USB 3.0 INTERNAL CONNECTOR AND CABLE SPECIFICATION

Revision 1.0

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REVISION HISTORY

Date	Specification Version	Revisions
05-22-2009	Rev. 0.0	Initial Draft
06-30-2009	Rev. 0.2	Rev 0.2, electrical specification.
08-16-2009	Rev. 0.4	Rev 0.4, electrical specification, mechanical specification
12-12-2009	Rev 0.8	Rev 0.8 Modified electrical specification
02-1-2010	Rev 0.9	Editorial
05-1-2010	Rev 0.95	Fixed a typo in Figure 3-1
07-20-2010	Rev 1.0 Draft	Slight changes in electrical spec and drawing cleanups
08-20-2010	Rev 1.0	Insertion loss is changed from 2.5 db to 3.0 dB at 2.5 GHz

CONTENTS

1. INTRODUCTION

Desktop PC's typically have USB ports on the front-panel of the enclosure. Internal cable assemblies are usually used to connect the external USB ports on the front panel to the motherboard.

The internal cable assembly may connect the motherboard to the external USB ports via a daughter card, bringing the necessary signals to the USB ports. The USB standard-A connector is mounted on the daughter card, accessible to an end-user from the front of a chassis. Figure 1-1 illustrated the USB 3.0 interconnect topology.

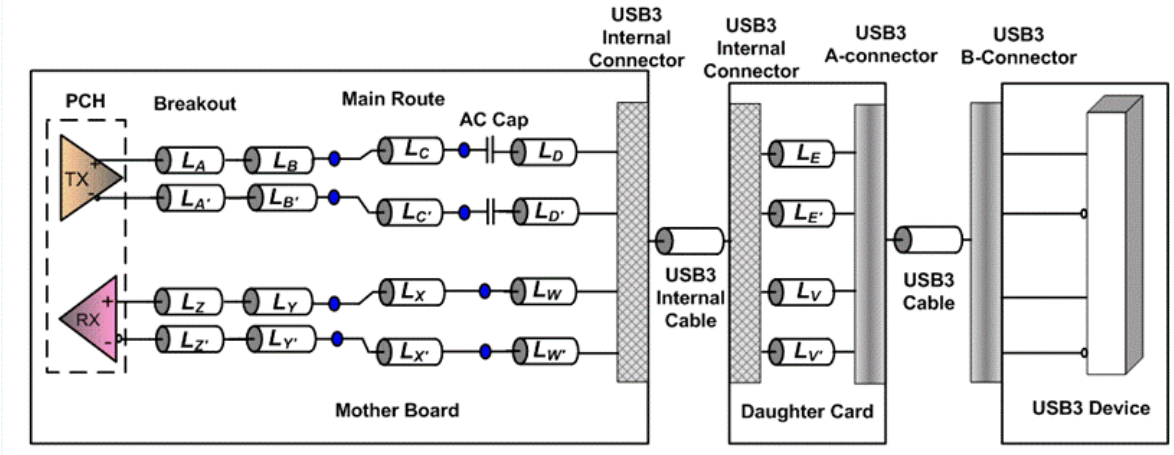


Figure 1-1: USB 3.0 interconnect topology with internal cable

Alternatively, the internal cable assembly may directly connect to the external USB ports, the Standard-A connectors, without the daughter card.

This document describes the internal cable interface for USB 3.0 implementation in desktop. It focuses on the electrical and mechanical requirements of the connector and cable assembly. The detailed daughter card or direct-cable implementation is out of the scope of this documentation.

2. ELECTRICAL SPECIFICATIONS

The Electrical Specification describes the cable connector interface pin out, signal integrity, and other electrical requirements.

2.1 Signal Descriptions and Pin Assignments

For the purpose of discussion, it is assumed that the front-panel implementation involves a daughter card. The USB 3.0 internal cable connector A, or USB3 ICC A, is mounted on the motherboard, while the USB 3.0 internal cable connector B, or USB3 ICC B, is mounted on the daughter card.

Figure 2-1 illustrates the USB3 ICC pin numbering. Note that the connector included two USB ports.

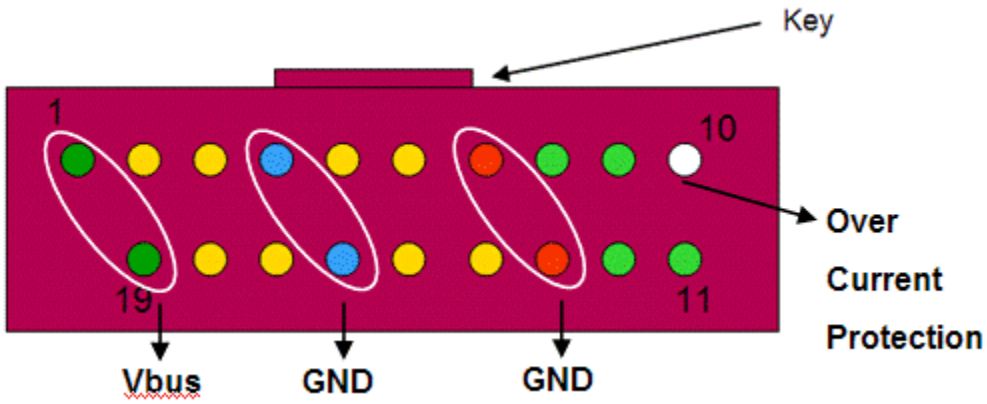


Figure 2-1: USB3 ICC pin numbering

Users may choose to include more or less USB ports by expanding or reducing the pin and wire counts. This document covers only the base unit with two USB ports.

