3 Cables and Connectors

The Previous Chapter

The previous chapter provided an overview of the primary concepts of USB transfers and described the interaction between USB system software, system hardware, and USB devices for USB 1.x systems and for USB 2.0 system. The USB communications process is described, including the concept of the device framework. Each hardware and software element in a USB system is introduced and its primary functions are described.

This Chapter

USB defines a single connector type for attaching all USB peripherals to the host system. This chapter introduces the primary mechanical elements of USB connectors and cables.

The Next Chapter

The next chapter discusses USB power distribution, along with issues related to bus-powered devices and the operation of self-powered devices. The chapter also discusses the role of host software in detecting and reporting power-related problems.

The Connectors

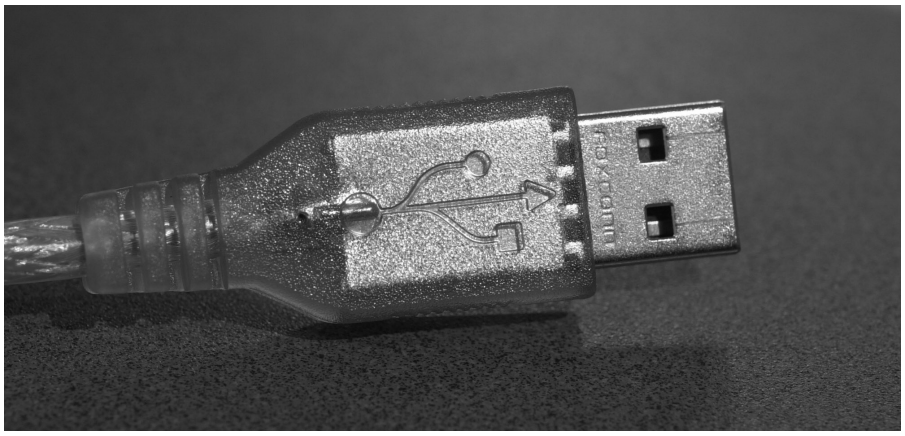
USB connectors are designed to permit any USB peripheral device to be attached to a hub port. Hub ports will be located at the back of the computer or may be associated with other peripheral devices such as monitors and printers, or are available on stand-alone hub devices.

Many USB peripherals have the USB cable permanently attached, while others have detachable USB cables. If the same connector were used on both ends of a

USB cable, it would be possible to connect the cable between two USB ports. To prevent a detachable cable from being plugged into two USB ports at the same time, a separate connector has been designed for the peripheral cable connection. The two connector types are described below:

- Series A connectors — provide the USB port connection to the USB peripheral cable. The series A receptacle is implemented as the hub port connector, while the series A plug is attached to the peripheral cable, permitting attachment of a USB peripheral device.
- Series B connectors — provide the cable connection to the USB peripheral device when a detachable cable is implemented. The series B receptacle is implemented at the peripheral and the series B plug is attached to the cable. A small form-factor B connector called the "Mini-B" connector has been defined. See MindShare's website for a direct link to the specification for this new connector.

Figure 3-1: A View of the Series A Plug



Each connector has four contacts: two for carrying differential data and two for powering the USB device. Note that the power contacts are longer than the data contacts to ensure that a USB device receives power prior to the data contacts mating (power pins are 7.41mm and the data pins are 6.41mm).

The connector contacts are numbered and the cable conductors are color coded for easy identification, as listed in Table 3-1.

Table 3-1: Connector Pin Designations

Contact Number	Signal Name	Cable Color
1	Vcc	Red
2	-Data	White
3	+Data	Green
4	Ground	Black

Series A Connectors

Series A connectors are used to connect a peripheral cable to a USB hub port. The receptacle comes in four variants and can be obtained in through-hole or Surface Mount Technology (SMT) versions. The four variant are:

- Vertical Mount
- Right Angle Mount
- Stacked Right Angle Mount
- Panel Mount

Series B Connectors

The series B connector is implemented in peripherals that have detachable cables. The specification does not define mounting variations for the series B receptacle; however, the author suspects that the same variants defined for the series A receptacle apply to the series B receptacle.

Cables

The USB specification defines two cables for compliant signaling. The low-speed cable is defined for 1.5Mb/s signaling and the full-speed cable defined by the 1.1 USB specification that supports both full- and high-speed transmission. The low speed cable permits a more economical cable implementation for low-speed/low-cost peripherals such as mice and keyboards. The following sections detail the characteristics of each cable type.

