USB 2.0 Specification Engineering Change Notice (ECN) #1: Mini-B connector
Date: 10/20/2000

Reason for ECN:
The USB 2.0 specified device-side connector – the B connector – is too large for use with a new generation of handheld and mobile devices, e.g., cell phones which would benefit from connectivity to the PC. This ECN incorporates a specification of a device-side mini connector (hereafter referred to as a mini-B connector). The new connector only applies to upstream facing ports, i.e., connectors on devices.

Summary of ECN:
The bulk of the ECN specifies the mechanical requirements for the mini-B plug, receptacle and cable assembly. It also identifies the usage scope of this connector. The last part of the ECN describes the minimum test criteria and performance requirements for the new connector.

Benefits of ECN:
The ECN enables standardization of miniature device-side USB connectors and consequent economies of scales and lower cost for a new and growing class of devices which will benefit from connectivity to the PC. The standardization also allows leveraging of the compliance test and certification model which is already in place for USB connectors.

Assessment of Impact on Current Specification and Current USB Products:
The connector specified in the ECN will not have any impact on hardware or software of existing USB products. The current USB spec already allows for vendor-specific device side connectors – such cable assemblies are called captive assemblies. All that the ECN does is to identify one such connector for use in devices which need the smaller size of connector. There is a potential for some end-user confusion because of two standard cable options; but this can be mitigated by appropriate end-user education.

Structure of ECN:
The ECN is in the form of a new Chapter 6 with the mini-B connector requirements inserted into the appropriate locations. This format enables specification of the new connector in context.

Chapter 6
Mechanical

This chapter provides the mechanical and electrical specifications for the cables, connectors, and cable assemblies used to interconnect USB devices. The specification includes the dimensions, materials, electrical, and reliability requirements. This chapter documents minimum requirements for the external USB interconnect. Substitute material may be used as long as it meets these minimums.

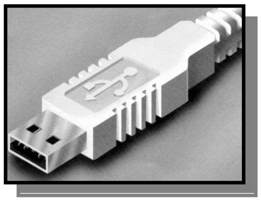
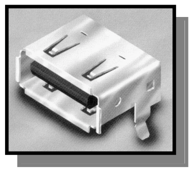
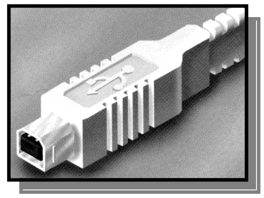
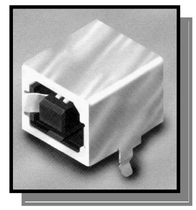
6.1 Architectural Overview

The USB physical topology consists of connecting the downstream hub port to the upstream port of another hub or to a device. The USB can operate at three speeds. High-speed (480 Mb/s) and full-speed (12 Mb/s) require the use of a shielded cable with two power conductors and twisted pair signal conductors. Low-speed (1.5 Mb/s) recommends, but does not require the use of a cable with twisted pair signal conductors.

The connectors are designed to be hot plugged. The USB Icon on the plugs provides tactile feedback making it easy to obtain proper orientation.

6.2 Keyed Connector Protocol

To minimize end user termination problems, USB uses a “keyed connector” protocol. The physical difference in the Series “A” and “B” (or “mini-B”) connectors insures proper end user connectivity. The “A” connector is the principle means of connecting USB devices directly to a host or to the downstream port of a hub. All USB devices must have the standard Series “A” connector specified in this chapter. The “B” (or “mini-B”) ~~“B”~~ connector allows device vendors to provide a standard detachable cable. This facilitates end user cable replacement. Figure 6-1~~Figure 6-1~~ illustrates the keyed connector protocol.

Series "A" Connectors	Series "B" Connectors
♦ Series "A" plugs are always oriented **upstream** towards the *Host System*  **"A" Plugs** (*From the USB Device*) **"A" Receptacles** (*Downstream Output from the USB Host or Hub*) 	♦ Series "B" plugs are always oriented **downstream** towards the *USB Device*  **"B" Plugs** (*From the Host System*) **"B" Receptacles** (*Upstream Input to the USB Device or Hub*) 

	Series "mini-B" Connectors
	♦ Series "mini-B" plugs are always oriented **downstream** towards the *USB Device*  **"mini-B" Plugs** (*From the Host System*) **"mini-B" Receptacles** (*Upstream Input to the USB Device or Hub*) 

Figure 6-1. Keyed Connector Protocol

The following list explains how the plugs and receptacles can be mated:

- Series "A" receptacle mates with a Series "A" plug. Electrically, Series "A" receptacles function as outputs from host systems and/or hubs.
- Series "A" plug mates with a Series "A" receptacle. The Series "A" plug always is oriented towards the host system.
- Series "B" receptacle mates with a Series "B" plug (male). Electrically, Series "B" receptacles function as inputs to hubs or devices.
- Series "B" plug mates with a Series "B" receptacle. The Series "B" plug is always oriented towards the USB hub or device.
- Series "mini-B" receptacle mates with a Series "mini-B" plug (male). Electrically, Series "mini-B" receptacles function as inputs to hubs or devices.
- Series "mini-B" plug mates with a Series "mini-B" receptacle. The Series "mini-B" plug is always oriented towards the USB hub or device.

6.3 Cable

USB cable consists of four conductors, two power conductors, and two signal conductors.

High-/full-speed cable consists of a signaling twisted pair, VBUS, GND, and an overall shield. High-/full-speed cable must be marked to indicate suitability for USB usage (see Section 6.6.2). High-/full-speed cable may be used with either low-speed, full-speed, or high-speed devices. When high-/full-speed cable is used with low-speed devices, the cable must meet all low-speed requirements.

Low-speed recommends, but does not require the use of a cable with twisted signaling conductors.

6.4 Cable Assembly

This specification describes three USB cable assemblies: standard detachable cable, high-/full-speed captive cable, and low-speed captive cable.

A standard detachable cable is a high-/full-speed cable that is terminated on one end with a Series "A" plug and terminated on the opposite end with a series "B" (or "mini-B") ~~"B"~~ plug. A high-/full-speed captive cable is terminated on one end with a Series "A" plug and has a vendor-specific connect means (hardwired or custom detachable) on the opposite end for the high-/full-speed peripheral. The low-speed captive cable is terminated on one end with a Series "A" plug and has a vendor-specific connect means (hardwired or custom detachable) on the opposite end for the low-speed peripheral. Any other cable assemblies are prohibited.

The color used for the cable assembly is vendor specific; recommended colors are white, grey, or black.

6.4.1 Standard Detachable Cable Assemblies

High-speed and full-speed devices can utilize the "B" (or "mini-B") ~~"B"~~ connector. This allows the device to have a standard detachable USB cable. This eliminates the need to build the device with a hardwired cable and minimizes end user problems if cable replacement is necessary.

Devices utilizing the "B" (or "mini-B") ~~"B"~~ connector must be designed to work with worst case maximum length detachable cable. Standard detachable cable assemblies may be used only on high-speed and full-speed devices. Using a high-/full-speed standard detachable cable on a low-speed device may exceed the maximum low-speed cable length.

Figure 6-2~~Figure 6-2~~ and Figure 6-3 illustrate~~s~~ ~~a~~ standard detachable cable assembl~~y~~ies.

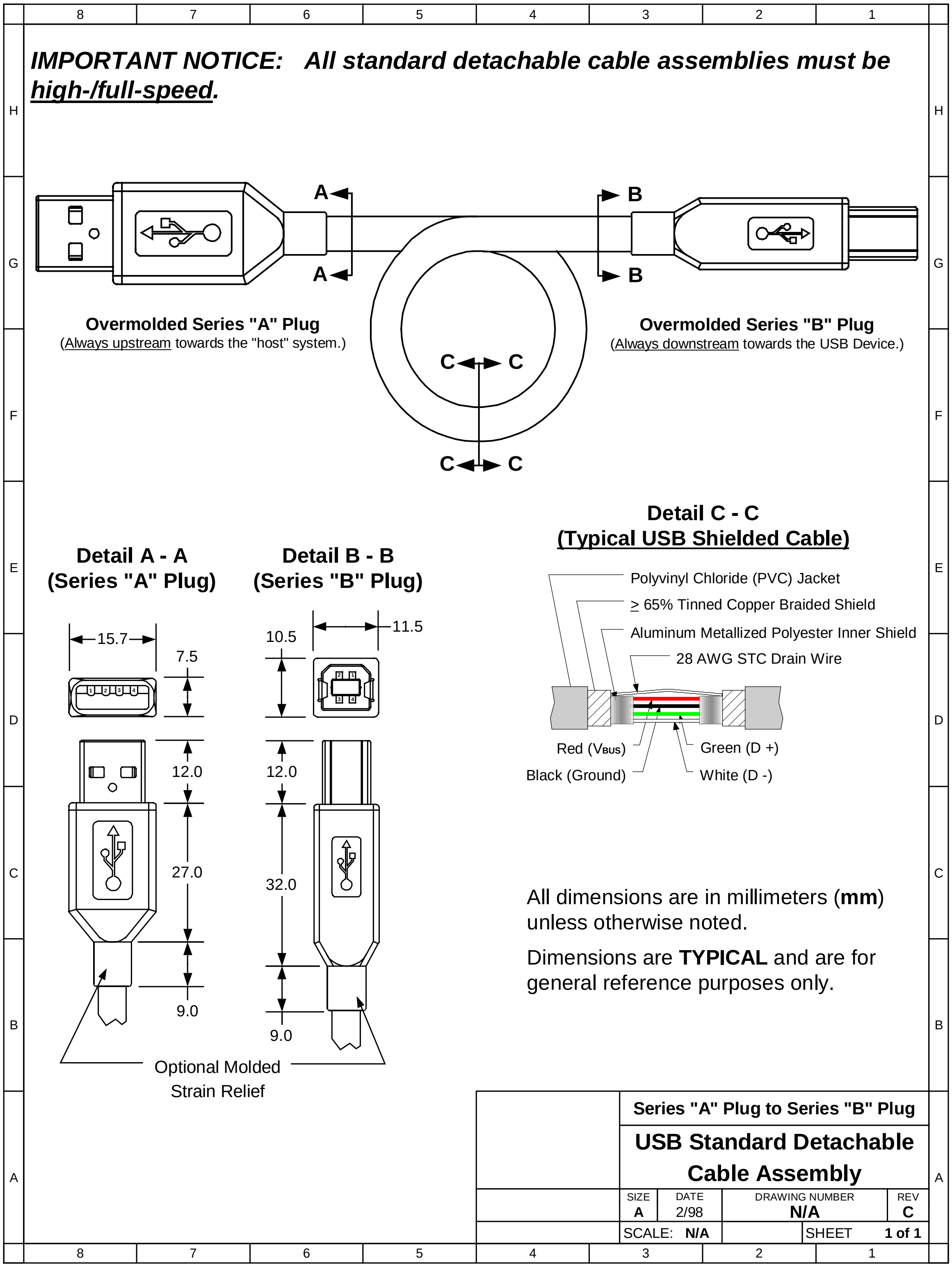


Figure 6-22. USB Standard Detachable Cable Assembly

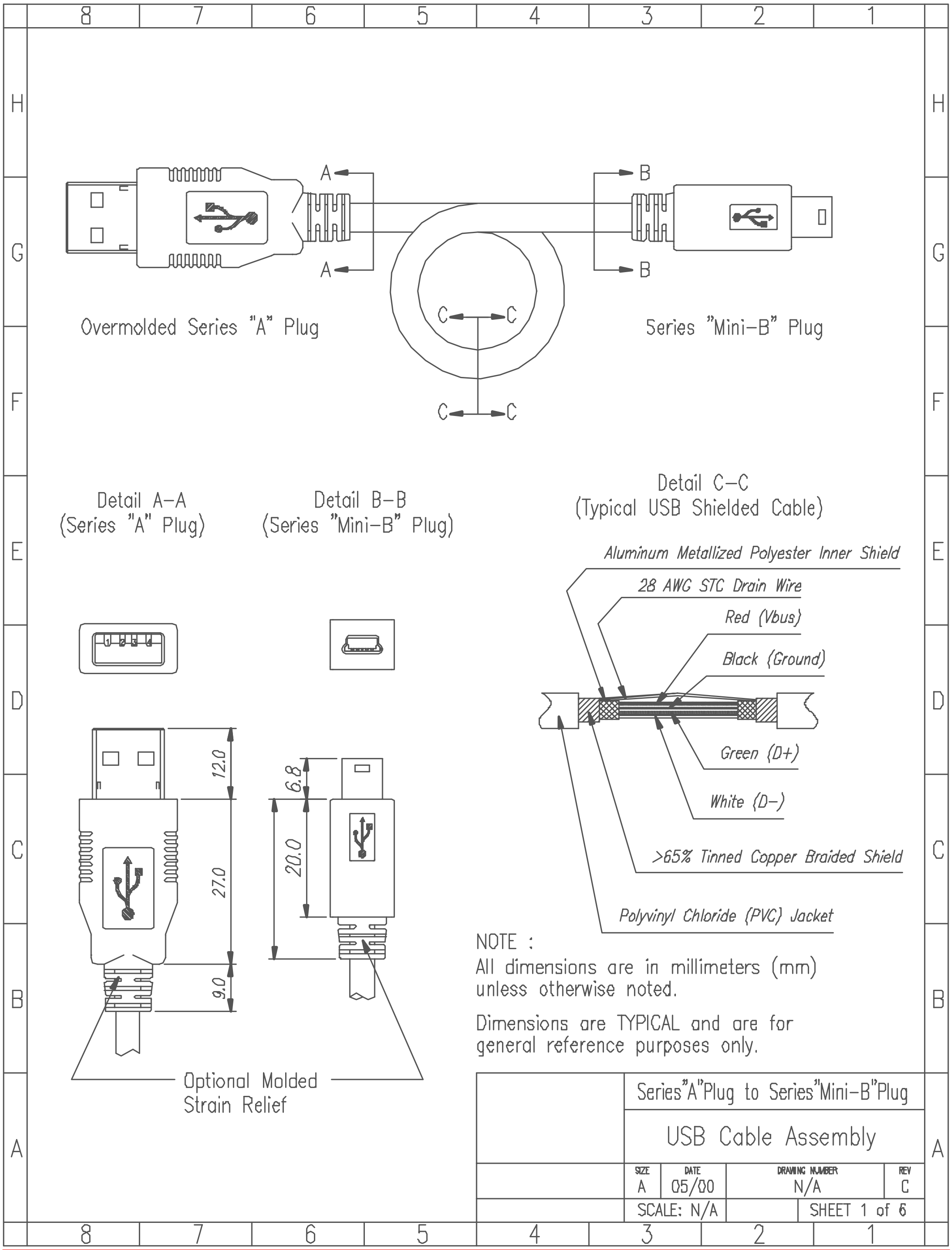


Figure 6-3. USB Standard Mini-connector Detachable Cable Assembly

Standard detachable cable assemblies must meet the following electrical requirements:

