

# 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®**



**THIS PUBLICATION IS COPYRIGHT PROTECTED**  
**Copyright © 2022 USB-IF**

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 IEC, or USB-IF at the respective address given below. Any questions about USB-IF copyright should be addressed to the USB-IF. Enquiries about obtaining additional rights to this publication and other information requests should be addressed to the IEC or your local IEC member National Committee.

IEC Secretariat  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland  
Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

USB Implementers Forum, Inc.  
3855 S.W. 153rd Drive  
Beaverton, OR 97003  
United States of America  
Tel. +1 503-619-0426  
[Admin@usb.org](mailto:Admin@usb.org)  
[www.usb.org](http://www.usb.org)

#### 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](http://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 It also gives information on projects, replaced and withdrawn publications.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](http://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](http://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](mailto:sales@iec.ch).

#### IEC Products & Services Portal - [products.iec.ch](http://products.iec.ch)

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

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 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](http://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](http://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](http://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](mailto:sales@iec.ch).

#### IEC Products & Services Portal - [products.iec.ch](http://products.iec.ch)

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

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 300 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 19 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 connecteurs  
USB Type-C®**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

---

ICS 33.120.20; 33.120.30; 35.200

ISBN 978-2-8322-5289-5

**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:

Draft	Report on voting
100/3715/CDV	100/3762/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.

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](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:

[IEC 62680-1-3:2022](#)

<https://www.usb.org/documents/standards/sist/c5497061-9c6f-4955-9523-a91787f9df50/iec->

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 2.1  
May 2021

iTeh STANDARD PREVIEW  
(standards.iteh.ai)

[IEC 62680-1-3:2022](https://standards.iteh.ai/catalog/standards/sist/c5497061-9c6f-4955-9523-a91787f9df50/iec-62680-1-3-2022)

<https://standards.iteh.ai/catalog/standards/sist/c5497061-9c6f-4955-9523-a91787f9df50/iec-62680-1-3-2022>

**Copyright © 2014-2021, USB 3.0 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 [usb.org/compliance](https://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 .....	25
Revision History.....	25
1 Introduction .....	26
1.1 Purpose .....	26
1.2 Scope.....	26
1.3 Related Documents .....	26
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 .....	35
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.....	37
2.4 VBUS .....	38
2.5 VCONN.....	38
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.....	41
3.1.4 Compliant USB Type-C to Legacy Adapter Assemblies.....	41
3.2 USB Type-C Connector Mating Interfaces .....	42
3.2.1 Interface Definition .....	42
3.2.2 Reference Designs .....	63
3.2.3 Pin Assignments and Descriptions.....	71
3.3 Cable Construction and Wire Assignments .....	72
3.3.1 Cable Construction (Informative) .....	72
3.3.2 Wire Assignments.....	74
3.3.3 Wire Gauges and Cable Diameters (Informative) .....	75
3.4 Standard USB Type-C Cable Assemblies .....	77
3.4.1 USB Full-Featured Type-C Cable Assembly.....	77
3.4.2 USB 2.0 Type-C Cable Assembly .....	78
3.4.3 USB Type-C Captive Cable Assemblies.....	79
3.4.4 USB Type-C Thumb Drive Assemblies.....	79
3.5 Legacy Cable Assemblies .....	79

