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Extending the Benefits of USB

>> Whitepaper

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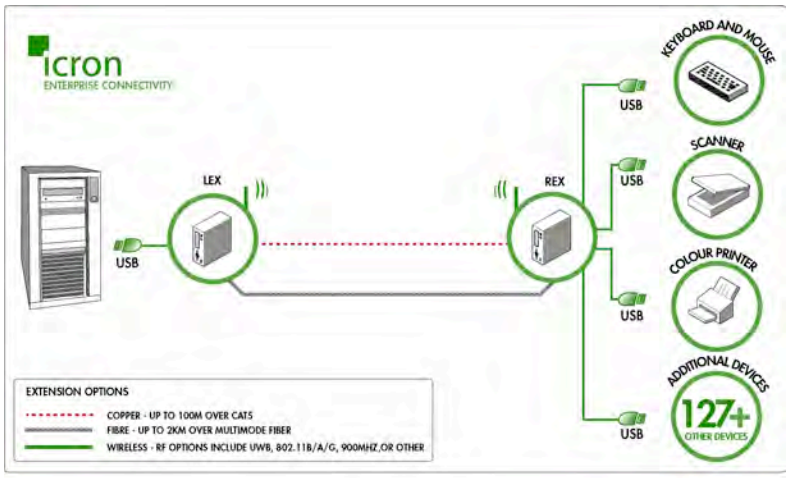
Extending the Benefits of USB

Icron Technologies Corporation s leading the drive to bring the benefits of extended range Universal Serial Bus technology to the industrial, commercial and consumer computing marketplaces. Icron's ExtremeUSB technology is the key component that enables these new applications of USB to occur. With ExtremeUSB technology, USB is no longer limited to the desktop range of 5 meters (15 feet), but can be extended to cover an entire campus with a range up to 2 km (1.2 miles).



USB Essentials

To fully appreciate the value that the ExtremeUSB technology brings to the market, you must first understand the USB specification, its value as the defacto standard in PC and CE connectivity and its inherent limitations. This section identifies the major technical attributes of USB. For greater detail please refer to the USB Specification, which can be found at www.usb.org.

Specifications

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

- Revision 1.0, January 1996 - This version introduced all of 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 Mb/s) operation

It should be noted that each revision of the specification is backwards compatible with previous versions. Since no functionality is deleted in later versions, all USB devices will continue to work in newer systems.

Topology

The USB system is constructed from three major subsystems:

- Host Controller - This unit is mounted on a PC motherboard or PCI card. Each USB domain is managed by a single Host Controller
- Hub - This unit provides multiple attachment points to the USB
- Device - This unit provides end-user functionality. Each USB domain may contain a maximum of 127 devices

USB hubs can be daisy-chained to a maximum depth of 5 units.

Bandwidth and Speed

USB supports three different speeds:

- Low-speed devices operate at 1.5 Mb/s - Typical examples include keyboards and mice
- Full-speed devices operate at 12 Mb/s - Typical examples include web-cams and printers
- High-speed devices operate at 480 Mb/s - Typical devices include external CD-ROM and DVD drives

Low-speed and full-speed devices are collectively known as "classic" devices. All USB Host Controllers and Hubs support any mixture of classic devices. All USB 2.0 Host Controllers and Hubs support hi-speed devices in addition to classic devices.

Power

USB devices are classified according to their power consumption requirements:

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

It must be recognised that USB has no capability to measure the power that is actually consumed. Although the PC operating system may disallow certain device configurations due to the power budget being exceeded, the decision is based on the software description of device power requirements, not on actual measured values.

ExtremeUSB Technology

ExtremeUSB technology, invented by Icron Technologies Corporation, enables USB peripherals to be placed wherever users need them, up to 2 km (1.2 miles) away from a host computer. With ExtremeUSB technology, peripheral devices function as if they are within the 5-meter (16.4 foot) limit specified by USB-IF.

Icron's communications protocol preserves standard USB functionality and timing restrictions while accommodating the increased cable delay incurred in extended range transmissions.

This technology can be incorporated into products by Original Equipment Manufacturers (OEMs), or purchased as a stand-alone product through one of Icron's distribution partners.

USB-IF Compliance

The USB-IF has confirmed that ExtremeUSB technology is 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 multi-vendor compatibility benefits of USB are retained.

System Architecture

Every ExtremeUSB system is composed of two subsystems connected by a transmission line. These subsystems are the Local Extender (LEX) and Remote Extender (REX). The LEX unit is connected a downstream-facing port of a USB Host Controller or Hub; the REX unit is connected to the upstream-facing port of a USB Hub or Device. Once operational, the entire ExtremeUSB system operates like a single Generic USB Hub.

