

Figure 4-20 Passive Cable eMarker State Diagram..... 198

Figure 4-21 Active Cable eMarker State Diagram 198

Figure 4-22 Cable Ra Management State Diagram 199

Figure 4-23 Source to Sink Functional Model..... 202

Figure 4-24 Source to DRP Functional Model.....	203
Figure 4-25 DRP to Sink Functional Model.....	204
Figure 4-26 DRP to DRP Functional Model – CASE 1	205
Figure 4-27 DRP to DRP Functional Model – CASES 2 & 3.....	206
Figure 4-28 Source to Source Functional Model	208
Figure 4-29 Sink to Sink Functional Model.....	208
Figure 4-30 DRP to VPD Model	209
Figure 4-31 Example DRP to Charge-Through VPD Model.....	210
Figure 4-32 Source to Legacy Device Port Functional Model	217
Figure 4-33 Legacy Host Port to Sink Functional Model.....	217
Figure 4-34 DRP to Legacy Device Port Functional Model.....	218
Figure 4-35 Legacy Host Port to DRP Functional Model.....	219
Figure 4-36 Sink Monitoring for Current in Pull-Up/Pull-Down CC Model.....	222
Figure 4-37 Sink Monitoring for Current in Current Source/Pull-Down CC Model.....	223
Figure 4-38 <i>USB PD</i> over CC Pins	224
Figure 4-39 <i>USB PD</i> BMC Signaling over CC	224
Figure 4-40 USB Type-C Cable’s Output as a Function of Load for Non-PD-based USB Type-C Charging.....	228
Figure 4-41 0 – 3 A <i>USB PD</i> -based Charger USB Type-C Cable’s Output as a Function of Load	229
Figure 4-42 3 – 5 A <i>USB PD</i> -based Charger USB Type-C Cable’s Output as a Function of Load	229
Figure 4-43 Electronically Marked Cable with VCONN connected through the cable	235
Figure 4-44 Electronically Marked Cable with SOP’ at both ends	235
Figure 4-45 Example Charge-Through VCONN-Power USB Device Use Case	238
Figure 4-46 DRP Timing.....	240
Figure 5-1 <i>USB4</i> Discovery and Entry Flow Model.....	249
Figure 5-2 <i>USB4</i> Hub with <i>USB4</i> Host and Device Connection Flow Alignment	256
Figure 5-3 <i>USB4</i> Hub with <i>USB 3.2</i> Host and <i>USB4</i> Device Connection Flow Alignment	257
Figure 5-4 <i>USB4</i> Hub with <i>USB4</i> Host and <i>USB 3.2</i> Device Connection Flow Alignment	258
Figure 5-5 <i>USB4</i> Hub with <i>USB 3.2</i> Host and Device Connection Flow Alignment	259
Figure 5-6 <i>USB4</i> Hub with <i>USB4</i> Host and DP Alt Mode Device Connection Flow Alignment	260
Figure 5-7 <i>USB4</i> Hub with <i>USB 3.2</i> Host and DP Alt Mode Device Connection Flow Alignment	261
Figure 6-1 Active Cable Topologies	267
Figure 6-2 SuperSpeed USB Electrical Test Points	270
Figure 6-3 SuperSpeed USB Compliance Test Setup	270
Figure 6-4 Compliance Points Definition.....	273
Figure 6-5 RX Differential Return-Loss Mask.....	274
Figure 6-6 Re-timer-based Active Cable Compliance Test Setup	275
Figure 6-7 Example of Transmitter Frequency Variation During Clock Switching.....	277
Figure 6-8 Active Cable Functional Test Setup.....	278
Figure 6-9 Linear Re-driver-based Active Cable Compliance Setup.....	279
Figure 6-10 Gain Parameters Specified for the Linear Re-driver Active Cable.....	282
Figure 6-11 OUTPUT_NOISE Limit Versus <i>ILfitatNq</i>	283
Figure 6-12 Gain Parameters for <i>USB4</i> Gen4 LRD Active Cables	286
Figure 6-13 <i>USB4</i> LRD Active Cable Snooping of TxFFE Negotiation	291
Figure 6-14 <i>USB4</i> State Machine per Channel (<i>Informative</i>).....	292
Figure 6-15 <i>USB4</i> Gen4 CL1/CL2 Exit Flow with LRD Active Cable	294
Figure 6-16 <i>USB4</i> Symmetric to Asymmetric Transition.....	295
Figure 6-17 <i>USB4</i> Asymmetric to Symmetric Transition.....	297
Figure 6-18 OIAC <i>USB PD</i> Message Forwarding	310
Figure 6-19 OIAC Successful Data Role Swap	313
Figure 6-20 OIAC Rejected Data Role Swap.....	313
Figure 6-21 OIAC Wait Data Role Swap.....	314

