

Extending the Benefits of USB

Break the 5-meter barrier!



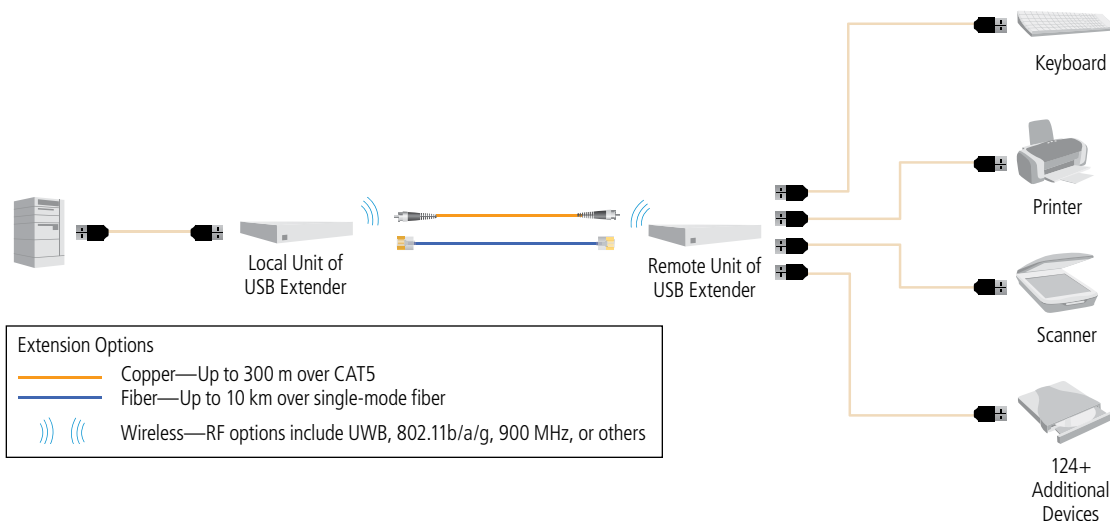
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We're here to help! If you have any questions about your application, our products, or this white paper, contact Black Box Tech Support at **724-746-5500** or go to **blackbox.com** and click on "Talk to Black Box." You'll be live with one of our technical experts in less than 20 seconds.

Introduction

Through the use of extenders, Universal Serial Bus (USB) is no longer limited to the desktop range of five meters (16.4 feet); you can now extend it to cover an entire campus with a range up to 10 kilometers (6.2 mi.). USB extenders are the key to bringing the benefits of extended-range USB technology to the industrial, commercial, and consumer computing marketplace.



USB Essentials

USB's main attraction is that it makes adding peripherals to your computer incredibly easy. It enables you to connect peripherals to the outside of the computer so you don't have to open your PC.

A USB peripheral simply plugs right into the port and works. You don't need to install a card; you don't even need to turn off your computer. Because USB configuration happens automatically, built-in USB means you don't have to fiddle with drivers and software when adding most peripherals.

To fully appreciate the value that USB extension technology brings to the market, you must first understand the USB specification, its value as the de facto standard in personal computer and consumer electronics connectivity, and its inherent limitations. This section identifies the major technical attributes of USB. For greater detail, refer to the USB specification at www.usb.org.

Specifications

USB technology is governed by specifications prepared by the USB Implementors' Forum (USB-IF). There have been three major revisions to this specification:

- Revision 1.0, January 1996 — This first version of USB introduced all the major components of the system.
- Revision 1.1, September 1998 — This version clarified some technical issues but did not introduce any new functionality.
- Revision 2.0, April 2000 — This version introduced high-speed (480-Mbps) operation.

Each revision of the specification is backwards compatible with previous versions. Also because no functionality is deleted in later versions, all USB devices will continue to work with newer versions of USB.

Topology

A USB system consists of three major subsystems:

- Host controller — The brains of the system, usually mounted on a PC motherboard or PCI card. Each USB domain is managed by a single host controller.
- Hub — Provides multiple attachment points to USB.
- Device — Provides end-user functionality. Each USB domain may contain a maximum of 127 devices.

USB hubs can be daisychained to a maximum depth of five units.

