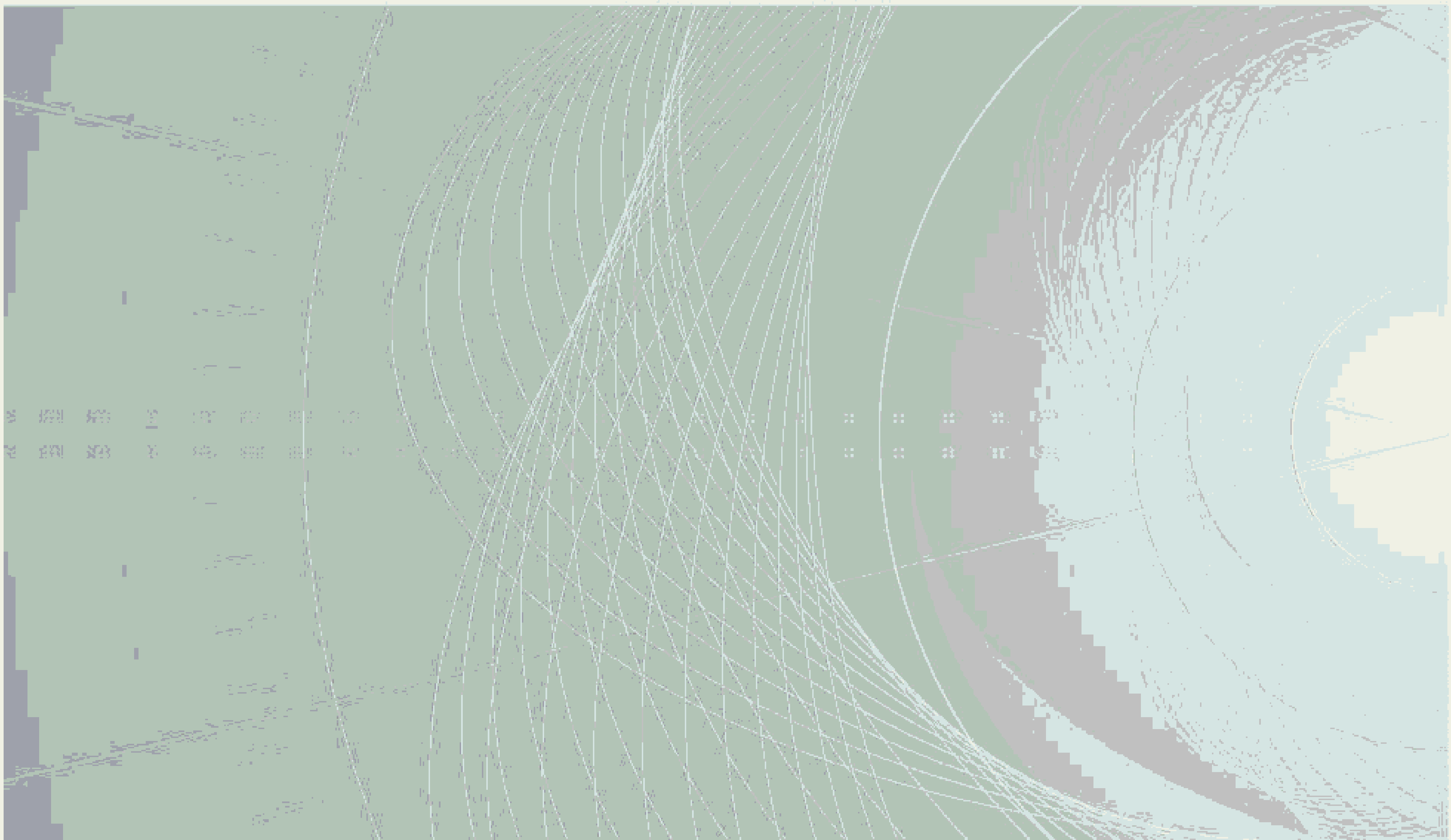
IEC 63002

Edition 2.0 2021-05

INTERNATIONAL STANDARD

Interoperability specifications and communication method for external power supplies used with computing and consumer electronics devices



IEC 63002:2021-05(en)

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

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

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

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

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 It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

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

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

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

IEC 63002

Edition 2.0 2021-05

INTERNATIONAL STANDARD

Interoperability specifications and communication method for external power supplies used with computing and consumer electronics devices

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.020; 35.200 ISBN 978-2-8322-9822-0

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

INTEROPERABILITY SPECIFICATIONS AND COMMUNICATION METHOD FOR EXTERNAL POWER SUPPLIES USED WITH COMPUTING AND CONSUMER ELECTRONICS DEVICES

FOREWORD

This document 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.

This second edition cancels and replaces the first edition published in 2016. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) title is changed from *Identification and communication interoperability method for external power supplies used with portable computing devices*;

b) Clause 4, *EPS interoperability based on USB technologies*, is added;

c) Clause 5, *EPS specification*, adds hardware and protection requirements; overvoltage protection is changed from optional to normative;

d) Annex B and Annex C are added, providing an explanation of the design features in USB Power Delivery that enhance reliability and an explanation of the concepts of charge rate and power.

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

CDV	Report on voting
100/3463/CDV	100/3540B/RVC

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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

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

INTRODUCTION

The objective of this document is to enable common charging interoperability of external power supplies (EPSs) used with the increasing variety of computing and consumer electronics devices that implement IEC 62680-1-3 (USB Type-C® [1] Cable and Connector Specification) and IEC 62680-1-2 (USB Power Delivery). Broad market adoption of this document is expected to make a significant contribution to the global goals of consumer convenience and re-usability of power supplies by expanding common charging interoperability across different product categories while preserving backwards compatibility with the installed base of billions of IEC 62680 compliant devices worldwide.

This document specifies the minimum technical requirements for interoperability and includes recommendations for EPS functionality when used with computing and electronics devices. The approach taken by this document, focused on enabling common charging interoperability, can allow manufacturers to innovate in aspects such as technical design, system performance, and energy efficiency. Furthermore, common charging interoperability enables manufacturers to design specific EPSs that match the requirements of target devices (functionality, cost, etc.) and use cases, while at the same time enabling consumers to use the EPS for charging other IEC 62680 compliant devices, across various product types.

IEC 62680-1-3 adoption is well underway in global markets for a wide range of devices using as much as 100 W, including notebook computers, tablets, smartphones, small form-factor desktop computers, and other consumer electronics devices. This document enables the reporting of the identity and power characteristics of power sources (EPSs and other Sources) supported by IEC 62680-1-3 (USB Type-C) and specifies interoperability guidelines when using IEC 62680-1-2 (USB Power Delivery). The method for identification of a specific power source can enable equipment manufacturers to ensure compliant operation using these specifications and promotes data communication that can be used by the device to predict and mitigate interoperability concerns when an unfamiliar or incompatible EPS is connected to the device. EPS power delivery applications can in the future extend beyond 100 W given updates to IEC 62680 that appropriately address the needs of higher-power products in the computing and consumer device market.

This document also provides important information regarding consumer safety, system reliability as well as relevant global standards and regulatory compliance.

Other international and regional standards, and government policies for "universal" or "common power adapters" that reference this document are expected to take into account open technical and regulatory compliance issues that are associated with untested or arbitrary combinations of EPSs and devices such as those identified in Annex A, as well as the limitations and issues with approaches to define "common chargers" in meeting market needs. For clarity, this document focuses on interoperability specifications in order to support global industry in developing safe, convenient, environmentally conscious, and end-to-end interoperable charging solutions that meet regulatory compliance and market requirements.

---

1 USB4™ and USB Type-C® are trademarks of the Universal Serial Bus Implementers Forum (USB-IF). This information is given for the convenience of users of this document and does not constitute an endorsement by IEC.

INTEROPERABILITY SPECIFICATIONS AND COMMUNICATION METHOD FOR EXTERNAL POWER SUPPLIES USED WITH COMPUTING AND CONSUMER ELECTRONICS DEVICES

1 Scope

This document defines common charging interoperability guidelines for power sources (external power supplies (EPSs) and other Sources) used with computing and consumer electronics devices that implement IEC 62680-1-3 (USB Type-C Cable and Connector Specification).

This document defines normative requirements for an EPS to ensure interoperability; in particular, it specifies the data communicated from a power source to a device (Figure 1) and certain safety elements of the EPS, cable, and device. While the requirements focus of this document is on the EPS and the behaviour at its USB Type-C connector interface, it is also important to comprehend cable assembly and device capabilities and behaviours in order to assure end-to-end charging interoperability. This document does not apply to all design aspects of an EPS. This document does not specify regulatory compliance requirements for aspects such as product safety, EMC or energy efficiency.

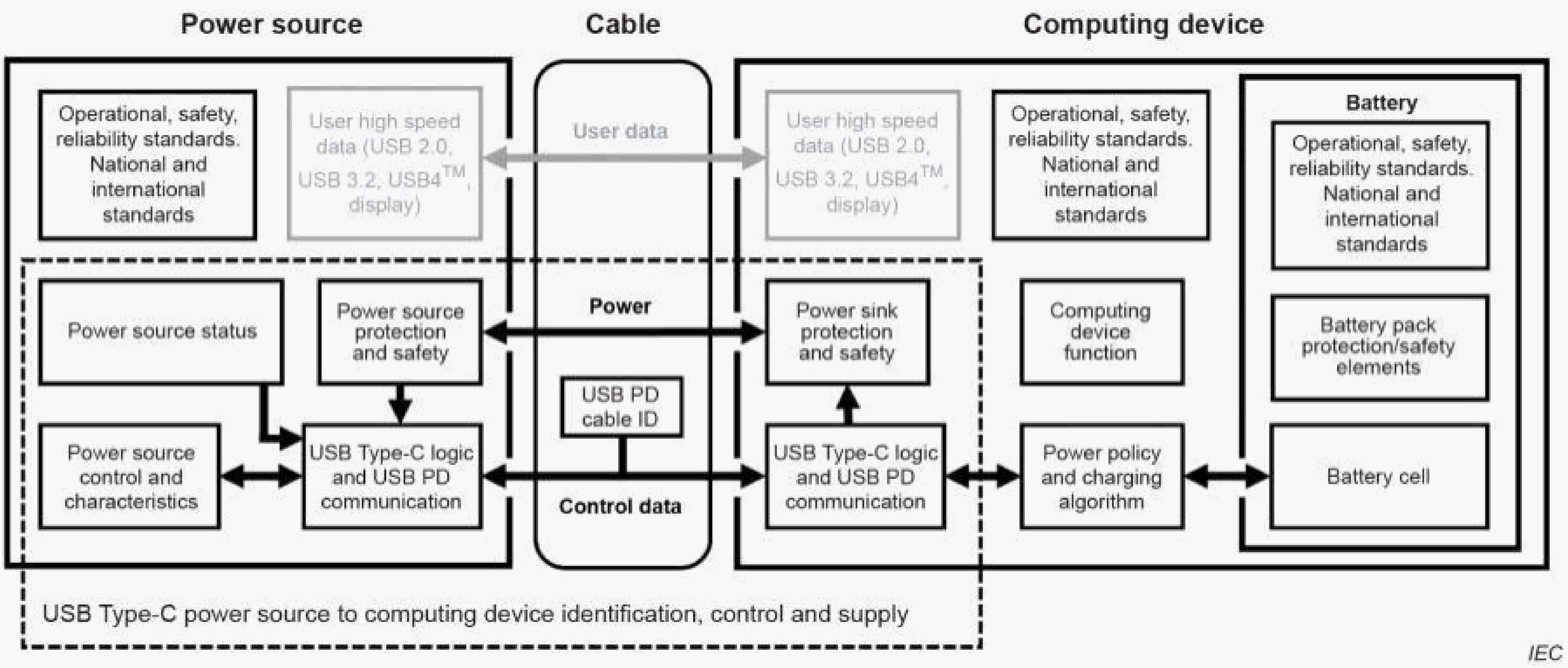


Figure 1 – Scope of the identification, communication and control method

This document provides recommendations for the behaviour of a device when used with a power source compliant with this document. It specifies the minimum hardware specification for an EPS implementing IEC 62680-1-3. This document also specifies the data objects used by a charging system utilizing IEC 62680-1-2 to understand the identity, design and performance characteristics, and operating status of an external power supply. IEC 62680-1-2 focuses on power delivery applications ranging to 100 W for a variety of computing and consumer electronics devices including notebook computers, tablets, smartphones, small form-factor desktops, monitor displays and other related multimedia devices.