- The cable must be terminated on one end with an overmolded Series "A" plug and the opposite end is terminated with an overmolded Series "B" (or "mini-B") "B" plug.
- The cable must be rated for high-speed and full-speed.
- The cable impedance must match the impedance of the high-speed and full-speed drivers. The drivers are characterized to drive specific cable impedance. Refer to Section 7.1.1 for details.
- The maximum allowable cable length is determined by signal pair attenuation and propagation delay. Refer to Sections 7.1.14 and 7.1.17 for details.
- Differences in propagation delay between the two signal conductors must be minimized. Refer to Section 7.1.3 for details.
- The GND lead provides a common ground reference between the upstream and downstream ports. The maximum cable length is limited by the voltage drop across the GND lead. Refer to Section 7.2.2 for details. The minimum acceptable wire gauge is calculated assuming the attached device is high power.
- The VBUS lead provides power to the connected device. For standard detachable cables, the VBUS requirement is the same as the GND lead.

6.4.2 High-/full-speed Captive Cable Assemblies

Assemblies are considered captive if they are provided with a vendor-specific connect means (hardwired or custom detachable) to the peripheral. High-/full-speed hardwired cable assemblies may be used with either high-speed, full-speed, or low-speed devices. When using a high-/full-speed hardwired cable on a low-speed device, the cable must meet all low-speed requirements.

Figure 6-3 Figure 6-4 illustrates a high-/full-speed hardwired cable assembly.

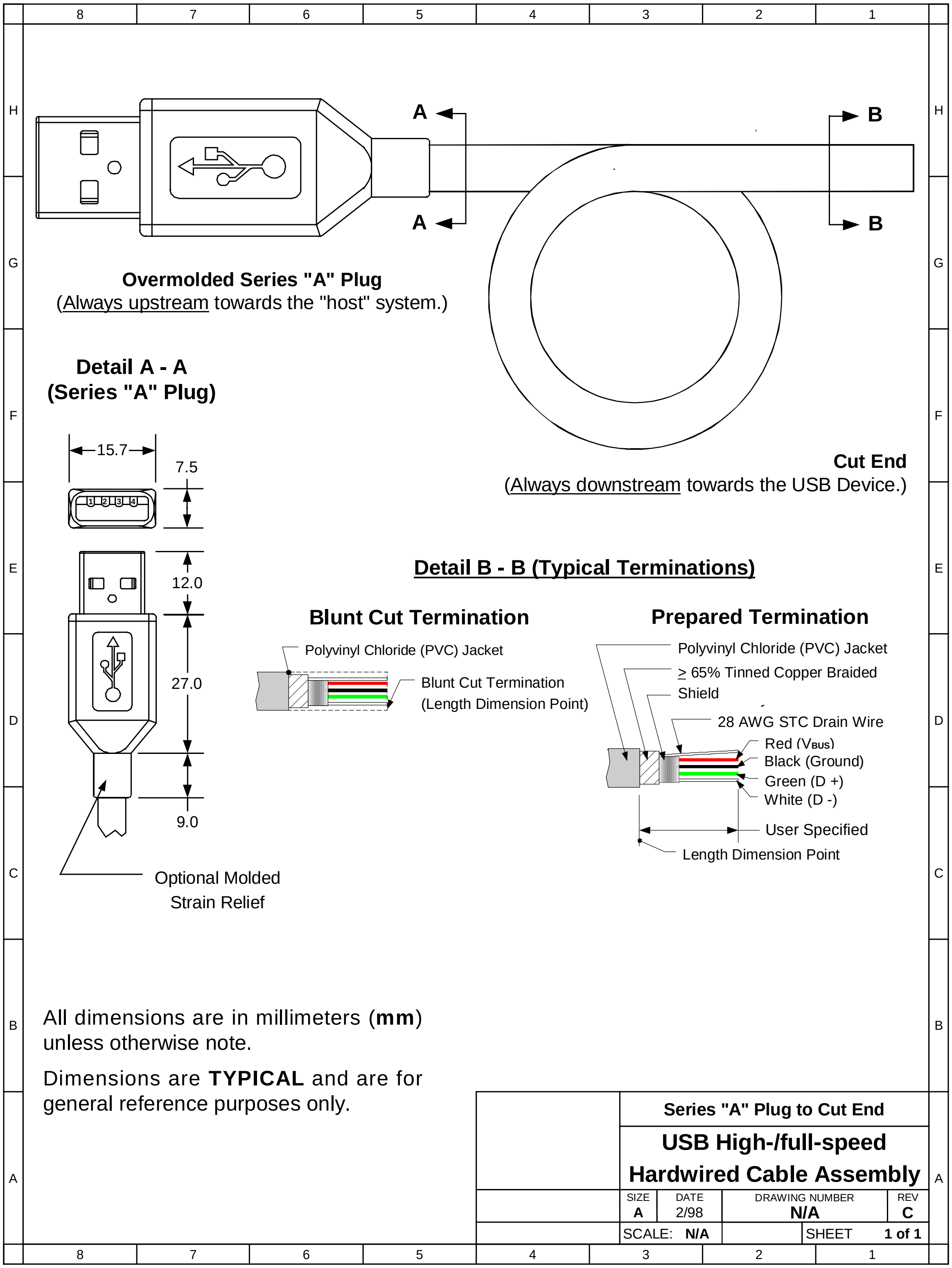


Figure ~~6-~~36-4. USB High-/full-speed Hardwired Cable Assembly

High-/full-speed captive cable assemblies must meet the following electrical requirements:

- The cable must be terminated on one end with an overmolded Series "A" plug and the opposite end is vendor specific. If the vendor specific interconnect is to be hot plugged, it must meet the same performance requirements as the USB "B" connector.
- The cable must be rated for high-speed and full-speed.
- The cable impedance must match the impedance of the high-speed and full-speed drivers. The drivers are characterized to drive specific cable impedance. Refer to Section 7.1.1 for details.
- The maximum allowable cable length is determined by signal pair attenuation and propagation delay. Refer to Sections 7.1.14 and 7.1.17 for details.
- Differences in propagation delay between the two signal conductors must be minimized. Refer to Section 7.1.3 for details.
- The GND lead provides a common reference between the upstream and downstream ports. The maximum cable length is determined by the voltage drop across the GND lead. Refer to Section 7.2.2 for details. The minimum wire gauge is calculated using the worst case current consumption.
- The VBUS lead provides power to the connected device. The minimum wire gauge is vendor specific.

6.4.3 Low-speed Captive Cable Assemblies

Assemblies are considered captive if they are provided with a vendor-specific connect means (hardwired or custom detachable) to the peripheral. Low-speed cables may only be used on low-speed devices.

~~Figure 6-4~~Figure 6-5 illustrates a low-speed hardwired cable assembly.

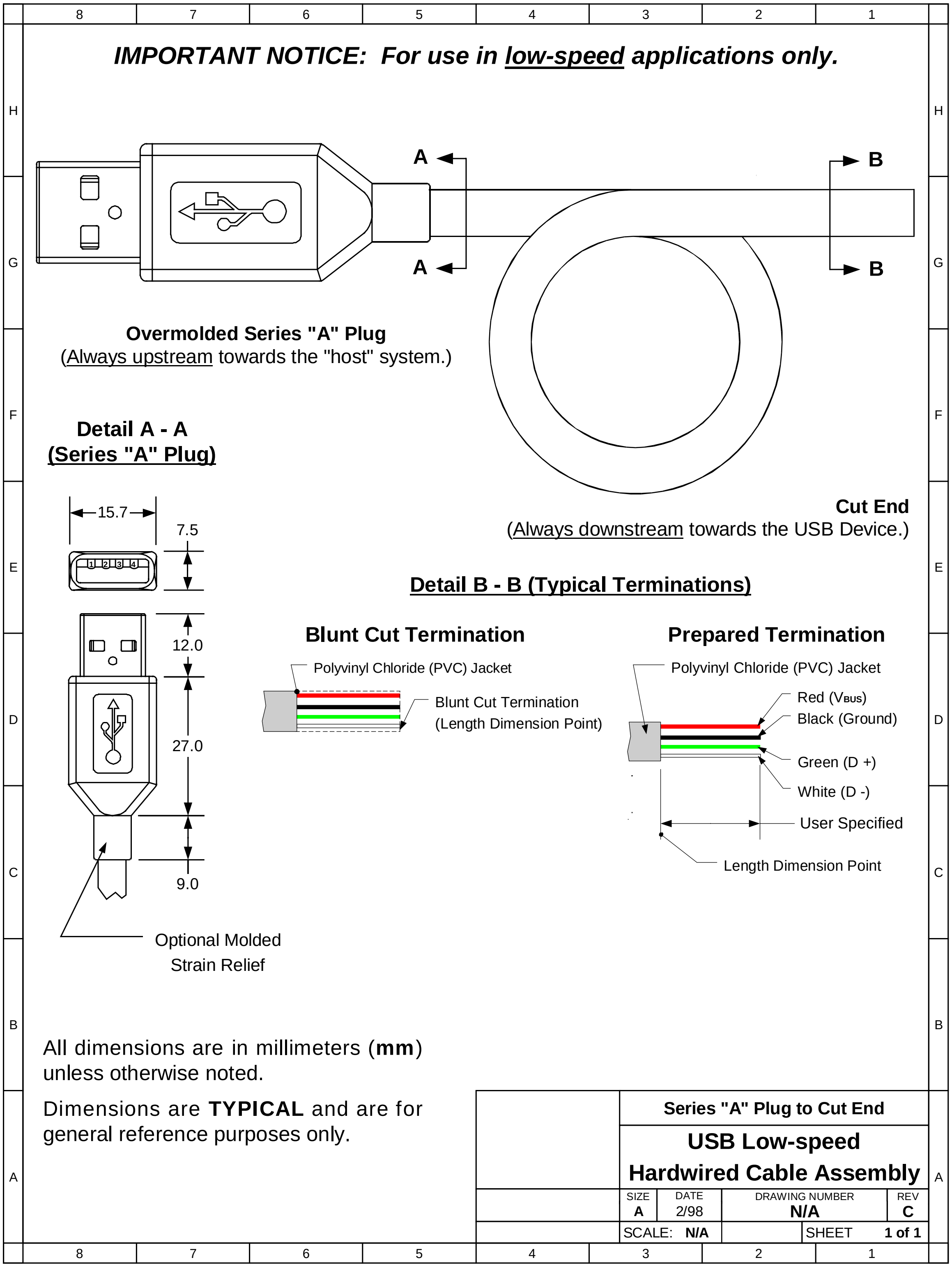


Figure 6-46-5. USB Low-speed Hardwired Cable Assembly

Low-speed captive cable assemblies must meet the following electrical requirements:

- The cable must be terminated on one end with an overmolded Series "A" plug and the opposite end is vendor specific. If the vendor specific interconnect is to be hot plugged, it must meet the same performance requirements as the USB "B" connector.
- Low-speed drivers are characterized for operation over a range of capacitive loads. This value includes all sources of capacitance on the D+ and D-lines, not just the cable. Cable selection must insure that total load capacitance falls between specified minimum and maximum values. If the desired implementation does not meet the minimum requirement, additional capacitance needs to be added to the device. Refer to Section 7.1.1.2 for details.
- The maximum low-speed cable length is determined by the rise and fall times of low-speed signaling. This forces low-speed cable to be significantly shorter than high-/full-speed. Refer to Section 7.1.1.2 for details.
- Differences in propagation delay between the two signal conductors must be minimized. Refer to Section 7.1.3 for details.
- The GND lead provides a common reference between the upstream and downstream ports. The maximum cable length is determined by the voltage drop across the GND lead. Refer to Section 7.2.2 for details. The minimum wire gauge is calculated using the worst case current consumption.
- The VBUS lead provides power to the connected device. The minimum wire gauge is vendor specific.

6.4.4 Prohibited Cable Assemblies

USB is optimized for ease of use. The expectation is that if the device can be plugged in, it will work. By specification, the only conditions that prevent a USB device from being successfully utilized are lack of power, lack of bandwidth, and excessive topology depth. These conditions are well understood by the system software.

