



モバイルコンピューティング推進コンソーシアム
Mobile Computing Promotion Consortium

MCPC TR-021
Safety Design Guideline
for
USB Interface for Charging

Version 1.01 (E)

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Mobile Computing Promotion Consortium
Technical committee

Change history

Date	Version	Changes
June 25, 2015	1.00(E)	English translation version release
July 1, 2015	1.01(E)	Amendment of the sentence

Notice

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How do we distinguish binary, decimal and hexadecimal numbers?

For binary numbers, we append small letter “b” (e.g. 10b)).

For binary numbers, we insert a space after every four bits. (e.g.: 1000 0101 0010b).

For hexadecimal numbers, we append small letter “h” (e.g.: FFFFh and 80h).

All other numbers shall be considered to be written in decimal.

Key Words

- “May” means that something is recommended or optional at the free discretion of the vendor.
- “Should” means that although something is not essential, it is strongly recommended. When implementing, the vendor shall take this requirement into consideration and determine whether this is essential or not.
- “Shall” means that something is an essential requirement. For connectivity and specification compliance, the feature must be implemented, and is mandatory.

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- In general “Inc.,” “Corporation,” “Co., Ltd.,” have been excluded from company names.

Application note

It is indicating as follows, when indicating a case of the operation on a document. :

Application note : Case-of-the-operation entry

Table of Contents

1.	Introduction	1
2.	The case history of an accident at USB charging	1
3.	USB Charger Functionality Outline	2
3.1	USB Charging Environment and the Scope of this Guideline.....	2
3.2	Overview on USB charging interface specification.....	3
4.	USB charging safety design specifications	4
4.1	Power supply input and output parameters.....	4
5.	USB charge safety design parameter list.....	5
5.1	Charging adapter input/output parameters	5
5.2	Safety parameters of charging adapter	6
5.3	Regulation of charging equipment	7
6.	Notes for designing a USB charging interface	8
6.1	The requirements for an AC/DC adapter.....	8
6.2	The requirements for a mobile battery	8
Appendix A.	Reference specifications (Normative).....	9
Appendix B.	Half short error and its counter measure examples	10
Appendix C.	Related specifications (for further investigation)	11

Table of Figures

Figure3-1 The variety of USB charging environments and the scope of this Edition.....	2
Figure3-2 Charging equipment and charging adapter.....	3

1. Introduction

An USB interface is used as a power charge interface by many smaller peripherals, and the Micro USB interface especially is widely implemented for smart phones, etc.

When USB has become widely used as a charging interface, some problems have started to be recognized in the market, such as causing a charging terminal fire and a higher temperature due to inappropriate uses by consumers or inappropriate implementations of safety circuits in the products.

This Guideline specifies the technical parameters for charging smart phones and other equipment which support Micro USB as a charging interface, for the purpose of the improvement in charging safety, a charging terminal fire prevention, and the heat generation control for a Micro USB interface.

This Guideline is intended to serve as the baseline for a safety design of a charging interface. The test specifications for a safety design certification and user promotion activities for safe charging will be followed.

2. The case history of an accident at USB charging

These are the cases of accidents that occurred during USB charging.

The purpose of this document is to reduce the risk of such accidents.

- i. The half short of a charging terminal
When conductive substances (ex. metal or moisture) attach to a connector terminal, or the resulting corrosion of the metal between connector terminals or between a connector terminal and a connector shell generates a half-energized state, the current that flows out of them may cause heat generation and fire .
In this Guideline, the term “charging terminal” includes both the power related terminals (Vbus, GND) of a Micro USB connector and a connector shell.
- ii. Short-circuit of the terminals by deforming a Micro USB connector
Inadequate handling of a connector, a charging terminal and a connector body cause them deformed resulting short circuit.
There is a risk of generating high heat and fire when a short protection function is not implemented in charging adapter.
- iii. Connection of an out-of-spec charging adapter and charging equipment
The electrical specifications of a charging adapter and charging equipment need to be matched. The charge cable that is specified or certified by a charging adapter and charging equipment must be used. Use of charging adapters or cables outside the specifications may generate higher heat and fire by the short circuit that is caused by electric mismatching or inappropriate insulation, or the impedance of a cable itself.
- iv. Connecting a charging adapter without overcurrent and overvoltage protection
Charging with a charging adapter without overcurrent/overvoltage protection functions may generate higher heat and fire, when current beyond the capability of a charging adapter flows.

