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Part 1-2: Common components - USB Power Delivery specification

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

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

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

Draft	Report on voting
100/4327/CDV	100/4380/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.

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Universal Serial Bus

Power Delivery Specification

Revision:	***3.2***
Version:	***1.1***
Release Date:	***2024-10***

Revision History

Revision	Version	Comments	Issue Date
1.0	1.0	Initial release Revision 1.0	5 July, 2012
1.0	1.1	Including errata through 31-October-2012	31 October 2012
1.0	1.2	Including errata through 26-June-2013	26 June, 2013
1.0	1.3	Including errata through 11-March-2014	11 March 2014
2.0	1.0	Initial release Revision 2.0	11 August 2014
2.0	1.1	Including errata through 7-May 2015	7 May 2015
2.0	1.2	Including errata through 25-March-2016	25 March 2016
2.0	1.3	Including errata through 11-January-2017	11 January 2017
3.0	1.0	Initial release Revision 3.0	11 December 2015
3.0	1.0a	Including errata through 25-March-2016	25 March 2016
3.0	1.1	Including errata through 12-January-2017	12 January 2017
3.0	1.2	Including errata through 21-June-2018	21 June 2018
3.0	2.0	Including errata through 29-August-2019	29 August 2019
3.1	1.0	Including errata through May 2021	May 2021
3.1	1.1	Including errata through July 2021 This version incorporates the following ECNs: • EPR Clarifications • Define AMS starting point	July 2021
3.1	1.2	Including errata through October 2021 This version incorporates the following ECNs: • Clarify use of Retries • Battery Capabilities • FRS timing problem • PPS power rule clarifications • Peak current support for EPR AVS APDO	October 2021
3.1	1.3	This version incorporates the following ECNs: • Robust EPR Source Operation • EPR Source Caps Editorial • SRC PPS behavior in low current request • Enter USB	January 2022
3.1	1.4	Editorial changes This version incorporates the following ECNs: • Capabilities Mismatch Update • Chunking Timing Issue • OT Mitigation	April 2022

Revision	Version	Comments	Issue Date
3.1	1.5	Editorial changes This version incorporates the following ECNs: • Timer Description Corrections • Change Source_Info Requirements • AMS Update	July 2022
3.1	1.6	Editorial changes This version incorporates the following ECNs: • USB4® V2 Updates • Data Reset Issues • Increase tSenderResponse • PPS Power Limit Bit Update • Support for Asymmetric Mode • Timer Description Corrections Revisited	October 2022
3.1	1.7	Editorial Changes This version incorporates the following ECNs: • Data Reset Invalid Reject Handling • Source request • Source Transition • EPR Entry	January 2023
3.1	1.8	Editorial Changes This version incorporates the following ECNs: • Slew rate exemption for Power Role Swap. • EUDO cable speed clarification. • Update to PPS Requirements. • Deprecate Interruptibility. • Section 7.3 restructure and update.	April 2023
3.1	1.9	Editorial Changes	July 2023

Revision	Version	Comments	Issue Date
3.2	1.0	This version incorporates the following ECNs: • VDM-use Conditions. • tTypeCSinkWaitCap. • tFirstSourceCap Clarification • Hard Reset Clarification. • Unrecognized Country Code • EPR Entry Process-1 • SPR AVS Definition • EPR Power Rules Clarifications	October 2023
3.2	1.1	This version incorporates the following ECNs: • Power Transition time from EPR to PR_Swap • Capabilities Mismatch Update • Deprecate GotoMin and GiveBack Features and Update Power Reserve • EPR Entry requirements Clarification • EPRMDO and Entry Clarification. • Remove 10.2.4 power sharing between ports • Source PDP rating field clarifications • Source Power Rules update. • Source_Info Message Clarifications. • Correction to BMC description. • EPR Source cap clarification. • Delaying of VCONN Swap. • EPR_Request in SPR Mode. • Generic transition diagram. • Removing the usage of Ping message • Sink Standby • Source Info Support	October 2024

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Editors

Bob Dunstan
Richard Petrie

Contributors

Charles Wang	ACON, Advanced-Connectek, Inc.	Zaki Moussaoui	Apple
Conrad Choy	ACON, Advanced-Connectek, Inc.	Jeff Liu	ASMedia Technology Inc.
Dennis Chuang	ACON, Advanced-Connectek, Inc.	Kuo Lung Li	ASMedia Technology Inc.
Steve Sedio	ACON, Advanced-Connectek, Inc.	Ming-Wei Hsu	ASMedia Technology Inc.
Sunney Yang	ACON, Advanced-Connectek, Inc.	PS Tseng	ASMedia Technology Inc.
Vicky Chuang	ACON, Advanced-Connectek, Inc.	Sam Tzeng	ASMedia Technology Inc.
Joseph Scanlon	Advanced Micro Devices	Thomas Hsu	ASMedia Technology Inc.
Sujan Thomas	Advanced Micro Devices	Weikao Chang	ASMedia Technology Inc.
Caspar Lin	Allion Labs, Inc.	Yang Cheng	ASMedia Technology Inc.
Casper Lee	Allion Labs, Inc.	Aaron Hou	Bizlink Technology Inc.
Danny Shih	Allion Labs, Inc.	Shawn Meng	Bizlink Technology Inc.
Howard Chang	Allion Labs, Inc.	Bernard Shyu	Bizlink Technology, Inc.
Greg Stewart	Analogix Semiconductor, Inc.	Eric Wu	Bizlink Technology, Inc.
Mehran Badii	Analogix Semiconductor, Inc.	Morphy Hsieh	Bizlink Technology, Inc.
Alexei Kosut	Apple	Sean O'Neal	Bizlink Technology, Inc.
Bill Cornelius	Apple	Tiffany Hsiao	Bizlink Technology, Inc.
Carlos Colderon	Apple	Weichung Ooi	Bizlink Technology, Inc.
Chris Uiterwijk	Apple	Rahul Bhushan	Broadcom Corp.
Colin Whitby-Strevens	Apple	Asila nahas	Cadence Design Systems, Inc.
Corey Axelowitz	Apple	Claire Ying	Cadence Design Systems, Inc.
Corey Lange	Apple	Jie min	Cadence Design Systems, Inc.
Dave Conroy	Apple	Mark Summers	Cadence Design Systems, Inc.
David Sekowski	Apple	Michal Staworko	Cadence Design Systems, Inc.
Girault Jones	Apple	Sathish Kumar Ganesan	Cadence Design Systems, Inc.
James Orr	Apple	Alessandro Ingrassia	Canova Tech
Jason Chung	Apple	Andrea Colognese	Canova Tech
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Kevin Hsiue	Apple	Paolo Pilla	Canova Tech
Matt Mora	Apple	Ray Huang	Canyon Semiconductor
Paul Baker	Apple	Yi-Feng Lin	Canyon Semiconductor
Reese Schreiber	Apple	YuHung Lin	Canyon Semiconductor
Ricardo Janezic Pregitzer	Apple	David Tsai	Chrontel, Inc.
Ruchi Chaturvedi	Apple	Anshul Gulati	Cypress Semiconductor
Sameer Kelkar	Apple	Anup Nayak	Cypress Semiconductor
Sasha Tietz	Apple	Benjamin Kropf	Cypress Semiconductor
Scott Jackson	Apple	Dhanraj Rajput	Cypress Semiconductor
Sree Raman	Apple	Ganesh Subramaniam	Cypress Semiconductor
William Ferry	Apple	Jagadeesan Raj	Cypress Semiconductor