The connector signal names and pin descriptions are given in Table 2-1 and Table 2-2, respectively for the motherboard (A-side) and the daughter card (B-side) connector. The pin connections diagram is given in Table 2-3.

Table 2-1: USB3 ICC A Pin Assignment and Description

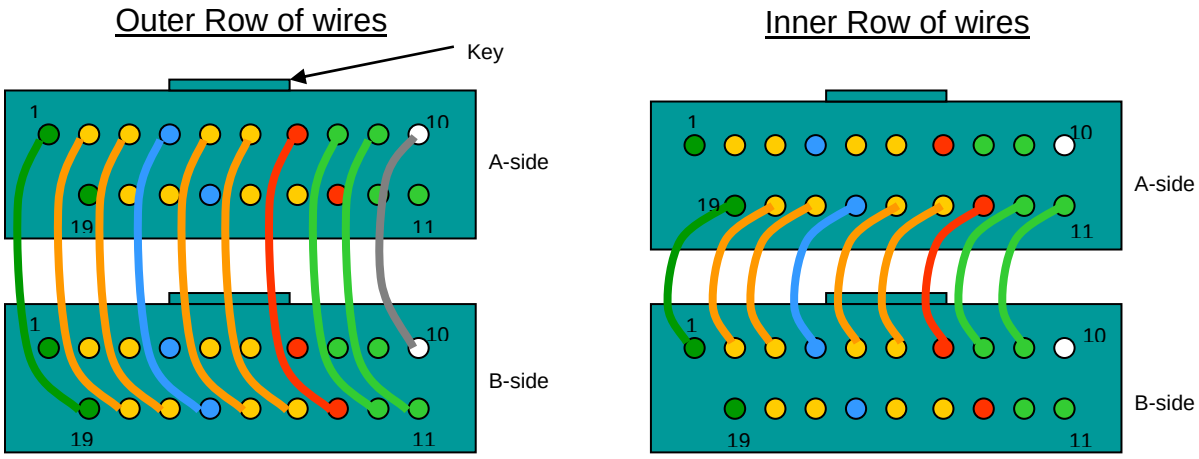
Pin No.	Signal	Description
1	Vbus	Power
2	IntA_P1_SSRX-	USB3 ICC Port1 SuperSpeed Rx-
3	IntA_P1_SSRX+	USB3 ICC Port1 SuperSpeed Rx+
4	GND	GND
5	IntA_P1_SSTX-	USB3 ICC Port1 SuperSpeed Tx-
6	IntA_P1_SSTX+	USB3 ICC Port1 SuperSpeed Tx+
7	GND	GND
8	IntA_P1_D-	USB3 ICC Port1 D- (USB2 Signal D-)
9	IntA_P1_D+	USB3 ICC Port1 D+ (USB2 Signal D+)
10	ID	Over Current Protection
11	IntA_P2_D+	USB3 ICC Port2 D+ (USB2 Signal D+)
12	IntA_P2_D-	USB3 ICC Port2 D- (USB2 Signal D-)
13	GND	GND
14	IntA_P2_SSTX+	USB3 ICC Port2 SuperSpeed Tx+
15	IntA_P2_SSTX-	USB3 ICC Port2 Super Speed Tx-
16	GND	GND
17	IntA_P2_SSRX+	USB3 ICC Port2 SuperSpeed Rx+
18	IntA_P2_SSRX-	USB3 ICC Port2 SuperSpeed Rx-
19	Vbus	Power

Table 2-2: USB3 ICC B Pin Assignment and Description

Pin No.	Signal	Description
1	Vbus	Power
2	IntA_P2_SSRX-	USB3 ICC Port2 SuperSpeed Rx-
3	IntA_P2_SSRX+	USB3 ICC Port2 SuperSpeed Rx+
4	GND	GND
5	IntA_P2_SSTX-	USB3 ICC Port2 SuperSpeed Tx-
6	IntA_P2_SSTX+	USB3 ICC Port2 SuperSpeed Tx+
7	GND	GND
8	IntA_P2_D-	USB3 ICC Port2 D- (USB D-)
9	IntA_P2_D+	USB3 ICC Port2 D+ (USB D+)
10	ID	Over Current Protection
11	IntA_P1_D+	USB3 ICC Port1 D+ (USB Signal D+)
12	IntA_P1_D-	USB3 ICC Port1 D- (USB Signal D-)
13	GND	GND