This document relies on established mechanical and electrical specifications, and communication protocols specified by IEC 62680-1-2 and IEC 62680-1-3. These specifications support methods for establishing the best performing interoperability between untested combinations of EPS and devices with the aim of improving consumer satisfaction.

Information describing the USB charging interoperability model, overview of USB Type-C and USB Power Delivery specifications, and factors for charging performance are also provided to support implementation of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60950-1, *Information technology equipment – Safety – Part 1: General requirements*

IEC 60990, *Methods of measurement of touch current and protective conductor current*

IEC 62368-1:2018, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*

IEC 62680-1-1, *Universal Serial Bus interfaces for data and power – Part 1-1: Common components – USB Battery Charging Specification, Revision 1.2*

IEC 62680-1-2:2021, *Universal Serial Bus interfaces for data and power – Part 1-2: Common components – USB Power Delivery specification*

IEC 62680-1-3, *Universal Serial Bus interfaces for data and power – Part 1-3: Common components – USB Type-C Cable and Connector Specification*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
vendor identification
VID
unique 16-bit unsigned value assigned by the USB-IF to a given vendor

3.1.2
power source
power supply
Source
device designed to comply with IEC 62680-1-2 that supplies power over V_{BUS}

EXAMPLE A USB connector on a PC, laptop computer, vehicle, AC outlet, docking station, battery pack, or EPS.

3.1.3
Sink
power sink
device designed to comply with IEC 62680-1-2 that receives and consumes power over V_{BUS}

EXAMPLE A computing device.

Note 1 to entry: Sometimes referred to as the device.

3.1.4
external power supply
EPS
power source contained in a separate physical enclosure external to the device casing and designed to convert mains power supply to lower DC voltage(s) for the purpose of powering the device

EXAMPLE A charging block.

3.1.5
Programmable Power Supply
PPS
optional capability in IEC 62680-1-2 where a device (Sink) can adaptively adjust the EPS (Source) output voltage in small increments and set maximum current within its advertised range

3.1.6
Fixed Supply
power source whose output voltage is regulated

Note 1 to entry: Standardized voltages in IEC 62680-1-2:2021 are 5 V, 9 V, 15 V and 20 V.

3.1.7
USB PD power
PDP
nominal power capacity of the charger defined by IEC 62680-1-2 for use to indicate to consumers

Note 1 to entry: The PDP rating is indicated both on the USB charger certification logo and within the USB PD source capabilities advertisement to the Sink. For any given PDP rating, the minimum capabilities in terms of supported voltages and currents are deterministic, as defined in IEC 62680-1-2.

3.1.8
charging cable
cable used between the EPS and device to be charged

Note 1 to entry: The cable connection to the EPS is a USB Type-C plug in accordance with IEC 62680-1-3. The cable connection to the device can be either a USB Type-C plug, a legacy USB plug (e.g. USB Micro-B in accordance with IEC 62680-2-2), or a non-USB device-specific connection (either permanent or detachable). Charging cables can be application-specific to enable interoperability between the USB Type-C-based EPS defined by this document and both existing and future devices and including devices that are not able to accommodate USB Type-C receptacles, e.g. smart watches.

3.1.9
captive cable
permanently attached cable
cable that has a USB Type-C plug on one end and is either hard-wired into a device on the other end or has a device-specific plug on the other end

Note 1 to entry: When a device-specific plug is used on one end, the cable can be detachable in a physical sense but is considered "functionally captive" to the device given it does not use a USB-defined connector on the device end but otherwise functions as a USB device. This definition has remained the USB definition since it was originally specified in IEC 62680-2-1 (USB 2.0).

3.2 Abbreviated terms

AC	alternating current
CC	configuration channel
CRC	cyclic redundancy check
DC	direct current
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EPS	external power supply
IoC	contracted operating current
LPS	limited power source
OEM	original equipment manufacturer
OVP	overvoltage protection
PDO	power data object
PFC	power factor correction
PDP	USB PD Power
PID	product identification
PPS	Programmable Power Supply
VAC	volts alternating current
USB	universal serial bus
USB PD	universal serial bus power delivery
USB-IF	Universal Serial Bus Implementers Forum
VID	vendor identification

4 EPS interoperability based on USB technologies

4.1 Overview

Clause 4 describes the USB common charging interoperability model and provides a summary of the USB Type-C and USB Power Delivery technologies specified in IEC 62680 -1-3 and IEC 62680-1-2, respectively.

4.2 General

Since its introduction over 20 years ago, USB charging technology has consistently provided 5 V DC power and relied on a common USB Standard-A connector on the power source. When used with defined legacy cables and adapters, USB Type-C-based power sources, including those that source higher voltages, remain electrically and mechanically interoperable with previous generation USB devices, while enabling new capabilities for devices that have evolved to align with these new capabilities.

Figure 2 illustrates the USB EPS charging application model consisting of the EPS (Source) with a USB Type-C receptacle, the device to be charged (Sink) and the charging cable connecting the device to the EPS. This model also enables compatibility with devices that are based on legacy USB connectors, have a permanently attached cable, or use a cable that is device specific. Several usage examples demonstrating end-to-end charging interoperability based on this comprehensive model are presented in Annex D.

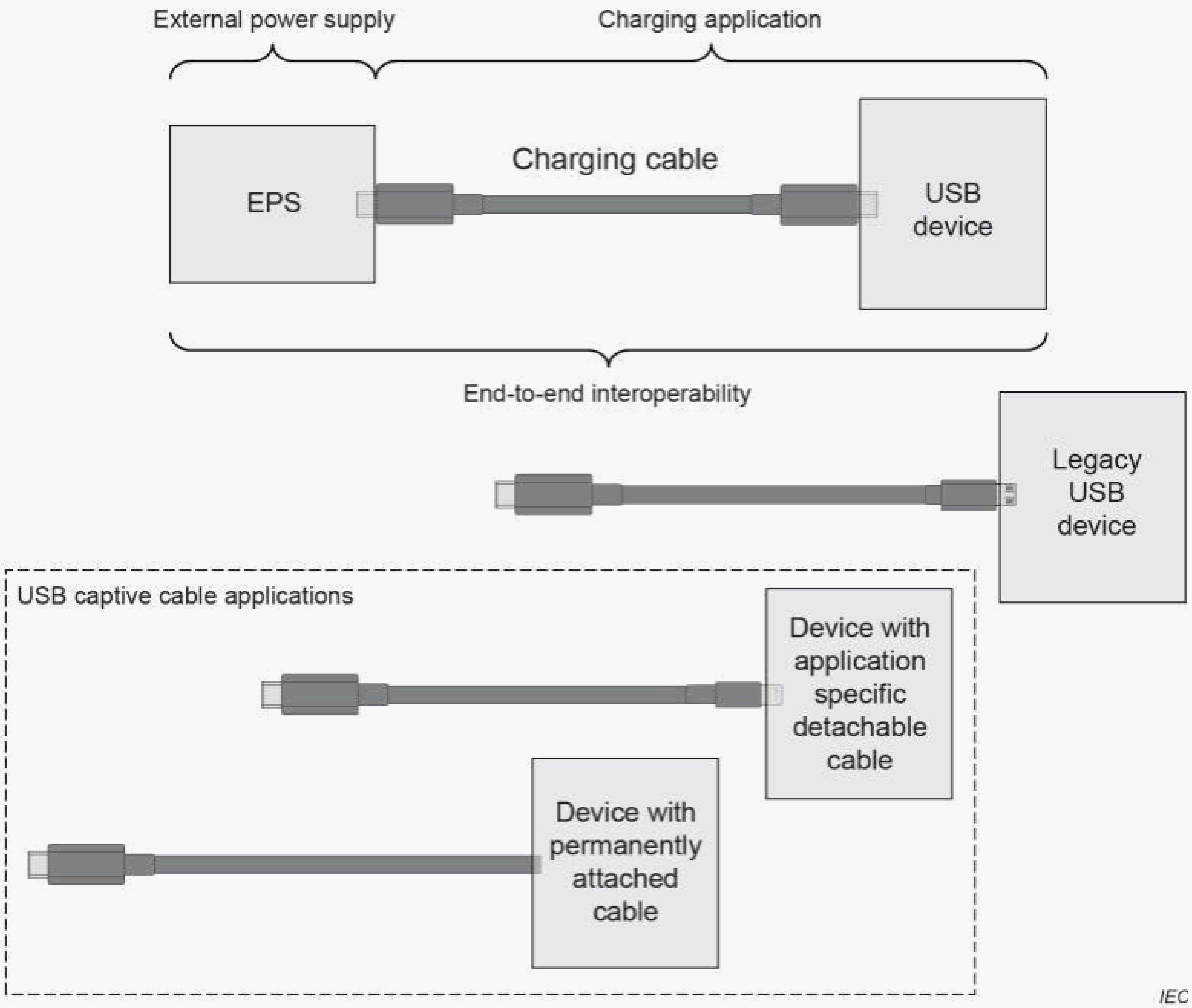


Figure 2 – USB EPS charging application model

In Figure 2, the last two devices illustrated align with the USB definition of a captive cable assembly – supporting these device usage configurations enables USB to support charging interoperability across a wider variety of applications that implement a non-USB standard receptacle or connector for any number of usage or design reasons but otherwise function as USB devices. Examples of these applications include a smartphone that has a non-USB receptacle and a USB power bank that incorporates a permanently attached cable for user convenience.

