ICS 33.120.20, 33.120.30, 35.200

SLOVENSKÁ TECHNICKÁ NORMA

Máj 2025

STN

Rozhrania univerzálnej sériovej zbernice pre dáta a napájanie Časť 1-3: Spoločné súčasti Špecifikácia USB kábla a konektora typu C®

STN
EN IEC 62680-1-3

36 8365

Universal serial bus interfaces for data and power - Part 1-3: Common components - USB Type-C® cable and connector specification

Táto norma obsahuje anglickú verziu európskej normy.
This standard includes the English version of the European Standard.

Táto norma bola oznámená vo Vestníku ÚNMS SR č. 04/25

Obsahuje: EN IEC 62680-1-3:2025, IEC 62680-1-3:2024

Oznámením tejto normy sa od 31.01.2028 ruší
STN EN IEC 62680-1-3 (36 8365) z januára 2023

obsahuje farebné strany

140369

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN IEC 62680-1-3

January 2025

ICS 33.120.20; 33.120.30; 35.200

Supersedes EN IEC 62680-1-3:2022

English Version

Universal serial bus interfaces for data and power - Part 1-3: Common components - USB Type-C(r) cable and connector specification (IEC 62680-1-3:2024)

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(r)
(IEC 62680-1-3:2024)

Universelle Bus-Schnittstellen für Daten und Energie - Teil 1-3: Gemeinsame Komponenten - Festlegung für USB Type-C Kabel und Steckverbindung
(IEC 62680-1-3:2024)

This European Standard was approved by CENELEC on 2025-01-17. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

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

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

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

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

Ref. No. EN IEC 62680-1-3:2025 E

European foreword

The text of document 100/4139/CDV, future edition 6 of IEC 62680-1-3, prepared by TC 100/Technical Area 18 "Multimedia home systems and applications for end-user networks" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 62680-1-3:2025.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2026-01-31
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2028-01-31

This document supersedes EN IEC 62680-1-3:2022 and all of its amendments and corrigenda (if any).

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

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

Endorsement notice

The text of the International Standard IEC 62680-1-3:2024 was approved by CENELEC as a European Standard without any modification.

IEC 62680-1-3

Edition 6.0 2024-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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®

IEC 62680-1-3:2024-12(en-fr)