14	IntA_P1_SSTX+	USB3 ICC Port1 SuperSpeed Tx+
15	IntA_P1_SSTX-	USB3 ICC Port1 SuperSpeed Tx-
16	GND	GND
17	IntA_P1_SSRX+	USB3 ICC Port1 SuperSpeed Rx+
18	IntA_P1_SSRX-	USB3 ICC Port1 SuperSpeed Rx-
19	Vbus	Power

Table 2-3: Pin connection diagram and table



Pin No. Motherboard header	Cable	Pin No. Daughter card header
1	Power, Discrete wire	19
2	USB3 SuperSpeed Rx, differential shielded pair	18
3		17
4	GND, Drain wire	16
5	USB3 SuperSpeed Tx, differential shielded twist pair	15
6		14
7	GND, Discrete wire	13
8	USB2 differential wire	12
9		11
10	Over current protection, Discrete	10
11	USB differential wire	9
12		8
13	GND, Discrete wire	7
14	USB3 SuperSpeed Tx, differential shielded pair.	6
15		5
16	GND, Drain wire	4
17	USB3 Super speed Rx, differential shielded pair.	3
18		2
19	Power, Discrete wire	1

2.2 Signal Integrity Requirements

This section specifies the signal integrity requirements for the USB 3.0 internal SuperSpeed signals. Unless otherwise specified, the requirements are for the entire signal path of the mated cable assembly, from the connector through-holes on the motherboard to the connector through-holes on the daughter card, not including PCB traces, as illustrated in Figure 2-1; the measurement is between TP1 (test point 1) and TP2 (test point 2).

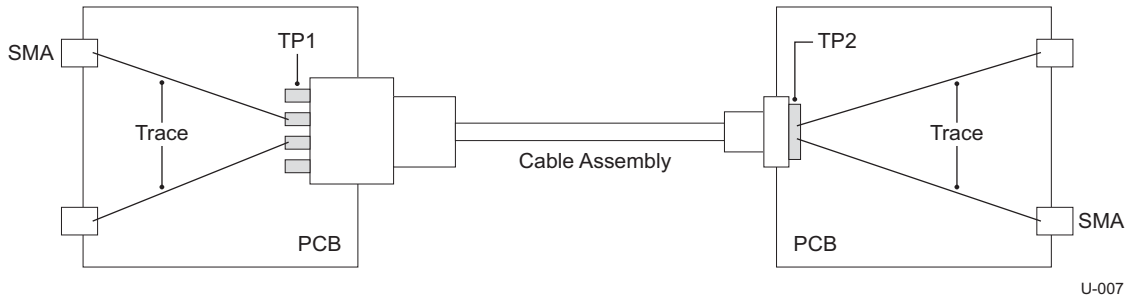


Figure 2-1: Illustration of Test Points for a Mated Cable Assembly

For proper measurements, the connectors shall be mounted on a test fixture. The test fixture shall have uncoupled access traces from SMA to the test points, preferably with 50 Ω +/-7% Ω single-ended characteristic impedance. All non-ground pins that are adjacent but not connected to measurement ports shall be terminated with 50 Ω loads.

The test fixture shall at least have the *thru* calibration structure to remove the fixture loss effect in the frequency domain measurement. For time domain measurements, removing the fixture loss effect is not required. However, the insertion loss of the thru must be no greater than 1.7 dB. In addition, the fixture shall also have an appropriate structure to verify the risetime entering the connector under test.

Note that signals shall be launched into the connector from the bottom of the PCB to minimize the through-hole stub effect.

2.2.1 Mated Connector

The differential impedance of a mated connector shall be within 78 ohm and 105 ohm, as seen from a 50 ps (20%-80%) risetime of a differential TDR at the connector. Figure 2-2 illustrates the impedance limits of a mated connector. The impedance profile of a mated connector must fall within the limits shown in Figure 2-2. Note that the impedance profile of the mated connector is defined from the receptacle footprints through the plug cable termination area.