This charging model for USB Type-C is fundamentally the same as the previous generation USB charging model consisting of an EPS with a USB Standard-A receptacle which is the basis for charging interoperability specified in IEC 62684 [1] [2]. This USB Standard-A EPS model will continue to be supported even with new devices which are based on USB Type-C receptacles since USB-defined transition cables and adapters are readily available to enable basic charging interoperability.

2 Numbers in square brackets refer to the Bibliography.

4.3 USB standard charging summary and interoperability

Table 1 summarizes the standard charging modes defined by USB specifications, including the applicable USB connectors for each of the defined power modes. While the USB Type-C connector is functionally compatible with all existing USB power options, the older USB Standard-A and USB Micro-B cannot support some advanced USB Type-C dedicated power modes – these power modes are indicated in the lower portion of the table. As read down the table rows, each subsequent power mode is required to support backward-compatibility with all of the power modes above it – in this way, USB-defined interoperability between newer power sources is readily assured with older power sinks given that an appropriate cable or adapter is used (as indicated in the Interoperability column and the table notes).

Table 1 – USB standard power modes and charging interoperability

IEC specification	Power mode	Applicable receptacle connectors	Voltage	Current	Interoperability
IEC 62680-2-1 [2] IEC 62680-2-2 [3] IEC 62680-2-3 [4]	USB 2.0 [a]	USB Standard-A (Source) USB Micro-B [b] (Sink) USB Type-C (Source or Sink)	5 V	0,5 A	Forward compatibility supported using USB Standard-A to USB Type-C cables or USB Micro-B to USB Type-C adapters. Backward compatibility supported using USB Type-C to USB Micro-B cables.
IEC 62680-3-1 [5]	USB 3.0, USB 3.1, USB 3.2 [a]	USB Standard-A (Source) USB Micro-B [b] (Sink) USB Type-C (Source or Sink)	5 V	0,9 A	
IEC 62684 [1]	USB BC 1.2	USB Standard-A (Source) USB Micro-B [c] (Sink) USB Type-C (Source or Sink)	~~5 V~~	~~Up to 1,5 A~~	
~~IEC 62680-1-3~~	USB Type-C Current at 1,5 A	USB Type-C (Source or Sink)	~~5 V~~	~~1,5 A~~	Functionally compatible with USB BC 1.2 compatible Sinks up to 1,5 A. Backward compatibility in BC 1.2 mode supported using USB Type-C to USB Micro-B cables.
IEC 62680-1-3	USB Type-C Current at 3,0 A	USB Type-C (Source or Sink)	5 V	3 A	Functionally compatible with USB BC 1.2 compatible Sinks up to 1,5 A Backward compatibility in BC 1.2 mode supported using USB Type-C to USB Micro-B cables.
IEC 62680-1-2	USB Power Delivery (USB PD)	USB Type-C (Source or Sink)	Configurable up to 20 V	Configurable up to 5 A [d]	USB4™ uses USB PD as its power mode.

[a] These specifications do not explicitly define charging support requirements. When USB data ports also support charging, the current capabilities of these ports are typically based on what is defined for a USB port operating in its high power configured state, i.e. 500 mA for USB 2.0.

[b] While less common, USB Standard-B and USB Mini-B are also applicable for a Sink.

[c] While less common, USB Micro-AB is also applicable for a Sink.

[d] Power transfer over 3 A requires use of an electronically marked 5 A cable if EPS is a detachable cable design.

Annex B provides further detail on the robustness and interoperability characteristics of USB Type-C and USB Power Delivery solutions.

4.4 USB Type-C® Current

The USB Type-C Current power mode is based on a regulated 5 V power source with up to 3 A operation. This power mode uses a simple analogue method over the USB Type-C Configuration Channel (CC) interface for a Source to advertise its available current to a Sink. A USB Type-C Source may advertise default USB Type-C Current (500 mA or 900 mA, based on the version of the USB port and cable), USB Type-C Current at 1,5 A or USB Type-C Current at 3 A. An EPS shall indicate USB BC 1.2 compatibility on the port such that a device (Sink) that doesn't recognize USB Type-C Current modes but is compatible with USB BC 1.2 can still draw 1,5 A.

4.5 USB Power Delivery (USB PD)

Power transfer at other than 5 V or over 3 A shall comply with IEC 62680-1-2 (USB Power Delivery). USB Power Delivery standardizes the discovery, configuration and functional operation of more capable USB Type-C power sources and battery chargers. The USB PD protocol, operating as a digital communication over the USB Type-C CC interface, enables a predictable, reliable user experience based on a common set of robust mechanisms and communication exchanges between the USB Source and the Sink. The comprehensive set of power delivery methods supported by the USB PD protocol enables a broad range of battery charging approaches and profiles that are specific to the design and operation of the device being charged (the Sink) – this enables device designs to evolve and innovate while the capabilities of a USB PD-based charger can remain a constant.

USB PD protocol is used to provide system control, error detection and handshaking. The four required steps for enabling power delivery are:

1) Source offers its capabilities.
2) Sink requests from the offered capabilities.
3) Source accepts the request.
4) Source indicates that it is ready to provide power.

USB PD protocol can also be used for reporting the status (overcurrent protection, overtemperature protection, overvoltage protection, etc.) of the Source.

The USB PD protocol specifies two principal modes of power transfer that can be implemented by a USB PD Source.

– Fixed Supply operation: Provides a set of selectable fixed voltage and current combinations. IEC 62680-1-2 defines voltages that include 5 V, 9 V, 15 V and 20 V. The Source can offer as much as 5 A, depending on the cable current rating and selected voltage.
– Programmable Power Supply (PPS) operation: Provides granular control of voltage or a maximum regulated source current limit. In PPS mode, the integrity of the connection is continually monitored and absence of a handshake message between Source or Sink forces the connection to lower safe power level. PPS places the burden of regulation in the Source instead of in the Sink, allowing the Sink to better manage thermal rise during higher power battery charging, which aids in lowering touch temperatures. Standard-defined voltage ranges for PPS PDOs are nominally aligned with the defined Fixed Supply PDOs (5 V, 9 V, 15 V and 20 V) with a range minimum of 3,3 V and maximum of 5,9 V, 11 V, 16 V and 21 V, respectively. The Source could offer as much as 5 A, depending on the cable current rating and selected voltage.

By default, all USB Type-C EPS are required to output power over a USB connector as a Fixed Supply capable of 5 V up to 1,5 A. USB Type-C EPS chargers can also support USB PD. USB Type-C EPSs that implement USB PD fall into one of two defined categories: a USB charger supporting only Fixed Supply operation, or a USB charger supporting both Fixed Supply and PPS operation. For both categories, charger products are required to indicate a user-visible USB PD Power (PDP) rating, which dictates the minimum set of available voltage and current ranges that a charger supports. The PDP rating, for example, which is expressed in watts ranging from 15 W to 100 W, eases user experience by matching chargers' capabilities with device needs and also indicates expected charging performance. For any given PDP rating, the capabilities associated with all lower PDP ratings are required in the charger in order to assure safe downward compatibility with lower-power devices. See Annex C for more information.

The USB Type-C and USB Power Delivery specifications will continue to evolve as data performance and power needs increase over time, supporting new product designs and technology innovations. While the USB PD protocol defines advertisement mechanisms to articulate power source capabilities of up to 50 V and 10 A, the USB Type-C connector has a practical continuous capability of 5 A.

5 External power supply (EPS) specification

5.1 General hardware specification

5.1.1 General

An EPS compliant with this document shall provide power on at least one USB Type-C receptacle compliant with IEC 62680-1-3:2021. A power cable assembly, supplied with EPS compliant with this document shall comply with IEC 62680-1-3:2021, Clause 3, mechanical and electrical specifications for cable assemblies and connectors including USB Type-C standard cable assemblies, captive cable assemblies and legacy cable assemblies.

5.1.2 AC input characteristic

The EPS AC input shall operate over the following range.

1) Voltage range: the rated input voltage range covers the range 100 V to 240 V.
2) Frequency: 50 Hz to 60 Hz.

5.1.3 Environmental specification

The EPS operational environmental range, over which the DC output characteristics shall be maintained, shall be the following.

1) Temperature range: 0 °C to +35 °C.
2) Relative humidity: up to 90 %.

5.1.4 EPS detection

To enable a device to detect that it is connected to an EPS, the EPS shall meet the charging port requirements for a Dedicated Charging Port as defined in IEC 62680-1-1 and IEC 62680 -1-3.

An EPS compliant with this document shall by default supply 5 V with a minimum current capacity of 1,5 A.

An EPS may also provide voltages other than 5 V and currents greater than 1,5 A. These power sources shall comply with IEC 62680-1-2 and use methods for power reporting compliant with IEC 62680-1-3.

5.2 EPS protection

An EPS shall comply with IEC 62368-1 requirements for ES1.

EPS delivered power on V_{BUS} shall comply with PS2 or Clause Q.1 of IEC 62368-1:2018, where it is unknown if the Sink is likely to comply with the requirements for PS3 operation as specified in IEC 62368-1.

EPS maximum available output current under normal operating and single fault conditions shall not exceed 6,5 A for more than 5 s.

An EPS shall have overvoltage protection, whereby a detected voltage threshold of no more than 130 % of contracted V_{BUS} (or 6,5 V, whichever is greater) leads to an overvoltage protection event, whereby a voltage above the threshold value shall interrupt output current within 250 ms.

5.3 Important characteristics of an external power supply

5.3.1 General

Untested combinations of a power source and a device can benefit from reporting of the power source identity, characteristics, and status to the device. The device is recommended to use such information to confirm operation of the power source, modify its operation with the power source, or to reject usage of the power source. Annex E summarizes the identification and static parameters reported by a power source to a device when the USB Type-C Source has USB PD capability.

5.3.2 Positive identification of a unique power source model

The specific product identity number of the power source can be recognized by the device to allow optimized and compliant operation. The device shall be able to distinguish whether the power source is generic or known.

Hardware revision can affect the quality and performance of the power source. Reporting the date of manufacture or a hardware version allows the device to identify a power source whose performance characteristics can vary.

The power source shall identify its vendor. The power source shall also report a unique model identity of the power source. The Source can report OEM specific information that helps identify the hardware version of the model of the power source or serial number. The contents of the OEM specific identifier and hardware version are not standardized by this document but can be read by any device.

IEC 62680-1-2 enables reporting of the vendor identity (VID) and product identity (PID) in the Discover_Identity and Source Capabilities Extended commands. Firmware and Hardware versions and USB IF certification ID can be communicated in the Source and Sink Extended Capabilities Data blocks. Other OEM defined identification can be provided in the Manufacturer_Info command.

5.3.3 Static characteristics of the external power source performance and design

5.3.3.1 General

IEC 62680-1-2 enables identification of the voltage and power capabilities of the power source as well as some key electrical parameters for voltage tolerance. This document extends the range of the power source capabilities that are communicated to the device.

5.3.3.2 Load current step performance of the power source

The power consumption of a device can change dynamically. The ability of the power source to regulate its voltage output can be important if the device is sensitive to fluctuations in voltage. Transient changes in the system load with a Fixed Supply will result in changes to the load current from the power source. The ability of the Source to respond to transient changes in Sink load is known as "load current step" and capabilities are expressed as the magnitude of current change and also the rate of current change ("slew rate").