Junjie cui	Cypress Semiconductor	Chien-Cheng Kuo	eEver Technology, Inc.
Manu Kumar	Cypress Semiconductor	Shyanjia Chen	eEver Technology, Inc.
Muthu M	Cypress Semiconductor	Abel Astley	Ellisys
Nicholas Bodnaruk	Cypress Semiconductor	Chuck Trefts	Ellisys
Pradeep Bajpai	Cypress Semiconductor	Emmanuel Durin	Ellisys
Rajaram R	Cypress Semiconductor	Mario Pasquali	Ellisys
Rama Vakkantula	Cypress Semiconductor	Tim Wei	Ellisys
Rushil Kadakia	Cypress Semiconductor	Chien-Cheng Kuo	Etron Technology, Inc.
Simon Nguyen	Cypress Semiconductor	Jack Yang	Etron Technology, Inc.
Steven Wong	Cypress Semiconductor	Richard Crisp	Etron Technology, Inc.
Subu Sankaran	Cypress Semiconductor	Shyanjia Chen	Etron Technology, Inc.
Sumeet Gupta	Cypress Semiconductor	TsungTa Lu	Etron Technology, Inc.
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Venkat Mandagulathar	Cypress Semiconductor	Oscar Freitas	Fairchild Semiconductor
Xiaofeng Shen	Cypress Semiconductor	Souhib Harb	Fairchild Semiconductor
Zeng Wei	Cypress Semiconductor	Amanda Ying	Feature Integration Technology Inc.
Adie Tan	Dell Inc.	Jacky Chan	Feature Integration Technology Inc.
Adolfo Montero	Dell Inc.	Kenny Hsieh	Feature Integration Technology Inc.
Bruce Montag	Dell Inc.	KungAn Lin	Feature Integration Technology Inc.
Gary Verdun	Dell Inc.	Paul Yang	Feature Integration Technology Inc.
Ken Nicholas	Dell Inc.	Su Jaden	Feature Integration Technology Inc.
Marcin Nowak	Dell Inc.	Yu-Lin Chu	Feature Integration Technology Inc.
Merle Wood	Dell Inc.	Yulin Lan	Feature Integration Technology Inc.
Mohammed Hijazi	Dell Inc.	AJ Yang	Foxconn / Hon Hai
Siddhartha Reddy	Dell Inc.	Bob Hall	Foxconn / Hon Hai
Terry Matula	Dell Inc.	Chihyin Kan	Foxconn / Hon Hai
Jay Hu	Derun Semiconductor	Fred Fons	Foxconn / Hon Hai
Shelly Liu	Derun Semiconductor	Jie Zheng	Foxconn / Hon Hai
Bindhu Vasu	Dialog Semiconductor (UK) Ltd	Patrick Casher	Foxconn / Hon Hai
Chanchal Gupta	Dialog Semiconductor (UK) Ltd	Shruti Deore	Foxconn / Hon Hai
Dipti Baheti	Dialog Semiconductor (UK) Ltd	Steve Sedio	Foxconn / Hon Hai
Duc Doan	Dialog Semiconductor (UK) Ltd	Terry Little	Foxconn / Hon Hai
Holger Petersen	Dialog Semiconductor (UK) Ltd	Bob McVay	Fresco Logic Inc.
Jianming Yao	Dialog Semiconductor (UK) Ltd	Christopher Meyers	Fresco Logic Inc.
John Shi	Dialog Semiconductor (UK) Ltd	Dian Kurniawan	Fresco Logic Inc.
KE Hong	Dialog Semiconductor (UK) Ltd	Tom Burton	Fresco Logic Inc.
Kevin Mori	Dialog Semiconductor (UK) Ltd	Abraham Levkoy	Google Inc.
Larry Ping	Dialog Semiconductor (UK) Ltd	Adam Rodriguez	Google Inc.
Mengfei Liu	Dialog Semiconductor (UK) Ltd	Alec Berg	Google Inc.
Scott Brown	Dialog Semiconductor (UK) Ltd	Bartosz Szpila	Google Inc.
Yimin Chen	Dialog Semiconductor (UK) Ltd	Benson Leung	Google Inc.
Yong Li	Dialog Semiconductor (UK) Ltd	Chao Fei	Google Inc.
Justin Lee	Diodes Incorporated	Dave Bernard	Google Inc.
Dan Ellis	DisplayLink (UK) Ltd.	David Schneider	Google Inc.
Jason Young	DisplayLink (UK) Ltd.	Diana Zigterman	Google Inc.
Kevin Jacobs	DisplayLink (UK) Ltd.	Eric Herrmann	Google Inc.
Paulo Alcobia	DisplayLink (UK) Ltd.	George-Daniel Matei	Google Inc.
Peter Burgers	DisplayLink (UK) Ltd.	Jameson Thies	Google Inc.
Richard Petrie	DisplayLink (UK) Ltd.	Jim Guerin	Google Inc.

