Universal Serial Bus 3.0 Connectors and Cable Assemblies Specification

Revision 0.3 Draft 3

May 17th, 2007

Revision History

Revision	Issue Date	Comment
0.3draft1	May 6, 2007	The first draft
0.3draft2	May 10, 2007	Included feedback to make terminologies consistent
0.3draft3	May 17, 2007	Updated all drawings and edited texts

THIS DRAFT SPECIFICATION IS PROVIDED FOR REVIEW OLY. IT IS USED AS A BASIS FOR THE FURTHER DEVELOPMENT OF THE USB 3.0 CONNECTORS AND CABLE ASSEMBLIES SPECIFICATION. EVERYTHING CONTAINED IN THIS SPECIFICATION IS SUBJECT TO CHANGES BASED ON FURTHER ENGINEERING ANALYSIS AND EVALUATIONS.

Contributors

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1. Introduction

1.1 Scope

This document defines form, fit and function of the USB 3.0 connectors and cable assemblies. It contains the following contents:

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

The intention of this document is to enable connector, system, and device designers and manufacturers to build, qualify and use the USB 3.0 connectors, cables, and cable assemblies.

1.2 Objective

This specification is developed with the following objectives:

- Supporting 5 Gbps data rate
- Backward compatible with USB 2.0
- Minimizing connector form factor variations
- Managing EMI
- Supporting OTG
- Low cost

1.3 Related Documents

USB 2.0 Specification

USB OTG Supplement

Micro-USB Cables and Connectors Supplement to USB 2.0 Specification

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

2. Acronyms and Terms

This section lists and defines terms and abbreviations used throughout this specification.

A-Device A device with a Type-A plug inserted into its receptacle. The A-device supplies power to VBUS and is host at the start of a session. If the A-device is On-The-Go, it may relinquish the role of host to an On-The-Go B-device under certain conditions,

B-Device A device with a Type-B plug inserted into its receptacle. The B-device is a peripheral at the start of a session. If the B-device is OTG, it may be granted the role of host from an OTG A-device.

Cable Raw cable with no plugs attached

Cable assembly Cable attached with plugs

Captive cable Cable assembly with only one end attached with a plug; the other end is permanently attached to a device

Connector Receptacle plus plug

D+ and D- Differential pair defined in USB 2.0 specification

FS Full Speed (max 12Mb/s)

HS High Speed (max 480 Mb/s)

Host A physical entity that is acting in the role of the USB host as defined in the USB Specification, Revision 3.0. This entity initiates all data transactions and provides periodic Start of Frames.

ID Identification. Denotes the pin on the USB 3.0 Micro-B connector family that is used to differentiate a USB 3.0 Micro-A plug from a USB 3.0 Micro-B plug.

LS Low Speed (max 1,5 Mb/s)

OTG On-The-Go

OTG device A device with the host and peripheral capabilities

Peripheral A physical entity that is attached to a USB cable and is currently operating as a “device” as defined in the USB Specification, Revision 3.0. The Peripheral responds to low level bus requests from the Host.

PCB Printed circuit board

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

SS	Super Speed (5 Gb/s)
STP (cable)	Shielded twist pair (cable)
Type-A Connector	The standard-A connector defined in the USB 2.0 specification
USB 3.0 Standard-A connector	USB 3.0 host connector, supporting SS mode
USB 3.0 Micro-A plug	Part of the USB 3.0 Micro-B connector family for OTG use; it can be plugged into a USB 3.0 Micro-AB receptacle; it differs from the USB 3.0 Micro-B plug only in keying and ID pin connection.
USB 3.0 Micro-AB receptacle	Part of the USB 3.0 Micro-B connector family; it accepts either a USB 3.0 Micro-B plug or a USB 3.0 Micro-A plug.
USB 3.0 Micro-B connector	USB 3.0 device connector, supporting SS mode
USB 3.0 Micro-B connector family	All the receptacles and plugs that are used on devices, including the USB 3.0 Micro-B, USB 3.0 Micro-AB and USB 3.0 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	Universal Serial Bus
USB-IF	USB Implementers Forum
UTP (cable)	Unshielded twist pair (cable)

3. Significant Features

This section identifies the significant features of the USB 3.0 connectors and cable assemblies specification. The purpose of this section is not to present all the technical details associated with each major feature, but rather to highlight its existence. Where appropriate, this section references other parts of the document where further details can be found.

3.1 Connectors

The USB 3.0 specification defines the following connectors:

- USB 3.0 Standard-A plug and receptacle
- USB 3.0 Micro-B plug and receptacle
- USB 3.0 Micro-A plug
- USB 3.0 Micro-AB receptacle

Table 3-1 below lists the compatible plugs and receptacles.

Table 3-1. Plugs Accepted By Receptacles

Receptacle	Plugs Accepted
USB 2.0 Standard-A	USB 2.0 Standard-A or USB 3.0 Standard-A
USB 3.0 Standard-A	USB 3.0 Standard-A or USB 2.0 Standard-A
USB 3.0 Micro-B	USB 3.0 Micro-B
USB 3.0 Micro-AB	USB 3.0 Micro-B or USB 3.0 Micro-A

Note that the USB 3.0 Standard-A connector is defined to be compatible with the USB 2.0 Standard-A connector. More discussion on connector compatibility can be found in Section 3.1.1.

3.1.1 USB 3.0 Standard-A Connector

The USB 3.0 Standard-A connector is defined as the host connector for USB 3.0, supporting the Super Speed (SS) mode. It has the same mating interface as the USB 2.0 Standard-A connector, but with additional pins for 2 more differential pairs. See Section 4.2.2 for detailed pin assignments and descriptions.

A USB 3.0 Standard-A receptacle accepts either a USB 3.0 Standard-A plug or a USB 2.0 Standard-A plug. In the former case, the link operates in a SS mode with a 5 Gbps data rate, using the two added differential pairs, while in the latter case, the link runs in a USB 2.0 or 1.0 mode using the D+ and D- pins. Similarly, a USB 3.0 Standard-A plug can be mated with either a USB 3.0 Standard-A receptacle or a USB 2.0 Standard-A receptacle.

A unique color coding is required for the USB 3.0 Standard-A connector to help users distinguish the USB 3.0 Standard-A connector from the USB 2.0 Standard-A connector- see Section 4.2.3 for detail.

3.1.2 USB 3.0 Micro-B Connector

This specification defines only one device connector form factor, referred to as the USB 3.0 Micro-B connector in an effort to minimize the connector form factor variations. The USB 3.0 Micro-B connector is similar to the USB 2.0 Micro-B connector in form factor. But it is not compatible with the USB 2.0 Micro-B or any other device connector defined in the USB 2.0 specification and its supplements. The USB 3.0 Micro-B connector is intended to be used for all USB 3.0 devices including small hand-held devices. It is the only standard device connector allowed in the USB 3.0 specification.

The USB 3.0 Micro-B connector has the same pin list as the USB 3.0 Standard-A connector, except that the USB 3.0 Micro-B connector has an ID pin to support OTG.

3.1.3 USB 3.0 Micro-AB and USB 3.0 Micro-A Connectors

The USB 3.0 Micro-AB receptacle is identical to the USB 3.0 Micro-B receptacle, except for keying difference. It accepts either a USB 3.0 Micro-A plug or a USB 3.0 Micro-B plug. The USB 3.0 Micro-AB receptacle is only allowed on OTG products, which may function as either a host or device. All other uses of the USB 3.0 Micro-AB receptacle are prohibited. .

The USB 3.0 Micro-A plug is identical to the USB 3.0 Micro-B plug, except for keying difference and ID pin connections. The USB 3.0 Micro-A plug, the USB 3.0 Micro-AB receptacle, and the USB 3.0 Micro-B receptacle and plug all belong to the USB 3.0 Micro-B connector family since their interfaces differ only in keying. Similar to the USB 2.0 Micro-A plug, the USB 3.0 Micro-A plug is defined for OTG applications only.

3.2 Compliant Cable Assemblies

The USB 3.0 specification defines the following cable assemblies:

- USB 3.0 Standard-A plug to USB 3.0 Micro–B plug
- USB 3.0 Micro-A plug to USB 3.0 Micro-B plug
- Captive cable with USB 3.0 Standard-A plug
- Captive cable with USB 3.0 Micro-A plug

The captive cable is the cable assembly with only one end attached with a plug while the other end is permanently attached to a device. This specification does not define how the permanent attachment shall be done on the device side; only the electrical budgets will be defined for the captive cable applications. Section 9.4 offers more discussion on the captive cables.

All the cable assemblies for USB 3.0 require color coding to help user distinguish between the USB 3.0 and USB 2.0 cable assemblies. No other types of cable assemblies are allowed by the USB 3.0 specification. Section 6 provides detailed discussion on USB 3.0 cable assemblies.

3.3 Raw Cables

Due to EMI and signal integrity requirements, each cable differential pair used for the SS mode in a USB 3.0 cable assembly must be shielded; the UTP (unshielded twist pair) cable used for USB 2.0 is NOT allowed for SS. Section 5.0 defines the cable construction for USB 3.0.

4. Connector Mating Interfaces

4.1 Introduction

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

4.2 USB 3.0 Standard-A Connector

4.2.1 Interface Definition

Figure 4-1 to Figure 4-3 show, respectively, the USB 3.0 Standard-A receptacle and plug interface dimensions, as well as the reference footprint for the USB 3.0 Standard-A receptacle. Note that only the dimensions that govern the mating interoperability are specified. All the REF dimensions are provided for reference only, not hard requirements.

Although the USB 3.0 Standard-A connector has basically the same form factor as the USB 2.0 Standard-A connector, it has dramatic differences inside. Below are the key features and design areas that need attentions for the USB 3.0 Standard-A connector:

- Besides the VBUS, D+, D- and GND pins that are required for USB 2.0, the USB 3.0 Standard-A connector includes five more pins- two differential pairs plus one GND. The two added differential pairs are for the SS data transfer, supporting the unidirectional, half-duplex SS signaling topology; the added GND is for drain wire termination, managing signal integrity and EMI performance.

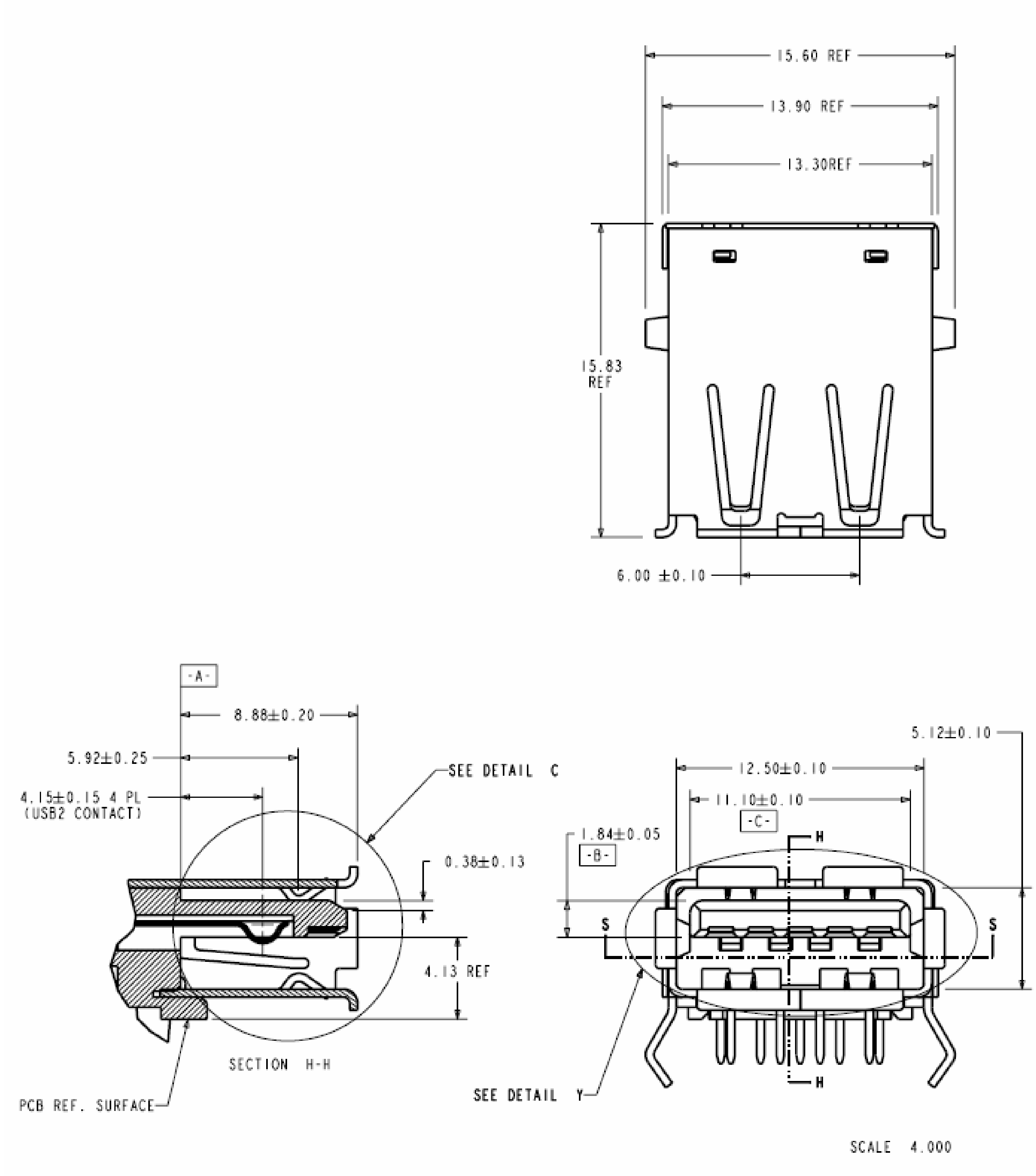
- The contact areas of the five SS pins are located towards the front of the receptacle as the blades, while the four USB 2.0 pins towards the back of the receptacle as the beams or springs. Accordingly in the plug, the SS contacts, as the beams, seat behind the USB 2.0 blades. In other words, the USB 3.0 Standard-A connector has a two-tier contact system.