The power source should announce its guaranteed load current step performance.

a) The default load current step magnitude in IEC 62680-1-2 is established at 25 % of contracted current. The power source can report a capability of up to 90 % of the full load output, including from both no load and 10 % initial load. A power source reporting capability greater than the default shall support changes in both positive and negative load current steps from 1 Hz to 5 000 Hz.

b) The default load current step slew rate capability for an IEC 62680-1-2 power source is established at 150 mA/µs. The power source can report higher capabilities, guaranteeing a 500 mA/µs slew rate.

IEC 62680-1-2 enables reporting of the Source capabilities load step slew rate and load step magnitude performance in the Source Capabilities Extended data block's Voltage Regulation field.

5.3.3.3 Holdup time

The acceptable holdup time capability of the EPS (the condition of voltage regulation being disturbed by a distortion of the AC input on the primary) can depend on whether the device has its own battery or capacitive backup.

The EPS can report its guaranteed holdup time, from 3 ms to 16 ms. The holdup time, T_{holdup}, is measured at 115 VAC RMS and 60 Hz (or 230 VAC RMS and 50 Hz for an EPS that does not support 115 VAC mains) with the load at rated maximum. The reported time describes the maximum length of time from the last completed cycle zero crossing until when the output voltage, V_{BUS}, decays below the guaranteed voltage regulation (Figure 3).

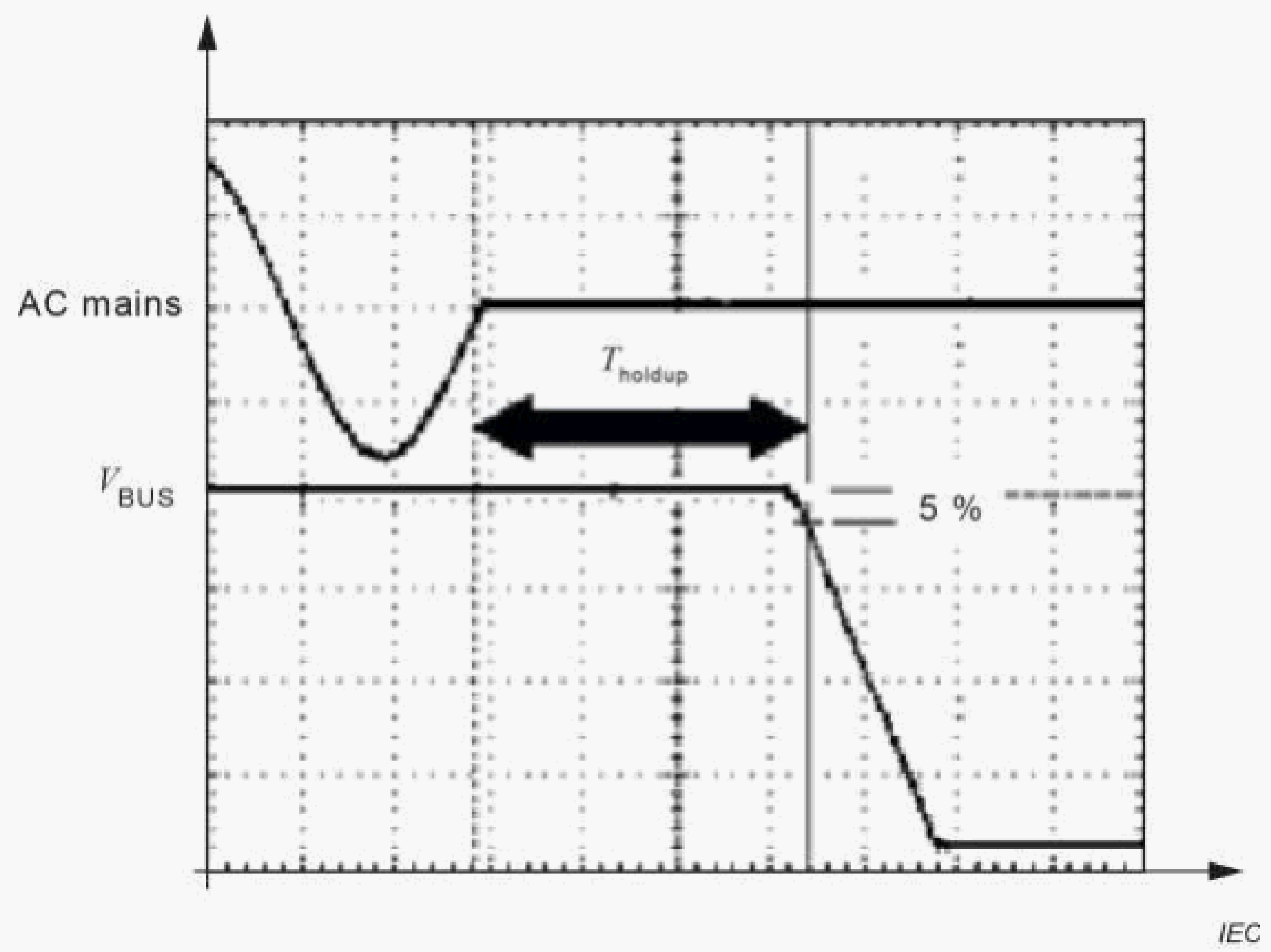


Figure 3 – Measurement of holdup time

IEC 62680-1-2 enables reporting of the holdup time capability performance in the Source Capabilities Extended data block's Holdup Time field.

5.3.3.4 Limited power source (LPS) compliance

A power source shall report to the device its level of compliance to LPS if in accordance with IEC 60950-1 and IEC 62368-1, or PS1 or PS2 if in accordance with IEC 62368-1.

IEC 62680-1-2 enables reporting of the limited power source compliance in the Source Capabilities Extended data block's Compliance field.

5.3.3.5 Touch current

Touch current relates to both ergonomic and functional aspects of the device, where electric currents pass through a human body. Touch current which is below safety limits can still be perceived by the user, usually when touching metallic chassis on the device, and worsened by higher (e.g. > 200 VAC RMS) AC mains. Touch current can also affect the performance of capacitive touch input devices such as touchscreens, touchpads, and capacitive buttons.

An EPS shall comply with IEC 62368-1 touch current requirements for ES1. An EPS can identify itself as a low touch current power source. A "low touch current" EPS shall be less than 65 µA RMS when the EPS's maximum rated power capability is less than or equal to 30 W, or less than 100 µA RMS when its power capability is more than 30 W. This current shall be measured in accordance with IEC 60990, in normal operating condition, using the perception and startle-reaction weighting network, at 250 VAC RMS AC mains and 50 Hz. When the EPS is provided with a functional earth connection, this current shall be measured with an open ground.

An EPS connecting to AC mains shall report whether a ground pin exists and shall report whether the ground pin is intended for functionality only or is relied upon as a protective earth for safety.

IEC 62680-1-2 enables reporting of the touch current performance and ground pin functionality in the Source Capabilities Extended report in the Touch Current field.

5.3.3.6 Minimum capabilities for peak current and overcurrent protection

Computing devices are highly power managed, and their power consumption is dynamic. Each power source can have its own capabilities for current at or in excess of the label rating, and power draw beyond those capabilities can result in overcurrent protection and surprise shutdown of the power source. A surprise shutdown of the power source can result in system slowdown if the computing device has a battery backup, or lost work or data if the computing device does not have battery backup. IEC 62680-1-2 allows optional reporting of peak current delivery in excess of the contracted amount reported in the Source PDO. Each Source PDO can report a Peak Current field that describes overcurrent capability for up to 10 ms. Two bits of information are used to communicate these power source capabilities. The duration of peak current shall be compensated by an immediate consumption below the Operating Current (IoC) in order to maintain a 20 ms average power delivery below the IoC.

The power source can report its capability of peak current. The amount of peak current shall be reported as a percentage of the maximum nominal operating current offered by the power source. For example, a power source with a nominal 1,0 A IoC but with peak current capability of 1,3 A RMS shall report "130 %".

The duration for the overcurrent (the debounce period) shall be a minimum uninterrupted trigger duration of 15 ms. Any decrease in power consumption below the reported peak current capability shall reset the trigger duration timer.

The power source should auto-restart after an overcurrent protection. A power source that does not auto-restart after an overcurrent protection event (a power source that requires manual intervention to restart after an overcurrent protection event) shall not report any greater capability of overcurrent tolerance (i.e. shall only report 100 % for this threshold).

IEC 62680-1-2 enables optional reporting of up to three combinations of capability of peak current and duration in the Source Capabilities Extended report in the Peak Current data fields. Overcurrent protection can be reported in the Event Flags fields of the SOP Status Data Block.

5.3.3.7 Surface temperature of the enclosure of the EPS

Safety limits for EPS touch temperature are set in applicable product safety standards (e.g. IEC 60950-1 or IEC 62368-1). The EPS can report when its touch temperature performance in normal operation conforms to the TS1 or TS2 limits defined in IEC 62368-1.

IEC 62680-1-2 enables reporting of the compliance with touch temperature performance in the Touch Temp data field. Dynamic temperature status of the Source or cable can be reported in the SOP Status Data Block Internal Temp field or Temperature Status field.

5.3.3.8 Overvoltage protection reporting in the EPS

Overvoltage of the EPS output can lead to damage of the device. The wide normal operating range allowed by IEC 62680-1-2 can be excessive for some devices. IEC 62680-1-2 includes protocol and detection methods to prevent the deliberate output voltage of the power source from exceeding the explicit requirements of the device. However, component failures in an EPS can randomly occur and cause an abnormal voltage output that exceeds the voltage tolerance of the device.

The Sink should consider its design capacity for overvoltage and include its own protective devices. The Sink should not consider overvoltage protection in the power source as principal or as redundant protection.

IEC 62680-1-2 enables optional reporting of the incidence of overvoltage protection. Status can be reported in the OVP bit of the Event Flags in the Status Data Block.

5.3.4 Example usage scenarios of enhanced reporting from the power source

5.3.4.1 General

This document recognizes that quality of operation for a device ultimately relies on testing and mitigation of potential interoperability issues. This document cannot address quality of a power source and does not require any operation of the device.

5.3.4.2 Unique identification of the power source

The VID, PID and hardware version can form an identity of the specific manufacturer and model of the power source. The device can use the identity to recognize that the power source has been tested. Or, the device can understand limitations or known characteristics of the attached power source and modify its policy. For example, the PID or VID can be interpreted to indicate that the power source is a particular power source, or instead a docking station or a monitor.

A device can use the identity to approve the use of a power source as a function of operating mode. For example, an untested power source can be considered to pose less of a user problem if its usage is only to provide battery charge while the system is off or enable only partial battery charge.

The identity can be used to recognize when a new device is attached or to establish usage models that suggest the device is used in a particular location. For example, the hardware version can be distinguished as "new" and USB data on the port disabled as a security measure. Or the identity can distinguish the location (work or home) to employ a particular power consumption policy. Or the identity can be used when the device is a dual mode (consumer and provider), for example, to automatically configure a direction of power sharing when both devices are battery powered.