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Alan Kinningham	Granite River Labs	Wang Feng	Huawei Technologies Co., Ltd.
Anand Murugan	Granite River Labs	Wei Haihong	Huawei Technologies Co., Ltd.
Balamurugan Manialagan	Granite River Labs	Zhenning Shi	Huawei Technologies Co., Ltd.
Medipalli Sowmya	Granite River Labs	James Xie	Hynetek Semiconductor Co., Ltd
Mike Engbretson	Granite River Labs	Yingyang Ou	Hynetek Semiconductor Co., Ltd
Mike Wu	Granite River Labs	Robert Heaton	Indie Semiconductor
Mukesh Tatiya	Granite River Labs	Vincent Wang	Indie Semiconductor
Naresh Botsa	Granite River Labs	Benjamin Kropf	Infineon Technologies
PoornaKumar M.	Granite River Labs	Sie Boo Chiang	Infineon Technologies
Prajwal Rathod	Granite River Labs	Tue Fatt David Wee	Infineon Technologies
Rajaraman V	Granite River Labs	Wee Tar Richard Ng	Infineon Technologies
Saai Ghoutham Revathi Selvam	Granite River Labs	Wolfgang Furtner	Infineon Technologies
Sivan Perumal	Granite River Labs	Aruni Nelson	Intel Corporation
Sivaram Murugesan	Granite River Labs	Bob Dunstan	Intel Corporation
Tim Lin	Granite River Labs	Brad Saunders	Intel Corporation
Vijay S.	Granite River Labs	Chee Lim Nge	Intel Corporation
Vijayakumar P	Granite River Labs	Christine Krause	Intel Corporation
Vishal Kakade	Granite River Labs	Chuen Ming Tan	Intel Corporation
Yogeshwaran Venkatesan	Granite River Labs	Dan Froelich	Intel Corporation
Jerry Qin	GuangDong OPPO Mobile Telecommunications Corp., Ltd.	David Harriman	Intel Corporation
Alan Berkema	Hewlett Packard	David Hines	Intel Corporation
Lee Atkinson	Hewlett Packard	David Thompson	Intel Corporation
Rahul Lakdawala	Hewlett Packard	Guobin Liu	Intel Corporation
Robin Castell	Hewlett Packard	Harry Skinner	Intel Corporation
Ron Schooley	Hewlett Packard	Henrik Leegaard	Intel Corporation
Steve Chen	Hewlett Packard	Jenn Chuan Cheng	Intel Corporation
Suketa Partiwala	Hewlett Packard	Jervis Lin	Intel Corporation
Vaibhav Malik	Hewlett Packard	John Howard	Intel Corporation
Walter Fry	Hewlett Packard	Karthi Vadivelu	Intel Corporation
Hideyuki HAYAFUJI	Hosiden Corporation	Leo Heiland	Intel Corporation
Keiji Mine	Hosiden Corporation	Maarit Harkonen	Intel Corporation
Masaki Yamaoka	Hosiden Corporation	Nge Chee Lim	Intel Corporation
Takashi Muto	Hosiden Corporation	Paul Durley	Intel Corporation
Yasunori Nishikawa	Hosiden Corporation	Rahman Ismail	Intel Corporation
Alan Berkema	HP Inc.	Rajaram Regupathy	Intel Corporation
Kenneth Chan	HP Inc.	Ronald Swartz	Intel Corporation
Lee Atkinson	HP Inc.	Sarah Sharp	Intel Corporation