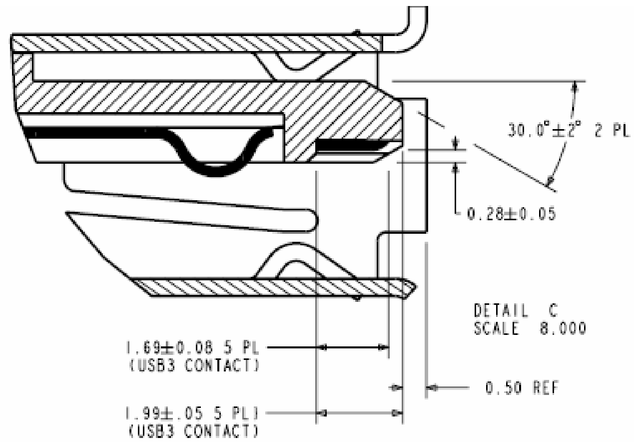
- The tiered contact approach within the Standard-A connector form factor inevitably results in less contact area to work with. The connector interface dimensions take considerations of contact mating requirements between the USB 3.0 Standard-A receptacle and USB 3.0 Standard-A plug, the USB 3.0 Standard-A receptacle and USB 2.0 Standard-A plug, and the USB 2.0 Standard-A receptacle and USB 3.0 Standard-A plug. Connector designers should carefully consider this aspect in design details.

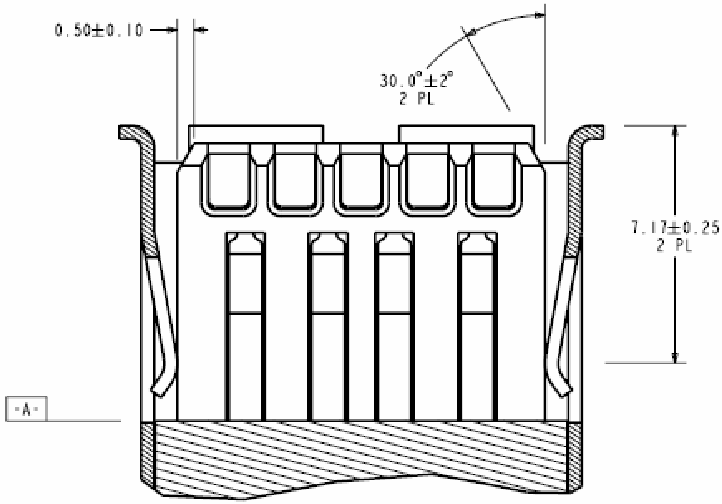
- The connector interface definition comprehended the need to avoid shorting between the SS and USB 2.0 pins during insertion when plugging a USB 2.0 Standard-A plug into a USB 3.0 Standard-A receptacle, or a USB 3.0 Standard-A plug into a USB 2.0 Standard-A receptacle. But connector designers should be conscious about this when detailing out designs.

- The through-hole footprint in Figure 4-3 is shown for reference. Other footprints, such as SMT (surface mount) are allowed.

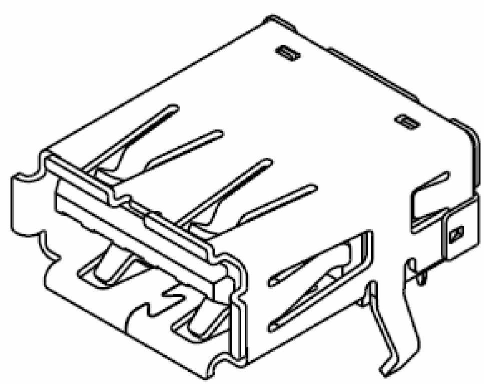
- Drawings for stacked USB 3.0 Standard-A receptacles are not shown in this specification. But they are allowed, as long as they meet all the electrical and mechanical requirements defined in this specification. In fact, a double-stacked USB 3.0 Standard-A receptacle will probably be more common than the stand-alone one. When designing a stacked USB 3.0 Standard-A receptacles, efforts must be made to minimize impedance discontinuity of the top connector in the stack because of its long electrical length.


15.60 REF
13.90 REF
13.30REF
15.83 REF
6.00 ±0.10
-A-
8.88±0.20
5.92±0.25
4.15±0.15 4 PL (USB2 CONTACT)
SEE DETAIL C
0.38±0.13
4.13 REF
SECTION H-H
PCB REF. SURFACE
5.12±0.10
12.50±0.10
11.10±0.10
-C-
1.84±0.05
-B-
H
S
S
H
SEE DETAIL Y
SCALE 4.000





SECTION S-S
SCALE 6.000



SCALE 4.000

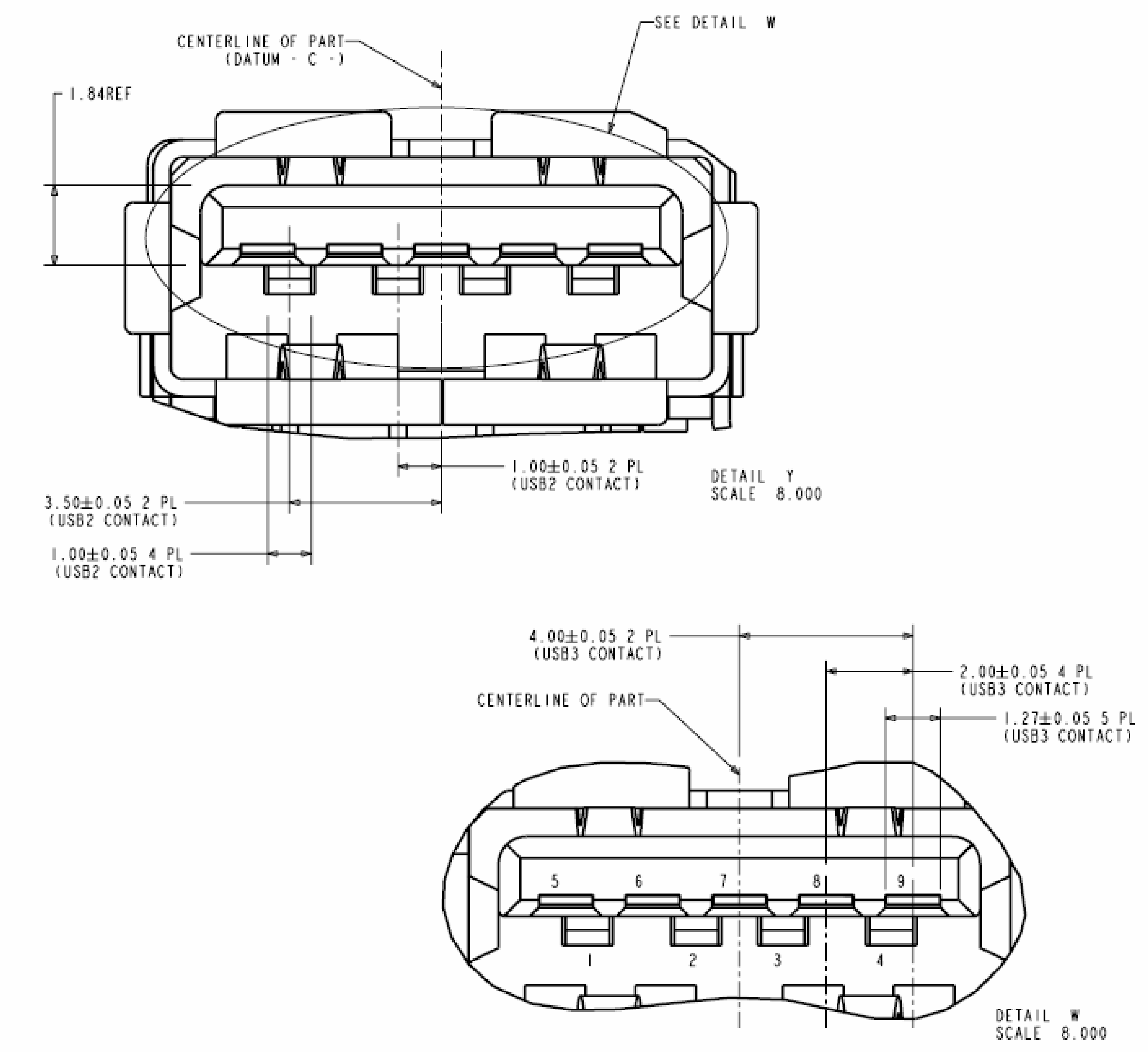
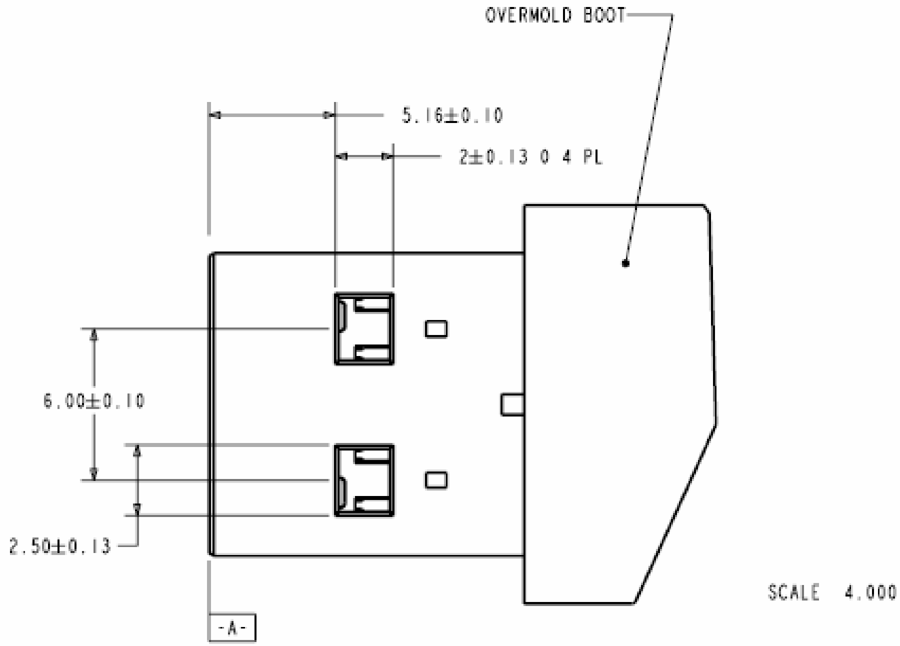
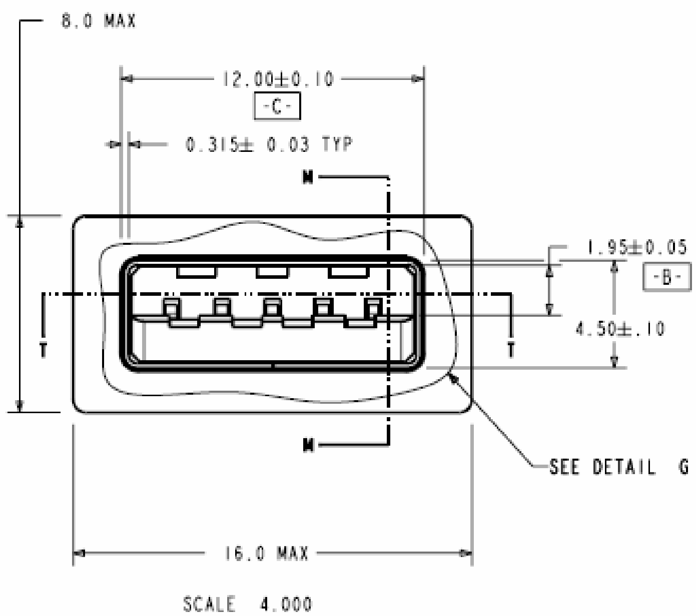
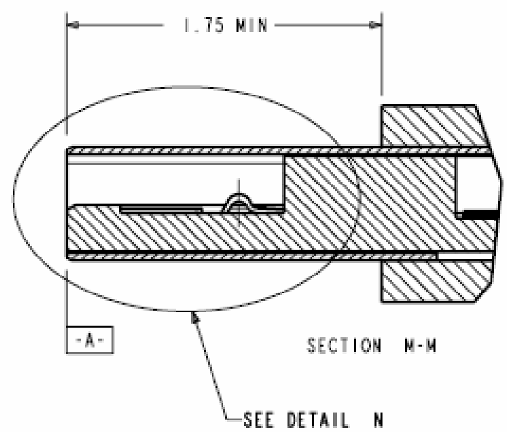
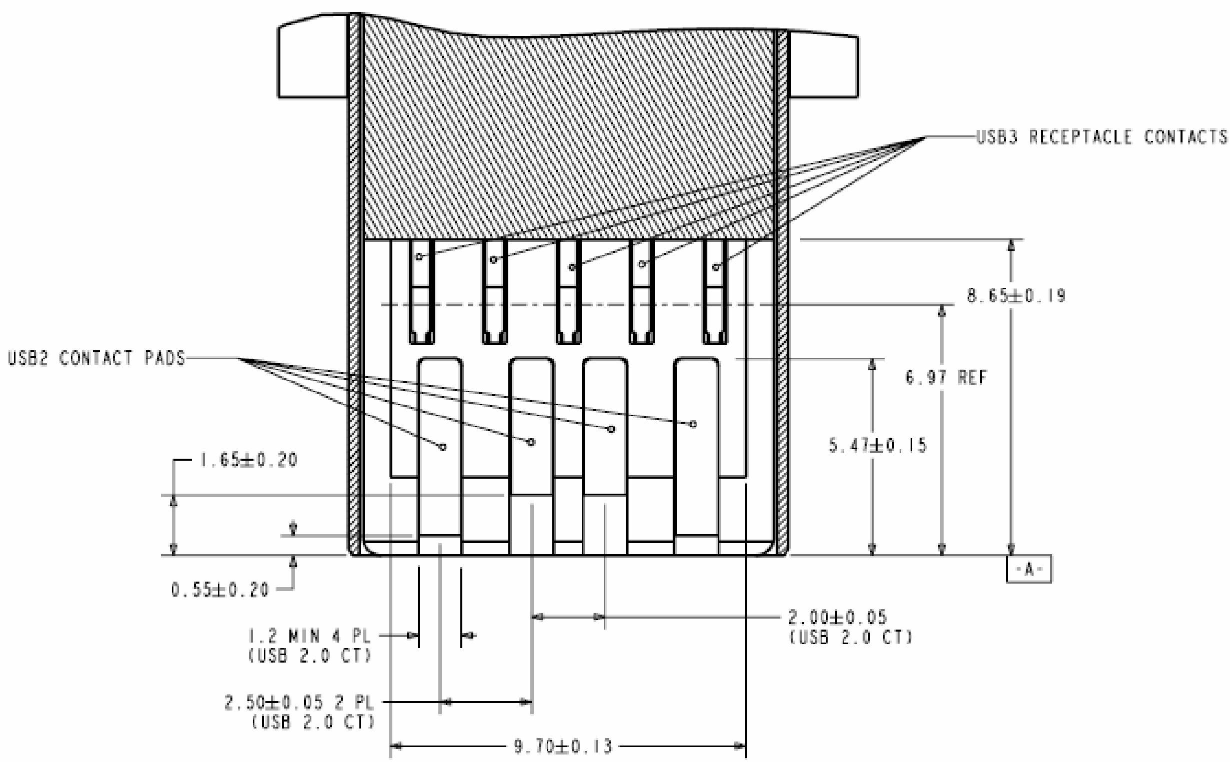