3. USB Charger Functionality Outline

3.1 USB Charging Environment and the Scope of this Guideline

USB interface is the specifications which USB Implementers Forum developed for the purpose of data communications by connecting host equipment (such as PC) with external devices using a cable. In order to connect small external devices without an external power supply, electric power can be supplied.

With the wide adoption of the USB interface to PCs, it is now used not only as a communication interface, but also as an electric power supply interface. It serves as a common power supply interface for small equipment such as smart phones.

Moreover in the product market of power supply adapters and devices with a USB power supply capability, various kinds of implementations using its environment have showed up in the market. Under such variety of implementations, this Guideline covers the case as shown in the **Figure 3-1** as the most common use case at the time of publishing this Guideline. As the charging specifications for a USB interface, the Battery Charging Specification Ver1.2 by USB Implementers Forum (**[BC1.2]**) is referred to in this Guideline.

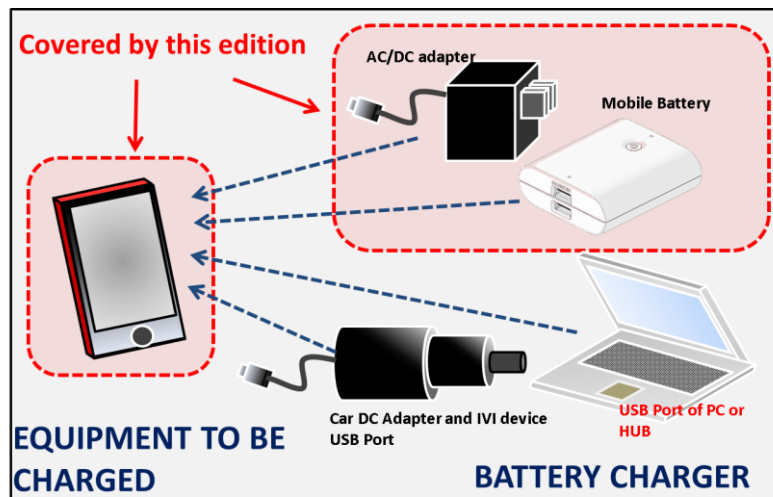
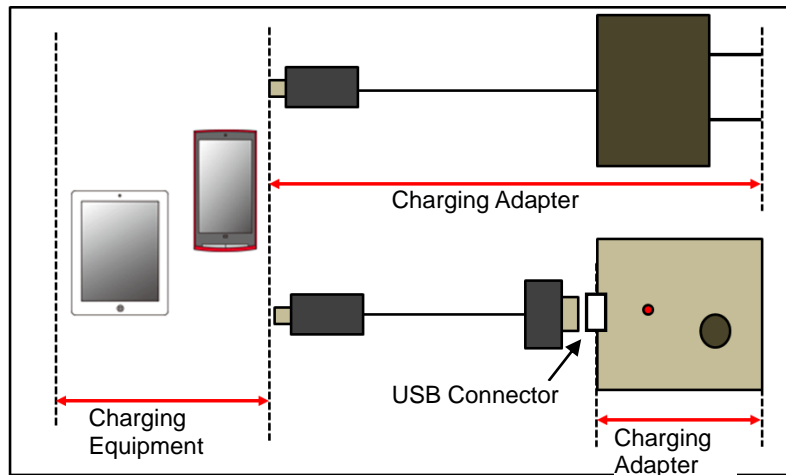


Figure3-1 The variety of USB charging environments and the scope of this Edition



Charging Adapter : Provide operational power to Charger Equipment
 Charging Equipment : Consume operational power provided by Charger Adapter

Figure3-2 Charging equipment and charging adapter

3.2 Overview on USB charging interface specification

(1) Charge from AC/DC adapters

Reference specifications **[BC1.2]**

A dedicated charging port (“Dedicated charging port, DCP”) is a port only for charge that does not support data communications. Power supplies without enumerations with hosts, such as an AC/DC adapter, are specified.

Charging equipment can draw 1.5A max from DCP, and is identified by the short circuit of D+ and D- terminals.

4. USB charging safety design specifications

4.1 Power supply input and output parameters

This parameter specifies the fundamental electric conditions over charging adapter. The parameters do not directly enhance the safety of charges. However, they serve as important design guidelines for the fundamental safety base.

(1) Power adapter parameter

The parameter specifies a DC power supply which is sourced from AC power.

As a prerequisite, the regulation by the Electrical Appliance and Material Safety Law (**[EAMS]**) shall be observed for the parameters for AC/DC adapters.

This Guideline sets forth the recommended operating environments for safe and stable operations.