Steve McGowan	Intel Corporation	Eric Wen	Luxshare-ICT
Tim McKee	Intel Corporation	James Kirk	Luxshare-ICT
Toby Opferman	Intel Corporation	James Stevens	Luxshare-ICT
Uma Medepalli	Intel Corporation	Josue Castillo	Luxshare-ICT
Venkataramani Gopalakrishnan	Intel Corporation	Pat Young	Luxshare-ICT
Ziv Kabiry	Intel Corporation	Scott Shuey	Luxshare-ICT
Jia Wei	Intersil Corporation	Stone Lin	Luxshare-ICT
Weijie Huang	iST - Integrated Service Technology Inc.	Chikara Kakizawa	Maxim Integrated Products
Al Hsiao	ITE Tech. Inc.	Jacob Scott	Maxim Integrated Products
Greg Song	ITE Tech. Inc.	Ken Helfrich	Maxim Integrated Products
Richard Guo	ITE Tech. Inc.	Michael Miskho	Maxim Integrated Products
Victor Lin	ITE Tech. Inc.	Chris Yokum	MCCI Corporation
Y.C. Chou	ITE Tech. Inc.	Geert Knapen	MCCI Corporation
Kenta Minejima	Japan Aviation Electronics Industry Ltd. (JAE)	Terry Moore	MCCI Corporation
Mark Saubert	Japan Aviation Electronics Industry Ltd. (JAE)	Velmurugan Selvaraj	MCCI Corporation
Toshio Shimoyama	Japan Aviation Electronics Industry Ltd. (JAE)	Tung-Sheng Lin	MediaTek Inc.
Brian Fetz	Keysight Technologies Inc.	Satoru Kumashiro	MegaChips Corporation
Jit Lim	Keysight Technologies Inc.	Brian Marley	Microchip Technology Inc.
Koji Asakawa	Kinetic Technologies Inc.	Dave Perchlik	Microchip Technology Inc.
Babu Mailachalam	Lattice Semiconductor Corp	Don Perkins	Microchip Technology Inc.
Gianluca Mariani	Lattice Semiconductor Corp	Fernando Gonzalez	Microchip Technology Inc.
Joel Coplen	Lattice Semiconductor Corp	John Sisto	Microchip Technology Inc.
Thomas Watza	Lattice Semiconductor Corp	Josh Averyt	Microchip Technology Inc.
Vesa Lauri	Lattice Semiconductor Corp	Kiet Tran	Microchip Technology Inc.
Bruce Chuang	Leadtrend	Mark Bohm	Microchip Technology Inc.
Eilian Liu	Leadtrend	Matthew Kalibat	Microchip Technology Inc.
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Daniel H Jacobs	LeCroy Corporation	Prasanna Vengateshan	Microchip Technology Inc.
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Roy Chestnut	LeCroy Corporation	Thomas Farkas	Microchip Technology Inc.
Tyler Joe	LeCroy Corporation	Venkataraman Krishnamoorthy	Microchip Technology Inc.
Phil Jakes	Lenovo	Andrew Yang	Microsoft Corporation
Do Kyun Kim	LG electronics	Anthony Chen	Microsoft Corporation
Won-Jong Choi	LG electronics	Arvind Murching	Microsoft Corporation
Won-Jong Choi	LG Electronics Ltd.	Dave Perchlik	Microsoft Corporation
Aaron Melgar	Lion Semiconductor	David Voth	Microsoft Corporation
Chris Zhou	Lion Semiconductor	Geoff Shew	Microsoft Corporation
Sehyung Jeon	Lion Semiconductor	Jayson Kastens	Microsoft Corporation
Wonyoung Kim	Lion Semiconductor	Kai Inha	Microsoft Corporation
Yongho Kim	Lion Semiconductor	Marwan Kadado	Microsoft Corporation
Dave Thompson	LSI Corporation	Michelle Bergeron	Microsoft Corporation
Alan Kinningham	Luxshare-ICT	Nathan Sherman	Microsoft Corporation
Alan Liu	Luxshare-ICT	Rahul Ramadas	Microsoft Corporation
Scott Brenden	Intel Corporation	Randy Aull	Microsoft Corporation
Sridharan Ranganathan	Intel Corporation	Shiu Ng	Microsoft Corporation
Daniel Chen	Luxshare-ICT	Tieyong Yin	Microsoft Corporation

Timo Toivola	Microsoft Corporation	Hung-Chih Chiu	Power Forest Technology Corporation
Toby Nixon	Microsoft Corporation	Jay Tu	Power Forest Technology Corporation
Vahid Vassey	Microsoft Corporation	Adel Lahham	Power Integrations
Vivek Gupta	Microsoft Corporation	Aditya Kulkarni	Power Integrations
Yang You	Microsoft Corporation	Akshay Nayaknur	Power Integrations
Adib Al Abaji	Molex LLC	Amruta Patra	Power Integrations
Aaron Xu	Monolithic Power Systems Inc.	K R Rahul Raj	Power Integrations
Bo Zhou	Monolithic Power Systems Inc.	Kaushik Raam	Power Integrations
Christian Sporck	Monolithic Power Systems Inc.	Rahul Joshi	Power Integrations
Di Han	Monolithic Power Systems Inc.	Ricardo Pregiteer	Power Integrations
Zhihong Yu	Monolithic Power Systems Inc.	Shruti Anand	Power Integrations
Dan Wagner	Motorola Mobility Inc.	Amit gupta	Qualcomm, Inc
Ben Crowe	MQP Electronics Ltd.	George Paparrizos	Qualcomm, Inc
Pat Crowe	MQP Electronics Ltd.	Giovanni Garcea	Qualcomm, Inc
Sten Carlsen	MQP Electronics Ltd.	Jack Pham	Qualcomm, Inc
Kenji Oguma	NEC Corporation	James Goel	Qualcomm, Inc
ChinJui Lin	Nexperia B.V.	Joshua Warner	Qualcomm, Inc
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Frank Borngräber	Nokia Corporation	Nicholas Cadieux	Qualcomm, Inc
Kai Inha	Nokia Corporation	Vamsi Samavedam	Qualcomm, Inc
Pekka Leinonen	Nokia Corporation	Vatsal Patel	Qualcomm, Inc
Richard Petrie	Nokia Corporation	Chris Sporck	Qualcomm, Inc.
Sten Carlsen	Nokia Corporation	Craig Aiken	Qualcomm, Inc.
Abhijeet Kulkarni	NXP Semiconductors	Narendra Mehta	Qualcomm, Inc.
Ahmad Yazdi	NXP Semiconductors	Terry Remple	Qualcomm, Inc.
Bart Vertenten	NXP Semiconductors	Will Kun	Qualcomm, Inc.
Dennis Ha	NXP Semiconductors	Yoram Rimoni	Qualcomm, Inc.
Dong Nguyen	NXP Semiconductors	Fan-Hau Hsu	Realtek Semiconductor Corp.
Guru Prasad	NXP Semiconductors	Tsung-Peng Chuang	Realtek Semiconductor Corp.
Ken Jaramillo	NXP Semiconductors	Atsushi Mitamura	Renesas Electronics Corp.
Krishnan TN	NXP Semiconductors	Bob Dunstan	Renesas Electronics Corp.
Michael Joehren	NXP Semiconductors	Brian Allen	Renesas Electronics Corp.
Robert de Nie	NXP Semiconductors	Dan Aoki	Renesas Electronics Corp.
Rod Whitby	NXP Semiconductors	Fengshuan Zhou	Renesas Electronics Corp.
Vijendra Kuroodi	NXP Semiconductors	Hajime Nozaki	Renesas Electronics Corp.
Winston Langeslag	NXP Semiconductors	John Carpenter	Renesas Electronics Corp.
Robert Heaton	Obsidian Technology	Kiichi Muto	Renesas Electronics Corp.
Andrew Yoo	ON Semiconductor	Masami Katagiri	Renesas Electronics Corp.
Brady Maasen	ON Semiconductor	Nobuo Furuya	Renesas Electronics Corp.
Bryan McCoy	ON Semiconductor	Patrick Yu	Renesas Electronics Corp.
Christian Klein	ON Semiconductor	Peter Teng	Renesas Electronics Corp.
Cor Voorwinden	ON Semiconductor	Philip Leung	Renesas Electronics Corp.
Edward Berrios	ON Semiconductor	Steve Roux	Renesas Electronics Corp.
Michael Smith	ON Semiconductor	Tetsu Sato	Renesas Electronics Corp.
Oscar Freitas	ON Semiconductor	Toshifumi Yamaoka	Renesas Electronics Corp.
Tom Duffy	ON Semiconductor	Yimin Chen	Renesas Electronics Corp.
Brian Collins	Parade Technologies Inc.	Chunan Kuo	Richtek Technology Corporation
Craig Wiley	Parade Technologies Inc.	Heinz Wei	Richtek Technology Corporation

