Industrial role for USB

The Hi-Speed USB standard lets industrial data-collection systems hit speeds faster than those available over most LANs.

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The CompactDAQ data-acquisition system from National Instruments is typical of the growing number of virtual instruments that have replaced proprietary interface protocols with standard USB connections.

Ethernet faced constant criticism upon its introduction to the industrial world. However, there is no doubt today that it has become a bus of choice for many industrial applications. History may repeat itself with the Universal Serial Bus (USB).

Skepticism facing the USB is understandable. The industrial market is empirically skeptical by nature. Industrial users constantly seek to become more productive and reduce costs, yet they are slow to adopt promising new technologies. However, as industry grows more familiar with a technology, so does its willingness to put that technology to work. That's the case with USB judging by the growing numbers of new products that use it.

First introduced in January of 1996, USB grew to become the standard connection between a computer and peripherals such as a mouse, keyboard, or external hard drive. The USB Implementers Forum today reports an average of two USB ports per computer with an estimated 2 billion ports worldwide. It is undoubtedly one of the fastest growing bus technologies in the computer industry.

USB owes this rapid adoption to its mix of ease of use and good performance. Those same qualities also make it attractive for such demanding industrial applications as data acquisition. A survey performed by *Sensors* magazine showed that most readers would choose USB for their next data-acquisition system over any other bus.

USB Versions 1.0 and 1.1 were introduced in the late 1990s to replace traditional computer peripheral buses such as RS-232 and parallel ports. They aimed to provide enough bandwidth for peripherals needing low to medium-speed data rates. The low-speed version at 1.5 Mbps targeted the mouse, keyboard, and other low-bandwidth peripherals. The full-speed version ran at 12 Mbps and handled medium-bandwidth peripherals such as low-resolution video cameras and small storage devices.

A high-speed USB specification came in 2000 and was standardized in 2001 as USB 2.0. It was called Hi-Speed USB by the USB Implementers Forum and had a data rate of 480 Mbps. The high data speeds worked well for high-bandwidth peripherals such as

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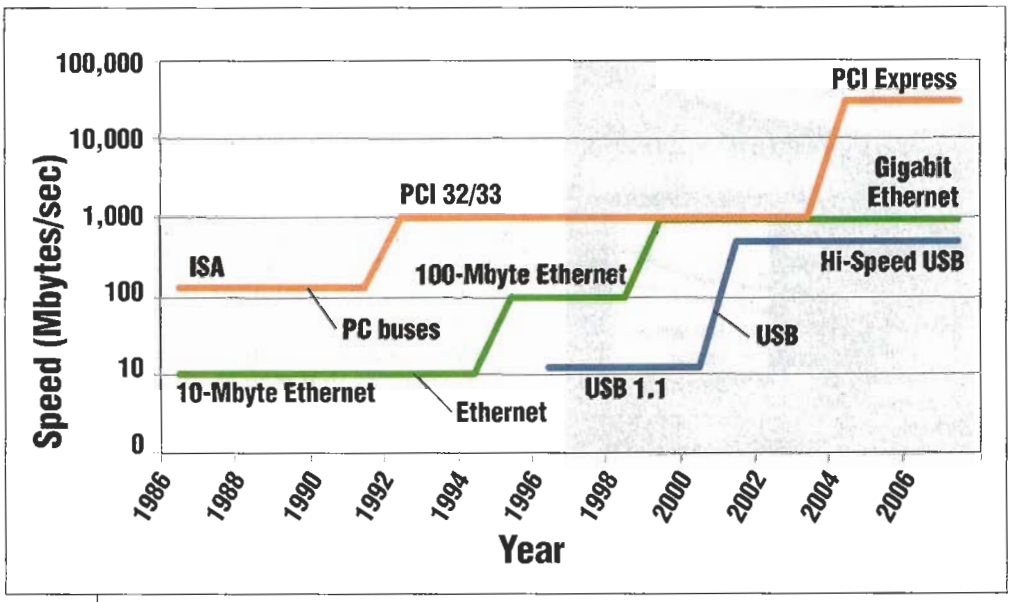
full-resolution video cameras and attached mass-storage devices such as hard-disk arrays and Flash drives.

The top differentiator between USB and other peripheral connection schemes is plug-and-play capability. To attach a USB device to a host computer the user need only plug the connector into the USB port. The completed electrical contact of the physical connection pulls one of two signal lines to a high state. The system detects this change of state and initiates a series of requests to the newly connected device.



This timeline graph shows the relative jumps in performance between PC interface buses over the last 20 years. It's interesting to note that Hi-Speed USB is 48× faster then local area networks using common 10Base-T wiring.