Bandwidth and Speed

USB supports three different speeds:

- Low-speed devices operating at 1.5 Mbps. Typical examples include keyboards and mice.
- Full-speed devices operating at 12 Mbps. Typical examples include Web cams and printers.
- High-speed devices operating at 480 Mbps. Typical examples include external CD-ROM and DVD drives.

Low-speed and full-speed devices are generally known as “classic” devices. All USB host controllers and hubs support classic devices. USB 2.0 host controllers and hubs also support high-speed devices.



Power

USB devices are also classified according to their power consumption requirements:

- Low-power devices may consume up to 100 mA from the USB interface. Typical examples include joysticks and mice.
- High-power devices may consume up to 500 mA from the USB interface. Typical examples include Web cams and certain keyboards with embedded hubs.
- Self-powered devices may consume up to 100 mA from the USB interface. If the device needs additional power, it must be drawn from an external power supply. Typical examples include printers and scanners. For most practical purposes, self-powered devices can be considered identical to low-power devices.

USB can't measure the amount of power consumed by each device. Although the PC operating system may disallow certain device configurations because of the power budget being exceeded, this decision is based on software descriptions of device power requirements, not on actual measured values.

USB Extenders

Although USB is a versatile serial interface, it's subject to an inherent distance limitation of five meters (16.4 ft.). USB extenders enable USB peripherals to be placed wherever users need them, up to 2 kilometers (1.2 mi.) from a host computer. With USB extenders, peripheral devices function as if they were within the five-meter limit specified by USB-IF.

USB extenders preserve standard USB functionality and timing restrictions while accommodating the increased cable delay incurred in extended-range transmissions.

USB-IF Compliance

USB extenders are fully compliant with the requirements for interoperability testing. This means that designers, manufacturers, and system integrators can integrate this technology into their own products knowing that all the plug-and-play and multivendor compatibility benefits of USB are retained.

System Architecture

USB extenders are composed of two units connected by a transmission line. These units are referred to as the local extender and remote extender. The local unit is connected to a downstream-facing port of a USB host controller or hub; the remote unit is connected to the upstream-facing port of a USB hub or device. Once operational, the entire USB extender system operates like a single standard USB hub.

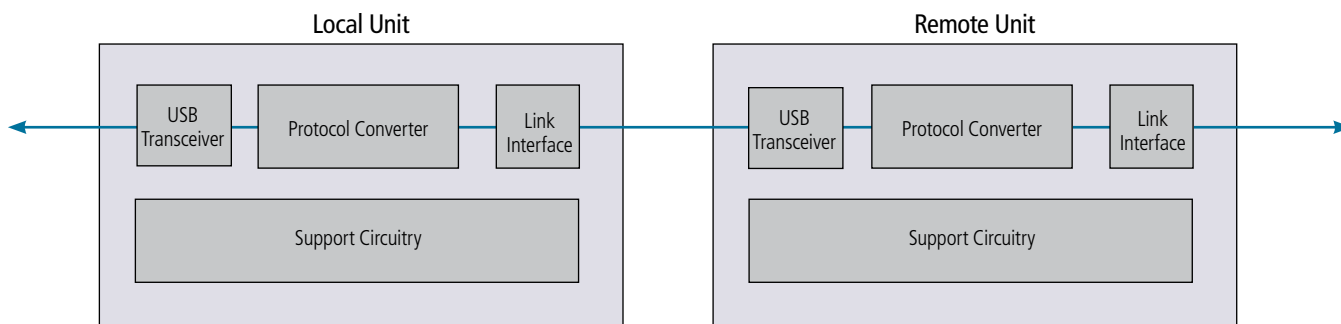
As a standard USB hub, the USB extender system is compatible with all operating systems that support USB hubs and requires no additional software to be loaded.

Because the system appears to USB as a conventional hub (albeit a very long one!) it can be connected to other hubs to the full depth permitted by USB. The system can be used as the first, last, or any intermediate hub in a chain. Multiple systems can also be used in parallel within a single domain—a common situation when opposite ends of a building need to be reached from a central computer room or telecom closet.