Max Huang	Richtek Technology Corporation	Shannon Cash	SMSC
TZUHSIEN CHUANG	Richtek Technology Corporation	Mark Bohm	SMSC
Tatsuya Irisawa	Ricoh Company Ltd.	Tim Knowlton	SMSC
Akihiro Ono	Rohm Co. Ltd.	William Chiechi	SMSC
Chris Lin	Rohm Co. Ltd.	Shigenori Tagami	Sony Corporation
Hidenori Nishimoto	Rohm Co. Ltd.	Shinichi Hirata	Sony Corporation
Kris Bahar	Rohm Co. Ltd.	Amanda Hosler	Specwerkz
Manabu Miyata	Rohm Co. Ltd.	Bob Dunstan	Specwerkz
Ruben Balbuena	Rohm Co. Ltd.	Brad Saunders	Specwerkz
Takashi Sato	Rohm Co. Ltd.	Diane Lenox	Specwerkz
Vijendra Kuroodi	Rohm Co. Ltd.	Michael Munn	StarTech.com Ltd.
Yusuke Kondo	Rohm Co. Ltd.	Fabien Friess	ST-Ericsson
Kazuomi Nagai	ROHM Co., Ltd.	Giuseppe Platania	ST-Ericsson
Matti Kulmala	Salcomp Plc	Jean-Francois Gatto	ST-Ericsson
Toni Lehimo	Salcomp Plc	Milan Stamenkovic	ST-Ericsson
Edward Lee	Samsung Electronics Co. Ltd.	Nicolas Florenchie	ST-Ericsson
Tong Kim	Samsung Electronics Co. Ltd.	Patrizia Milazzo	ST-Ericsson
Amit Bouzaglo	Scosche Industries	Christophe Cochard	STMicroelectronics
Alvin Cox	Seagate Technology LLC	Christophe Lorin	STMicroelectronics
Emmanuel Lemay	Seagate Technology LLC	Filippo Bonaccorso	STMicroelectronics
John Hein	Seagate Technology LLC	Jessy Guilbot	STMicroelectronics
Marc Noblitt	Seagate Technology LLC	Joel Huloux	STMicroelectronics
Michael Morgan	Seagate Technology LLC	John Bloomfield	STMicroelectronics
Ronald Rueckert	Seagate Technology LLC	Massimo Panzica	STMicroelectronics
Tony Priborsky	Seagate Technology LLC	Meriem Mersel	STMicroelectronics
Chin Chang	Semtech Corporation	Nathalie Ballot	STMicroelectronics
Tom Farkas	Semtech Corporation	Pascal Legrand	STMicroelectronics
Ankit Garg	Siemens Industry Software Inc.	Patrizia Milazzo	STMicroelectronics
Ning Dai	Silergy Corp.	Richard O'Connor	STMicroelectronics
Wanfeng Zhang	Silergy Corp.	Morten Christiansen	Synopsys, Inc.
Kafai Leung	Silicon Laboratories, Inc.	Nivin George	Synopsys, Inc.
Kok Hong Soh	Silicon Laboratories, Inc.	Prishkit Abrol	Synopsys, Inc.
Sorin Badiu	Silicon Laboratories, Inc.	Zongyao Wen	Synopsys, Inc.
Steven Ghang	Silicon Laboratories, Inc.	Joan Marrinan	Tektronix
Abhishek Sardeshpande	SiliConch Systems Private Limited	Kimberley McKay	Teledyne-LeCroy
Aniket Mathad	SiliConch Systems Private Limited	Matthew Dunn	Teledyne-LeCroy
Chandana N	SiliConch Systems Private Limited	Tony Minchell	Teledyne-LeCroy
Jaswanth Ammineni	SiliConch Systems Private Limited	Anand Dabak	Texas Instruments
Jinisha Patel	SiliConch Systems Private Limited	Annamalai Kasthuri	Texas Instruments
Kaustubh Kumar	SiliConch Systems Private Limited	BIJU Erayamkot Panayamthatta	Texas Instruments
Nitish	SiliConch Systems Private Limited	Bill Waters	Texas Instruments
Pavitra Balasubramanian	SiliConch Systems Private Limited	Bing Lu	Texas Instruments
Rakesh Polasa	SiliConch Systems Private Limited	Deric Waters	Texas Instruments
Satish Anand Verkila	SiliConch Systems Private Limited	Grant Ley	Texas Instruments
Shubham Paliwal	SiliConch Systems Private Limited	Gregory Watkins	Texas Instruments
Vishnu Pusuluri	SiliConch Systems Private Limited	Ingolf Frank	Texas Instruments
John Sisto	SMSC	Ivo Huber	Texas Instruments
Ken Gay	SMSC	Javed Ahmad	Texas Instruments
Richard Wahler	SMSC	Jean Picard	Texas Instruments