3.5.1	USB Type-C to <i>USB 3.1</i> Standard-A Cable Assembly .....	80
3.5.2	USB Type-C to <i>USB 2.0</i> Standard-A Cable Assembly .....	82
3.5.3	USB Type-C to <i>USB 3.1</i> Standard-B Cable Assembly .....	83
3.5.4	USB Type-C to <i>USB 2.0</i> Standard-B Cable Assembly .....	84
3.5.5	USB Type-C to <i>USB 2.0</i> Mini-B Cable Assembly .....	85
3.5.6	USB Type-C to <i>USB 3.1</i> Micro-B Cable Assembly .....	86
3.5.7	USB Type-C to <i>USB 2.0</i> Micro-B Cable Assembly .....	87
3.6	Legacy Adapter Assemblies .....	88
3.6.1	USB Type-C to <i>USB 3.1</i> Standard-A Receptacle Adapter Assembly .....	88
3.6.2	USB Type-C to <i>USB 2.0</i> Micro-B Receptacle Adapter Assembly .....	90
3.7	Electrical Characteristics .....	91
3.7.1	Raw Cable (Informative) .....	91
3.7.2	USB Type-C to Type-C Passive Cable Assemblies (Normative) .....	92
3.7.3	Mated Connector (Informative – USB 3.2 Gen2 and USB4 Gen2) .....	111
3.7.4	Receptacle Connector SI Requirements and Testing (Normative – USB4 Gen3) .....	114
3.7.5	USB Type-C to Legacy Cable Assemblies (Normative) .....	115
3.7.6	USB Type-C to USB Legacy Adapter Assemblies (Normative) .....	119
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 .....	126
3.8.2	Environmental Requirements .....	131
3.9	Docking Applications (Informative) .....	132
3.10	Implementation Notes and Design Guides .....	133
3.10.1	EMC Management (Informative) .....	133
3.10.2	Stacked and Side-by-Side Connector Physical Spacing (Informative) .....	135
3.10.3	Cable Mating Considerations (Informative) .....	136
3.11	Extended Power Range (EPR) Cables .....	136
3.11.1	Electrical Requirements .....	136
3.11.2	EPR Cable Identification Requirements .....	137
4	Functional .....	138
4.1	Signal Summary .....	138
4.2	Signal Pin Descriptions .....	138
4.2.1	SuperSpeed USB Pins .....	138
4.2.2	USB 2.0 Pins .....	138
4.2.3	Auxiliary Signal Pins .....	139
4.2.4	Power and Ground Pins .....	139
4.2.5	Configuration Pins .....	139
4.3	Sideband Use (SBU) .....	139
4.4	Power and Ground .....	139
4.4.1	IR Drop .....	139
4.4.2	V <sub>BUS</sub> .....	140
4.4.3	V <sub>CONN</sub> .....	142
4.5	Configuration Channel (CC) .....	147
4.5.1	Architectural Overview .....	147
4.5.2	CC Functional and Behavioral Requirements .....	160
4.5.3	USB Port Interoperability Behavior .....	195
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 .....	221
4.8.1	DFP as a Power Source .....	221
4.8.2	Non-USB Charging Methods .....	223
4.8.3	Sinking Host .....	223
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 .....	228
4.10	VCONN-Powered Accessories (VPAs) and VCONN-Powered USB Devices (VPDs) .....	228
4.10.1	VCONN-Powered Accessories (VPAs) .....	228
4.10.2	VCONN-Powered USB Devices (VPDs) .....	229
4.11	Parameter Values .....	230
4.11.1	Termination Parameters .....	230
4.11.2	Timing Parameters .....	232
4.11.3	Voltage Parameters .....	235
5	USB4 Discovery and Entry .....	237
5.1	Overview of the Discovery and Entry Process .....	237
5.2	USB4 Functional Requirements .....	238
5.2.1	USB4 Host Functional Requirements .....	238
5.2.2	USB4 Device Functional Requirements .....	238
5.2.3	USB4 Alternate Mode Support .....	238
5.2.3.1	USB4 Alternate Mode Support on Hosts .....	238
5.2.3.2	USB4 Alternate Mode Support on Hubs and USB4-based Docks .....	238
5.3	USB4 Power Requirements .....	238
5.3.1	Source Power Requirements .....	239
5.3.2	Sink Power Requirements .....	239
5.3.3	Device Power Management Requirements .....	239
5.4	USB4 Discovery and Entry Flow Requirements .....	240
5.4.1	USB Type-C Initial Connection .....	240
5.4.2	USB Power Delivery Contract .....	240
5.4.3	USB4 Discovery and Entry Flow .....	240
5.4.3.1	USB4 Device Discovery (SOP) .....	241
5.4.3.2	USB4 Cable Discovery (SOP') .....	242
5.4.3.3	USB4 Operational Entry .....	244
5.4.4	USB4 Post-Entry Operation .....	244
5.4.4.1	During USB4 Operation .....	244
5.4.4.2	Exiting USB4 Operation .....	244
5.5	USB4 Hub Connection Requirements .....	244
5.5.1	USB4 Hub Port Initial Connection Requirements .....	245
5.5.2	USB4 Hub UFP and Host Capabilities Discovery .....	245
5.5.3	Hub DFP Connection Requirements .....	246
5.5.3.1	Speculative Connections .....	246
5.5.3.2	Operational Connections .....	246