Figure 6-22 OIAC Initiator Reject Data Role Swap 314

Figure 6-23 OIAC Initiator Wait Data Role Swap..... 315

Figure 6-24 OIAC Discovery – Phase 1..... 317

Figure 6-25 OIAC Reboot – Phase 2 318

Figure 6-26 OIAC Plug-A Configured as DFP – Phase 3 319

Figure 6-27 OIAC Plug-A Configured as UFP – Phase 3 320

Figure 6-28 OIAC Plug-A No Connection Possible Billboard – Phase 3 321

Figure 6-29 OIAC Plug-A State Diagram Part 1 (Phase 1 and 2) 322

Figure 6-30 OIAC Plug-A State Diagram Part 2 (Phase 3) 323

Figure 6-31 OIAC Plug-B State Diagram..... 329

Figure 6-32 Illustration of Usages for OIAC that Require an Adapter or Hub 335

Figure A-1 Electrolytic Liquid Corrosion Example 337

Figure A-2 Corrosion Mitigation in Pull-Up/Pull-Down CC Model..... 338

Figure A-3 Corrosion Mitigation in Current Source/Pull-Down CC Model..... 338

Figure A-4 Corrosion Mitigation in Current Source/Pull-Down CC Model with Alternate Mitigation 338

Figure A-5 Liquid Detection by Leakage Measurement 339

Figure A-6 Liquid Detection by Pulsed Measurement 340

Figure A-7 Example Measurement of a Dry Port..... 341

Figure A-8 Example Measurement of a Port with Reverse Osmosis Water 341

Figure A-9 Example Measurement of a Port with Tap Water 342

Figure A-10 Example Measurement of a Port with Artificial Sweat 342

Figure A-11 Example Measurement of a Port with Ocean Water..... 343

Figure A-12 Example Liquid Detect Pin(s)/Pad(s) Location Area 344

Figure A-13 Example Liquid Detect Pad Along All Connector Pins..... 344

Figure A-14 Example Liquid Detect Pins Adjacent to VBUS/SBU/CC..... 345

Figure A-15 Example Liquid Detect Connector Surface Mount View..... 345

Figure B-1 USB Type-C Debug Accessory Layered Behavior 346

Figure B-2 DTS Plug Interface..... 346

Figure B-3 Connection State Diagram: DTS Source..... 348

Figure B-4 Connection State Diagram: DTS Sink..... 349

Figure B-5 Connection State Diagram: DTS DRP 350

Figure B-6 TS Sink Power Sub-States 354

Figure D-1 Active Cable Model (Single Port, Top Mount Receptacle) 368

Figure D-2 Model Architecture..... 368

Figure D-3 Heat Sources and Heat Flow Paths..... 369

Figure D-4 Vertically Stacked Horizontal Connectors 3x1 Configuration (VERT)..... 370

Figure D-5 Horizontally Stacked Vertical Connectors 1x3 Configuration (HZ90)..... 371

Figure D-6 Horizontally Stacked Horizontal Connectors 1x3 Configuration (HORZ)..... 371

Figure D-7 USB 3.2 Single-Lane 3A Active Cable in a 3-Port Configuration..... 372

Figure D-8 USB 3.2 Single-Lane 5A Active Cable in a 3-Port Configuration..... 372

Figure D-9 Impact of Overmold Power P_0 and Thermal Boundary Temperature T_{MB} at 3 A VBUS in a Single Port Configuration 374

Figure D-10 Impact of Overmold Power P_0 and Thermal Boundary Temperature T_{MB} at 5 A VBUS in a Single Port Configuration 374

Figure D-11 USB 3.2 Active Cable Dongle Design (One End Shown) 375

Figure D-12 USB 3.2 Dual-Lane 3A Active Cable in a 3-Port Configuration..... 375

Figure D-13 USB 3.2 Dual-Lane 5A Active Cable in a 3-Port Configuration..... 376

Figure D-14 Example: Additional Heat Spreader on Receptacle in Host or Device 377

Figure D-15 Example: Heat Sinking on Chassis of Host or Device..... 377

Figure E-1 Pins Available for Reconfiguration over the Full-Featured Cable 379

Figure E-2 Pins Available for Reconfiguration for Direct Connect Applications 379

Figure E-3 Alternate Mode Implementation using a USB Type-C to USB Type-C Cable 381
Figure E-4 Alternate Mode Implementation using a USB Type-C to Alternate Mode Cable or Device..... 381
Figure E-5 USB DisplayPort Dock Example 383
Figure E-6 *USB4* DFP Mode Entry Flow Example..... 385
Figure F-1 *TBT3* Discovery Flow 389
Figure H-1 Arcing Damage to USB Type-C VBUS Contacts 405
Figure H-2 Arcing Due to Discharge..... 406
Figure H-3 Arcing Prevention During Sink Discharge by Limiting Slew Rate 408
Figure H-4 Arcing Prevention During Sink Discharge by Load Removal..... 410

