USB 3.1 Legacy Cable and Connector Specification

Hewlett-Packard Inc.
Intel Corporation
Microsoft Corporation
Renesas Corporation
STMicroelectronics
Texas Instruments

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Acknowledgement of Technical Contribution

Dedication

Dedicated to the memory of Brad Hosler, the impact of whose accomplishments made the Universal Serial Bus one of the most successful technology innovations of the Personal Computer era.

The authors of this specification would like to recognize the following people who participated in the USB 3.0 Bus Specification technical work group. We would also like to acknowledge the many unnamed others throughout the industry who provided feedback and contributed to the development of this specification.

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1 Introduction

1.1 Background

The original Universal Serial Bus (USB) was driven by the need to provide a user-friendly plug-and-play way to attach external peripherals to a Personal Computer (PC). USB has gone beyond just being a way to connect peripherals to PCs. Printers use USB to interface directly to cameras. Mobile devices use USB connected keyboards and mice. USB technology commonly finds itself in automobiles, televisions, and set-top boxes. USB, as a protocol, is also being picked up and used in many nontraditional applications such as industrial automation. And USB as a source of power has become the mobile device charging solution endorsed by international communities across the globe.

Initially, USB provided two speeds (12 Mbps and 1.5 Mbps) that peripherals could use. As PCs became increasingly powerful and able to process larger amounts of data, users needed to get more and more data into and out of their PCs. This led to the definition of the USB 2.0 specification in 2000 to provide a third transfer rate of 480 Mbps while retaining backward compatibility. By 2006, two things in the environment happened: the transfer rates of HDDs exceeded 100 MB/sec, far outstripping USB 2.0's ~32 MB/sec bandwidth and the amount of digital content users were creating was an ever increasing pace. USB 3.0 was the USB community's response and provided users with the ability to move data at rates up to 450 MB/sec while retaining backward compatibility with USB 2.0.

~~Now~~In 2013, with the continued trend for more bandwidth driven by larger and faster storage solutions, higher resolution video, and broader use of USB as an external expansion/docking solution, USB 3.1 ~~extends~~extended the performance range of USB up to 1 GB/sec by doubling the SuperSpeed USB clock rate to 10 Gbps and enhancing data encoding efficiency.

Now, with the addition of USB Type-C™ to the USB connector/cable ecosystem, USB 3.2 extends the performance range of USB up to 2 GB/sec by enabling two lanes of SuperSpeed signaling to be used in combination over two sets of SuperSpeed pins/wires across the USB Type-C standard connector/cable solution.

Given that the multi-lane capabilities of USB 3.2 are *not applicable* to the USB 3.1 series of legacy USB cables and connectors, this separate cable and connector specification has been derived from Chapter 5 of the USB 3.1 specification to separate going forward the USB bus functional specifications from the electro-mechanical specifications for USB.

1.2 Objective of the Specification

This document defines the ~~latest~~legacy generation of USB cables and connectors as derived from the USB 3.1 industry-standard. The specification covers the electro-mechanical requirements and recommendations for the USB SuperSpeed-capable cables and connectors for USB Standard-A, USB Standard-B and the USB Micro-series of receptacles and plugs.

1.3 Scope of the Document

The specification is primarily targeted at developers of cables and connectors as well as for USB system and device product developers that incorporate or use USB connectors or cables.

Product developers using this specification are expected to know and understand both the USB 2.0 Specification and USB 3.2 Specification.

Please note that all prior references to USB Power Delivery specification and USB PD variants of USB legacy connectors or cables were removed from this release of the specification. USB Power Delivery is only applicable to USB Type-C connectors and cables.

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1.4 USB Product Compliance

Adopters of the USB 3.1 Legacy Cable and Connector specification have signed the USB 3.0 Adopters Agreement, which provides them access to a reasonable and nondiscriminatory (RANDZ) license from the Promoters and other Adopters to certain intellectual property contained in products that are compliant with the USB 3.1 Legacy Cable and Connector specification. Adopters can demonstrate compliance with the specification through the testing program as defined by the USB Implementers Forum (USB-IF). Products that demonstrate compliance with the specification will be granted certain rights to use the USB-IF logos as defined in the logo license.

Starting with USB 3.1, product compliance requirements ~~are being~~were tightened up to prohibit non-certified cables and connectors. Use of any registered icons or logos on products, documentation or packaging will require a license and license requirements will include passing specific product certification.

1.5 Related Documents

Universal Serial Bus Specification, Revision 2.0

USB On-the-Go Supplement to the USB 2.0 Specification, Revision 1.3

USB On-the-Go and Embedded Host Supplement to the USB 3.0 Specification, Revision 1.0

Universal Serial Bus Micro-USB Cables and Connectors Specification, Revision 1.01

EIA-364-1000.01: Environmental Test Methodology for Assessing the Performance of Electrical Connectors and Sockets Used in Business Office Applications

USB 3.~~0~~1 Legacy Connectors and Cable Assemblies Compliance Document

USB SuperSpeed Electrical Test Methodology white paper

USB 3.0 Jitter Budgeting white paper

INCITS TR-35-2004, INCITS Technical Report for Information Technology – Fibre Channel – Methodologies for Jitter and Signal Quality Specification (FC-MJSQ)

Universal Serial Bus 3.~~0~~2 Specification

1.6 Conventions

1.6.1 Precedence

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

1.6.2 Keywords

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

1.6.2.1 Informative

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

1.6.2.2 May

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

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1.6.2.3 N/A

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

1.6.2.4 Normative

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

1.6.2.5 Optional

Optional is a keyword that describes features not mandated by this specification. However, if an optional feature is implemented, the feature shall be implemented as defined by this specification (optional normative).

1.6.2.6 Reserved

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

1.6.2.7 Shall

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

1.6.2.8 Should

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

1.6.2.9 Numbering

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

2 Terms and Abbreviations

This chapter lists and defines terms and abbreviations used throughout this specification. Note, for terms and abbreviations not defined here, use their generally accepted or dictionary meaning.

Term/Abbreviation	Definition
AWG#	The measurement of a wire’s cross section, as defined by the American Wire Gauge standard.
cable	Raw cable with no plugs attached.
cable assembly	Cable attached with plugs.
captive cable	Cable assembly that has a Type-A plug on one end and that is either permanently attached or has a vendor specific connector on the other end.

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Term/Abbreviation	Definition
D+ and D-	Differential pair defined in the USB 2.0 specification.
Gbps	Transmission rate expressed in gigabits per second (1,000,000,000 bits per second).
Gen 1	Gen 1 is an adjective used to refer to the Physical layer associated with a 5.0 Gbps signaling rate. The original USB SuperSpeed Phy and a Gen 1 Phy refer to the same Phy.
Gen 2	Gen 2 is an adjective used to refer to the Physical layer associated with a 10 Gbps signaling rate.
host	The host computer system where the USB host controller is installed. This includes the host hardware platform (CPU, bus, etc.) and the operating system in use.
ID pin	Denotes the pin on the USB 3.1 Micro connector family that is used to differentiate a USB 3.1 Micro-A plug from a USB 3.1 Micro-B plug.
peripheral	A physical entity that is attached to a USB cable and is currently operating as a "device" as defined in this specification.
plug	Connector attached to the cable, to be mated with the receptacle
receptacle	Connector mounted on the host or device, to be mated with the plug.
SuperSpeed	An adjective referring to the architectural layer portions of a device defined in this specification when operating with a Gen 1 PHY. Note previously defined as USB operation at 5 Gbps.
SuperSpeedPlus	An adjective referring to the architectural layer portions of a device defined in this specification when operating with a Gen 2 PHY
Type-A connector	The Standard-A connector defined in this specification.
USB 3.1 Standard-A connector	USB 3.1 host connector, supporting either SuperSpeed or both SuperSpeed and SuperSpeedPlus modes.
USB 3.1 Standard-B connector	USB 3.1 standard Type-B device connector, supporting either SuperSpeed or both SuperSpeed and SuperSpeedPlus modes.
USB 3.1 Micro-A plug	Part of the USB 3.1 Micro connector family for OTG use; it can be plugged into a USB 3.1 Micro-AB receptacle; it differs from the USB 3.1 Micro-B plug only in keying and ID pin connection.
USB 3.1 Micro-AB receptacle	Part of the USB 3.1 Micro connector family; it accepts either a USB 3.1 Micro-B plug or a USB 3.1 Micro-A plug.
USB 3.1 Micro-B connector	USB 3.1 device connector, supporting either SuperSpeed or both SuperSpeed and SuperSpeedPlus modes.
USB 3.1 Micro connector family	All the receptacles and plugs supporting either SuperSpeed or both SuperSpeed and SuperSpeedPlus modes that are used on devices, including the USB 3.1 Micro-B, USB 3.1 Micro-AB, and USB 3.1 Micro-A connectors.
USB 2.0 Standard-A connector	The Type-A connector defined by the USB 2.0 specification.
USB 2.0 Standard-B connector	The standard Type-B connector defined by the USB 2.0 specification.
USB-IF	USB Implementers Forum, Inc. is a nonprofit corporation formed to facilitate the development of USB compliant products and promote the technology.

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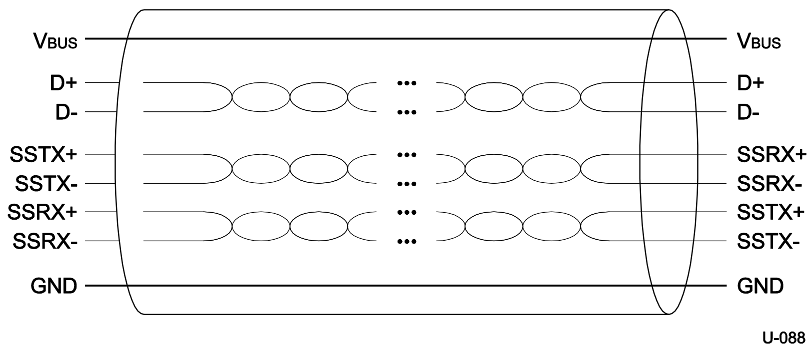
3 Overview

The mechanical specifications for USB 3.1 cables and connector assemblies are provided in ~~Chapter 5~~this specification. All USB devices have an upstream connection. Hosts and hubs (defined below) have one or more downstream connections. Upstream and downstream connectors are not mechanically interchangeable, thus eliminating illegal loopback connections at hubs.

USB 3.1 cables have eight primary conductors: three twisted signal pairs for USB data paths and a power pair. Figure 4-1 illustrates the basic signal arrangement for the USB 3.1 cable. In addition to the twisted signal pair for USB 2.0 data path, two twisted signal pairs are used to provide the ~~Enhanced~~ SuperSpeed data path, one for the transmit path and one for the receive path.

Figure 4-1. USB 3.1 Cable



USB 3.1 receptacles (both upstream and downstream) are backward compatible with USB 2.0 connector plugs. USB 3.1 cables and plugs are not intended to be compatible with USB 2.0 upstream receptacles. As an aid to users, USB 3.1 recommends standard coloring for plastic portions of USB 3.1 plugs and receptacles.

Electrical (insertion loss, return loss, crosstalk, etc.) performance for USB 3.1 is defined with regard to raw cables, mated connectors, and mated cable assemblies, with compliance requirements using industry test specifications established for the latter two categories. Similarly, mechanical (insertion/extraction forces, durability, etc.) and environmental (temperature life, mixed flowing gas, etc.) requirements are defined and compliance established via recognized industry test specifications.

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4 Intentionally Blank

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45 Mechanical

This chapter defines form, fit, and function of the USB 3.1 <u>legacy</u> connectors and cable assemblies. It contains the following:

- Connector mating interfaces
- Cables and cable assemblies
- Electrical requirements
- Mechanical and environmental requirements
- Implementation notes and guidelines

The intention of this chapter is to enable connector, system, and device designers and manufacturers to build, qualify, and use the USB 3.1 connectors, cables, and cable assemblies.

If any part of this chapter conflicts with the USB 2.0 specification, the USB 3.1 specification supersedes the USB 2.0 specification.

With some clearly noted exceptions, USB 3.1 connectors and cable assemblies provide the same functionally as the previously defined USB 3.0 connectors and cables assemblies. The primary differences are that USB 3.1 connectors and cable assemblies ~~are specifically intended to support 10 Gbps SuperSpeed USB operation and USB 3.1 connectors and cable assemblies~~ include features and requirements associated with improved EMI/RFI performance. From the perspective of interface mating interoperability, USB 3.0 connectors and cable assemblies are the same as USB 3.1 connectors and cable assemblies therefore, only USB 3.1 is listed for interface interoperability requirements and is inclusive of USB 3.0.

5.1 Objective

The mechanical layer specification has been developed with the following objectives:

- Supporting Gen 1 speed (5 Gbps)~~ and Gen 2 speed (10 Gbps)~~
- Backward compatible with USB 2.0
- Minimizing connector form factor variations
- Providing the system designer features that allow implementations to comply with EMI and RFI requirements
- Supporting On-The-Go (OTG)
- ~~Supporting compatibility with the Universal Serial Bus Power Delivery Specification~~
- Low cost

5.2 Significant Features

This section identifies the significant features of the USB 3.1 (~~Enhanced~~ SuperSpeed) connectors and cable assemblies' specification. The purpose of this section is not to present all technical details associated with each major feature, but rather to highlight their existence. Where appropriate, this section references other parts of the document where additional details are found,

5.2.1 Connectors

The USB 3.1 specification defines the following connectors:

- ~~Enhanced~~ SuperSpeed Standard A plug and receptacle
- ~~Enhanced~~ SuperSpeed Standard B plug and receptacle

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- ~~Enhanced~~ SuperSpeed Micro B plug and receptacle
- ~~Enhanced~~ SuperSpeed Micro A plug
- ~~Enhanced~~ SuperSpeed Micro-AB receptacle

All SuperSpeed connectors have the same mating interfaces and are compatible with each other. ~~The USB Enhanced SuperSpeed Gen 2 connectors have unique electrical requirements to support the Gen 2 speed in addition to the Gen 1 speed.~~

Table 5-1 lists the compatible plugs and receptacles.

Table 5-1. Plugs Accepted by Receptacle

Receptacle ~~(Standard or PD)~~	Plugs Accepted ~~(Standard or PD)~~
USB 2.0 Standard-A	USB 2.0 Standard-A or USB 3.1 Standard-A
USB 3.1 Standard-A	USB 3.1 Standard-A or USB 2.0 Standard-A
USB 2.0 Standard-B	USB 2.0 Standard-B
USB 3.1 Standard-B	USB 3.1 Standard-B or USB 2.0 Standard-B
USB 2.0 Micro-B	USB 2.0 Micro-B
USB 3.1 Micro-B	USB 3.1 Micro-B or USB 2.0 Micro-B
USB 2.0 Micro-AB	USB 2.0 Micro-B or USB 2.0 Micro-A
USB 3.1 Micro-AB	USB 3.1 Micro-B, USB 3.1 Micro-A, USB 2.0 Micro-B, or USB 2.0 Micro-A

5.2.1.1 USB 3.1 Standard-A Connector

The USB 3.1 Standard-A connector is defined as the host connector. It has the same mating interface as the USB 2.0 Standard-A connector, but with additional pins for two more differential pairs and a drain. Refer to Section 5.3.1.3 for pin assignments and descriptions.

A USB 3.1 Standard-A receptacle accepts either a USB 3.1 Standard-A plug or a USB 2.0 Standard-A plug. Similarly, a USB 3.1 Standard-A plug may be mated with either a USB 3.1 Standard-A receptacle or a USB 2.0 Standard A receptacle.

A unique color coding is recommended for the USB 3.1 Standard-A connector plastic housings to help users distinguish the USB 3.1 Standard-A connector from the USB 2.0 Standard-A connector (refer to Section 5.3.1.4 for details).

5.2.1.2 USB 3.1 Standard-B Connector

The USB 3.1 Standard-B connector is defined for relatively large, stationary peripherals, such as external hard drives and printers. It is defined so that the USB 3.1 Standard-B receptacle accepts either a USB 3.1 Standard-B plug, or a USB 2.0 Standard-B plug. Inserting a USB 3.1 Standard B plug into a USB 2.0 Standard-B receptacle is physically disallowed (refer to Section 5.3.2 for details).

5.2.1.3 USB 3.1 Micro-B Connector

The USB 3.1 Micro-B plug and USB 3.1 Micro-B receptacle connectors are defined for small handheld devices and other applications where a small connector size may be used. It is defined so that the USB 3.1 Micro-B receptacle accepts either a USB 3.1 Micro-B plug, or a USB 2.0 Micro-B plug. Inserting a USB 3.1 Micro-B plug into a USB 2.0 Micro-B receptacle or USB 2.0 Micro-AB receptacle is physically disallowed by the implementation.

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5.2.1.4 USB 3.1 Micro-AB and USB 3.1 Micro-A Connectors

The USB 3.1 Micro-AB receptacle is similar to the USB 3.1 Micro-B receptacle except for different keying. It accepts a USB 3.1 Micro-A plug, a USB 3.1 Micro-B plug, a USB 2.0 Micro-A plug, or a USB 2.0 Micro-B plug. The USB 3.1 Micro-AB receptacle is only allowed on OTG products which may function as either a host or device. All other uses of the USB 3.1 Micro-AB receptacle are prohibited.

The USB 3.1 Micro-A plug is similar to the USB 3.1 Micro-B plug except for different keying and ID pin connections. Similar to the USB 2.0 Micro-A plug, the USB 3.1 Micro-A plug is defined for OTG applications only. Section 5.3.3 defines the USB 3.1 Micro connector family.

5.2.2 Allowed Cable Assemblies

The USB 3.1 specification defines the following cable assemblies:

- USB 3.1 Standard-A plug to USB 3.1 Standard-B plug
- USB 3.1 Standard-A plug to USB 3.1 Micro-B plug
- USB 3.1 Standard-A plug to USB 3.1 Standard-A plug
- USB 3.1 Micro-A plug to USB 3.1 Micro-B plug
- USB 3.1 Micro-A plug to USB 3.1 Standard-B plug
- Captive cable with USB 3.1 Standard-A plug
- Captive cable with USB 3.1 Micro-A plug

A captive cable is a cable assembly that has a USB Standard-A plug on one end and that is either hardwired or has a vendor-specific connector on the other end. A hardwired cable is directly wired to the device and it is not detachable from the device. This specification does not define how the vendor-specific connector or hardwired attachment is done on the device side.

For electrical compliance purposes, a USB 3.1 captive cable (hardwired or with vendor-specific connector on the device end) shall be considered part of the USB 3.1 device.

No other types of cable assemblies are allowed by this specification. Section 5.5 provides detailed discussion on USB 3.1 cable assemblies.

5.2.3 Raw Cable

Due to EMI, RFI, and signal integrity requirements, each cable differential pair used for the SuperSpeed lines in a USB 3.1 cable assembly shall be shielded; the Unshielded Twisted Pair (UTP) used for USB 2.0 is not allowed for SuperSpeed lines. Section 0 defines the cable construction for USB 3.1.

5.3 Connector Mating Interfaces

This section defines the connector mating interfaces, including the connector interface drawings, pin assignments, and descriptions.

5.3.1 USB 3.1 Standard-A Connector

5.3.1.1 Interface Definition

Figure 5-1 and Figure 5-2 show the USB 3.1 Standard-A receptacle and required ground spring mating areas, respectively. Figure 5-4 shows the USB Standard-A plug interface dimensions for USB 3.1. Only the dimensions that govern the mating interoperability are specified. All REF dimensions are informative.

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~~The Universal Serial Bus Power Delivery Specification defines the mechanical and electrical requirements for the Insertion Detect feature to support cold socket capability. It may be implemented in a USB Standard-A receptacle or a PD-enabled USB Standard-A receptacle. Implementation is vendor-specific. The Insertion Detect feature shall be implemented for cold socket USB Standard-A applications and is optional for all other USB Standard-A implementations. See the Universal Serial Bus Power Delivery Specification for complete Insertion Detect requirements. Example connector configurations including Insertion Detect features are shown in .~~

Although the USB 3.1 Standard-A connector has basically the same form factor as the USB 2.0 Standard-A connector, it has significant differences inside. Below are the key features and design areas that need attention:

- In addition to the VBUS, D−, D+, and GND pins that are required for USB 2.0, the USB 3.1 Standard-A connector includes five more pins: two differential signal pairs plus one ground (GND_DRAIN). The two added differential signal pairs are for SuperSpeed data transfer, supporting dual simplex SuperSpeed signaling. The added GND_DRAIN pin is for drain wire termination and managing EMI, RFI, and signal integrity.

- The contact areas of the five SuperSpeed pins are located towards the front of the receptacle as blades, while the four USB 2.0 pins towards the back of the receptacle as beams or springs. Accordingly, in the plug, the SuperSpeed contacts are beams located behind the USB 2.0 blades. In other words, the USB 3.1 Standard-A connector has a two-tier contact system.

- The tiered-contact approach within the USB Standard-A connector form factor results in less contact area as compared to the USB 2.0 Standard-A connector. The connector interface dimensions take into consideration contact mating requirements between the USB 3.1 Standard-A receptacle and USB 3.1 Standard-A plug, the USB 3.1 Standard-A receptacle and USB 2.0 Standard-A plugs, and the USB 2.0 Standard-A receptacles and USB 3.1 Standard-A plug.

- The connector interface definition avoids shorting between the SuperSpeed and USB 2.0 pins during insertion when plugging a USB 2.0 Standard-A plug into a USB 3.1 Standard-A receptacle or a USB 3.1 Standard-A plug into a USB 2.0 Standard-A receptacle.

- There may be some increase in the USB 3.1 Standard-A receptacle connector depth (into a system board) to support the two-tiered-contacts as compared to the USB 2.0 Standard-A receptacle.

- Drawings for stacked USB 3.1 Standard-A receptacles are not shown in this specification. They are allowed as long as they meet all the electrical and mechanical requirements defined in this specification. When designing a stacked USB 3.1 Standard-A receptacle, efforts need to be made to minimize impedance discontinuity of the top connector in the stack because of its long electrical path. Attention to the high speed electrical design of USB 3.1 Standard-A connectors is required. In addition to minimizing the connector impedance discontinuities, crosstalk between the SuperSpeed differential signal pairs and USB 2.0 D+/D− pair should also be minimized.

- The receptacle connector should have a back-shield to ensure that the receptacle connector is fully enclosed. The USB 3.1 receptacle should also make good contact to the PCB ground by providing sufficient number of ground tabs to ensure a low impedance path to PCB ground. The USB 3.1 receptacle connector should have a

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robust mating interface to the shield of the USB 3.1 plug when it is inserted. Previous versions of this specification required providing a grounding spring tab in the middle of the side closest to the USB SuperSpeed signal contacts and grounding springs on both sides of the shell for USB 3.0 Standard-A receptacles. New designs shall have three grounding spring tabs on the side closest to the USB SuperSpeed signal contacts, two grounding spring tabs on the side opposite the USB SuperSpeed signal contacts, and a grounding spring on both sides of the shell of the USB 3.1 Standard-A receptacle. See Figure 5-2.

Figure 5-1. USB 3.1 Standard-A Receptacle Interface Dimensions

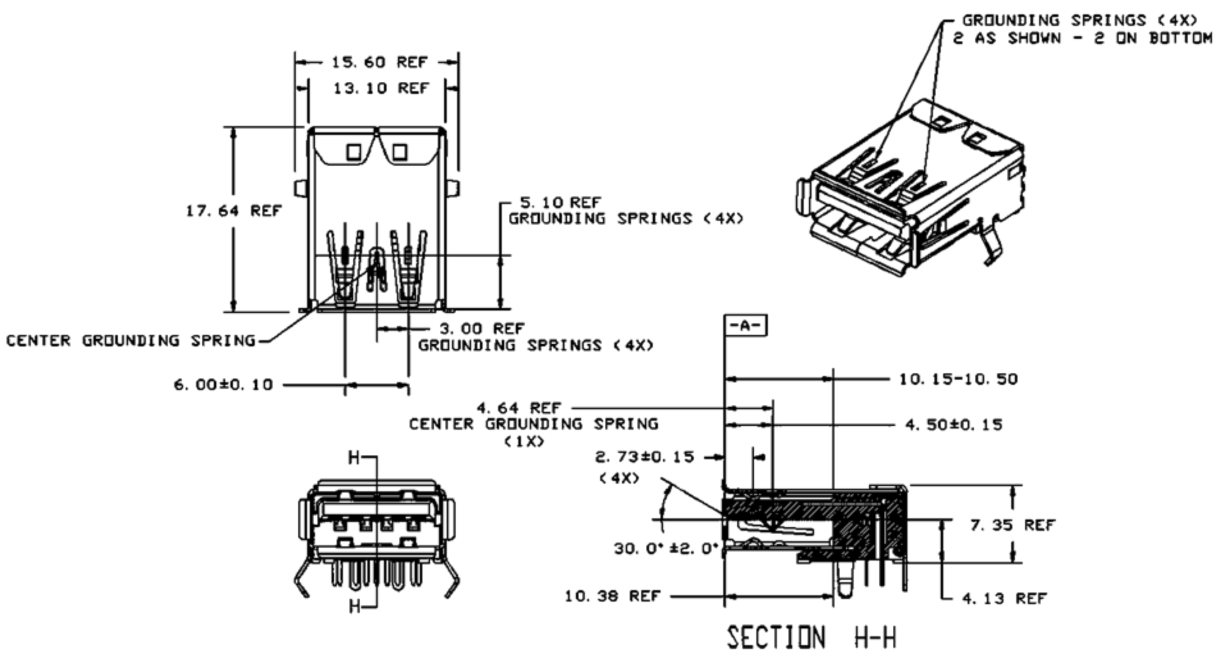

Figure 5-1. USB 3.1 Standard-A Receptacle Interface Dimensions, cont.