The hardware version and Manufacturer_Info fields can also be used, for example, to recognize devices that can be prone to failure and alert the user to a maintenance action.

The power source identity can be used by the device rejecting any usage.

5.3.4.3 Identification of voltage regulation, load current step and slew rate

Battery-powered devices generally are tolerant of broad changes in voltage. The actual voltage regulation to the device can depend on both the power source voltage range and the detachable cable. The device can consider the potential voltage variance of the power source, consider its own active power consumption, and, for example, can choose a different voltage if the total voltage tolerance cannot guarantee complete operation or battery charge.

5.3.4.4 Load current step magnitude and slew rate capability

Load current step magnitude and slew rate of the power source can be evaluated by the device and the amount of dynamic power consumption affected. For example, a power source guaranteed for only 25 % load current step magnitude can be perfectly accepted by a notebook with a small processor and dominant static load (display, battery charge). A desktop computer without significant static load can reject a power source with less than 90 % magnitude guarantee or can include sufficient local capacitance so as to accept a power source with limited load current step slew rate. A device can limit performance capabilities or establish policies that modify their transitions in power consumption to operate within the reported capabilities of the power source.

5.3.4.5 Holdup time

Holdup time is especially relevant to a system without battery backup. A device can limit its maximum power consumption in order to operate reliably from a power source without significant local capacitance or can reject the use of the power source.

5.3.4.6 Low touch current reporting

Certain users can have internal requirements for touch current or can reject use of a power source if the touch current is higher. If the device has a non-conductive chassis, or is rarely in contact with the user, touch current is unlikely to be noticed. If the device chassis is metal, or if there is a suggestion that it is physically being used on a person's lap, or in a location with high voltage AC mains, the device can reject use of a power source that has a touch current that is higher than desired.

5.3.4.7 Peak current capability

Knowledge of the power source peak current capability can be used as a performance tool for the device. In contrast to static loads (such as battery charging), the power management of a computing device is highly dynamic. Portable computing devices generally have very limited local energy storage (capacitance) and the variation in load current and power can be significant. Peak current consumptions are generally instantaneous, and characterization (not closed loop feedback) is essential to avoid normal power consumption of the device from being confused as circuit failure or short circuit by the power source.

5.3.4.8 Surface temperature of the power source

The device can consider the reported IEC 62368-1 TS1 or TS2 value of the power source, compare to its own power consumption, and can decide to limit battery charge rate or otherwise average its own power consumption in order to limit the touch temperature of the EPS.

The EPS can optionally report dynamically its temperature and the Sink can reduce its power consumption to limit heating of the power source.

Annex A
(informative)

Open issues related to arbitrary combinations of power source and device

A.1 EMC, safety, and performance

Untested or arbitrary combinations of power source and device cannot guarantee the same level of assurance for EMC and safety as specific combinations that were tested by Certification Bodies.

EPSs supplied to the end user with devices are typically designed for use and tested together. System performance and reliability can be guaranteed only for those tested combinations.

A.2 Authentication, attestation, and data integrity protection

This document relies on a foundation of trust between the power source and the device. Functionality, EMC compliance and safety (and the mitigation methods suggested in this International Standard) assume that the information provided by the power source is genuine.
A counterfeit power source can masquerade and report the identity or characteristics of a trusted power source, but not follow the quality of design or manufacturing that ensured the original's operation.

IEC 62680-1-4 [6] specifies means for authenticating products with regard to identification and configuration. Products that use the authentication protocol retain control over the security policies to be implemented and enforced. USB Type-C authentication protocol relies on 128-bit security for all cryptographic methods. The specification references existing internationally accepted cryptographic methods for certificate format, digital signing, hash and random number generation. USB Type-C Authentication allows an organization to set and enforce a policy about acceptable products. This can permit useful security assurances in real world situations.

EXAMPLE 1 A vendor, concerned about product damage resulting from substandard charging devices, can set a Policy requiring that only certified PD Products be used for charging.

EXAMPLE 2 A user, concerned about charging his phone at a public terminal, can set a Policy in his phone requiring that the phone only charge from certified PD Products.

EXAMPLE 3 An organization, concerned about unidentifiable storage devices gaining access to corporate PC assets, can set a Policy in its PCs requiring that only USB storage devices that have been verified and signed by corporate IT are used.

Because all cryptographic methods rely on secrets, attack vectors to extract private keys or exploit software vulnerabilities and create clones remain possible. Establishing an industry standard method of surveillance that can help recognize clones and identifying a supported set of policies for warning the user or revoking private keys is beyond the scope of this document.

A.3 Conducted noise from the EPS

Common mode output noise can affect the operation of the device, particularly capacitive sensors (touchscreen or touchpad) that rely on sensing a capacitive path to earth ground. Common mode noise is typically a product of the switching frequency of the conversion topology of the power source. The power source can have multiple stages of power conversion and each switching frequency can change dynamically, for example as a function of the output voltage, mains voltage, or activation of PFC. Reporting narrowband noise characteristics of the power source can conceivably allow the device to "frequency hop" to avoid functional problems due to this interference. However, further work is needed in this area; as touchscreens have become a standard user interface, the issue of power source common mode noise remains a problem for common power.

Annex B
(informative)

USB Type-C and USB Power Delivery robustness and interoperability

B.1 Overview

This annex summarizes aspects of the USB Type-C (IEC 62680-1-3) and USB Power Delivery (IEC 62680-1-2) specifications that pertain to robustness and interoperability.

B.2 USB Type-C Cable and Connector (IEC 62680-1-3)

B.2.1 General

USB Type-C-based products can terminate in either a plug or receptacle. IEC 62680-1-3 provides detailed requirements for cable assemblies with USB Type-C connectors in order to minimize interoperability issues. For example, all cables that support either SuperSpeed USB signalling or currents above 3 A are required to contain a Cable Identifier (electronic marker). Without detection of an appropriate Cable ID, all charging is limited to 3 A regardless of the capabilities of the power source and the device.

B.2.2 Current capacity and cable identity

USB Type-C connectors (plugs and receptacles) support 5 A over VBUS. This limit has been established based on the physical characteristics of the electrical contact design and requirements, and in consideration of maintaining tolerances in a high-volume manufacturing process while still allowing interoperability of suppliers and reliable operation after thousands of connect cycles.

Standard USB Type-C cables have two choices with respect to current carrying capability of the cables: default 3 A and optional 5 A. The current limit of a USB Type-C cable is a result of the resistance of the cable that guarantees a certain maximum voltage drop between Source and Sink for purposes of efficiency as well as for assuring reliable USB PD and USB data communication. "Ampacity" is not relevant to cable damage; a 5 A cable can be only a shorter version of a 3 A cable. Cable design variables include the DC resistance of the power and ground conductors and the cable length.

USB Type-C to USB Type-C cables rated for up to 5 A applications are identified by an electronic marker using USB PD digital communication. The Source is required to positively identify the electronic marking of the cable before offering more than 3 A to the Sink.

Power transfer over USB Type-C is intended for operation when Source and Sink are physically adjacent, connected by a cable assembly.

NOTE This document does not address requirements for the use of USB cables as building wiring.

B.2.3 Interoperability

Power from USB sources is commonly provided to small devices such as mobile phones and tablets from power sources other than EPS, such as higher-power computing devices (e.g. laptop computers) and electrical charging outlets. Connection to computing devices often carries data as well as power and the user can use one cable for charging and data communication needs.

An EPS terminating in a USB Type-C receptacle, used with detachable cables, has several benefits.

– It can support interoperability with products that do not implement a USB Type-C receptacle when an appropriate device-compatible cable is used.
– The charging cable can be readily replaced if the cable wears out.
– It can be easier to store and carry.

Some higher power EPSs, for example one that is used for laptop computers, are implemented with a permanently attached USB Type-C cable to allow the power source supplier to control the quality of the cable, or to match the characteristics of the power source to the cable. Conductor resistance and EMI characteristics of the cable are inherently part of the EPS with permanently attached cable.

B.2.4 Legacy support

IEC 62680-1-3 defines standard and supported legacy cabling connections. All USB Type-C receptacle-based EPSs support legacy USB BC 1.2 (IEC 62680-1-1) interoperability for device charging using USB Type-C Current announcement of a minimum of 1,5 A along with USB BC 1.2-defined D+ and D − termination.

IEC 62680-1-3 defines USB Micro-B receptacle to USB Type-C plug adapters to enable interoperability of existing USB Standard-A chargers with a USB Standard-A to USB Micro-B cable and existing USB chargers that have a permanently attached cable terminating in a USB Micro-B plug.

To address USB Type-C EPS use with legacy devices based on USB Micro-B, IEC 62680-1-3 defines a USB Type-C to USB Micro-B cable.

B.3 USB Power Delivery (IEC 62680-1-2)

B.3.1 General

IEC 62680-1-3 specifies that negotiation of voltages above 5 V or power capability over 15 W use only IEC 62680-1-2 methods.

B.3.2 Robustness

USB Power Delivery communication is limited to a point-to-point channel that extends only between the Source, a single cable, and the Sink. Bridges or routers are not permitted for USB PD communication; the Source, cable, and Sink always have direct, unhindered, and unaffected communication to each other.

A single, common wire (the configuration channel, CC) in the USB Type-C interface is used for both detection and communication. A single hardware fault on the CC line will lead to safe disconnect of all power transfer by the Source. Communication is fixed rate, low speed, using a half-duplex Poll and Response protocol. Failure of connection or communication (connector or cable, by short or open, excessive noise, etc.) will lead to default 5 V operation or electrical detach as required in IEC 62680-1-3.

Data Communication is robust, with every message accompanied by a cyclic redundancy check (CRC), error checked and acknowledged. Messages are sequentially numbered and rigidly processed in order. As required in IEC 62680-1-2, data message sequences used for configuration are atomic (non-interruptible), such that unexpected or interrupted communication is detected as an error and leads to reset of the bus and returns power to its 5 V default.

Implementation of USB PD does not decrease the responsibility of the device to charge its battery safely and reliably. Safety requirements for protecting cell voltage, current, or temperature are in all cases the responsibility of the Sink, not the Source. The USB PD PPS protocol increases robustness of USB PD communication with a required periodic message exchange to reaffirm the voltage or current requested, but in no way changes the responsibility of the Source and Sink to respond independently to abnormal operation or abuse.

B.3.3 Error detection and recovery

As defined in IEC 62680-1-2, the Source and Sink operate independently to detect failure in communication or operation and react to errors. Errors can be detected by either the Source and Sink and are enforced by hardware to lead to a safe state or disconnection of the USB Type-C bus.

When implementing USB PD, overall system robustness is reinforced by hardware sensors and timers in both the Source and Sink that monitor:

- communication errors, absence of communication, or unacknowledged communication;
- voltage out of regulation, or incomplete or untimely voltage transitions;
- failure of a swap of power direction between Source and Sink;
- failure of a soft or hard reset;
- loss of periodic affirmation messaging in PPS mode.