Figure 4-1 USB 3.0 Standard-A Receptacle Interface Dimensions


OVERMOLD BOOT
5.16±0.10
2±0.13 0 4 PL
6.00±0.10
2.50±0.13
-A-
SCALE 4.000


8.0 MAX
12.00±0.10
-C-
0.315± 0.03 TYP
M
1.95±0.05
-B-
4.50±.10
T
T
SEE DETAIL G
M
16.0 MAX
SCALE 4.000


1.75 MIN
-A-
SECTION M-M
SEE DETAIL N



SECTION T-T
SCALE 6.000

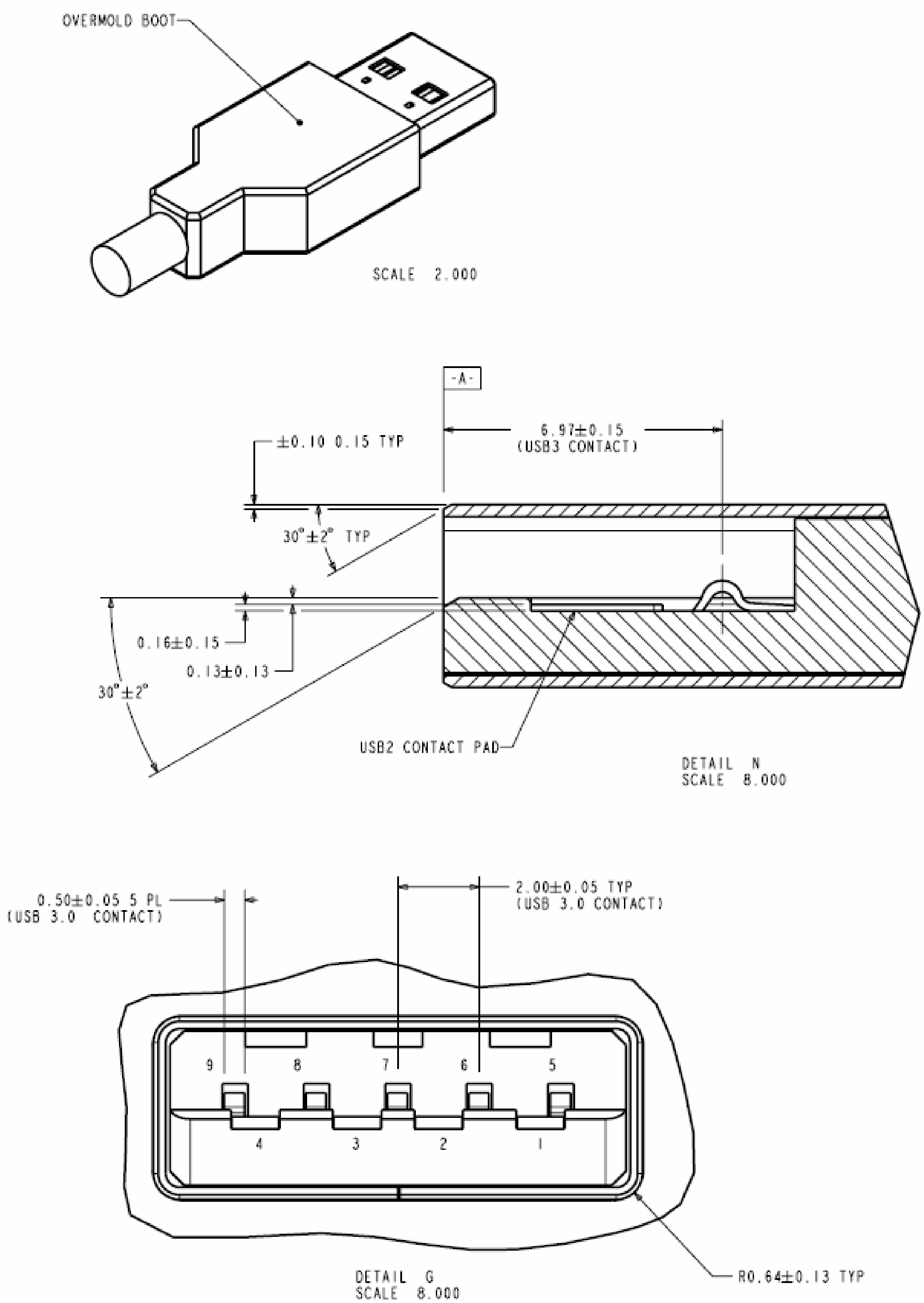


Figure 4-2 USB 3.0 Standard-A Plug Interface Dimensions

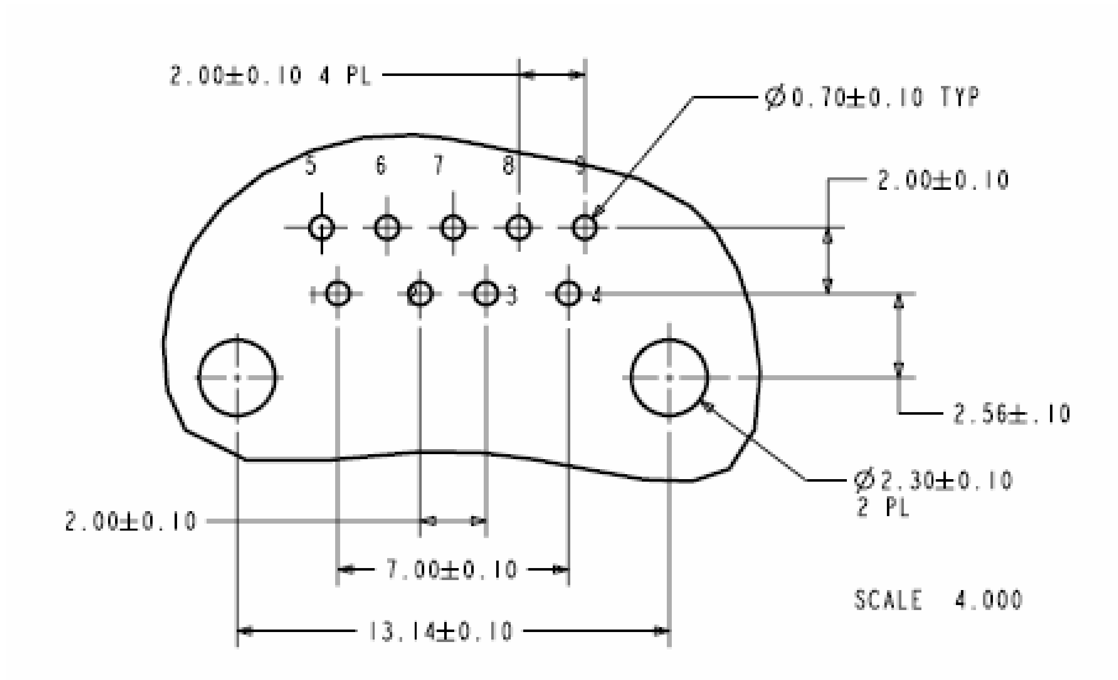


Figure 4-3 Reference Footprint for the USB 3.0 Standard-A Receptacle

4.2.2 Pin Assignments and Description

The usage and assignments of the nine pins in the USB 3.0 Standard-A connector are defined in the following table.

Table 4-1. USB 3.0 Standard-A Connector Pin Assignments

Pin Number	Signal Name	Description	Mating Sequence
1	VBUS	Power	Second
2	D-	USB 2.0 differential pair	
3	D+		
4	GND	Ground for power return	Second
5	SSTX+	Super Speed transmitter differential pair	
6	SSTX-		
7	GND	Ground for signal return	
8	SSRX+	Super Speed receiver differential pair	
9	SSRX-		
Shell	Shield	Connector metal shell	First

The physical location of the pins in the connector is illustrated in Figure 4-1 to Figure 4-3. Note that pins 1 to 4 are referred to as the USB 2.0 pins, while pins 5 to 9 the SS pins.

4.2.3 USB 3.0 Standard-A Receptacle Color Code

Since both the USB 2.0 Standard–A and USB 3.0 Standard-A receptacles may co-exist in a platform, color coding is required for the USB 3.0 Standard-A receptacle housing to help users distinguish it from the USB 2.0 Standard-A receptacle.

BLUE is the required color for the USB 3.0 Standard-A receptacle plastic housing.

4.3 USB 3.0 Micro-B Connector

4.3.1 Interface Definition

Figure 4-4 and Figure 4-5 show the USB 3.0 Micro-B receptacle and plug interface dimensions. Note that only the dimensions that govern the mating interoperability are specified.