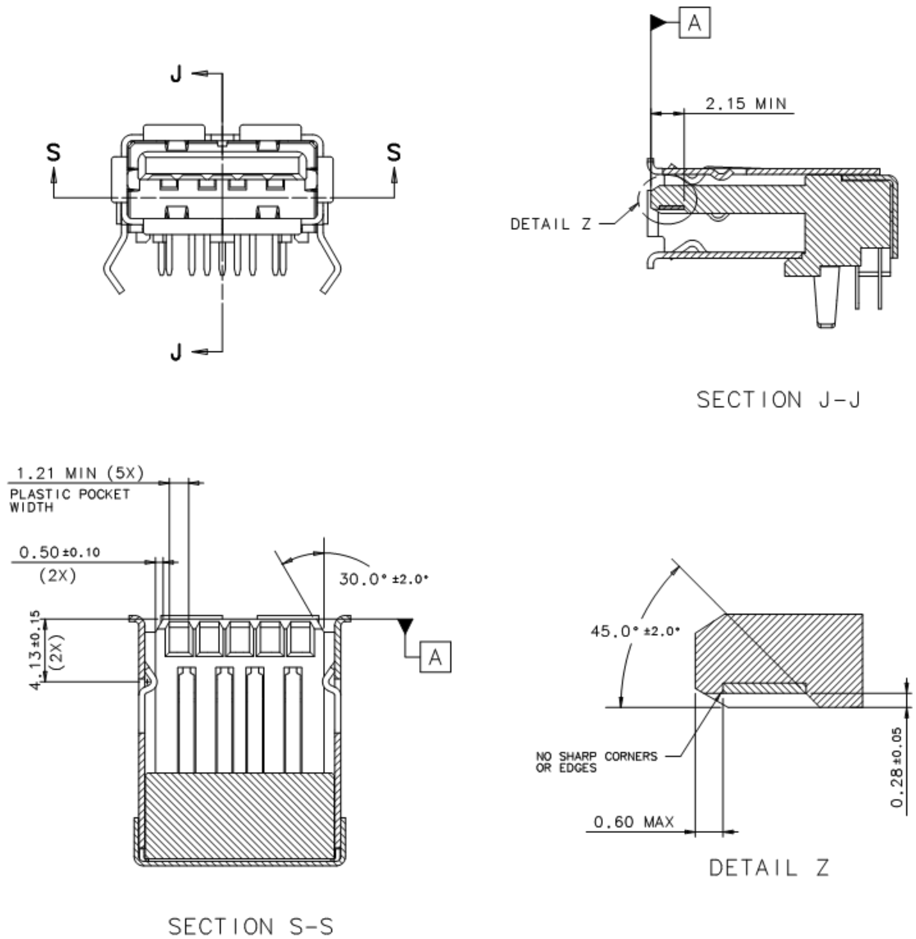

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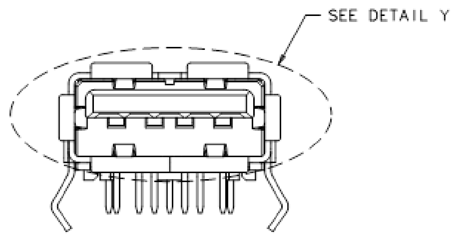
Figure 5-1. USB 3.1 Standard-A Receptacle Interface Dimensions, cont.



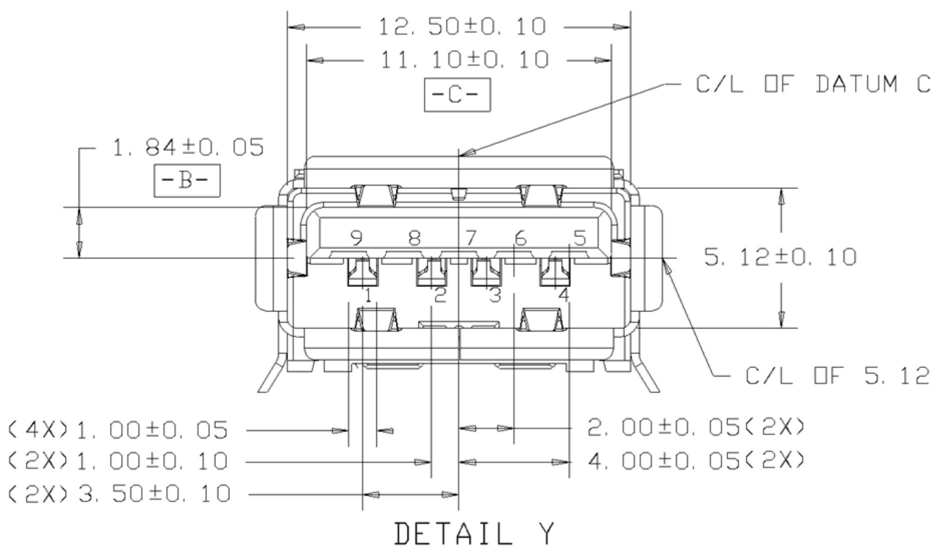


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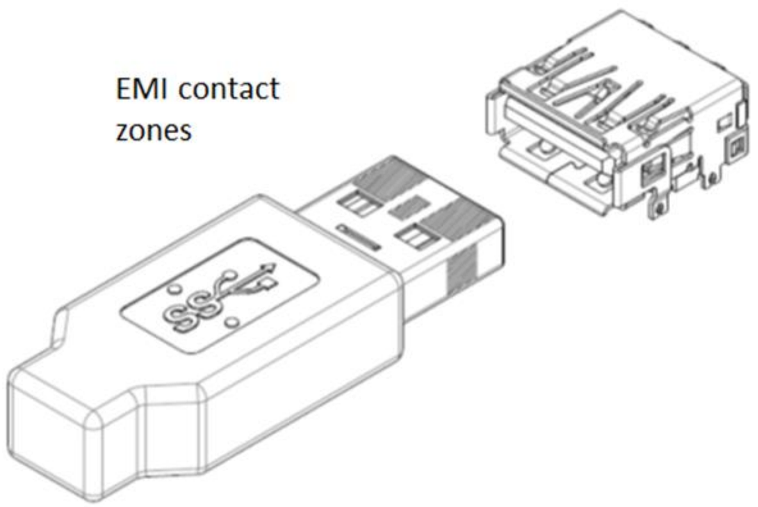
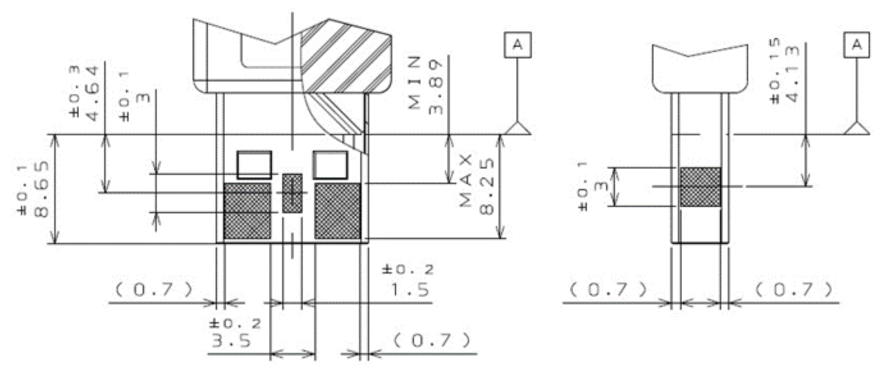
Figure 5-2. Example USB 3.1 Standard-A Receptacle with Grounding Springs and Required contact zones on the USB Standard-A Plug



TOP VIEW (SIDE NEAREST SUPERSPEED CONTACTS)

USB 3.1 PLUG



USB 3.1 PD PLUG

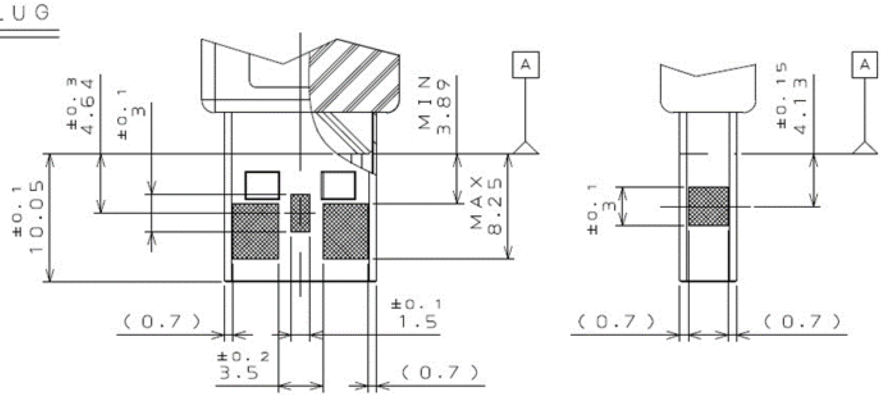


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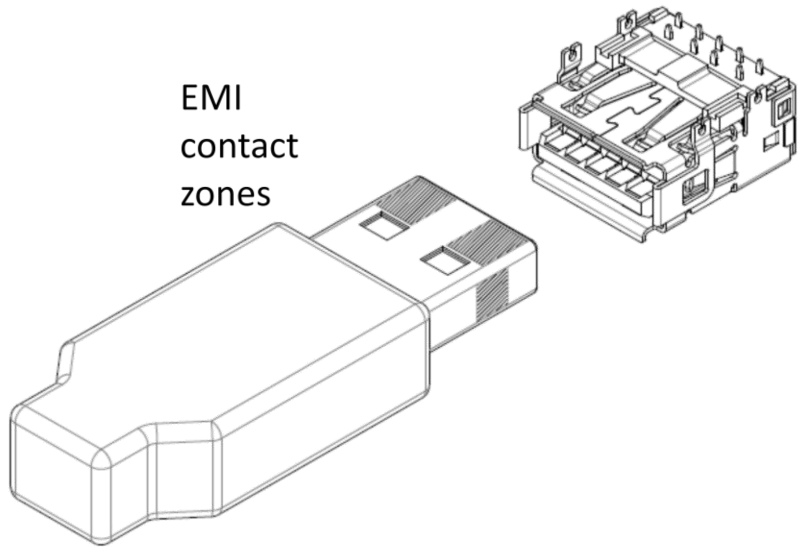
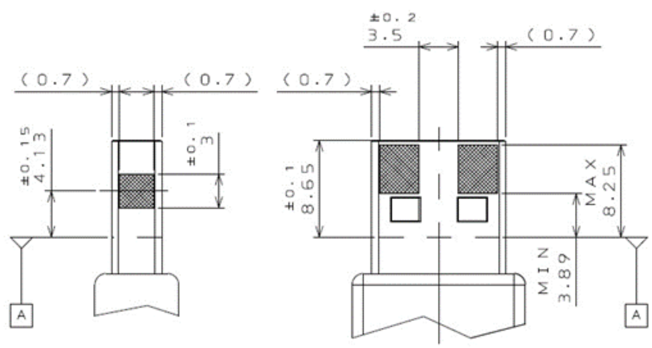
Figure 5-2. Example USB 3.1 Standard-A Receptacle with Grounding Springs and Required contact zones on the USB Standard-A Plug, cont.



BOTTOM VIEW (SIDE OPPOSITE SUPERSPEED CONTACTS)

USB 3.1 PLUG



USB 3.1 PD PLUG

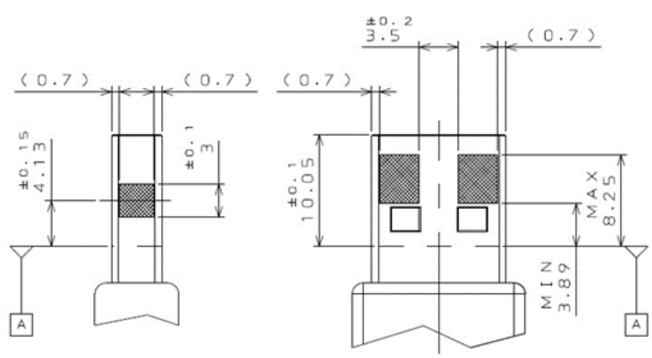


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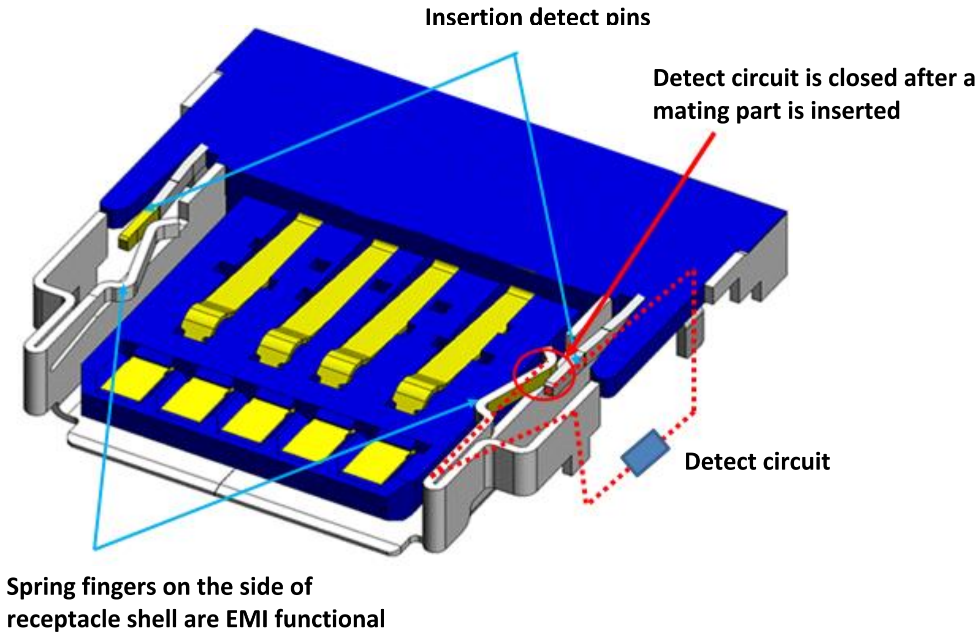
Figure 5-3. Example USB 3.1 Standard-A Mid-Mount Receptacles ~~with Insertion Detect~~



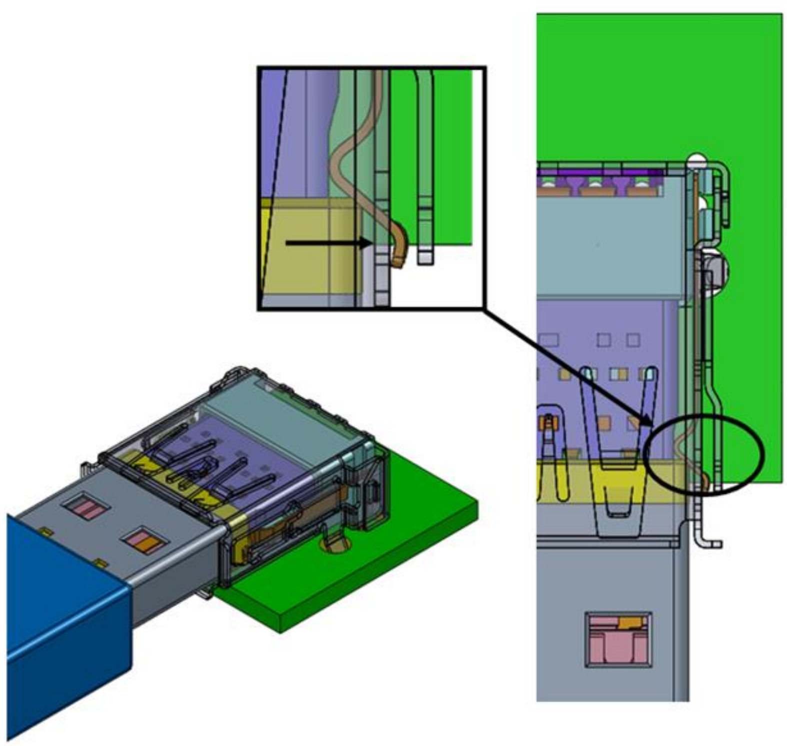
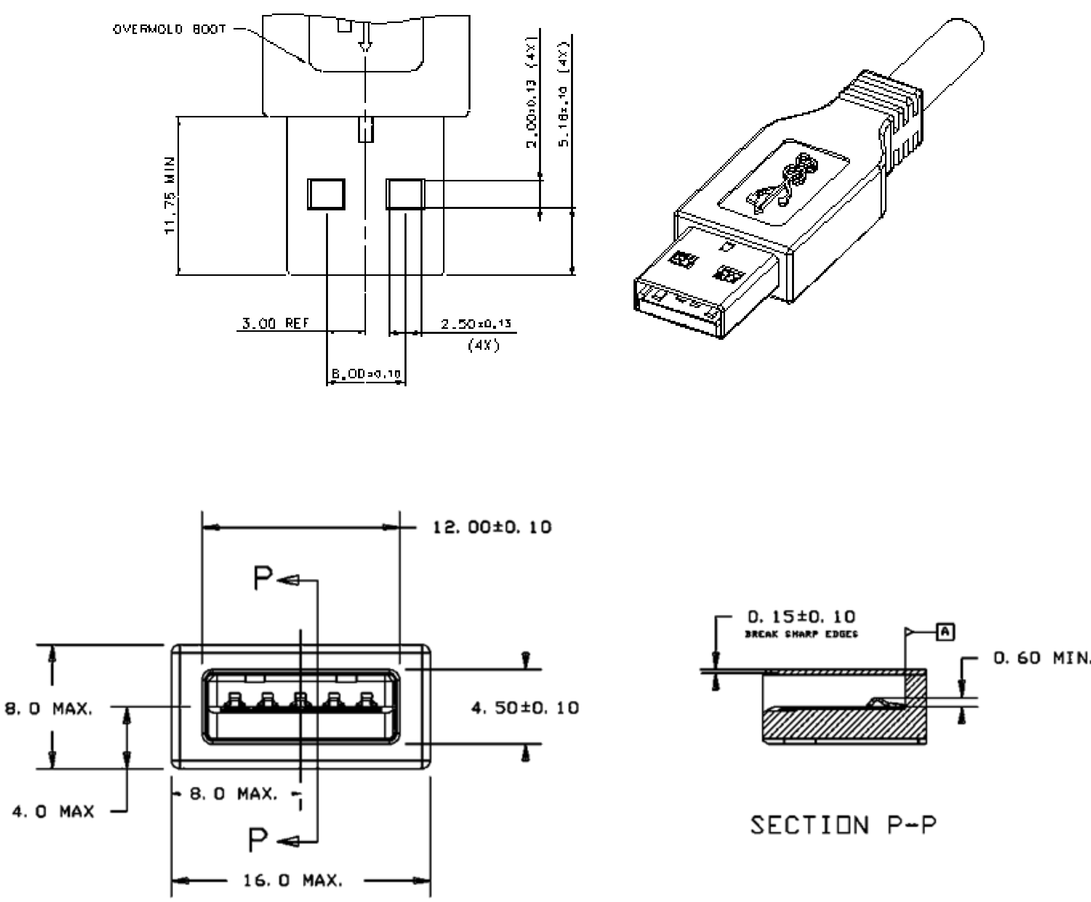


Figure 5-4. USB 3.1 Standard-A Plug Interface Dimensions



NOTES:
1) NON-DIMENSIONED GEOMETRY FOR REFERENCE ONLY. SUBJECT TO CHANGE
2) DRAWING FOR MATING INTERFACE DIMENSIONS ONLY. VIEWS MAY NOT SHOW REALISTIC MANUFACTURING CONDITION.

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Figure 5-4. USB 3.1 Standard-A Plug Interface Dimensions, cont.

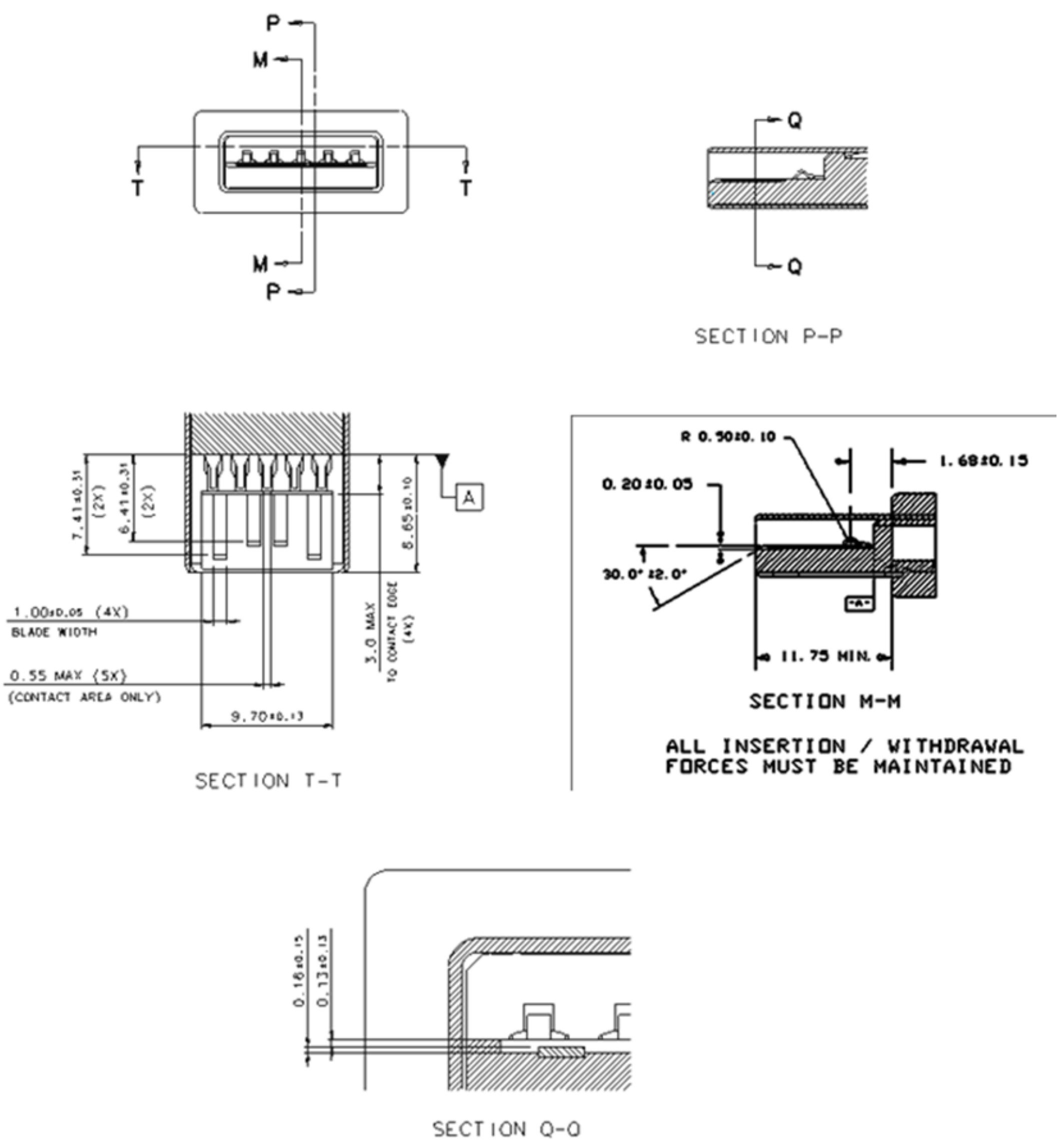

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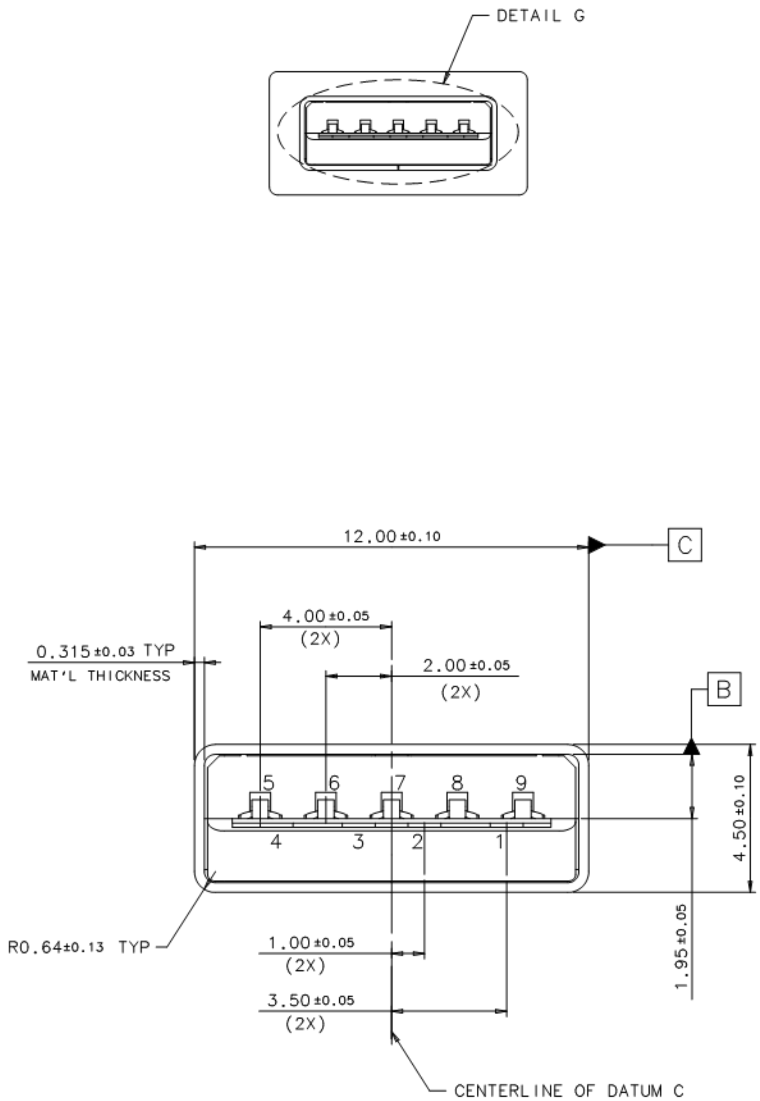
Figure 5-4. USB 3.1 Standard-A Plug Interface Dimensions, cont.



DETAIL G

5.3.1.2 USB 3.1 Standard-A Reference Footprints

This specification does not define standard footprints. Any footprint may be used as long as all mechanical and electrical requirements are met. Example footprints are provided for reference only.

Figure 5-5 shows through-hole example footprints for the USB 3.1 Standard-A receptacle with a back-shield. Pin numbers are marked.

Figure 5-6 shows an example footprint for a mid-mount standard mount (mounted on the top of the PCB) Standard-A receptacle~~ that includes Insertion Detect~~.