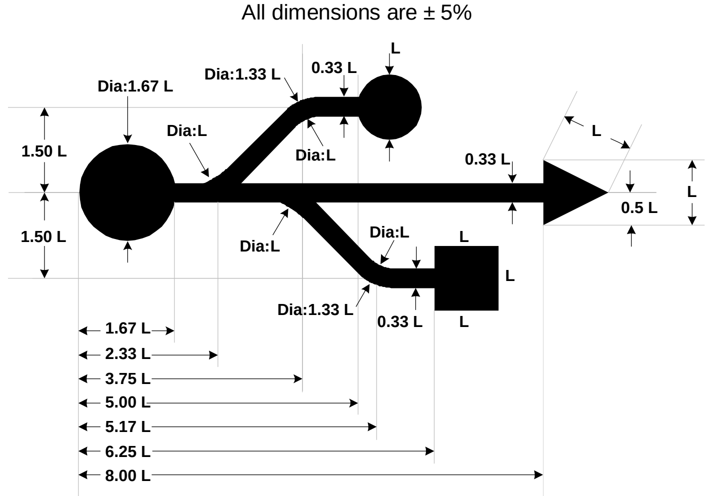
Prohibited cable assemblies may work in some situations, but they cannot be guaranteed to work in all instances.

- **Extension cable assembly**
  A cable assembly that provides a Series "A" plug with a series "A" receptacle or a Series "B" plug with a Series "B" receptacle or a Series "mini-B" plug with a Series "mini-B" receptacle. This allows multiple cable segments to be connected together, possibly exceeding the maximum permissible cable length.
- **Cable assembly that violates USB topology rules**
  A cable assembly with both ends terminated in either Series "A" plugs or Series "B" (or "mini-B") ~~"B"~~ receptacles. This allows two downstream ports to be directly connected.

  Note: This prohibition does not prevent using a USB device to provide a bridge between two USB buses.
- **Standard detachable cables for low-speed devices**
  Low-speed devices are prohibited from using standard detachable cables. A standard detachable cable assembly must be high-/full-speed. Since a standard detachable cable assembly is high-/full-speed rated, using a long high-/full-speed cable exceeds the capacitive load of low-speed.

6.5 Connector Mechanical Configuration and Material Requirements

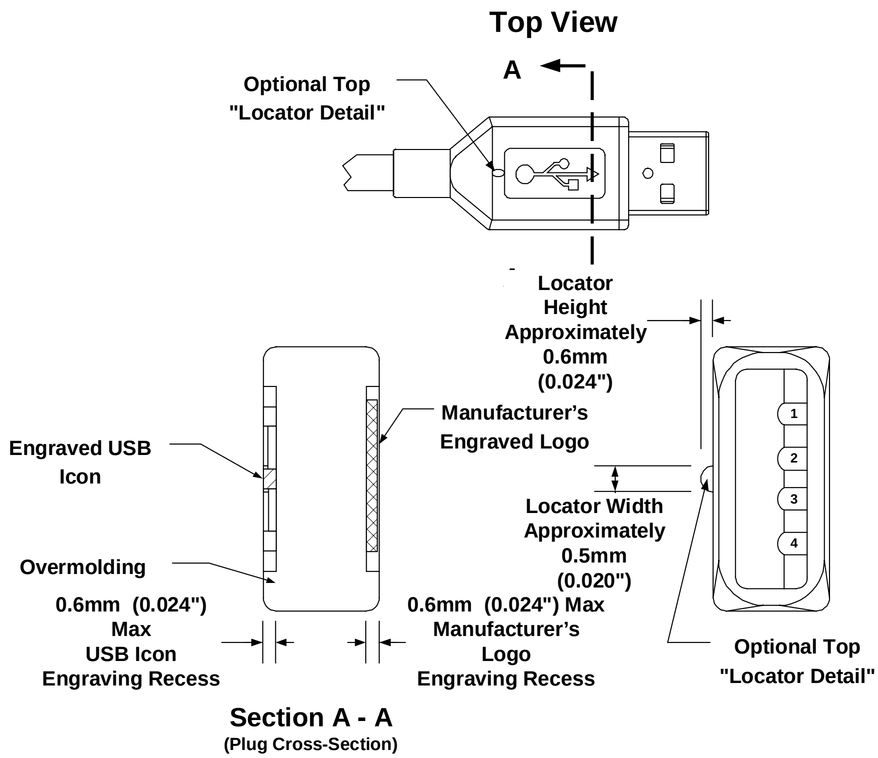
The USB Icon is used to identify USB plugs and the receptacles. ~~Figure 6-5~~Figure 6-6 illustrates the USB Icon.



~~Figure 6-5~~Figure 6-6. USB Icon

6.5.1 USB Icon Location

The USB Icon is embossed, in a recessed area, on the topside of the USB 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 Icon is required, while the Manufacturer's logo is recommended, for both Series "A" and "B" (or "mini-B") ~~"B"~~ plug assemblies. The USB Icon is also located adjacent to each receptacle. Receptacles should be oriented to allow the Icon on the plug to be visible during the mating process. ~~Figure 6-6~~Figure 6-7 and Figure 6-8 illustrate~~s~~ the typical plug orientations.



~~Figure 6-6~~Figure 6-7. Typical USB Plug Orientation

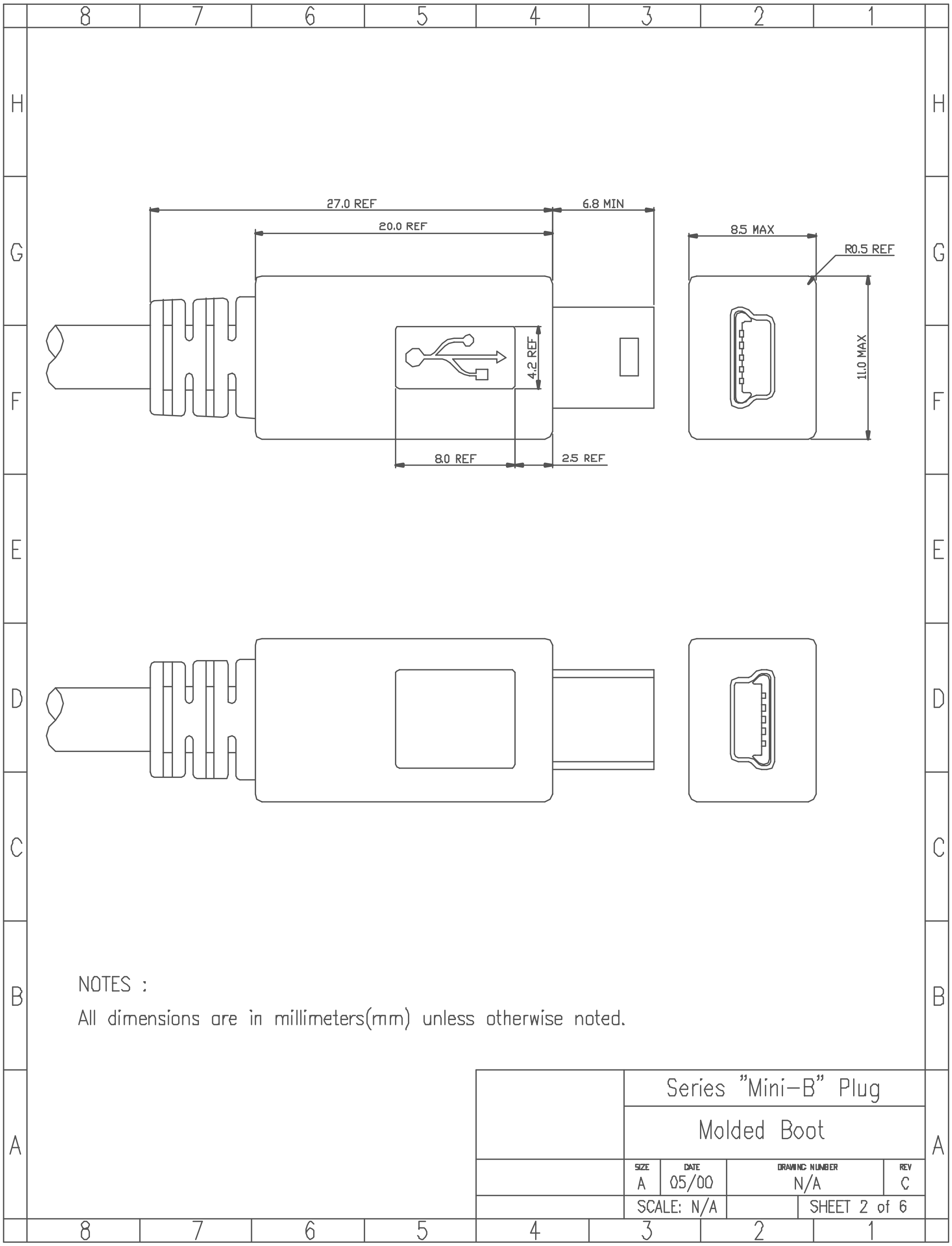


Figure 6-8. Typical USB "Mini-B" Connector Plug Orientation

6.5.2 USB Connector Termination Data

Table 6-1Table 6-1 provides the standardized contact terminating assignments by number and electrical value for Series "A" and Series "B" connectors.

Table 6-1. USB Series "A" and Series "B" Connector Termination Assignment

Contact Number	Signal Name	Typical Wiring Assignment
1	VBUS	Red
2	D-	White
3	D+	Green
4	GND	Black
Shell	Shield	Drain Wire

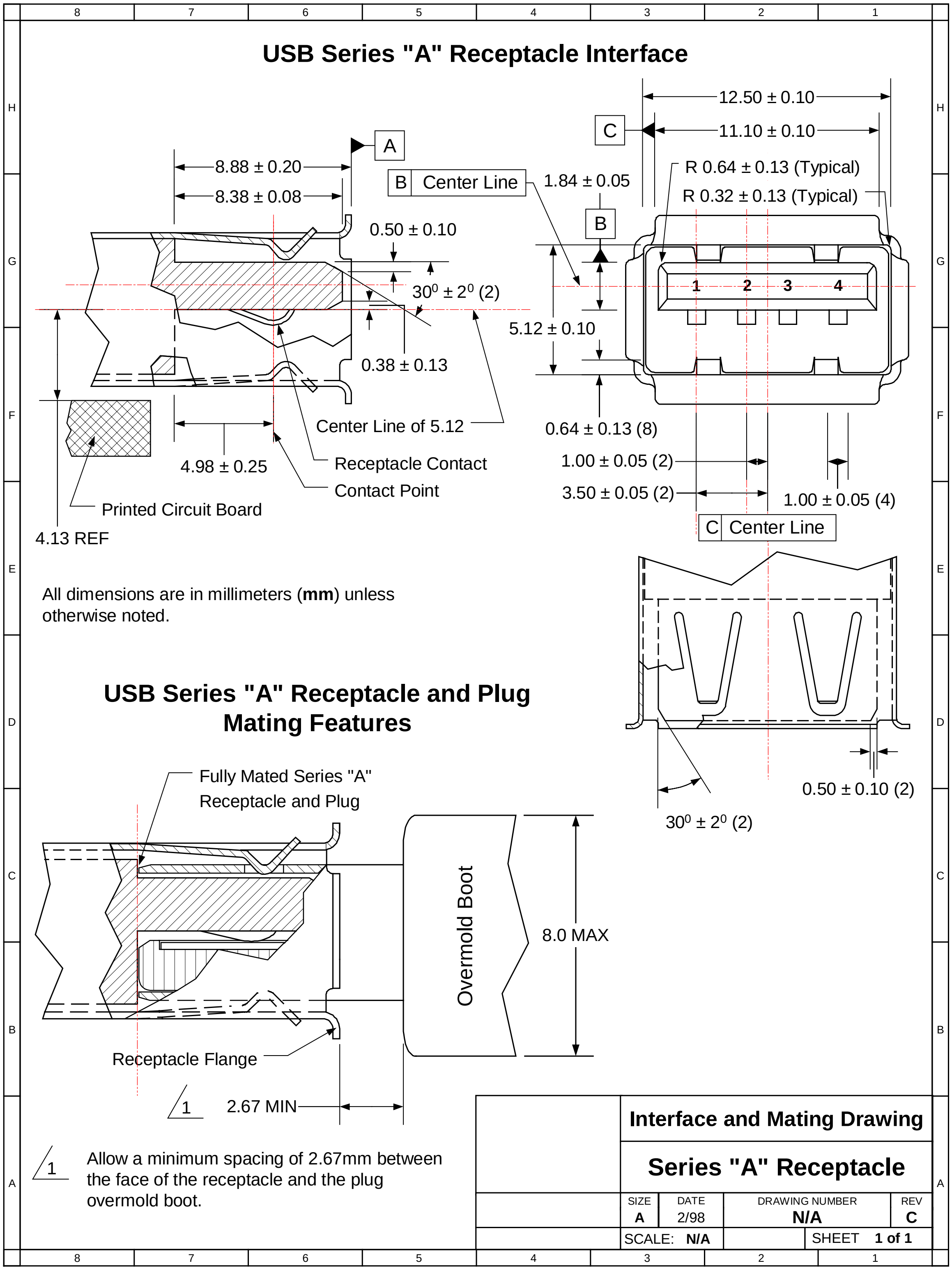
Table 6-2 provides the standardized contact terminating assignments by number and electrical value for Series "mini-B" connectors.