Tables

Table 2-1 Summary of power supply options 42
Table 3-1 USB Type-C Standard Cable Assemblies 45
Table 3-2 USB Type-C Legacy Cable Assemblies 46
Table 3-3 USB Type-C Legacy Adapter Assemblies 46
Table 3-4 USB Type-C Receptacle Interface Pin Assignments 74
Table 3-5 USB Type-C Receptacle Interface Pin Assignments for *USB 2.0*-only Support 75
Table 3-6 USB Type-C Standard Cable Wire Assignments 77
Table 3-7 USB Type-C Cable Wire Assignments for Legacy Cables/Adapters..... 78
Table 3-8 Reference Wire Gauges for standard USB Type-C Cable Assemblies..... 79
Table 3-9 Reference Wire Gauges for standard USB Type-C to Legacy Cable Assemblies 79
Table 3-10 USB Full-Featured Type-C Standard Cable Assembly Wiring..... 81
Table 3-11 *USB 2.0* Type-C Standard Cable Assembly Wiring..... 82
Table 3-12 USB Type-C to *USB 3.1* Standard-A Cable Assembly Wiring 84
Table 3-13 USB Type-C to *USB 2.0* Standard-A Cable Assembly Wiring 85
Table 3-14 USB Type-C to *USB 3.1* Standard-B Cable Assembly Wiring 86
Table 3-15 USB Type-C to *USB 2.0* Standard-B Cable Assembly Wiring 87
Table 3-16 USB Type-C to *USB 2.0* Mini-B Cable Assembly Wiring 88
Table 3-17 USB Type-C to *USB 3.1* Micro-B Cable Assembly Wiring 89
Table 3-18 USB Type-C to *USB 2.0* Micro-B Cable Assembly Wiring 90
Table 3-19 USB Type-C to *USB 3.1* Standard-A Adapter Assembly Wiring 91
Table 3-20 USB Type-C to *USB 2.0* Micro-B Receptacle Adapter Assembly Wiring 92
Table 3-21 Differential Insertion Loss Examples for USB TX/RX with Twisted Pair Construction 93
Table 3-22 Differential Insertion Loss Examples for USB TX/RX with Coaxial Construction 94
Table 3-23 Key Parameters in COM Configuration File 110
Table 3-24 Electrical Requirements for CC and SBU Wires 111
Table 3-25 Coupling Matrix for Low Speed Signals..... 111
Table 3-26 Maximum Mutual Inductance (M) between VBUS and Low Speed Signal Lines 114
Table 3-27 USB D+/D– Signal Integrity Requirements for USB Type-C to USB Type-C Passive Cable Assemblies..... 116
Table 3-28 USB Type-C Mated Connector Recommended Signal Integrity Characteristics (*Informative*) 118
Table 3-29 USB Type-C Receptacle Connector Signal Integrity Characteristics for *USB4* Gen3 (*Normative*) .. 121
Table 3-30 USB D+/D– Signal Integrity Requirements for USB Type-C to Legacy USB Cable Assemblies (*Normative*)..... 122
Table 3-31 Design Targets for USB Type-C to *USB 3.1* Gen2 Legacy Cable Assemblies (*Informative*)..... 123
Table 3-32 USB Type-C to *USB 3.1* Gen2 Legacy Cable Assembly Signal Integrity Requirements (*Normative*) 124
Table 3-33 USB D+/D– Signal Integrity Requirements for USB Type-C to Legacy USB Adapter Assemblies (*Normative*)..... 126
Table 3-34 Design Targets for USB Type-C to *USB 3.1* Standard-A Adapter Assemblies (*Informative*) 127

Table 3-35 USB Type-C to *USB 3.1* Standard-A Receptacle Adapter Assembly Signal Integrity Requirements
(*Normative*).....128

Table 3-36 Current Rating Test PCB.....132

Table 3-37 Maximum DC Resistance Requirement (*Normative*).....133

Table 3-38 Force and Moment Requirements136

Table 3-39 Environmental Test Conditions139

Table 3-40 Reference Materials140

Table 4-1 USB Type-C List of Signals146

Table 4-2 VBUS Source Characteristics149

Table 4-3 VBUS Sink Characteristics149

Table 4-4 USB Type-C Source Port’s VCONN Requirements Summary.....150

Table 4-5 VCONN Source Characteristics150

Table 4-6 Cable VCONN Sink Characteristics.....151

Table 4-7 VCONN-Powered Accessory (VPA) Sink Characteristics.....152

Table 4-8 VCONN-Powered Device (VPD) Sink Characteristics153

Table 4-9 USB Type-C Port Interoperability.....156

Table 4-10 Source Perspective158

Table 4-11 Source (Host) and Sink (Device) Behaviors by State158

Table 4-12 Recommended Implementation of Try.SRC and Try.SNK for Dual-Role Ports with Preferred Roles
.....165

Table 4-13 *USB PD* Swapping Port Behavior Summary.....165

Table 4-14 Use of Power and Data Role Swaps for Dual-Role Ports with Preferred Roles.....166

Table 4-15 Power Role Behavioral Model Summary166

Table 4-16 Source Port CC Pin State.....175

Table 4-17 Sink Port CC Pin State.....175

Table 4-18 Mandatory and Optional States200

Table 4-19 Precedence of Power Source Usage220

Table 4-20 USB Type-C Current Advertisement and PDP Equivalent.....222

Table 4-21 Sink Maximum Current Limit When Attached to CTVPD225

Table 4-22 Example Charge-Through VPD Sink Maximum Currents based on VBUS Impedance and GND
Impedance.....226

Table 4-23 Examples of 4-port Shared Capacity Chargers and Power Sharing Policies.....232

Table 4-24 SOP’ and SOP’’ Timing235

Table 4-25 Charge-Through VPD CC Impedance (RccCON) Requirements237

Table 4-26 CTVPD Charge-Through Port VBUS Bypass Requirements237

Table 4-27 Source CC Termination (Rp) Requirements238

Table 4-28 Sink CC Termination (Rd) Requirements239

Table 4-29 Powered Cable Termination Requirements239

Table 4-30 CC Termination Requirements for Disabled state, ErrorRecovery state, and Unpowered Source.....239