John Perry	Texas Instruments
Kasthuri Annamalai	Texas Instruments
Martin Patoka	Texas Instruments
Mike Campbell	Texas Instruments
Scott Jackson	Texas Instruments
Shafiuddin Mohammed	Texas Instruments
Srinath Hosur	Texas Instruments
Steven Tom	Texas Instruments
Yoon Lee	Texas Instruments
Tim Wilhelm	The Silanna Group Pty. Ltd.
Tod Wolf	The Silanna Group Pty. Ltd.
Chris Yokum	Total Phase
Dylan Su	UL LLC
Eric Wall	UL LLC
Jason Smith	UL LLC
Terry Kao	UL LLC
Steven Chen	Unigraf OY
Topi Lampiranta	Unigraf OY
Brad Cox	Ventev Mobile
Colin Vose	Ventev Mobile
Dydron Lin	VIA Technologies, Inc.
Fong-Jim Wang	VIA Technologies, Inc.
Jay Tseng	VIA Technologies, Inc.
Rex Chang	VIA Technologies, Inc.
Terrance Shih	VIA Technologies, Inc.
Ho Wen Tsai	Weltrend Semiconductor
Hung Chiang	Weltrend Semiconductor
Jeng Cheng Liu	Weltrend Semiconductor
Priscilla Lee	Weltrend Semiconductor
Wayne Lo	Weltrend Semiconductor
Charles Neumann	Western Digital Technologies, Inc.
Curtis Stevens	Western Digital Technologies, Inc.
John Maroney	Western Digital Technologies, Inc.
Joe O'Brien	Wilder Technologies
Will Miller	Wilder Technologies
Canfeng Chen	Xiaomi Communications Co., Ltd.
Juejia Zhou	Xiaomi Communications Co., Ltd.
Xiaoxing Yang	Xiaomi Communications Co., Ltd.
Liu Qiong	Zhuhai Smartware Technology Co., Ltd.
Long Zhang	Zhuhai Smartware Technology Co., Ltd.
Yuanchao Liang	Zhuhai Smartware Technology Co., Ltd.

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1 Introduction

USB has evolved from a data interface capable of supplying limited power to a primary provider of power with a data interface. Today many devices charge or get their power from USB Ports contained in laptops, cars, aircraft or even wall sockets. USB has become a ubiquitous power socket for many small devices such as cell phones and other hand-held devices. Users need USB to fulfill their requirements not only in terms of data but also to provide power to, or charge, their devices simply, often without the need to load a driver, in order to carry out “traditional” USB functions.

There are, however, still many devices which either require an additional power connection to the wall, or exceed the USB default current in order to operate. Increasingly, international regulations require better energy management due to ecological and practical concerns relating to the availability of power. Regulations limit the amount of power available from the wall which has led to a pressing need to optimize power usage. The USB Power Delivery Specification has the potential to minimize waste as it becomes a standard for charging devices that are not satisfied by ***[USBBC 1.2]*** or ***[USB Type-C 2.4]***.

Wider usage of wireless solutions is an attempt to remove data cabling but the need for “tethered” charging remains. In addition, industrial design requirements drive wired connectivity to do much more over the same connector.

USB Power Delivery is designed to enable the maximum functionality of USB by providing more flexible power delivery along with data over a single cable. Its aim is to operate with and build on the existing USB ecosystem; increasing power levels from existing USB standards, for example ***[USBBC 1.2]***, enabling new higher power use cases such as USB powered Hard Disk Drives (HDDs), laptops and monitors.

With USB Power Delivery the power direction is no longer fixed. This enables the product with the power (USB Host or Peripheral) to provide the power. For example, a display with a supply from the wall can power, or charge, a laptop. Alternatively, USB Chargers are able to supply power to laptops and other Battery powered devices through their, traditional power providing, USB Ports.

USB Power Delivery enables Hubs (including Hubs embedded in other devices such as docks or monitors) to become the means to optimize power management across multiple peripherals by allowing each device to take only the power it requires, and to get more power when required for a given application. ***Optionally*** the Hubs can communicate with the PC to enable even more intelligent and flexible management of power either automatically or with some level of user intervention.

USB Power Delivery allows low power cases such as headsets to Negotiate for only the power they require. This provides a simple solution that enables USB devices to operate at their optimal power levels.

The Power Delivery Specification, in addition to providing mechanisms to Negotiate power also can be used as a side-band channel for standard and vendor defined messaging. The specification enables discovery of cable Capabilities such as supported speeds and current levels. Power Delivery enables alternative modes of operation by providing the mechanisms to discover, enter and exit Modes such as EPR Mode, USB4® Mode or Alternate Modes.

1.1 Overview

This specification defines how USB Devices can Negotiate for more current and/or higher or lower voltages over the USB cable (using the USB Type-C® CC wire as the communications channel) than are defined in the ***[USB 2.0]***, ***[USB 3.2]***, ***[USB4]***, ***[USB Type-C 2.4]*** or ***[USBBC 1.2]*** specifications. It allows Devices with greater power requirements than can be met with today's specification to get the power they require to operate from V_{BUS} and Negotiate with external power sources (e.g., Chargers).

In addition, it allows a Source and Sink to swap Power Roles such that a USB Device could supply power to the USB Host. For example, a display could supply power to a laptop to operate or charge its Battery. This specification also adds a mechanism to swap the Data Roles such that the upstream facing Port becomes the downstream facing Port and vice versa. It also enables a swap of the end supplying V_{CONN} to a powered cable.