Figure 5-7 shows an example mid-mount reverse mount (mounted on the bottom of the PCB~~)~~ ~~with Insertion Detect.~~). The reverse mount configuration locates the SuperSpeed signals

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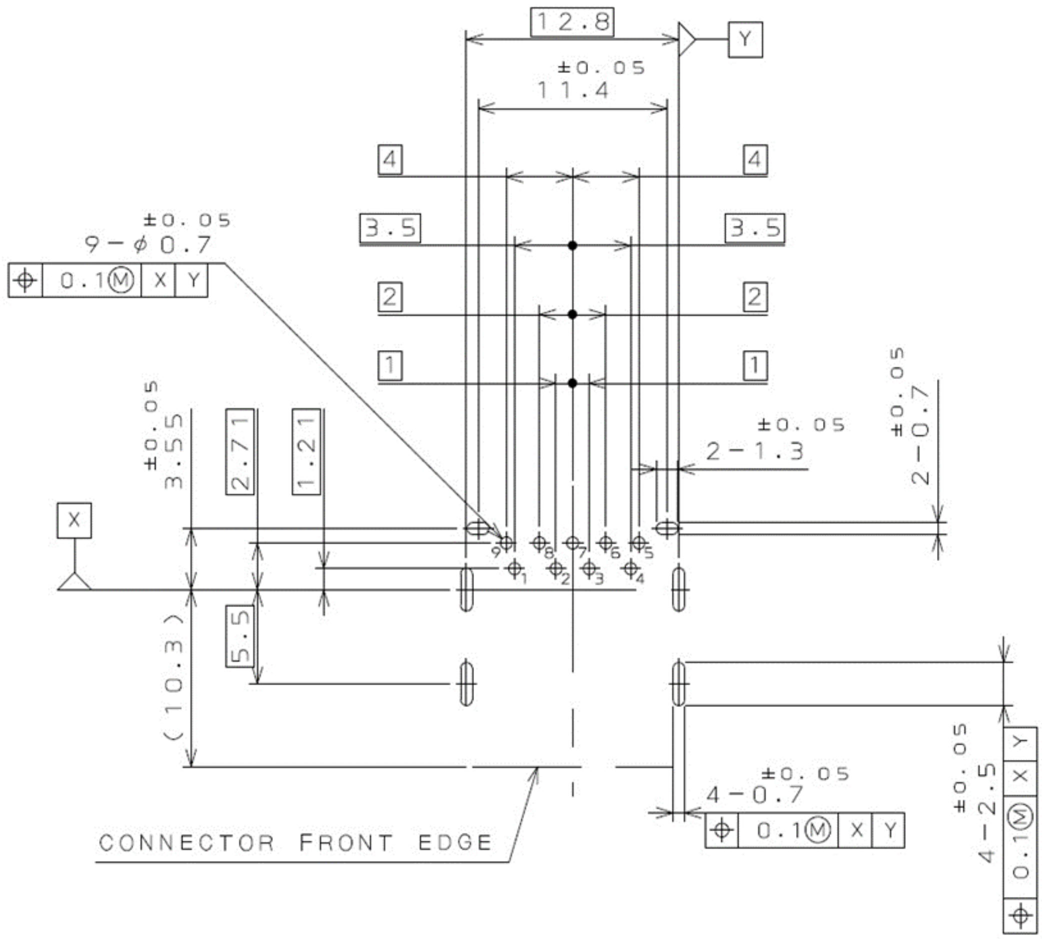
between the USB 2.0 signals and the PCB edge, making the SuperSpeed signal routing more challenging.

See Section 0 for target characteristic impedance.

Figure 5-5. Example Footprint for the USB 3.1 Standard-A Receptacle – Through-Hole with Back-Shield



PCB LAYOUT(REF.)
(STANDARD MOUNT TYPE)

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Figure 5-5. Example Footprint for the USB 3.1 Standard-A Receptacle – Through-Hole with Back-Shield, cont.

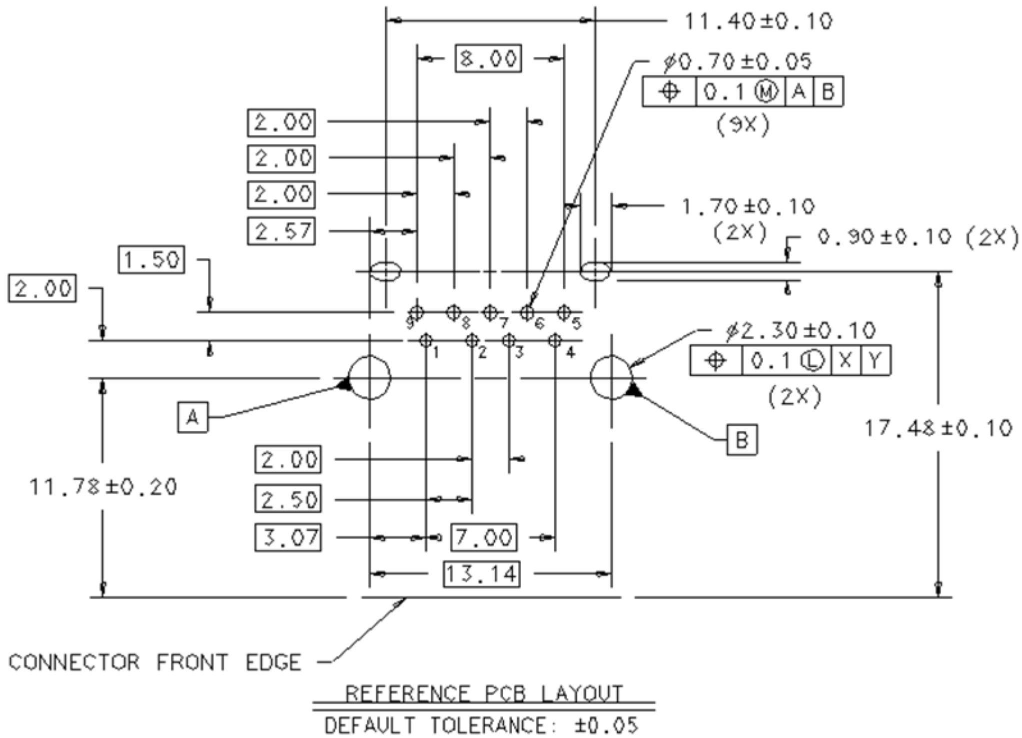

Figure 5-5. Example Footprint for the USB 3.1 Standard-A Receptacle – Through-Hole with Back-Shield, cont.

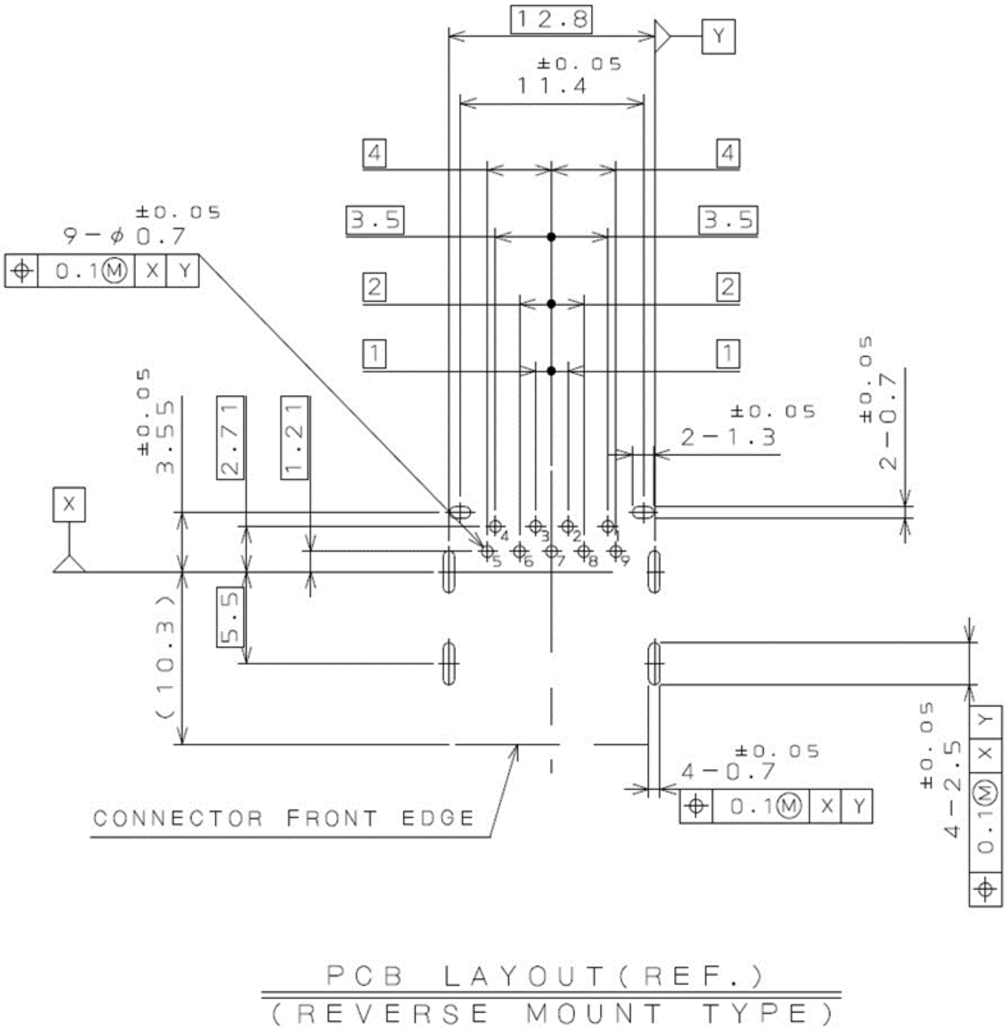

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Figure 5-6. Example Footprint for the USB 3.1 Standard-A Receptacle – Mid-Mount Standard Mount Through-Hole~~ with Insertion Detect~~

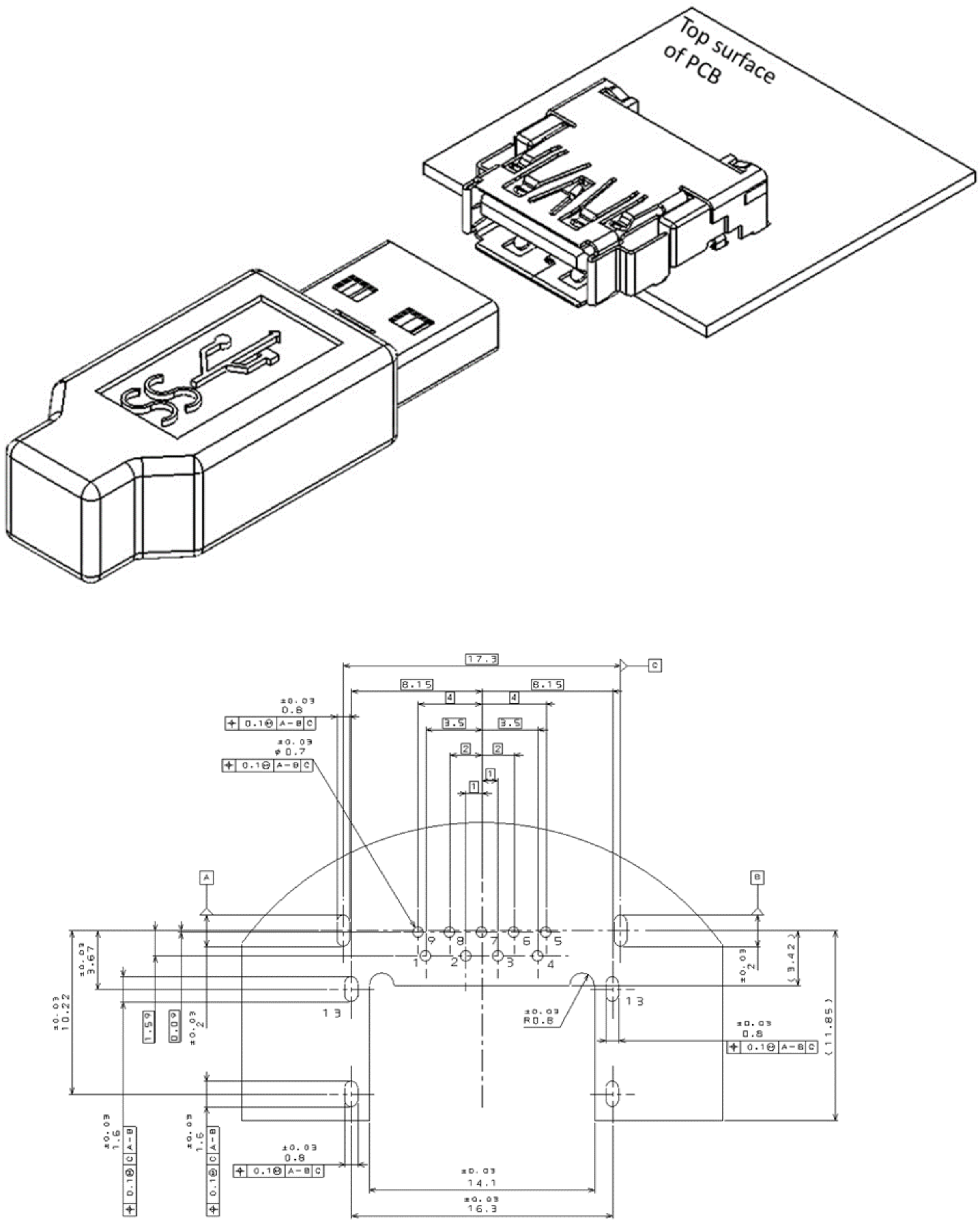

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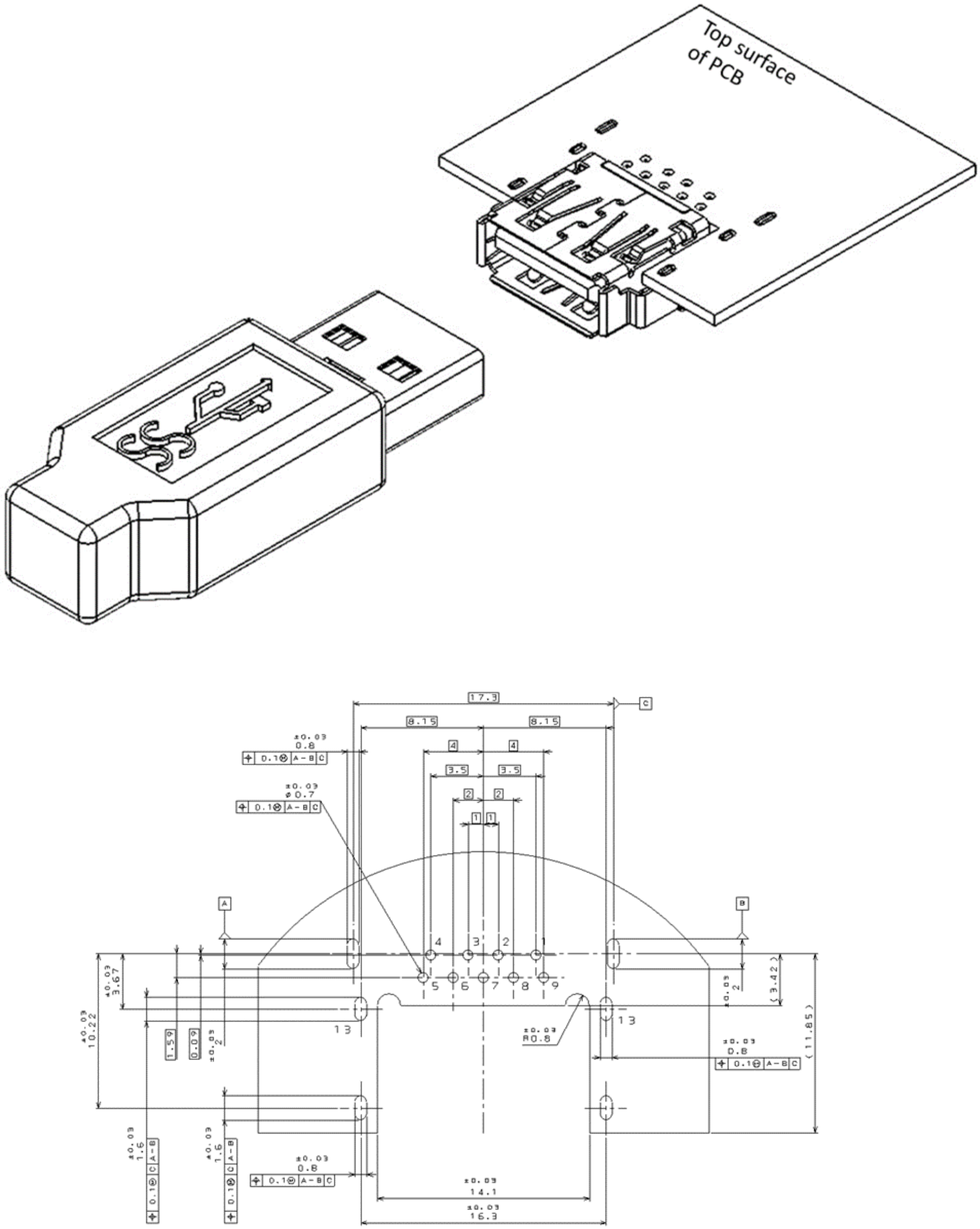
Figure 5-7. Example Footprint for the USB 3.1 Standard-A Receptacle – Mid-Mount Reverse Mount Through-Hole ~~with Insertion Detect~~



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5.3.1.3 Pin Assignments and Description

The usage and assignments of the nine pins in the USB 3.1 Standard A connector are defined in Table 5-2.

Table 5-2. USB 3.1 Standard-A Connector Pin Assignments

Pin Number[1]	Signal Name[2]	Description	Mating Sequence[3]
1	VBUS	Power	Third
2	D−	USB 2.0 differential pair	Fourth
3	D+		
4	GND	Ground for power return	Third
5	StdA_SSRX−	SuperSpeed receiver differential pair	Last
6	StdA_SSRX+		
7	GND_DRAIN	Ground for signal return	
8	StdA_SSTX−	SuperSpeed transmitter differential pair	
9	StdA_SSTX+		
~~12[4], 13~~	~~INSERTION DETECT~~	~~Receptacle only. Detects insertion of a plug into the receptacle. Optional except for cold socket applications. See the USB Power Delivery Specification for details.~~	~~Second~~
Shell	Shield	Connector metal shell	First

Notes:

1. Pin numbers not included in this table do not have contacts present.
2. ~~2.~~ Tx and Rx are defined from the host perspective.
3. ~~3. The mating sequence assumes support of INSERTION DETECT.~~
4. ~~4.~~2. ~~Pin 12, if present, shall be connected to the Shield.~~

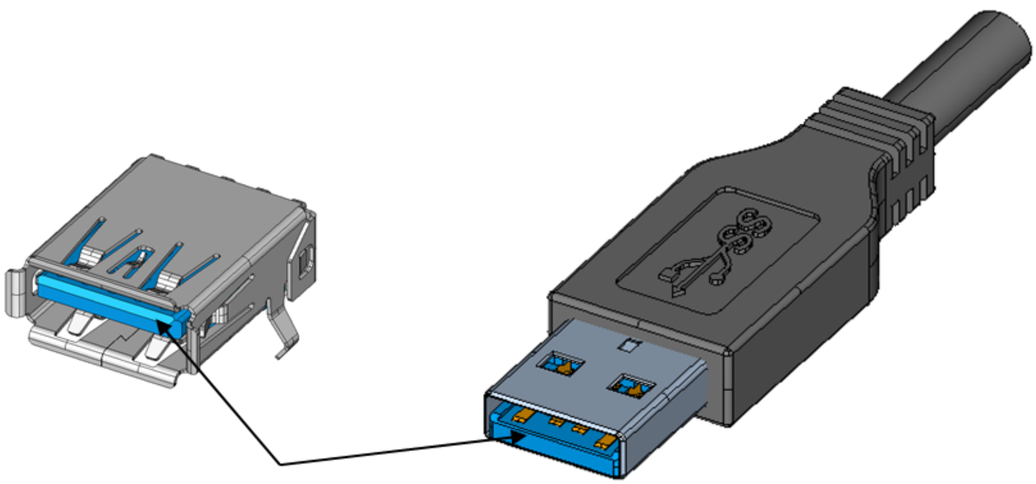
The physical location of the pins in the connector is illustrated in Figure 5-1 to Figure 5-7. Pins 1 to 4 are referred to as the USB 2.0 pins, while pins 5 to 9 are referred to as the SuperSpeed pins. ~~See the Universal Serial Bus Power Delivery Specification for location of pins 12 and 13.~~

5.3.1.4 USB 3.1 Standard-A Connector Color Coding

Since both the USB 2.0 Standard A and USB 3.1 Standard-A receptacles may co-exist on a host, color coding is recommended for the USB 3.1 Standard-A connector (receptacle and plug) housings to help users distinguish it from the USB 2.0 Standard-A connector.

Blue (Pantone 300C) is the recommended color for the USB 3.1 Standard-A receptacle and plug plastic housings. When the recommended color is used, connector manufacturers and system integrators should make sure that the blue-colored receptacle housing is visible to users. Figure 5-8 illustrates the color coding recommendation for the USB 3.1 Standard-A connector.

Figure 5-8. Illustration of Color Coding Recommendation for USB 3.1 Standard-A Connector



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5.3.2 USB 3.1 Standard-B Connector

5.3.2.1 Interface Definition

Figure 5-9, Figure 5-10, and Figure 5-11 show the USB Standard-B receptacle dimensions, the USB Standard-B plug dimensions, and a USB Standard-B receptacle reference footprint, respectively. See Section 0 for target characteristic impedance.

Figure 5-9. USB 3.1 Standard-B Receptacle Interface Dimensions

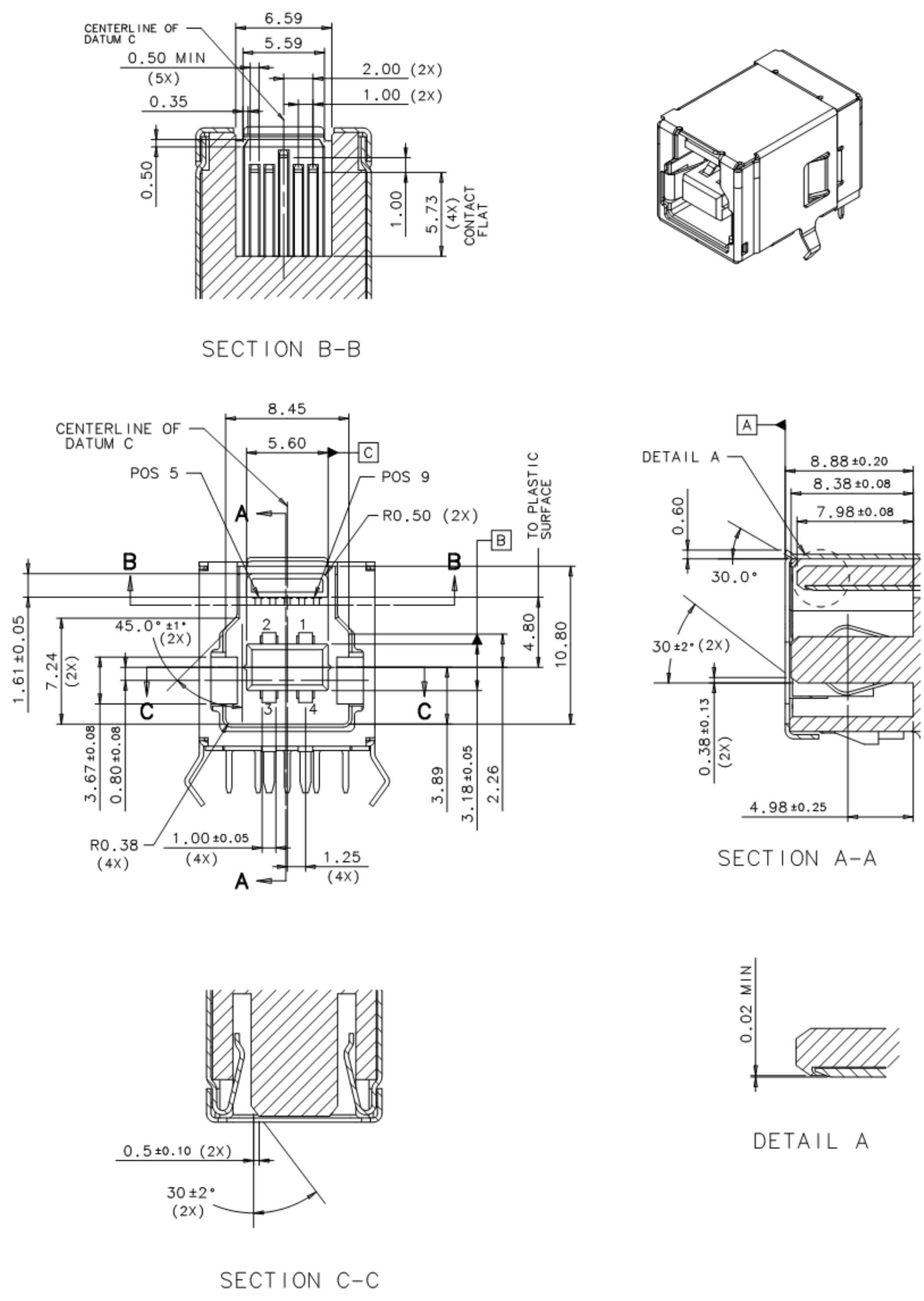

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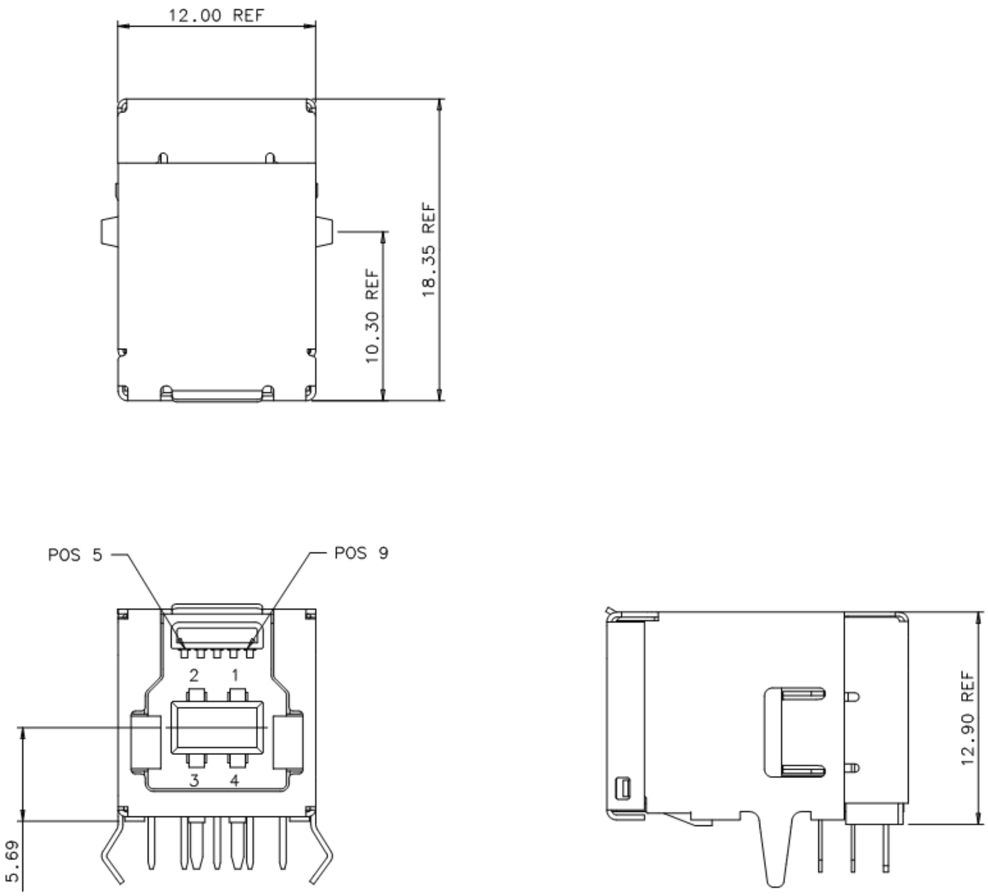
Figure 5-9. USB 3.1 Standard-B Receptacle Interface Dimensions, cont.