IEC 62680-1-3

Edition 6.0 2024-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

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

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 Editor 21
Specification Work Group Contributors 21
Pre-Release Draft Industry Reviewing Companies That Provided Feedback 29
Revision History 29
1 Introduction 30
1.1 Purpose 30
1.2 Scope 30
1.3 Related Documents 30
1.4 Conventions 31
1.4.1 Precedence 31
1.4.2 Keywords 31
1.4.3 Numbering 32
1.5 Terms and Abbreviations 32
2 Overview 37
2.1 Introduction 37
2.2 USB Type-C Receptacles, Plugs and Cables 38
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 Extensions 42
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 Assemblies 44
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 Interfaces 46
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 (*Informative*) 75
3.3.2 Wire Assignments 77
3.3.3 Wire Gauges and Cable Diameters (*Informative*) 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 (*Informative*) 93
3.7.2 USB Type-C to USB Type-C Passive Cable Assemblies 94
3.7.3 Mated Connector (*Informative – USB 3.2* Gen2 and *USB4* Gen2) 116
3.7.4 Receptacle Connector SI Requirements and Testing (*Normative – USB4* Gen3/Gen4) 120
3.7.5 USB Type-C to USB Legacy Cable Assemblies (*Normative*) 122
3.7.6 USB Type-C to USB Legacy Adapter Assemblies (*Normative*) 126
3.7.7 Shielding Effectiveness Requirements (*Normative*) 129
3.7.8 DC Electrical Requirements (*Normative*) 131
3.8 Mechanical and Environmental Requirements (*Normative*) 133
3.8.1 Mechanical Requirements 134
3.8.2 Environmental Requirements 139
3.9 Docking Applications (*Informative*) 140
3.10 Implementation Notes and Design Guides 141
3.10.1 EMC Management (*Informative*) 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 *USB4* Discovery and Entry 245
5.1 Overview of the Discovery and Entry Process 245
5.2 *USB4* Functional Requirements 246
5.2.1 *USB4* Host Functional Requirements 246
5.2.2 USB Device Functional Requirements 246
5.2.3 *USB4* Alternate Mode Support 246
5.3 *USB4* 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 *USB4* 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 *USB4* Discovery and Entry Flow 248
5.4.4 *USB4* Post-Entry Operation 253
5.5 *USB4* Hub Connection Requirements 254
5.5.1 *USB4* Hub Port Initial Connection Requirements 254
5.5.2 *USB4* 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 *USB4* Hubs 261
5.5.6 Fallback Functional Requirements for *USB4* Hubs 261
5.6 *USB4* Device Connection Requirements 261
5.6.1 Fallback Mapping of *USB4* 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 Diagram 300
6.2.2 *USB4* Asymmetric Mode Support 300
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 Cables 301
6.3.1 OIAC Block Diagrams 302
6.3.2 OIAC Limitations and General Requirements 304
6.3.3 OIAC Cable Power Requirements 305
6.3.4 OIAC *USB PD* Requirements 305
6.3.5 OIAC Connection Flow and State Diagrams 315
6.3.6 Additional Electrical Requirements for OIAC 333
6.3.7 Additional Mechanical Requirements for OIAC 336
A Liquid Corrosion Mitigation Mode 337
A.1 Overview 337
A.2 Detail 337
A.3 Liquid Detection Methods 339
A.3.1 Liquid Measurement Method 339
A.3.2 Pulsed Measurement Method 339
A.3.3 Impedance Measurement Method 340
A.4 Liquid Detection Pins in the Connector 343
B Debug Accessory Mode 346
B.1 Overview 346
B.2 Functional 346
B.2.1 Signal Summary 346
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 Requirements 365
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 Introduction 367

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 Responses 398
F.2.7 *TBT3* Cable Enter Mode Command 399
F.2.8 *TBT3* Device Enter Mode Command 400
F.2.9 *TBT3* Cable Functional Difference Summary 402
G Extracting Pulse Response from Sampled Data and Calculating Non-Linearity Noise 403
H *USB PD* High-Voltage Design Considerations 405
H.1 Potential for Arcing Damage During Cable Withdrawal 405
H.2 Arcing During USB Type-C Cable Withdrawal 405
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 Removal 409
H.3.3 Limiting Source Current Capability 412
I *USB PD* Encoding Guidelines for USB Type-C Product Types 413
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 Specification 426