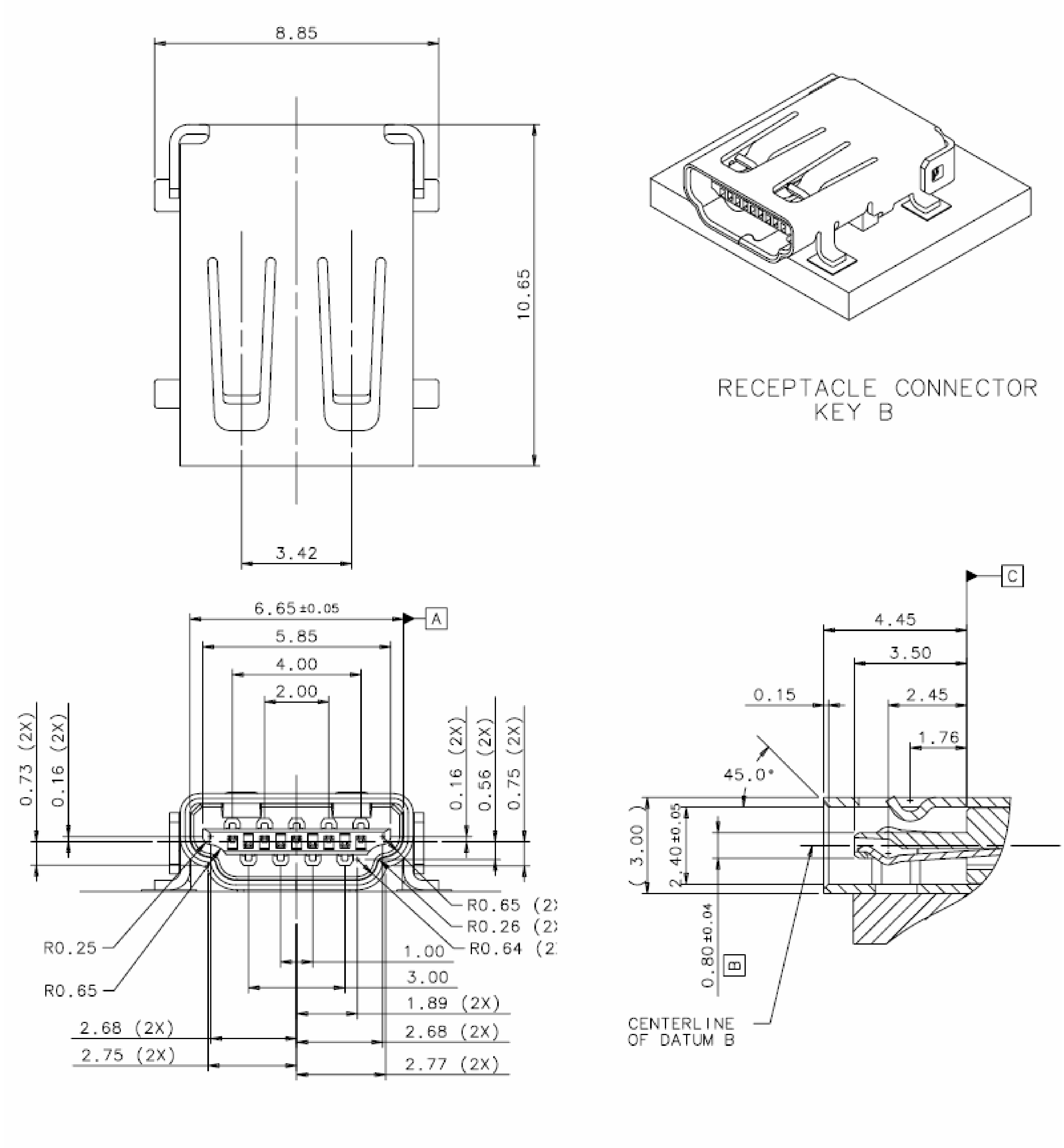


Figure 4-4 USB 3.0 Micro-B Receptacle Interface Dimensions

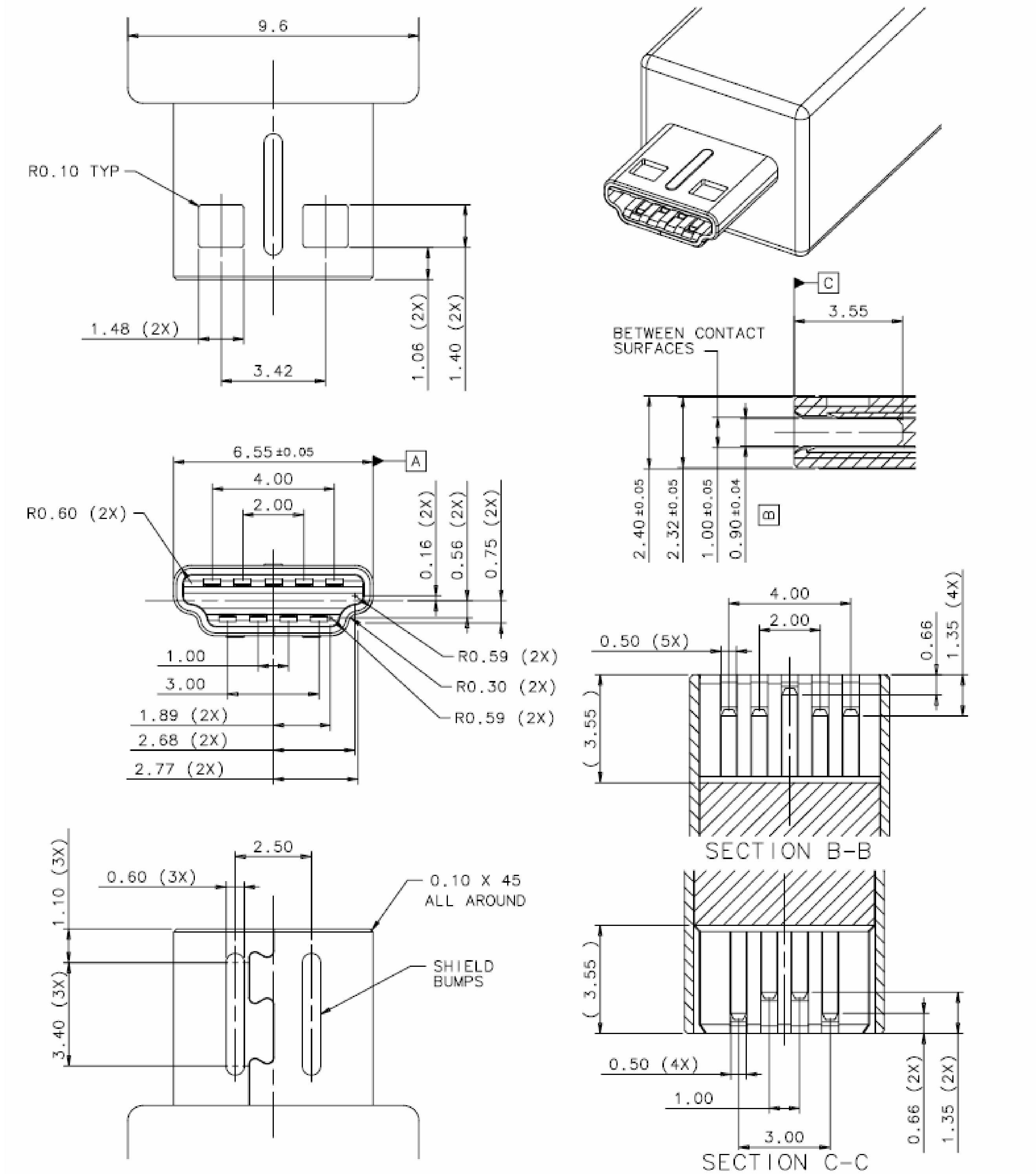


Figure 4-5 USB 3.0 Micro-B Plug Interface Dimensions

The USB 3.0 Micro-B connector is a completely new interface defined for USB 3.0 device uses. It does not have compatibility with any other connectors defined in the USB 2.0 specification and its supplements. All USB 3.0 compliant devices are required to have the USB 3.0 Micro-B or the USB 3.0 Micro-AB (for OTG products) receptacles. The USB 3.0 Micro-B connector has the following characteristics:

- The connector form factor is similar to the USB 2.0 Micro-B to meet the small cell-phone and handheld device needs, with a total height of 3 .00 mm.
- There are two rows of contacts at a 1.00 mm centerline or pitch.
- Two latches are defined in the connector for friction, or passive lock and for EMI grounding. Attentions should be paid to the latch design in order to meet the unmating force and durability requirement to be specified in Section 8.
- There are embossment features defined in the plug metal shell to enhance the metal-to-metal contact between receptacle and plug shells for EMI management.
- The USB 3.0 Micro-B connectors are intended to be used for small and large devices. Connector designers should make sure the receptacles have sufficient mechanical strength. Section 8 lists the connector pull strength requirements; Section 9 offers an implementation note about how to take advantage of the cable plug overmold to protect the receptacle connector in a relatively large device from user “abuse”.

4.3.2 Pin Assignments and Description

Table 4-2 shows the pin assignments for the USB 3.0 Micro-B connectors. Note that the same pin assignments are applicable to the USB 3.0 Micro-AB receptacle and USB 3.0 Micro-A plug.

Table 4-2. USB 3.0 Micro-B and -AB Connector Pin Assignments

Pin Number	Signal Name	Description	Mating Sequence
1	SSTX+	Super Speed transmitter differential pair	
2	SSTX-		
3	GND	Ground	Second
4	SSRX+	Super Speed receiver differential pair	
5	SSRX-		
6	ID	OTG identification	
7	D+	USB 2.0 differential pair	
8	D-		
9	VBUS	Power	Second
Shell	Shield	Connector metal shell	First

The physical location of the pins in the connector is illustrated in Figure 4-4 and Figure 4-5.

4.3.3 Color Coding

All the receptacle plastic housings in the USB 3.0 Micro-B connector family must be colored BLUE, matching the color with the USB 3.0 Standard-A receptacle housing.

4.4 USB 3.0 Micro-AB Receptacle and USB 3.0 Micro-A Plug

Figure 4-6 and Figure 4-7 show the USB 3.0 Micro-AB receptacle and the USB 3.0 Micro-A plug interface dimensions, respectively.

The USB 3.0 Micro-AB receptacle is identical to the USB 3.0 Micro-B receptacle except for the keying difference in the connector shell outline, and the USB 3.0 Micro-A plug is identical to the USB 3.0 Micro-B plug with different keying and ID pin connections. Section 6.2 discusses the ID pin connections.

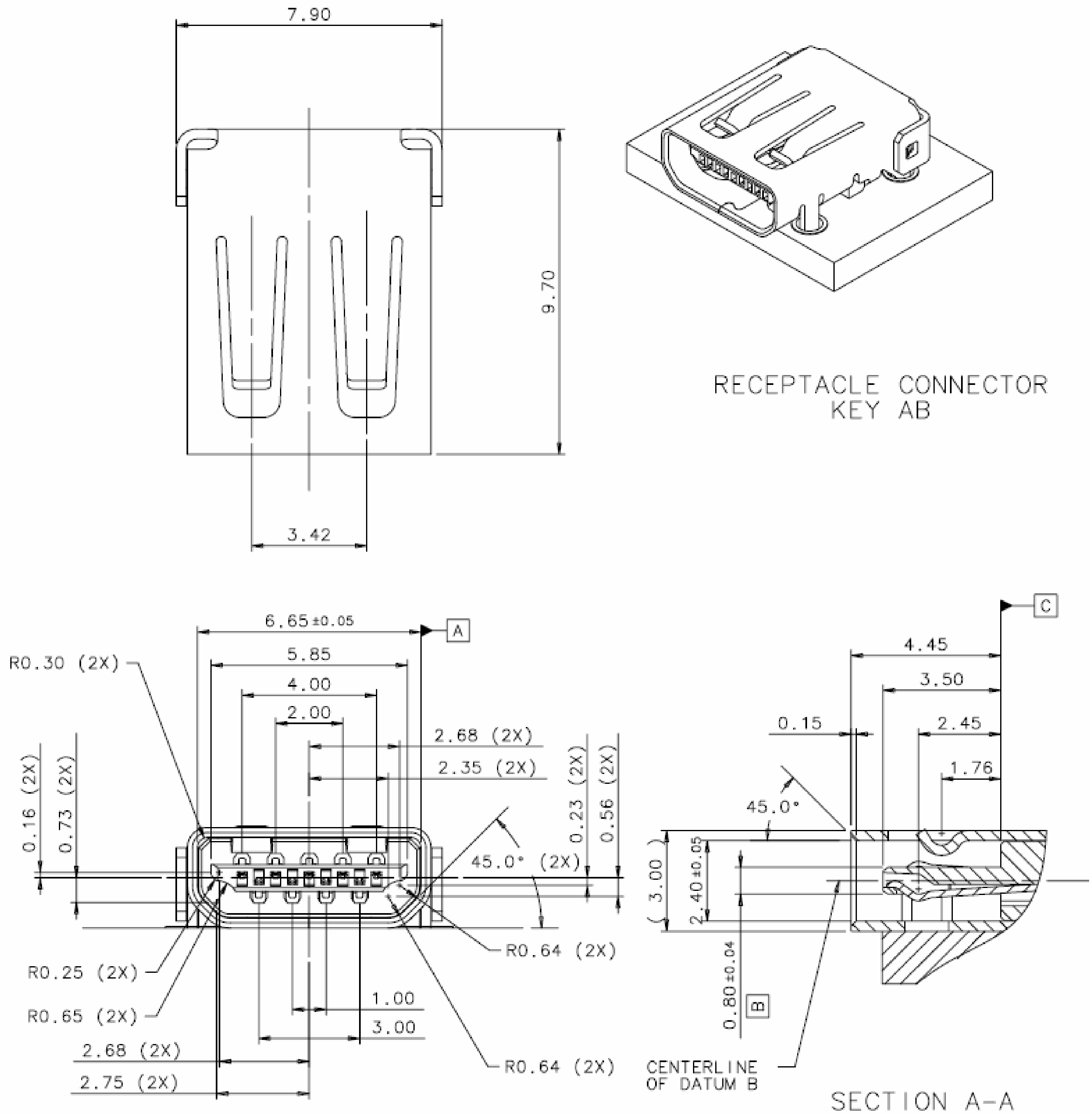


Figure 4-6 USB 3.0 Micro-AB receptacle Interface Dimensions

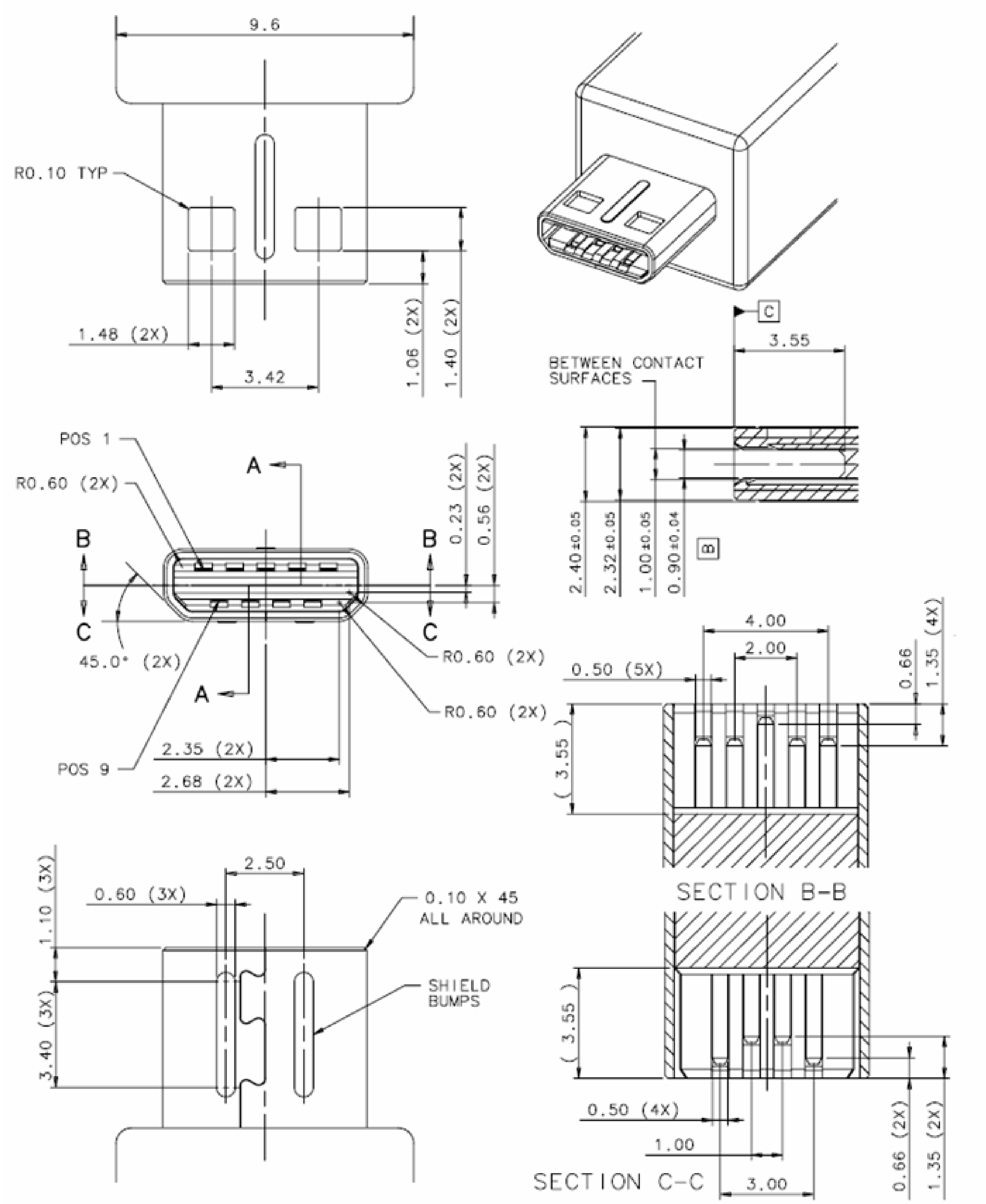


Figure 4-7 USB 3.0 Micro-A Plug Interface Dimensions

5. Cable Construction and Wire Assignments

This section discusses the USB 3.0 cables, including cable construction, wire assignments, and wire gauges. The performance requirements will be specified in sections 7 and 8.