NOTES:
1) CRITICAL DIMENSIONS ARE TOLERANCED AND SHALL NOT BE DEVIATED.
2) GENERAL TOLERANCE IS ±0.10 OTHERWISE THE SPECIFIED TOLERANCE APPLIES.
3) ALL DIMENSIONS ARE IN MILLIMETERS.
4) DIMENSIONS THAT ARE LABELED REF ARE TYPICAL DIMENSIONS AND MAY VARY FROM MANUFACTURER TO MANUFACTURER.
5) NON-DIMENSIONED GEOMETRY FOR REFERENCE ONLY, SUBJECT TO CHANGE.

Figure 5-10. USB 3.1 Standard-B Plug Interface Dimensions

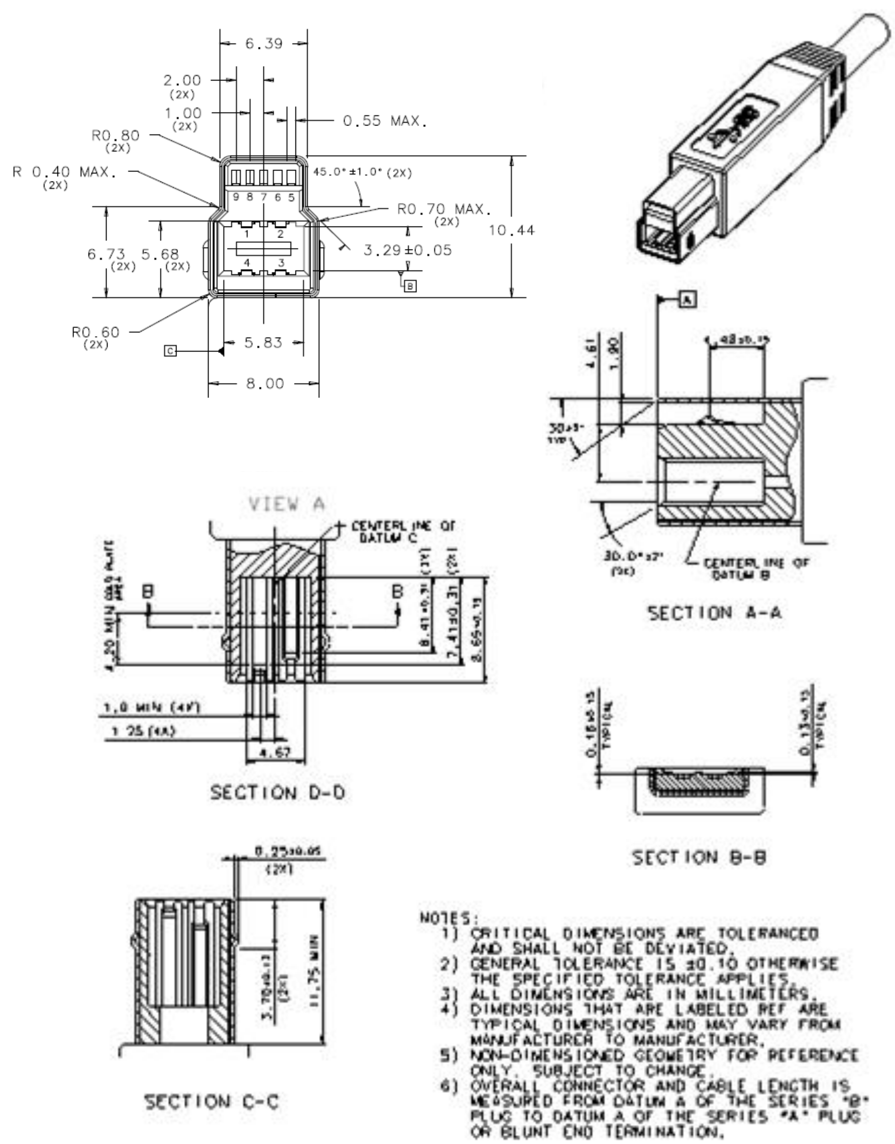


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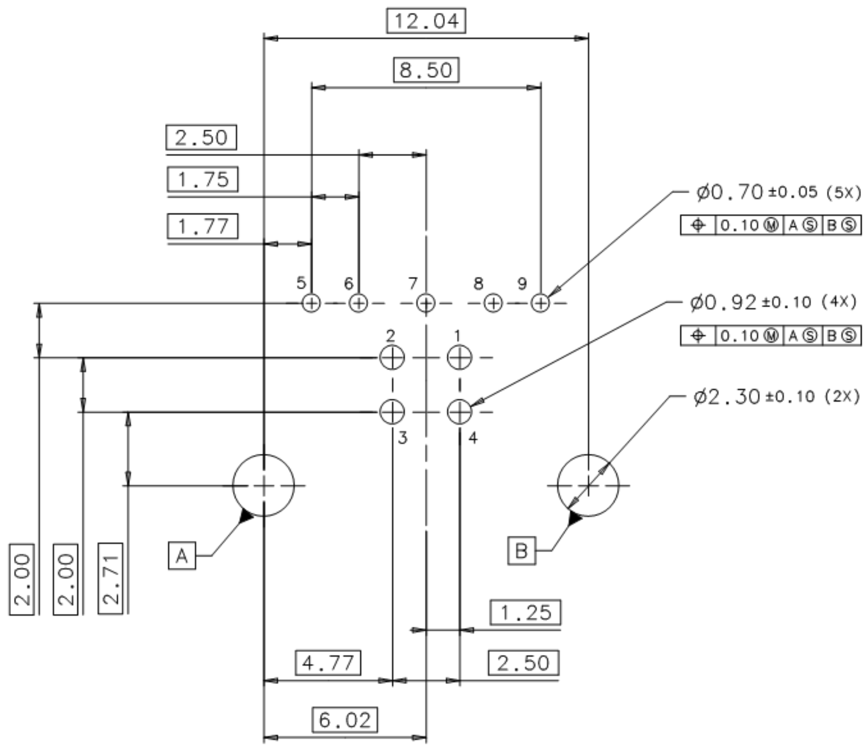
Figure 5-11. Reference Footprint for the USB 3.1 Standard-B Receptacle



REFERENCE PCB LAYOUT

The USB 3.1 Standard-B receptacle interfaces have two portions: the USB 2.0 interface and the SuperSpeed interface. The USB 2.0 interface consists of pins 1 to 4, while the SuperSpeed interface consists of pins 5 to 9.

When a USB 2.0 Standard-B plug is inserted into the USB 3.1 Standard-B receptacle, only the USB 2.0 interface is engaged and the link will not take advantage of the ~~Enhanced~~ SuperSpeed capability. Since the USB 3.1 SuperSpeed portion is visibly not mated when a USB 2.0 Standard-B plug is inserted in the USB 3.1 Standard-B receptacle, users have the visual feedback that the cable plug is not matched with the receptacle. Only when a USB 3.1 Standard-B plug is inserted into the USB 3.1 Standard-B receptacle, is the interface completely visibly engaged.

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5.3.2.2 Pin Assignments and Description

The usage and assignments of the nine pins in the USB 3.1 Standard-B connector are defined in Table 5-3.

Table 5-3. USB 3.1 Standard-B Connector Pin Assignments

Pin Number	Signal Name	Description	Mating Sequence
1	VBUS	Power	Second
2	D−	USB 2.0 differential pair	Third or beyond
3	D+		
4	GND	Ground for power return	Second
5	StdB_SSTX−	SuperSpeed transmitter differential pair	Third or beyond
6	StdB_SSTX+		
7	GND_DRAIN	Ground for signal return	
8	StdB_SSRX−	SuperSpeed receiver differential pair	
9	StdB_SSRX+		
Shell	Shield	Connector metal shell	First

Notes: Tx and Rx are defined from the device perspective.

The physical location of the pins in the connector is illustrated in Figure 5-9 to Figure 5-11.

5.3.3 USB 3.1 Micro Connector Family

5.3.3.1 Interfaces Definition

The USB 3.1 Micro connector family consists of the USB 3.1 Micro-B receptacle, USB 3.1 Micro-AB receptacle, USB 3.1 Micro-B plug, and USB 3.1 Micro-A plug. Figure 5-12 and Figure 5-13 show the USB 3.1 Micro family receptacle and plug interface dimensions, respectively. Only dimensions that govern the mating interoperability are specified.

The USB 3.1 Micro connector family has the following characteristics:

- The USB 3.1 Micro-B connector may be considered a combination of USB 2.0 Micro-B interface and the USB 3.1 SuperSpeed contacts. The USB 3.1 Micro-B receptacle accepts a USB 2.0 Micro-B plug, maintaining backward compatibility.
- The USB 3.1 Micro-B connector maintains the same connector height and contact pitch as the USB 2.0 Micro-B connector.
- The USB 3.1 Micro-B connector uses the same latch design as the USB 2.0 Micro-B connector.
- The USB 3.1 Micro-AB receptacle is identical to the USB 3.1 Micro-B receptacle except for a keying difference in the connector shell outline.
- The USB 3.1 Micro-A plug is similar to the USB 3.1 Micro-B plug with different keying and ID pin connections. ~~The Universal Serial Bus Power Delivery Specification discusses the ID pin connections.~~

There is no required footprint for the USB 3.1 Micro connector family. Figure 5-14 shows reference Micro-B and Micro-AB connector footprints.

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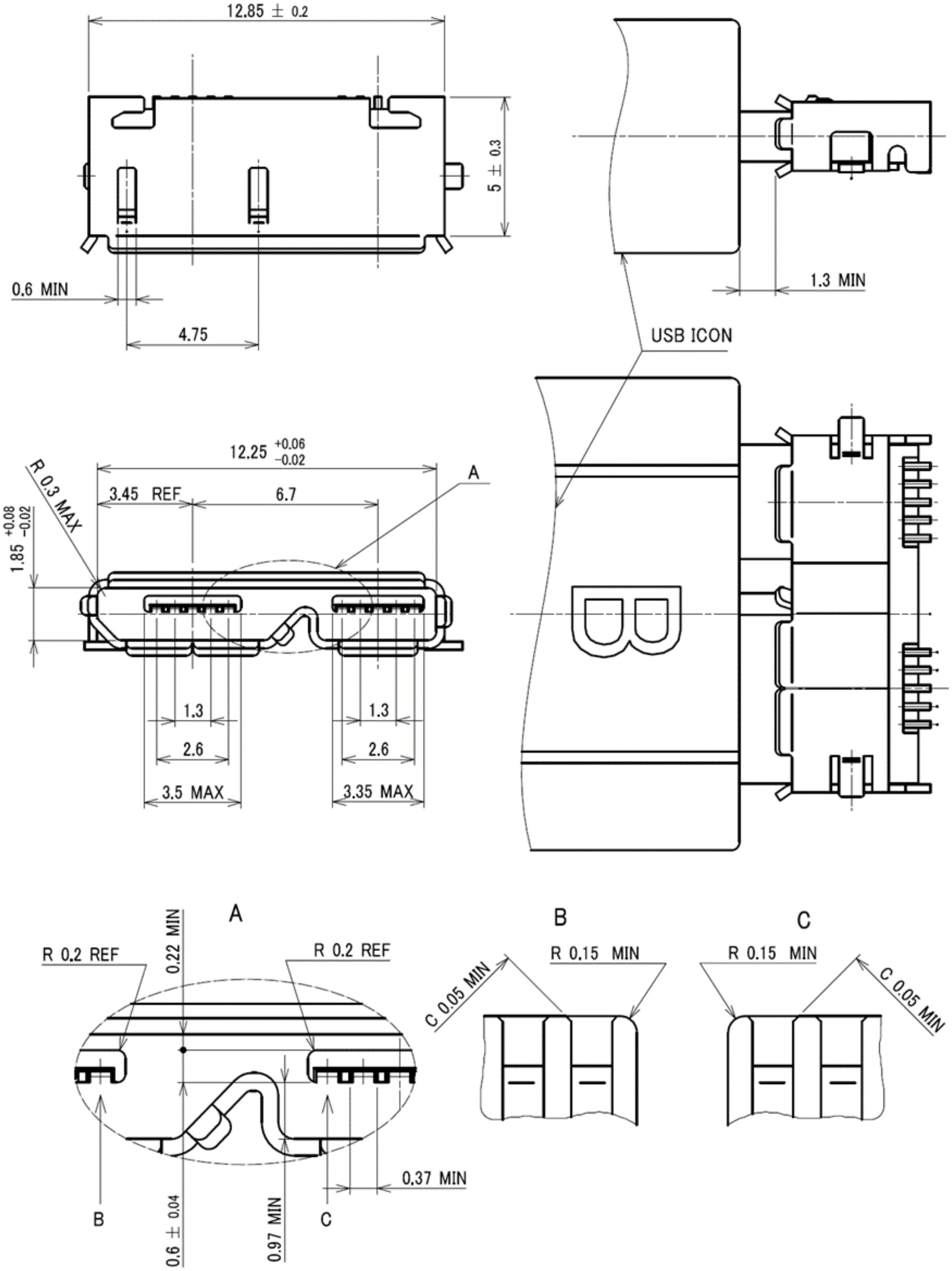
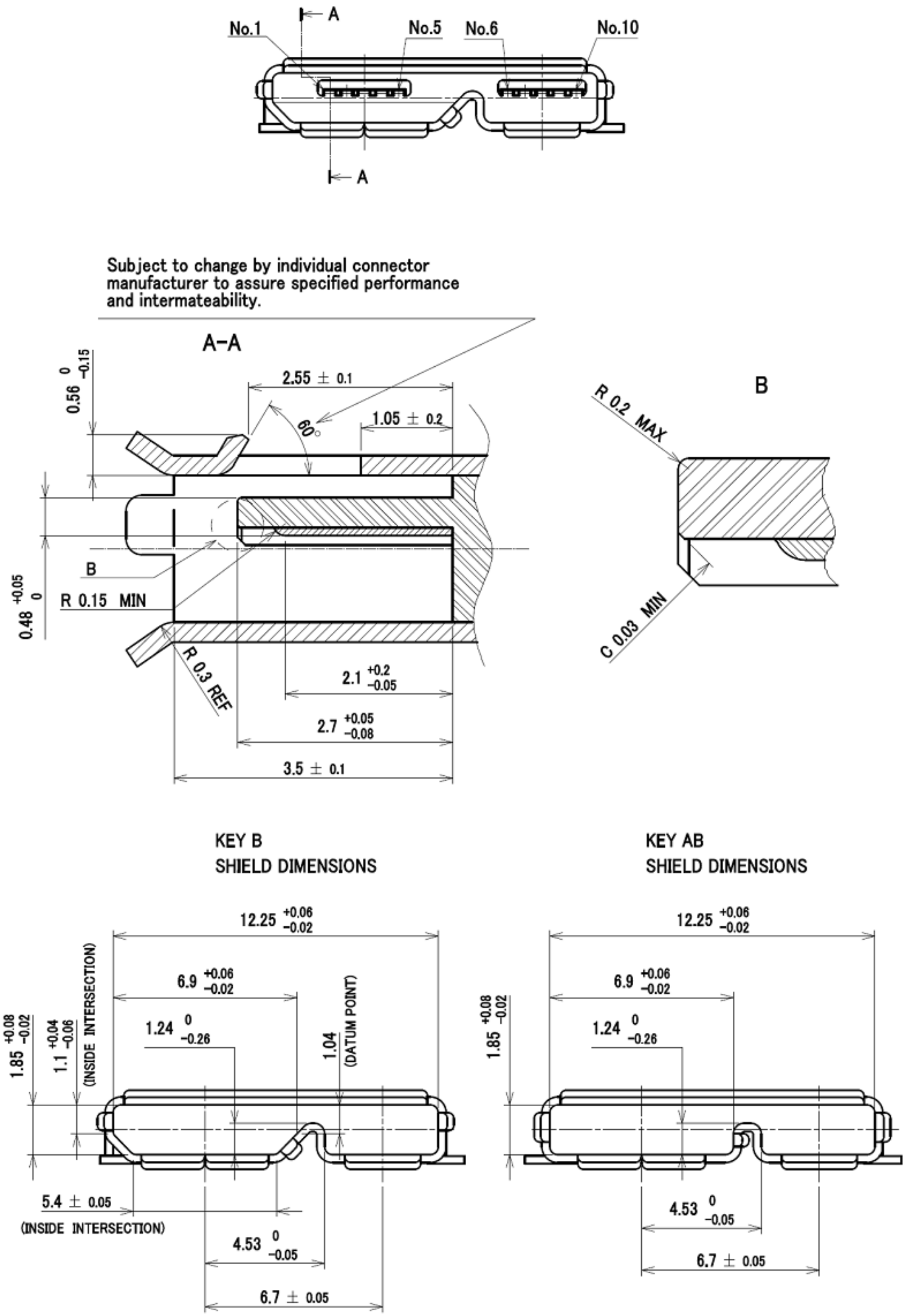
Figure 5-12. USB 3.1 Micro-B and Micro-AB Receptacle Interface Dimensions



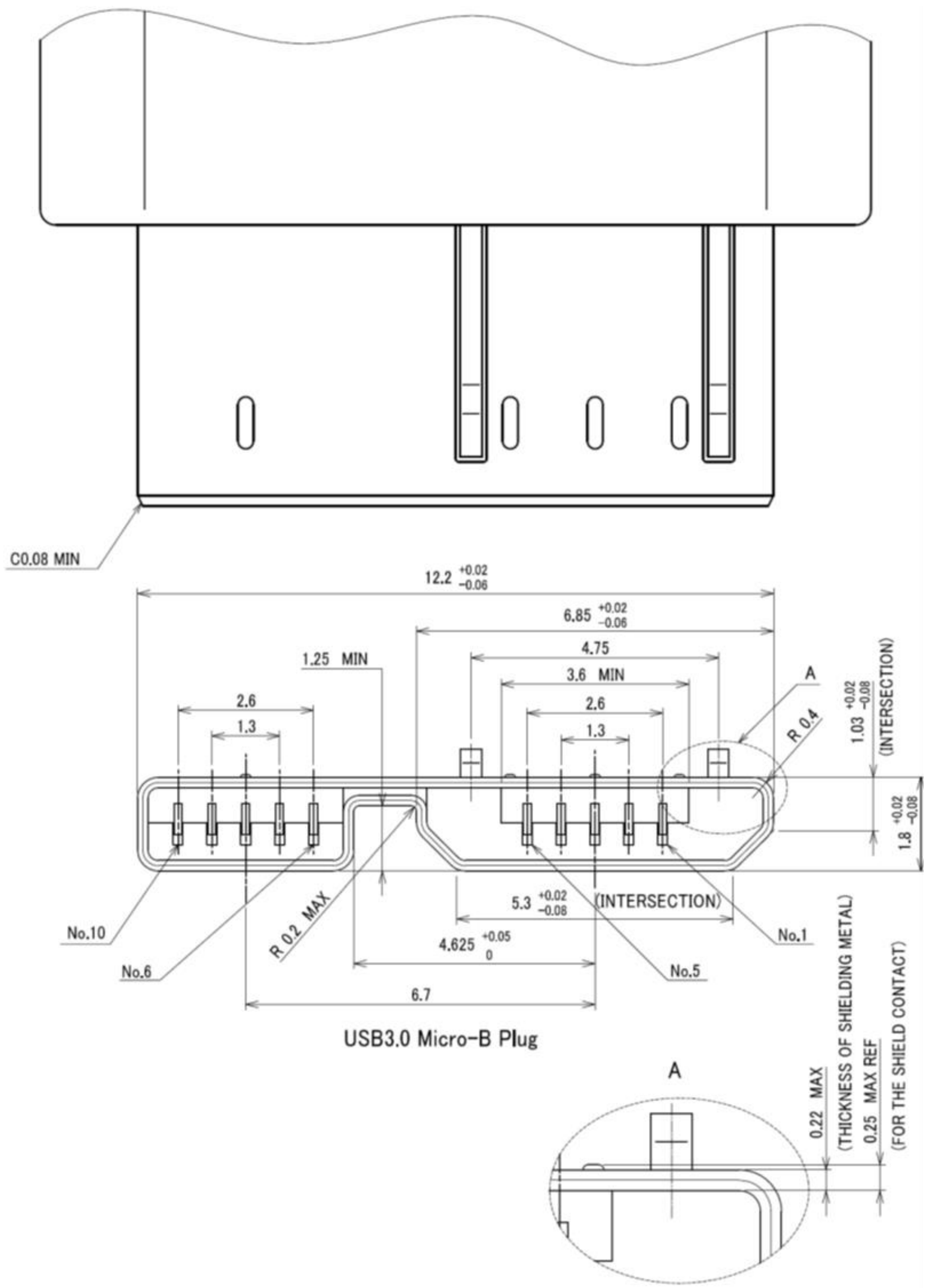
NOTE : General tolerance is +/− 0.05 mm, otherwise the specified tolerances apply.

Figure 5-12. USB 3.1 Micro-B and Micro-AB Receptacle Interface Dimensions, cont.



NOTE : Chamfer metals are optional with no sharp edges.

Figure 5-13. USB 3.1 Micro-B and Micro-A Plug Interface Dimensions



NOTES:

1. Dimensions that are labeled REF may vary from manufacturer to manufacturer.
2. General tolerance is +/−0.05mm, otherwise the specified tolerances apply.

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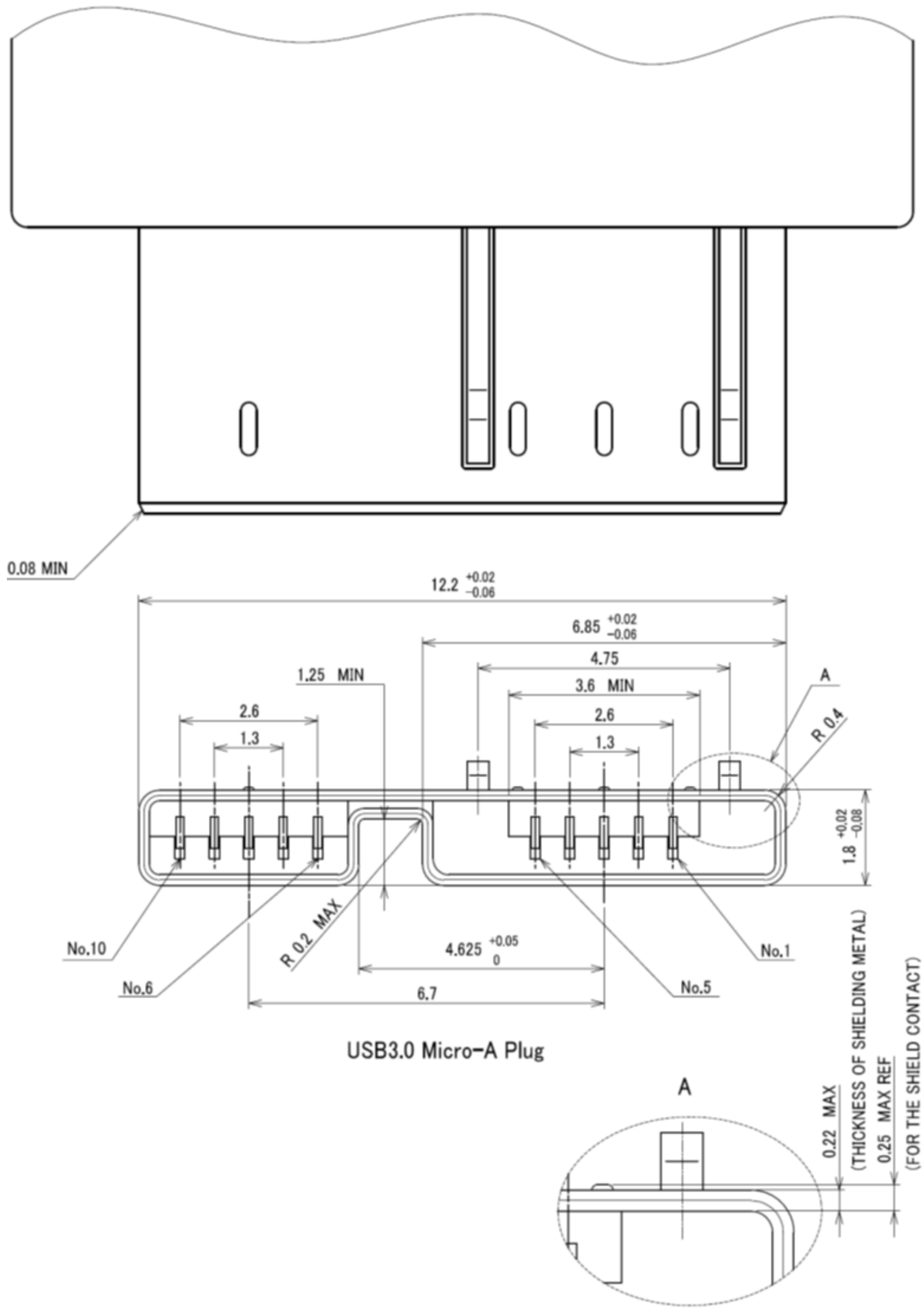
Figure 5-13. USB 3.1 Micro-B and Micro-A Plug Interface Dimensions, cont.



NOTES:

1. Dimensions that are labeled REF may vary from manufacturer to manufacturer.
2. General tolerance is +/−0.05mm, otherwise the specified tolerances apply.

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Figure 5-13. USB 3.1 Micro-B and Micro-A Plug Interface Dimensions, cont.