5.5.4 Hub Ports Connection Behavior Flow Examples ..... 246

5.5.5 Connecting to Downstream USB4 Hubs ..... 252

5.5.6 Fallback Functional Requirements for USB4 Hubs ..... 252

5.6 USB4 Device Connection Requirements ..... 252

5.6.1 Fallback Mapping of USB4 Peripheral Functions to USB Device Class Types ..... 252

5.7 Parameter Values ..... 253

5.7.1 Timing Parameters ..... 253

6 Active Cables ..... 255

6.1 USB Type-C State Machine ..... 257

6.2 USB PD Requirements ..... 257

6.2.1 Active Cable USB PD Requirements ..... 259

6.2.2 USB PD Messages for OIAC ..... 260

6.2.3 Short Active Cable Behaviors in Response to Power Delivery Events ..... 270

6.3 OIAC Connection Flow and State Diagrams ..... 270

6.3.1 OIAC Connection Flow – Discovery – Phase 1 ..... 271

6.3.2 OIAC Connection Flow – Reboot – Phase 2 ..... 272

6.3.3 OIAC Connection Flow – Configuration – Phase 3 ..... 273

6.3.4 OIAC Connection State Diagram Plug-A ..... 276

6.3.5 OIAC Connection State Diagram Plug-B ..... 283

6.4 Active Cable Power Requirements ..... 288

6.4.1 VBUS Requirements ..... 288

6.4.2 OIAC VBUS Requirements ..... 288

6.4.3 USB PD Rules in Active State ..... 289

6.4.4 VCONN Requirements ..... 290

6.5 Mechanical ..... 290

6.5.1 Thermal ..... 290

6.5.2 Plug Spacing ..... 291

6.6 Electrical Requirements ..... 291

6.6.1 Shielding Effectiveness Requirement ..... 291

6.6.2 Low Speed Signal Requirement ..... 291

6.6.3 USB 2.0 ..... 292

6.6.4 USB 3.2 ..... 293

6.6.5 USB4 ..... 299

6.6.6 Return Loss ..... 312

6.7 Active Cables That Support Alternate Modes ..... 312

6.7.1 Discover SVIDs ..... 312

6.7.2 Discover Modes ..... 313

6.7.3 Enter/Exit Modes ..... 313

6.7.4 Power in Alternate Modes ..... 313

A Audio Adapter Accessory Mode ..... 314

A.1 Overview ..... 314

A.2 Detail ..... 314

A.3 Electrical Requirements ..... 315

A.4 Example Implementations ..... 316

A.4.1 Passive 3.5 mm to USB Type-C Adapter – Single Pole Detection Switch ..... 316

A.4.2 3.5 mm to USB Type-C Adapter Supporting 500 mA Charge-Through ..... 317

B Debug Accessory Mode ..... 319

B.1	Overview .....	319
B.2	Functional .....	319
B.2.1	Signal Summary .....	320
B.2.2	Port Interoperability .....	320
B.2.3	Debug Accessory Mode Entry .....	320
B.2.4	Connection State Diagrams .....	321
B.2.5	DTS Port Interoperability Behavior .....	329
B.2.6	Orientation Detection .....	337
B.3	Security/Privacy Requirements: .....	338
C	USB Type-C Digital Audio .....	339
C.1	Overview .....	339
C.2	USB Type-C Digital Audio Specifications .....	339
D	Thermal Design Considerations for Active Cables .....	341
D.1	Introduction .....	341
D.2	Model .....	341
D.2.1	Assumptions .....	341
D.2.2	Model Architecture .....	342
D.2.3	Heat Sources .....	342
D.2.4	Heat Flow .....	343
D.3	USB 3.2 Single Lane Active Cable .....	344
D.3.1	USB 3.2 Single-Lane Active Cable Design Considerations .....	344
D.4	Dual-Lane Active Cables .....	346
D.4.1	USB 3.2 Dual-Lane Active Cable Design Considerations .....	347
D.4.2	USB 3.2 Dual-Lane Active Cable in a Multi-Port Configuration .....	349
D.5	USB 3.2 Host and Device Design Considerations .....	350
D.5.1	Heat Spreading or Heat Sinking from Host or Device .....	350
D.5.2	Motherboard Temperature Control .....	351
D.5.3	Wider Port Spacing for Multi-Port Applications .....	351
D.5.4	Power Policies .....	351
E	Alternate Modes .....	352
E.1	Alternate Mode Architecture .....	352
E.2	Alternate Mode Requirements .....	352
E.2.1	Alternate Mode Pin Reassignment .....	353
E.2.2	Alternate Mode Electrical Requirements .....	353
E.3	Parameter Values .....	356
E.4	Example Alternate Mode – USB DisplayPort™ Dock .....	356
E.4.1	USB DisplayPort™ Dock Example .....	357
E.4.2	Functional Overview .....	357
E.4.3	Operational Summary .....	358
F	Thunderbolt 3 Compatibility Discovery and Entry .....	360
F.1	TBT3 Compatibility Mode Functional Requirements .....	360
F.1.1	TBT3-Compatible Power Requirements .....	360
F.1.2	TBT3-Compatible Host Requirements .....	360
F.1.3	TBT3-Compatible Device Upstream Requirements .....	360
F.1.4	TBT3-Compatible Device Downstream Requirements .....	360
F.1.5	TBT3-Compatible Self-Powered Device Without Predefined Upstream Port Rules .....	361
F.1.6	TBT3-Compatible Devices with a Captive Cable .....	361
F.2	TBT3 Discovery and Entry Flow .....	361