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 *USB 2.0* Type-C Through Hole Right Angle Receptacle (*Informative*) 61
Figure 3-10 Reference Footprint for a *USB 2.0* Type-C Single Row Right Angle Receptacle (*Informative*) 62
Figure 3-11 *USB 2.0* 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 *USB 2.0* 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 *USB 3.1* Standard-A Cable Assembly 84
Figure 3-25 USB Type-C to *USB 2.0* Standard-A Cable Assembly 85
Figure 3-26 USB Type-C to *USB 3.1* Standard-B Cable Assembly 86
Figure 3-27 USB Type-C to *USB 2.0* Standard-B Cable Assembly 87
Figure 3-28 USB Type-C to *USB 2.0* Mini-B Cable Assembly 88
Figure 3-29 USB Type-C to *USB 3.1* Micro-B Cable Assembly 89
Figure 3-30 USB Type-C to *USB 2.0* Micro-B Cable Assembly 90
Figure 3-31 USB Type-C to *USB 3.1* Standard-A Receptacle Adapter Assembly 91
Figure 3-32 USB Type-C to *USB 2.0* 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 (*USB 3.2* Gen2 and *USB4* 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 (*USB4* 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 (*USB4* 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 (*USB4* Gen3/Gen4) 107
Figure 3-47 IRL Limit as Function of ILfit at 10 GHz (*USB4* Gen3/Gen4) 108
Figure 3-48 Differential-to-Common Mode Conversion Requirement (*USB4* 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 *USB 2.0* 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 *USB PD* over CC Pins 224
Figure 4-39 *USB PD* 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 *USB PD*-based Charger USB Type-C Cable's Output as a Function of Load 229
Figure 4-42 3 – 5 A *USB PD*-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 *USB4* Discovery and Entry Flow Model 249
Figure 5-2 *USB4* Hub with *USB4* Host and Device Connection Flow Alignment 256
Figure 5-3 *USB4* Hub with *USB 3.2* Host and *USB4* Device Connection Flow Alignment 257
Figure 5-4 *USB4* Hub with *USB4* Host and *USB 3.2* Device Connection Flow Alignment 258
Figure 5-5 *USB4* Hub with *USB 3.2* Host and Device Connection Flow Alignment 259
Figure 5-6 *USB4* Hub with *USB4* Host and DP Alt Mode Device Connection Flow Alignment 260
Figure 5-7 *USB4* Hub with *USB 3.2* 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 *ILfitatNq* 283
Figure 6-12 Gain Parameters for *USB4* Gen4 LRD Active Cables 286
Figure 6-13 *USB4* LRD Active Cable Snooping of TxFFE Negotiation 291
Figure 6-14 *USB4* State Machine per Channel (*Informative*) 292
Figure 6-15 *USB4* Gen4 CL1/CL2 Exit Flow with LRD Active Cable 294
Figure 6-16 *USB4* Symmetric to Asymmetric Transition 295
Figure 6-17 *USB4* Asymmetric to Symmetric Transition 297
Figure 6-18 OIAC *USB PD* 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_O and Thermal Boundary Temperature T_{MB} at 3 A VBUS in a Single Port Configuration 374
Figure D-10 Impact of Overmold Power P_O 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 Requirements 136
Table 3-39 Environmental Test Conditions 139
Table 3-40 Reference Materials 140
Table 4-1 USB Type-C List of Signals 146
Table 4-2 VBUS Source Characteristics 149
Table 4-3 VBUS Sink Characteristics 149
Table 4-4 USB Type-C Source Port's VCONN Requirements Summary 150
Table 4-5 VCONN Source Characteristics 150
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 Characteristics 153
Table 4-9 USB Type-C Port Interoperability 156
Table 4-10 Source Perspective 158
Table 4-11 Source (Host) and Sink (Device) Behaviors by State 158
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 Summary 166
Table 4-16 Source Port CC Pin State 175
Table 4-17 Sink Port CC Pin State 175
Table 4-18 Mandatory and Optional States 200
Table 4-19 Precedence of Power Source Usage 220
Table 4-20 USB Type-C Current Advertisement and PDP Equivalent 222
Table 4-21 Sink Maximum Current Limit When Attached to CTVPD 225
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" Timing 235
Table 4-25 Charge-Through VPD CC Impedance (RccCON) Requirements 237
Table 4-26 CTVPD Charge-Through Port VBUS Bypass Requirements 237
Table 4-27 Source CC Termination (Rp) Requirements 238
Table 4-28 Sink CC Termination (Rd) Requirements 239
Table 4-29 Powered Cable Termination Requirements 239
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 Parameters 242
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 Advertisements 244
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 *USB4* Device Entry Failure....263
Table 6-1 *USB4* 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 *USB 3.2* U0 Delay....269
Table 6-6 *USB 3.2* U-State Requirements....269
Table 6-7 Active Cable *USB 3.2* Stressed Source Swing, TP1....271
Table 6-8 Active Cable *USB 3.2* Stressed Source Jitter, TP1....271
Table 6-9 Active Cable *USB 3.2* Input Swing at TP2 (*Informative*)....272
Table 6-10 Active Cable *USB 3.2* Output Swing at TP3 (*Informative*)....272
Table 6-11 Compliance Points Definition....273
Table 6-12 *USB4* CL-State Requirements for Active Cables....274
Table 6-13 Re-timer-based *USB4* Active Cable Output Specifications Applied for All Speeds (at TP3')....276
Table 6-14 Stressed Receiver Conditions for *USB4* 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 *USB4* Gen4 LRD-based Active Cable ILfitMask Limits....285
Table 6-18 *USB4* Gen4 LRD-based Active Cable Wiring Diagram for Compliance....287
Table 6-19 *USB4* Gen4 Active Cable SBx Transaction Snooping....288
Table 6-20 *USB4* LRD Active Cable Logical Timing Parameters....289
Table 6-21 *USB4* LRD Tuning Register Snooping....298
Table 6-22 Cable Temperature Requirements....299
Table 6-23 OIAC *USB PD* 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 *USB PD* Message Timing....311
Table 6-28 Port and Plug Capabilities....316
Table 6-29 *USB 3.2* U-State Requirements....335
Table 6-30 *USB4* 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 *USB 3.2* Active Cable Design Single Port Case Study at 35 °C Ambient and 60 °C Thermal Boundary (Single Lane)....370
Table D-3 *USB 3.2* 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 *TBT3* Passive Cable Discovery Identity VDO Responses....390
Table F-2 *TBT3* Passive Cable VDO for *USB PD* Revision 2.0, Version 1.3....391
Table F-3 *TBT3* Passive Cable VDO for *USB PD* Revision 3.0, Version 1.2....391
Table F-4 *TBT3* Active Cable Discovery Identity VDO Responses....392
Table F-5 *TBT3* Active Cable VDO for *USB PD* Revision 2.0, Version 1.3....393
Table F-6 *TBT3* Active Cable VDO 1 for *USB PD* Revision 3.0, Version 1.2....393
Table F-7 *TBT3* Active Cable VDO 2 for *USB PD* Revision 3.0, Version 1.2....394
Table F-8 *TBT3* Device Discovery Identity VDO Responses....395