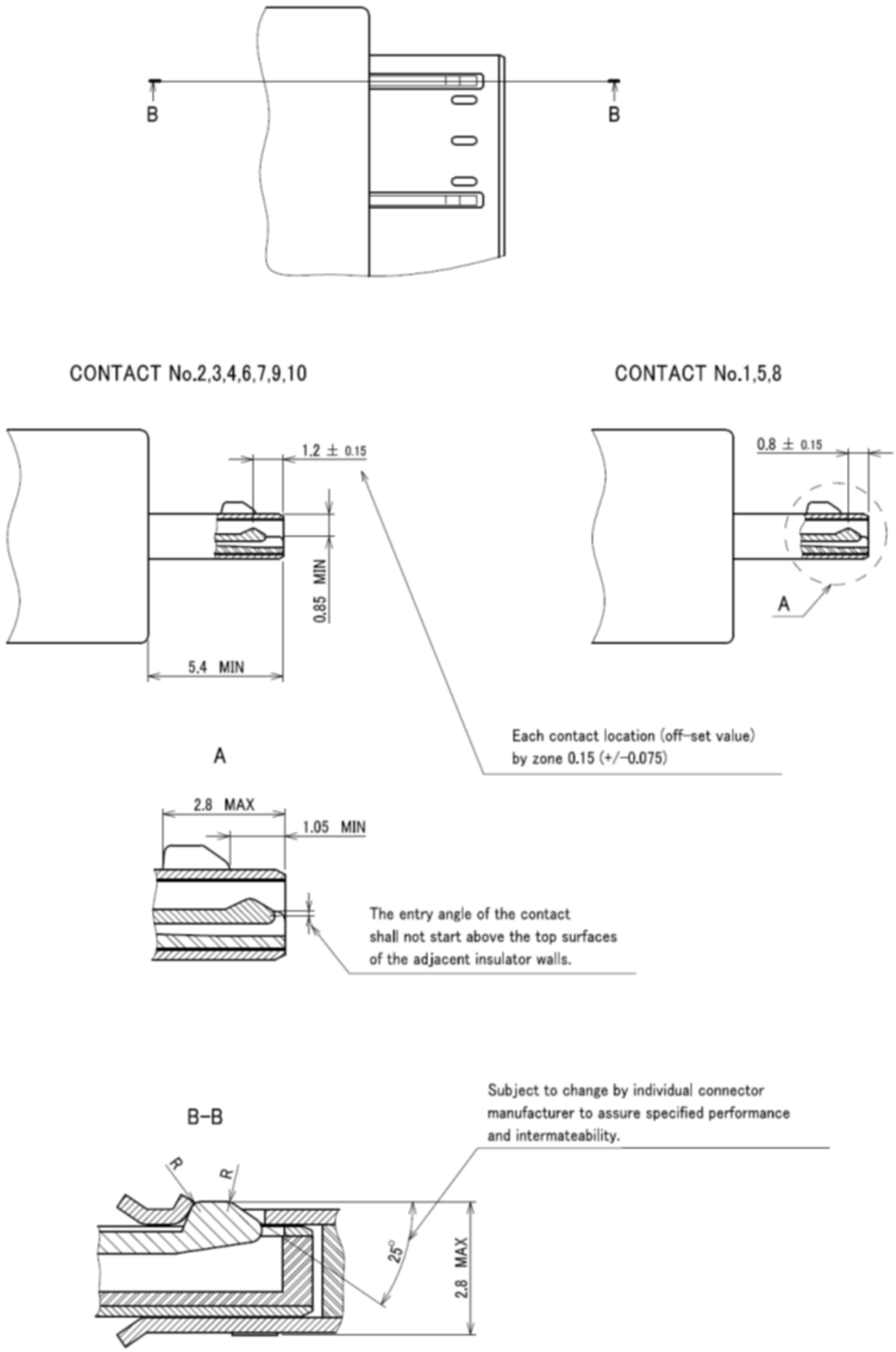

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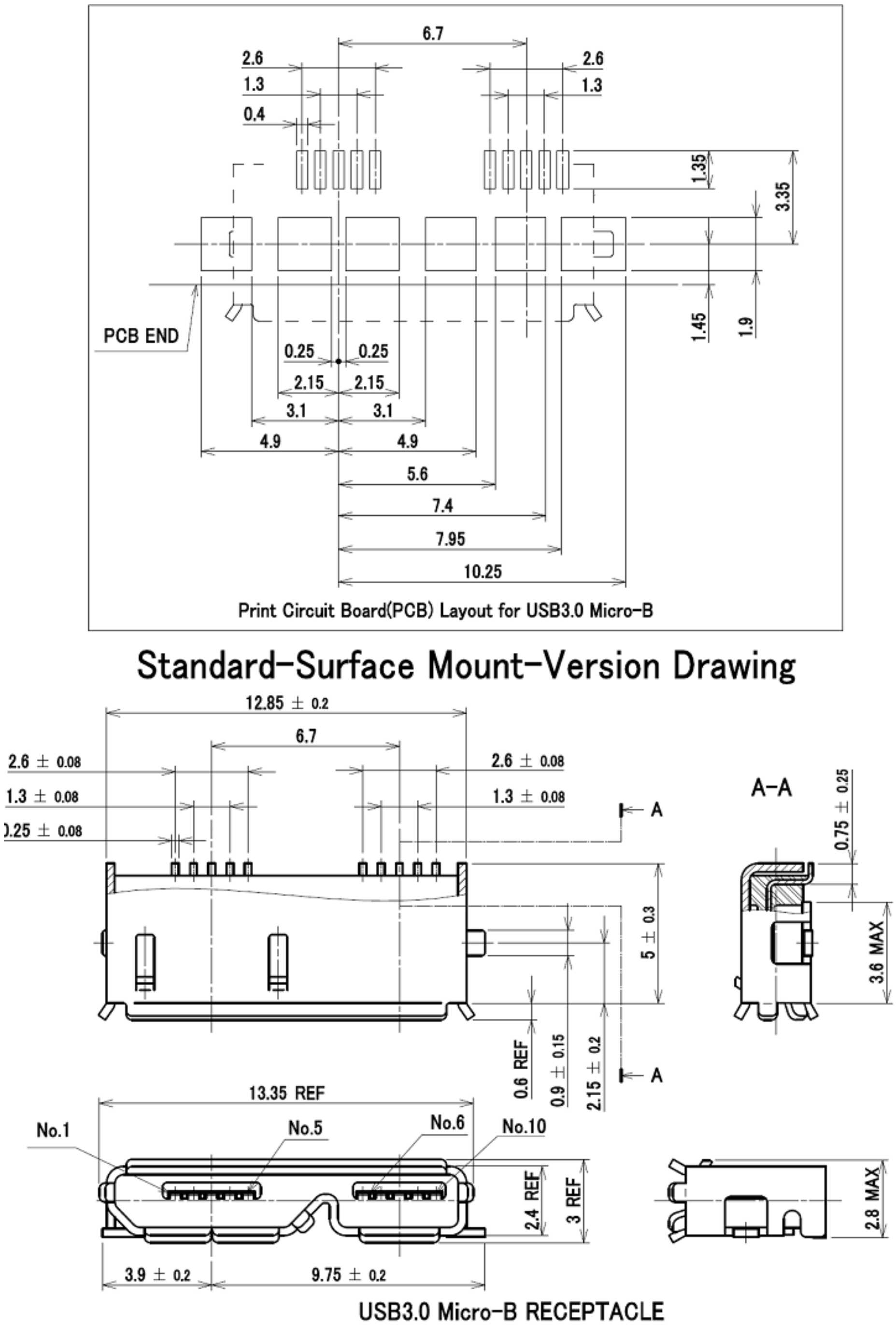
Figure 5-14. Reference Footprint for the USB 3.1 Micro-B and Micro-AB Receptacle



NOTES :

1. Critical Dimensions are TOLERANCED and shall not be deviated.
2. Dimensions that labeled REF are typical dimensions and may vary from manufacturer to manufacturer.
3. General tolerance is +/− 0.05 mm, otherwise the specified tolerances apply.
4. Chamfer metals are optional with no sharp edges.

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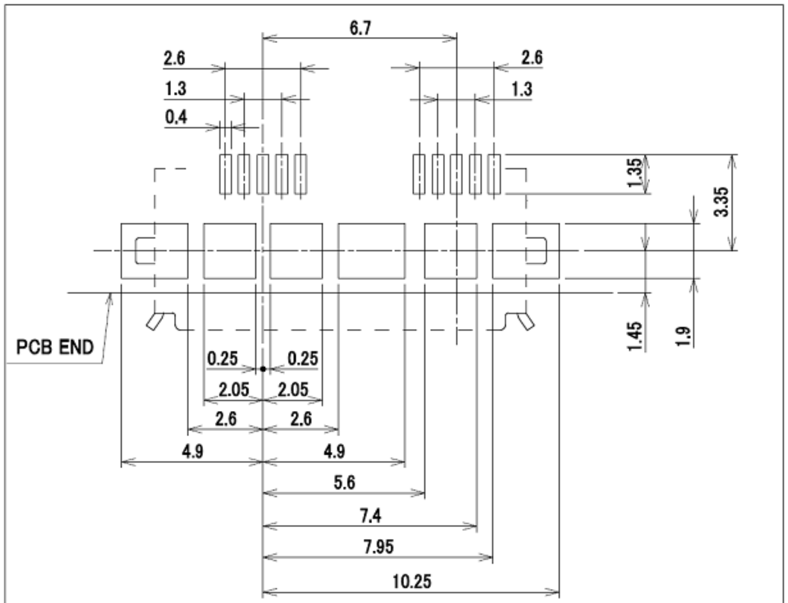
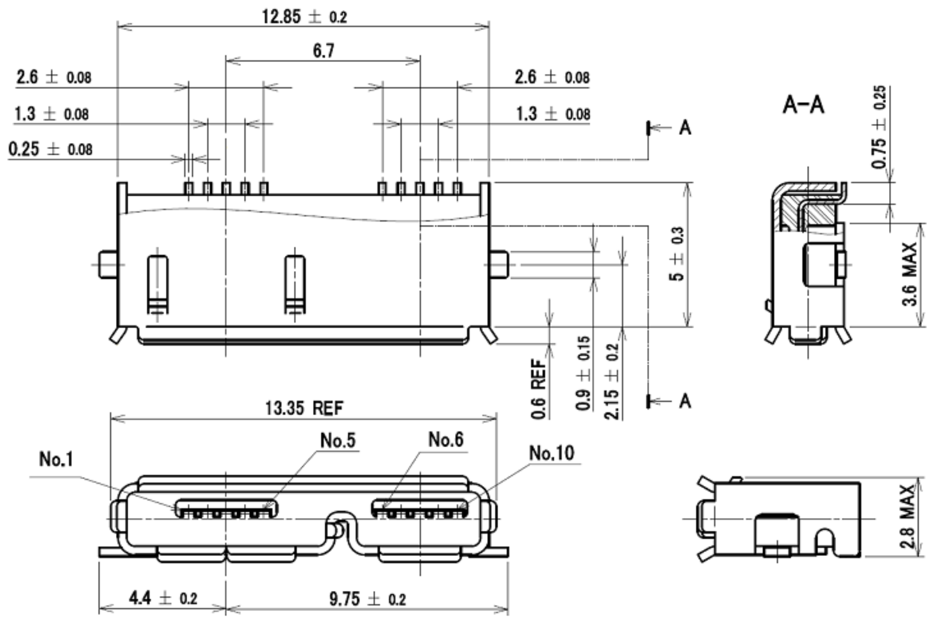
Figure 5-14. Reference Footprint for the USB 3.1 Micro-B and Micro-AB Receptacle, cont.



Print Circuit Board(PCB) Layout for USB3.0 Micro-AB

Standard-Surface Mount-Version Drawing



USB3.0 Micro-AB RECEPTACLE

NOTES :

1. Critical Dimensions are TOLERANCED and shall not be deviated.
2. Dimensions that labeled REF are typical dimensions and may vary from manufacturer to manufacturer.
3. General tolerance is +/- 0.05 mm, otherwise the specified tolerances apply.
4. Chamfer metals are optional with no sharp edges.

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5.3.3.2 Pin Assignments and Description

Table 5-4 and Table 5-5 show the pin assignments for the USB 3.1 Micro connector family.

Table 5-4. USB 3.1 Micro-B Connector Pin Assignments

Pin Number	Signal Name	Description	Mating Sequence
1	VBUS	Power	Second
2	D−	USB 2.0 differential pair	Last
3	D+		
4	ID	OTG Identification	
5	GND	Ground for power return	Second
6	MicB_SSTX−	SuperSpeed transmitter differential pair	Last
7	MicB_SSTX+		
8	GND_DRAIN	Ground for SuperSpeed signal return	Second
9	MicB_SSRX−	SuperSpeed receiver differential pair	Last
10	MicB_SSRX+		
Shell	Shield	Connector metal shell	First

Notes: Tx and Rx are defined from the device perspective.

Table 5-5. USB 3.1 Micro-AB/Micro-A Connector Pin Assignments

Pin Number	Signal Name	Description	Mating Sequence
1	VBUS	Power	Second
2	D−	USB 2.0 differential pair	Last
3	D+		
4	ID	OTG Identification	
5	GND	Ground for power return	Second
6	MicA_SSTX−	SuperSpeed transmitter differential pair	Last
7	MicA_SSTX+		
8	GND_DRAIN	Ground for SuperSpeed signal return	Second
9	MicA_SSRX−	SuperSpeed receiver differential pair	Last
10	MicA_SSRX+		
Shell	Shield	Connector metal shell	First

Notes: Tx and Rx are defined when an OTG device serves as a host.

The physical location of the pins in the connector is illustrated in Figure 5-12 to Figure 5-14.

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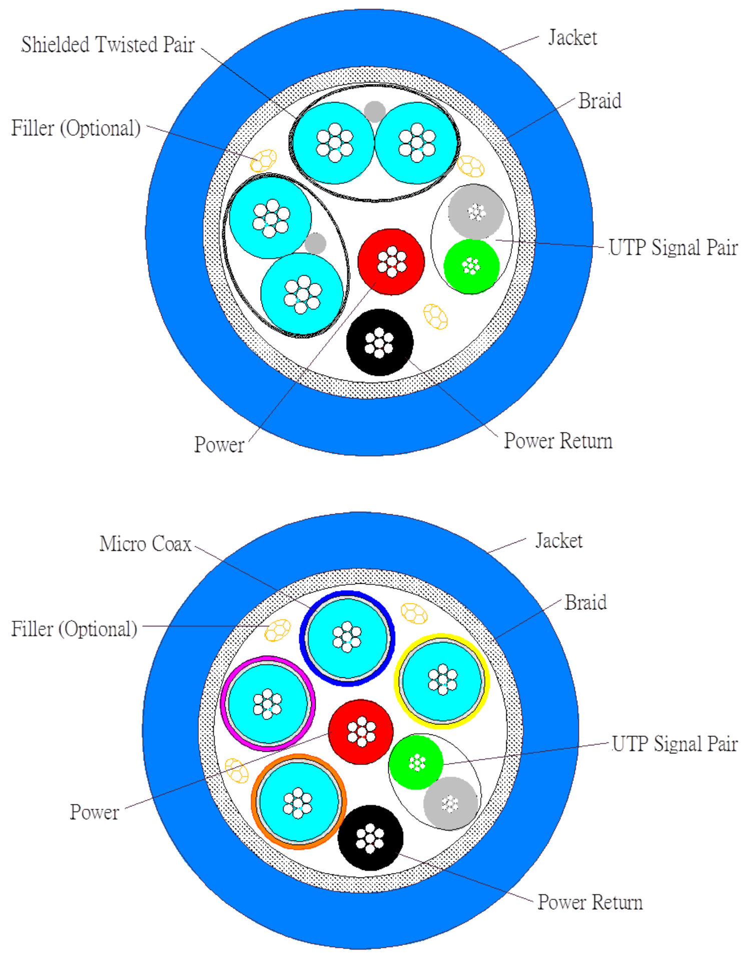
5.4 Cable Construction and Wire Assignments

This section discusses the USB 3.1 cables, including cable construction, wire assignments, and wire gauges. The performance requirements are specified in Section 5.6.1.

5.4.1 Cable Construction

Figure 5-15 illustrates a USB 3.1 cable cross-section. There are three groups of wires: D+/D− signal pair (typically unshielded twisted pair (UTP)), ~~Enhanced~~ SuperSpeed signal pairs (typically Shielded Differential Pair (SDP), twisted, twinax, or coaxial signal pairs), and power and ground wires.

Figure 5-15. Illustration of a USB 3.1 Cable Cross-Section



The D+/D− signal pair is intended to transmit the USB 2.0 signaling while the ~~Enhanced~~ SuperSpeed signal pairs are used for SuperSpeed; the shield is needed for the SuperSpeed differential pairs for signal integrity and EMI performance. Each ~~Enhanced~~ SuperSpeed drain wire is connected to the system ground through the GND_DRAIN pin(s) in the connector.

A metal braid is required to enclose all the wires in the USB 3.1 cable. The braid shall be terminated to the plug metal shells, as close to 360° as possible, to reduce EMI.

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5.4.2 Wire Assignments

Table 5-6 defines the wire number, signal assignments of the wires.

Table 5-6. Cable Wire Assignments

Wire Number	Signal Name	Description
1	PWR	Power
2	D−	Unshielded twist pair, negative
3	D+	Unshielded twist pair, positive
4	GND_PWRrt	Ground for power return
5	P1−	Shielded differential pair 1, negative
6	P1+	Shielded differential pair 1, positive
7	P1_Drain	Drain wire for SDP1
8	P2−	Shielded differential pair 2, negative
9	P2+	Shielded differential pair 2, positive
10	P2_Drain	Drain wire for SDP2
Braid	Shield	Cable external braid to be 360° terminated on to plug metal shell

5.4.3 Wire Gauges and Cable Diameters

This specification does not specify wire gauges. Table 5-7 lists typical wire gauges for reference purposes only. A large gauge wire incurs less loss, but at the cost of cable flexibility. It is recommended to use the smallest possible wire gauges that meet the cable assembly electrical requirements.

To maximize cable flexibility, all wires should be stranded and the cable outer diameter should be minimized as much as possible. A typical ~~non-USB 3.1 Power Delivery capable~~ cable outer diameter may range from 3 mm to 6 mm.

Table 5-7. Reference Wire Gauges

Wire Number	Signal Name	Wire Gauge (AWG)
1	PWR	20 – 28
2	D−	28 – 34
3	D+	28 – 34
4	GND_PWRrt	20 – 28
5	P1−	26 – 34
6	P1+	26 – 34
7	P1_Drain	28 – 34
8	P2−	26 – 34
9	P2+	26 – 34
10	P2_Drain	28 – 34

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5.5 Cable Assemblies

5.5.1 USB 3.1 Standard-A to USB 3.1 Standard-B Cable Assembly

Figure 5-16 shows a USB 3.1 Standard-A to USB 3.1 Standard-B cable assembly. ~~Due to increased wire sizes required for some PD cable implementations, the overmold dimensions for PD cables have larger maximum dimensions than the non-PD cables specified. See the *Universal Serial Bus Power Delivery Specification* for the maximum overmold dimensions of PD cable assemblies.~~

Figure 5-16. USB 3.1 Standard-A to USB 3.1 Standard-B Cable Assembly

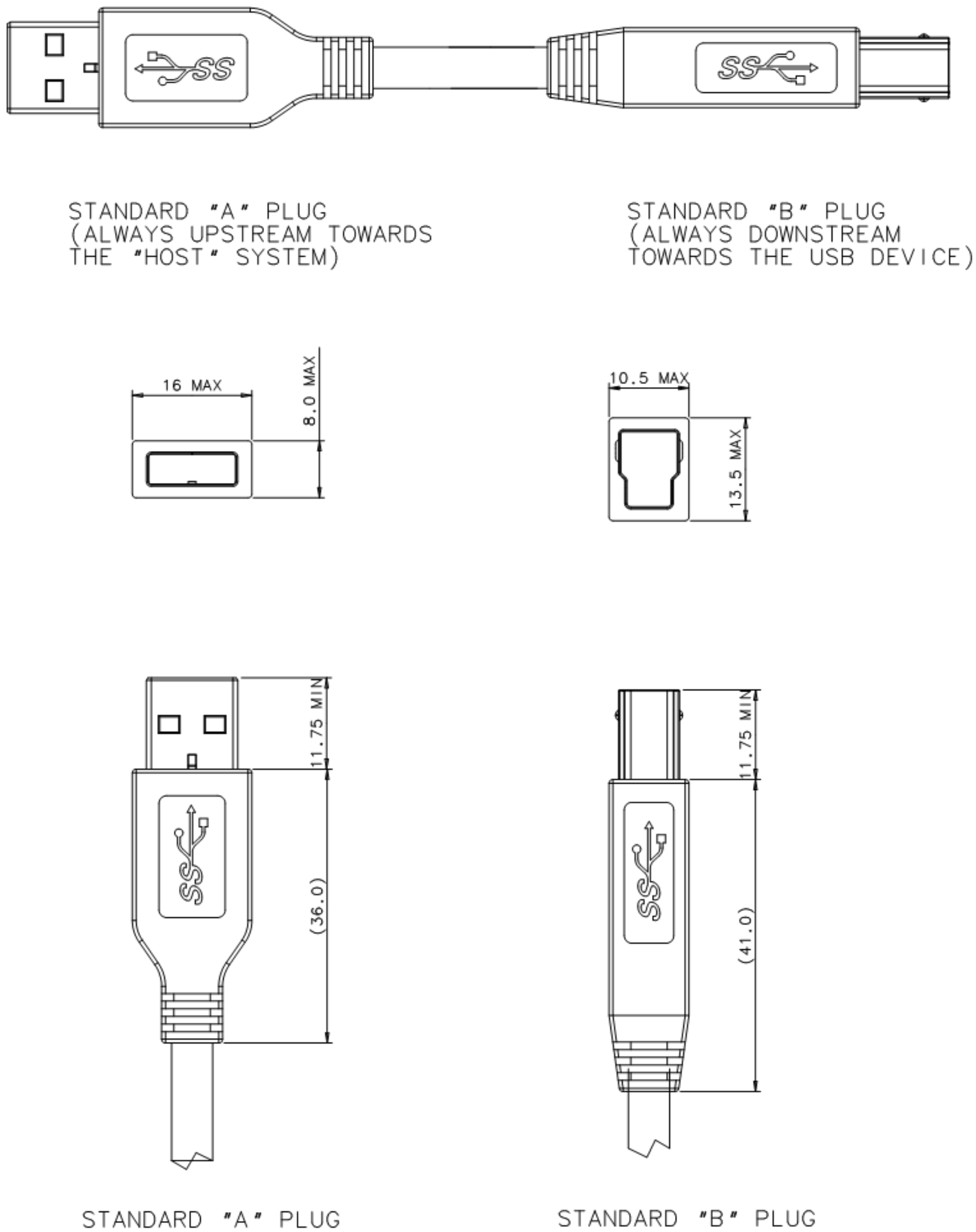

Table 5-8 defines the wire connections for the USB 3.1 Standard-A to USB 3.1 Standard-B cable assembly.

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Table 5-8. USB 3.1 Standard-A to USB 3.1 Standard-B Cable Assembly Wiring

USB 3.1 Standard-A Plug		Wire		USB 3.1 Standard-B plug	
Pin Number	Signal Name	Wire Number	Signal Name	Pin Number	Signal Name
1	VBUS	1	PWR	1	VBUS
2	D−	2	D−	2	D−
3	D+	3	D+	3	D+
4	GND	4	GND_PWRrt	4	GND
5	StdA_SSRX−	5	P1−	5	StdB_SSTX−
6	StdA_SSRX+	6	P1+	6	StdB_SSTX+
7	GND_DRAIN	7 and 10	P1_Drain P2_Drain	7	GND_DRAIN
8	StdA_SSTX−	8	P2−	8	StdB_SSRX−
9	StdA_SSTX+	9	P2+	9	StdB_SSRX+
Shell	Shield	Braid	Shield	Shell	Shield

5.5.2 USB 3.1 Standard-A to USB 3.1 Standard-A Cable Assembly

The USB 3.1 Standard-A to USB 3.1 Standard-A cable assembly is defined for operating system debugging and other host-to-host connection applications. Table 5-9 shows wire connections for such a cable assembly. Refer to Figure 5-16 for the USB 3.1 Standard A plug cable overmold dimensions.