The response to any kind of error between the Source and Sink is progressively soft reset (where power is not disrupted), then hard reset (where power transitions to a 5 V safe level), then removal of power. This process is hardware enforced by each side and does not require user interaction. Failure to receive an acknowledgement in any message exchange between the Source and Sink will result in a message retry, and after two retries or after hardware timeout, the interface is reset to a safe state.

When a Sink or the interconnecting charger cable is detached from either the Source or the Sink, the Source port returns to a "cold" state where power at the receptacle is turned Off, until a Sink is reattached, and 5 V is once again made available.

Annex C
(informative)

USB charging profiles and device charging performance

C.1 Overview

USB Type-C and USB Power Delivery standardize a common toolset that allows higher power delivery and more control of power for battery charging than was available with legacy USB technologies. Consistency and predictability of the time needed to charge a battery-powered device improve with USB Type-C.

As described in Clause 4, the USB Type-C charging application model recognizes that the device being charged (the Sink) is fundamentally responsible for implementing and managing the charging profile of its internal battery using the capabilities and adaptive power delivery methods provided by the Source.

The charging profiles or algorithms implemented by the device in conjunction with the capabilities of the power source, battery capacity and the current battery state will ultimately determine the time required to charge the device's battery. The time required to charge a battery can be limited by the following.

– Power capability of the source and charging cable.

  NOTE Power capability affects size and cost of a source.

– Power conversion inefficiency in the device and its effect on reliability or touch temperature.

– The battery cell state of charge. For example, the charging rate to a lithium-ion battery above approximately 75 % full could be limited.

– Environmental conditions. Battery temperatures can slow charging rate.

– Battery lifecycle requirements. Higher power charging to reduce charge time causes stress that reduces the useful life of the battery, and so is typically only used when the battery is between 0 % and 75 % full.

With a given EPS, the user's charging experience will vary across different but similar devices, e.g. different mobile phones, based on many device designs, battery state and environmental factors outside the control of the EPS. The comprehensive range of charging technologies within USB Type-C and USB PD-enabled EPS chargers help to deliver the best possible charging experiences across different devices that are capable of using them – even devices that are not designed to use more advanced USB capabilities could at least be able to receive a basic charge at a default USB compatibility level.

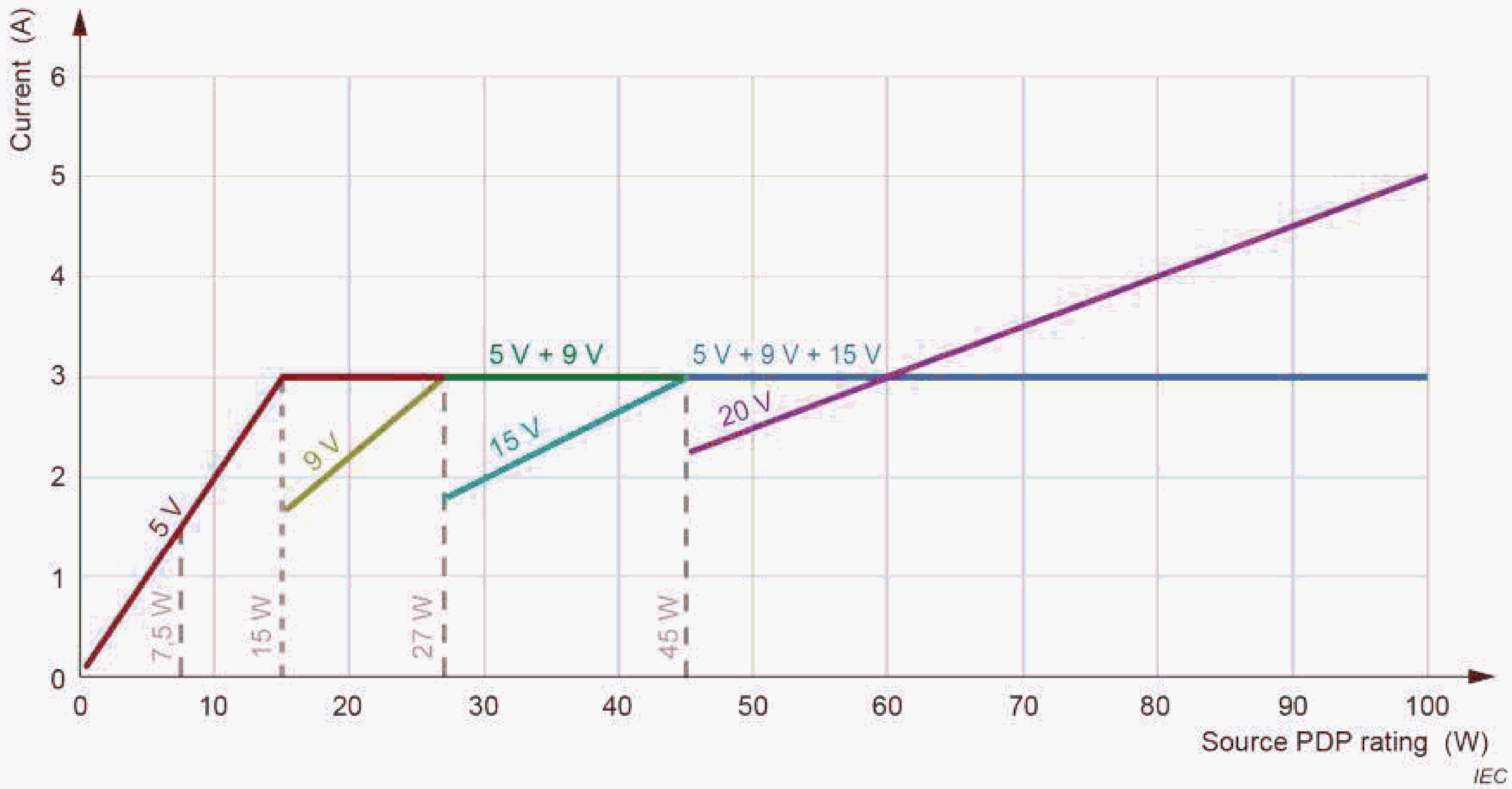
Because USB PD-based EPSs support a wide range of power levels and power transfer methods, innovation in the device market for battery charging is readily enabled – manufacturers can design their device charging circuits and operational profiles to best match the battery technology and the intended user experience. As battery technology evolves and user experience requirements shift in future products, the manufacturer can adjust or programme its use of the USB Power Source as needed without the need for a new EPS.

C.2 USB Type-C and USB PD power capabilities model

As outlined in Table 1, a USB Type-C-based power source that offers only up to 15 W is not required to support USB Power Delivery. Only Fixed Supply 5 V power transfer at up to 3 A is available based on the USB Type-C Current protocol. Above 15 W, USB PD technology is incorporated to communicate and establish the power contract between the power source and the device to be charged.

All USB PD power sources are rated for the maximum available power capacity of the source using a figure of merit known as USB PD Power (PDP). The required minimum functional capabilities of a given power source with a given PDP rating is deterministic in conjunction with the category of power source (USB Charger or USB Fast Charger). This model is architected to enforce the downward compatibility of higher-performance chargers with lower-power devices.

For all USB Type-C power sources that implement USB PD, Figure C.1 illustrates the minimum required power capabilities (the "Source Power Rules") for Fixed Supply operation. By establishing a vertical line that intersects the horizontal axis at the rated PDP of the power source, the minimum current (A) requirements for the defined fixed voltages are determined. For example, for an EPS with a PDP rating of 30 W, the minimum required set of fixed voltages and current capacities would be: 5 V at 3 A, 9 V at 3 A, and 15 V at 2 A.



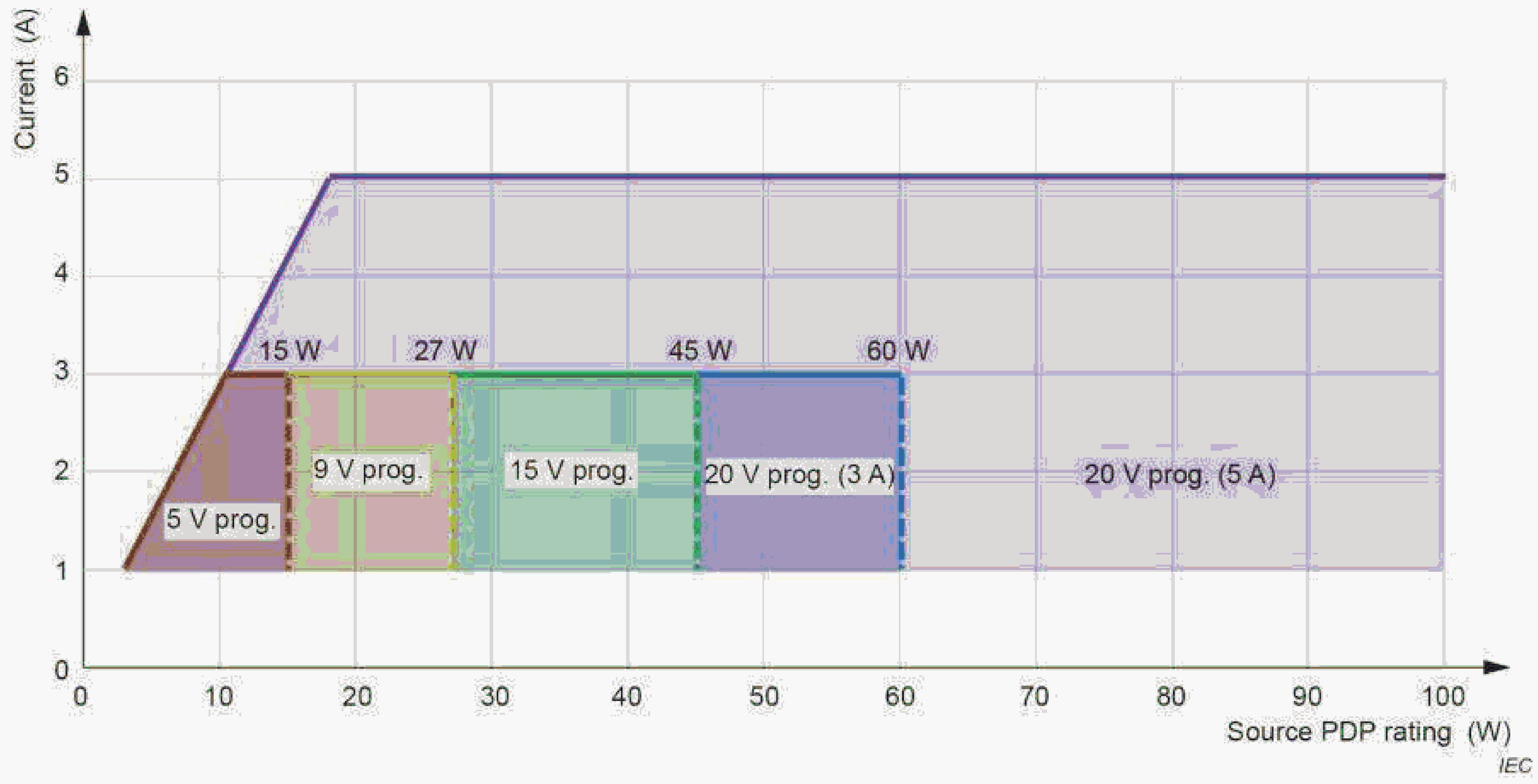
(Reference: IEC 62680-1-2:2021 Clause 10)

Figure C.1 – Source power rules for Fixed Supply operation

Optional fixed voltages (up to 20 V) and currents (up to 5 A) could be provided by a USB PD power source if the total power product for these is not greater than the PDP rating and does not violate the current limit of the attached cable.