Table 6-2. USB Series "mini-B" Connector Termination Assignment

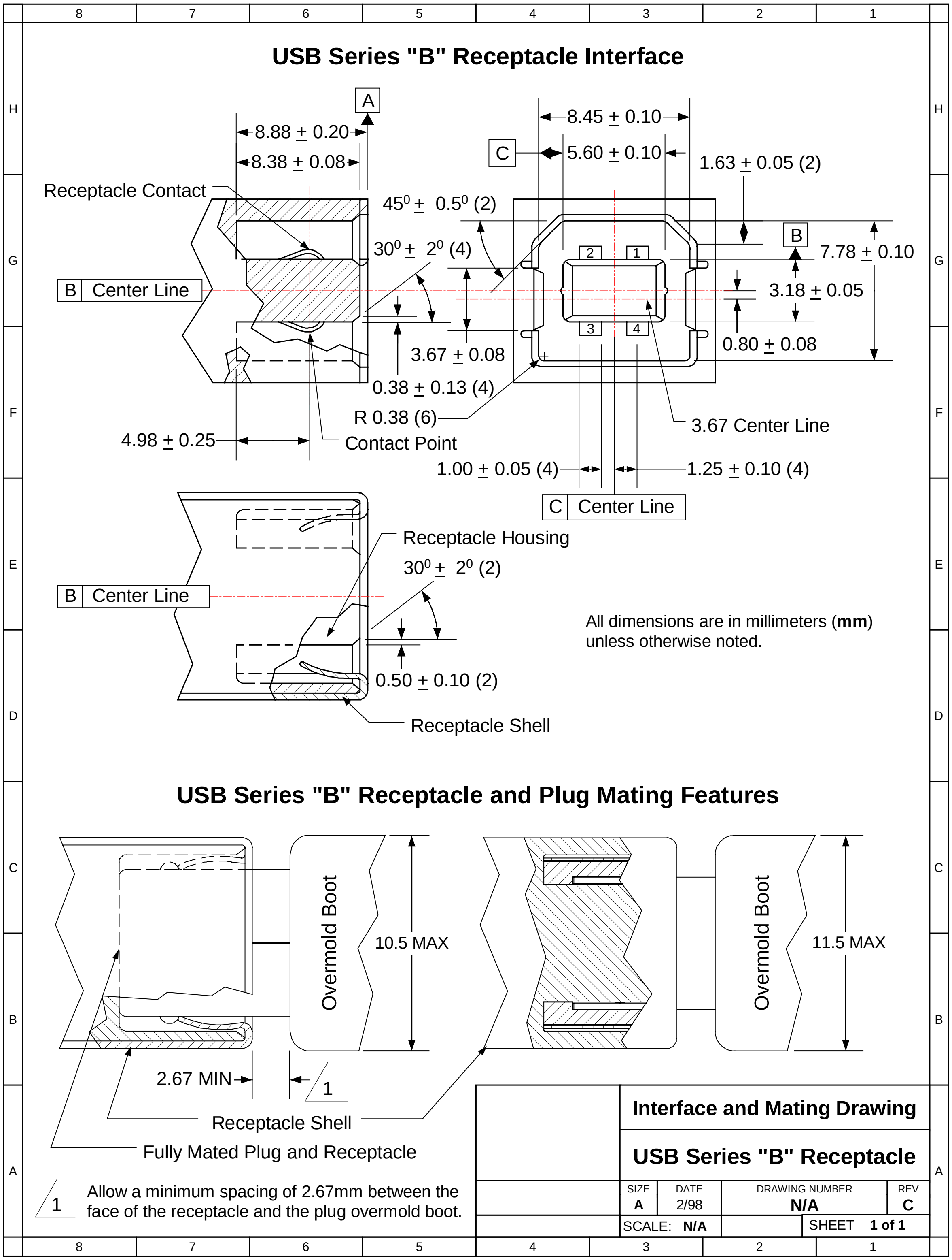
Contact Number	Signal Name	Typical Wiring Assignment
1	VBUS	Red
2	D-	White
3	D+	Green
4	ID	not connected
5	GND	Black
Shell	Shield	Drain Wire

6.5.3 Series "A" and Series "B" (or "Mini-B") "B" Receptacles

Electrical and mechanical interface configuration data for Series "A" and Series "B" receptacles are shown in Figure 6-7Figure 6-9 through Figure 6-12 and Figure 6-8. Also, refer to Figure 6-12Figure 6-17 through Figure 6-20, Figure 6-13, and Figure 6-14 at the end of this chapter for typical PCB receptacle layouts.



~~Figure 6-7~~Figure 6-9. USB Series "A" Receptacle Interface and Mating Drawing



~~Figure 6-8~~Figure 6-10. USB Series "B" Receptacle Interface and Mating Drawing

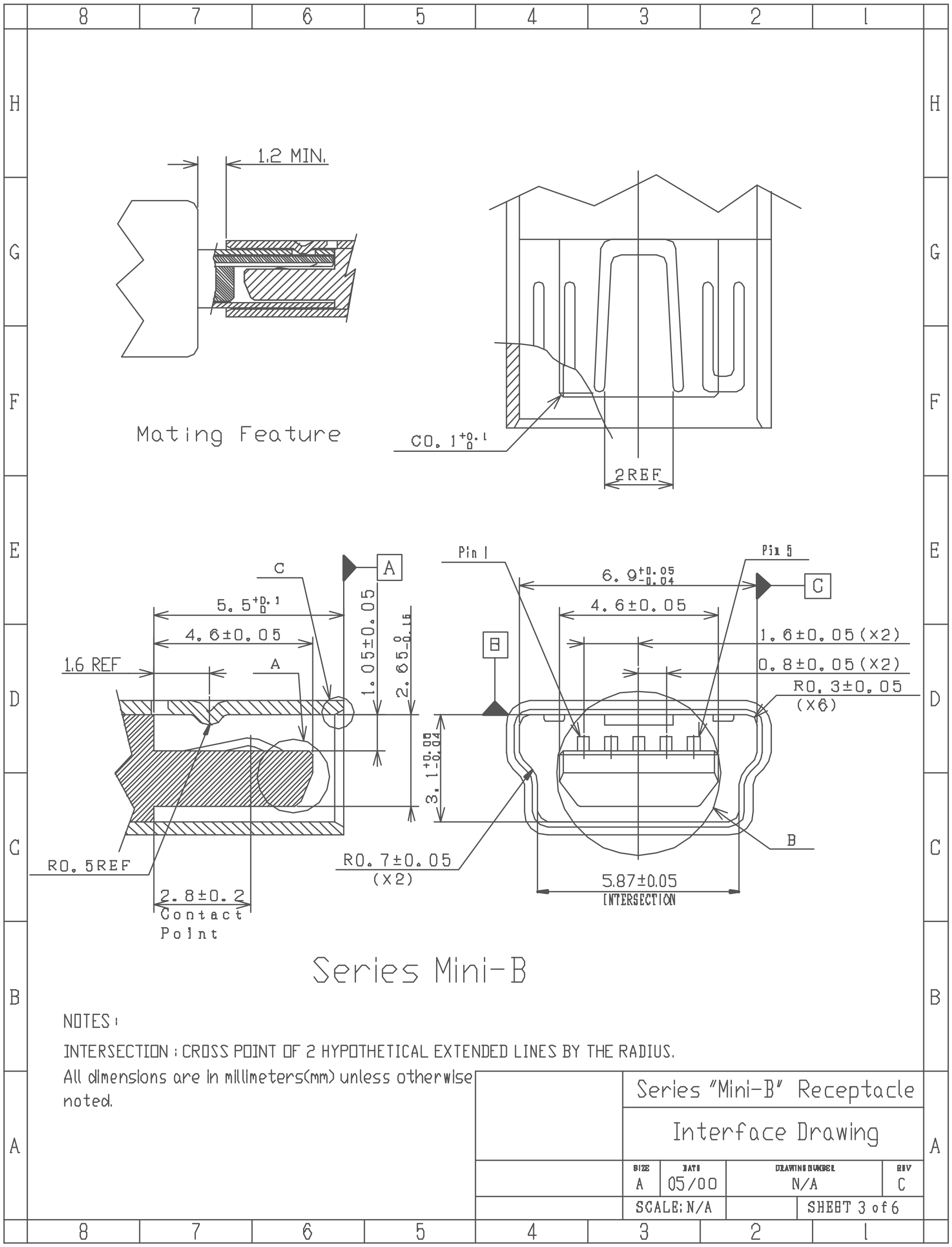


Figure 6-11. USB Series "Mini-B" Receptacle Interface and Mating Drawing

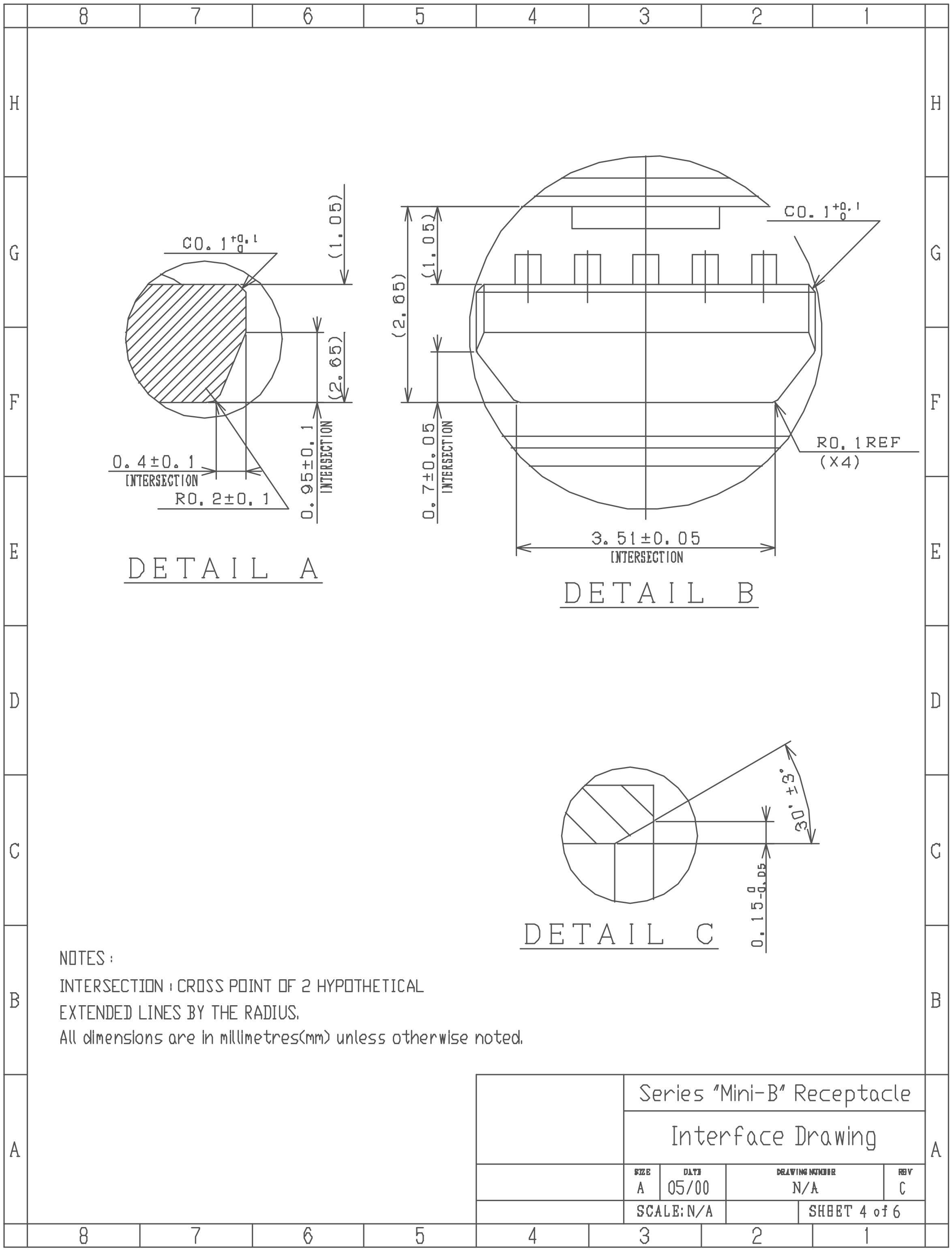


Figure 6-12. USB Series "Mini-B" Receptacle Interface Drawing (Detail)

6.5.3.1 Receptacle Injection Molded Thermoplastic Insulator Material

Minimum UL 94-V0 rated, thirty percent (30%) glass-filled polybutylene terephthalate (PBT) or polyethylene terephthalate (PET) or better.

Typical Colors: Black, gray, and natural. The "mini-B" receptacle insulator must be black in color.

Flammability Characteristics: UL 94-V0 rated.

Flame Retardant Package must meet or exceed the requirements for UL, CSA, VDE, etc.

Oxygen Index (LOI): Greater than 21%. ASTM D 2863.

6.5.3.2 Receptacle Shell Materials

6.5.3.2.1 Series "A" and Series "B"

Substrate Material: 0.30 + 0.05 mm phosphor bronze, nickel silver, or other copper based high strength materials.

Plating:

1. Underplate: Optional. Minimum 1.00 micrometers (40 microinches) nickel. In addition, manufacturer may use a copper underplate beneath the nickel.
2. Outside: Minimum 2.5 micrometers (100 microinches) bright tin or bright tin-lead.

6.5.3.2.2 Series "mini-B"

Substrate Material: 0.3 mm minimum phosphor bronze, nickel silver, or other suitable material.

The plating information below describes an example of acceptable "mini-B" receptacle plating.

Plating:

1. Underplate: Optional. Minimum 1.00 micrometers (40 microinches) nickel. In addition, manufacturer may use a copper underplate beneath the nickel.
2. Outside: Minimum 2.5 micrometers (100 microinches) bright tin or bright tin-lead.

6.5.3.3 Receptacle Contact Materials

6.5.3.3.1 Series "A" and Series "B"

Substrate Material: 0.30 $\pm$ 0.05 mm minimum half-hard phosphor bronze or other high strength copper based material.

Plating: Contacts are to be selectively plated.

A. Option I
   1. Underplate: Minimum 1.25 micrometers (50 microinches) nickel. Copper over base material is optional.
   2. Mating Area: Minimum 0.05 micrometers (2 microinches) gold over a minimum of 0.70 micrometers (28 microinches) palladium.
   3. Solder Tails: Minimum 3.8 micrometers (150 microinches) bright tin-lead over the underplate.

B. Option II
   1. Underplate: Minimum 1.25 micrometers (50 microinches) nickel. Copper over base material is optional.

2. Mating Area: Minimum 0.05 micrometers (2 microinches) gold over a minimum of 0.75 micrometers (30 microinches) palladium-nickel.