F.2.1	TBT3 Passive Cable Discover Identity Responses .....	363
F.2.2	TBT3 Active Cable Discover Identity Responses .....	365
F.2.3	TBT3 Device Discover Identity Responses .....	368
F.2.4	TBT3 Discover SVID Responses .....	369
F.2.5	TBT3 Device Discover Mode Responses .....	370
F.2.6	TBT3 Cable Discover Mode Responses .....	371
F.2.7	TBT3 Cable Enter Mode Command .....	372
F.2.8	TBT3 Device Enter Mode Command .....	373
F.2.9	TBT3 Cable Functional Difference Summary .....	374
G	Extracting Pulse Response from Sampled Data and Calculating Non-Linearity Noise .....	375
H	USB PD High-Voltage Design Considerations .....	377
H.1	Potential for Arcing Damage During Cable Withdrawal .....	377
H.2	USB Type-C Cable Withdrawal Arcing Due to Sink Discharge .....	377
H.3	Mitigating Arcing Damage During Cable Withdrawal .....	379
H.3.1	Limiting Sink Discharge Rate .....	380
H.3.2	Load Removal .....	381
H.3.3	Limiting Source Current Capability .....	383

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 .....	45
Figure 3-2	Reference Design USB Type-C Plug External EMC Spring Contact Zones .....	48
Figure 3-3	USB Full-Featured Type-C Plug Interface Dimensions .....	49
Figure 3-4	Reference Footprint for a USB Type-C Vertical Mount Receptacle (Informative) .....	52
Figure 3-5	Reference Footprint for a USB Type-C Dual-Row SMT Right Angle Receptacle (Informative) .....	53
Figure 3-6	Reference Footprint for a USB Type-C Hybrid Right-Angle Receptacle (Informative) .....	54
Figure 3-7	Reference Footprint for a USB Type-C Mid-Mount Dual-Row SMT Receptacle (Informative) .....	55
Figure 3-8	Reference Footprint for a USB Type-C Mid-Mount Hybrid Receptacle (Informative) .....	56
Figure 3-9	Reference Footprint for a USB 2.0 Type-C Through Hole Right Angle Receptacle (Informative) .....	57
Figure 3-10	Reference Footprint for a USB 2.0 Type-C Single Row Right Angle Receptacle (Informative) .....	58
Figure 3-11	USB 2.0 Type-C Plug Interface Dimensions .....	60
Figure 3-12	USB Type-C Plug EMC Shielding Spring Tip Requirements .....	63
Figure 3-13	Reference Design of Receptacle Mid-Plate .....	64
Figure 3-14	Reference Design of the Retention Latch .....	64
Figure 3-15	Illustration of the Latch Soldered to the Paddle Card Ground .....	65
Figure 3-16	Reference Design of the USB Full-Featured Type-C Plug Internal EMC Spring .....	66
Figure 3-17	Reference Design of the USB 2.0 Type-C Plug Internal EMC Spring .....	67
Figure 3-18	Reference Design of Internal EMC Pad .....	68
Figure 3-19	Reference Design of a USB Type-C Receptacle with External EMC Springs .....	69
Figure 3-20	Reference Design for a USB Full-Featured Type-C Plug Paddle Card .....	70
Figure 3-21	Illustration of a USB Full-Featured Type-C Cable Cross Section, a Coaxial Wire Example with Vconn .....	73
Figure 3-22	Illustration of a USB Full-Featured Type-C Cable Cross Section, a Coaxial Wire Example without Vconn .....	73
Figure 3-23	USB Full-Featured Type-C Standard Cable Assembly .....	77
Figure 3-24	USB Type-C to USB 3.1 Standard-A Cable Assembly .....	80
Figure 3-25	USB Type-C to USB 2.0 Standard-A Cable Assembly .....	82
Figure 3-26	USB Type-C to USB 3.1 Standard-B Cable Assembly .....	83

