The advent of PXIe (Peripheral Component Interconnect Express) created new opportunities for PXI systems to handle more data faster. Module developers turned to FPGAs (field-programmable gate arrays) as hardware-configurable alternatives to high-speed or multicore CPUs for handling this data. Now, such FPGA performance and configurability are becoming available to system developers and end users, adding a new range of design possibilities for PXI systems.

PXI-module developers began using FPGAs in their high-performance designs nearly a decade ago to handle ever-increasing data rates and to reduce latency. The configurable hardware offered significant performance advantages over software-based designs. Sebastien Maury, Sundance Multiprocessor Technology's (www.sundance.com) regional director for the Americas, estimates that an FPGA can provide 20 to 30 times more digital-processing performance than a PXI host controller.

According to Ryan Verret, FPGA-for-test product manager at National Instruments (www.ni.com), the performance boost can be as much as several orders of magnitude. “It’s really staggering what computation you can do on an FPGA,” he says. “Some devices have more than 500 DSP blocks on them, allowing you to do lots of FFTs [fast Fourier transforms] in real time.”

Flexibility is another reason for incorporating FPGAs into module designs. David Manor, vice president of hardware engineering at Geotest-Marvin Test Systems (www.geotestinc.com), points out several advantages that stem from field configurability. “Using FPGAs allows us to get products that relate to new standards out early, even before the standards are fully defined,” he says. “We have to make some assumptions, so we may not get everything exactly right at first, but we can release updates and bug fixes for users to download without the need to return their boards to us.”

The use of FPGAs also simplifies the creation of unique functions for customers. “The customer simply installs new firmware to gain new features,” Manor says. He adds that the ability to upgrade and modify module functions in the field helps keep Geotest’s products viable longer in a given application.

**CONFIGURABLE FPGAs**

Until recently, however, the FPGAs in PXI modules have been nearly inaccessible to end users. Upgrades and enhancements came from module vendors, and users could not readily implement their own design ideas. That situation changed in the last year with the introduction of user-configurable FPGA modules for PXI from at least four manufacturers: Geotest, NI, OpenATE (www.openate.com), and Sundance.

The Geotest GX3500 PXI module connects 160 digital I/O channels to an Altera (www.altera.com) Cyclone III FPGA with 55,000
logic elements, four PLLs (phase-locked loops), and 2.34 Mbits of memory. The FPGA has access to all PXI-bus resources, including clocks and triggering. The module also supports an internal expansion-card assembly that customers can use to customize the front-panel I/O connections (Figure 1).

NI offers the FlexRIO family of FPGA modules, which uses Xilinx (www.xilinx.com) Virtex-5 FPGAs of varying capacities. The NI PXI-795x series comprises conventional PXI modules, whereas the PXIe-796x-series instruments are PXIe modules. FlexRIO modules offer 132 I/O lines and accept front-panel-mounted adapters that customize the I/O interface for connection to analog, Ethernet, IEEE 1394 (FireWire), Camera Link, and other specialized interfaces (Figure 2). Adapter modules are available from NI as well as from third-party partners, such as Adsys Controls, Averna, NexFrontier Solutions, and Prevas (www.adsyscontrols.com, www.averna.com, www.nexfs.com, www.prevas.com).

OpenATE also uses a Xilinx Virtex-5 FPGA on its FPGA carrier card. The OpenATE card offers a more basic design than those from Geotest and NI, however, with the FPGA handling the PXI-bus interface. The company does provide PXI-interface IP (intellectual property), as well as IP for a DIMM (dual-inline-memory-module) interface. The FPGA carrier supports a user-defined daughtercard that handles 156 I/O lines but provides no built-in front-panel connections. Users must customize the front panel along with the daughtercard.

The Sundance SMT-700 FPGA card offers a PXIe interface, a variety of front-panel serial interfaces, and internal digital-I/O headers along with a choice of several Xilinx Virtex-5 devices. Front-panel serial interfaces include 10/100/1000 GbE (gigabit Ethernet), fiber optic, and USB (Universal Serial Bus). Dual internal mezzanine connections allow developers to attach Sundance analog modules or additional digital I/O to the FPGA card. The connections reside on both sides of the board, causing the FPGA card to occupy two PXI slots when populated.

**CUSTOMIZED I/O**

Although these FPGA modules have significant differences, they do share some attributes. For example, you can convert each of them from a simple data-processing card into a fully defined instrument with the addition of customization circuitry, through either a mezzanine or an extension card. FPGA-module vendors offer both predefined cards and open specifications from which users can develop their own cards. This ability to define the module’s I/O-signal conditioning and formatting combines with the FPGA’s configurability to give users an unprecedented opportunity for creating innovative PXI-module functions from off-the-shelf building blocks.

An FPGA module with high-speed ADCs on the customization card, for instance, has all the necessary hardware to serve as a digital spectrum analyzer. Because of the tremendous parallelism available in the FPGA, the analyzer can provide continuous monitoring across a wide frequency band in place of the usual swept-spectrum analysis. As NI’s Verret points out, this feature allows the FPGA-based instrument to analyze time-multiplexed communications protocols, such as RFID (radio-frequency identification), that use short energy bursts. Swept-spectrum instruments can easily miss these bursts. Verret also notes that the continuous monitoring allows an FPGA-based instrument to generate triggering signals based on complex power-frequency spectrum masks. This feature can be helpful in reducing the capture-depth requirements of downstream data-acquisition systems.

Developers can also configure an FPGA module to dynamically generate test signals, reducing the number of test vectors necessary in an ATE (automated-test-equipment) system. For example, when a conventional ATE system needs to send data to a communications port on an IC under test, the system must use a long series of test vectors to drive arbitrary-waveform generators that produce the signals driving the port. These vectors must describe the signal values at every time
will an FPGA help?

Although the level of programming involved in customizing a user-configurable FPGA module for their applications may be daunting to many PXI users, the results can be well worth the effort. The key is deciding whether the effort is necessary. NI’s Verret recommends that users consider an FPGA module if they can benefit from custom triggering that will reduce the amount of data the host controller must process and when data-processing requirements demand the performance that an FPGA provides. Geotest’s Manor says that the use of an FPGA card is justified when there is nothing available to support a special function that an application requires or when there is a need to change functions on the fly.

Ultimately, customer feedback will determine the long-term future of these user-configurable PXI modules. Vendors anticipate continuing to offer larger, faster FPGAs as they become available and will likely create additional daughtercards and IP based on the frequency of customer requests.

Even if the FPGA module remains only a specialty item, however, the future is secure for FPGAs in stock PXI-instrument modules. “We couldn’t be where we are today in PXI without FPGAs,” says Geotest’s Manor. “They have been a key component in the success of PXI as a performance platform.”

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