Table 4-31 SBU Termination Requirements.....239

Table 4-32 VBUS and VCONN Timing Parameters.....240

Table 4-33 DRP Timing Parameters.....241

Table 4-34 CC Timing Parameters242

Table 4-35 CC Voltages on Source Side – Default USB.....243

Table 4-36 CC Voltages on Source Side – 1.5 A @ 5 V.....243

Table 4-37 CC Voltages on Source Side – 3.0 A @ 5 V.....243

Table 4-38 Voltages on Sink CC Pins – Default USB Type-C Current Only.....243

Table 4-39 Voltages on Sink CC Pins – Multiple Source Current Advertisements244

Table 4-40 CC Pin Clamping Voltage.....244

Table 5-1 Certified Cables Where *USB4*-compatible Operation is Expected.....251

Table 5-2 Fallback Mapping *USB4* Functions to USB Device Class Types.....262

Table 5-3 USB Billboard Device Class Availability Following <i>USB4</i> Device Entry Failure.....	263
Table 6-1 <i>USB4</i> Cable Identity Summary.....	265
Table 6-2 Active Cable Features.....	266
Table 6-3 Active Cable SBU Requirements.....	267
Table 6-4 Active Cable Power-on Requirements.....	268
Table 6-5 Maximum <i>USB 3.2</i> U0 Delay.....	269
Table 6-6 <i>USB 3.2</i> U-State Requirements.....	269
Table 6-7 Active Cable <i>USB 3.2</i> Stressed Source Swing, TP1.....	271
Table 6-8 Active Cable <i>USB 3.2</i> Stressed Source Jitter, TP1.....	271
Table 6-9 Active Cable <i>USB 3.2</i> Input Swing at TP2 (<i>Informative</i>).....	272
Table 6-10 Active Cable <i>USB 3.2</i> Output Swing at TP3 (<i>Informative</i>).....	272
Table 6-11 Compliance Points Definition.....	273
Table 6-12 <i>USB4</i> CL-State Requirements for Active Cables.....	274
Table 6-13 Re-timer-based <i>USB4</i> Active Cable Output Specifications Applied for All Speeds (at TP3').....	276
Table 6-14 Stressed Receiver Conditions for <i>USB4</i> Gen2 and Gen3 Cable Compliance Testing (at TP2).....	278
Table 6-15 Linear Re-driver-based Active Cable Output Parameters.....	280
Table 6-16 Input Signal at TP2 for Compliance Testing.....	281
Table 6-17 <i>USB4</i> Gen4 LRD-based Active Cable ILfitMask Limits.....	285
Table 6-18 <i>USB4</i> Gen4 LRD-based Active Cable Wiring Diagram for Compliance.....	287
Table 6-19 <i>USB4</i> Gen4 Active Cable SBx Transaction Snooping.....	288
Table 6-20 <i>USB4</i> LRD Active Cable Logical Timing Parameters.....	289
Table 6-21 <i>USB4</i> LRD Tuning Register Snooping.....	298
Table 6-22 Cable Temperature Requirements.....	299
Table 6-23 OIAC <i>USB PD</i> Message Handling.....	306
Table 6-24 Recommended OIAC Sink_Capabilities PDO (SOP) on Initial Connection.....	307
Table 6-25 Recommended OIAC Sink_Capabilities PDO (SOP) on Active Connection.....	307
Table 6-26 Recommended OIAC Active Sink RDO (SOP).....	308
Table 6-27 OIAC <i>USB PD</i> Message Timing.....	311
Table 6-28 Port and Plug Capabilities.....	316
Table 6-29 <i>USB 3.2</i> U-State Requirements.....	335
Table 6-30 <i>USB4</i> CL-State Requirements for OIAC.....	336
Table A-1 Example Measurement Test Conditions.....	340
Table B-1 DTS to TS Port Interoperability.....	347
Table B-2 Rp/Rp Charging Current Values for a DTS Source.....	354
Table B-3 Mandatory and Optional States.....	356
Table D-1 Heat Sources and Heat Dissipation Example (1.5 W cable and 5 A).....	369
Table D-2 <i>USB 3.2</i> Active Cable Design Single Port Case Study at 35 °C Ambient and 60 °C Thermal Boundary (Single Lane).....	370
Table D-3 <i>USB 3.2</i> Active Cable Design Single Port Case Study at 35 °C Ambient and 60 °C Thermal Boundary (Dual Lane).....	373
Table E-1 USB Safe State Electrical Requirements.....	382
Table E-2 USB Billboard Device Class Availability Following Alternate Mode Entry Failure.....	382
Table E-3 Alternate Mode Signal Noise Ingression Requirements.....	382
Table F-1 <i>TBT3</i> Passive Cable Discovery Identity VDO Responses.....	390
Table F-2 <i>TBT3</i> Passive Cable VDO for <i>USB PD</i> Revision 2.0, Version 1.3.....	391
Table F-3 <i>TBT3</i> Passive Cable VDO for <i>USB PD</i> Revision 3.0, Version 1.2.....	391
Table F-4 <i>TBT3</i> Active Cable Discovery Identity VDO Responses.....	392
Table F-5 <i>TBT3</i> Active Cable VDO for <i>USB PD</i> Revision 2.0, Version 1.3.....	393
Table F-6 <i>TBT3</i> Active Cable VDO 1 for <i>USB PD</i> Revision 3.0, Version 1.2.....	393
Table F-7 <i>TBT3</i> Active Cable VDO 2 for <i>USB PD</i> Revision 3.0, Version 1.2.....	394
Table F-8 <i>TBT3</i> Device Discovery Identity VDO Responses.....	395