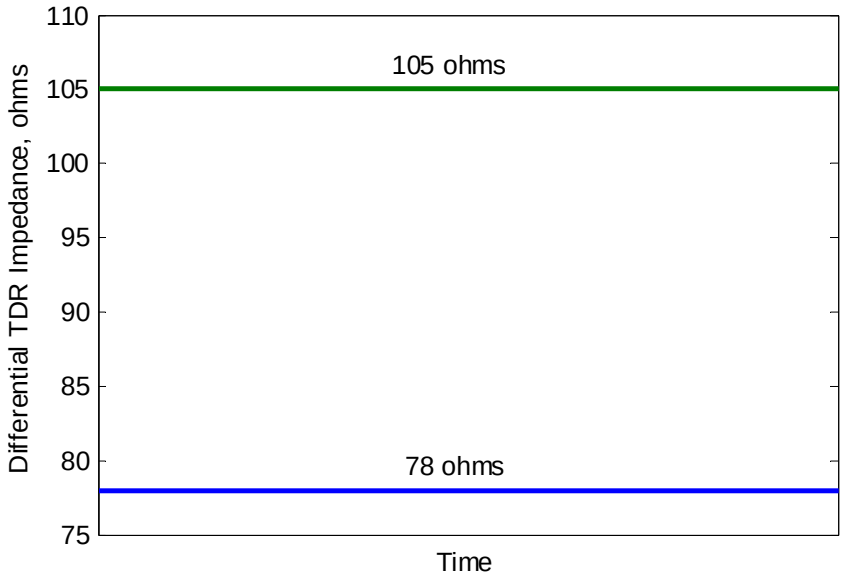


Figure 2-2: Impedance Limits of a Mated Connector

2.2.2 Mated Cable Assemblies

A mated cable assembly refers to a cable assembly mated with the corresponding receptacles mounted on a test board fixture at the both ends of the cable.

2.2.2.1 Differential Insertion Loss

The differential insertion loss, SDD21, measures the differential signal energy transmitted through the mated cable assembly. Figure 2-3 shows the differential insertion loss limit, defined by the following vertices: (100 MHz, -1 dB), (2.5GHz, -3.0 dB), and (7.5GHz, -14.0 dB). The measured differential insertion loss of a mated cable assembly must be above or on the differential insertion loss limit. Note again that the requirement is for the mated cable assembly only, not including fixture; the simple thru, or more sophisticated TRL calibration may be used to remove the fixturing effect.

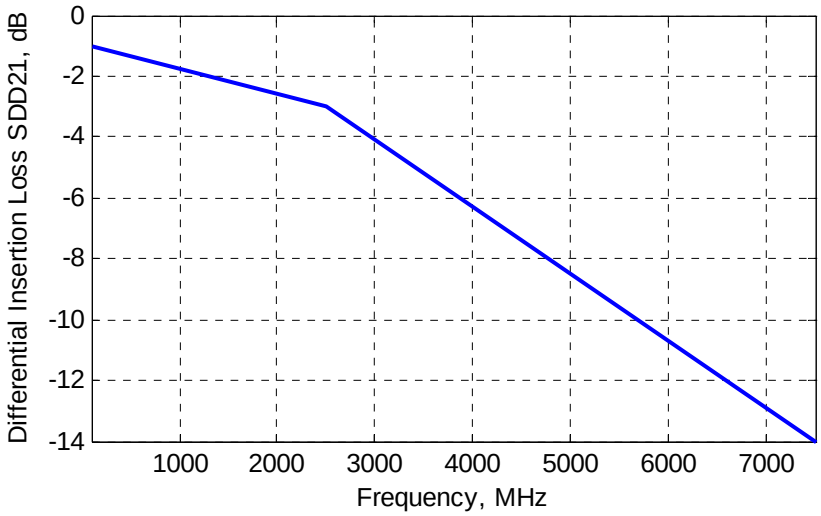


Figure 2-3: Differential Insertion Loss Requirement

2.2.2.2 Differential Near-End Crosstalk between SuperSpeed Pairs

The differential crosstalk measures the unwanted coupling between differential pairs. Figure 2-4 illustrated the differential pair coupling diagram.

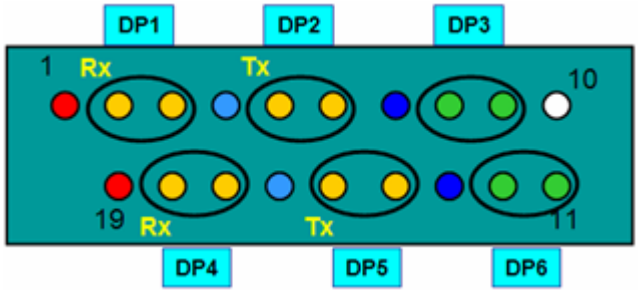


Figure 2-4: Differential pair coupling diagram

The differential near-end crosstalk is required for the TX-RX pairs DP1-DP2, DP4-DP5 and DP2-DP4. The differential near-end crosstalk shall be measured in the time-domain with TDT in differential mode and the risetime shall be verified to be 50 ps (20-80%) at the connector under test. The measured crosstalk shall be no greater than 0.9%, peak to peak, as illustrated in Figure 2-5.