Figure 3-27 USB Type-C to USB 2.0 Standard-B Cable Assembly .....	84
Figure 3-28 USB Type-C to USB 2.0 Mini-B Cable Assembly .....	85
Figure 3-29 USB Type-C to USB 3.1 Micro-B Cable Assembly .....	86
Figure 3-30 USB Type-C to USB 2.0 Micro-B Cable Assembly .....	87
Figure 3-31 USB Type-C to USB 3.1 Standard-A Receptacle Adapter Assembly .....	88
Figure 3-32 USB Type-C to USB 2.0 Micro-B Receptacle Adapter Assembly .....	90
Figure 3-33 Illustration of Test Points for a Mated Cable Assembly .....	92
Figure 3-34 Recommended Differential Insertion Loss Requirement (USB 3.2 Gen2 and USB4 Gen2) .....	93
Figure 3-35 Recommended Differential Return Loss Requirement .....	93
Figure 3-36 Recommended Differential Crosstalk Requirement .....	94
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) .....	95
Figure 3-39 Illustration of Insertion Loss Fit at Nyquist Frequency .....	96
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) .....	102
Figure 3-45 Definition of Port, Victim, and Aggressor .....	103
Figure 3-46 IXT_DP and IXT_USB Limit as Function of ILfit at 10 GHz (USB4 Gen3) .....	103
Figure 3-47 IRL Limit as Function of ILfitatNq (USB4 Gen3) .....	104
Figure 3-48 Differential-to-Common-Mode Conversion Requirement (USB4 Gen3) .....	104
Figure 3-49 Cable Assembly in System .....	105
Figure 3-50 Requirement for Differential Coupling between CC and D+/D- .....	107
Figure 3-51 Requirement for Single-Ended Coupling between CC and D- in USB 2.0 Type-C Cables .....	107
Figure 3-52 Requirement for Single-Ended Coupling between CC and D- in USB Full-Featured Type-C Cables .....	108
Figure 3-53 Requirement for Differential Coupling between Vbus and D+/D- .....	108
Figure 3-54 Requirement for Single-Ended Coupling between SBU_A and SBU_B .....	109
Figure 3-55 Requirement for Single-Ended Coupling between SBU_A/SBU_B and CC .....	109
Figure 3-56 Requirement for Coupling between SBU_A and differential D+/D-, and SBU_B and differential D+/D- .....	110
Figure 3-57 Illustration of USB Type-C Mated Connector .....	111
Figure 3-58 Recommended Impedance Limits of a USB Type-C Mated Connector .....	111
Figure 3-59 Recommended Ground Void Dimensions for USB Type-C Receptacle .....	112
Figure 3-60 Recommended Differential Near-End and Far-End Crosstalk Limits between D+/D- Pair and TX/RX Pairs .....	113
Figure 3-61 Recommended Limits for Differential-to-Common-Mode Conversion .....	114
Figure 3-62 IMR Limit as Function of ILfitatNq for USB Type-C to Legacy Cable Assembly .....	118
Figure 3-63 IRL Limit as Function of ILfitatNq for USB Type-C to Legacy Cable Assembly .....	118
Figure 3-64 Cable Assembly Shielding Effectiveness Testing .....	121
Figure 3-65 Shielding Effectiveness Pass/Fail Criteria .....	122
Figure 3-66 LLCR Measurement Diagram .....	123
Figure 3-67 Temperature Measurement Point .....	124
Figure 3-68 Example Current Rating Test Fixture Trace Configuration .....	125
Figure 3-69 Example of 4-Axis Continuity Test Fixture .....	127
Figure 3-70 Example Wrenching Strength Test Fixture for Plugs without Overmold .....	129
Figure 3-71 Reference Wrenching Strength Continuity Test Fixture .....	129
Figure 3-72 Example of Wrenching Strength Test Mechanical Failure Point .....	130
Figure 3-73 Wrenching Strength Test with Cable in Fixture .....	130
Figure 3-74 USB Type-C Cable Receptacle Flange Example .....	133
Figure 3-75 EMC Guidelines for Side Latch and Mid-plate .....	134
Figure 3-76 EMC Finger Connections to Plug Shell .....	134
Figure 3-77 EMC Pad Connections to Receptacle Shell .....	135
Figure 3-78 Examples of Connector Apertures .....	135
Figure 3-79 Recommended Minimum Spacing between Connectors .....	135
Figure 3-80 Recommended Minimum Plug Overmold Clearance .....	136
Figure 3-81 Cable Plug Overmold and an Angled Surface .....	136
Figure 4-1 Cable IR Drop .....	140