Each USB device contains a descriptor that gives the host computer the information it needs to set up the device and to find and install the right software driver. Once installation completes, the device is ready for use. The entire setup is invisible to the user except for the pop-up windows that announce the status of the installation process.

Removing a device is as simple as unplugging it from the computer. The computer automatically disables the port the device formerly used and removes its listing from the device manager. USB is hot-pluggable so the user needn't turn off the computer to add or remove a device.

Another facet of USB's ease of use is its capacity to power some devices from the bus. The bus interface includes power supply and ground lines that offer 5 V at up to 500 mA to USB peripherals. This power comes from either the computer or the power supply of the USB hub, a unit that connects multiple USB devices.

Bus-powered devices need no external power source. All their power comes from the USB bus. This contrasts with other devices that must either include an internal power supply or use a bulky external supply.

As previously stated, USB offers three bus speeds: Hi-Speed at 480 Mbps, full-speed at 12 Mbps, and low-speed at 1.5 Mbps. While Hi-Speed USB 2.0 is 40× faster than the full-speed version, the speeds are backwards compatible. That means computers with Hi-Speed USB 2.0 connections can also handle full-speed and low-speed peripherals. With more than four times the speed of 100-Mbps Ethernet, USB 2.0 offers a faster alternative for industrial data-streaming applications.

The USB standard provides two levels of reliability. At the hardware level, data travels across a twisted pair of data lines using differential signaling. The differential design eliminates most noise that could otherwise cause data errors during transfer. The standard also provides data error checking built into the transfer protocol on top of the hardware protection.

USB data is formatted according to one of four distinct transfer modes: control, interrupt, isochronous, and bulk. Control, interrupt, and bulk transfer all enable error checking. The receiver checks the data packets it receives and asks the sender to resend the bad ones. Isochronous transfer is about the timely delivery of packets and does not include error checking. Its primary use is for audio or video streaming.

All computers shipping today carry USB ports. All major operating systems and some handheld devices support the standard. Many human-machine interface (HMI) products used on industrial floors sport USB ports. Industrial USB-device vendors also provide OLE (Object Linking and Embedding) for Process

Control (OPC) support for easy system-software integration.

Isolation is the most talked about electrical limitation for USB. USB specifications do not address isolation concerns between the ground on the device and the computer ground. This lack of isolation can cause ground-loop currents that may affect the accuracy of measurement devices. In addition, it is a hazard in industrial settings where electrical surges could easily find their way to the computer and possibly affect entire systems.

Most industrial USB devices, such as National Instruments CompactDAQ, solve this problem by building in isolation to protect against transient and nontransient electrical surges. Engineers can also isolate devices by using isolated hubs.

The USB standard specifies a maximum cable length between the host computer and the peripheral of five meters. Use of a hub may boost that figure up to 30 m; but no more than five hubs may be strung in series. However, most users find 5 m long enough to connect a rack-mounted device to a rack-mounted HMI.

Several companies offer USB hub extenders that boost the host-to-device distance up to 500 m. The extenders give industrial customers high-speed USB data streaming over distances comparable to Ethernet.

On the hardware side, the industrial world mostly criticizes USB for its connectors. Mechanical features for the connectors are defined in the USB specification documents. To improve ease of use, USB implementers defined the connectors for minimum effort when connecting or disconnecting devices. The fact that connectors can be easily removed, even by mistake, adds an extra level of reliability concern for industrial customers.

To help solve this problem most companies add extra strain relief with their industrial USB devices and systems. Some companies have even integrated additional strain relief directly into their connectors.

USB may not be suitable for all industrial applications, but it has the bandwidth, reliability, and ruggedness for such applications as data logging and data monitoring. While it has features comparable to Ethernet, it also brings its ease of use with plug-and-play and bus-power capabilities. In the end, USB deserves less skepticism and more consideration. **MD**

COMPARING ETHERNET TO USB

Function	Ethernet (100 Mbps, TCP/IP)	Hi-Speed USB
Multidrop extensibility	Very good	Good
Distance extensibility	Very good	Very good
Plug-and-play ease of use	Good	Very good
Bus bandwidth	Good	Very good
Bus-power capability	Good	Very good
Strain relief	Good	Good
Port isolation	Very good	Good
OPC	Very good	Very good

Comparisons of standard TCP/IP Ethernet to Hi-Speed USB shows each has advantages in some areas. However, the Hi-Speed USB interface offers almost 5× the speed of the Ethernet connection albeit over shorter distances.

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