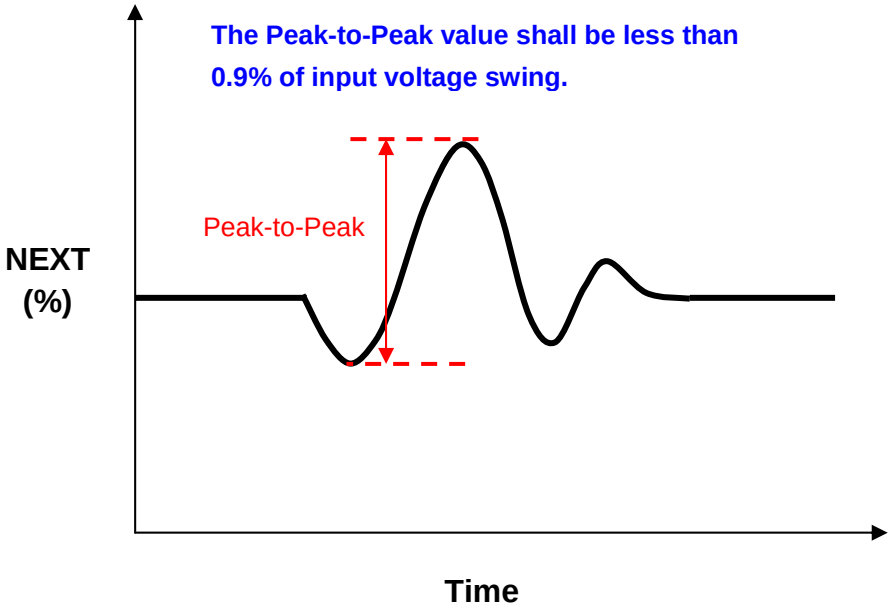


Figure 2-5: Illustration of peak-to-peak crosstalk

2.2.2.3 Differential Far-end Crosstalk between SuperSpeed Pairs

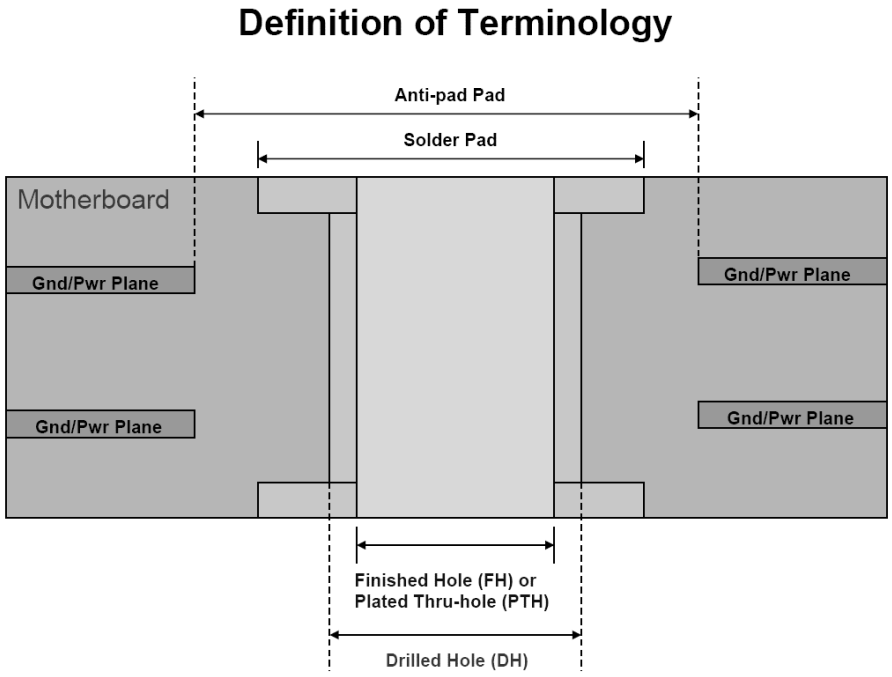
The differential far-end crosstalk is required for all the TX-to-TX and RX-to-RX SuperSpeed pairs. The differential far-end crosstalk shall be measured in the time-domain with TDT in differential mode and the risetime shall be verified to be 50 ps (20-80%) entering the connector under test. The measured crosstalk shall be no greater than 1.85%, peak to peak.

2.2.2.4 Intra-Pair Skew

The intra-pair skew of the mated cable assembly shall be controlled to be less than 15 ps. The measurement shall be done with a TDT in differential mode for each of the SuperSpeed pairs with a 50 ps (20-80%) risetime. The propagation delay of each line in a differential pair at the 50% crossing shall be measured and the delay difference reported as the intra-pair skew.

2.3 Connector Via and Anti Pad Requirements

Since the impedance control of the USB 3.0 internal connector is critical to USB 3.0 channel performance, it is important to meet connector via requirements shown in Figure 2-6.