5.1 Cable Construction

Figure 5-1 illustrates a USB 3.0 cable cross-section. There are three groups of wires: UTP (unshielded twist pair) signal pair, STP (shielded twist pair) signal pairs, and power that includes the power and ground return wires.

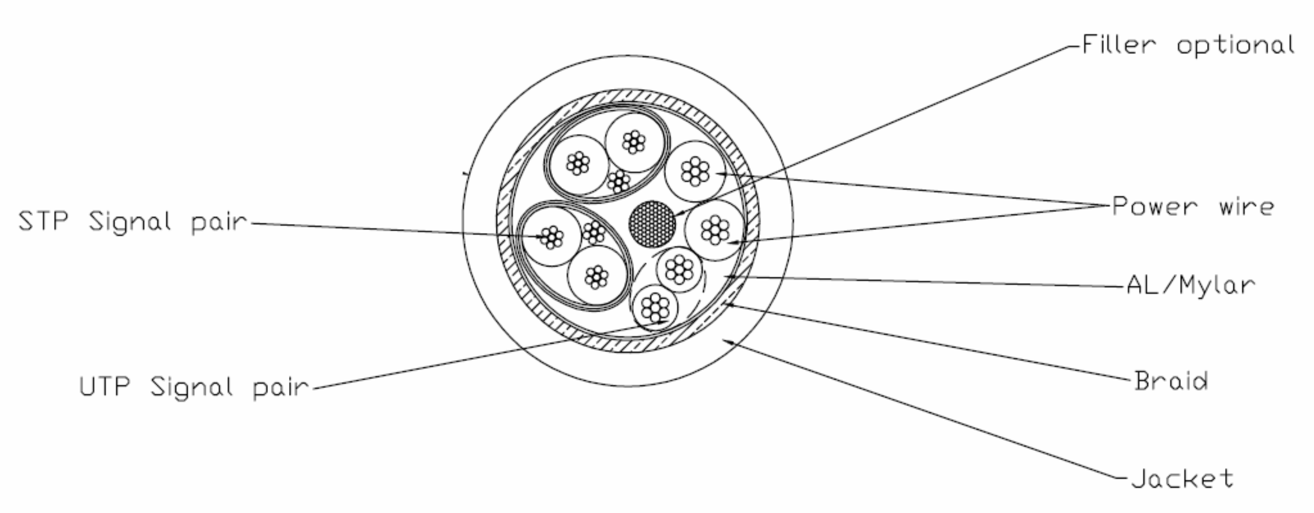


Figure 5-1 Illustration of a USB 3.0 Cable Cross-Section

The UTP is intended to transmitter the USB 2.0 signaling while the STP's are for the SS use; the shield is needed for the SS differential pairs for signal integrity and EMI performance. Each STP is attached with a drain wire, which is eventually connected to the system ground through the GND pin in the connector.

A metal braid is required to enclose all the wires in the USB 3,0 cable. The braid is to be terminated to the plug metal shells to, as close to 360° as possible, to contain EMI.

5.2 Wire Assignments

Table 5-1 defines the wire number, signal assignments and colors.

Table 5-1. Cable Wire Assignments

Wire Number	Signal Name	Description	Color
1	PWR	Power	Red
2	GND_PWRrt	Ground for power return	Black
3	UTP_D+	Unshielded twist pair, positive	White
4	UPT_D-	Unshielded twist pair, negative	Green
5	STP_TX+	Shielded twist pair, transmitter, positive	Yellow
6	STP_TX-	Shielded twist pair, transmitter, positive	Blue
7	STP_TX_Drain	Drain wire for STP_TX	
8	STP_RX+	Shielded twist pair, receiver, positive	Orange
9	STP_RX-	Shielded twist pair, receiver, positive	Purple
10	STP_RX_Drain	Drain wire for STP_RX	
Braid	Shield	Cable external braid to be 360° terminated on to plug metal shell	

5.3 Wire Gauges and Cable Diameters

This specification chooses not to specify wire gauges; Table 5-2 lists the typical wire gauges for reference. A large gauge wire incurs less loss, but at the cost of cable flexibility. One should choose the smallest possible wire gauges that meet the cable assembly electrical budgets.

To maximize cable flexibility, all wires are required to be stranded and the cable outer diameter should be minimized as much as possible.

The cable outer diameter should be minimized as much as possible also. A typical USB 3.0 cable outer diameter may range from 4 to 6 mm.

Table 5-2. Reference Wire Gauges

Wire Number	Signal Name	Wire Gauge (AWG)
1	PWR	26-28
2	GND_PWRrt	26-28
3	UTP_D+	26-30
4	UPT_D-	26-30
5	STP_TX+	26-30
6	STP_TX-	26-30
7	STP_TX_Drain	28-30
8	STP_RX+	26-30
9	STP_RX-	26-30
10	STP_RX_Drain	28-30

6. Cable Assemblies

6.1 USB 3.0 Standard-A to USB 3.0 Micro-B Cable Assembly

6.1.1 Drawing

Figure 6-1 illustrates a USB 3.0 Standard-A to USB 3.0 Micro-B cable assembly.

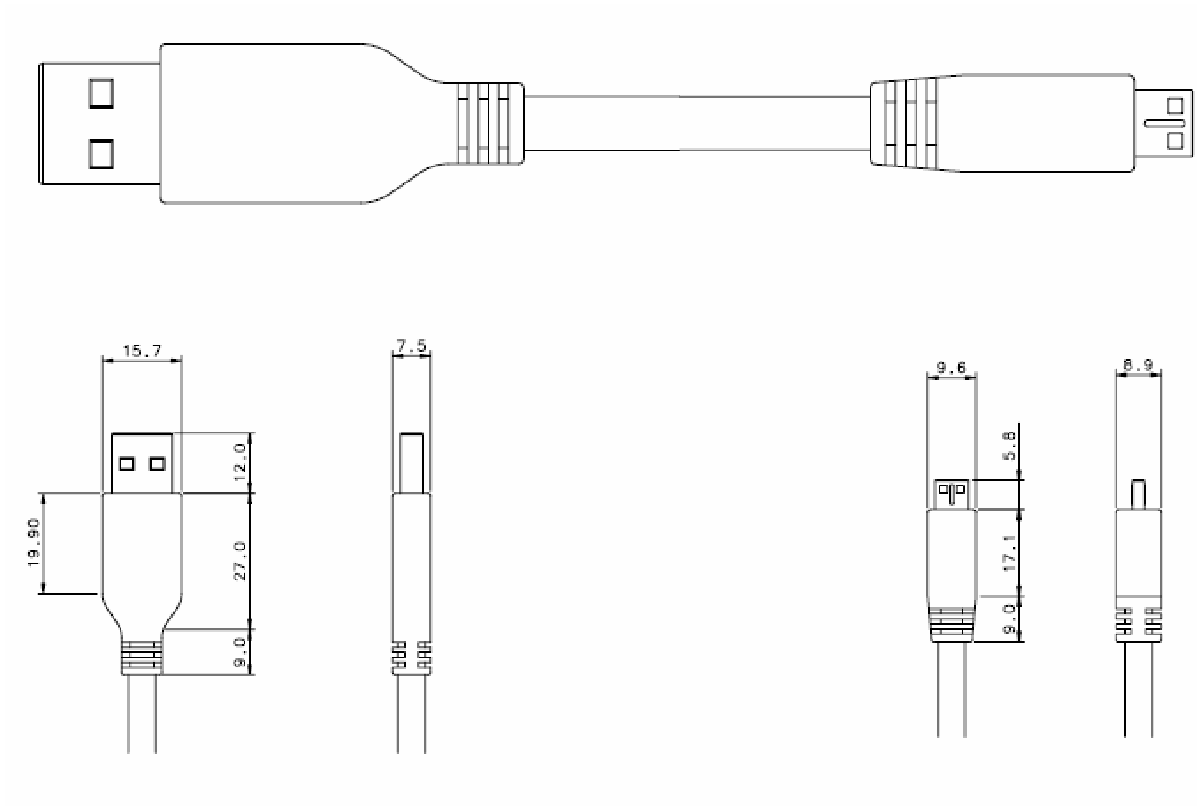


Figure 6-1 USB 3.0 Standard-A to USB 3.0 Micro-B Cable Assembly

6.1.2 Wiring

Table 6-1 shows the wire connections for the USB 3.0 Standard-A to USB 3.0 Micro-B cable assembly. Note the ID pin in the USB 3.0 Micro-B plug should be a no-connect, leaving open.

Table 6-1. USB 3.0 Standard-A to Super B Cable Assembly Wiring

USB 3.0 Standard-A Plug		Wire		USB 3.0 Micro-B Plug	
Pin Number	**Signal Name**	**Wire Number**	**Wire Name**	**Pin Number**	**Signal Name**
1	VBUS	1	PWR	9	VBUS
2	D+	3	UTP_D+	7	D+
3	D-	4	UTP_D-	8	D-
4	GND	2	GND_PWRrt	3	GND
5	SSTX+	5	STP_TX+	1	SSTX+
6	SSTX-	6	STP_TX+	2	SSTX-
7	GND	7,10	STP_TX_Drain STP_RX_Drain	3	GND
8	SSRX+	8	STP_RX+	4	SSRX+
9	SSRX-	9	STP_RX+	5	SSRX-
				6	ID
Shell	Shield	Braid	Shield	Shell	Shield

6.2 USB 3.0 Micro-A to USB 3.0 Micro-B Cable Assembly

6.2.1 Overmold Dimensions

Figure 6-2 shows a USB 3.0 Micro-A to USB 3.0 Micro-B cable assembly.

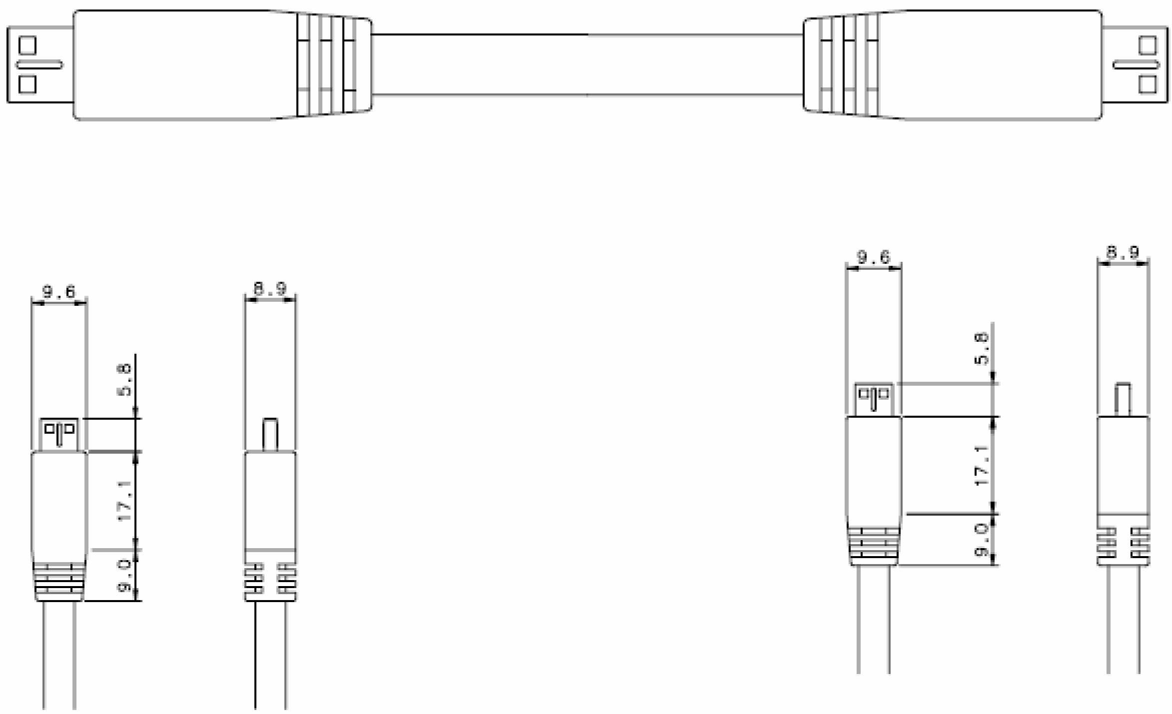


Figure 6-2 USB 3.0 Micro-A to USB 3.0 Micro-B Cable Assembly

6.2.2 Wiring

Table 6-2 shows the wire connections for the USB 3.0 Micro-A to USB 3.0 Micro-B cable assembly. The ID pin on a USB 3.0 Micro-A plug shall be connected to the GND pin. The ID pin on a USB 3.0 Micro-B plug is not connected or is connected to ground by a resistance of greater than Rb_PLUG_ID (100kΩ MIN). An On-The-Go device is required to be able to detect whether a USB 3.0 Micro-A or USB 3.0 Micro-B plug is inserted by determining if the ID pin resistance to ground is less than Ra_PLUG_ID (10Ω MAX) 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 4-2. USB 3.0 Micro-A to USB 3.0 Micro-B Cable Assembly Wiring

USB 3.0 Standard-A Plug			Wire	USB 3.0 Micro-B Plug	
Pin Number	**Signal Name**	**Wire Number**	**Wire Name**	**Pin Number**	**Signal Name**
1	SSTX+	5	STP_TX+	1	SSTX+
2	SSTX-	6	STP_TX+	2	SSTX-
3	GND	2,7,10	GND_PWRrt STP_TX_Drain STP_RX_Drain	3	GND
4	SSRX+	8	STP_RX+	4	SSRX+
5	SSRX-	9	STP_RX+	5	SSRX-
6	ID [1]			6	ID [2]
7	D+	3	UTP_D+	7	D+
8	D-	4	UTP_D-	8	D-
9	VBUS	1	PWR	9	VBUS
Shell	Shield	Braid	Shield	Shell	Shield

[1] Connect to the GND or shield

[2] No connect

6.3 Captive Cables

Two captive cables are allowed in this specification: the captive cable with the USB 3.0 Standard-A plug and the captive cable with the USB 3.0 Micro-A plug. All other captive cables are prohibited. Figure 6-3 and 6-4 illustrate those two captive cables.