The USB Power Delivery Specification is guided by the following principles:

- Works seamlessly with legacy USB Devices.

- Compatible with existing spec-compliant USB cables.
- Minimizes potential damage from non-compliant cables (e.g., 'Y' cables etc.).
- Optimized for low-cost implementations.

This specification defines mechanisms to discover, enter and exit Alternate Modes defined either by a standard or by a particular vendor. These Alternate Modes can be supported either by the Port Partner or by a cable connecting the two Port Partners.

The specification defines mechanisms to discover the Capabilities of cables which can communicate using Power Delivery.

To facilitate optimum charging, the specification defines two mechanisms a USB Charger can Advertise for the device to use:

1) A list of Fixed Supply voltages each with a maximum current. The device selects a voltage and current from the list. This is the traditional model used by devices that use internal electronics to manage the charging of their Battery including modifying the voltage and current actually supplied to the Battery. The side-effect of this model is that the charging circuitry generates heat that can be problematic for small form factor devices.

2) A list of programmable voltage ranges, in SPR PPS Mode, each with a maximum current. The device requests a voltage (in 20mV increments) that is within the Advertised range and a maximum current. The USB PPS Charger delivers the requested voltage until the maximum current is reached at which time the USB PPS Charger reduces its output voltage so as not to supply more than the requested maximum current. During the high current portion of the charge cycle, the USB PPS Charger can be directly connected (through an appropriate safety device) to the Battery. This model is used by devices that want to minimize the thermal impact of their internal charging circuitry.

3) A list of adjustable voltage ranges, in SPR AVS Mode or EPR AVS Mode, each with a maximum current. The device requests a voltage (in 100mV increments) that is within the Advertised range and a maximum current. The USB AVS Charger delivers the requested voltage.

1.2 Purpose

The USB Power Delivery specification defines a power delivery system covering all elements of a USB system including USB Hosts, USB Devices, Hubs, Chargers and cable assemblies. This specification describes the architecture, protocols, power supply behavior, connectors and cabling necessary for managing power delivery over USB at up to 100W in SPR Mode and 240W in EPR Mode. This specification is intended to be fully compatible with and extend the existing USB infrastructure. It is intended that this specification will allow system OEMs, power supply and Peripheral developers adequate flexibility for product versatility and market differentiation without losing backwards compatibility.

USB Power Delivery is designed to operate independently of the existing USB bus defined mechanisms used to Negotiate power which are:

- ***[USB 2.0]***, ***[USB 3.2]*** in band requests for high power interfaces.
- ***[USBBC 1.2]*** mechanisms for supplying higher power (not mandated by this specification).
- ***[USB Type-C 2.4]*** mechanisms for supplying higher power.

Initial operating conditions remain the USB Default Operation as defined in ***[USB 2.0]***, ***[USB 3.2]***, ***[USB Type-C 2.4]*** or ***[USBBC 1.2]***.

- The DFP sources ***vSafe5V*** over V_{BUS}.
- The UFP consumes power from V_{BUS}.

1.2.1 Scope

This specification is intended as an extension to the existing ***[USB 2.0]***, ***[USB 3.2]***, ***[USB Type-C 2.4]*** and ***[USBBC 1.2]*** specifications. It addresses only the elements required to implement USB Power Delivery. It is targeted at power supply vendors, manufacturers of ***[USB 2.0]***, ***[USB 3.2]***, ***[USB Type-C 2.4]*** and ***[USBBC 1.2]*** platforms, devices and cable assemblies.

Normative information is provided to allow interoperability of components designed to this specification. ***Informative*** information, when provided, illustrates possible design implementation.

1.3 Section Overview

This specification contains the following sections:

Table 1.1 Section Overview

Section	Description
Section 1, "Introduction"	Introduction, conventions used in the document, list of terms and abbreviations, references, and details of parameter usage.
Section 2, "Overview"	Overview of the document including a description of the operation of *PD* and the architecture.
Section 3, "USB Type-A and USB Type-B Cable Assemblies and Connectors"	Mechanical and electrical characteristics of the cables and connectors used by *PD*. Section ***Deprecated***. See ***[USBPD 2.0]*** for legacy *PD* connector specification.
Section 4, "Electrical Requirements"	Electrical requirements for *Dead Battery* operation and cable detection.
Section 5, "Physical Layer"	Details of the *PD PHY Layer* requirements
Section 6, "Protocol Layer"	*Protocol Layer* requirements including the *Message*s, timers, counters, and state operation.
Section 7, "Power Supply"	Power supply requirements for both *Provider*s and *Consumer*s.
Section 8, "Device Policy"	*Device Policy Manager* requirements. *Policy Engine Atomic Message Sequence* (*AMS*) diagrams and state diagrams
Section 9, "States and Status Reporting"	*PDUSB Device* requirements including mapping of V_{BUS} to USB states. *System Policy Manager* requirements including descriptors, events, and requests.
Section 10, "Power Rules"	*PDP Rating* definitions for *PD*.
Section A, "CRC calculation"	Example *CRC* calculations.
Section B, "Message Sequence Examples (Deprecated)"	Scenarios illustrating *Device Policy Manager* operation. ***Deprecated***
Section C, "VDM Command Examples"	Examples of *Structured VDM* usage.Section ***Deprecated***.
Section D, "BMC Receiver Design Examples"	*BMC* Receiver Design Examples.
Section E, "FRS System Level Example"	*FRS* System Level Example.

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.

In there is a conflict between a generic statement and a more specific statement, the more specific statement ***Shall*** apply.