3. Solder Tails: Minimum 3.8 micrometers (150 microinches) bright tin-lead over the underplate.

C. Option III

1. Underplate: Minimum 1.25 micrometers (50 microinches) nickel. Copper over base material is optional.

2. Mating Area: Minimum 0.75 micrometers (30 microinches) gold.

3. Solder Tails: Minimum 3.8 micrometers (150 microinches) bright tin-lead over the underplate.

6.5.3.3.2 Series “mini-B”

Substrate Material: 0.2 mm minimum half-hard phosphor bronze or other high strength suitable material.

Plating: Contacts are to be selectively plated.

The following underplate, mating area, and solder tails options below describe examples of acceptable "mini-B" receptacle contact plating.

D. Option I

1. Underplate: Minimum 1.25 micrometers (50 microinches) nickel. Copper over base material is optional.

2. Mating Area: Minimum 0.05 micrometers (2 microinches) gold over a minimum of 0.70 micrometers (28 microinches) palladium.

3. Solder Tails: Minimum 3.8 micrometers (150 microinches) bright tin-lead over the underplate.

E. Option II

1. Underplate: Minimum 1.25 micrometers (50 microinches) nickel. Copper over base material is optional.

2. Mating Area: Minimum 0.05 micrometers (2 microinches) gold over a minimum of 0.75 micrometers (30 microinches) palladium-nickel.

3. Solder Tails: Minimum 3.8 micrometers (150 microinches) bright tin-lead over the underplate.

F. Option III

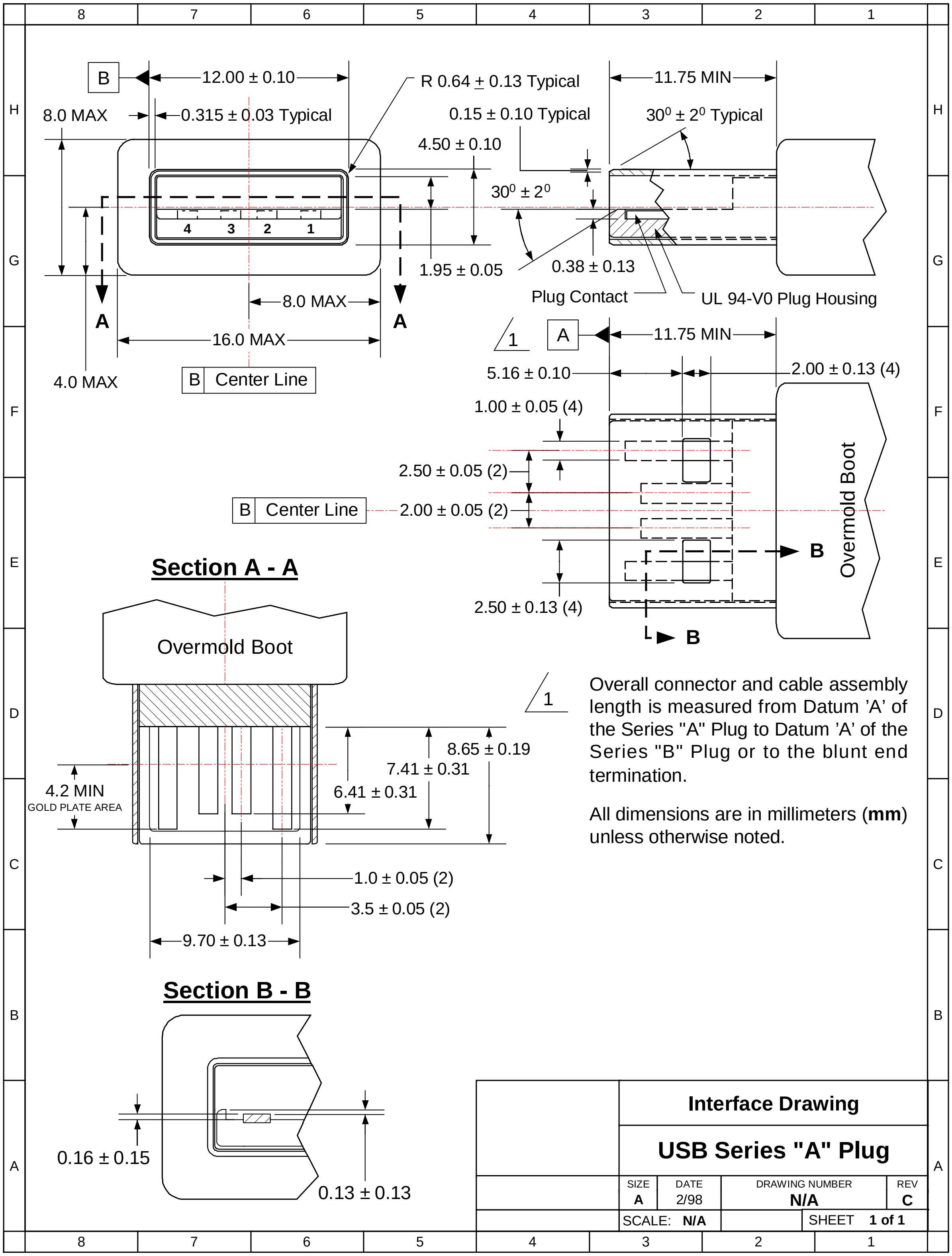
1. Underplate: Minimum 1.25 micrometers (50 microinches) nickel. Copper over base material is optional.

2. Mating Area: Minimum 0.75 micrometers (30 microinches) gold.

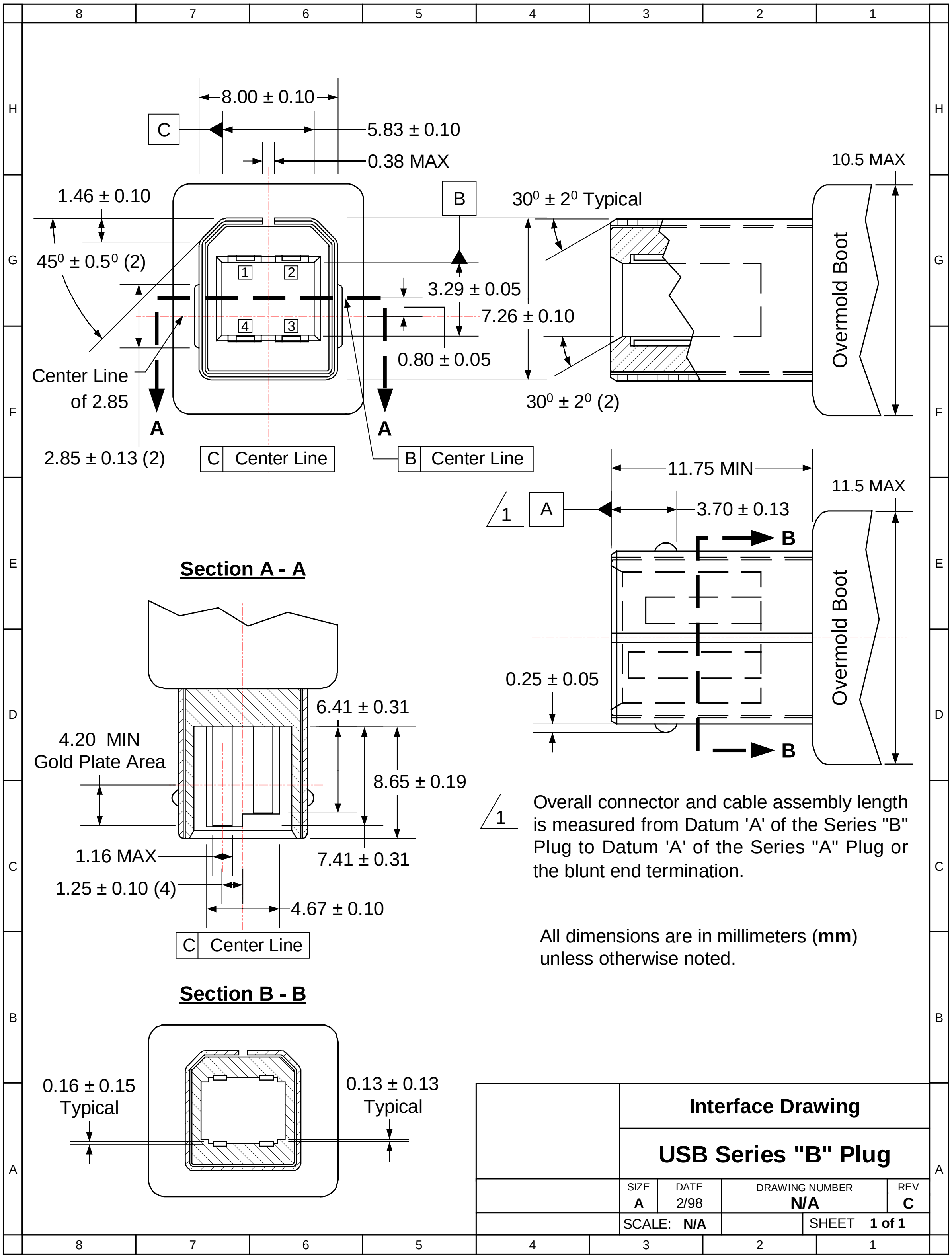
3. Solder Tails: Minimum 3.8 micrometers (150 microinches) bright tin-lead over the underplate.

6.5.4 Series “A” and Series “B” (or “Mini-B”) ~~“B”~~ Plugs

Electrical and mechanical interface configuration data for Series "A" and Series “B” (or “mini-B”) ~~"B"~~ plugs are shown in ~~Figure 6-9~~Figure 6-13 through Figure 6-15 ~~and Figure 6-10~~.



~~Figure 6-9~~Figure 6-13. USB Series "A" Plug Interface Drawing



~~Figure 6-10~~Figure 6-14. USB Series "B" Plug Interface Drawing

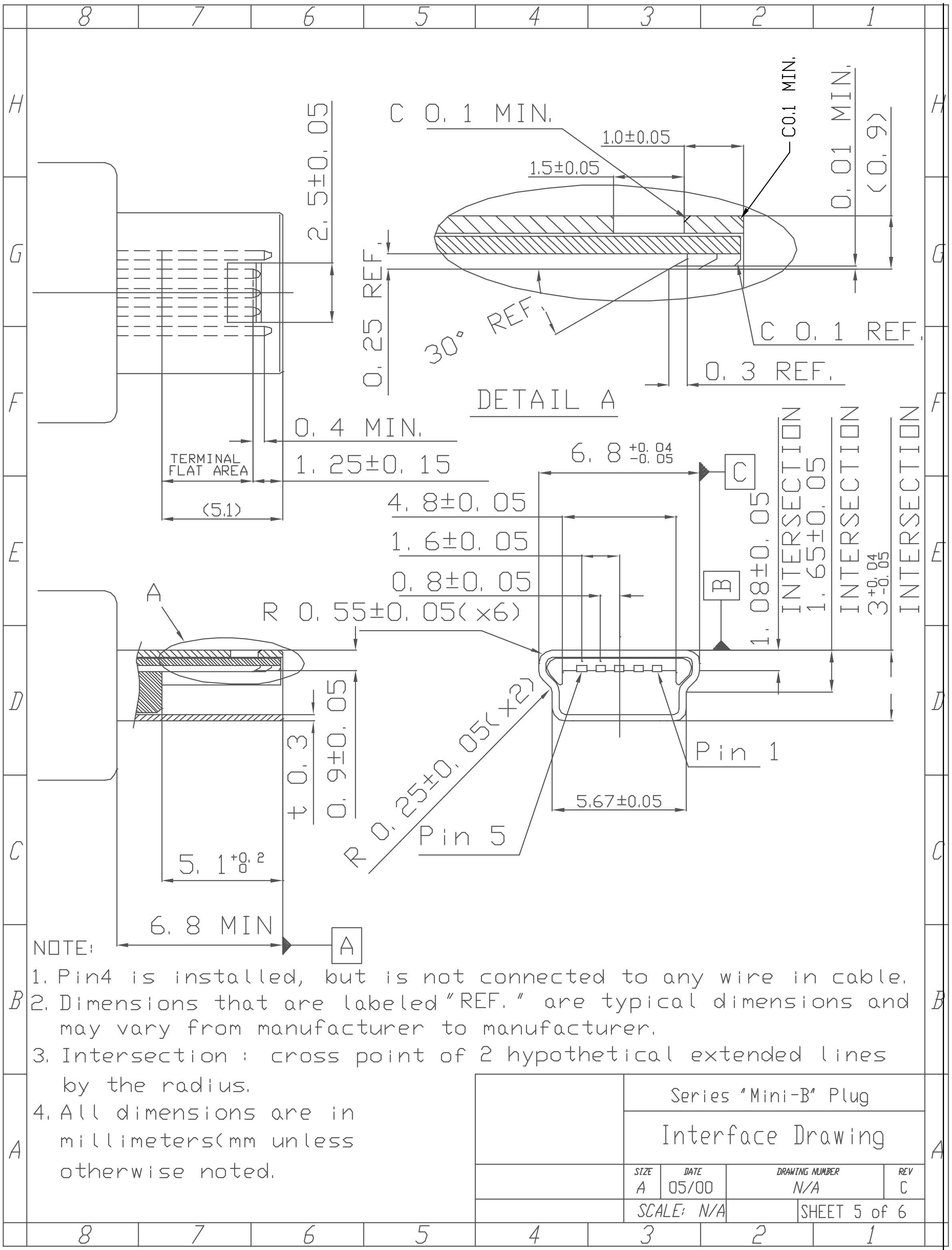


Figure 6-15. USB Series "Mini-B" Plug Interface Drawing

6.5.4.1 Plug Injection Molded Thermoplastic Insulator Material

Minimum UL 94-V0 rated, thirty percent (30%) glass-filled polybutylene terephthalate (PBT) or polyethylene terephthalate (PET) or better.