Table F-9 <i>TBT3</i> Discover SVID VDO Responses.....	396
Table F-10 <i>TBT3</i> Device Discover Mode VDO Responses	397
Table F-11 <i>TBT3</i> Cable Discover Mode VDO Responses.....	398
Table F-12 <i>TBT3</i> Cable Enter Mode Command.....	399
Table F-13 <i>TBT3</i> Device Enter Mode Command	400
Table F-14 <i>TBT3</i> Cable Functional Difference Summary	402
Table G-1 Linear Fit Pulse Extraction Parameters.....	404
Table I-1 USB Type-C Product Example Clarifying Notes.....	415
Table I-2 <i>USB PD</i> Encoding Guidelines for Example Products.....	418

Specification Editor

SpecWerkz

Brad Saunders

Specification Work Group Contributors

The following is a list of contributor companies and the individuals that were members of the work group roster at the time of this release. Note: For historical reasons, the following list also includes individuals that were members of the work group and associated with their company affiliations at the time of each release going back to Release 1.0.

Acroname Inc.	Grant Fritz	Connor Goss	Matt Krugman
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
	Michael Comai	Juan Martinez	Peter Teng
	Walter Fry	Gerald Merits	Sujan Thomas
	Will Harris	Tim Perley	
Allion Labs, Inc.	Howard Chang	Yan Ken	Minoru Ohara
	Alex Chuang	Lexus Lee	Brian Shih
	Maroco Fan	Stan Lin	Chester Tsai
	Jesse Jiang	Denver Mishima	Chou Tsungbo
	Terry Kao		
Amphenol Corporation	Louis Chan	Terry Ke	Shawn Wei
	Zhineng Fan	Martin Li	Alan Yang
	Jesse Jaramillo	Lino Liu	
Agilent Technologies, Inc.	James Choate		
Analogix Semiconductor, Inc.	Mehran Badii	Haijian Sui	Yueke Tang
	Greg Stewart		
Apple Inc. (USB Promoter company)	Colin Abraham	Brian Follis	Nathan Ng
	Mahmoud Amini	Zheng Gao	James Orr
	Sree Anantharaman	Derek Iwamoto	Keith Porthouse
	Brian Baek	Scott Jackson	Breton Saunders
	Paul Baker	Girault Jones	Reese Schreiber
	Michael Bonham	Keong Kam	Jay Sha
	Jonathan Brown	Kevin Keeler	Sascha Tietz
	Carlos Calderon	Min Kim	Jennifer Tsai
	Jason Chung	Woopoung Kim	Colin Whitby-Strevens
	David Conroy	Alan Kobayashi	Jeff Wilcox
	Bill Cornelius	Alexei Kosut	Eric Wiles
	Christophe Daniel	Christine Krause	Dan Wilson
	Raju Desai	Chris Ligtenberg	Dennis Yarak
	William Ferry	Matthew Mora	
	Aptiv Consumer Connectivity	Andrew Burchett	Moe Elghrawi
ASMedia Technology Inc.	Kuo Lung Li		
Bizlink Technology, Inc.	Alex Chou	CY Tsai	Giovanni Wang
	Morphy Hsieh	Kevin Tsai	

Cadence Design Systems, Inc.	Marcin Behrendt Huzaifa Dalal Pawel Eichler Sanjai Gandhi Sathish Kumar Ganesan	Dariusz Kaczmarczyk Tomasz Klimek Sanjeet Kumar 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
China Telecommunications Technology Labs	Ming Wei		
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	
Credo Semiconductor, Inc.	Jim Bartenslager Yifei Dai Kevin Gao	Yasuo Hidaka Justin Lee Phil Sun	Ping Xiong
Cypress Semiconductor	Chia Hua Chang Mark Fu Naman Jain Savan Javia	Rushil Kadakia Benjamin Kropf Venkat Mandagulathur Anup Nayak	Jagadeesan Raj Sanjay Sancheti Subu Sankaran Anita Thimma Govarthanarajan
Dell	Mohammed Hijazi David Meyers Sean O'Neal	Ken Nicholas 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	Jin-sheng Wang Ada Yip
DisplayLink (UK) Ltd.	Pete Burgers		
DJI Technology Co., Ltd.	Steve Huang		
eEver Technology, Inc.	Chien-Cheng Kuo		
Electronics Testing Center, Taiwan	Sophia Liu		
Elka International Ltd.	Roy Ting		
Ellisys	Abel Astley Rick Bogart	Wenhui Luo Mario Pasquali	Chuck Trefts Tim Wei
Etron Technology, Inc.	Chien-Cheng Kuo		
EverPro Technologies Company, Ltd.	Hui Jiang	Silane Zhou	
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 Brandon Chen Joe Chen Allen Cheng Jason Chou Edmond Choy Shruti Deore	Fred Fons Chris Goralka 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.	Brian Collins	Bob McVay	Christopher Meyers
Google	Naga Viswanadha Udaya Kiran Ammu Alec Berg Joshua Boilard Alec Berg Todd Broch Chao Fei Jim Guerin Jeffrey Hayashida Mark Hayter	Eric Herrmann Nithya Jagannathan Nathan Kolluru Lawrence Lam Adam Langley Benson Leung Abraham Levkoy Ingrid Lin Prashant Malani Richard Palatin	Vincent Palatin Dylan Reid Adam Rodriguez David Schneider Stephan Schooley Toshak Singhal Jameson Thies Ken Wu Songping Wu Diana Zigterman
Granite River Labs	Yung Han Ang Velmurugan Ayyakkannu Rajesh B Pascal Berten Hariprasad Bhat Sandy Chang Allen Chen Swee Guan Chua Alan Chuang	Mike Engbretson Mark Jiang Vishal Kakade Jesson Li Caspar Lin Olivia Lu Bala M Prasannakumar Marikunte Nagaraju Winson Mok	Kristof Mommen Krishna Murthy Amy Peng Johnson Tan Annie Tao Vasudev Uttharahalli Chin Hun Yaep Mike Yang Yun Yang
GuangDong OPPO Mobile Telecommunications Corp, Ltd.	Jerry Qin		
Honor Device Co., Ltd.	Wang Feng		
Hirose Electric Co., Ltd.	Jeremy Buan William Kysiak Sang-Muk Lim	William MacKillop Gourgen Oganessyan	Eungsoo Shin Sid Tono
Hosiden Corporation	Takahisa Otsuji	Fumitake Tamaki	
HP Inc. (USB Promoter company)	Lee Atkinson Srinath Balaraman Rami Bathaniah Roger Benson Alan Berkema	Robin Castell Steve Chen Michael Krause Rahul Lakdawala	Jim Mann Linden McClure Mike Pescetto Asjad Shamim
Huawei Technology Co., Ltd.	Jianhong He Zhengbing Li	Gang Liang	Liansheng Zheng