Table F-9 *TBT3* Discover SVID VDO Responses....396
Table F-10 *TBT3* Device Discover Mode VDO Responses....397
Table F-11 *TBT3* Cable Discover Mode VDO Responses....398
Table F-12 *TBT3* Cable Enter Mode Command....399
Table F-13 *TBT3* Device Enter Mode Command....400
Table F-14 *TBT3* 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 *USB PD* 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
	Zhinenng 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	Dariusz Kaczmarczyk	Neelabh Singh
	Huzaifa Dalal	Tomasz Klimek	Michal Staworko
	Pawel Eichler	Sanjeet Kumar	Fred Stivers
	Sanjai Gandhi	Jie Min	Mark Summers
	Sathish Kumar Ganesan	Asila Nahas	Claire Ying
		Uyen Nguyen	
Canova Tech	Piergiorgio Beruto	Michael Marioli	Paola Pilla
	Andrea Maniero	Antonio Orzelli	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	Yasuo Hidaka	Ping Xiong
	Yifei Dai	Justin Lee	
	Kevin Gao	Phil Sun	
Cypress Semiconductor	Chia Hua Chang	Rushil Kadakia	Jagadeesan Raj
	Mark Fu	Benjamin Kropf	Sanjay Sancheti
	Naman Jain	Venkat Mandagulathur	Subu Sankaran
	Savan Javia	Anup Nayak	Anita Thimma Govarthanarajan
Dell	Mohammed Hijazi	Ken Nicholas	Thomas Voor
	David Meyers	Ernesto Ramirez	Merle Wood
	Sean O'Neal	Siddhartha Reddy	
Dialog Semiconductor (UK) Ltd.	Yimin Chen		
Diodes Incorporated	Kay Annamalai	Bob Lo	Jin-sheng Wang
	Justin Lee	Jaya Shukla	Ada Yip
	Paul Li	Qun Song	
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	Wenhui Luo	Chuck Trefts
	Rick Bogart	Mario Pasquali	Tim Wei
Etron Technology, Inc.	Chien-Cheng Kuo		
EverPro Technologies Company, Ltd.	Hui Jiang	Silane Zhou	
Feature Integration Technologies Inc.	Jacky Chan	KungAn Lin	Paul Yang
	Chen Kris	Yuchi Tsao	Amanda Ying
	Yulin Lan		