The only restriction placed on the configuration is that multiple USB extenders cannot be connected in series. Most USB extenders use CAT5 cable; if you require extra distance, you might need to consider a different cable type, such as fiber.

Subsystems

USB is available in a variety of formats, however, all these varieties share a common structure.



USB Extender Components

USB Transceiver	Provides a standard upstream-facing USB port
Protocol Converter	Converts between a USB data stream and a USB extender
Hub	Embedded USB Hub
Link Interface	Provides a digital interface for connection to a wide range of link transceivers
USB Support Circuitry	Power regulation, power management, connectorization, line drivers, etc.

USB extenders vary mainly in the configurations available. If you have a requirement that is not met by one of these configurations, contact our FREE Tech Support.

Transmission

For USB 1.1, the extender protocol requires a point-to-point transmission system with 16-Mbps, full-duplex capacity. It can operate over any transmission media that can support these requirements. Approximate maximum distances are as follows:

- 300-meter (984.3-ft.) transmission over 2-pair Category 5 UTP
- 500-meter (1640.4-ft.) transmission over 2-strand multimode fiber
- 10-kilometer (6.2-mi.) transmission over 2-strand multimode fiber

For USB 2.0, the extender protocol requires a point-to-point transmission system with 480-Mbps full-duplex capacity. It can operate over any transmission media that can support these requirements. Approximate maximum distances are as follows:

- 100-meter (328-feet) transmission over 2-pair CATx UTP
- 500-meter (1640.4-ft.) transmission over 2-strand multimode fiber
- 10-kilometer (6.2-mi.) transmission over 2-strand single-mode fiber

Operating System Support

USB is supported by the vast majority of operating systems in use today. Support for USB host controllers and USB hubs is provided “out-of-the-box” by these systems.

Because USB extender products are designed to simulate the operation of a standard USB hub, no additional software is required, so these products offer true cross-platform flexibility.

If you have an operating system not listed below, contact our FREE Tech Support.

USB Compatible Operating Systems

Windows	Mac	Linux	Others
Windows® 98 SE	Mac® OS 8.6	Corel Linux® SE	Sun® Solaris™ 5.8
Windows Me	Mac OS 9.0	Mandriva® Linux 8.1	Silicon Graphics® Onyx®
Windows 2000	Mac OS 9.2	Red Hat® Linux 7.2	
Windows XP	Mac OS X		
Windows CE			
Windows Vista®			

Frequently Asked Questions about USB Distance

Q. What are the distance limitations of USB?

A. The maximum range of USB is limited by the length of an individual USB cable and the number of cables that can be connected in series through USB hubs. The maximum length of a USB cable is 5 meters (16 ft.). The maximum number of USB hubs that can be daisy-chained (connected in series) is five. Thus, if a device is connected to a PC through five hubs, then the maximum distance from the device to the PC is 30 meters (98 ft.) (6 cables @ 5 meters [16 ft.] each).

Q. Why is USB cable length limited to 5 meters (16 ft.)?

A. This is the maximum capability of the standard drivers that are provided in USB devices and hubs.

Q. Why is the number of hubs limited to five?

A. Each hub delays the USB signal by a certain amount of time. When the host controller issues a request for data from a device, this request must pass through each hub in the chain, incurring incremental delay as it does so. A similar effect is experienced by the reply (data) from the device as it passes back through the chain of hubs to the host controller. The number of hubs is limited to five to place a limit on the round-trip delay of a signal from host controller to device and back to host controller.

Q. Why does USB impose a limit on a round-trip delay?

A. This is required to keep occupancy of the bus high. The host controller is not able to process commands for any other device while it is waiting for a reply.

Q. What would happen if the delay were too long?

A. The host controller would believe that the transaction had failed. Repeated failures might result in the device being taken out of service.

Q. How do USB extenders solve the delay problem?

A. A USB extender generates local responses that comply with the USB timing restrictions while the data is being retrieved from the remote source.