Typical Colors: Black, gray, and natural. The "mini-B" plug insulator must be black in color.

Flammability Characteristics: UL 94-V0 rated.

Flame Retardant Package must meet or exceed the requirements for UL, CSA, and VDE.

Oxygen Index (LOI): 21%. ASTM D 2863.

6.5.4.2 Plug Shell Materials

6.5.4.2.1 Series "A" and Series "B"

Substrate Material: 0.30 ± 0.05 mm phosphor bronze, nickel silver, or other suitable material.

Plating:

A. Underplate: Optional. Minimum 1.00 micrometers (40 microinches) nickel. In addition, manufacturer may use a copper underplate beneath the nickel.

B. Outside: Minimum 2.5 micrometers (100 microinches) bright tin or bright tin-lead.

6.5.4.2.2 Series "mini-B"

Substrate Material: 0.2 mm minimum phosphor bronze, nickel silver, or other suitable material.

The information below describes an example of acceptable "mini-B" plug plating.

Plating:

1. Underplate: Optional. Minimum 1.00 micrometers (40 microinches) nickel. In addition, manufacturer may use a copper underplate beneath the nickel.
2. Outside: Minimum 2.5 micrometers (100 microinches) bright tin or bright tin-lead.

6.5.4.3 Plug (Male) Contact Materials

6.5.4.3.1 Series "A" and Series "B"

Substrate Material: 0.30 ± 0.05 mm half-hard phosphor bronze.

Plating: Contacts are to be selectively plated.

A. Option I

1. Underplate: Minimum 1.25 micrometers (50 microinches) nickel. Copper over base material is optional.
2. Mating Area: Minimum 0.05 micrometers (2 microinches) gold over a minimum of 0.70 micrometers (28 microinches) palladium.
3. Solder Tails: Minimum 3.8 micrometers (150 microinches) bright tin-lead over the underplate.

B. Option II

1. Underplate: Minimum 1.25 micrometers (50 microinches) nickel. Copper over base material is optional.
2. Mating Area: Minimum 0.05 micrometers (2 microinches) gold over a minimum of 0.75 micrometers (30 microinches) palladium-nickel.
3. Wire Crimp/Solder Tails: Minimum 3.8 micrometers (150 microinches) bright tin-lead over the underplate.

C. Option III

1. Underplate: Minimum 1.25 micrometers (50 microinches) nickel. Copper over base material is optional.
2. Mating Area: Minimum 0.75 micrometers (30 microinches) gold.
3. Solder Tails: Minimum 3.8 micrometers (150 microinches) bright tin-lead over the underplate.

6.5.4.3.2 Series “mini-B”

Substrate Material: 0.2 mm minimum half-hard phosphor bronze or other suitable material.

Plating: Contacts are to be selectively plated.

The underplate, mating area, and solder tails options below describe examples of acceptable "mini-B" plug contact plating.

D. Option I

1. Underplate: Minimum 1.25 micrometers (50 microinches) nickel. Copper over base material is optional.
2. Mating Area: Minimum 0.05 micrometers (2 microinches) gold over a minimum of 0.70 micrometers (28 microinches) palladium.
3. Solder Tails: Minimum 3.8 micrometers (150 microinches) bright tin-lead over the underplate.

E. Option II

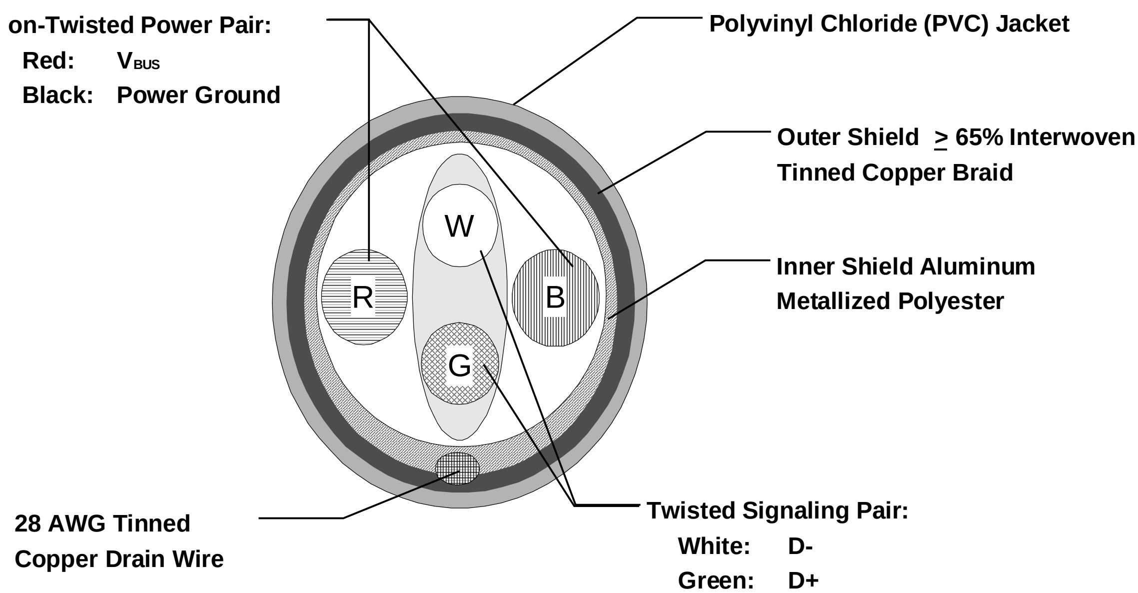
1. Underplate: Minimum 1.25 micrometers (50 microinches) nickel. Copper over base material is optional.
2. Mating Area: Minimum 0.05 micrometers (2 microinches) gold over a minimum of 0.75 micrometers (30 microinches) palladium-nickel.
3. Wire Crimp/Solder Tails: Minimum 3.8 micrometers (150 microinches) bright tin-lead over the underplate.

F. Option III

1. Underplate: Minimum 1.25 micrometers (50 microinches) nickel. Copper over base material is optional.
2. Mating Area: Minimum 0.75 micrometers (30 microinches) gold.
3. Solder Tails: Minimum 3.8 micrometers (150 microinches) bright tin-lead over the underplate.

6.6 Cable Mechanical Configuration and Material Requirements

High-/full-speed and low-speed cables differ in data conductor arrangement and shielding. Low-speed recommends, but does not require, use of a cable with twisted data conductors. Low speed recommends, but does not require, use of a cable with a braided outer shield. ~~Figure 6-11~~Figure 6-16 shows the typical high-/full-speed cable construction.



~~Figure 6-11~~Figure 6-16. Typical High-/full-speed Cable Construction

6.6.1 Description

High-/full-speed cable consists of one 28 to 20 AWG non-twisted power pair and one 28 AWG twisted data pair with an aluminum metallized polyester inner shield, 28 AWG stranded tinned copper drain wire, ≥ 65% tinned copper wire interwoven (braided) outer shield, and PVC outer jacket.

Low-speed cable consists of one 28 to 20 AWG non-twisted power pair and one 28 AWG data pair (a twist is recommended) with an aluminum metallized polyester inner shield, 28 AWG stranded tinned copper drain wire and PVC outer jacket. A ≥ 65% tinned copper wire interwoven (braided) outer shield is recommended.

6.6.2 Construction

Raw materials used in the fabrication of this cable must be of such quality that the fabricated cable is capable of meeting or exceeding the mechanical and electrical performance criteria of the most current USB Specification revision and all applicable domestic and international safety/testing agency requirements; e.g., UL, CSA, BSA, NEC, etc., for electronic signaling and power distribution cables in its category.

Table 6-3~~2~~. Power Pair

American Wire Gauge (AWG)	Nominal Conductor Outer Diameter	Stranded Tinned Conductors
28	0.381 mm (0.015")	7 x 36
	0.406 mm (0.016")	19 x 40
26	0.483 mm (0.019")	7 x 34
	0.508 mm (0.020")	19 x 38
24	0.610 mm (0.024")	7 x 32
	0.610 mm (0.024")	19 x 36
22	0.762 mm (0.030")	7 x 30
	0.787 mm (0.031")	19 x 34
20	0.890 mm (0.035")	7 x 28
	0.931 mm (0.037")	19 x 32

Note: Minimum conductor construction must be stranded tinned copper.

Non-Twisted Power Pair:

A. Wire Gauge: Minimum 28 AWG or as specified by the user contingent upon the specified cable length. Refer to Table 6-3~~Table 6-2~~.

B. Wire Insulation: Semirigid polyvinyl chloride (PVC).

1. Nominal Insulation Wall Thickness: 0.25 mm (0.010")
2. Typical Power (V_{BUS}) Conductor: Red Insulation
3. Typical Ground Conductor: Black Insulation

Signal Pair:

A. Wire Gauge: 28 AWG minimum. Refer to Table 6-4~~Table 6-3~~.

Table 6-4~~3~~. Signal Pair

American Wire Gauge (AWG)	Nominal Conductor Outer Diameter	Stranded Tinned Conductors
28	0.381 mm (0.015”)	7 x 36
	0.406 mm (0.016”)	19 x 40

Note: Minimum conductor construction must be stranded tinned copper.

B. Wire Insulation: High-density polyethylene (HDPE), alternately foamed polyethylene or foamed polypropylene

1. Nominal Insulation Wall Thickness: 0.31 mm (0.012”)

2. Typical Data Plus (+) Conductor: Green Insulation

3. Typical Data Minus (-) Conductor: White Insulation

C. Nominal Twist Ratio (not required for low-speed): One full twist every 60 mm (2.36”) to 80 mm (3.15”)

Aluminum Metallized Polyester Inner Shield (required for low-speed):

A. Substrate Material: Polyethylene terephthalate (PET) or equivalent material

B. Metallizing: Vacuum deposited aluminum

C. Assembly:

1. The aluminum metallized side of the inner shield must be positioned facing out to ensure direct contact with the drain wire.

2. The aluminum metallized inner shield must overlap by approximately one-quarter turn.

Drain Wire (required for low-speed):

A. Wire Gauge: Minimum 28 AWG stranded tinned copper (STC) non-insulated. Refer to Table 6-5~~Table 6-4~~.

Table 6-5~~4~~. Drain Wire Signal Pair

American Wire Gauge (AWG)	Nominal Conductor Outer Diameter	Stranded Tinned Conductors
28	0.381 mm (0.015”)	7 x 36
	0.406 mm (0.016”)	19 x 40

Interwoven (Braided) Tinned Copper Wire (ITCW) Outer Shield (recommended but not required for low-speed):

A. Coverage Area: Minimum 65%.

B. Assembly: The interwoven (braided) tinned copper wire outer shield must encase the aluminum metallized PET shielded power and signal pairs and must be in direct contact with the drain wire.

Outer Polyvinyl Chloride (PVC) Jacket:

A. Assembly: The outer PVC jacket must encase the fully shielded power and signal pairs and must be in direct contact with the tinned copper outer shield.

B. Nominal Wall Thickness: 0.64 mm (0.025”).

Marking: The cable must be legibly marked using contrasting color permanent ink.

A. Minimum marking information for high-/full-speed cable must include:

USB SHIELDED <Gauge/2C + Gauge/2C> UL CM 75 °C — UL Vendor ID.

B. Minimum marking information for low-speed cable shall include:

USB specific marking is not required for low-speed cable.

Nominal Fabricated Cable Outer Diameter:

This is a nominal value and may vary slightly from manufacturer to manufacturer as a function of the conductor insulating materials and conductor specified. Refer to Table 6-6~~Table 6-5~~.

Table 6-6~~5~~. Nominal Cable Diameter

Shielded USB Cable Configuration	Nominal Outer Cable Diameter
28/28	4.06 mm (0.160”)
28/26	4.32 mm (0.170”)
28/24	4.57 mm (0.180”)
28/22	4.83 mm (0.190”)
28/20	5.21 mm (0.205”)

6.6.3 Electrical Characteristics

All electrical characteristics must be measured at or referenced to +20 °C (68 °F).

Voltage Rating: 30 V rms maximum.

Conductor Resistance: Conductor resistance must be measured in accordance with ASTM-D-4566 Section 13. Refer to Table 6-7~~Table 6-6~~.

Conductor Resistance Unbalance (Pairs): Conductor resistance unbalance between two (2) conductors of any pair must not exceed five percent (5%) when measured in accordance with ASTM-D-4566 Section 15.

The DC resistance from plug shell to plug shell (or end of integrated cable) must be less than 0.6 ohms.

Table 6-7~~6~~. Conductor Resistance

American Wire Gauge (AWG)	Ohms (Ω) / 100 Meters Maximum
28	23.20
26	14.60
24	9.09
22	5.74
20	3.58

6.6.4 Cable Environmental Characteristics

Temperature Range:

A. Operating Temperature Range: 0 ºC to +50 ºC

B. Storage Temperature Range: -20 ºC to +60 ºC

C. Nominal Temperature Rating: +20 ºC

Flammability: All plastic materials used in the fabrication of this product shall meet or exceed the requirements of NEC Article 800 for communications cables Type CM (Commercial).

6.6.5 Listing

The product shall be UL listed per UL Subject 444, Class 2, Type CM for Communications Cable Requirements.

6.7 Electrical, Mechanical, and Environmental Compliance Standards

Table 6-8~~Table 6-7~~ lists the minimum test criteria for all USB cable, cable assemblies, and connectors.

