

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 © 2021 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 Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

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

About the IEC

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

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a 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 It also gives information on projects, replaced and withdrawn publications.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 online collection - oc.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.

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.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 18 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online

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.

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 online collection - oc.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.

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.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

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.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



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

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 33.120.20; 33.120.30; 35.200

ISBN 978-2-8322-9337-9

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

INTERNATIONAL ELECTROTECHNICAL COMMISSION

UNIVERSAL SERIAL BUS INTERFACES FOR DATA AND POWER

Part 1-3: Common components – USB Type-C® Cable and Connector Specification

FOREWORD

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

International Standard IEC 62680-1-3 has been prepared by technical area 18: Multimedia home systems and applications for end-user networks, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

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

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

CDV	Report on voting
100/3439/CDV	100/3501/RVC

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

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

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

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

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

[IEC 62680-1-3:2021](https://standards.itech.ai/catalog/standards/sist/4fae56ff-2520-4f55-87b5-824e4d30de5f/iec-62680-1-3-2021)

<https://standards.itech.ai/catalog/standards/sist/4fae56ff-2520-4f55-87b5-824e4d30de5f/iec-62680-1-3-2021>

INTRODUCTION

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

This standard is the USB-IF publication Universal Serial Bus Type-C Cable and Connector Specification Revision 2.0.

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

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

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

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

<https://standards.iteh.ai/catalog/standards/sist/4fae56ff-2520-4f55-87b5-824e4d30de5f/iec-62680-1-3-2021>

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

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

Universal Serial Bus Type-C[®] Cable and Connector Specification

iTeh STANDARD PREVIEW
(standards.iteh.ai)

Release 2.0
August 2019

<https://standards.iteh.ai/catalog/standards/sist/4fae56ff-2520-4f55-87b5-824e4d30de5f/iec-62680-1-3-2021>

**Copyright © 2014-2019, USB 3.0 Promoter Group:
Apple Inc., Hewlett-Packard Inc., Intel Corporation, Microsoft
Corporation, Renesas, STMicroelectronics, and Texas Instruments
All rights reserved.**

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

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

iTeh STANDARD PREVIEW

INTELLECTUAL PROPERTY DISCLAIMER

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

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

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

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

CONTENTS

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

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

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

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

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

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

FIGURES

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

Figure 3-15	Illustration of the Latch Soldered to the Paddle Card Ground.....	64
Figure 3-16	Reference Design of the USB Full-Featured Type-C Plug Internal EMC Spring.....	65
Figure 3-17	Reference Design of the <i>USB 2.0</i> Type-C Plug Internal EMC Spring	66
Figure 3-18	Reference Design of Internal EMC Pad	67
Figure 3-19	Reference Design of a USB Type-C Receptacle with External EMC Springs.....	68
Figure 3-20	Reference Design for a USB Full-Featured Type-C Plug Paddle Card	69
Figure 3-21	Illustration of a USB Full-Featured Type-C Cable Cross Section, a Coaxial Wire Example with VCONN.....	72
Figure 3-22	Illustration of a USB Full-Featured Type-C Cable Cross Section, a Coaxial Wire Example without VCONN.....	72
Figure 3-23	USB Full-Featured Type-C Standard Cable Assembly.....	76
Figure 3-24	USB Type-C to USB 3.1 Standard-A Cable Assembly	79
Figure 3-25	USB Type-C to <i>USB 2.0</i> Standard-A Cable Assembly.....	80
Figure 3-26	USB Type-C to <i>USB 3.1</i> Standard-B Cable Assembly.....	81
Figure 3-27	USB Type-C to <i>USB 2.0</i> Standard-B Cable Assembly.....	82
Figure 3-28	USB Type-C to <i>USB 2.0</i> Mini-B Cable Assembly.....	83
Figure 3-29	USB Type-C to <i>USB 3.1</i> Micro-B Cable Assembly.....	84
Figure 3-30	USB Type-C to <i>USB 2.0</i> Micro-B Cable Assembly.....	86
Figure 3-31	USB Type-C to <i>USB 3.1</i> Standard-A Receptacle Adapter Assembly.....	87
Figure 3-32	USB Type-C to <i>USB 2.0</i> Micro-B Receptacle Adapter Assembly.....	89
Figure 3-33	Illustration of Test Points for a Mated Cable Assembly	91
Figure 3-34	Recommended Differential Insertion Loss Requirement (USB 3.2 Gen2 and USB4 Gen2).....	92
Figure 3-35	Recommended Differential Return Loss Requirement	92
Figure 3-36	Recommended Differential Crosstalk Requirement.....	93
Figure 3-37	Recommended Differential Near-End and Far-End Crosstalk Requirement between USB D+/D- Pair and TX/RX Pair.....	94
Figure 3-38	Recommended Differential Insertion Loss Requirement (USB4 Gen3).....	94
Figure 3-39	Illustration of Insertion Loss Fit at Nyquist Frequency	95
Figure 3-40	Input Pulse Spectrum.....	96
Figure 3-41	IMR Limit as Function of ILfitatNq.....	97
Figure 3-42	IRL Limit as Function of ILfitatNq	99
Figure 3-43	Differential-to-Common-Mode Conversion Requirement	99
Figure 3-44	IMR Limit as Function of ILfit at 10 GHz (USB4 Gen3).....	100
Figure 3-45	Definition of Port, Victim, and Aggressor	101
Figure 3-46	I _X T _{DP} and I _X T _{USB} Limit as Function of ILfit at 10 GHz (USB4 Gen3).....	101
Figure 3-47	IRL Limit as Function of ILfitatNq (USB4 Gen3)	102
Figure 3-48	Differential-to-Common-Mode Conversion Requirement (USB4 Gen3).....	102
Figure 3-49	Cable Assembly in System	103
Figure 3-50	Requirement for Differential Coupling between CC and D+/D-	105
Figure 3-51	Requirement for Single-Ended Coupling between CC and D- in USB 2.0 Type-C Cables.....	105
Figure 3-52	Requirement for Single-Ended Coupling between CC and D- in USB Full-Featured Type-C Cables	106
Figure 3-53	Requirement for Differential Coupling between V _{BUS} and D+/D-.....	106
Figure 3-54	Requirement for Single-Ended Coupling between SBU_A and SBU_B.....	107
Figure 3-55	Requirement for Single-Ended Coupling between SBU_A/SBU_B and CC.....	108
Figure 3-56	Requirement for Coupling between SBU_A and differential D+/D-, and SBU_B and differential D+/D-.....	108
Figure 3-57	Illustration of USB Type-C Mated Connector.....	109
Figure 3-58	Recommended Impedance Limits of a USB Type-C Mated Connector	110
Figure 3-59	Recommended Ground Void Dimensions for USB Type-C Receptacle.....	111
Figure 3-60	Recommended Differential Near-End and Far-End Crosstalk Limits between D+/D- Pair and TX/RX Pairs	112
Figure 3-61	Recommended Limits for Differential-to-Common-Mode Conversion.....	113
Figure 3-62	IMR Limit as Function of ILfitatNq for USB Type-C to Legacy Cable Assembly	117
Figure 3-63	IRL Limit as Function of ILfitatNq for USB Type-C to Legacy Cable Assembly.....	117
Figure 3-64	Cable Assembly Shielding Effectiveness Testing	120