(2) USB output parameter

The parameter specifies a USB output to charging adapter.

In addition to the DCP support, this Guideline sets forth the recommended operating environments for safe and stable operations.

5. USB charge safety design parameter list

5.1 Charging adapter input/output parameters

No.	Item	Specification	Reference document / remarks
1	Rated input voltage	- AC/DC adapter : AC100V/240V - Other adapter: should comply with the specs of a connected device.	[EAMS] It should support up to 240V to accommodate overseas travel use cases.
2	Operating input voltage	- AC/DC adapter: 90V-264V - Other adapter: Allow $\pm 10\%$ margin to the specification requirements of a connection target.	
3	Rated input frequency	50/60Hz	[EAMS]
4	Rated output voltage	5V $\pm 5\%$ at measurement point (*). (*). measurement point is defined as follows; 1. When Charging Adapter and power cable is un-removable, a measurement point is a micro B connector end. 2. When a Charging Adapter and a Cable are removable, but the connector between them are not a USB Type A connector, a measurement point is a micro B connector end. 3. When USB Type A connector is mounted to a Charging Adapter and it does not provide a cable, a measurement point is a Type A connector end. 4. When a USB Type A connector is mounted to a Charging Adapter, and provides a specific cable, a measurement point is a micro B connector end.	
5	Rated output current	The minimum requirements and more of rated output current should be provided.	

MCPC TR-021 Safety Design Guideline of USB Interface for Charging Version 1.00(E)

6	Overshoot in output voltage	6.0 V max in the load change environment in the range of zero to a rated load.	[BC1.2] Section4.1.1(VCHG_OVRSH T=6.0V)
7	Undershoot in output voltage	4.1 V min in the load change environment in the range of the following conditions; I _{DCP_LOW} ~I _{DCP_MID} I _{DCP_MID} ~I _{DCP_HI} definition I _{DCP_LOW} =0~30mA I _{DCP_MID} =30~100mA I _{DCP_HI} =100-mA~rated load	[BC1.2] Section4.4.2(VCHG_UNDSH T=4.1V)

5.2 Safety parameters of charging adapter

No.	Item	Specification proposal	Reference document / remarks
8	Insulation resistance	3 Mohm min	[EAMS]
9	The temperature rise in a portion where a user can touch during normal operations	The surface temperature of the main part of a Charging Adapter shall be 70 °C or less. (Temperature rise $\Delta T=40$ degree max at the ambience temperature of 30 °C.)	[EAMS]
10	Leakage current	250 uA max at the measurement circuit of IEC60950-1.	[60950-1]
11	Fire prevention	Materials for Charging Adapter (case, cable, connector, etc.) should have the flame resistant class of IEC/UL60950. 4.7.3.2(UL4.7.3.4) Body, Bush-V1, Cable-VW1 or higher	[60950]
12	Lightning surge	Conform to IEC61000-4-5	[61000-4-5]
13	Half short protection between charging terminals	Protection functionality should be implemented in order to avoid smoke or fire, etc. in time for a minute resistance occurrence between charging terminals.	Refer to Appendix B.1 for counter measure examples

MCPC TR-021 Safety Design Guideline of USB Interface for Charging Version 1.00(E)

14	Safety considerations for a thermally closure environment without air flows	Ensure a safe operation in a thermally closure environment without air flows.	
15	Overvoltage protection	Do not exceed 9V max in the range of a zero to rated load condition.	[BC1.2] Section4.1.5 (VCHG_FAIL=9.0V)
16	Overcurrent protection	Implement overcurrent protection. The protection ensured within +30% max of a rated output current is recommended.	
17	Output short circuit protection	Implement output short circuit protection(s).	
18	Cable	For a charging purpose only cable, a plug shell should not connect to GND in a direct current mode.	

5.3 Regulation of charging equipment

No.	Item	Specification proposal	Reference document / remarks
19	Half short protection between charging terminals	Protection functionality should be implemented in order to avoid smoke or fire, etc. in time for a minute resistance occurrence between charging terminals.	Refer to Appendix B.2 for the counter measure examples
20	Avoid corrosion in charging terminals	Do not load a voltage output to the Vbus in a micro USB receptacle when a Charging adapter or equipment etc. is not connected.	