Hynetek Semiconductor Co., Ltd.	Yingyang Ou	James Xie	
I-PEX (Dai-ichi Seiko)	Alan Kinningham	Jack Ozeki	Ro Richard
Indie Semiconductor	Ian Board	Jim Wilshire	
Infineon Technologies	Godwin Gerald Arulappan	Naman Jain	Shopitham Ram
	Pradeep Baipai	Behzad Jamasbi	Gayathri Vasudevan
	Dominic Gutierrez	Benjamin Kropf	Tue Fatt David Wee
		Venkat Mandagulathur	
Intel Corporation (USB Promoter company)	Dave Ackelson	James Jaussi	Rajaram Regupathy
	Nirmala Bailur	Ziv Kabiry	Oren Salomon
	Mike Bell	Vijaykumar Kadgi	Brad Saunders
	Dmitriy Berchanskiy	Luke Johnson	Tomer Savariago
	Brad Berlin	Jerzy Kolinski	Ehud Shoor
	Pierre Bossart	Rolf Kuhn	Amit Srivastava
	Huimin Chen	Henrik Leegaard	Einat Surijan
	Kuan-Yu Chen	Edmond Lau	Eliahu Suued
	Hengju Cheng	Xiang Li	Ron Swartz
	Oded David	Yun Ling	Chuen Ming Tan
	Sourabh Das	Guobin Liu	David Thompson
	Jhuda Dayan	Steve McGowan	Pranav Tipnis
	Hem Doshi	Sankaran Menon	Karthi Vadivelu
	Paul Durley	Udaya Natarajan	Venkataramani
	Saranya Gopal	Aruni Nelson	Gopalakrishnan
	Venkataramani Gopalakrishnan	Chee Lim Nge	Tsion Vidal
	Yaniv Hayat	Asutosh Pathak	Stephanie Wallick
	Howard Heck	Sagar Pawar	Rafal Wielicki
	Hao-Han Hsu	Duane Quiet	Devon Worrell
	Seppo Ingalsuo	Amardeep Rai	Gal Yedidia
	Abdul (Rahman) Ismail	Kannappan Rajaraman	Li Yuan
		Sridharan Ranganathan	Reza M. Zamani
			Vitaly Zhivov
Japan Aviation Electronics Industry Ltd. (JAE)	Kenji Hagiwara	Tadashi Okubo	Jussi Takaneva
	Hiroaki Ikeda	Kazuhiro Saito	Junichi Takeuchi
	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
	Norihiko Nakamura	Masaaki Takaku	
JPC/Main Super Inc.	Sam Tseng	Ray Yang	
Kandou Bus SA	Amanda Dong	Hitaish Sharma	Paul Wilson
	Majid Foodeei	David Stauffer	
Keysight Technologies Inc.	Jit Lim	Pedro Merlo	Xiao Zhang
Kinetic Technologies, Inc.	Ramesh Dandapani	Jay Slivkoff	Kei Yasuno
	Akihiro Moto	Sireesha Vemulapalli	
Leadtrend	Yao-Wei Hsieh		
LeCroy Corporation	Mike Engbretson	Tyler Joe	Giuseppe Leccia
	Daniel H. Jacobs	Chetan Kopalle	