FH or PTH (Finished Hole)	Solder Pad	Anti Pad Size
0.8 mm (31 mils)	<=1.17 mm (46 mils)	>=1.65 mm (65 mil) for SuperSpeed pins 1.47 mm (58 mil) for other pins

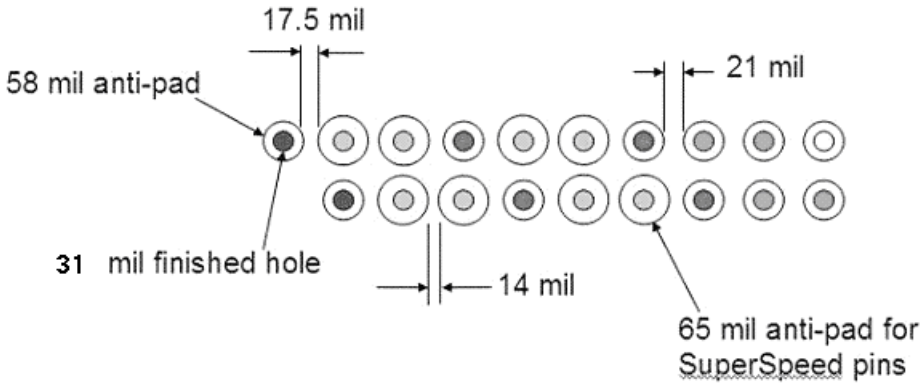


Figure 2-6: Connector Via and Anti-Via requirements

Signals shall be launched into the connector from the bottom of the PCB to minimize the through-hole stub effect. Smaller hole and pad sizes are preferred for signal integrity purposes, as long as board assembly DFM (Design for Manufacturing) rules allow.

2.4 EMI Requirement

Host systems that implement USB 3.0 front panel connector and cable assembly must meet the relevant FCC EMI requirements.

2.5 Other Electrical Requirements

Table 2-4 lists the other electrical requirements that the cable assembly must meet, including the low-level contact resistance and current rating.

Table 2-4: Other Electrical Requirements

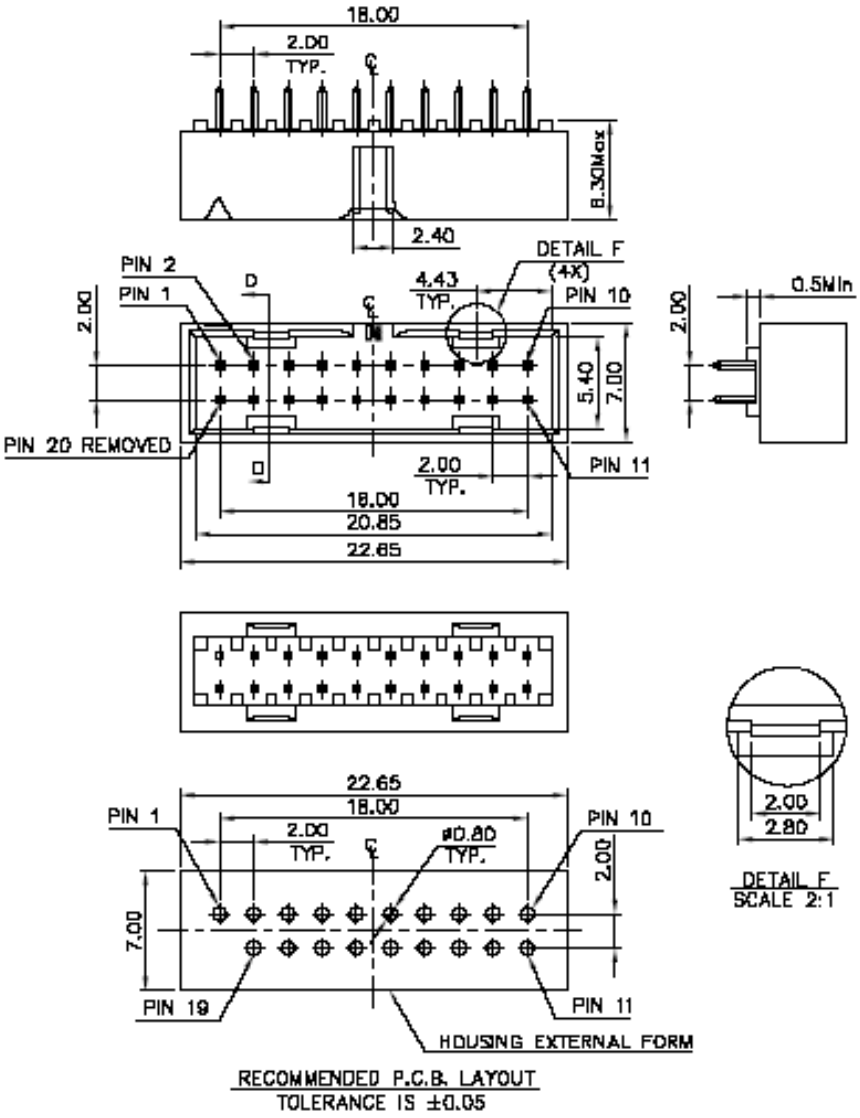
Parameter	Procedure	Requirements
Contact Resistance (LLCR)	EIA 364- 23B Subject mated contacts assembled in housing to 20 mV max open circuit at 100 mA max	Initial: 30 mΩ max for a mated connector Final (after stress): 50 mΩ max (allowable resistance change: 20 mΩ)
Current rating	EIA 364-70 method 2 Test the mated cable assembly: 1. The sample size is a minimum of three mated connectors. 2. The sample shall be soldered on a PCB board with the appropriate footprint. 3. Wire all the voltage and all the ground pins in a series circuit. 4. A thermocouple of 30 AWG or less shall be placed to as close to the mating contact as possible. 5. Conduct a temperature rise vs. current test.	0.5 A per pin minimum for signals; 1.5 A per pin minimum for VBUS. The temperature rise above ambient shall not exceed 30 °C. The ambient condition is still air at 25 °C.