Foxconn / Hon Hai	Patrick Casher	Fred Fons	Christine Tran
	Asroc Chen	Chris Goralka	Pei Tsao
	Brandon Chen	Bob Hall	AJ Yang
	Joe Chen	Chien-Ping Kao	Yuan Zhang
	Allen Cheng	Ji Li	Jessica Zheng
	Jason Chou	Ann Liu	Jie Zheng
	Edmond Choy	Terry Little	Andy Yao
	Shruti Deore	Steve Sedio	
Foxlink/Cheng Uei Precision Industry Co., Ltd.	Robert Chen	Armando Lee	Steve Tsai
	Sunny Chou	Dennis Lee	Wen Yang
	Carrie Chuang	Justin Lin	Wiley Yang
	Wen-Chuan Hsu	Robert Lu	Junjie Yu
	Alex Hsue	Tse Wu Ting	
Fresco Logic Inc.	Brian Collins	Bob McVay	Christopher Meyers
Google	Naga Viswanadha Udaya Kiran Ammu	Eric Herrmann	Vincent Palatin
	Alec Berg	Nithya Jagannathan	Dylan Reid
	Joshua Boilard	Nathan Kolluru	Adam Rodriguez
	Alec Berg	Lawrence Lam	David Schneider
	Todd Broch	Adam Langley	Stephan Schooley
	Chao Fei	Benson Leung	Toshak Singhal
	Jim Guerin	Abraham Levkoy	Jameson Thies
	Jeffrey Hayashida	Ingrid Lin	Ken Wu
	Mark Hayter	Prashant Malani	Songping Wu
		Richard Palatin	Diana Zigterman
Granite River Labs	Yung Han Ang	Mike Engbretson	Kristof Mommen
	Velmurugan Ayyakkannu	Mark Jiang	Krishna Murthy
	Rajesh B	Vishal Kakade	Amy Peng
	Pascal Berten	Jesson Li	Johnson Tan
	Hariprasad Bhat	Caspar Lin	Annie Tao
	Sandy Chang	Olivia Lu	Vasudev Uttharahalli
	Allen Chen	Bala M	Chin Hun Yaep
	Swee Guan Chua	Prasannakumar Marikunte Nagaraju	Mike Yang
	Alan Chuang	Winson Mok	Yun Yang
GuangDong OPPO Mobile Telecommunications Corp, Ltd.	Jerry Qin		
Honor Device Co., Ltd.	Wang Feng		
Hirose Electric Co., Ltd.	Jeremy Buan	William MacKillop	Eungsoo Shin
	William Kysiak	Gourgen Oganessyan	Sid Tono
	Sang-Muk Lim		
Hosiden Corporation	Takahisa Otsuji	Fumitake Tamaki	
HP Inc. (USB Promoter company)	Lee Atkinson	Robin Castell	Jim Mann
	Srinath Balaraman	Steve Chen	Linden McClure
	Rami Bathaniah	Michael Krause	Mike Pescetto
	Roger Benson	Rahul Lakdawala	Asjad Shamim
	Alan Berkema		
Huawei Technology Co., Ltd.	Jianhong He	Gang Liang	Liansheng Zheng
	Zhengbing Li		