For USB Type-C power sources that also include Programmable Power Supply (PPS) capabilities, the minimum required power capabilities follow a pattern aligned with Fixed Supply operation with set voltage ranges associated with each of the nominal fixed voltages. Figure C.2 summarizes the relationship of USB PD Power (PDP) rating and PPS operation. Note that the minimum PPS voltage is 3,3 V and the minimum PPS current is 1 A.

PPS charging methods commonly rely on incrementally increasing the requested charge voltage in sync with the current battery voltage level while maintaining a high level of current enforced by a programmed current limit until the battery reaches a voltage level close to its maximum voltage capacity. At this point, the required level of current decreases as the battery more gradually increases to its maximum voltage. It is because of this that PPS operation generally does not get to a maximum voltage at the same time as being supplied a maximum current.



(Reference: IEC 62680-1-2:2021)

Figure C.2 – Source power rules for PPS operation

For example (Figure C.3), for an EPS with a PDP rating of 30 W, the minimum required set of PPS voltage range and current capacities would be: 9 V prog. at 3 A (includes the 5 V prog. mode) and 15 V prog. at 2 A.

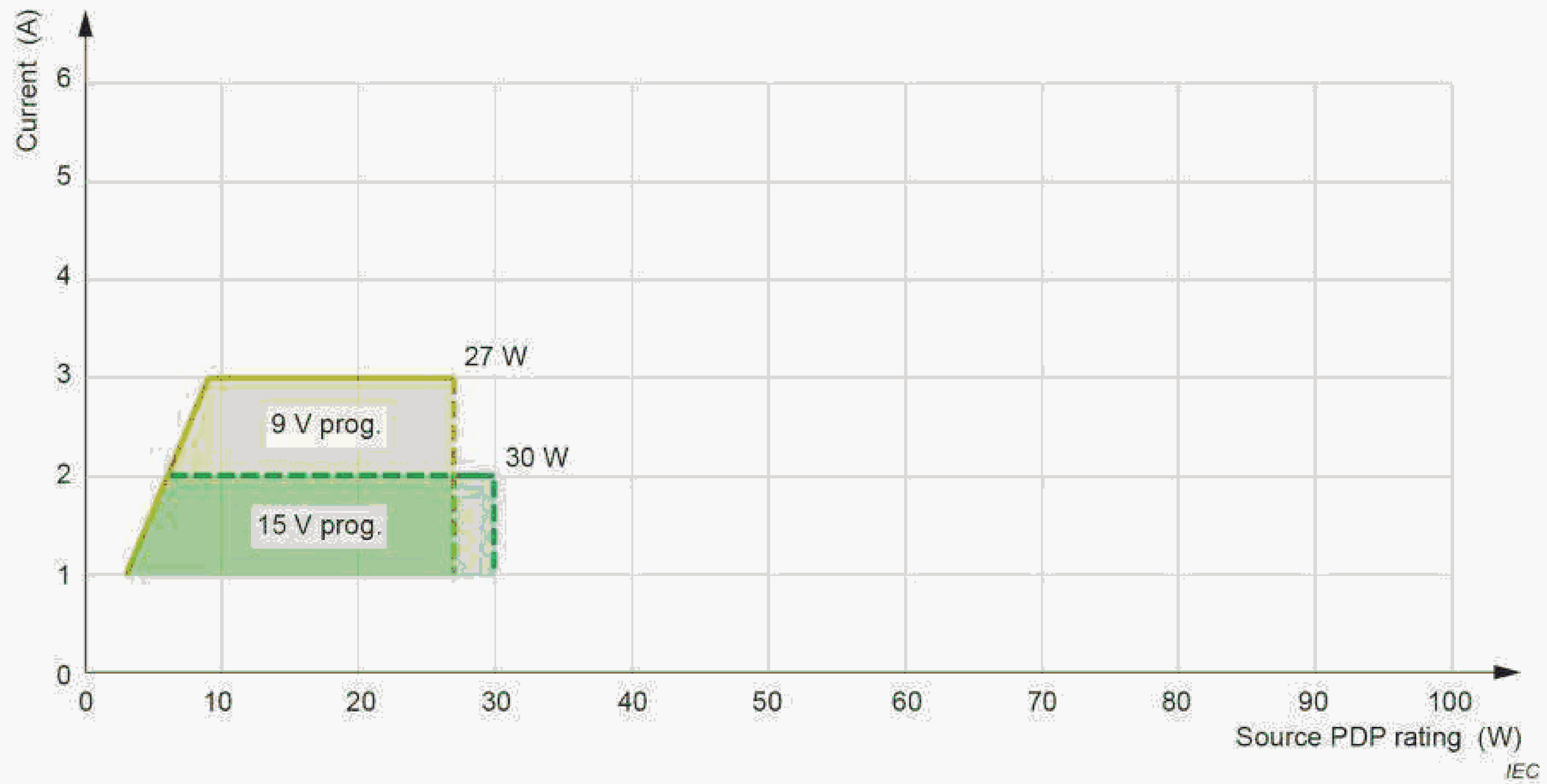


Figure C.3 – 30 W PDP PPS example

C.3 Battery charging performance

The control and management of the battery charging profile is the responsibility of the device that is being charged – the USB Type-C power source is only capable of transferring power based on its defined capabilities as communicated to the device, and the power source has no specific knowledge of the state of the device's battery.

Given that the capabilities of the power source are deterministic based on its PDP rating, the device can rely on the minimum set of capabilities being offered by the EPS. In some cases, the EPS can offer additional capabilities as specified in USB PD protocol where devices can take advantage of those additional capabilities if the device can intelligently adapt to them – for example, an EPS could offer fixed voltages in addition to the standard required voltages that can be better for some use cases, e.g. charging laptop computers.

User experience demands have driven device manufacturers toward implementing charging solutions that reduce the time required to deliver typically 75 % or more charge state – this has led to a market that characterizes battery performance not only in terms of useful battery life but now also emphasizes performance in terms of charging times. However, owing to the significant variability between device designs of different manufacturers, simply characterizing charging rates as either fast or slow is not necessarily meaningful as an indicator of the user's device-charging experience. In general, being able to deliver higher levels of current to the battery during the primary or middle stage of the charging profile is key to decreasing charging times, although supplied current versus charge time is not necessarily a linear relationship, e.g. doubling the current does not equate to halving the charge time.

Devices that rely on USB Type-C and USB Power Delivery for charging are designed to at least charge at some assured level with any USB Type-C charger even if the charging experience is not optimum for the user. Devices could be designed to align their charging profile to best match the capabilities of the attached charger – such that as capabilities increase with higher-rated chargers, the charging performance improves until the capabilities of the attached charger reach or exceed the optimum charging profile designed into the device.

C.4 Fixed Supply charging versus PPS charging

The Programmable Power Supply (PPS) charging mode offers some specific advantages over Fixed Supply charging mode. Most significantly, PPS power transfer methods allow a device to better manage the efficiency of its battery charging circuits and profiles which can help reduce the thermal losses in the device. While the device supports operation with Fixed Supply chargers, charging performance in these situations can be lower due to the thermal constraints of the device design.

PPS charging methods enhance the efficiency of high-power transfer for battery charging. PPS protocol enables dynamic fine-grain adjustments to voltage and current regulation in the EPS as dictated by the device. Efficiency inside the device can be enhanced as coarse regulation is not performed within the device chassis, but instead by precise power control from the external power source. For example, the improved efficiency results in optimally decreased temperatures inside a mobile phone while charging, increasing ergonomic comfort (by lowering touch temperature of the phone) while also avoiding unnecessary temperature escalation of the battery (which decreases the lifecycle capacity of the battery cell).

PPS does not specify a charge algorithm. Battery charge taper and charge current algorithm are completely the responsibility of the device, not the Source. PPS and USB Power Delivery do not define power budgeting policies in the device; for example, neither IEC 62680-1-2 nor IEC 62680-1-3 describes policy for power allocation to battery charging when the system is simultaneously being used. USB specifications do not address "charging time" performance of any device. The rate of charging and algorithms implemented in devices are expected to continue to evolve as chemistry and charging technologies for device batteries change.

Annex D
(informative)

Common charging interoperability use cases

D.1 General

It is expected that this document will continue to support global industry in developing market solutions for improving re-usability of EPSs and other power sources across a broad range of mainstream device categories and facilitate future charging interoperability use cases. The greatly increased potential for re-use of power sources enables significant environmental benefits such as e-waste reduction in addition to increasing user convenience.

D.2 Examples of device use cases

D.2.1 General

Adoption of this document facilitates increased interoperability of power adapters (EPS) within a device category and across different device categories. This document also enhances the capability of devices to identify capabilities and detect potential technical issues, so to reduce functional problems and increase protection of devices and users. These capabilities can assist diagnosis and technical support. Devices can also be enabled to provide enhanced information to users regarding the power adapter used and charging characteristics.

D.2.2 Smartphone

Smartphone charging interoperability has been enabled by global market adoption of USB technologies (IEC 62680-1-1, IEC 62680-2 and IEC 62684). Compliance with this document further enhances charging interoperability as follows.

– Standardized methods with IEC 62680-1-2 (USB Power Delivery) and IEC 62680-1-3 (USB Type-C) to support higher-power smartphone charging applications.

– Enables cases of using higher-power adapters (compliant with this document) for charging smartphones.

– Enables cases of using smartphone power adapters with higher-power devices such as tablets and notebook computers (with longer charging time considerations).

D.2.3 Higher power computing devices (tablets, notebook computers, etc.)

– Users can charge their personal computing device with power adapters that were provided with a different device. Users can efficiently charge their device when using a power adapter for the same product category or higher power product categories. Users can maintain charge or charge their device more slowly when using a power adapter for lower power product categories.

EXAMPLE 1: Users can charge a smartphone with a notebook computer power adapter.

EXAMPLE 2: Users can charge a tablet with a smartphone power adapter.

EXAMPLE 3: Users can use a small power adapter with a laptop in "hybrid" mode so as to slow the decline of the battery capacity.

EXAMPLE 4: Users can travel with just one power adapter for charging multiple devices such as a small and light power adapter for smartphone and notebook computer (with overnight charging), or a larger power adapter for charging multiple higher power devices.