Lenovo	Rob Bowser Tomoki Harada	Jianye Li Wei Liu	Howard Locker Munefumi Nakata
LG Electronics Inc.	Won-Jong Choi Do Kyun Kim	Jeeyoung Kim	Seung Hyun Yoo
Lintes Technology Co., Ltd.	Tammy Huang Charles Kaun RD Lintes	Max Lo CT Pien	JinYi Tu Jason Yang
Lotes Co., Ltd.	Ariel Delos Reyes Ernest Han Mark Ho Regina Liu-Hwang	Charles Kaun Chi-Chang Lin James Lin Max Lo	John Lynch Scott Shuey JinYi Tu Jason Yang
LSI Corporation	Dave Thompson		
Luxshare-ICT	Josue Castillo Daniel Chen Kenny Chen Lisen Chen Sally Chiu Blue Ho CY Hsu	Alan Kinningham Peter Jhou Antony Lin Gorden Lin John Lin Stone Lin Alan Liu	Sean O'Neal Scott Shuey James Stevens Carr Wang Yangli Wang Eric Wen Pat Young
Maxim Integrated Products	Forrest Christo Ken Helfrich	Sang Kim Jeff Lo	Michael Miskho Jacob Scott
MCCI Corporation	Terry Moore		
MediaTek Inc.	Henry Chen Yishu Hsieh Jason Hsu Liang-Yu Hsu	Jing-Hao Huang Shih Jyun-Yang Akan Lin	Alex YC Lin Tung-Sheng Lin Chasel Wang
MegaChips Corporation	Alan Kobayashi	Satoru Kumashiro	
Mercedes-Benz Research & Development, North America, Inc.	Hans Wickler		
Microchip (SMSC)	Josh Averyt Mark Bohm Shannon Cash Thomas Farkas Fernando Gonzalez	Matthew Kalibat Donald Perkins Richard Petrie Mohammed Rahman Andrew Rogers	John Sisto Anthony Tarascio Kiet Tran Christopher Twigg Prasanna Vengateshan
Microsoft Corporation (USB Promoter company)	Randy Aull Jim Belesiu Michelle Bergeron Fred Bhesania Anthony Chen Philip Froese Vivek Gupta David Hargrove Robbie Harris Teemu Helenius Robert Hollyer Lily Huang	Dan Iatco Kai Inha Jayson Kastens Andrea Keating Shoaib Khan Patrick Law Eric Lee Ivan McCracken Arvind Murching Gene Obie Toby Nixon Arjun Padmanabhan	Praveen Kumar Palacharla Rahul Ramadas Srivatsan Ravindran Nathan Sherman Bala Sivakumar Timo Toivola Vahid Vassey David Voth Andrew Yang Panu Ylihaavisto
Molex LLC	Adib Al Abaji	Alan MacDougall	

Monolithic Power Systems	Junyong Gong Di Han Yuncong Jiang	Istvan Nagy Chris Sporck Ao Sun	Greg Virnig Vincent Wu
MQP Electronics Ltd.	Sten Carlsen	Pat Crowe	
Multilane Inc.	Fadi Daou	Rita Khawaja	Elias Khoury
NEC Corporation	Kenji Oguma		
Newnex Technology Corp.	Sam Liu	Nimrod Peled	
Nokia Corporation	Daniel Gratiot Pekka Leinonen	Samuli Makinen Pekka Talmola	Timo Toivola Panu Ylihaavisto
Nuvoton Technology Corp.	Nimrod Peled		
NVIDIA	Jamie Aitken		
NXP Semiconductors	Mahmoud EL Sabbagh Dennis Ha Ken Jaramillo	Nate Johnson Vijendra Kuroodi Roger Lo	Guru Prasad Wouter Sijm Krishnan TN
Oculus VR LLC	Amish Babu	Marty Evans	Joaquin Fierro
ON Semiconductor	Edward Berrios Rod Comer Eduardo De Reza Alan Finkel	Oscar Freitas Christian Klein Amir Lahooti	Eric Maier Rick Pierce Michael Smith
Parade Technologies, Inc.	Jian Chen Brian Collins Robert McVay	Craig Wiley Paul Xu	Alan Yuen Jingfan Zhang
Power Integrations	Shruti Anand Daryll Bonavente Rahul Joshi	Aditya Kulkarni Akshay Nayaknur	Amruta Patra Kaushik Raam
Qualcomm, Inc.	Lior Amarilio Vara Prasad Arikatla Aris Balatsos Nicholas Cadieux David Chang Tomer Ben Chen Richard Burrows Amit Gil	James Goel Amit Gupta Philip Hardy Will Kun Jonathan Luty Adi Menachem 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 Jason Wang Changhung Wu
Renesas Electronics Corp. (USB Promoter company)	Kai Bao Yen-Mo Chen Yimin Chen Nobuo Furuya Tony Lai	Philip Leung Mengfei Liu Kiichi Muto Ziba Nami Hajime Nozaki	Yosuke Sasaki Toshifumi Yamaoka Fengshuan Zhou Yuhuan Zhou
Richtek Technology Corp.	Ben Chiang Tzuhsien Chuang Bryan Huang	Max Huang Leo Kang Roger Lo	Ken Shih Alex Yang
Rohde & Schwarz GmbH & Co. KG	Curtis Donahue Kai Uwe Schmidt	Martin Stumpf	Randy White

