USB for Automated Test

Overview

USB products are ideal additions to test systems requiring hot-swappable, conditioned, and specialized I/O. To design an automated test system with USB in mind, it is important to understand the USB position relative to other buses available for automated test; USB advantages and disadvantages; and USB benefits and requirements for a modern, high-performance hybrid automated test system.

USB for Automated Test

USB has been a hot topic in the test and measurement world for both consumers and manufacturers. A recent online survey conducted by *Sensors* magazine showed that engineers are more likely to choose USB over other buses for their next data acquisition applications. However, as with any new bus, there is a great degree of interest from the scientific and engineering community on how USB compares with other buses and how it can be used.

USB products are ideal additions to test systems requiring hot-swappable, conditioned, and specialized I/O. To design an automated test system with USB in mind, it is important to understand the USB position relative to other buses available for automated test; USB advantages and disadvantages; and USB benefits and requirements for a modern, high-performance hybrid automated test system.

USB Evolution

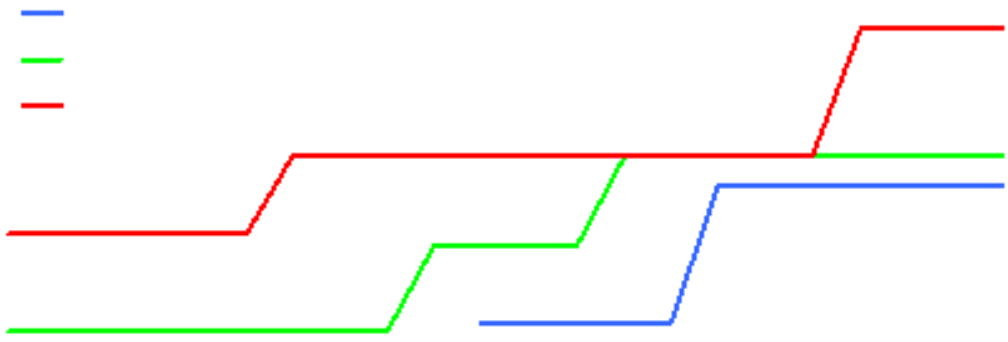

Figure 1. This chart shows the bandwidth progression for various buses.

USB 2.0 delivers faster performance than 100 Mb/s Ethernet, which is currently found on most PCs, laptops, and network routers. With more than 2 billion ports around the world, it is one of the fastest-growing bus technologies in the

computing industry. USB has evolved from a simple, low-speed peripheral bus for accessories such as mice and keyboards to a Hi-Speed USB theoretical rate of 480 Mb/s for more demanding applications such as streaming multimedia.