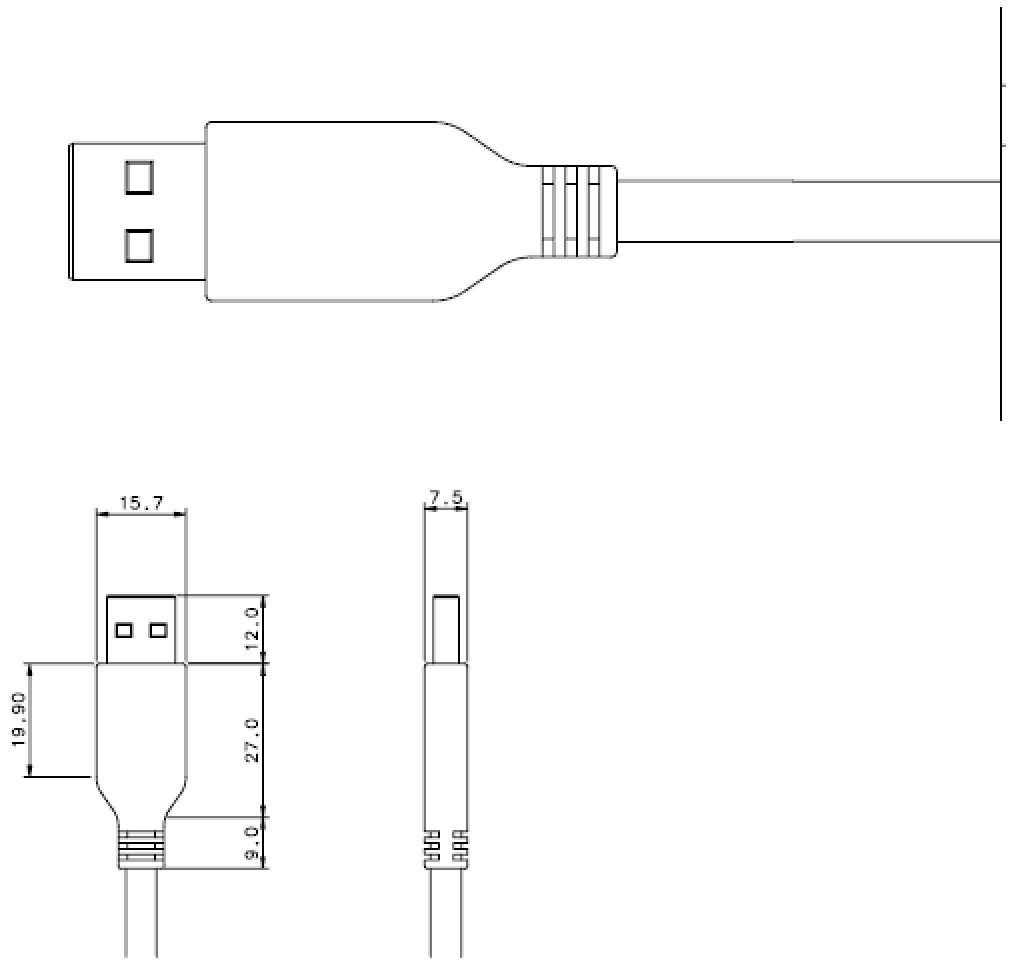


Figure 6-3 Captive Cable Attached with the USB 3.0 Standard-A Plug (placeholder)

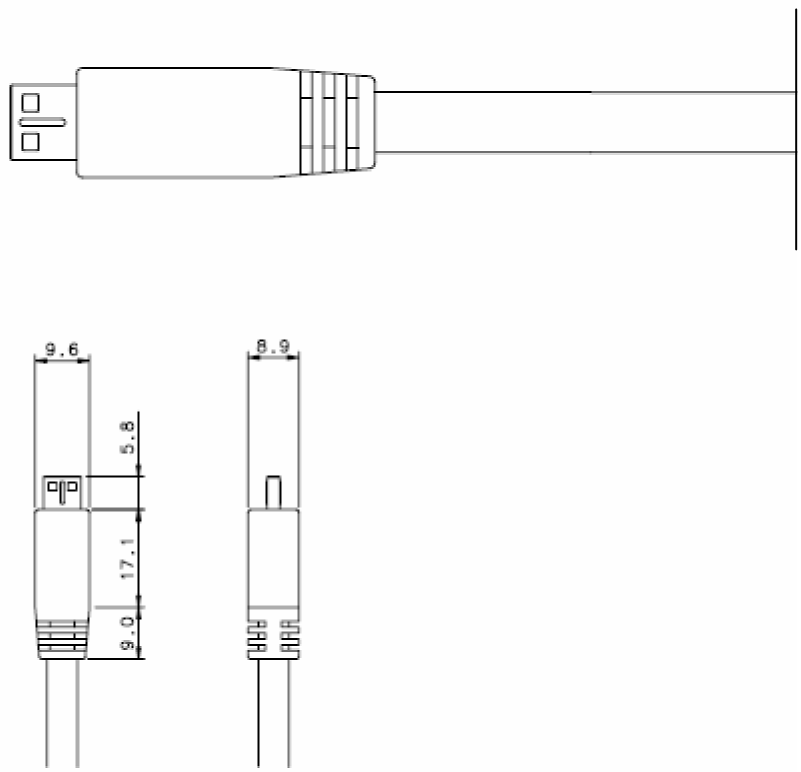


Figure 6-4 Captive Cable Attached with the USB 3.0 Micro-A Plug (placeholder)

6.4 Color Coding

ALL USB 3.0 cable plug overmolds are required to be BLUE, match the color with the USB 3.0 receptacle housings.

6.5 USB 3.0 Icon Location

The USB 3.0 cable assemblies, compliant with the USB 3.0 Connectors and Cable Assemblies Compliance Specification, may display the USB 3.0 Icons illustrated in Figure 6-5.

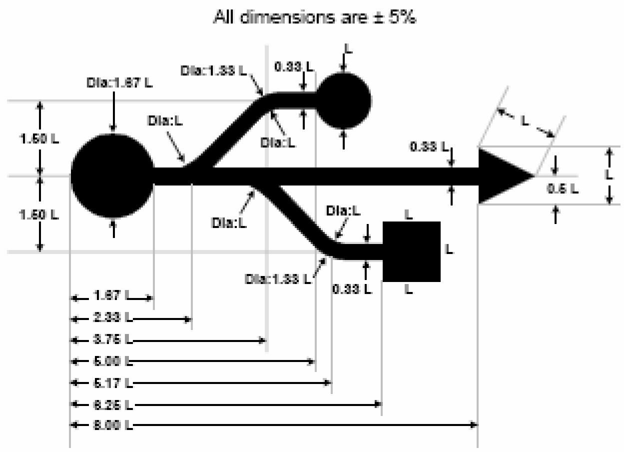


Figure 6-5 USB 3.0 Logo (placeholder)

The USB 3.0 Icon is embossed, in a recessed area, on the top side of the USB 3.0 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 3.0 compliant cable assembly is required to have the USB 3.0 Icons on the plugs at both ends, while the manufacturer's logo is recommended. USB 3.0 receptacles should be orientated to allow the Icon on the plug to be visible during the mating process. Figure 6-6 shows a typical plug orientation.

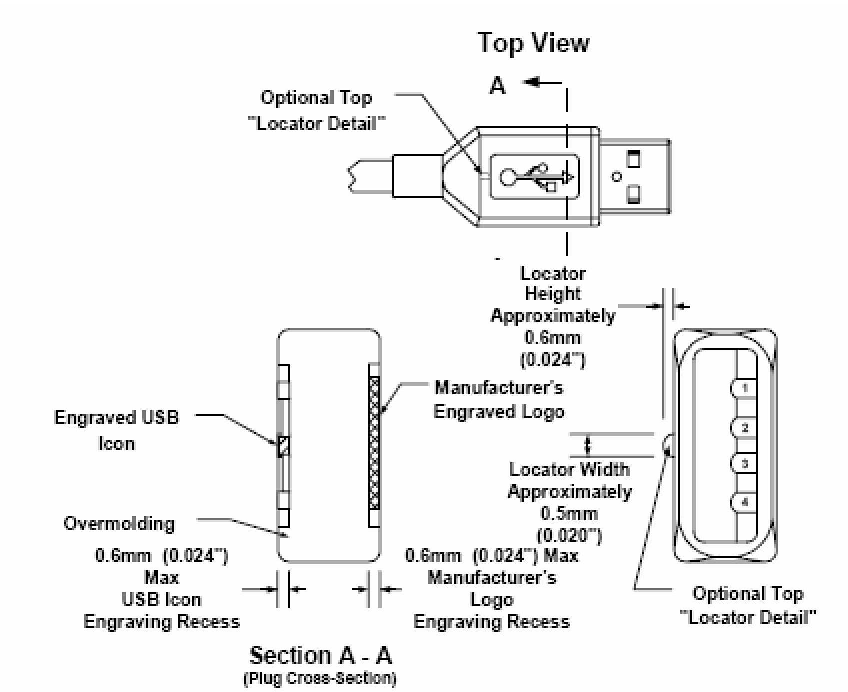


Figure 6-6 Typical Plug Orientation (placeholder)

6.6 Cable Assembly Length

This specification does not specify cable assembly lengths. A USB 3.0 cable assembly can be of any length, as long as it meets all the requirements defined in this specification. The cable assembly loss budget defined in Section 8 will limit the cable assembly length; the loss budget is defined to support a minimum of 2-meter cable length. Longer cable is possible at a higher cost.

7. Electrical Requirements

This section covers the electrical requirements for raw cables, mated connectors, and mated cable assemblies. The electrical requirements include high speed and DC requirements. The high speed requirements involve mainly the S-parameters, while the DC requirements are mainly the contact resistance and current carrying capability.

7.1 High Speed Electrical Requirements

The high speed requirements apply only to the SS signals. The requirements for the USB 2.0 signals are governed by the USB 2.0 specification.

7.1.1 Raw Cable

The raw cable electrical performance targets are provided here to help cable assembly manufacturers manage raw cable suppliers. Those targets are not part of the USB 3.0 compliance items; the ultimate requirements will be the mated cable assembly performance to be specified in Section 7.1.3.

7.1.1.1 Characteristic Impedance

The differential characteristic impedance for the STP pairs should be controlled within 90+/- 7% ohms. It should be measured with a TDR in a differential mode using a 50 ps (10-90%) rise time.

7.1.1.2 Intra-Pair Skew

The intra-pair skew for the STP pairs should be less than 15 ps per meter. It should be measured with a TDT in differential mode using a 50 ps (10-90%) rise time with a crossing at 25% of the input voltage.

7.1.1.3 Differential Attenuation

Cable attenuation depends on wire gauges and dielectric materials. Table 7-1 lists the typical differential attenuations for the STP pair.

Table 7-1. STP Differential Attenuation

Frequency	30AWG	28AWG	26AWG
0.625 GHz	TBD	1.20 dB/m	TBD
1.25 GHz	TBD	1.80 dB/m	TBD
2.50 GHz	TBD	2.65 dB/m	TBD
5.00 GHz	TBD	4.35 dB/m	TBD

7.1.2 Mated Connector

The mated connector impedance is provided here as a design guideline for connector designers. The differential impedance of a mated connector, which includes the receptacle PCB launch and cable termination areas, should be within 90+/-10% ohms, as seen from a 50 ps (10-90%) risetime of a differential TDR. Figure 6-7 illustrates an example of a mated connector TDR.

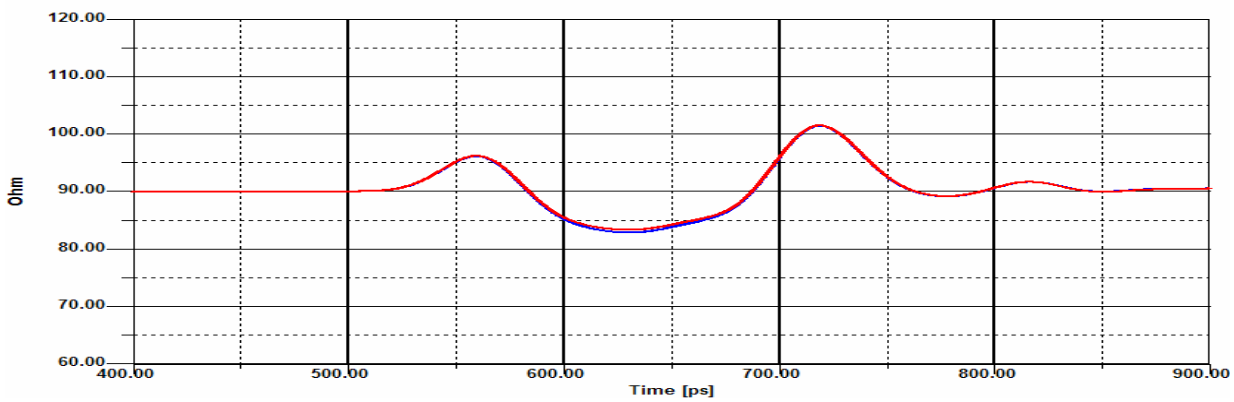


Figure 7-1 A TDR Example of a Mated Connector (placeholder)

7.1.3 Mated Cable Assemblies

A mated cable assembly refers to a cable assembly mated with the corresponding receptacles, which are mounted on PCB's, at the both ends. The requirements are for the entire signal path of the mated cable assembly, from the host receptacle contact solder pads ot 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 6-2; the measurement is between TP1 (test point 1) and TP2 (test point 2).