Rohm Co., Ltd.	Mark Aldering 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 Junhwa Choi Woojin Choi Yeongbok Choi Cheolyoon Chung Ilhyung Chung JaeRyong Han Jaehyeok Jang Wonseok Jang	Sung Geun Joo Koyoungwon Kim 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
SB C&S Corp.	Toshinari Nakamura Morito Ogikubo	Eiji Sakai	Kenji Watanabe
Scosche Industries	Josh Aguilera	Kevin Trejo	
Seagate	Alvin Cox Emmanuel Lemay	Tony Priborsky Tom Skaar	Dan Smith Curtis Stevens
Shenzhen Deren Electronic Co., Ltd.	Smark (Zhudong) Huo Wen Fa Lei	Yang Lirong Valerie Yang	Lucy Zhang
Silicon Line GmbH	Ian Jackson	Boleslaw Wojtowicz	Zhiying Zhang
SiliConch Systems Private Limited	Jaswanth Ammineni Pavitra Balasubramanian Kaustubh Kumar Aniket Mathad	Shubham Paliwal Jinisha Patel Vinay Patel Rakesh Polasa	Vishnu Pusuluri Ranjith S Abhishek Sardeshpande Satish Anand Verkila
Simula Technology Inc.	John Chang Voss Cheng Thomas Li	Jung Lin Jyunming Lin Doris Liu	Richard Liu CK Wang Alice Yu
Softnautics LLP	Bhavesh Desai Hetal Jariwala	Dipakkumar Modi Ishita Shah	Ujjwal Talati
Sony Corporation	Shinichi Hirata	Shigenori Tagami	
Spectra7 Microsystems Corp.	Andrew Kim	James McGrath	John Mitchell
SpecWerkz	Robert Dunstan Amanda Hosler	Diane Lenox Steve McGowan	Brad Saunders
STMicroelectronics (USB Promoter company)	Jerome Bach Nathalie Ballot Filippo Bonaccorso Guenaël Cadier Dominique Chaillot Christophe Cochard Nicolas Florenchie	Cedric Force Gregory Gosciniak Chekib Hammami Joel Huloux Christophe Lorin Yohann Martiniault Patrizia Milazzo	Federico Musarra Pascal Legrand Richard O'Connor Massimo Panzica Nicolas Perrin Mathieu Rouviere
Sumitomo Electric Ind., Ltd.	Takeshi Inoue Yasuhiro Maeda	Wataru Sakurai Sainer Siagian	Masaki Suzuki Mitsuaki Tamura
Synaptics Inc.	Daniel Bogard Dan Ellis	Jeff Lukanc	Prashant Shamarao

Synopsys, Inc.	Prishkrit Abrol Subramaniam Aravindhnan	Morten Christiansen Jaspreet Gambhir Nivin George	Satya Patnala John Stonick
Taiwan Testing and Certification Center	Sophia Liu		
Tektronix, Inc.	Sourabh Das Mark Guenther	Nitin Jhanwar Abhijeet Shinde	Randy White
Texas Instruments (USB Promoter company)	Jawaid Ahmad Kasthuri Annamalai Mike Campbell Prajith Cheerakkoda Greg Collins Gary Cooper Biju Erayamkot Panayamthatta Anant Gole GP Gopalakrishnan Craig Greenberg Richard Hubbard Nate Johnson	Michael Koltun IV Kevin Kosta Yoon Lee Grant Ley Win Maung Shafiuddin Mohammed Lauren Moore Jacob Ontiveros 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
Thine Electronica, Inc.	Yuseke Fujita	Shuheii Yamamoto	
Total Phase	Chris Yokum		
Trinity Co., Ltd.	Tetsushi Hoshikawa	Kinya Kishita	
Tyco Electronics Corp. (TE Connectivity Ltd.)	Max Chao Robert E. Cid Calvin Feng Kengo Ijro 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	Leo Chung Michael Hu Terry Kao	Dylan Su Henry Tsou Paul Vanderlaan	Eric Wall Lance Yang Chien-Wei Yeh
Unigraf OY	Steven Chen Sergey Grushin	Alexander Gushchin	Topi Lampiranta
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 Liu	Wayne Lo Ho Wen Tsai	Eric Wu
Western Digital, HGST	Larry McMillan		
Xiaomi Communications Co., Ltd.	Xiaoxing Yang	Juejia Zhou	Qi Zhu
Zhuhai iSmartWare Technology Co., Ltd.	Yuanchao Liang	Liu Qiong	Long Zhang

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	SMK Corporation
Joinsoon Electronics Mfg. Co. Ltd.	PalCONN/PalNova (Palpilot International Corp.)	Toshiba Corporation

Revision History

Release	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.
2.1	May 2021	New release primarily for enabling Extended Power Range (EPR) and defining EPR cables aligning with USB Power Delivery Specification R3.1 V1.0. Also includes incorporation of all approved ECNs as the revision date plus editorial clean-up.
2.2	October 2022	New release primarily for enabling USB4 Version 2.0 (80 Gbps) over USB Type-C connectors and cables. Also includes incorporation of all approved ECNs as of the revision date plus editorial clean-up.
2.3	October 2023	New release primarily for <i>deprecating</i> the Audio Adapter Accessory Mode and <i>replacing it with</i> the Liquid Corrosion Mitigation Mode , and for updating the Multi-port Charger Shared Capacity definition and behaviors. Also includes incorporation of all approved ECNs as of the revision date. Note: this release was created using a newly developed document template that includes some style adjustments and 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 establishes a new USB connector ecosystem that addresses the evolving needs of platforms and devices while retaining all 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 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.