Table 6-8~~7~~. USB Electrical, Mechanical, and Environmental Compliance Standards

Test Description	Test Procedure	Performance Requirement
Visual and Dimensional Inspection	EIA 364-18 Visual, dimensional, and functional inspection in accordance with the USB quality inspection plans.	Must meet or exceed the requirements specified by the most current version of Chapter 6 of the USB Specification.
Insulation Resistance	EIA 364-21 The object of this test procedure is to detail a standard method to assess the insulation resistance of USB connectors. This test procedure is used to determine the resistance offered by the insulation materials and the various seals of a connector to a DC potential tending to produce a leakage of current through or on the surface of these members.	1,000 (100 for “mini-B” connector)MΩ minimum.
Dielectric Withstanding Voltage	EIA 364-20 The object of this test procedure is to detail a test method to prove that a USB connector can operate safely at its rated voltage and withstand momentary over-potentials due to switching, surges, and/or other similar phenomena.	The dielectric must withstand 500 (100 for “mini-B” connector)V AC for one minute at sea level.

Table 6-8~~Table 6-7~~. USB Electrical, Mechanical, and Environmental Compliance Standards (Continued)

Test Description	Test Procedure	Performance Requirement
Low Level Contact Resistance	EIA 364-23 The object of this test is to detail a standard method to measure the electrical resistance across a pair of mated contacts such that the insulating films, if present, will not be broken or asperity melting will not occur.	30 (50 for “mini-B” connector)mΩ maximum when measured at 20 mV maximum open circuit at 100 mA. Mated test contacts must be in a connector housing.
Contact Current Rating	EIA 364-70 — Method B The object of this test procedure is to detail a standard method to assess the current carrying capacity of mated USB connector contacts.	1.5(1 for “mini-B” connector) A at 250 V AC minimum when measured at an ambient temperature of 25 °C. With power applied to the contacts, the Δ T must not exceed +30 °C at any point in the USB connector under test.
Contact Capacitance	EIA 364-30 The object of this test is to detail a standard method to determine the capacitance between conductive elements of a USB connector.	2 pF maximum unmated per contact.
Insertion Force	EIA 364-13 The object of this test is to detail a standard method for determining the mechanical forces required for inserting a USB connector.	35 Newtons maximum at a maximum rate of 12.5 mm (0.492”) per minute.
Extraction Force	EIA 364-13 The object of this test is to detail a standard method for determining the mechanical forces required for extracting a USB connector.	10 Newtons minimum at a maximum rate of 12.5 mm (0.492”) per minute. For “mini-B” connector with Detent Latch at a maximum rate of 12.5 mm (0.492”) per minute 7 N min. initial 3 N min. after 5000 cycles

Table 6-8~~Table 6-7~~. USB Electrical, Mechanical, and Environmental Compliance Standards (Continued)

Test Description	Test Procedure	Performance Requirement
Durability	EIA 364-09 The object of this test procedure is to detail a uniform test method for determining the effects caused by subjecting a USB connector to the conditioning action of insertion and extraction, simulating the expected life of the connectors. Durability cycling with a gauge is intended only to produce mechanical stress. Durability performed with mating components is intended to produce both mechanical and wear stress.	1,500(5,000 for “mini-B” connector) insertion/extraction cycles at a maximum rate of 200 cycles per hour.
Cable Pull-Out	EIA 364-38 Test Condition A The object of this test procedure is to detail a standard method for determining the holding effect of a USB plug cable clamp without causing any detrimental effects upon the cable or connector components when the cable is subjected to inadvertent axial tensile loads.	After the application of a steady state axial load of 40 Newtons for one minute.
Physical Shock	EIA 364-27 Test Condition H The object of this test procedure is to detail a standard method to assess the ability of a USB connector to withstand specified severity of mechanical shock.	No discontinuities of 1 μs or longer duration when mated USB connectors are subjected to 11 ms duration 30 Gs half-sine shock pulses. Three shocks in each direction applied along three mutually perpendicular planes for a total of 18 shocks.

Table 6-8~~Table 6-7~~. USB Electrical, Mechanical, and Environmental Compliance Standards (Continued)

Test Description	Test Procedure	Performance Requirement
Random Vibration	EIA 364-28 Test Condition V Test Letter A This test procedure is applicable to USB connectors that may, in service, be subjected to conditions involving vibration. Whether a USB connector has to function during vibration or merely to survive conditions of vibration should be clearly stated by the detailed product specification. In either case, the relevant specification should always prescribe the acceptable performance tolerances.	No discontinuities of 1 µs or longer duration when mated USB connectors are subjected to 5.35 Gs RMS. 15 minutes in each of three mutually perpendicular planes.
Thermal Shock	EIA 364-32 Test Condition I The object of this test is to determine the resistance of a USB connector to exposure at extremes of high and low temperatures and to the shock of alternate exposures to these extremes, simulating the worst case conditions for storage, transportation, and application.	10 cycles –55 °C and +85 °C. The USB connectors under test must be mated.
Humidity Life	EIA 364-31 Test Condition A Method III The object of this test procedure is to detail a standard test method for the evaluation of the properties of materials used in USB connectors as they are influenced by the effects of high humidity and heat.	168 hours minimum (seven complete cycles). The USB connectors under test must be tested in accordance with EIA 364-31.
Solderability	EIA 364-52 The object of this test procedure is to detail a uniform test method for determining USB connector solderability. The test procedure contained herein utilizes the solder dip technique. It is not intended to test or evaluate solder cup, solder eyelet, other hand-soldered type, or SMT type terminations.	USB contact solder tails must pass 95% coverage after one hour steam aging as specified in Category 2.

Table 6-8. USB Electrical, Mechanical, and Environmental Compliance Standards~~Table 6-7. USB Electrical, Mechanical, and Environmental Compliance Standards~~ (Continued)

Test Description	Test Procedure	Performance Requirement
Flammability	UL 94 V-0 This procedure is to ensure thermoplastic resin compliance to UL flammability standards.	The manufacturer will require its thermoplastic resin vendor to supply a detailed C of C with each resin shipment. The C of C shall clearly show the resin's UL listing number, lot number, date code, etc.
~~Flammability~~	~~UL 94 V-0~~ ~~This procedure is to ensure thermoplastic resin compliance to UL flammability standards.~~	~~The manufacturer will require its thermoplastic resin vendor to supply a detailed C of C with each resin shipment. The C of C shall clearly show the resin's UL listing number, lot number, date code, etc.~~
Cable Impedance (Only required for high-/full-speed)	The object of this test is to insure the signal conductors have the proper impedance. 1. Connect the Time Domain Reflectometer (TDR) outputs to the impedance/delay/skew test fixture (Note 1). Use separate 50 Ω cables for the plus (or true) and minus (or complement) outputs. Set the TDR head to differential TDR mode. 2. Connect the Series "A" plug of the cable to be tested to the text fixture, leaving the other end open-circuited. 3. Define a waveform composed of the difference between the true and complement waveforms, to allow measurement of differential impedance. 4. Measure the minimum and maximum impedances found between the connector and the open circuited far end of the cable.	Impedance must be in the range specified in Table 7-9 (ZO).

Table 6-8. USB Electrical, Mechanical, and Environmental Compliance StandardsTable 6-7. USB Electrical, Mechanical, and Environmental Compliance Standards (Continued)

Test Description	Test Procedure	Performance Requirement
Signal Pair Attenuation (Only required for high-/full-speed)	The object of this test is to insure that adequate signal strength is presented to the receiver to maintain a low error rate. 1. Connect the Network Analyzer output port (port 1) to the input connector on the attenuation test fixture (Note 2). 2. Connect the Series "A" plug of the cable to be tested to the test fixture, leaving the other end open-circuited. 3. Calibrate the network analyzer and fixture using the appropriate calibration standards over the desired frequency range. 4. Follow the method listed in Hewlett Packard Application Note 380-2 to measure the open-ended response of the cable. 5. Short circuit the Series "B" (or "mini-B") "B" end (or bare leads end, if a captive cable) and measure the short-circuit response. 6. Using the software in H-P App. Note 380-2 or equivalent, calculate the cable attenuation accounting for resonance effects in the cable as needed.	Refer to Section 7.1.17 for frequency range and allowable attenuation.

Table 6-8. USB Electrical, Mechanical, and Environmental Compliance Standards~~Table 6-7. USB Electrical, Mechanical, and Environmental Compliance Standards~~ (Continued)

Test Description	Test Procedure	Performance Requirement
Propagation Delay	The purpose of the test is to verify the end to end propagation of the cable. 1. Connect one output of the TDR sampling head to the D+ and D- inputs of the impedance/delay/skew test fixture (Note 1). Use one 50 Ω cable for each signal and set the TDR head to differential TDR mode. 2. Connect the cable to be tested to the test fixture. If detachable, plug both connectors in to the matching fixture connectors. If captive, plug the series "A" plug into the matching fixture connector and solder the stripped leads on the other end to the test fixture. 3. Measure the propagation delay of the test fixture by connecting a short piece of wire across the fixture from input to output and recording the delay. 4. Remove the short piece of wire and remeasure the propagation delay. Subtract from it the delay of the test fixture measured in the previous step.	High-/full-speed. See Section 7.1.1.1, Section 7.1.4, Section 7.1.16, and Table 7-9 (T_{FSCBL}). Low-speed. See Section 7.1.1.2, Section 7.1.16, and Table 7-9 (T_{LSCBL}).

Table 6-8. USB Electrical, Mechanical, and Environmental Compliance Standards~~Table 6-7. USB Electrical, Mechanical, and Environmental Compliance Standards~~ (Continued)

Test Description	Test Procedure	Performance Requirement
Propagation Delay Skew	This test insures that the signal on both the D+ and D- lines arrive at the receiver at the same time. 1. Connect the TDR to the fixture with test sample cable, as in the previous section. 2. Measure the difference in delay for the two conductors in the test cable. Use the TDR cursors to find the open-circuited end of each conductor (where the impedance goes infinite) and subtract the time difference between the two values.	Propagation skew must meet the requirements as listed in Section 7.1.3.
Capacitive Load Only required for low-speed	The purpose of this test is to insure the distributed inter-wire capacitance is less than the lumped capacitance specified by the low-speed transmit driver. 1. Connect the one lead of the Impedance Analyzer to the D+ pin on the impedance/delay/skew fixture (Note 1) and the other lead to the D- pin. 2. Connect the series "A" plug to the fixture, with the series "B" (or "mini-B") ~~"B"~~ end leads open-circuited. 3. Set the Impedance Analyzer to a frequency of 100 kHz, to measure the capacitance.	See Section 7.1.1.2 and Table 7-7 (CLINUA).

Note1: Impedance, propagation delay, and skew test fixture
This fixture will be used with the TDR for measuring the time domain performance of the cable under test. The fixture impedance should be matched to the equipment, typically 50 Ω. Coaxial connectors should be provided on the fixture for connection from the TDR.

Note 2: Attenuation text fixture
This fixture provides a means of connection from the network analyzer to the Series "A" plug. Since USB signals are differential in nature and operate over balanced cable, a transformer or balun (North Hills NH13734 or equivalent) is ideally used. The transformer converts the unbalanced (also known as single-ended) signal from the signal generator which is typically a 50 Ω output to the balanced (also known as differential) and likely different impedance loaded presented by the cable. A second transformer or balun should be used on the other end of the cable under test to convert the signal back to unbalanced form of the correct impedance to match the network analyzer.

6.7.1 Applicable Documents

American National Standard/Electronic Industries Association

ANSI/EIA-364-C (12/94)	Electrical Connector/Socket Test Procedures Including Environmental Classifications

American Standard Test Materials

ASTM-D-4565	Physical and Environmental Performance Properties of Insulation and Jacket for Telecommunication Wire and Cable, Test Standard Method
ASTM-D-4566	Electrical Performance Properties of Insulation and Jacket for Telecommunication Wire and Cable, Test Standard Method

Underwriters' Laboratory, Inc.

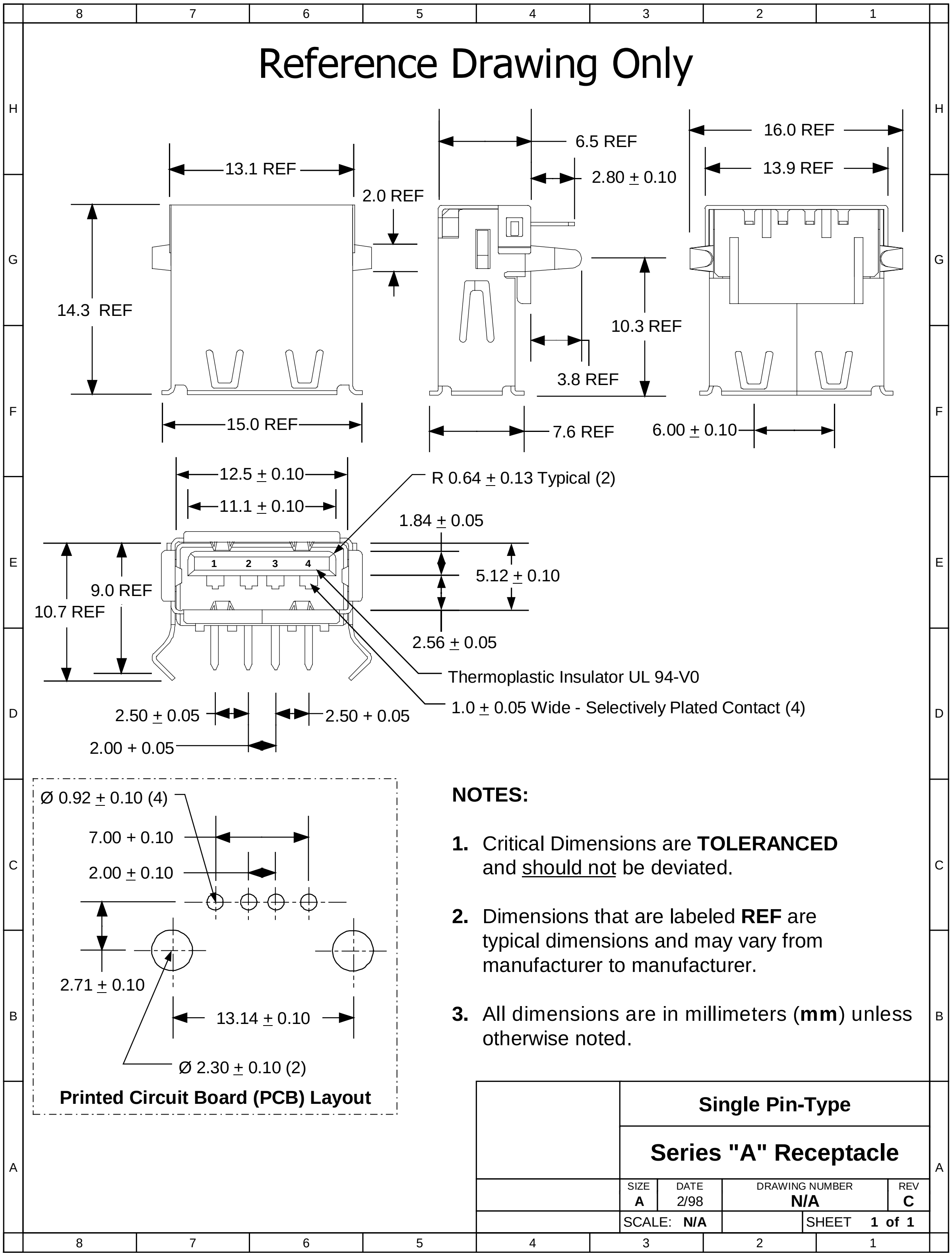
UL STD-94	Test for Flammability of Plastic materials for Parts in Devices and Appliances
UL Subject-444	Communication Cables

