September 2011

Test & Measurement World

MODULAR INSTRUMENTATION

TEST REPORT

VXI 4.0 adds power and bandwidth

By Richard A. Quinnell, Contributing Technical Editor

It has been more than a year since Revision 4.0 of the VXI specification was finalized in May 2010. To learn what impact VXI 4.0 will have on the test industry, I spoke with Tom Sarfi, the VXIbus Consortium president.

Q: What prompted VXI Rev. 4.0?

A: More and more applications require test instruments that can supply more power and increased data throughput, particularly in the high-speed digital and data-acquisition domains. While the VXIbus has been an excellent platform for high-performance applications, there were certain limitations in the specification that presented challenges for instrumentation suppliers. The VXI Consortium saw an opportunity to leverage the specification's ties to the VMEbus and adopted a few of the enhancements that have occurred on that platform over the years. The result was additional power and bandwidth capacity in the VXIbus core infrastructure to better satisfy the emerging application requirements.

Q: What bandwidth improvements has the Rev. 4.0 spec brought to VXI?

A: We addressed bus bandwidth in two ways. One was to adopt the 2eSST [dual-edge source-synchronous] protocol to achieve rates to 320 Mbytes/s on the backplane. We also added a VITA 41 VXS [VMEbus switched-serial] bus connector to support PCI Express implementations. The backplane offers switched routing for up to 12 modules with links supporting 2 Gbytes/s in each direction and an aggregate bandwidth up to 8 Gbytes/s to and from the host.

Q: What about the power issue?

A: Using the VME-64 five-row connector allowed VXI Rev. 4.0 to provide more power lines to each module, supporting up to 418 W per slot. In addition, we added 3.3 V to the traditional rail power options.

Q: How does Rev. 4.0 fit in with earlier VXI equipment?

A: One of the objectives was to ensure backward compatibility with legacy products. The 4.0 backplane was designed to accept 3.0 and earlier cards.

Q: What application areas will benefit from Rev. 4.0?

A: In the high-speed digital domain, Rev. 4.0 will be useful as the increase in power will allow for increased voltage levels and higher slew rates than what is commonly available on the market. Data-acquisition applications such as vibration and acoustic analysis and digital-bus emulation will all benefit from the ability of Rev. 4.0 to support more channels and higher data-throughput rates to disk. In some applications, like signal switching, the previous specifications were sufficient, and end users can continue to use those cards alongside Rev. 4.0 modules.

Tom Sarfi
President
VXIbus Consortium

Q: What kind of Rev. 4.0 equipment has become available?

A: One of the first devices out was a slot 0 card using the 2eSST protocol and offering a PCI Express link to a host controller. Cards like this are important in VXI because the flexibility in remotely interfacing to a VXIbus mainframe is a valuable and unique ability of VXI. High-speed digital-bus emulation modules have also been introduced, as well as high-speed data-acquisition cards. Also, a lot of vendors are keeping up with operating system changes by introducing drivers that support 64-bit OSes such as Windows 7.

Q: What's next for VXI that Rev. 4.0 enables?

A: We can expect to see carrier cards that can adapt other modular card types to VXI. For instance, VME modules and XMC mezzanines that provide digital-signal processing and high-performance CPUs can be adapted to work in a VXIbus environment, and simple carriers will allow VXI 4.0 to support PXI and PXI Express modules with no software changes needed. Access to all this capability will make VXIbus one of the most versatile modular instrument platforms available for years to come. □

INSIDE THIS REPORT

EDITOR'S NOTE

Vindication at last

By Richard A. Quinnell
Contributing Technical Editor

Back in the mid-'90s I was a technical editor with *EDN,* working on a "hands-on" project using the newly released Universal Serial Bus. This was revision 1.1, the first to begin entering the market. It was so new I had to get beta software from Microsoft in order to access the bus on the new computer I was using.

My goal was to evaluate the USB as a data-acquisition channel for test-and-measurement purposes. The plug-and-play connectivity and host-power attributes of USB convinced me that there was tremendous potential for using the bus to implement highly portable instruments. I wanted to see how well it actually worked in practice.

Well, it didn't go smoothly. What I finally wrote about the bus in October 1996 was entitled, "USB: a neat package with a few loose ends." There were some problems with that first release.

From what I discovered researching the feature article in this Test Report, however, it seems that those early problems have long since been overcome (p. XX). USB is now well-established as a viable means for turning a PC into a test instrument.

A co-worker at the time thought that USB would only be good for keyboards, mice, and printers, and that FireWire was the way to go for high-speed external connections.