Table 5-9. USB 3.1 Standard-A to USB 3.1 Standard-A Cable Assembly Wiring

USB 3.1 Standard-A Plug #1		Wire		USB 3.1 Standard-A plug #2	
Pin Number	Signal Name	Wire Number	Signal Name	Pin Number	Signal Name
1	VBUS	No connect		1	VBUS
2	D−	No connect		2	D−
3	D+	No connect		3	D+
4	GND	4	GND_PWRrt	4	GND
5	StdA_SSRX−	5	P1−	8	StdA_SSTX−
6	StdA_SSRX+	6	P1+	9	StdA_SSTX+
7	GND_DRAIN	7 and 10	P1_Drain P2_Drain	7	GND_DRAIN
8	StdA_SSTX−	8	P2−	5	StdA_SSRX−
9	StdA_SSTX+	9	P2+	6	StdA_SSRX+
Shell	Shield	Braid	Shield	Shell	Shield

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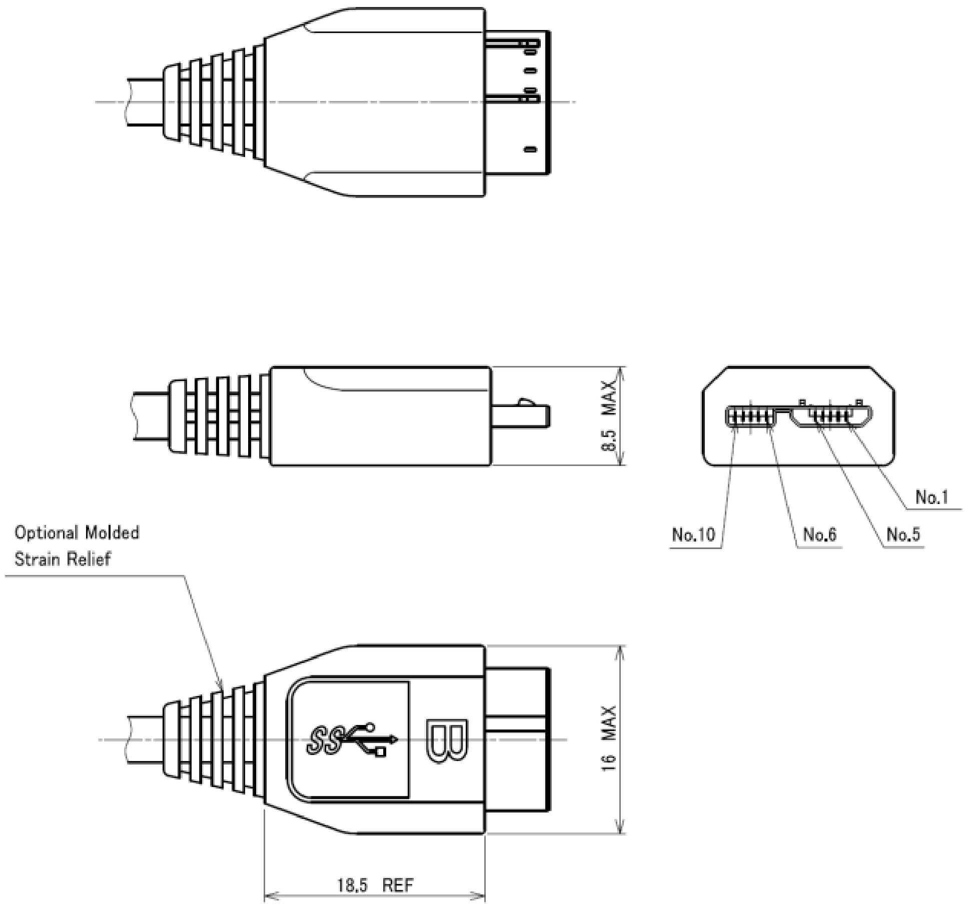
5.5.3 USB 3.1 Standard-A to USB 3.1 Micro-B Cable Assembly

Figure 5-17 shows the USB 3.1 Micro-B plug overmold dimensions for a USB 3.1 Standard-A to USB 3.1 Micro-B cable assembly. The USB 3.1 Standard-A plug overmold dimensions are found in Figure 5-16. ~~Due to increased wire sizes required for some PD cable implementations, the overmold dimensions for PD cables have larger maximum dimensions than the non-PD cables specified. See the *Universal Serial Bus Power Delivery Specification* for the maximum overmold dimensions of PD cable assemblies.~~

Figure 5-17. USB 3.1 Micro-B Plug Cable Overmold Dimensions



Notes:
1. Any surface may have texturing up to 0.3 mm below the surface.
2. A square area around the letter B may be lowered as much as 0.5 mm.
3. USB authorized icon, connector type letter designation (i.e., B), color of the insulator body, and maximum dimensions are mandatory. Overmold outer configuration, color, and final shape are reference.
4. Pin 4 is not connected to pin 5 inside the plug.

Table 5-10 shows the wire connections for the USB 3.1 Standard-A to USB 3.1 Micro-B cable assembly. Note that the ID pin in the USB 3.1 Micro-B plug shall not be connected, but left in the open condition.

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Table 5-10. USB 3.1 Standard-A to USB 3.1 Micro-B Cable Assembly Wiring

USB 3.1 Standard-A Plug		Wire		USB 3.1 Micro-B plug	
Pin Number	**Signal Name**	**Wire Number**	**Signal Name**	**Pin Number**	**Signal Name**
1	VBUS	1	PWR	1	VBUS
2	D−	2	D−	2	D−
3	D+	3	D+	3	D+
4	GND	4	GND_PWRrt	5	GND
5	StdA_SSRX−	5	P1−	6	MicB_SSTX−
6	StdA_SSRX+	6	P1+	7	MicB_SSTX+
7	GND_DRAIN	7 and 10	P1_Drain P2_Drain	8	GND_DRAIN
8	StdA_SSTX−	8	P2−	9	MicB_SSRX−
9	StdA_SSTX+	9	P2+	10	MicB_SSRX+
				4	ID
Shell	Shield	Braid	Shield	Shell	Shield

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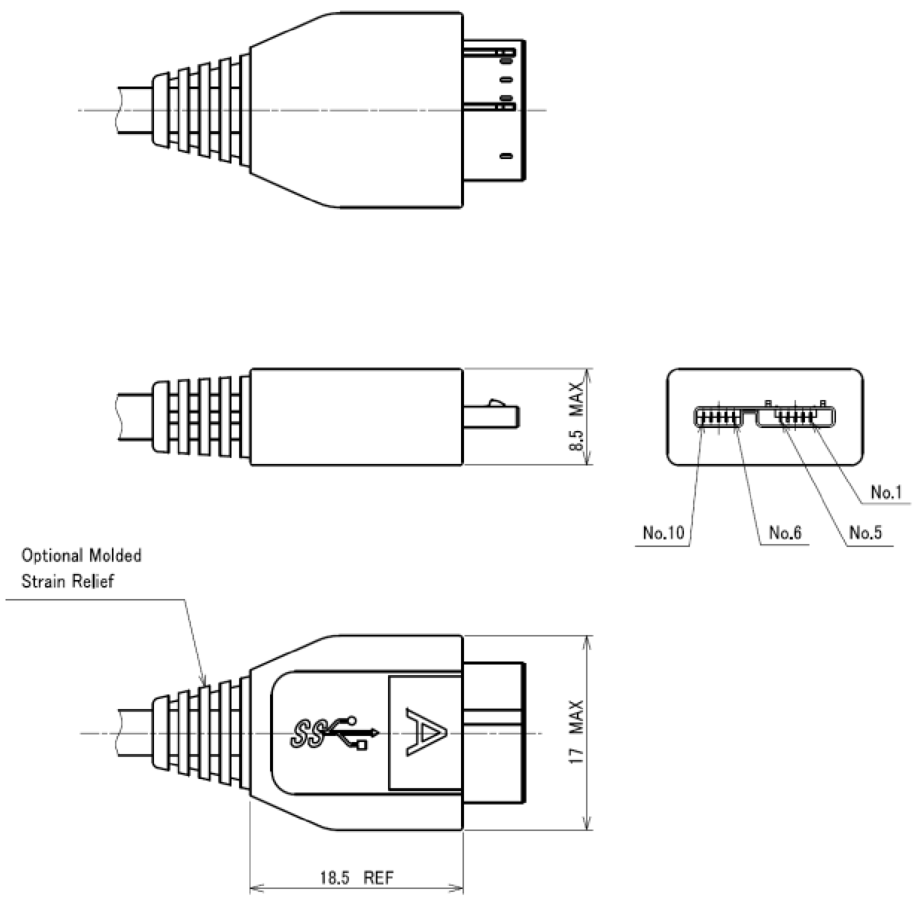
5.5.4 USB 3.1 Micro-A to USB 3.1 Micro-B Cable Assembly

Figure 5-18 shows the USB 3.1 Micro-A plug cable overmold dimensions in a USB 3.1 Micro-A to USB 3.1 Micro-B cable assembly. The USB 3.1 Micro-B plug cable overmold dimensions are shown in Figure 5-17. ~~Due to increased wire sizes required for some PD cable implementations, the overmold dimensions for PD cables have larger maximum dimensions than the non-PD cables specified. See the *Universal Serial Bus Power Delivery Specification* for the maximum overmold dimensions of PD cable assemblies.~~

Figure 5-18. USB 3.1 Micro-A Plug Cable Overmold Dimensions



Notes:
1. Any surface may have texturing up to 0.3 mm below the surface.
2. A square area around the letter A may be lowered as much as 0.5 mm.
3. USB authorized icon, connector type letter designation (i.e., A), color of the insulator body, and maximum dimensions are mandatory. Overmold outer configuration, color, and final shape are reference.
4. Pin 4 is connected to pin 5 inside the plug.

Table 5-11 shows the wire connections for the USB 3.1 Micro-A to USB 3.1 Micro-B cable assembly. The ID pin on a USB 3.1 Micro-A plug shall be connected to the GND pin. The ID pin on a USB 3.1 Micro-B plug shall be a no-connect or connected to ground by a resistance of greater than Rb_PLUG_ID (1 MΩ minimum). See the ~~*Universal Serial Bus Power*~~

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~~Delivery~~USB On-the-Go Supplement to the USB 2.0 *Specification* for additional details regarding electrical connections to ID pins. An OTG device is required to be able to detect whether a USB 3.1 Micro-A or USB 3.1 Micro-B plug is inserted by determining if the ID pin resistance to ground is less than Ra_PLUG_ID (10 Ω maximum) or if the resistance to ground is greater than Rb_PLUG_ID. Any ID resistance less than Ra_PLUG_ID shall be treated as ID = FALSE and any resistance greater than Rb_PLUG_ID shall be treated as ID = TRUE.

Table 5-11. USB 3.1 Micro-A to USB 3.1 Micro-B Cable Assembly Wiring

USB 3.1 Micro-A Plug		Wire		USB 3.1 Micro-B plug	
Pin Number	**Signal Name**	**Wire Number**	**Signal Name**	**Pin Number**	**Signal Name**
1	VBUS	1	PWR	1	VBUS
2	D−	2	D−	2	D−
3	D+	3	D+	3	D+
4	ID (see Note 1)	No connect		4	ID (see Note 2)
5	GND	4	GND_PWRrt	5	GND
6	MicA_SSTX−	5	P1−	9	MicB_SSRX−
7	MicA_SSTX+	6	P1+	10	MicB_SSRX+
8	GND_DRAIN	7 and 10	P1_Drain P2_Drain	8	GND_DRAIN
9	MicA_SSRX−	8	P2−	6	MicB_SSTX−
10	MicA_SSRX+	9	P2+	7	MicB_SSTX+
Shell	Shield	Braid	Shield	Shell	Shield

Notes:

1. Connect to the GND
2. No connect or connect to ground by a resistance greater than 1 MΩ minimum.

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5.5.5 USB 3.1 Micro-A to USB 3.1 Standard-B Cable Assembly

A USB 3.1 Micro-A to USB 3.1 Standard-B cable assembly is also allowed. Figure 5-18 and Figure 5-16 show, respectively, the USB 3.1 Micro-A cable overmold and the USB 3.1 Standard-B cable overmold dimensions.

Table 5-12 shows the wire connections for the USB 3.1 Micro-A to USB 3.1 Standard-B cable assembly.

Table 5-12. USB 3.1 Micro-A to USB 3.1 Standard-B Cable Assembly Wiring

USB 3.1 Micro-A Plug		Wire		USB 3.1 Micro-B plug	
Pin Number	Signal Name	Wire Number	Signal Name	Pin Number	Signal Name
1	VBUS	1	PWR	1	VBUS
2	D−	2	D−	2	D−
3	D+	3	D+	3	D+
4	ID (see Note 1)	No connect			
5	GND	4	GND_PWRrt	4	GND
6	MicA_SSTX−	5	P1−	8	StdB_SSRX−
7	MicA_SSTX+	6	P1+	9	StdB_SSRX+
8	GND_DRAIN	7 and 10	P1_Drain P2_Drain	7	GND_DRAIN
9	MicA_SSRX−	8	P2−	5	StdB_SSTX−
10	MicA_SSRX+	9	P2+	6	StdB_SSTX+
Shell	Shield	Braid	Shield	Shell	Shield

Notes:

1. Connect to the GND

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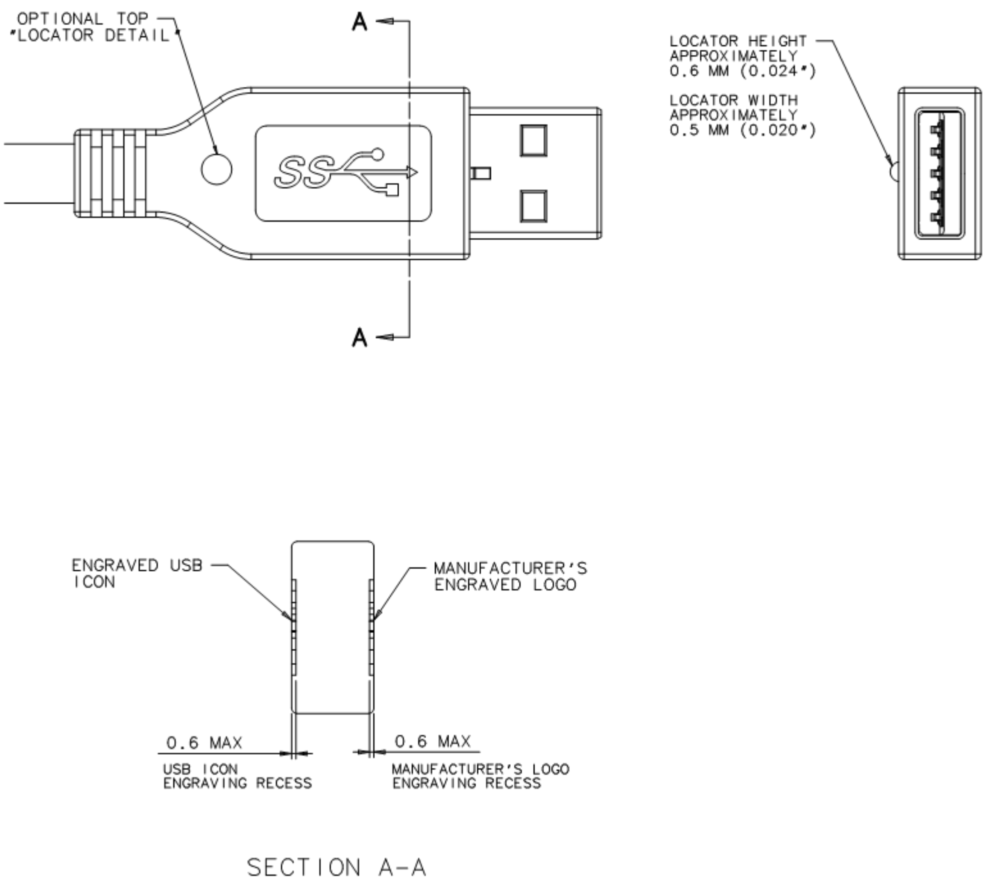
5.5.6 USB 3.1 Icon Location

USB 3.1 cable assemblies compliant with the *USB 3.1 Legacy Connectors and Cable Assemblies Compliance Specification* shall display the appropriate USB 3.1 Icon. A dimensioned drawing and allowable usage of the icon are supplied with the license from the USB-IF.

The USB 3.1 Icon is embossed in a recessed area on the side of the USB 3.1 plug. This provides easy user recognition and facilitates alignment during the mating process. The USB Icon and Manufacturer's logo should not project beyond the overmold surface. The USB 3.1 compliant cable assembly is required to have the USB 3.1 Icons on the plugs at both ends, while the manufacturer's logo is recommended. USB 3.1 receptacles should be orientated to allow the Icon on the plug to be visible during the mating process. Figure 5-19 shows a typical plug orientation.

Figure 5-19. Typical Plug Orientation



5.5.7 Cable Assembly Length

This specification does not specify cable assembly lengths. A USB 3.1 cable assembly may be of any length as long as it meets all the requirements defined in this specification. The cable assembly voltage drop budget defined in Section 5.8.4 and the cable assembly loss budget defined in Section 5.6.1.3.1, limit the cable assembly length.

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5.6 Electrical Requirements

This section covers the electrical requirements for ~~USB 3.1~~ raw cables, mated connectors, and mated cable assemblies. ~~USB 3.1 signals, known as Enhanced~~ SuperSpeed USB signals are governed by this specification. The USB 2.0 signals are governed by the USB 2.0 specification, unless otherwise specified.

Compliance to the USB 3.~~1~~2 specification is established through normative requirements of mated connectors and mated cable assemblies. SuperSpeed requirements are specified mainly in terms of S-parameters, using industry test specification with supporting details when required.

~~Enhanced SuperSpeed requirements supporting Gen 2 speed are specified in the frequency domain. Components and assemblies meeting Enhanced SuperSpeed Gen 2 speed electrical requirements do not require separate qualification testing for Gen 1 speed compliance.~~

DC requirements, such as contact resistance and current carrying capability, are also specified in this section.

Any informative specification for cable and connector products is for the purpose of design guidelines and manufacturing control.

In conjunction with performance requirements, the required test method is referenced for the parameter stated. A list of the industry standards for DC requirements is found in the Section 5.6.2. Additional supporting test procedures are found in the *USB 3.1 Legacy Connectors and Cable Assemblies Compliance Document*.

The requirements in the section apply to all USB 3.1 connectors and/or cable assemblies unless specified otherwise.

5.6.1 ~~Enhanced~~ SuperSpeed Electrical Requirements

The following sections outline the requirements for SuperSpeed signals.

5.6.1.1 Raw Cable

Informative raw cable electrical performance targets are provided to help cable assembly manufacturers manage raw cable suppliers. These targets are not part of the USB 3.1 compliance requirements. The mandatory requirements are that the mated cable assembly performance specified in Section 5.6.1.3 and other tests specified in the *USB 3.1 Legacy Connectors and Cable Assemblies Compliance Document*.

5.6.1.1.1 Characteristic Impedance

The differential characteristic impedance for the SDP pairs is recommended to be 90 Ω ± 5 Ω. The single-ended characteristic impedance of coaxial ~~Enhanced~~ SuperSpeed signal wires is recommended to be 45 Ω ± 3 Ω. It should be measured with a TDR in a differential mode using a 200 ps (10% – 90%) rise time.

5.6.1.1.2 Intra-Pair Skew

The intra-pair skew for the SDP pairs is recommended to be less than 15 ps/m. It should be measured with a Time Domain Transmission (TDT) in a differential mode using a 200 ps (10% – 90%) rise time with a crossing at 50% of the input voltage.

5.6.1.1.3 Differential Insertion Loss

Cable loss depends on wire gauges~~, plating~~ and dielectric materials. Table 5-13 ~~and show~~lists examples of ~~average~~ differential insertion ~~loss~~losses for the SDP pairs ~~for Enhanced SuperSpeed Gen 2 speed. To meet~~. Note that the ~~cable assembly~~ differential

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~~insertion loss target, support of the Gen 2 speed requires better performance from the raw cable than required for support of the Gen 1 speed~~loss values are referenced to a 90 Ω differential impedance.

Table 5-13. SDP Differential Insertion Loss Examples ~~for Gen 2 Speed~~

Frequency	34AWG	30AWG~~32AWG~~	28AWG~~30AWG~~	26AWG~~28AWG~~
0.625 GHz	−~~1.8~~2.7 dB/m	−1.~~4~~3 dB/m	−1.~~2~~0 dB/m	−~~1.~~0.9 dB/m
1.25 GHz	−~~2.5~~3.3 dB/m	−~~2.0~~1.9 dB/m	−1.~~7~~5 dB/m	−1.~~4~~3 dB/m
2.50 GHz	−~~3.7~~4.4 dB/m	−~~2.9~~3.0 dB/m	−2.5 dB/m	−~~2.~~1.9 dB/m
5.00 GHz	−~~5.5~~6.7 dB/m	−4.~~5~~6 dB/m	−3.~~9~~6 dB/m	−3.1 dB/m
7.50 GHz	−~~7~~9.0 dB/m	−5.9 dB/m	−~~5.0~~4.7 dB/m	−4.~~1~~2 dB/m

~~**Table -. SDP Differential Insertion Loss Examples for Gen 2 Speed with Coaxial Construction**~~

~~Frequency~~	~~34AWG~~	~~32AWG~~	~~30AWG~~	~~28AWG~~
~~0.625 GHz~~	~~−1.6 dB/m~~	~~−1.3 dB/m~~	~~−1.1 dB/m~~	~~−1.0 dB/m~~
~~1.25 GHz~~	~~−2.3 dB/m~~	~~−1.8 dB/m~~	~~−1.5 dB/m~~	~~−1.3 dB/m~~
~~2.50 GHz~~	~~−3.5 dB/m~~	~~−2.7 dB/m~~	~~−2.3 dB/m~~	~~−1.9 dB/m~~
~~5.00 GHz~~	~~−5.3 dB/m~~	~~−4.2 dB/m~~	~~−3.5 dB/m~~	~~−3.1 dB/m~~
~~7.50 GHz~~	~~−7.2 dB/m~~	~~−5.5 dB/m~~	~~−4.9 dB/m~~	~~−4.2 dB/m~~

5.6.1.2 Mated Connector Impedance

SuperSpeed signal routing on the PCB should minimize the stub length and minimize impedance discontinuities in the signal path. It is recommended that the SuperSpeed signals be routed on the opposite side of the PCB from the side the lead is inserted for through-hole implementations. It is recommended that the SuperSpeed signals be routed on the same side of the PCB as the solder pads for SMT implementations.

~~For Enhanced SuperSpeed Gen 2 speed applications, electrical optimization is required to achieve the best performance. The PCB stack up, lead geometry, and solder pad geometry should be modeled in three dimensions.~~ Example ground voids under pads shown in Figure 5-20 are based on pad geometry, mounting type, and PCB stack up.

Figure 5-20. Recommended Ground Void Dimension for USB Standard-A Receptacle

Example PTH Example SMT pad Example PCB stack-up

Note: See Section 5.6.1.3 for recommended electrical requirements in determining void dimensions

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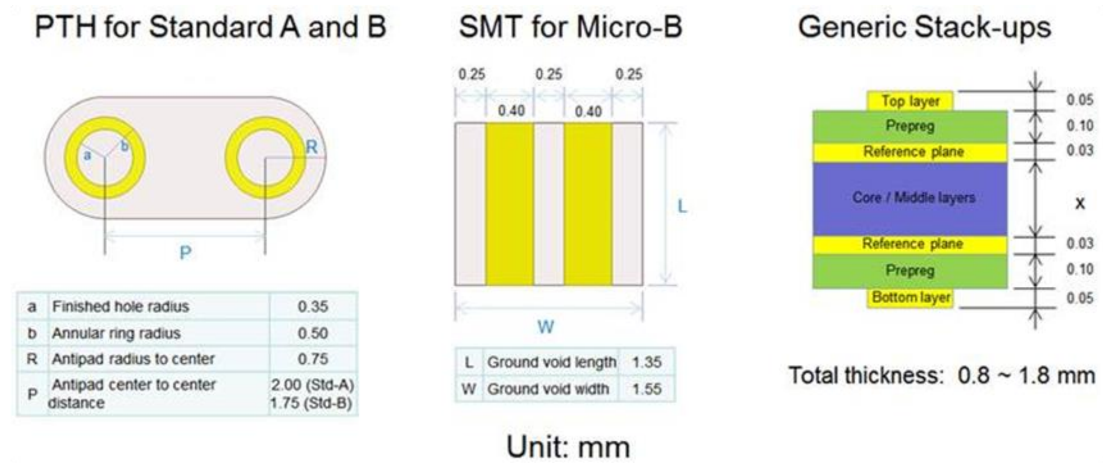
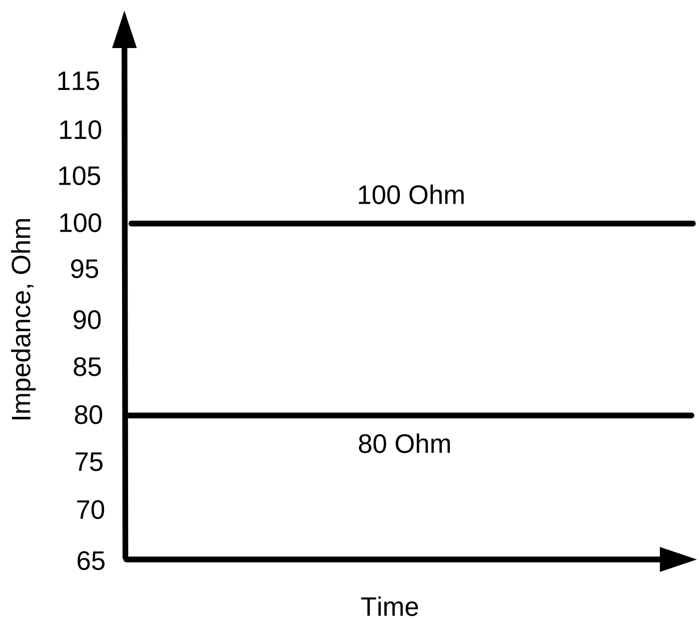


~~5.6.1.2.1 Mated Connector Impedance for Gen 2 Speed~~

The recommended mated connector impedance is needed to maintain signal integrity. The differential impedance of a mated connector should be 90 Ω ± 10 Ω, as seen from a 40 ps (20% – 80%) rise time of a differential TDR. The impedance profile of a mated connector should fall within the limits shown in Figure 5-21. The impedance profile of the mated connector is defined from the receptacle footprints through the plug cable termination area. In a case where the plug is directly attached to a device PCB, the mated connector impedance profile includes the path from the receptacle footprints to the plug footprints.

The normative cable assembly requirements are specified in Section 5.6.1.3.

Figure 5-21. Impedance Limits of a Mated Connector for Gen ~~2~~1 Speed



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5.6.1.3 Mated Cable Assemblies for Gen 21 Speed

A mated cable assembly refers to a cable assembly mated with the corresponding receptacles mounted on a test fixture at the both ends. The requirements are for the entire signal path of the mated cable assembly, from the host receptacle contact solder pads or through-holes on the host system board to the device receptacle contact solder pads or through holes on the device system board, not including PCB traces, as illustrated in Figure 5-22The requirements for mated cable assemblies for Gen 2 speed are divided into informative and normative requirements. The informative requirements are provided as design targets and normative requirements are pass/fail criteria for mated cable assembly compliance testing.

5.6.1.3.1 Design Targets

The design targets are summarized in . Cable assemblies that meet the target performance should pass the cable assembly compliance tests, but it is not guaranteed. Compliance is determined with the normative requirements.

Table -. Design Targets

Components	Items	Design Targets
Raw Cable	Differential impedance	Section 5.6.1.1.1
	Intra-pair skew	Section 5.6.1.1.2
	Differential insertion loss	Section 5.6.1.1.3
Mated Connector	Mated connector impedance	Section 5.6.1.2.1
Mated Cable Assembly	Differential insertion loss	≥ −6 dB from DC to 5 GHz and no strong resonance within DC to 5 GHz
	Differential near-end crosstalk between SuperSpeed Gen 2 signal pairs	≤ −34 dB to 5 GHz
	Differential near-end and far-end crosstalk between D+/D− pair and SuperSpeed Gen 2 pairs	≤ −30 dB to 5 GHz

5.6.1.3.2 Normative Requirements

The normative requirements manage the impact of insertion loss, multi-reflection, and crosstalk for the end-to-end link performance and mode conversion for EMI/RFI purposes.