1.4.2 Keywords

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

Table 1.2 Keywords

Keyword	Definition
Conditional Normative	***Conditional Normative*** is a keyword used to indicate a feature that is mandatory when another related feature has been implemented. Designers are mandated to implement all such requirements, when the dependent features have been implemented, to ensure interoperability with other compliant devices.
Deprecated	***Deprecated*** is a keyword used to indicate a feature, supported in previous releases of the specification, which is no longer supported.
Discard	See ***Discarded***.
Discarded	***Discard***, ***Discards*** and ***Discarded*** are equivalent keywords indicating that a *Packet* when received ***Shall*** be thrown away by the *PHY Layer* and not passed to the *Protocol Layer* for processing. No ***GoodCRC*** *Message* ***Shall*** be sent in response to the *Packet*.
Discards	See ***Discarded***.
Ignore	See ***Ignored***.
Ignored	***Ignore***, ***Ignores*** and ***Ignored*** are equivalent keywords indicating *Message*s or *Message* fields which, when received, ***Shall*** result in no special action by the receiver. An ***Ignored*** *Message* ***Shall*** only result in returning a ***GoodCRC*** *Message* to acknowledge *Message* receipt. A *Message* with an ***Ignored*** field ***Shall*** be processed normally except for any actions relating to the ***Ignored*** field.
Ignores	See ***Ignored***.
Informative	***Informative*** is a keyword indicating text with no specific requirements, provided only to improve understanding.
Invalid	***Invalid*** is a keyword when used in relation to a *Packet* indicates that the *Packet*'s usage or fields fall outside of the defined specification usage. When ***Invalid*** is used in relation to an *Explicit Contract* it indicates that a previously established *Explicit Contract* which can no longer be maintained by the *Source*. When ***Invalid*** is used in relation to individual *K-code*s or *K-code* sequences indicates that the received *Signaling* falls outside of the defined specification.
May	***May*** is a keyword that indicates a choice with no implied preference.
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.
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.
Normative	See ***Shall***.
Optional	***Optional***, ***Optionally*** and ***Optional Normative*** 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	See ***Optional***.
Optionally	See ***Optional***.

Table 1.2 Keywords (Continued)

Keyword	Definition
Reserved	***Reserved*** is a keyword indicating 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 ***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 ***Shall*** be ***Ignored*** by the receiver.
Shall	***Shall*** and ***Normative*** are equivalent keywords indicating a mandatory requirement. Designers are mandated to implement all such requirements to ensure interoperability with other compliant devices.
Shall Not	***Shall Not*** is a keyword that is the inverse of ***Shall*** indicating non-compliant operation.
Should	***Should*** is a keyword indicating flexibility of choice with a preferred alternative; equivalent to the phrase “it is recommended that…”.
Should Not	***Should Not*** is a keyword is the inverse of ***Should***; equivalent to the phrase “it is recommended that implementations do not…”.
Static	***Static*** is a keyword indicating that a field that never changes.
Valid	***Valid*** is a keyword that is the inverse of ***Invalid*** indicating either a Packet or *Signaling* that fall within the defined specification or an *Explicit Contract* that can be maintained by the *Source*.

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) or are preceded by “0x” (e.g., 0xFF00) are hexadecimal values. Numbers not immediately followed by either a “b”, “B”, or “h” are decimal values.

1.5 Related Documents

Document references listed in *Table 1.3, "Document References"* are inclusive of all approved and published ECNs and Errata.

Table 1.3 Document References

Bookmark Reference	Title
[DPTC2.1]	DisplayPort™ Alt Mode on *USB Type-C* Standard *www.vesa.org*.
[IEC 60950-1]	IEC 60950-1:2005 Information technology equipment – Safety – Part 1: General requirements: Amendment 1:2009, Amendment 2:2013. *www.iec.ch*.
[IEC 60958-1]	IEC 60958-1:2021 Digital Audio Interface Part:1 General. *www.iec.ch*.
[IEC 62368-1]	IEC 62368-1:2018 Audio/Video, information, and communication technology equipment – Part 1: Safety requirements. *www.iec.ch*.
[IEC 62368-3]	IEC 62368-3:2017 Audio/video, information, and communication technology equipment - Part 3: Safety aspects for DC power transfer through communication cables and ports *www.iec.ch*.
[IEC 63002]	IEC 63002:2021 Interoperability specifications and communication method for external power supplies used with computing and consumer electronics devices *www.iec.ch*.
[ISO 3166]	ISO 3166 international Standard for country codes and codes for their subdivisions. *http://www.iso.org/iso/home/standards/country_codes.htm*.
[TBT3]	see [USB4] Chapter 13 for Thunderbolt™ 3 device operation.
[UCSI]	*USB Type-C* Connector System Software Interface (UCSI) Specification *https://www.usb.org/documents*.
[USB 2.0]	Universal Serial Bus 2.0 Specification, *https://www.usb.org/documents*.
[USB 3.2]	Universal Serial Bus 3.2 Specification *https://www.usb.org/documents*.
[USB Type-C 2.4]	Universal Serial Bus Type-C Cable and Connector Specification, *https://www.usb.org/documents*.
[USB4]	Universal Serial Bus 4 Specification (USB4®), *https://www.usb.org/documents*.
[USBBC 1.2]	Universal Serial Bus Battery Charging Specification plus Errata (referred to in this document as the Battery Charging specification). *https://www.usb.org/documents*.
[USBPD 2.0]	Universal Serial Bus Power Delivery Specification, *https://www.usb.org/documents*.
[USBPDCompliance]	USB Power Delivery Compliance Test Specification, *https://www.usb.org/documents*.
[USBPDFirmwareUpdate 1.0]	Universal Serial Bus Power Delivery Firmware Update Specification, *https://www.usb.org/documents*.
[USBTypeCAuthentication 1.0]	Universal Serial Bus Type-C Authentication Specification, *https://www.usb.org/documents*.
[USBTypeCBridge 1.1]	Universal Serial Bus Type-C Bridge Specification, *https://www.usb.org/documents*.