6.8 USB Grounding

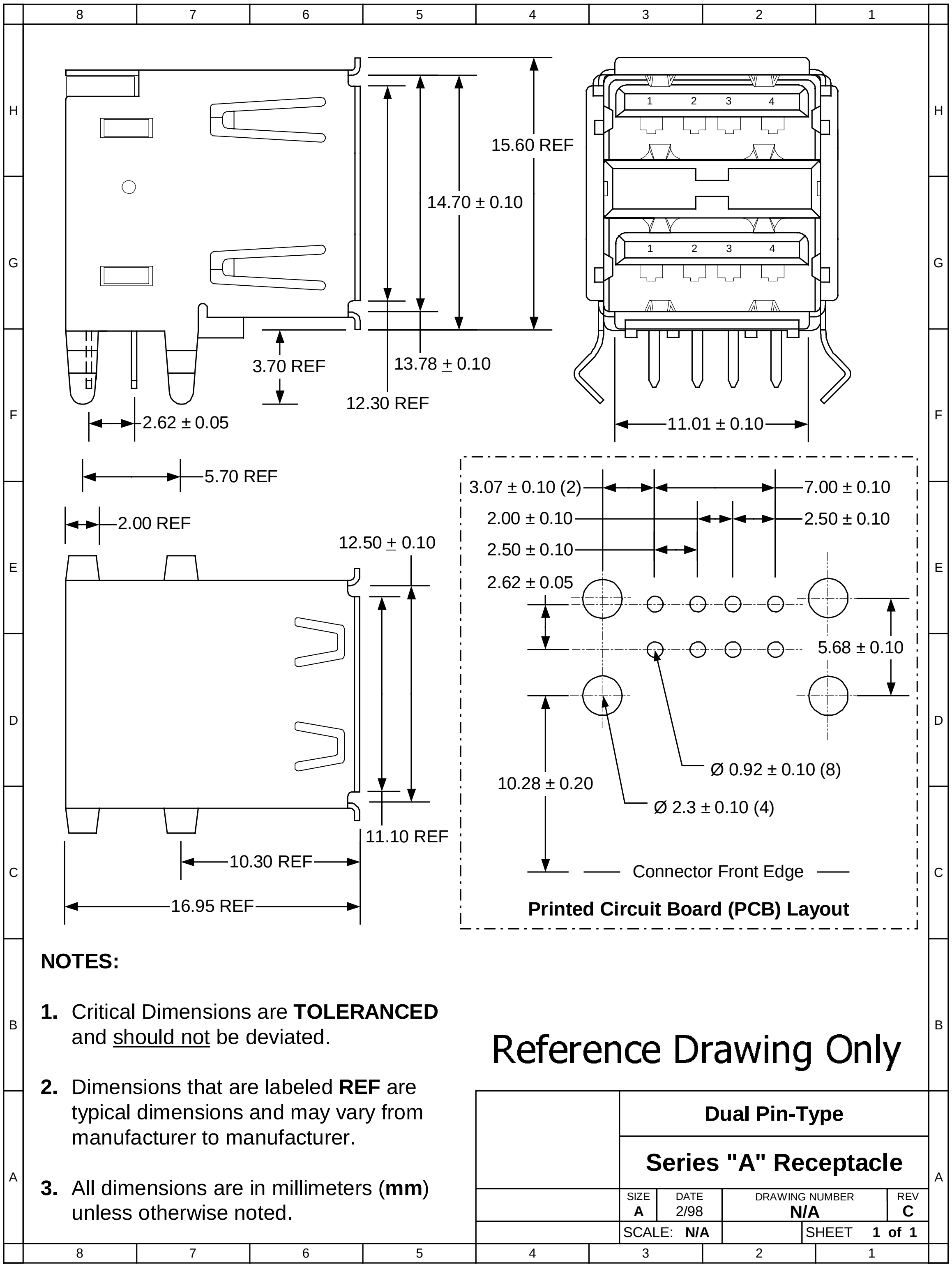
The shield must be terminated to the connector plug for completed assemblies. The shield and chassis are bonded together. The user selected grounding scheme for USB devices, and cables must be consistent with accepted industry practices and regulatory agency standards for safety and EMI/ESD/RFI.

6.9 PCB Reference Drawings

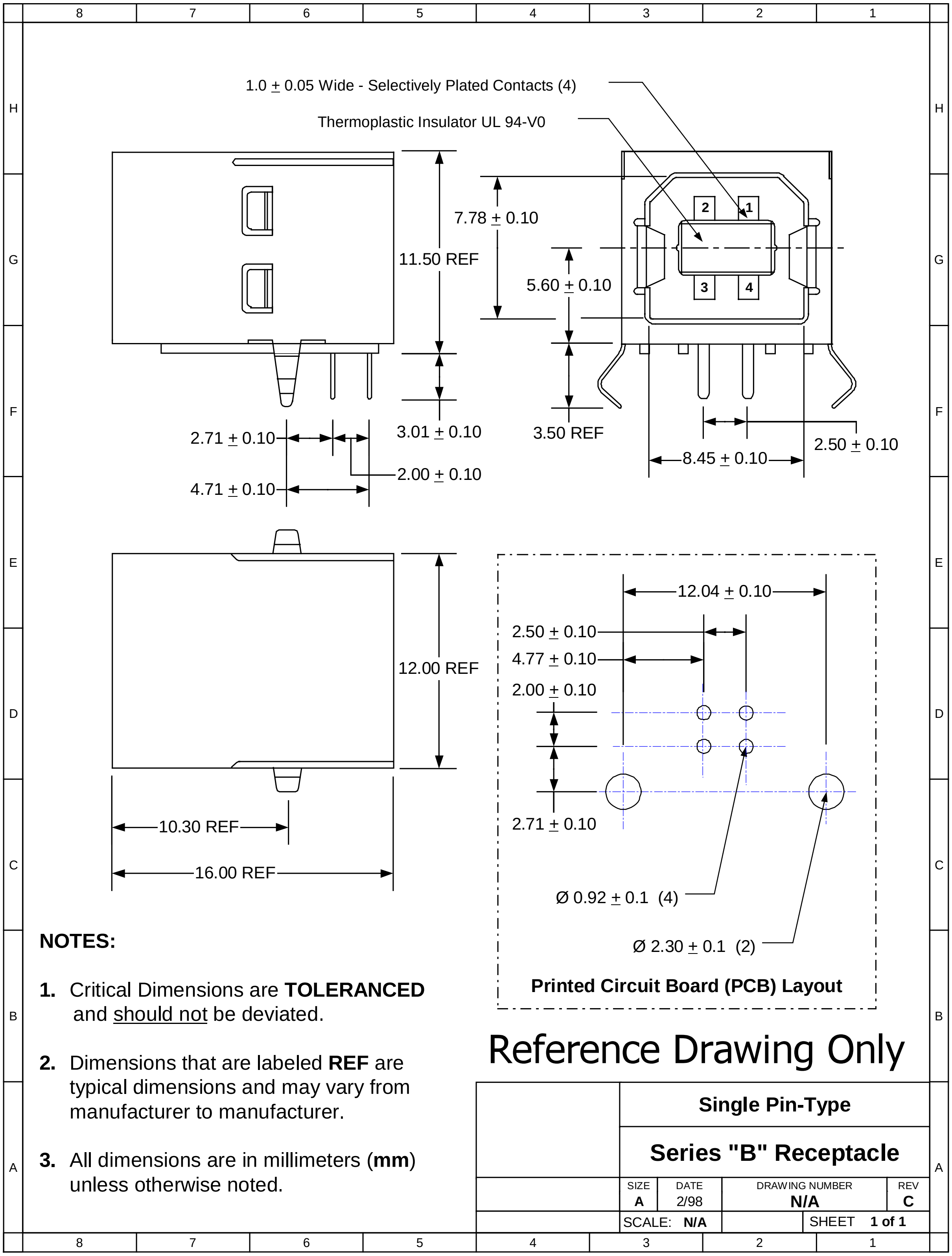
The drawings in ~~Figure 6-12, Figure 6-13,~~Figure 6-17 through Figure 6-20 ~~and Figure 6-14~~ describe typical receptacle PCB interfaces. These drawings are included for informational purposes only.



~~Figure 6-12~~Figure 6-17. Single Pin-type Series "A" Receptacle



~~Figure 6-13~~Figure 6-18. Dual Pin-type Series "A" Receptacle



~~Figure 6-14~~Figure 6-19. **Single Pin-type Series "B" Receptacle**

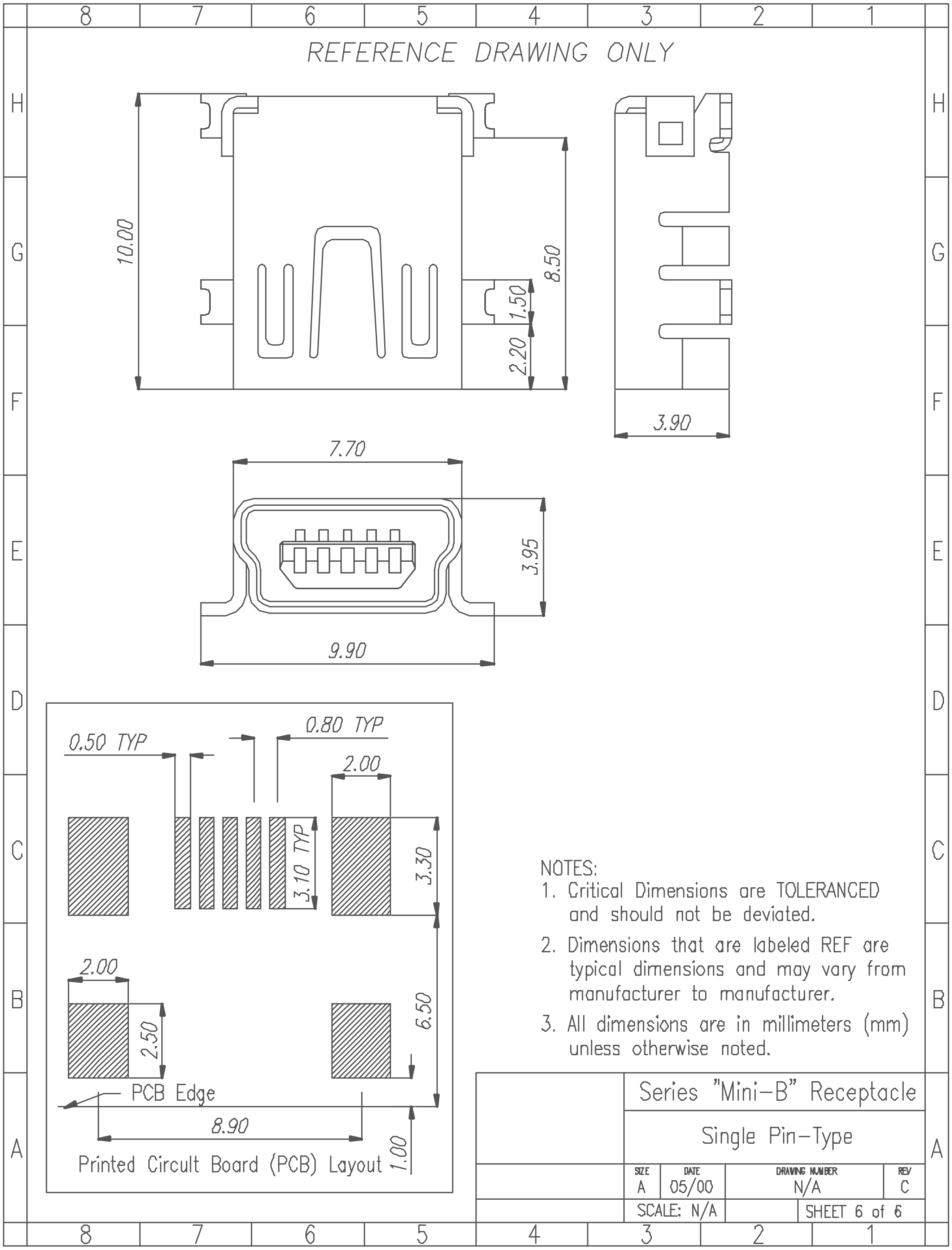


Figure 6-20. Single Pin-Type Series "Mini-B" Receptacle