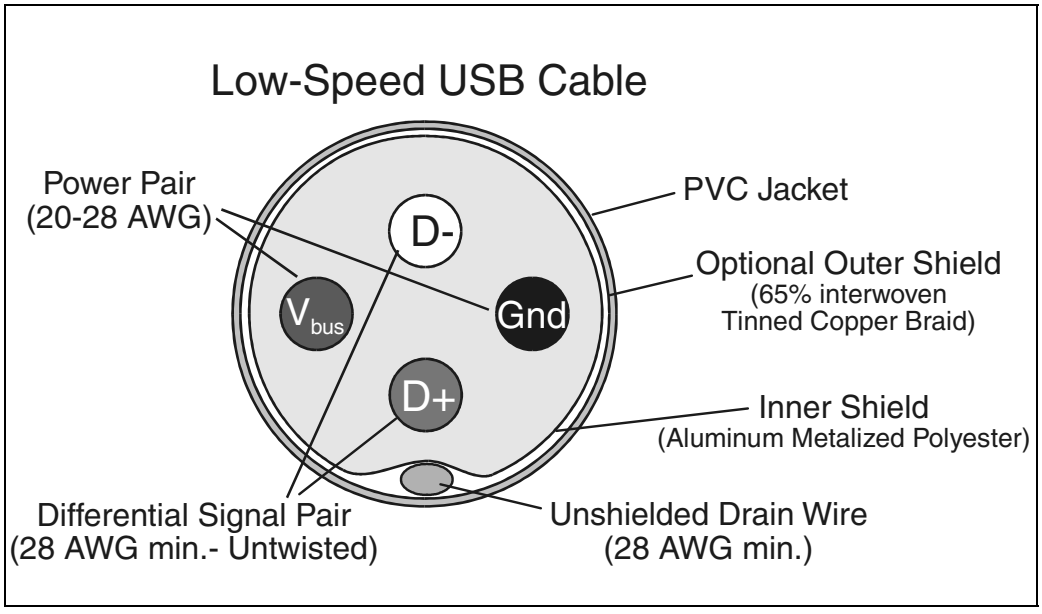
Low-Speed Cables

Figure 3-2 illustrates the cross section of a low-speed cable, sometimes referred to as a sub-channel cable. These cables are intended only for 1.5Mb/s signaling and are used in applications where the wider bandwidths are not required.

The differential data signaling pair may be non-twisted 28 AWG stranded conductors. In addition, low-speed cables require an inner shield (with the conducting side out) and drain wire that contacts the inner shield. The drain wire is attached to the plug and socket case. The outer shield is recommended but not required by the specification.

Low-speed cables are limited in the specification to 3.0 meters and must have the maximum propagation delay no greater than 18ns (one-way). The maximum cable length is a function of the maximum rise and fall times defined for low-speed signaling and the capacitive load seen by the low-speed drivers. Refer to the specification for details regarding these parameters.

Figure 3-2: Cross Section of a Low-Speed Cable Segment



Full- and High-Speed Cables

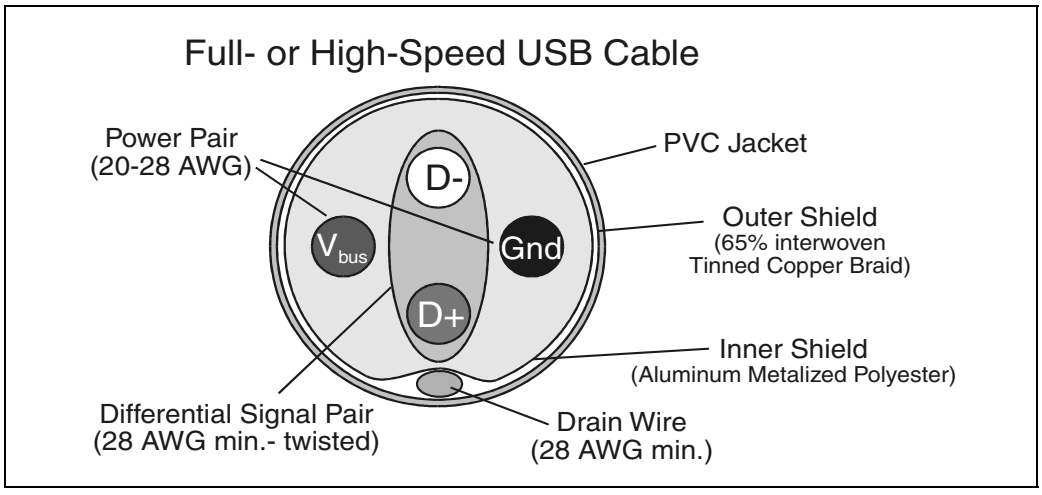
Full-speed and high-speed USB devices require "twisted pair" for the differential data lines, along with inner and outer shielding and the drain wire as illustrated in Figure 3-3. The maximum propagation delay must be equal to or less than 26ns over the length of the cable when operating in the frequency range of 1-480MHz. If the cable cannot meet the propagation delay limit of 26ns then the cable must be shortened as shown in Table 3-2 (see the specification for details).

Table 3-2: Cable Propagation Delay

Cable Propagation Delay	Maximum Cable Length
9.0ns/m	3.3m
8.0ns/m	3.7m
7.0ns/m	4.3m
6.5ns/m	4.6m

The maximum cable length supported for full- and high-speed cables is 5.0 meters. This length is determined by the propagation delay of the cable as mentioned above and the attenuation of the signal pair.

Figure 3-3: Cross Section of a High-Speed Cable Segment



Note that cable information included in this chapter is based on the 1.1 USB specification. Older full-speed cables based on the 1.0 specification are not compliant with the USB 2.0 specification and do not support high-speed devices.

Cable Power

Cable power is 5Vdc and can be used to power the peripheral. Cable power provides up to 500ma or as little as 100ma of current. Some peripherals may include their own local power supply and not use cable power.

Electrical and Mechanical Specifications

The electrical and mechanical specifications for the connectors and cables is not included in this text and can be found in the USB 2.0 specification. See “How to Get the USB Specifications” on page 24.