Bus Comparison

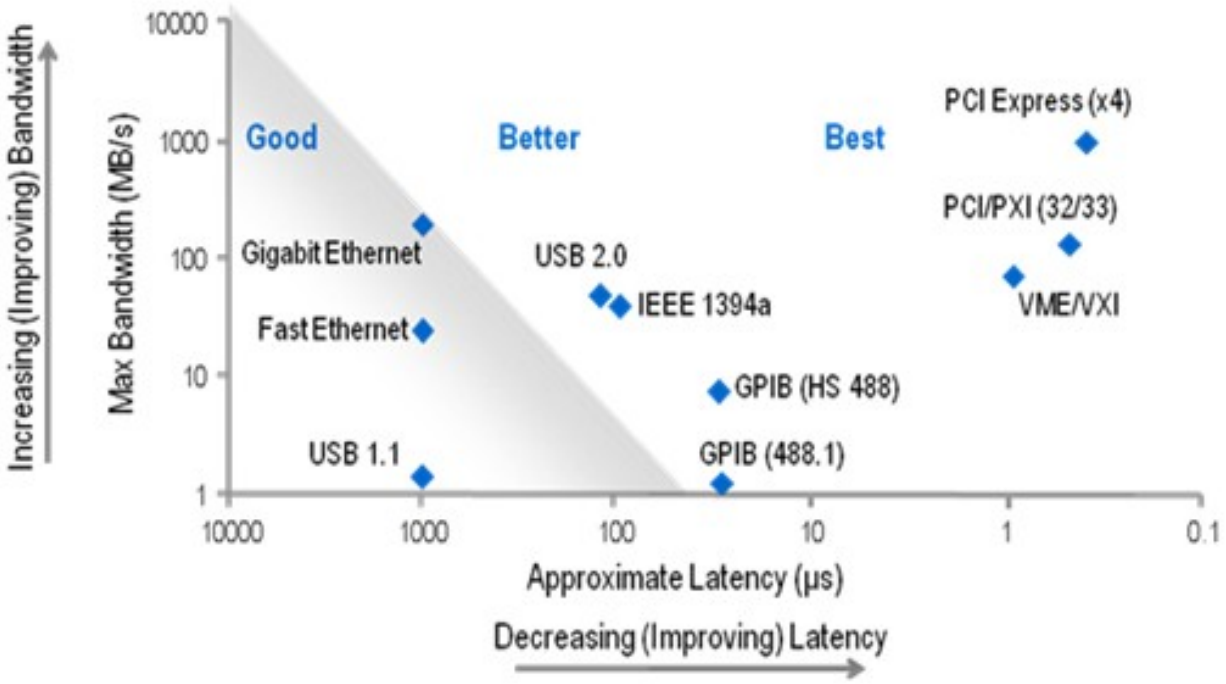

Figure 2. This chart shows bus comparisons for bandwidth and latency.

Figure 2 plots various buses based on their bandwidths and latencies – two important bus attributes in automated test. Bandwidth is defined as the amount of data that can be transferred within a prescribed amount of time, and latency (also known as responsiveness) is defined as the time delay between the initiation of a request for data and the beginning of actual data transfer. Although USB is typically faster than 100 Mb/s Ethernet and slower than internal buses such as PCI, its latency is about 100 times longer than that of its PC bus counterparts. Buses typically used for instrument control, such as local area networks (LANs), GPIB, and serial, are listed toward the bottom and left sides of the chart.

NI Signal Streaming Technology

USB was not originally designed for high-speed measurements, which limited its functionality in automated test. In the test and measurement industry, engineers have traditionally used USB as a replacement for slower serial and GPIB buses on stand-alone instruments with their own displays and processors. Due to its ubiquity on PCs, USB has become a popular communication bus for stand-alone instrumentation and applications including low-cost, low-speed, and low-accuracy measurements.

On the other hand, PCI-based devices have generally been associated with high-throughput automated test. Although the USB protocol provides high data transfer rates for peripherals such as external hard drives when a single stream of data flows in a single direction, multiple streams and bidirectional data transfers can be extremely slow over USB. To overcome throughput challenges and extend the use of USB in test and measurement instrumentation, National Instruments has created an innovative technology called NI signal streaming.

NI signal streaming technology offers three main innovations for higher throughput and reduced latency. First is the ability to quickly transfer large data sets through USB. NI achieved this capability with a custom application-specific integrated circuit (ASIC) that manages data flow between the data acquisition front end and USB. Second is optimized message-based communication between the USB controller and the device, so a single message can replace dozens of low-level register command transfers on USB. Finally, with additional device-side intelligence, devices can choose the size of data transfers depending on pending requests, thereby making them more responsive. This custom design, combined with the other two innovations, delivers a performance increase of up to 1,600 percent for single-point analog input and up to 250 percent for single-point analog output.

National Instruments offers more than 30 devices that use NI signal streaming technology including multifunction USB data acquisition devices and modular data acquisition systems.

Specialized USB Products for Automated Test

While NI signal streaming technology provides a solution for higher-throughput data acquisition, other application requirements still challenge potential users of USB instrumentation. Among them, the need for higher-performance measurements is common for cutting-edge design and research. NI has expanded USB performance with three new specialized instruments for automated test – a 6½-digit digital multimeter (DMM), a 100 MS/s digitizer/oscilloscope, and a 6 GHz RF power meter, which all offer a bus-powered form factor.

Figure 3. A recently released USB digitizer/oscilloscope and DMM expand the measurement performance available with bus-powered instruments for USB.

The NI USB-5133 100 MS/s digitizer/oscilloscope offers two simultaneously sampled channels with 8-bit resolution. This USB digitizer/oscilloscope features 10 input ranges from 40 mV to 40 V and programmable DC offset, and it comes standard with 4 MB/ch of onboard memory for measurements requiring extended data captures. The NI USB-4065 DMM offers 6½ digits of resolution at up to 10 readings per second and up to 3,000 readings per second at lower resolutions. With ±300 V of isolation, current measurements up to 3 A, and 2- or 4-wire resistance measurements, the USB-4065 offers a complete multimeter solution for portable 6½-digit measurement needs. Finally, the NI USB-5680 RF power meter features high measurement accuracy and wide dynamic range in a package similar in size to a typical power head. This instrument features better than ±0.18 dB of linearity from -40 to +23 dBm and from 50 MHz to 6 GHz.