3. MECHANICAL SPECIFICATIONS

The cable assembly mechanical specification defines the cable assembly interface dimensions, header footprint, and mechanical performance requirements, such as durability, mating/unmating forces.

3.1 Header

The USB 3.0 Internal cable assembly connects the motherboard and daughter card together via connectors. The vertical connector mounted on the PCB is referred to as the header. Figure 3-1 shows the header mechanical interface dimensions.



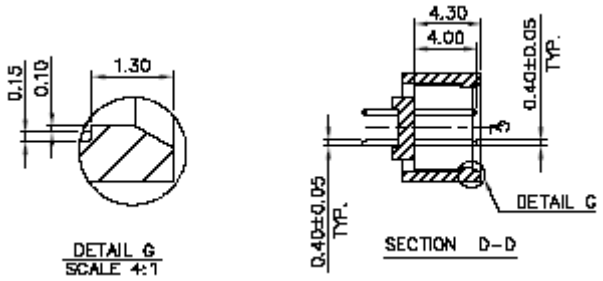
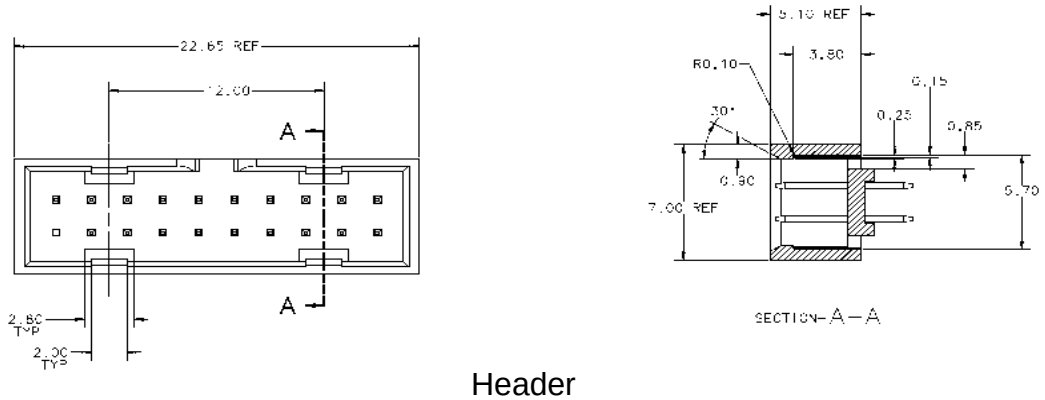


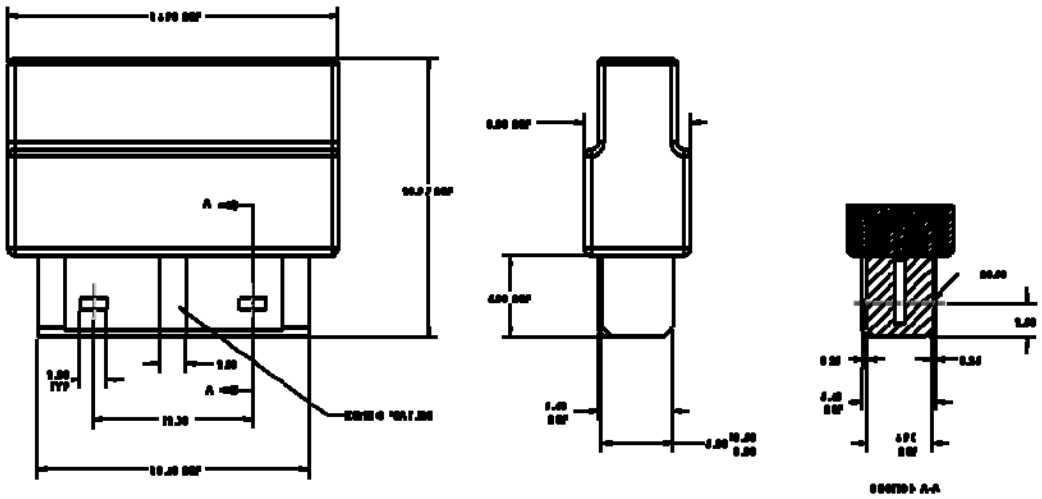
Figure 3-1: Header interface dimensions

3.2 Cable Plug

Figure 3-2 shows some reference dimensions for the header and outline dimensions for the cable plug. The mating interface dimensions of the plug can be derived from header dimensions. Note that the indent features defined in the header housing are for mechanical retention when the plug is mated with the header. Figure 3-3 shows the nominal contact point location when the plug is in the header.