5.6.1.3.2.1 Test Fixtures

The mated cable assembly electrical requirements for Gen 2 speed are mostly specified in the frequency domain. To accurately measure the frequency response of the Gen 2 speed mated cable assembly, the fixture design and its performance characteristics are critical items. Common fixtures defined by the USB-IF or equivalent shall be used. Refer to *USB 3.1 Connectors and Cable Assemblies Compliance Document* for detailed descriptions of test fixtures. illustrates an example of a cable assembly mounted on a text fixture.

; the measurement is between TP1 (test point 1) and TP2 (test point 2).

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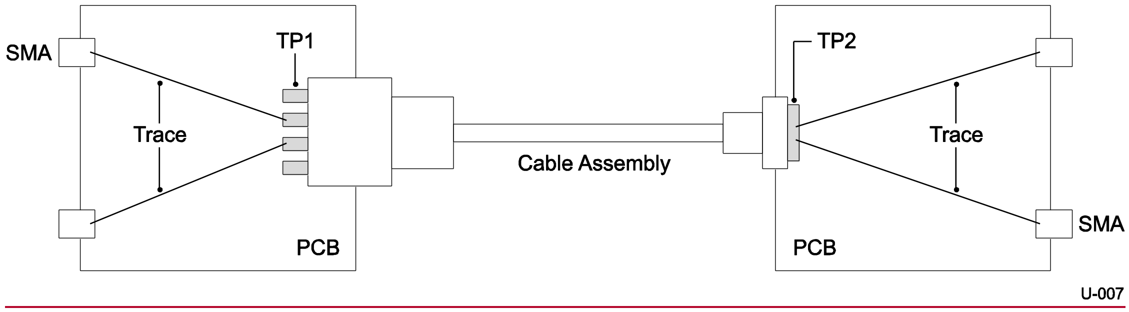
Figure 5-22. Illustration of Test Points for a Mated Cable Assembly ~~Mounted on Test Fixture~~



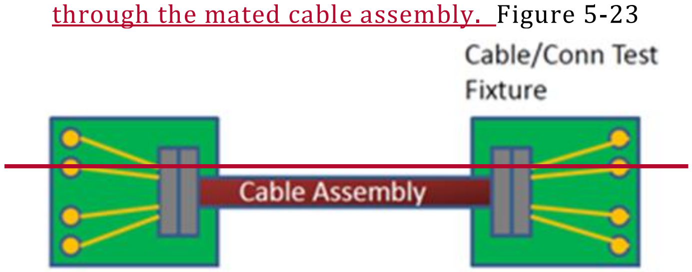
For proper measurements, the receptacles shall be mounted on a test fixture. The test fixture shall have uncoupled access traces from SMA or microprobe launches to the reference planes or test points, preferably with 50 Ω +/−7% Ω single-ended characteristic impedance. The test fixture shall have appropriate calibration structures to calibrate out the fixturing effect. All non-ground pins that are adjacent but not connected to measurement ports shall be terminated with 50 Ω loads.

To be consistent with the USB 3.1 channel nominal differential characteristic impedance requirement of 90 Ω, all measured differential S-parameters shall be normalized with a 90-Ω reference differential impedance. Most VNA measurement software allows normalization of measured S-parameters to a different reference impedance. For example, in PLTS, one can set the port impedance to 45 Ω to normalize the measured 50- Ω single-ended S-parameters to 45 Ω; this will result in 90- Ω differential S-parameters after the singled-ended-to-differential conversion.

A reference USB 3.1 mated cable assembly test fixture is defined in the *USB 3.1 Legacy Connectors and Cable Assemblies Compliance Document*, in which the detailed testing procedures are given.

5.6.1.3.1 Differential Insertion Loss (EIA-360-101)

The differential insertion loss, SDD12, measures the differential signal energy transmitted through the mated cable assembly. Figure 5-23



~~5.6.1.3.2.2 Reference Hosts and Devices~~

~~To avoid channel margin loss associated with assigning interconnect budgets to the host, cable assembly, and device, the compliance of a Gen 2 speed cable assembly is established with reference hosts and reference devices to emulate the end-to-end condition as illustrated in .~~

shows the differential insertion loss limit, which is normalized with 90-Ω differential impedance and defined by the following vertices:

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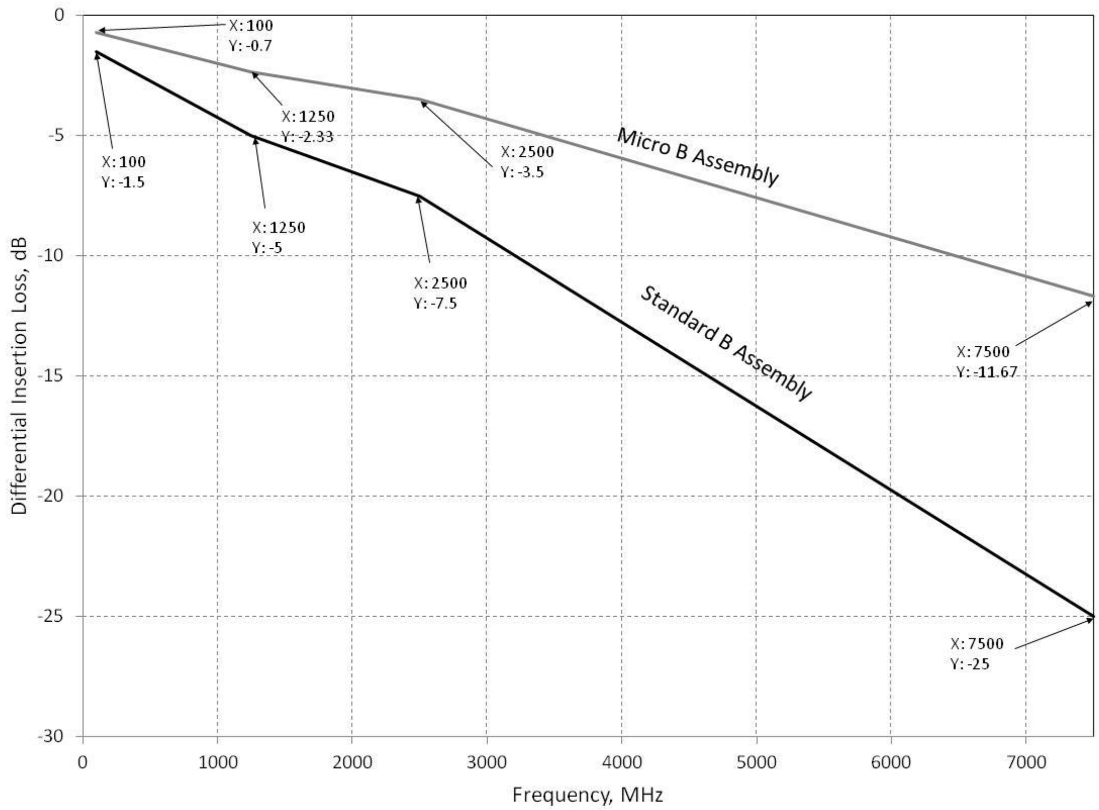
Standard B assembly: (100 MHz, −1.5 dB), (1.25 GHz, -5.0 dB), (2.5 GHz, −7.5 dB), and (7.5 GHz, −25 dB).

Micro B assembly: (100 MHz, −0.6 dB), (1.25 GHz, −2.33 dB), (2.5 GHz, −3.5 dB), and (7.5 GHz, −11.67 dB).

The measured differential insertion loss of a mated cable assembly must not exceed the differential insertion loss limit.

Figure 5-23. ~~Illustration of Cable Assembly with Reference Host and Device~~Differential Insertion Loss Requirement



5.6.1.3.2 Differential Near-End Crosstalk Between SuperSpeed Pairs (EIA-360-90)

The differential crosstalk measures the unwanted coupling between differential pairs. Since the Tx pair is right next to the Rx pair for SuperSpeed, only the differential near-end crosstalk (DDNEXT) is specified for SuperSpeed pairs. The DDNEXT shall be measured in time domain with a rise time of 50 ps (20-80%) entering the connector under test. The mated cable assembly meets the DDNEXT requirement if its peak-to-peak DDNEXT does not exceed the limits below (see Figure 5-24

The USB 3.1 specification defines the standard reference hosts and devices in the form of S-parameter files, which are available for download from the USB website. The measured S parameters of the Gen 2 speed cable assembly (with fixture effects removed) are cascaded with the S-parameters of the reference hosts and reference devices, resulting in frequency responses for total channels. The pass/fail criteria of the Gen 2 speed cable assembly are based on the channel frequency responses, as described in the following subsections.

5.6.1.3.2.3 Channel Metrics

There are three signal integrity impairments that impact the end-to-end link performance: attenuation, reflection, and crosstalk. Three parameters are used as the channel metrics to represent these three impairments: insertion loss fit at Nyquist frequency (ILfitatNq), integrated multi-reflection (*IMR*), and integrated crosstalk (*IXT*).

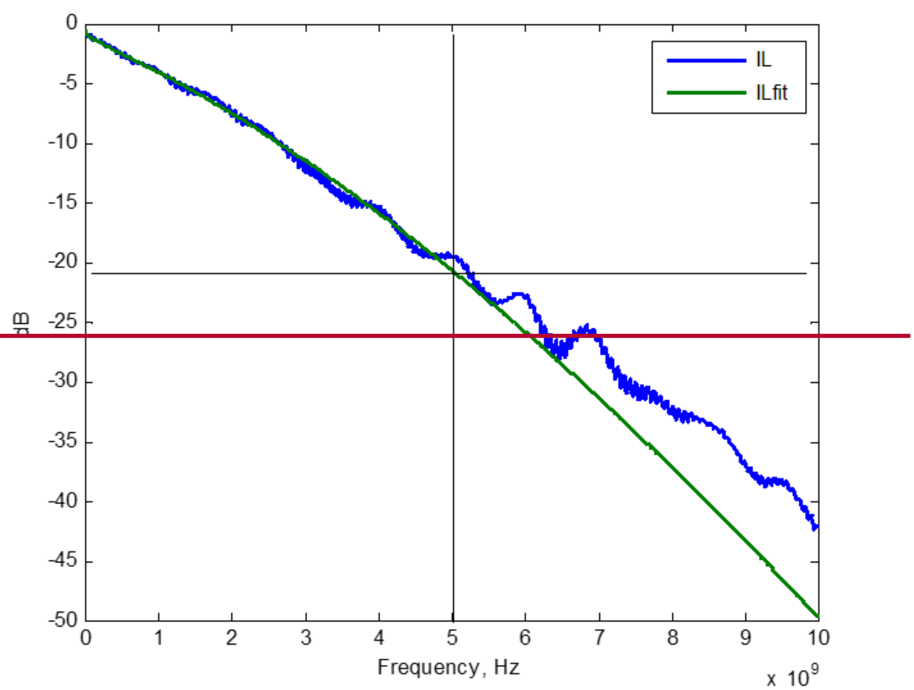
To obtain the channel insertion loss fit at Nyquist frequency (5 GHz for SuperSpeed Gen 2), the measured (cascaded) differential insertion loss, *IL(f)*, is fitted with a smoothing function:

, (5-1)

where *f* is frequency and *a*, *b*, *c*, and *d* are fitting coefficients. shows an example of *IL(f)* and *ILfit(f)* plotted together; ILfitatNq = –20.6 dB, measured at 5 Ghz along *ILfit(f)*. for illustration of the peak-to-peak crosstalk):

- USB 3.1 Standard-A connector: 0.9%
- USB 3.1 Standard-B connector: 1.8%
- USB 3.1 Micro connector family: 1.2%

Figure 5-24. Illustration of Insertion Loss Fit at Nyquist FrequencyPeak-to-Peak Crosstalk



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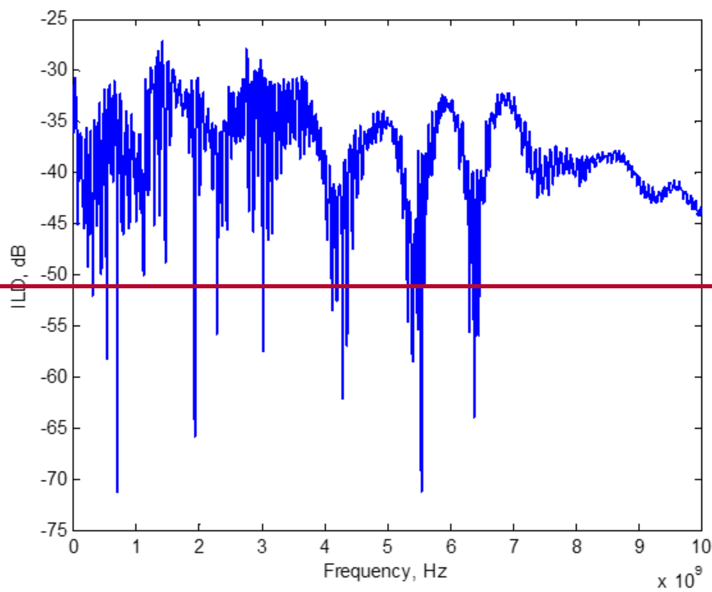
The difference between *IL(f)* and *ILfit(f)* is defined as the insertion loss deviation, ILD:

. (5-2)

It measures the ripple of the insertion loss, or the multi-reflection. shows an example of insertion loss deviation plotted against frequency.

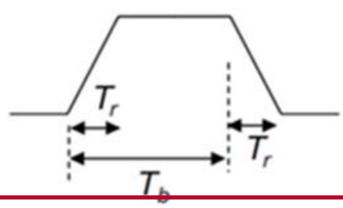
Figure -. Examples of Insertion Loss Deviation



The integrated multi-reflection, *IMR*, is calculated with the equation below:

(in mV), (5-3)

where f_{Nq} is the Nyquist frequency (5 GHz), f_{max} is chosen as the 2 times the Nyquist frequency (10 GHz), and $V_{in}(f)$ is the input trapezoidal pulse spectrum, defined as:



$$|V_{in}(\omega)| = \left| \frac{\sin\left(\frac{\omega T_r}{2}\right)}{\frac{\omega T_r}{2}} \cdot \frac{\sin\left(\frac{\omega T_b}{2}\right)}{\frac{\omega T_b}{2}} \right|$$

T_b=Unit Interval=100 ps
T_r=Rise time (0-100%)=0.2T_b
$\omega=2\pi f$

The integrated crosstalk, *IXT*, is defined as:

(in mV), (5-4)

where *NEXT(f)* is the near-end crosstalk between the SuperSpeed Gen 2 signal pairs. The contribution of USB 2 D+/D– pair to SuperSpeed signal pairs is relatively small and is not included in *IXT* for simplicity.

More detailed discussion of ILfitatNq, *IMR* and *IXT* is given in a USB-IF whitepaper *Establishing USB SuperSpeed Gen 2 Channel and Cable Assembly High Speed Compliance Specification*. The USB-IF also provides a standard tool to convert measured cable assembly S parameters into ILfitatNq, *IMR* and *IXT*.

5.6.1.3.2.4 Pass/Fail Criteria

SuperSpeed Gen 2 channel performance is based on ILfitatNq, *IMR*, and *IXT*. In general, a channel with more loss, more reflection, and more crosstalk has less margin. Channel margin is measured with BER (bit error ratio) eye height (*eH*) and eye width (*eW*) at BER=10^{-12}. The correlation between *eH* and *eW* and the channel metrics ILfitatNq, *IMR*, and *IXT* is established following the methodology described in the USB-IF whitepaper *Establishing USB SuperSpeed Gen 2 Channel and Cable Assembly High Speed Compliance Specification*. For each channel with a metrics ILfitatNq, *IMR*, and *IXT*, *eH* and *eW* is calculated:

(5-5)

Note that the effect of Tx and Rx equalization, jitter, and sampling noise is included in the eye height and eye width calculations. The pass/fail criteria are then expressed as

(5-6)

and

. (5-7)

Equation (5-6) is an open-eye (at BER=10-12) requirement, while Equation (5-7) constrains the maximum channel loss, multi-reflection, and crosstalk. A SuperSpeed Gen 2 cable assembly is considered pass if both Equations (5-6) and (5-7) are satisfied. shows pass and fail examples.

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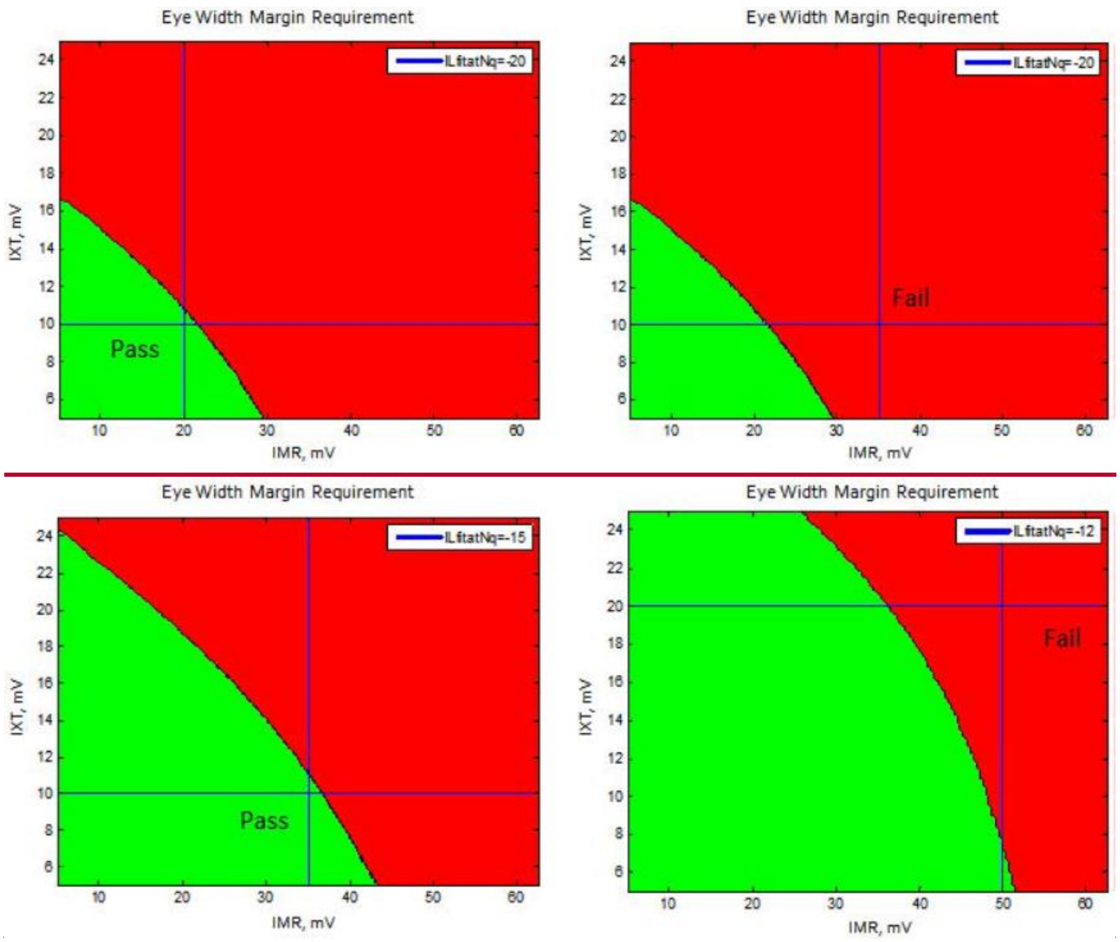
~~**Figure -. Pass/Fail Examples**~~



~~The x axis is *IMR* in mV and the y axis is *IXT* in mV. The "green" part represents the passing region with open eyes, while the "red" area the failing region with closed eyes. The passing area increases as |ILfitatNq| decreases. This pass/fail criteria allows tradeoffs among ILfitatNq, *IMR*, and *IXT*. For example, a cable assembly may have more loss if *IMR* and/or *IXT* is smaller.~~

~~USB-IF provides a standard tool to calculate *eH* and *eW* based on the input cable assembly S-parameters. This tool, or an equivalent, is integrated into the USB SuperSpeed Gen 2 compliance test suite in the USB CabCon compliance program.~~

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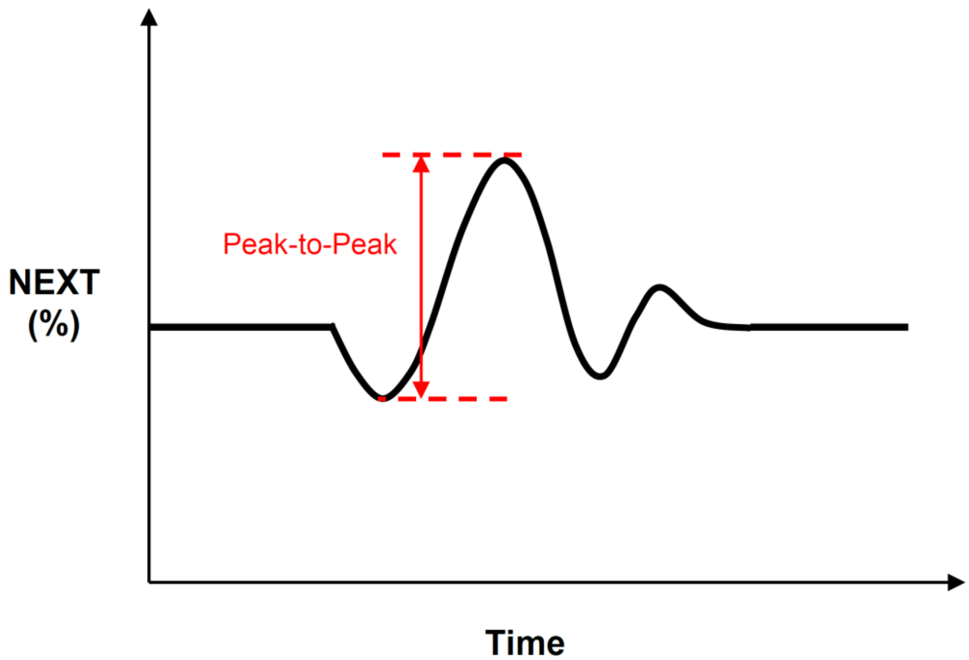
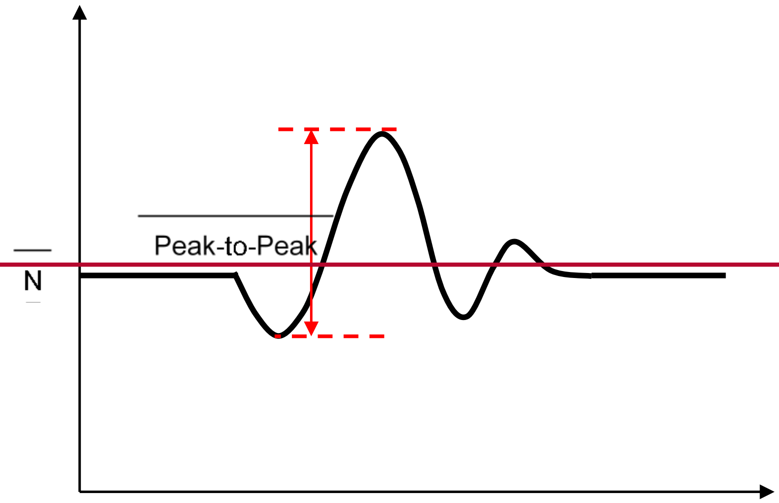


5.6.1.3.3 Differential Crosstalk Between D+/D– and SuperSpeed ~~Gen 2 Signal~~ Pairs (EIA-360-90)

The differential near-end crosstalk (DDNEXT) and far-end crosstalk (DDFEXT between the D+/D~~–~~- pair and the SuperSpeed ~~Gen 2 signal~~ pairs shall be measured in time domain with a rise time of 500 ps (10~~–~~-90%) entering the connector under test. The mated cable assembly meets the DDNEXT/DDFEXT requirement if its peak-to-peak value does not exceed the limits below (see Figure 5-24 for illustration of the peak-to-peak crosstalk):

- USB 3.1 Standard-A connector: 2%
- USB 3.1 Standard-B connector: 2%
- USB 3.1 Micro connector family: 2%

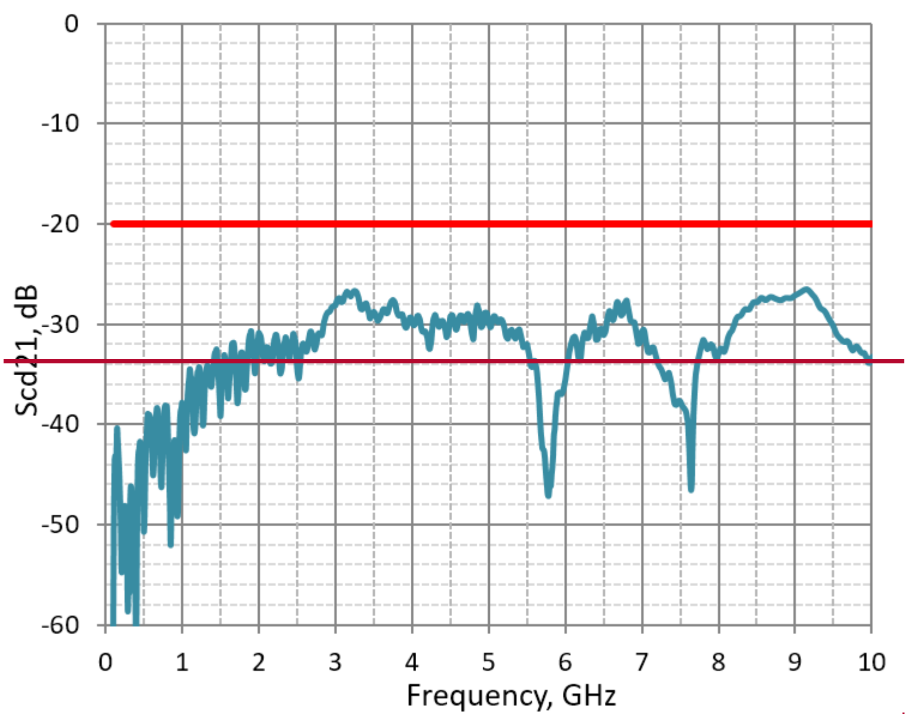
Figure -. Illustration of Peak-to-Peak Crosstalk



5.6.1.3.4 Differential-to-Common-Mode Conversion

The differential to Since the common mode current is directly responsible for EMI, limiting the differential-to-common-mode conversion (SCD21 or, SCD12) does not require embedding the reference host, will limit EMI generation within the connector and the reference device with the mated cable assembly. Figure 5-25; it is for illustrates the mated cable assembly only. SCD12 requirement; a mated cable assembly passes the SCD12 requirement if its SCD12 is less than or equal to −20 dB across the frequency range of 100MHz to 10 GHz, as shown in Figure 5-25.