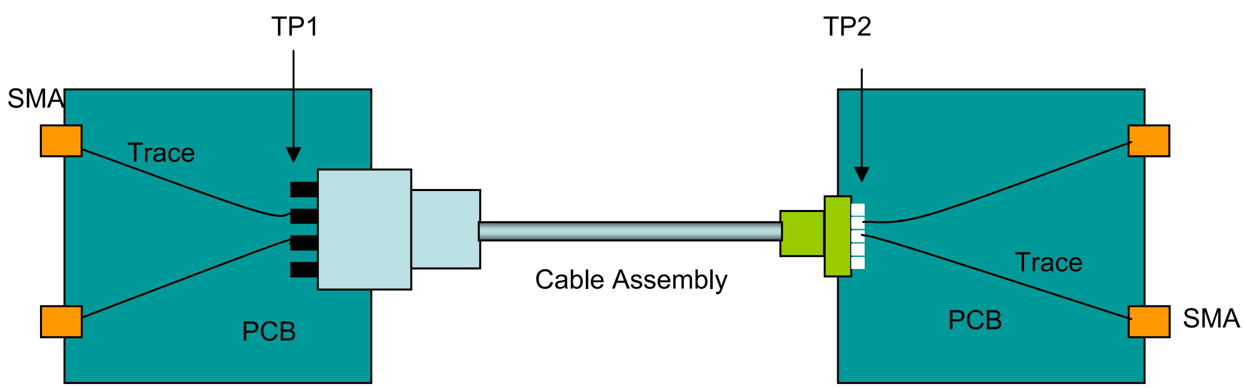


Figure 7-2 Illustration of Test Points for a Mated Cable Assembly

For proper measurements, the receptacles shall be mounted on a test fixture made of FR4. The fixture shall have a stack-up about 4 mils. The signal pins are routed to SMA connectors, or microprobe pads through traces of 50 Ω +/-7% single-ended characteristic impedance. Those traces shall be uncoupled. The test fixture shall have calibration structures, such as TRL, to calibrate out the fixturing effect. Except for the ground pins, all other pins that are adjacent, but not connected to measurement ports shall be terminated with 50 Ω resistors.

A reference USB 3.0 mated cable assembly signal integrity test fixture will be defined in the USB 3.0 Connectors and Cable Assemblies Compliance Testing Specification, in which the detailed testing procedures will be given.

7.1.3.1 Differential Return Loss (EIA-360-108)

The differential return loss, SDD11, measures the impedance mismatch in the frequency domain. The differential return loss envelop is defined by following vertices: (100MHz, -20 dB), (f0/2, -20 dB), (f0, -15 dB), and (3*f0, -5 dB), where f0=2.5 GHz being the fundamental frequency. This is shown in Figure 6-3; the measured differential return loss of a mated cable assembly must be below or on the differential return loss envelop.

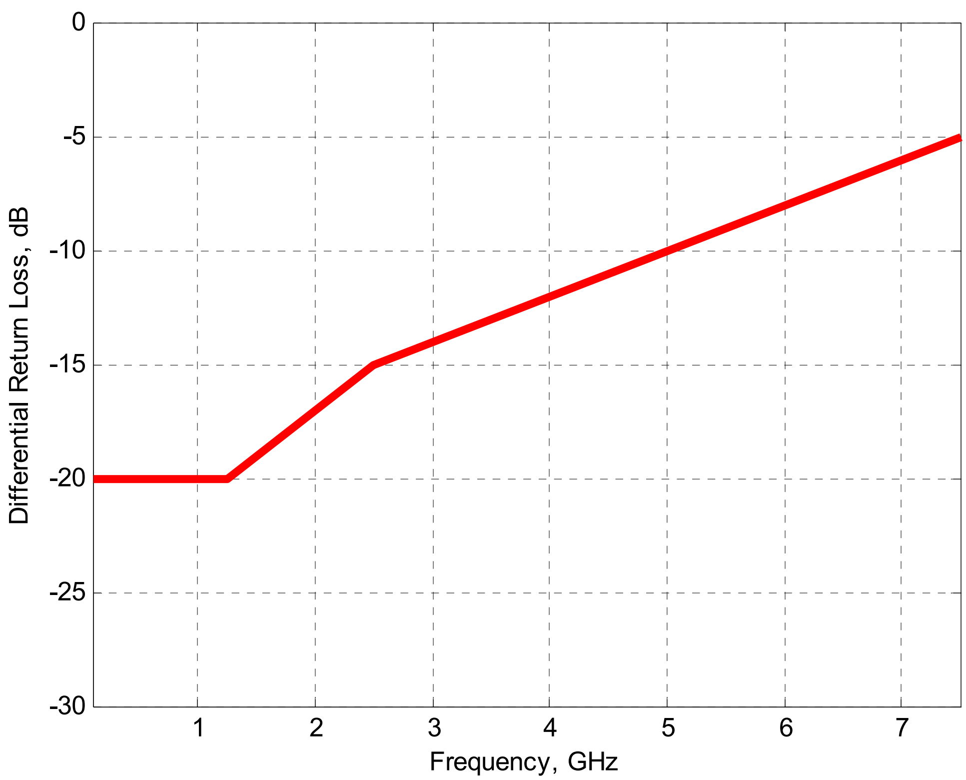


Figure 7-3 Differential Return Loss Requirement

To be consistent with the USB 3.0 channel nominal differential characteristic impedance requirement of 90 ohms, the differential return loss shall be normalized with a 90-ohm reference differential impedance.

Controlling the mated connector TDR impedance profile within the recommendation in Section 7.1.2 should result in meeting the differential return loss requirement in this section. But bear in mind that the differential return loss is the hard requirement.

7.1.3.2 Differential Insertion Loss (EIA-360-101)

The differential insertion loss, SDD12, measures the differential signal energy transmitted through the mated cable assembly. Figure 6-4 shows the differential insertion loss limit, which is normalized with a 90-ohm differential impedance and defined by the following vertices: (100MHz, -1 dB), (f0/2, -4.0 dB), (f0, -7.5

dB), and (3*f0, -25 dB). The measured differential return loss of a mated cable assembly must be above or on the differential insertion loss limit.

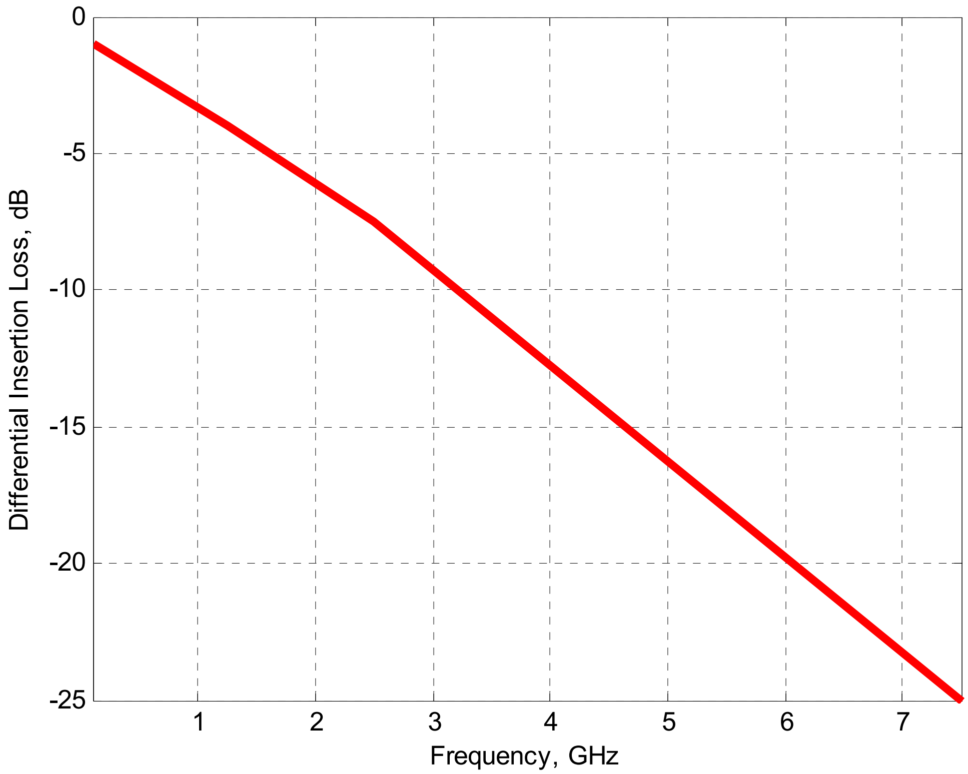


Figure 7-4 Differential Insertion Loss Requirement

7.1.3.3 Differential Near-End Crosstalk (EIA-360-90)

The differential crosstalk measures the unwanted coupling between differential pairs. Since the TX pair is right next to the RX pair, only the differential near-end crosstalk (DDNEXT) is specified, as shown in Figure 6-5. The mated cable assembly meets the DDNEXT requirement if its DDENXT is below or on the limits shown in Figure 6-5; the vertices that defines the DDNEXT limits are: (100MHz, -32 dB), (f0, -32 dB), and (3*f0, -26 dB).

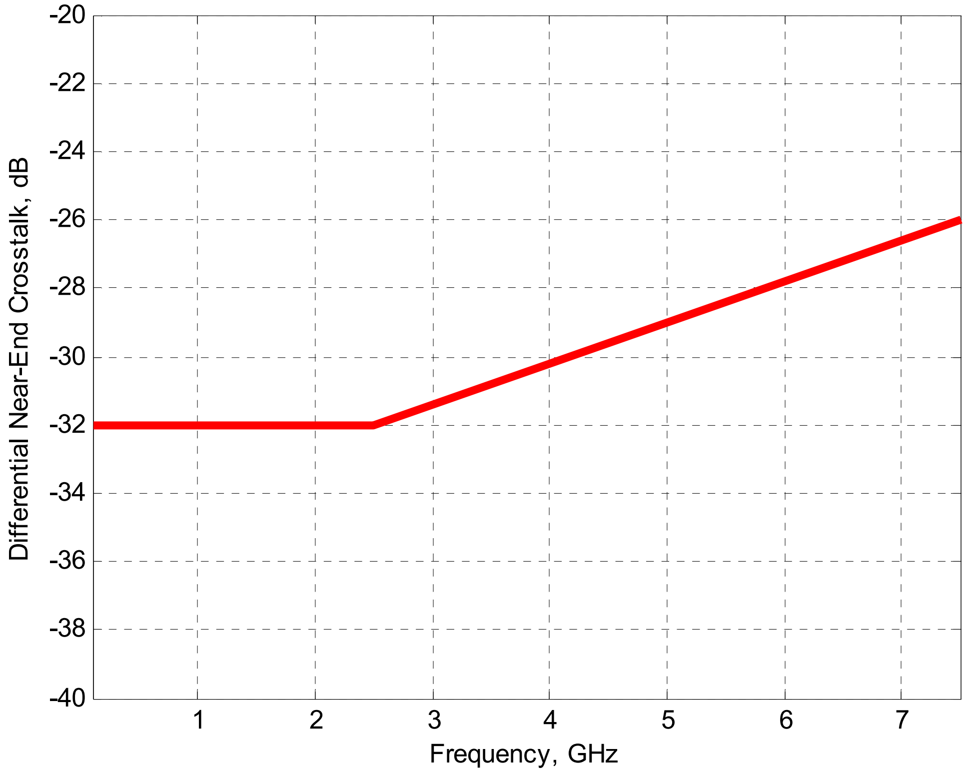


Figure 7-5 Differential Near-End Crosstalk Requirement

7.1.3.4 Differential to Common Mode Conversion

This parameter is specified mainly for controlling EMI. Since the common mode current is directly responsible for EM emission, limiting the differential-to-common-mode conversion, SCD12, will limit EM emission. Figure 6-6 illustrates the 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 shown in Figure 6-6.