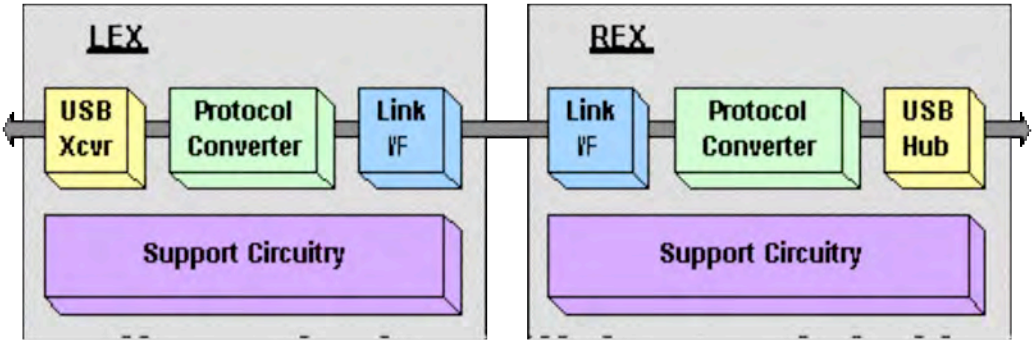
As a Generic USB Hub, the ExtremeUSB system is compatible with all operating systems that support USB Hubs and requires no additional software to be loaded

Since 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 central computer room or telecom closet.

The only restriction placed on the configuration is that multiple ExtremeUSB systems cannot be connected in series. If you require extra distance then this may be accomplished by selecting a more capable transmission scheme, such as fiber.

Subsystems

Icron supplies the LEX and REX subsystems in a variety of formats to suit the needs of OEM customers, distributors and end users. However, all of these variants share a common structure.



USB Xcvr	Provides a standard upstream-facing USB port
Protocol Converter	Converts between a USB data stream and ExtremeUSB
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.

Icron's standard products vary mainly in the configuration of the Support Circuitry provided. If you have a requirement that is not met by one of these formats, then please contact our Marketing Department.

Transmission

For USB 1.1 the ExtremeUSB protocol requires a point-to-point transmission system with 16 Mb/s full-duplex capacity. It can operate over any transmission media that can support these requirements. Examples of the following

- 70 meter (229 foot) transmission over 1-pair Category 5 UTP
- 100 meter (328 foot) transmission over 2-pair Category 5 UTP
- 2 kilometer (1.24 mile) transmission over 2-strand multimode fiber

For USB 2.0 the ExtremeUSB protocol requires a point-to-point transmission system with 480 Mb/s full-duplex capacity. It can operate over any transmission media that can support these requirements. Examples of the following:

- 70 meter transmission over 1-pair Category 5 UTP

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, without the need for the user to install additional software.

Since all of Icron's range extender products are designed to simulate the operation of a Generic USB Hub, no additional software is required. This attribute enables our products to offer true cross-platform flexibility.

To maintain this high level of compatibility, Icron regularly tests its products across a wide spectrum of operating systems. The USB functionality of the following Operating Systems has been tested and support for USB hubs has been confirmed:

Windows	Mac	Linux	Others
Windows 98 SE	Mac OS 8.6	Corel Linux SE	Sun Solaris 5.8
Windows ME	Mac OS 9.0	Mandrake Linux 8.1	SGI Onyx
Windows 2000	Mac OS 9.2	Red Hat Linux 7.2	
Windows XP	Mac OS X		
Windows CE			

If you have a requirement for an operating system not listed above, then please contact technical support and we will be pleased to investigate its compatibility. If you are already using USB hubs with such an OS, then please let us know so we can extend the list.

Frequently Asked Questions about Distance

Q. What are the distance limits 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 feet). 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 5 hubs, then the maximum distance from the device to the PC is 30 meters (98 feet) (6 cables @ 5 meters or 16 feet each).

Q. Why is the cable length limited to 5 meters (16 feet)?

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 finite 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 in order 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 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 was 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 does ExtremeUSB solve the delay problem?

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

Q. Does ExtremeUSB support all device speeds?

A. ExtremeUSB supports both 1.5 Mb/s and 12 Mb/s speeds for USB 1.1 and 480Mb/s for USB 2.0

Q. Why are competitors' products limited to 50 - 60 meters (164 – 197 feet)?

A. They are limited to this distance because they are unable to compensate for the round-trip delay. In addition, these products are unable to support the full complement of USB hubs because they consume the delay budget that is allocated to each hub in a chain.

Using ExtremeUSB for Your Applications

Icron is facilitating the growth of these markets with a family of products suitable for OEMs, distributors and end users. Whether you wish to build ExtremeUSB technology into your own products, brand label an existing design, or simply deploy a standard product, Icron has a solution that will fit your needs. Icron will also take on custom design projects to adapt an existing design or to create an entirely new product that benefits from our in-depth knowledge of the USB specifications.

Ranger Products

Icron's Ranger products are ready for sale to end users. They may be distributed under the Icron brand name or re-labeled to suit your requirements.

Board-level Products

Icron supplies a range of board-level products that enable OEMs to incorporate ExtremeUSB technology quickly and easily. The Turnkey form factor provides the fastest route to an end product while the Core form factor allows greater flexibility to select powering and connectorization options.

Development Tools & Services

Get a quick start to your extended range project with one of Icron's developer kits. Select one of Icron's UTP or fiber-optic transmission systems or design your own using our schematics as a starting point.

Accessories

Power supplies, cables, firmware updates and more are available.