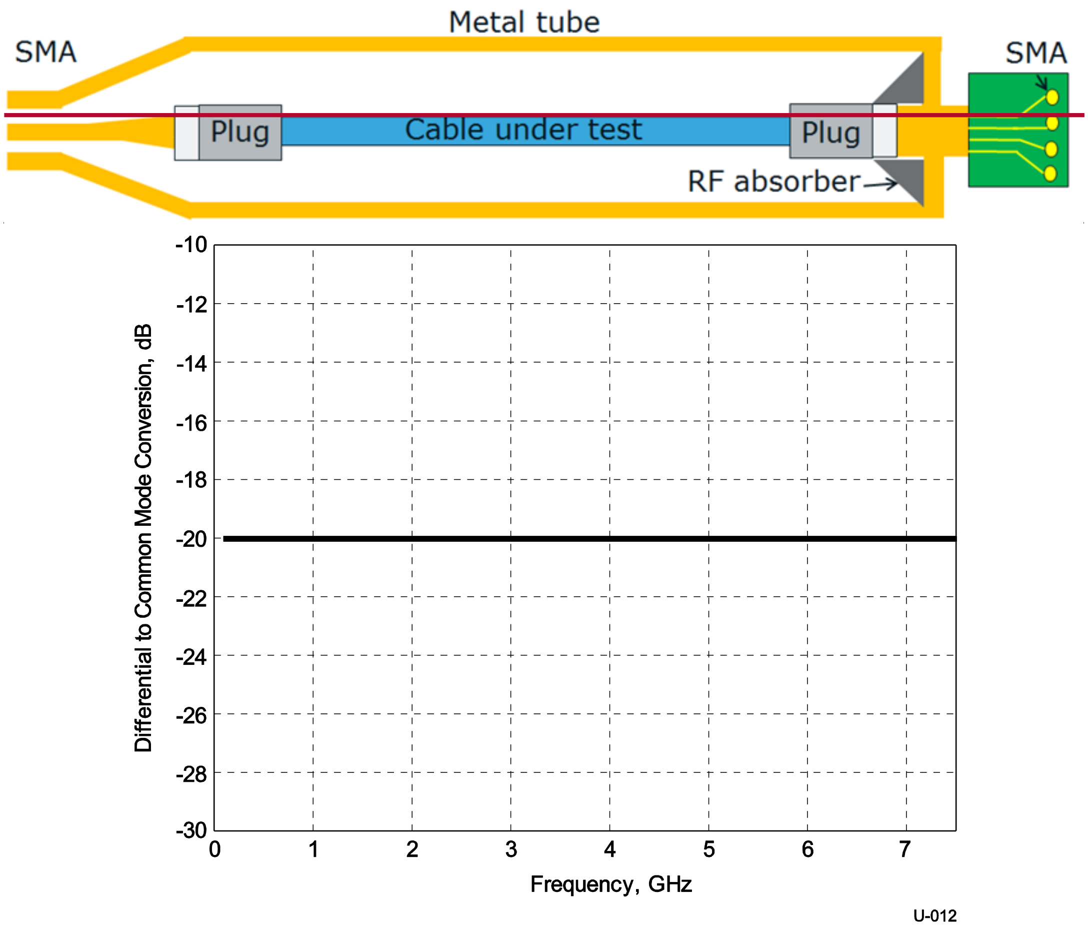
Figure 5-25. Differential-to-Common-Mode Conversion Requirement for Gen 2



5.6.1.3.4.1 Cable Shielding Effectiveness

The cable assembly shielding effectiveness (SE) test measures the radio frequency interference (RFI) level from the cable assembly. To perform the measurement, the cable assembly shall be installed in the cable SE test fixture as shown in . The coupling factors from the cable to the fixture are characterized. The Cable SE test fixtures and specification values are under development and are to be included in future updates to this specification.

Figure -. Set Up for Cable SE Measurement (subject to change)



5.6.2 DC Electrical Requirements

5.6.2.1 Low Level Contact Resistance (EIA 364-23B)

The following requirement applies to both the power and signal contacts:

- 30 mΩ (Max) initial for VBUS and GND contacts.
- 50 mΩ (Max) initial for all other contacts.
- Maximum change (delta) of +10 mΩ after environmental stresses.
- Measure at 20 mV (Max) open circuit at 100 mA.
- Refer to Section 5.7 for environmental requirements and test sequences.

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5.6.2.2 Dielectric Strength (EIA 364-20)

No breakdown shall occur when 100 Volts AC (RMS) is applied between adjacent contacts of unmated and mated connectors.

5.6.2.3 Insulation Resistance (EIA 364-21)

A minimum of 100 MΩ insulation resistance is required between adjacent contacts of unmated and mated connectors.

5.6.2.4 Contact Current Rating (EIA 364-70, Method 2)

A current of 1.8 A shall be applied to VBUS pin and its corresponding GND pin (pin 1 and pin 4 of the USB 3.1 Standard-A and Standard-B connectors; pin 1 and pin 5 of the USB 3.1 Micro connector family). Additionally, a minimum current of 0.25 A shall be applied to all the other contacts. When the current is applied to the contacts, the delta temperature shall not exceed +30 °C at any point on the USB 3.1 connectors under test, when measured at an ambient temperature of 25 °C.

5.7 Mechanical and Environmental Requirements

The requirements in this section apply to all USB 3.1 connectors and/or cable assemblies unless specified otherwise.

5.7.1 Mechanical Requirements

5.7.1.1 Insertion Force (EIA 364-13)

The connector insertion force shall not exceed 35 N at a maximum rate of 12.5 mm (0.492") per minute.

It is recommended to use a non-silicon based lubricant on the latching mechanism to reduce wear. The effects of lubricants should be restricted to insertion and extraction characteristics.

5.7.1.2 Extraction Force Requirements (EIA 364-13)

5.7.1.2.1 Extraction Force (EIA 364-13, USB Standard Connector)

The connector extraction force shall not be less than 10 N initial and 8 N after the specified insertion/extraction or durability cycles (at a maximum rate of 12.5 mm (0.492") per minute).

No burs or sharp edges are allowed on top of locking latches (hook surfaces that will rub against the receptacle shield).

It is recommended to use a non-silicon based lubricant on the latching mechanism to reduce wear. The effects of lubricants should be restricted to insertion and extraction characteristics.

5.7.1.2.2 Extraction Force (EIA 364-13, USB Micro Connector Family Only)

The connector extraction force shall not be less than 10 N or more than 25 N initial and less than 8 N and more than 25 N after the specified insertion/extraction or durability cycles (at a maximum rate of 12.5 mm (0.492”) per minute).

No burs or sharp edges are allowed on top of locking latches (hook surfaces that will rub against the receptacle shield).

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It is recommended to use a non-silicon based lubricant on the latching mechanism to reduce wear. The effects of lubricants should be restricted to insertion and extraction characteristics.

5.7.1.3 Durability or Insertion/Extraction Cycles (EIA 364-09)

The durability ratings listed in Table 5-14 are specified for the USB 3.1 connectors.

Table 5-14. Durability Ratings

Connector	Standard Durability Class	High Durability Class
USB 3.1 Standard-A connector	1500 cycles minimum	5000 cycles minimum
USB 3.1 Standard-b connector	1500 cycles minimum	5000 cycles minimum
USB 3.1 Micro connector family	10000 cycles minimum	

The durability test shall be done at a maximum rate of 200 cycles per hour and no physical damage to any part of the connector or cable assembly shall occur.

5.7.1.4 Cable Flexing (EIA 364-41, Condition I)

No physical damage or discontinuity over 1 ms during flexing shall occur to the cable assembly with Dimension X = 3.7 times the cable diameter and 100 cycles in each of two planes.

5.7.1.5 Cable Pull-Out (EIA 364-38, Condition A)

No physical damage to the cable assembly shall occur when it is subjected to a 40 N axial load for a minimum of 1 minute while clamping one end of the cable plug.

5.7.1.6 Peel Strength (USB 3.1 Micro Connector Family Only)

No visible physical damage shall be noticed to a soldered receptacle when it is pulled up from the PCB in the vertical direction with a minimum force of 150 N.

5.7.1.7 4-Axes Continuity Test (USB 3.1 Micro Connector Family Only)

The USB 3.1 Micro connector family shall be tested for continuity under stress using the test configurations shown below. Plugs shall be supplied in a cable assembly with a representative overmold. A USB 3.1 Micro-B or Micro-AB receptacle shall be mounted on a 2 layer printed circuit board (PCB) between 0.8 and 1.0 mm thickness. The PCB shall be clamped on either side of the receptacle no further than 5 mm away from the solder tails. The PCB shall initially be placed in a horizontal plane, and an 8 N tensile force shall be applied to the cable in a downward direction, perpendicular to the axis of insertion, for a period of at least 10 seconds.

The continuity across each contact shall be measured throughout the application of the tensile force. The PCB shall then be rotated 90 degrees such that the cable is still inserted horizontally and the 8 N tensile force will be applied again in the downward direction and continuity measured as before. This test is repeated for 180 degree and 270 degree rotations. Passing parts shall not exhibit any discontinuities greater than 1 μs duration in any of the four orientations.

One method for measuring the continuity through the contacts is to short all the wires at the end of the cable pigtail and apply a voltage through a pull-up to each of VBUS, D+, D−, ID, and the SuperSpeed pins, with the GND pins connected to ground.

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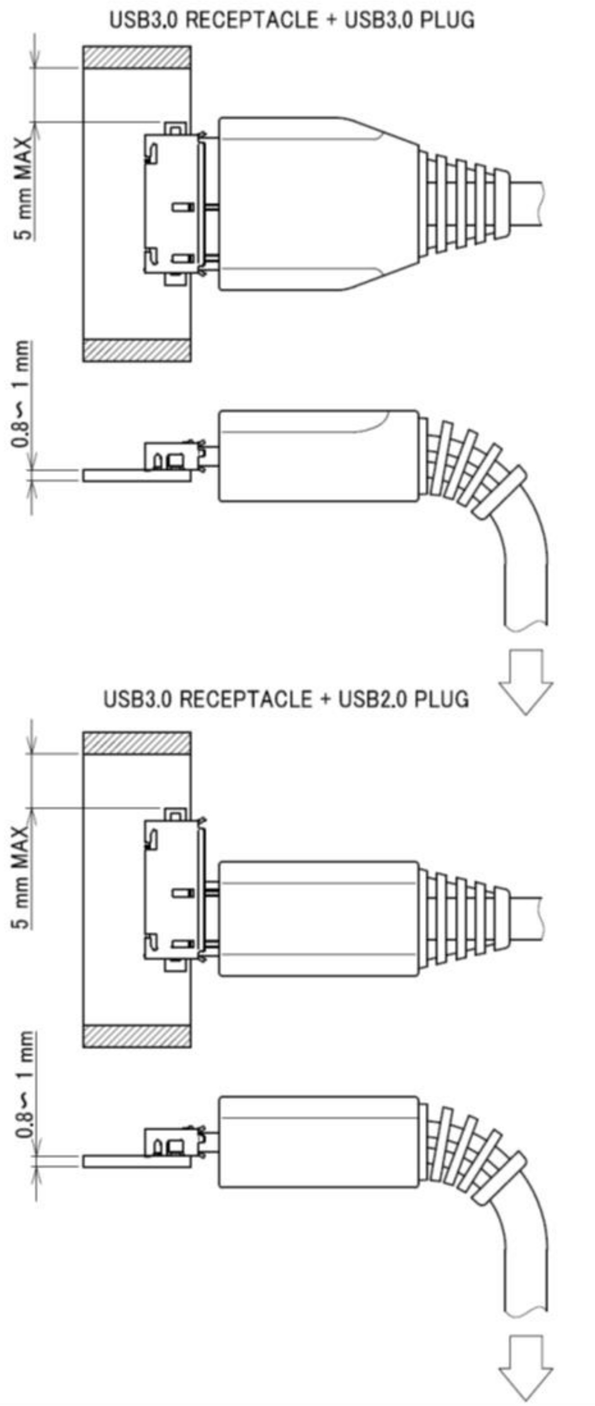
When testing a USB 3.1 Micro-A plug, all the sense resistors shall stay pulled down for the length of the test. When testing a USB 3.1 Micro-B plug, the ID pin shall stay high and the other pins shall remain low for the duration of the test. Alternate methods are allowed to verify continuity through all pins.

The 4 axes continuity tests shall be done with a USB 3.1 Micro-B/Micro-A plug in a USB 3.1 Micro-B/Micro-AB receptacle and with a USB 2.0 Micro-B/Micro-A plug in a USB 3.1 Micro-B/Micro-AB receptacle, as illustrated in Figure 5-26.

Figure 5-26. 4-Axes Continuity Test



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5.7.1.8 Wrenching Strength (Reference, USB 3.1 Micro Connector Family Only)

The wrenching strength test shall be performed using virgin parts. Perpendicular forces (Fp) are applied to a plug when inserted at a distance (L) of 15 mm from the edge of the receptacle. Testing conditions and method shall be agreed to by all parties. These forces shall be applied in all four directions (i.e., left, right, up, and down). Compliant connectors shall meet the following force thresholds:

- No plug or receptacle damage shall occur when a force of 0 25 N is applied.

The plug may be damaged, but only in such a way that the receptacle does not sustain damage when a force of 25 – 50 N is applied.

5.7.1.9 Lead Co-Planarity

Co-planarity of all SMT leads shall be within a 0.08 mm range.

5.7.1.10 Solderability

Solder shall cover a minimum of 95% of the surface being immersed, when soldered at a temperature 255 °C +/ 5 °C for an immersion duration of 5 s.

5.7.1.11 Restriction of Hazardous Substances (RoHS) Compliance

It is recommended that components be RoHS compliant.

5.7.2 Environmental Requirements

The connector interface environmental tests shall follow EIA 364-1000.01, Environmental Test Methodology for Assessing the Performance of Electrical Connectors and Sockets Used in Business Office Applications.

Since the connector defined has far more than 0.127 mm wipe length, Test Group 6 in EIA 364-1000.01 is not required. The temperature life test duration and the mixed flowing gas test duration values are derived from EIA 364-1000.01 based on the field temperature per the following.

Table 5-15. Environmental Test Conditions

Temperature Life test temperature and duration	105 °C for 120 hours
Temperature Life test temperature and duration for preconditioning	105 °C for 72 hours
Mixed flowing gas test duration	7 days

The pass/fail criterion for the low-level contact resistance (LLCR) is as defined in Section 5.6.2.1. The durability ratings are defined in Section 5.7.1.3.

5.7.3 Materials

This specification does not specify materials for connectors and cables. Connector and cable manufactures should select appropriate materials based on performance requirements. Table 5-16 below is provided for reference only.

Note:

Connector and cable manufacturers shall comply with contact plating requirements per the following options:

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Option I

Receptacle

Contact area: (Min) 0.05 µm Au + (Min) 0.75 µm Ni-Pd on top of (Min) 2.0 µm Ni

Plug

Contact area: (Min) 0.05 µm Au + (Min) 0.75 µm Ni-Pd on top of (Min) 2.0 µm Ni

Option II

Receptacle

Contact area: (Min) 0.75 µm Au on top of (Min) 2.0 µm Ni

Plug

Contact area: (Min) 0.75 µm Au on top of (Min) 2.0 µm Ni.

Other material parameters, which connector and cable manufacturers select based on performance parameters, are listed below in Table 5-16 for reference only.

Table 5-16. Reference Materials[1]

Component	Materials
Cable	Conductor: copper with tin or silver plating
	SDP shield: AL foil of AL/Mylar foil
	Coaxial shield: copper strand
	Braid: Tin plated copper or aluminum
	Jacket: PVC or halogen-free substitute material
Cable Overmold	Thermoset or thermoplastic
Connector Shell	Copper alloy or stainless steel, depending on durability requirement
Housing	Thermoplastics capable of withstanding lead-free soldering temperature.

Note:

1. Halogen-free materials should be considered for all plastics

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5.8 Implementation Notes and Design Guides

This section discusses a few implementation notes and design guides to help users design and use the USB 3.1 connectors and cables.

5.8.1 Mated Connector Dimensions

Figure 5-27, Figure 5-28, and Figure 5-29 show the mated plugs and receptacles for the USB 3.1 Standard-A, USB 3.1 Standard-B, and USB 3.1 Micro-B connectors, respectively. The distance between the receptacle front surface and the cable overmold should be observed by system designers to avoid interference between the system enclosure and the cable plug overmold.

Provisions ~~shall be~~are made in connectors and chassis to ground the connector metal shells to the metal chassis to reduce EMI and RFI.

Figure 5-27. Mated USB 3.1 Standard-A Connector

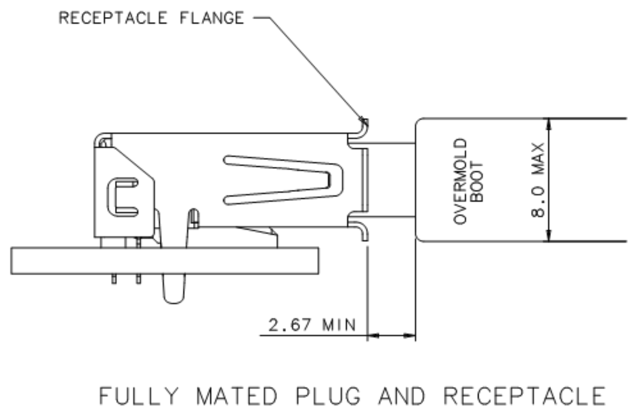

Figure 5-28. Mated USB 3.1 Standard-B Connector

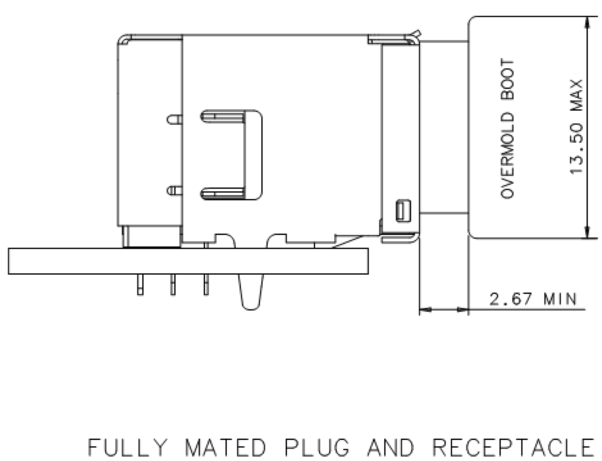

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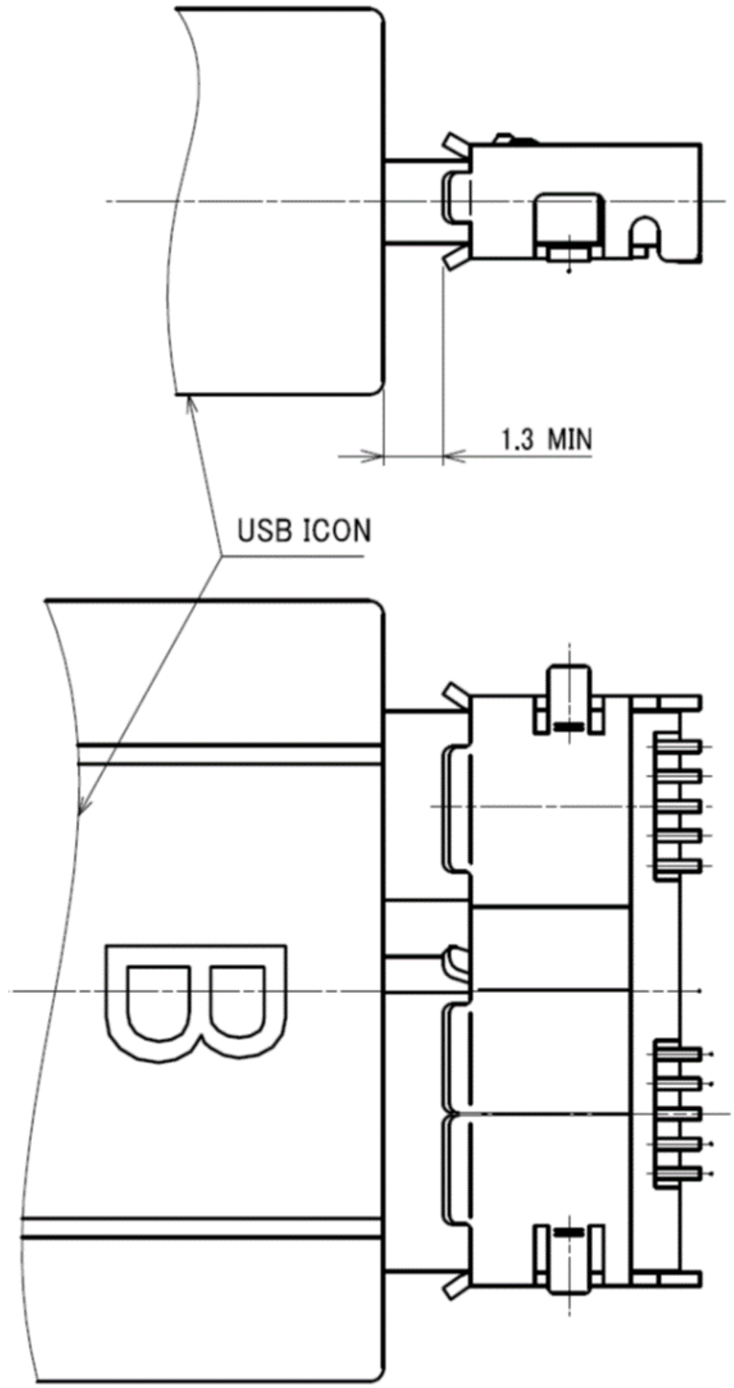
Figure 5-29. Mated USB 3.1 Micro-B Connector



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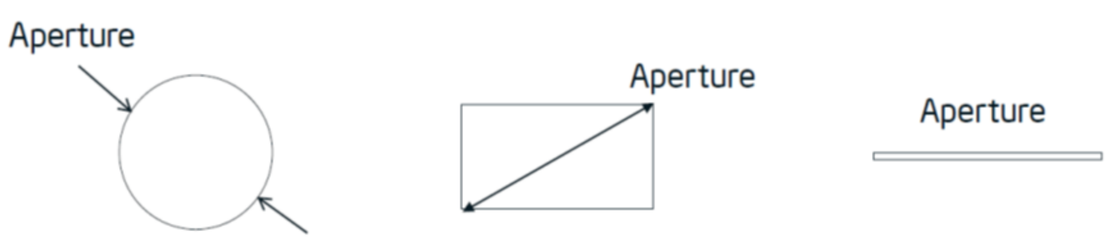
5.8.2 EMI and RFI Management

Systems that include USB 3.1 connectors and cable assemblies need to meet the relevant EMI/EMC regulations.

Connector and cable assembly designers, as well as system implementers should pay attention to receptacle and cable plug shielding to ensure a low-impedance grounding path. The following are guidelines for EMI and RFI management:

- The quality of raw cables should be ensured. The intra-pair skew or the differential to common mode conversion of the SuperSpeed pairs has a significant impact on cable EMI performance and should be controlled within the limits of this specification.
- The cable external braid should be terminated to the cable plug metal shell as close to 360° as possible. Without appropriate shielding termination, even a perfect cable with zero intra-pair skew may not meet EMI requirements.
- The wire termination contributes to the differential-to-common-mode conversion. The breakout distance for the wire termination should be kept as small as possible for EMI, RFI, and signal integrity. If possible, symmetry should be maintained for the two lines within a differential pair.
- The mating interface between the receptacle and cable plug should have a sufficient number of grounding fingers, or springs, to provide a continuous return path from the cable plug to system ground. Friction locks should not compromise ground return connections.
- The receptacle connectors should be designed with a back-shield as part of the receptacle connector metal shell. The back-shield should have connections to adjacent shell surfaces and provide multiple connections for ground termination. The back-shield should be designed with a short return path to the chassis ground.
- The receptacle connectors should be connected to metal chassis or enclosures through grounding fingers, screws, or any other way to mitigate EMI and RFI.
- Plug connectors should have back-shields when possible.
- Outer connector shell surfaces in the mated configuration should have a maximum aperture size of 2 mm. This applies to both mounted connectors (e.g., soldered to a circuit board) and connectors used in cable assemblies. See Figure 5-30.

Figure 5-30. Examples of Connector Apertures



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5.8.3 Stacked Connectors

Stacked USB connectors are commonly used in PC systems. This specification does not explicitly define the stacked USB 3.1 Standard-A receptacles, but they are allowed. The following are a few points that should be taken into account when designing a stacked USB 3.1 connector:

- A stacked connector introduces additional crosstalk between the top and bottom connectors. Such crosstalk should be minimized when designing a stacked USB 3.1 connector. ~~Enhanced~~ SuperSpeed Gen ~~2~~1 Standard-A stacked ~~connectors~~connector differential NEXT and FEXT should ~~limit the total crosstalk sum from all sources~~be managed within ~~the connector to –40~~–32 dB (up to the fundamental frequency of ~~5.0 GHz and limiting the power sum to include aggressors having a magnitude greater than or equal to –50 dB).~~2.5 GHz) between differential pairs in the top and bottom connectors.

- Due to the additional electrical length, the top connector generally does not perform as well as the bottom connector. Connector designers should carefully design the top connector contact geometries and materials to minimize impedance discontinuity.

- Regardless of how many connectors within a stack one may choose to design, the electrical requirements defined in Section 5.6 shall be met.

5.8.4 Steady-State Voltage Drop Budget

This analysis is based on the following:

- 3 meter cable assembly with A-series and B-series plugs
- #22AWG wire used for power and ground (0.019 Ω/foot)
- A-series and B-series plug/receptacle pair have a contact resistance of 30 mΩ
- Wire ~380 mΩ series resistance
- IR Drop at device = (((2 * 30 mΩ) + 190 mΩ) * 900 mA) * 2 or 0.450 V

The steady–state voltage drop budget is determined by:

- The nominal 5 V source is 4.75 V to 5.50 V.
- The maximum voltage drop (for detachable cables) between the USB A-series plug and USB B-series plug on VBUS is 171 mV.
- The maximum current for the calculations is 0.9 A.
- The maximum voltage drop for all cables between upstream and downstream on GND is 171 mV.
- The maximum voltage drop for all mated connectors is 27 mV.
- All hubs and peripheral devices ~~shall be~~are able to provide configuration information with as little as 4.00 V at the device end of their B-series receptacle. Both low and high-power devices need to be operational with this minimum voltage.

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