I got to be proven right. He, on the other hand, got promoted. Which is better, I wonder? □

Contact Richard A. Quinnell at richquinnell@att.net

USB test instruments provide portable modularity

By Richard A. Quinnell, Contributing Technical Editor

The USB (Universal Serial Bus) provides PC connectivity with many desirable attributes, so it is no surprise that test instruments have arisen that use the USB to link to a host computer. What may be surprising, however, is the range of functions and performance levels available from USB test instruments. Data-acquisition, signal-generation, measurement, and RF instruments are all available with USB connectivity, and engineers can mix-and-match multiple instruments to form a complete test platform.

True to their "universal" name, USB ports have become pervasive, available on virtually every personal and industrial computer in production. Even production-test systems based on the personal computer architecture offer USB ports. And for good reason. A USB 2.0 port (the most commonly available) provides hot-swappable plug-and-play connectivity, transfers data at rates up to 480 Mbps (faster than 100-Mbps Ethernet), offers host power to attached devices, and has the ability to connect 128 unique endpoints to the host through a single port. The new USB 3.0 specification boosts data rates nearly tenfold.

To leverage the availability and simplicity of USB, a number of companies have created test instruments that link through USB to a host PC for processing, control, and display. The most common of these instruments are DSOs (digital storage oscilloscopes) and function generators, many from small companies that specialize in these portable instruments. The Australian company Esis and the UK-based Elan Digital Systems, for instance, both offer the USBscope50—a PC plug-in not much larger than a flash drive that accepts standard BNC probes (**Figure 1**). The instrument has a 75-MHz input bandwidth and can capture 8-bit samples at a rate of 50 Msamples/s in single-shot capture. For repetitive signals, the instrument provides capture timing equivalent to 1 Gsample/s.

Fig. 1 USB instruments can pack considerable test capability into a tiny package, such as this 50-Msamples/s shirt-pocket digital storage oscilloscope. Courtesy of Elan Digital Systems.

The two companies also offer a 12.5-MHz DDS function generator with 0.2-Hz resolution and +/-10-V output, a 100-MHz clock and pulse generator, and a 50-MHz frequency/period counter, all in the same form factor. The modules are stackable to form a suite of interrelated instruments, using an adapter that permits four modules to share the same USB port. Thus, you can provide a test stimulus, measure output frequency, and examine two waveform channels using an ordinary laptop and a collection of modules that could fit into a shirt pocket.

China's Novatek offers a series of larger and higher-performance dual-channel DSOs with analog bandwidths ranging up to 200 MHz. The devices also double as spectrum analyzers by using FFT (fast-Fourier transform) software on the host PC. The company also offers a DDS (direct-digital synthesis) arbitrary waveform generator for frequencies up to 5 MHz with 0.1-Hz resolution that also serves as a frequency counter with an input range to 2.7 GHz. Novatek's dual-direction GPIB module allows the USB port to control up to 14 instruments with data transfer rates above 1 Mbyte/s.

Link Instruments in the US offers a dual-channel DSO with 100-MHz analog bandwidth and sample rates to 500 Msamples/s in single-shot mode. The company also offers mixed-signal oscilloscopes that incorporate signal generators with the DSO. The MSO-19, for instance, is a combination DSO, pattern generator, logic analyzer, and time-domain reflectometer, with all functions operating at 200 Msamples/s.

USB handles RF/microwave test

While these DSOs and related instruments are the most commonly available, there are other types of USB-based test equipment to be found. Both Telemakus and LadyBug Technologies, for instance, offer instruments addressing RF and microwave test needs. Telemakus has RMS (root-mean-square) detectors, vector modulators, signal generators, attenuators, and switches that serve a variety of RF and microwave frequencies ranging from the L-band to the X-band. LadyBug Technology offer sensors for continuous-wave, peak, profile, and average power measurements covering the 10-MHz to 26.5-GHz frequency range (**Figure 2**).

The USB test-instrument market is not limited to specialty companies, either. Both Agilent Technologies and National Instruments offer numerous

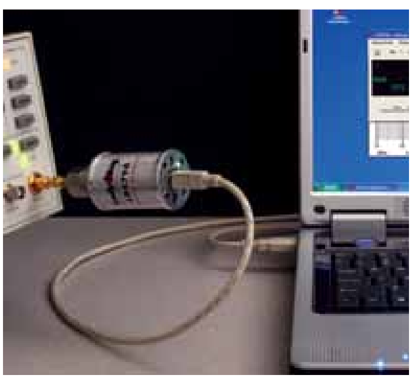

Fig. 2 In addition to DSOs and data-acquisition units, USB instrumentation provides RF and microwave test capabilities such as power meters and synthesized sources. Courtesy of LadyBug Technologies.