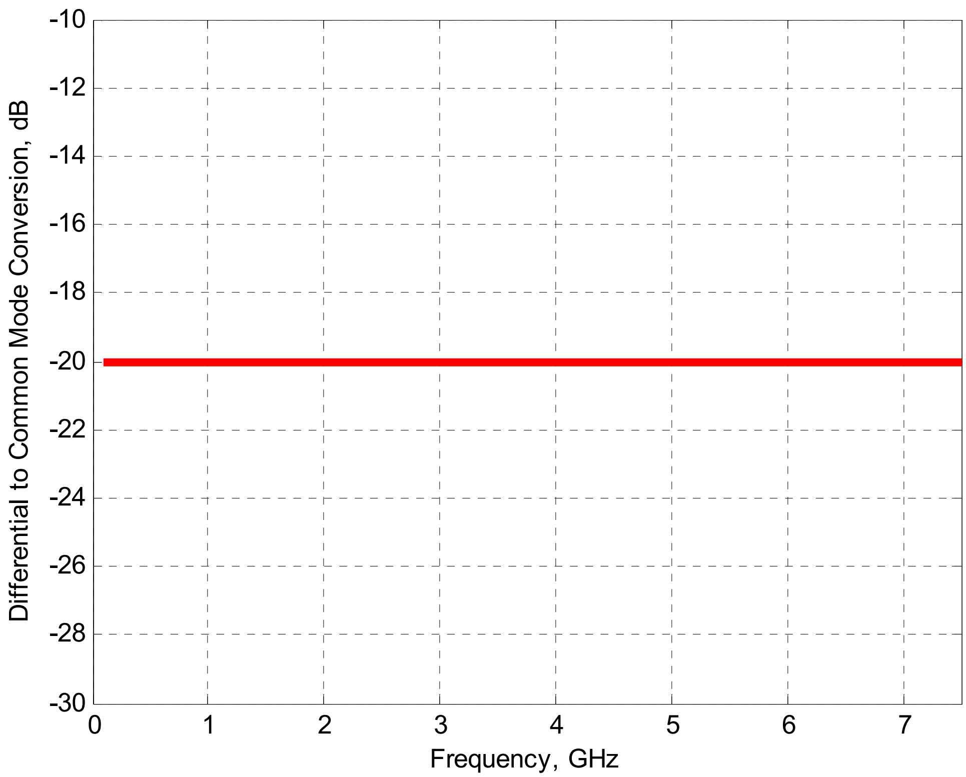


Figure 7-6 Differential to Common Mode Conversion Requirement

7.2 DC Electrical Requirements

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

The following requirement applies to both the signal contacts and the connector shell contacts:

- **30 mΩ** (Max) initial when measured at 20 mV (Max) open circuit at 100mA. Maximum change (delta) of +20 **mΩ** after environmental stresses. See Section 8.2 for environmental requirements and test sequences.

7.2.2 Dielectric Strength (EIA 364-20, Method 301)

No breakdown under the following conditions:

- Unmated connectors: apply 350 Volts AC (RMS) between adjacent contacts.
- Mated connector: apply 200 Volts DAC (RMS) between adjacent contacts.

7.2.3 Insulation Resistance (EIA 364-21, Method 302)

100 mega ohms minimum under the following conditions:

- Unmated connectors: apply 350 Volts DC between adjacent contacts.
- Mated connector: apply 150 Volts DC between adjacent contacts.

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

1.8A for VBUS and its corresponding GND pins (1 and 4 for the USB 3.0 Standard-A connector; 9 and 3 for the USB 3.0 Micro-B connector family) and at the same time 0.25A for all the other contacts minimum when measured at an ambient temperature of 25 degrees Celsius. With power applied to the contacts, the delta temperature must not exceed +30 degrees Celsius at any point in the USB 3.0 connectors under test.

7.2.5 Electrostatic Discharge (IEC-801-2)

No evidence of discharge to contacts at 8 kVolts when testing an unmated connector from 1 to 8 kV in 1 kV steps using an 8 mm ball probe.

8. Mechanical and Environmental Requirements

8.1 Mechanical Requirements

8.1.1 Insertion Force (EIA 364-13)

35 N maximum 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. If used, the lubricant may not affect any other characteristic of the system.

8.1.2 Extraction Force (EIA 364-13)

10 N min initial and 8 N min after the specified insertion/extraction, or durability cycles (at a maximum rate of 12.5mm (0.492") per minute).

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

It is recommended to use a non-silicon based lubricant on the latching mechanism to reduce wear. If used the lubricant may not affect any other characteristic of the system.

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

Three different durability ratings are specified: 1500 cycles min, 5000 cycles min, and 10,000 cycles min. Done at a max rate of 200 cycles per hour.

No physical damage to any part of the connector and cable assembly. Meet requirements of additional tests as specified in the test sequences in Section 8.2.

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

Dimension X=3.7x cable diameter and 100 cycles in each of two planes.

No physical damage. No discontinuity over 1 ms during flexing.

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

Subject the cable assembly to a 50 N axial load for a min of one minute while clamping one end of the cable plug.

No physical damage.

8.1.6 Latch Strength

Pull the cable plug from the mated connector with a 66 N min force. No visible physical damage shall occur.

8.1.7 Peel Strength (Reference Only)

Minimum 150N when a soldered receptacle is pulled up from PCB in the vertical direction. No visible physical damages.

8.1.8 Wrenching Strength (Reference Only)

Perpendicular Force Test: This test shall be performed using virgin parts. Perpendicular forces (Fp) are applied to a plug when inserted at a distance (L) of 15mm from the edge of the receptacle. Testing conditions & method should be agreed with all parties. These forces are to four directions (left, right, up, down). Compliant connectors will meet the following force thresholds with the following results:

- No plug or receptacle damage: 0 - 25N

- The plug can be damaged, but in such a way that the receptacle does not sustain damage: 25 - 50N

8.1.9 Lead Co-Planarity

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

8.1.10 Solderability

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

8.1.11 RoHS Compliance

Component is to be RoHS compliant. Lead Free plug and receptacle materials must conform to Directive 2002/95/EC of January 27,2003 on Restriction of Hazardous Substances (RoHS).

8.2 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. The test groups/sequences and durations shall be derived from the following requirements:

- Durability (mating/un-mating) rating of 2500 cycles
- Field temperature: 65 °C
- Field life: 5 years

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 8-1. 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 Section 7.2.1.

8.3 Materials

This specification does not specify materials for connectors and cables. Connector and cable manufactures shall select appropriate materials based on performance requirements. Table 8-2 below is provided for reference only.

Table 8-2. Reference Materials

Component	Materials	Comments
Cable	Conductor: copper with tin plating	
	STP Shield: AL foil	
	Braid: Tin plated copper	
	Jacket: PVC	
Cable Overmold	Thermoset, colored BLUE at the USB 3.0 Standard-A plug end	Color is a requirement
Connector Shell	Copper alloy or stainless steel, depending on durability requirement	
Contact	Base material: Phosphor bronze	
	Under-plating: 2.0 µm Ni	
	Contact area plating: (Min) 0.05 µm Au + (Min) 0.75 µm Ni-Pd	
	Solder tail plating: (Min) 0.05 µm Au	
Housing	Thermoplastics capable of withstanding lead-free soldering temperature.	The USB 3.0 Standard-A housing is required to be BLUE

9. Implementation Notes and Design Guides

The section discusses a few implementation notes and design guides to help users design and use the USB 3.0 connectors and cables.

9.1 Mated Connector Dimensions

Figures 9-1 and 9-2 show the mated plugs and receptacles for the USB 3.0 Standard-A and USB 3.0 Micro-B connectors, respectively. The distance between the receptacle front surface to the cable overmold should be noticed by system designers to avoid interference between the system enclosure and the cable plug overmold.

Provisions must be made in connectors and chassis to ground the connector metal shells to the metal chassis to contain EMI emission.

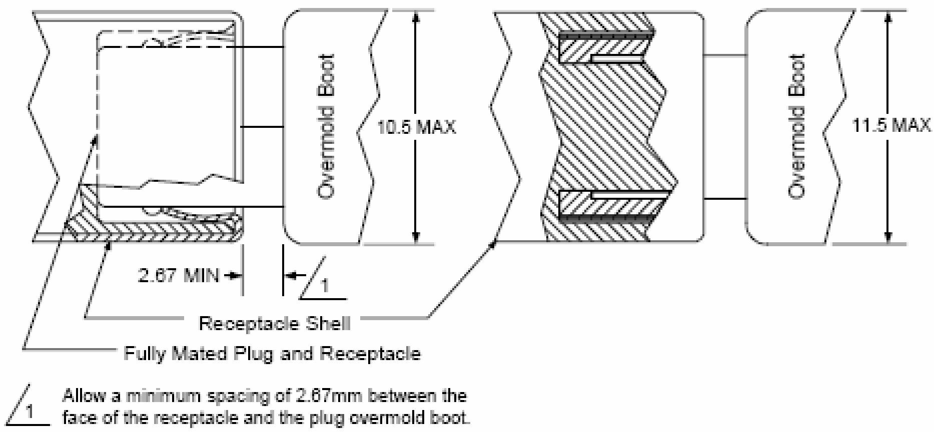


Figure 9-1 Mated USB 3.0 Standard-A connector (placeholder)

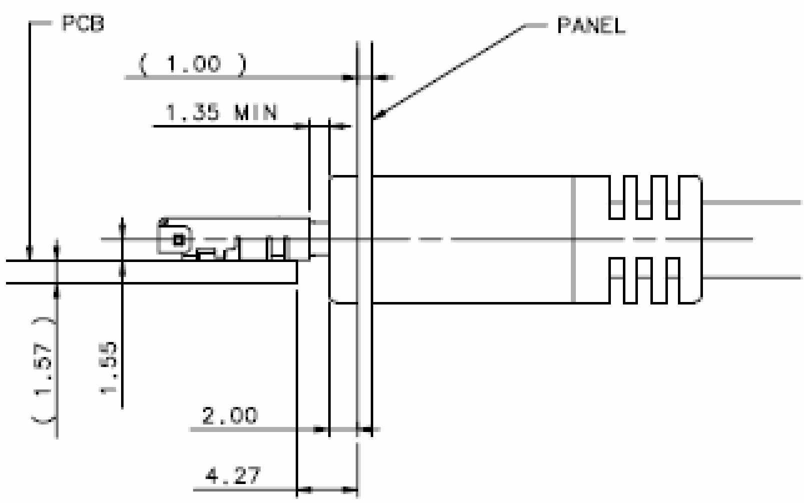


Figure 9-2 Mated USB 3.0 Micro-B connector

9.2 EMI Management

Systems that include the USB 3.0 connectors and cable assemblies must meet the relevant EMI/EMC regulations. Because of the complex nature of EMI, it is difficult to specify a component level EMI test for the cable assemblies. However, connector and cable assembly designers, as well as system implementers must pay a great attention to receptacle and cable plug shielding to ensure a low impedance grounding path. The followings are a few guidelines for EMI management:

- The quality of raw cables must be ensured. The intra-pair skew or the differential to common mode conversion of the SS pairs has a significant impact on cable EMI performance and it must be controlled within the limit 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 can break EMI.
- If not done properly, the wire termination can contribute a lot to differential-to-common-mode conversion. The breakout distance for the wire termination should be kept as small as possible for both EMI and signal integrity. If possible, always maintain symmetry 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. The presence of the friction lock features should not compromise ground return connections.
- It is recommended that the receptacle connectors be designed with a back-shield, as a part of the receptacle connector metal shell. The back-shield should be designed with a short return path to the system ground plane.
- System implementers should ensure that the receptacle connectors be connected to metal chassis or enclosures through grounding fingers, screws, or any other way to mitigate EMI.

9.3 Stacked Connectors

Stacked USB connectors are commonly used in PC systems. Though this specification does not explicitly define the stacked USB 3.0 Standard-A receptacles, they are certainly supported. The following are a few points that should be noticed when designing a stacked USB 3.0 connector:

- A stacked connector introduces additional crosstalks between the stacks. Such crosstalks should be minimized when designing a stacked USB 3.0 connector. The differential NEXT and FEXT should be managed within -32 dB (up to the fundamental frequency 2.5 GHz) between differential pairs across stacks.
- Due to the additional electrical length, the connector on the top stack will generally perform worse than the one on the bottom. Connector designers should carefully design the top contact geometries and materials to minimize impedance discontinuity. Regardless how many stacks one may choose to design, the same electrical requirements defined in Section 7 must be met.

9.4 Captive Cables

The captive cables must still meet the mated connector requirements specified in Section 7 and 8. But a captive cable is not considered a stand-alone component. For electrical budgeting purposes, a captive cable is considered part of a device. The electrical PHY chapter defines the electrical budgets for devices attached with captive cables.

9.5 Direct-plug-in Devices

For a relatively large device that uses the USB 3.0 Micro-B receptacle, there might be a need to protect the mated USB 3.0 Micro-B connector in case of user “abuse”. While the connector itself has to meet the mechanical strength requirements defined in Section 8, there are other ways to help protect the connector. One example would be to use the bezel on the device and the overmold on the cable assembly; a small clearance between the overmold and bezel will protect the connector from excessive wiggling of the cable assembly. Note that the bezel opening depth should be so designed to still allow the finger space to unplug the cable assembly.

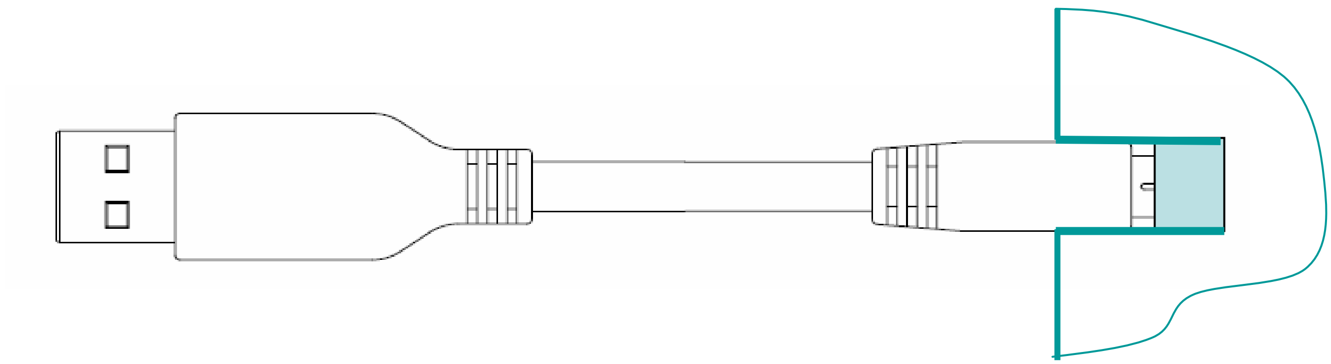


Figure 9-3 An Example to Use Bezel and Overmold to Protect Mated Connector