In addition to these high-performance instruments, USB can also control stand-alone switching chassis that can house more than 30 different switch topologies with bandwidths ranging from DC to 5 GHz, currents up to 8 A, voltages up to 300 V, and densities up to 256 crosspoints on a single matrix module.

Hybrid Test Systems

No single bus can satisfy all needs and applications. Regardless of the performance of any bus or platform, it may not be possible to build a test system based on a single technology. To achieve greater flexibility and extend system longevity without redesigning entire systems to fight obsolescence, more engineers are choosing a hybrid system approach.

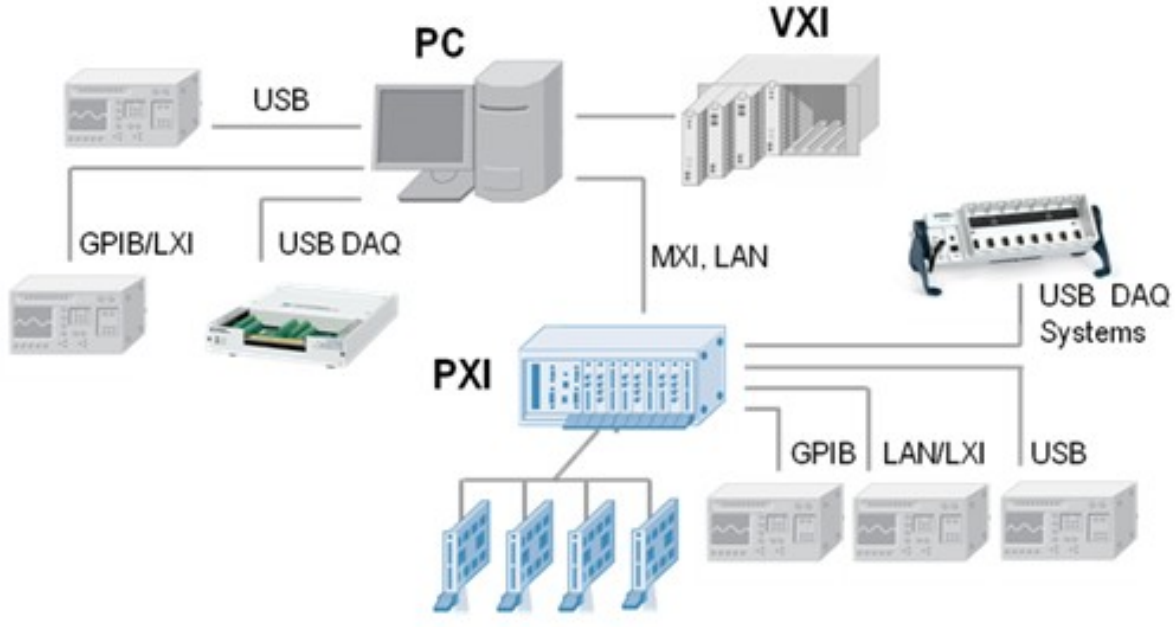

Figure 4. To achieve greater flexibility and extend system longevity, engineers are choosing hybrid systems.

Because modular instruments have built-in timing and synchronization that may not be possible between stand-alone

instruments, engineers commonly use PXI at the cores of their hybrid systems. In such a configuration, they can choose PXI modular instruments for their test system components that require the tightest timing and synchronization and connect other instruments as peripherals. Engineers also can treat a PXI system as a peripheral by cabling it to a PC as if it were a stand-alone instrument. With hybrid systems, they also can integrate long-established technologies such as VXI. The key to creating and maintaining a hybrid system is implementing a software architecture that transparently supports multiple bus technologies such as the NI LabVIEW graphical programming environment.

New Capabilities for USB

With new innovations, USB data acquisition devices can complement existing test systems as USB reaches capabilities never thought possible on a widespread commercial external bus.

Get more information on NI USB products for automated test.

– Nathan Yang

Nathan Yang is a product marketing engineer in the data acquisition group at NI. He holds a bachelor's degree in electrical engineering from McGill University.

– Travis White

Travis White is responsible for the product management and marketing of precision DC products at NI. He holds a bachelor's degree in electrical engineering from Rice University.