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

Monolithic Power Systems	Junyong Gong	Istvan Nagy	Greg Virnig
	Di Han	Chris Sporck	Vincent Wu
	Yuncong Jiang	Ao Sun	
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	Samuli Makinen	Timo Toivola
	Pekka Leinonen	Pekka Talmola	Panu Ylihaavisto
Nuvoton Technology Corp.	Nimrod Peled		
NVIDIA	Jamie Aitken		
NXP Semiconductors	Mahmoud EL Sabbagh	Nate Johnson	Guru Prasad
	Dennis Ha	Vijendra Kuroodi	Wouter Sijm
	Ken Jaramillo	Roger Lo	Krishnan TN
Oculus VR LLC	Amish Babu	Marty Evans	Joaquin Fierro
ON Semiconductor	Edward Berrios	Oscar Freitas	Eric Maier
	Rod Comer	Christian Klein	Rick Pierce
	Eduardo De Reza	Amir Lahooti	Michael Smith
	Alan Finkel		
Parade Technologies, Inc.	Jian Chen	Craig Wiley	Alan Yuen
	Brian Collins	Paul Xu	Jingfan Zhang
	Robert McVay		
Power Integrations	Shruti Anand	Aditya Kulkarni	Amruta Patra
	Daryll Bonavente	Akshay Nayaknur	Kaushik Raam
	Rahul Joshi		
Qualcomm, Inc.	Lior Amarilio	James Goel	Vatsal Patel
	Vara Prasad Arikatla	Amit Gupta	Jack Pham
	Aris Balatsos	Philip Hardy	Vamsi Samavedam
	Nicholas Cadieux	Will Kun	Matthew Sienko
	David Chang	Jonathan Luty	Dmitrii Vasilchenko
	Tomer Ben Chen	Adi Menachem	Joshua Warner
	Richard Burrows	Lalan Mishra	Chris Wiesner
	Amit Gil	George Paparrizos	
Realtek Semiconductor Corp.	Marco Chiu	Ty Kingsmore	Terry Lin
	Tsung-Peng Chuang	Ray Lee	Chuting Su
	Charlie Hsu	Jay Lin	Jason Wang
	Fan-Hau Hsu	Ryan Lin	Changhung Wu
Renesas Electronics Corp. (USB Promoter company)	Kai Bao	Philip Leung	Yosuke Sasaki
	Yen-Mo Chen	Mengfei Liu	Toshifumi Yamaoka
	Yimin Chen	Kiichi Muto	Fengshuan Zhou
	Nobuo Furuya	Ziba Nami	Yuhuan Zhou
	Tony Lai	Hajime Nozaki	
Richtek Technology Corp.	Ben Chiang	Max Huang	Ken Shih
	Tzuhsien Chuang	Leo Kang	Alex Yang
	Bryan Huang	Roger Lo	
Rohde & Schwarz GmbH & Co. KG	Curtis Donahue	Martin Stumpf	Randy White
	Kai Uwe Schmidt		