Q. Do USB extenders support all device speeds?

A. USB extenders support both 1.5-Mbps and 12-Mbps speeds for USB 1.1 and 480-Mbps speed for USB 2.0.

USB Extender Applications

- Connect your PC to your TV — Many newer LCD monitors and TVs can connect to a PC through a USB port rather than a graphics card. Send video across a USB extender to watch movies from your PC on your TV.
- Set up a kiosk — Using a USB extender is an easy way to place a USB-enabled touch screen in a public space for advertising or information purposes. This application is perfect for trade shows.
- Link to industrial controls — USB extenders are ideal for remote control and monitoring in industrial applications.
- Take to the air — A USB wireless adapter doesn't always get the best reception sitting next to your computer. Use a USB extender to place it for optimal wireless reception.
- Place a surveillance camera — Set up a surveillance camera using a USB camera linked to a PC. A USB extender enables you to place the camera exactly where you need it.
- Reach a printer — A USB extender enables you to place a printer where you need it, even if that location is more than 5 meters (16 ft.) away.
- Back up your hard drive — Use a USB extender to connect a USB backup drive placed in a secure location away from your PC.
- Build a convenient remote workstation— Set up a remote workstation consisting of a keyboard, USB-enabled monitor, and mouse. Link the workstation to your PC with a USB extender hub.
- Listen to music — USB speakers don't need to be next to the PC; use a USB extender to place speakers for the best sound.
- Get creative — There's virtually no end to gizmos developed for the USB interface. Whether you have a USB laser-guided missile launcher, a USB coffee warmer, or a USB flowerpot, a USB extender will ensure that you can place your USB device where you need it.

Appendix: Black Box Buyer's Guides

USB over CATx Extenders Buyer's Guide

Name	Code	USB Version	Media Type	Ports	Distance
USB 2.0 CATx Extender, 1-Port	IC253A	2.0/1.1	CATx	1	100 m (328 ft.)
USB 2.0 CATx Extender, 4-Port	IC254A	2.0/1.1	CATx	4	100 m (328 ft.)
Remote Port USB 2.0→CAT5 1-Port	IC247A	2.0/1.1	CAT5	4	50 m (164 ft.)
Remote Port USB 2.0→CAT5 4-Port	IC248A	2.0/1.1	CAT5	4	50 m (164 ft.)
USB X-Tender	IC169A	2.0/1.1	CAT5	1	Low speed: 1000 ft. (304.8 m); High speed: 150 ft. (45.7 m)
Single USB→CAT5 Extender	IC244A-R2	1.1	CAT5	1	50 m (164 ft.)
Single USB→CAT5 Extender	IC245A-R2	1.1	CAT5	1	100 m (328 ft.)
Remote Port USB, 1-Port	IC240A-R2	1.1	CAT5	1	100 m (328 ft.)
Remote Port USB, 4-Port	IC241A	1.1	CAT5	4	100 m (328 ft.)
Dual USB→CAT5 Extender	IC246A-R2	1.1	CAT5	2	50 m (164 ft.)

USB over Fiber Extenders Buyer's Guide

Name	Code	USB Version	Fiber Type	Ports	Distance
USB 2.0 4-Port Extender	IC249A-MM	2.0/1.1	Multimode	4	500 m (1640.4 ft.)
USB 2.0 4-Port Extender	IC249A-SM	2.0/1.1	Single-mode	4	10 km (6.2 mi.)
Fiber Remote Port USB	IC243A	1.1	Multimode	1	500 m (1640.4 ft.)

About Black Box

Black Box Network Services is a leading connectivity solutions provider, serving 175,000 clients in 141 countries with 192 offices throughout the world. Catalog and on-line offerings from Black Box include more than 118,000 products including USB hubs and extenders. Black Box offers an extensive line of USB extenders including CATx USB extenders, fiber USB extenders, and wireless USB extenders. More information is available at <http://www.blackbox.com/go/USBextenders>

Black Box also offers extenders for many other applications, including video extenders, Ethernet extenders, and KVM extenders, as well as cabinets, racks, cables, connectors, and other video, audio, and data infrastructure products. To view Black Box's comprehensive offering, see our Web site at blackbox.com

Black Box is also known as the world's largest technical services company dedicated to designing, building, and maintaining today's complicated data and voice infrastructure systems.

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