USB-based test instruments. NI, for instance, has more than 50 different USB instrument modules with functions such as 6.5-digit DMMs (digital multimeters), RF power meters, data-acquisition units, thermocouple signal conditioners, and DSOs. Agilent has many similar types of instruments along with unique functions such as a 4x8 two-wire switch matrix and source-measure units with four-quadrant operation.

The USB instruments from both companies can operate as stand-alone devices or can be plugged into a chassis that aggregates several instruments into a test-equipment platform. The chassis enables triggering and synchronization of module operation as well as aggregating the command and data transfer for multiple instruments onto a single USB port. Further, chassis mounting helps ruggedize the USB modules, providing added protection against field hazards. NI offers four- and eight-slot USB module enclosures and has recently introduced a one-slot CompactDAQ enclosure for USB, Ethernet, or wireless connectivity. Agilent has a chassis capable of handling six modules (**Figure 3**).

The use of a chassis to combine multiple USB modules into an integrated test platform can push the bus to its limits. While a USB port can supply power to the attached instrument, for instance, that power is limited to 500 mA at 5 V. As a result, chassis systems must use an external power "brick" rather than drawing from the host, and then supply power to the plug-in modules from this external source.

Handling USB bandwidth limits

Chassis operation also pushes against USB's bandwidth capacity. The bus's 480-Mbps bandwidth must be shared among all the channels that the instruments provide, reducing the data rate each can sustain. Aggravating the situation is the fact that USB was not designed for reliable high-speed transfers. The USB protocol provides four types of communications: control, interrupt, isochronous, and bulk. All communications are initiated by the host controller, which polls the endpoints of devices attached to the port to allocate bus capacity.

Of the four types, only control transfers (which are typically short messages carrying setup or status information) and interrupt transfers (which can carry a modest data payload) offer reliable data transmission with low, bounded latency. Isochronous transfers have the largest bandwidth potential and lowest latency, but have no resend mechanism. As a result, isochronous transfers can lose data with no recovery. Bulk transfers offer a reliable means of transferring large files, but they operate on a space-available basis and provide no guarantee of bandwidth or latency.

The vendors of USB test instruments address this bandwidth issue in different ways. Some instruments, such as RF power meters, don't have high data-transmission requirements and so work well within USB's bandwidth limits. DSOs typically capture a signal at a high speed and send it to the PC for display later, while function generators form their signals from pre-loaded patterns. Both uses can tolerate latency in the data transfers as long as the trigger or update rates are moderate.

In supporting its multi-instrument platform using USB, Agilent simply works within the limitations of standard PC host USB drivers. NI, on the other hand, provides a patented signal-streaming USB stack to replace the host drivers and help eliminate overhead in the protocol and boost achievable bandwidth. Both methods target applications that need single-point measurements rather than applications needing high levels of involvement from the user.

Similar limitations exist with GPIB instruments, though, according to Telemakus CEO Craig Walsh. He pointed out that users creating stimulus-and-response test setups using USB can be successful as long as they are aware of the delays inherent in USB data transfers. "The test programmer has to know what events must happen in the right order and to manage how Windows handles the traffic," said Walsh.

Fig. 3 USB instruments are available in a wide variety of functions, operating as individual units or by plugging into a chassis to form a complete test platform. Courtesy of Agilent Technologies.

Compelling advantages for key applications

If the application can tolerate the limitations, though, USB instruments can provide a compelling alternative to their larger competitors. The USB devices are easy to setup and use, are highly portable, and can be extremely low cost. An eight-channel, 12-bit USB data-acquisition module from NI costs less than $170, and a 200-Msample/s DSO from Link Instruments sells for less than $800. As Walsh pointed out, this places many USB instruments within the spending-authorization limits of many engineers, allowing them to acquire a "personal" suite of test instruments that they can use at their convenience rather than having "to wait for access to that $200K tester". He added, "USB instruments can give people a lot of freedom to do testing that they might not otherwise have in their work situation."

Other instrument vendors agree that price is a major benefit of USB devices. "USB instruments are the best value for the money in applications that can work within their specifications," said Edwin Hoh, market segment manager for Agilent's USB instrument product line. "USB reaches out to certain customers perfectly by being cost-effective and compact." □