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

Synopsys, Inc.	Prishkrit Abrol	Morten Christiansen	Satya Patnala
	Subramaniam Aravindhan	Jaspreet Gambhir	John Stonick
		Nivin George	
Taiwan Testing and Certification Center	Sophia Liu		
Tektronix, Inc.	Sourabh Das	Nitin Jhanwar	Randy White
	Mark Guenther	Abhijeet Shinde	
Texas Instruments (USB Promoter company)	Jawaid Ahmad	Michael Koltun IV	Louis Peryea
	Kasthuri Annamalai	Kevin Kosta	Brian Quach
	Mike Campbell	Yoon Lee	Sai Karthik Rajaraman
	Prajith Cheerakkoda	Grant Ley	Wes Ray
	Greg Collins	Win Maung	Dafydd Roche
	Gary Cooper	Shafiuddin Mohammed	Anwar Sadat
	Biju Erayamkot Panayamthatta	Lauren Moore	Cory Stewart
	Anant Gole	Jacob Ontiveros	Sue Vining
	GP Gopalakrishnan	Brian Parten	Bill Waters
	Craig Greenberg	Martin Patoka	Deric Waters
	Richard Hubbard	Jason Peck	Gregory Watkins
	Nate Johnson	John Perry	Roy Wojciechowski
Thine Electronica, Inc.	Yuseke Fujita	Shuhei Yamamoto	
Total Phase	Chris Yokum		
Trinity Co., Ltd.	Tetsushi Hoshikawa	Kinya Kishita	
Tyco Electronics Corp. (TE Connectivity Ltd.)	Max Chao	Mike Lockyer	Hiroshi Shirai
	Robert E. Cid	Jeff Mason	Hidenori Taguchi
	Calvin Feng	Takeshi Nakashima	Nathan Tracy
	Kengo Ijiro	Luis A. Navarro	Bernard Vetten
	Eiji Ikematsu	Masako Saito	Ryan Yu
	Joan Leu	Yoshiaki Sakuma	Noah Zhang
	Clark Li	Gavin Shih	Sjoerd Zwartkruis
UL LLC	Leo Chung	Dylan Su	Eric Wall
	Michael Hu	Henry Tsou	Lance Yang
	Terry Kao	Paul Vanderlaan	Chien-Wei Yeh
Unigraf OY	Steven Chen	Alexander Gushchin	Topi Lampiranta
	Sergey Grushin		
Varjo Technologies	Kai Inha		
Ventev Mobile	Brad Cox	Colin Vose	
VIA Technologies Inc.	Terrance Shih	Jay Tseng	Fong-Jim Wang
Weltrend Semiconductor	Hung Chiang	Wayne Lo	Eric Wu
	Jeng Cheng Liu	Ho Wen Tsai	
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 *deprecating* the ***Audio Adapter Accessory Mode*** and *replacing it with* 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.

USB 3.2 ***Universal Serial Bus Revision 3.2 Specification***
This includes the entire document release package.
USB 3.1 Legacy Cable and Connector Specification, Revision 1.0

USB4 ***USB4 Specification, Version 2.0, October 2022***
(including posted errata and ECNs)

TBT3 *Chapter 13 of* ***USB4 Specification, Version 2.0, October 2022***

USB PD ***USB Power Delivery Specification, Revision 2.0, Version 1.3, January 12, 2017***
USB Power Delivery Specification, Revision 3.2, Version 1.0, October 2023
(including posted errata and ECNs)

USB BB ***USB Billboard Device Class Specification, Revision 1.2.2, January 29, 2021***

USB BC ***Battery Charging Specification, Revision 1.2, March 15, 2012***
(including posted errata and ECNs)

DP AM ***DisplayPort™ Alt Mode on USB Type-C Standard, Version 2.1, October 2022***

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

1.4 Conventions

1.4.1 Precedence

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

1.4.2 Keywords

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

1.4.2.1 Informative

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

1.4.2.2 May

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

1.4.2.3 May Not

May not is a keyword that is the inverse of ***May***. Indicates a choice to not implement a given feature with no implied preference.

1.4.2.4 N/A

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

1.4.2.5 Normative

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

1.4.2.6 Optional and Optionally

Optional and ***Optionally*** are equivalent keywords that describe features not mandated by this specification. However, if an ***optional*** feature is implemented, the feature ***shall*** be implemented as defined by this specification (***optional normative***).

1.4.2.7 Reserved

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

1.4.2.8 Shall

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

1.4.2.9 Shall Not

Shall not is a keyword that is the inverse of ***Shall*** indicating non-compliant operation.

1.4.2.10 Should

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

1.4.2.11 Should Not

Should not is a keyword that is the inverse of ***Should***. Equivalent to the phrase “it is recommended that implementations do not ...”.

1.4.3 Numbering

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