Header



Plug

Figure 3-2: Header and cable plug dimensions

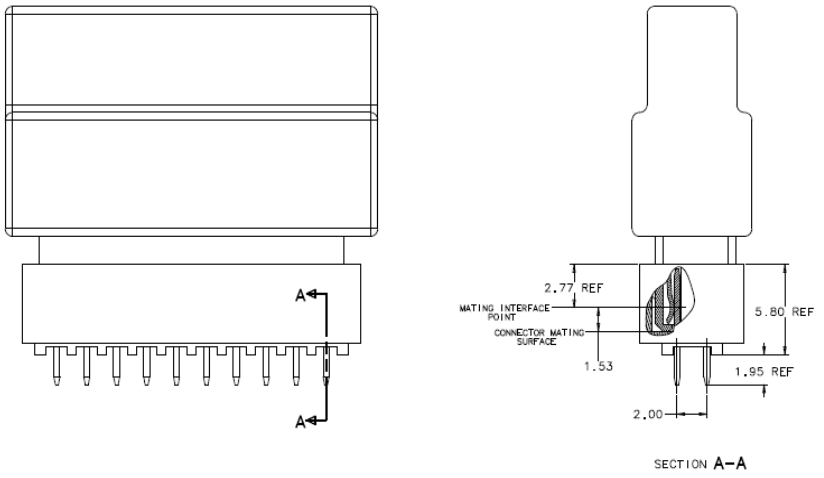


Figure 3-3: Header and cable plug contact location

3.3 Cable

This specification defines only the form, fit, and function of the cable assembly. Thus, the specific cable construction is up to each connector and cable assembly manufacturer. The following cable requirements and/or guidelines apply:

- The maximum cable assembly length shall not exceed 457.2 mm (18″). For most small form factor systems, a 12″ is recommended.
- To ensure the cable flexibility, the cable shall be able to be bent to a radius less than 25.4 mm (1.0″).
- The raw cable impedance should be managed to be within 90+/-7 ohms.

3.4 Mechanical Requirements and Tests

Table 3-1 lists the USB 3.0 internal cable mechanical requirements.

Table 3-1: Cable assembly mechanical requirements

Parameter	Procedure	Requirements
Mating force	EIA 364-13 Measure the force necessary to mate the connector assemblies at a max rate of 12.5 mm per minute.	35 N max
Unmating force	EIA 364-13 Measure the force necessary to unmate the connector assemblies at a max rate of 12.5 mm per minute.	15 N min
Durability	EIA 364-09 25 cycles. Done at a max rate of 200 cycles per hour.	No physical damage to any part of the connector and cable assembly.
Cable flexing	EIA 364-41 Condition I Dimension X=5.5x cable diameter. 50 cycles in each of two planes	No physical damage. No discontinuity over 1 ms during flexing.
Visual and dimensional inspection	EIA 364- 18 Visual, dimensional and functional inspection per applicable quality inspection plan.	Meets product drawing requirements
Flammability	UL 94V-1	Material certification or certificate of compliance required with each lot to satisfy the Underwriters Laboratories follow-up service requirements.
Lead-free soldering		Contact finish and header housing material be compatible with lead-free soldering process.

Special attention shall be paid to the unmating force. Since there is no positive retention mechanism defined for the cable assembly, the unmating force between the cable connector and header is the only mechanism to retain the cable assembly during shock and vibration.

3.5 System Shock and Vibration requirements

The mated cable assembly shall pass the system level shock and vibration tests to be performed by system OEMs. The table below specifies the baseline shock and vibration requirements. Variation from those baseline requirements is allowed at each OEM's discretion.

Table 3-2: Baseline Shock and Vibration Requirements

Test Name	Description	Requirements
System level Shock, unpackaged	30G trapezoidal, 170 in/second; 3 drops in each of the 6 axes.	No visible damage. No displacement of components, cable, or hardware. The product must operate normally after the completion of the stress.
System level vibration, unpackaged	Random profile: 5 Hz @ 0.001 g^2 / Hz to 20 Hz @ 0.01 g^2/Hz (slope up); 20 Hz to 500 Hz @ 0.01 g^2 / Hz (flat). Input acceleration is 2.20 g RMS. 10 minutes per axis for all 3 axes.	No visible damage. No displacement of the cable interface. No more than one intermittent failure during random vibration stress. The product must operate normally after the completion of the stress.

3.6 Additional Requirements

This document does not attempt to specify all the requirements for the USB 3.0 internal connector and cable assembly. Specifying additional requirements, for example, the environmental requirements, is up to the OEMs and/or end users.