– Users can charge their personal computing device from an AC-powered external display connected by USB Type-C.

– Users can charge their personal computing device, without a power adapter, directly from IEC 62680-1-3 compliant sockets in automobiles, aeroplanes, furniture, electrical wall plates, desktop computers, etc. connected with an IEC 62680-1-3 compliant cable.

EXAMPLE 5: Users can charge their notebook computer from an in-seat socket in an airport departure lounge while waiting for a flight. This expands the use cases beyond smartphones and lower-power tablets which have been enabled by IEC 62680-2-3 (USB Standard-A) compliant sockets.

D.2.4 Other consumer electronics devices (smart watches, electric toothbrushes, etc.)

– Users can power a wireless charging device from a USB Type-C power source.

EXAMPLE A user with a wearable device such as a smart watch can charge their connector-less device from a wireless power transmitter that sources its power from a USB power source.

D.3 Examples of consumer use cases

The following are examples of consumer use cases enhanced by broad market adoption of this document, IEC 62680-1-2, and IEC 62680-1-3.

– Backwards compatibility for charging between legacy USB chargers and mobile phones. Using appropriate USB Type-C to legacy cables, phones using USB Micro-B can be directly charged with new USB Type-C chargers and sources and older chargers with USB Standard-A receptacles can charge newer phones with USB Type-C.

– Users can typically charge the battery in their mobile devices faster when using an EPS with a higher PDP rating compared to the originally supplied EPS.

– Users can charge their personal computing device and electronics devices (notebook computer, tablet, smartphone and other related devices such as wearables, music or video players, gaming machines, rechargeable toys) with power adapters from different manufacturers and product types.

– Users can charge their personal computing device from a USB hub or dock which is itself connected to a USB PD power source, both connections using USB Type-C.

– Users can view enhanced information provided by the device on charging characteristics or any issues with the specific power adapter used for charging.

– Users can charge their battery-powered device from another battery-powered device.

EXAMPLE: A user can charge their mobile phone and tablet directly from their laptop computer.

– Users can power or charge their device from an external battery pack.

Annex E
(informative)

Conformance and market considerations

E.1 General

Annex E summarizes the compliance requirements of this document, as well as examples of other existing regulatory, conformance, and market compliance programmes which are in practice.

– Clause E.2 describes the identification and static parameter reporting required by this document and their test references.

– Clause E.3 provides information on the USB-IF compliance programme for EPSs.

– Clause E.4 provides examples of other regulatory and market compliance programmes relevant to EPSs.

Compliance requirements relating to IEC 62680 are covered under the USB-IF Compliance Program [7].

E.2 Summary of reported items and test references

Table E.1 summarizes the identification and static parameters reported by a power source to a device when the USB Type-C Source has USB PD capability.

Table E.1 – Summary of reported parameters from USB PD power source and their test references

IEC 63002 sub-clause	Name	Values	Description	IEC 63002 Compliance requirement	Test reference
5.3.2	VID PID Hardware version, Manufacturer_Info	Hex or ASCII strings	Identification of manufacturer, model number of the power source , and hardware version. VID is assigned by USB-IF. PID, hardware version, Manufacturer_Info are OEM assigned.	VID and PID required Hardware version and Manufacturer_Info recommended	USB-IF Compliance Program [7] *Universal Serial Bus Type-C and Power Delivery Source Power Requirements Test Specification* . [8]
5.3.3.2	Load current step magnitude	25 % of IoC (default), or 90 % of IoC	Guaranteed capability of the power source, magnitude of the load change supported.	Recommended	5.3.3.2
	Load current step slew rate	150 mA/µs (default), or 500 mA/µs, or 1 A/µs, or 2 A/µs	Guaranteed capability of the power source.	Recommended	
5.3.3.3	Holdup time	3 ms to 16 ms	Duration voltage stays in regulation upon interruption of AC mains.	Recommended	5.3.3.3

IEC 63002 sub-clause	Name	Values	Description	IEC 63002 Compliance requirement	Test reference
5.3.3.4	Compliance with LPS/PS1/PS2	Yes or no for each: PS1 compliant PS2 compliant LPS compliant	PS1 and PS2 compliance in accor-dance with IEC 62368-1. LPS compliance in accordance with IEC 60950-1.	Required	IEC 60950-1 IEC 62368-1
5.3.3.5	Low touch current EPS	Yes or no	A low touch current EPS is less than 100 µA for EPS with more than 30 W PDP power capability, 65 µA or less for EPS lower than 30 W power capability.	Recommended	IEC 60990
	Ground	EPS has a ground pin (yes or no)	Simple reporting of the option for ground on the EPS body.	Required	
		Ground pin is intended for functionality only, or Ground is intended as protective earth.	Distinguish purpose for the ground pin as functional or protective.	Required	IEC 62368-1 5.3.3.6
5.3.3.6 5.3.3.7	Peak current	100 % to 200 %	Peak current as a percentage of highest guaranteed IoC of the EPS that will not trip overcurrent protection if applied continuously for 15 ms.	Recommended Recommended	
	Touch temperature	60950-1 (default), or 62368-1 TS1, or 62638-1 TS2	Touch temperature performance under normal operation.		IEC 60950-1 IEC 62368-1

E.3 USB-IF Compliance Program [7]

The Universal Serial Bus (USB) specifications define the product design targets at the level of interfaces and mechanisms. To complement the specifications and enable measurement of compliance in real products, the USB-IF has instituted a Compliance Program that provides reasonable measures of acceptability. Products that pass this level of acceptability are added to the Integrators List. Use of any of the registered USB-IF logos and icons requires that the product has been certified by the USB-IF and the company has executed the USB-IF logo licence agreement.

For EPS based on USB Type-C and USB Power Delivery specifications, there are two product certification categories: Certified USB Charger (Fixed Supply) and Certified USB Fast Charger (Fixed Supply and Programmable Power Supply). In addition to the two functional categories, chargers are also certified to the USB PD Power (PDP) rating, which is also incorporated into the certification logo.

Examples of the certification logos PDP rated at 45 W are provided in Figure E.1.

a) Example for Fixed Supply source

b) Example for Fixed Supply plus PPS source

Figure E.1 – USB certified charger logos

Products certified by the USB-IF and listed on the Integrators List are compliant with the specific specification and have been tested for interoperability.

E.4 General regulatory compliance for a power source

Each power source is expected to be so designed and manufactured to meet the regulatory requirements for its intended markets.

Examples of current regulations and standards applicable to power source for the US and EU in the areas of safety, EMC, energy and environmental requirements are given in Table E.2. This table is for illustration only and is not intended to be exhaustive.

Table E.2 – Examples of current regulations and standards in the US and EU applicable to external power supplies used with devices (non-exhaustive list)

Compliance area	Regulation	Standard(s)	Applicable country/region
Safety	NEC/OSHA/NRTL Listing	UL 62368-1	USA
	KC (safety)	K 60950-1	KR
	Electrical appliances and materials safety act	JIS C 62368-1:2018 and amendment 1:2019 [9]	JP
	Low Voltage Directive	EN 62368-1	EU
EMC	FCC	FCC Part 15 Sub B [10]	USA
	EMC Directive	EN 55022 [11] or EN 55032 [12] EN 55024 [13] IEC 61000-3-2 [14], IEC 61000-3-3 [15], etc.	EU
	Electrical appliances and materials safety act	CISPRJ 32:2017 [16]	JP
	Harmonic current suppression measures implementation procedure	JIS C 61000-3-2 2017 [16]	JP
	KC (EMC)	KN 32, KN35	KR
Energy efficiency	Department of Energy	79 FR 7845 [16]	USA
	Energy use rationalization act	Energy Efficiency Labeling and Standard	KR
	Regulation (EC) No. 1782/2019	EN 50563 [17]	EU
Environmental	RoHS Directive	EN 50581 [18]	EU
	WEEE Directive	See national provisions	EU

Compliance area	Regulation	Standard(s)	Applicable country/region
	Act on resource circulation of electrical and electronic equipment and vehicles	Restrictions on the use of hazardous substances and Containing criteria	KR

E.5 Other considerations for system testing

Manufacturers also need to be aware of other standards related to existing regional market requirements or voluntary programmes for power source and host devices, for example IEC 62623 [19]. IEC 62623 enables the measurement of the power and/or energy consumption in each of the power modes identified in the scope. In addition, it highlights the test method for calculating the energy efficiency of single-voltage external AC-DC and AC-AC power supplies.

E.6 After-market firmware updates to power source

Before an aftermarket firmware update is distributed, it is important for the responsible organization to ensure the power source has had appropriate testing with the firmware update applied.

Bibliography

[1] IEC 62684, *Interoperability specifications of common external power supply (EPS) for use with data-enabled mobile phones*

[2] IEC 62680-2-1, *Universal serial bus interfaces for data and power – Part 2-1: Universal Serial Bus Specification*, Revision 2.0

[3] IEC 62680-2-2, *Universal serial bus interfaces for data and power – Part 2-2: Micro-USB Cables and Connectors Specification*, Revision 1.01

[4] IEC 62680-2-3, *Universal Serial Bus interfaces for data and power – Part 2-3: Universal Serial Bus Cables and Connectors Class Document*, Revision 2.0

[5] IEC 62680-3-1, *Universal Serial Bus interfaces for data and power – Part 3-1: Universal Serial Bus 3.1 Specification*

[6] IEC 62680-1-4, *Universal Serial Bus interfaces for data and power- Part 1-4: Common Components – USB Type-C Authentication Specification*

[7] USB-IF Compliance Program. Available at: www.usb.org/developers/compliance

[8] *Universal Serial Bus Type-C and Power Delivery Source Power Requirements Test Specification*. Available at: www.usb.org/document-library/usb-type-c-and-power-delivery-source-power-requirements-test-specification

[9] JIS C 62368-1:2018 and amendment 1:2019 – *Audio/video, information and communication technology equipment – Part 1: Safety requirements (Amendment 1)*

[10] FCC, *Part 15 subpart B-Unintentional Radiators, Code of Federal Regulations, Title 47 Part 15 (47 CFR 15)*

[11] EN 55022, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

[12] EN 55032, *Electromagnetic compatibility of multimedia equipment – Emission requirements (CISPR 32)*

[13] EN 55024, *Information technology equipment – Immunity characteristics – Limits and methods of measurement*

[14] IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

[15] IEC 61000-3-3, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection*

[16] 79 FR 7845, *Energy Conservation program: Energy conservation standards for external power supplies, Department of energy*

[17] EN 50563, *External a.c. – d.c. and a.c. – a.c. power supplies – Determination of no-load power and average efficiency of active modes*

[18] EN 50581, *Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances*

[19] IEC 62623, *Desktop and notebook computers Measurement of energy consumption*

[20] CISPRJ 32:2017 – *Electromagnetic compatibility of multimedia equipment – Emission requirements*

[21] JIS C 61000-3-2 – *Electromagnetic compatibility (EMC)-Part 3-2: Limits- Limits for harmonic current emissions (equipment input current ≦ 20 A per phase)*

____