6. Notes for designing a USB charging interface

6.1 The requirements for an AC/DC adapter

The parameters for AC/DC Adapter defined at the Chapter 5 are as follows;

Items 1-7 (all the items) in Chapter 5.1

Items 8-18 (all the items) in Chapter 5.2

6.2 The requirements for a mobile battery

The parameters for a mobile battery defined at the Chapter 5 are as follows;

Items 4-7 in the Chapter 5.1

Items 9, 11 and 13-18 in the Chapter 5.2

Appendix A. Reference specifications (Normative)

[60950-1]	IEC60950-1 Information technology equipment Safety Part 1: General requirements
[61000-4-5]	IEC61000-4-5 Electromagnetic compatibility (EMC) Part 4-5: Testing and measurement techniques - Surge immunity test
[BC1.2]	Battery Charging Specification Revision 1.2 by USB Implementers Forum
[USB2.0]	Universal Serial Bus Specification Revision 2.0 by USB Implementers Forum
[USB3.1]	Universal Serial Bus Specification Revision 3.1 by USB Implementers Forum
[EAMS]	Electrical Appliance and Material Safety Law

Appendix B. Half short error and its counter measure examples

B.1 Examples for measures in charging adapter

- In order to avoid abnormal heat generation in a connector that may cause the danger of a fire and a skin burn, a charging adapter should implement temperature protecting functionality.
- Ensure the electrical circuit(V-I) properties of a charging adapter to avoid an abnormal heat generation upon generating half short at a charging terminal,.

[Examples]

- Enlarge the termination voltage for a drooping characteristic, or eliminate a drooping characteristic.
- The cycle of an automatic recovery (auto-restart) after entering a short protection must be long enough to avoid a frequent activation of the protection function, or no automatic recovery is supported.

B.2 Examples for measures in charging equipment

- Even in case of occurrence of minute resistances in between charging terminals (especially in between a connector power source terminal and a connector shell), smoke and fire can be prevented by implementing the following (1) or (2) of the measures to the chargers as set forth in this Guideline

[Example (1) of the measures]

A capacitor is mounted between a connector shell and the GND electrode of a substrate, without directly grounding the conductive connector shell in the Micro USB connector (receptacle) of equipment to a GND of a substrate. In addition, it is desirable to set a capacitance value in consideration of the influence over USB data communications.

[Example (2) of measures]

The PTC (Positive Temperature Coefficient) thermistor is mounted between a connector shell and a substrate GND electrode without directly grounding the conductive connector shell in the Micro USB connector (receptacle) of equipment to GND in a substrate,

Appendix C. Related specifications (for further investigation)

These are due to be examined at the time of the future revisions of this Specification.

(1) To perform both USB communications and charging from a PC host port and a USB-HUB

Reference specifications **[USB2.0]** / **[USB3.1]** / **[BC1.2]**

A standard downstream port ("SDP"), data communications and charging can be performed simultaneously between a USB host and a device. The operational mode and the maximum current that can be supplied are defined as follows;

Operational mode that a USB host set up	Maximum current that can be taken from an upper port	Reference specification	Remarks
USB2.0 Low power operation (Full Speed / High Speed)	100mA	[USB2.0]	When an upper port is a bus powered hub
USB2.0 High power operation (Full Speed / High Speed)	500mA	[USB2.0]	When an upper port is a self powered hub or a root port
USB3.x low power operation (SuperSpeed / SuperSpeed Plus)	150mA	[USB3.1]	When an upper port is a bus powered hub
USB3.x high power operation (SuperSpeed / SuperSpeed Plus)	900mA	[USB3.1]	When an upper port is a self powered hub or a root port

Current value which charging equipment can draw in SDP mode.

(2) Port in a PC main part without USB communications, Charge from /USB-HUB

Reference specifications **[BC1.2]**

A charging downstream port ("CDP") can handle a bigger current than a SDP from a host, such as a personal computer. CDP -a maximum of - 1.5A can be supplied and this current can be supplied before an enumeration.

A CDP can recognize a CDP using the handshake of the hardware with an operation and a monitoring of D+ and D-line.

(3) New charge interfaces at time of this Edition publication (not described in this Edition):

The charging specifications from a USB interface are being sequentially upgraded to include the functionalities that enable more rapid charging, and monitor a charging status, etc. Examples of the specifications currently available at the time of this edition publication is shown below;

Specification name	Specification outline
Universal Serial Bus Power Delivery Specification Revision 2.0, V1.0	USB Implementers Forum publication The increase in supply capability to the USB interface by Vbus voltage change, a charge status monitor, etc.
Universal Serial Bus Type-C Cable and Connector Specification Revision 1.0	USB Implementers Forum publication USB new connector The increase in supply capability to a USB interface

New USB charge interface specifications available at time of this Edition