PXI, meet FMC

Combining two standards, PXI and FMC, enables more innovation and flexibility than either standard does on its own.

Submitted by Sundance DSP

Two standards, PXI and FMC, have different roots and have historically served differing markets. So separate are the markets, that most users are familiar with either one or the other, but not both. However, creatively combining the two standards onto a single product can expand the advantages of either past their current application space. To understand the synergies, it is necessary to review each standard.

PXI and FMC

PXI is a modular pluggable card-based standard common in test and measurement applications. It was released as a standard in 1997 as an abbreviation for PCI eXtensions for Instrumentation, and is maintained by the PXI Systems Alliance. PXI adopts the rugged CompactPCI form factor and adds integrated clocks, triggers, and synchronization critical to test and measurement applications. PXI modules fit into a multi-slot chassis, and are configured and managed by a PC and software. As PCI speeds increased by the adoption of PCIe (PCI Express), PXI has followed with high-speed PCIe fabrics in the chassis and on the modules. Though occasionally referred to as PXIe, PXI remains a generic name, whether the backplane relies on PCI or PCIe. Since 1997, PXI has grown to exceed $700M in annual sales, addressing many measurement applications in mil/aero, communications, and data acquisition. PXI modules may be either 3U or 6U form factor, but 3U is the most common.

FMC is an abbreviation for FPGA Mezzanine Cards, standardized as VITA 57.1. VITA itself is a standards organization, originally the VMEbus International Trade Association, and continues to standardize next generation VME and VPX-related specifications. FMC was standardized in 2010. As its name implies, FMC describes a low-profile mezzanine module envisioned to connect from above, typically onto 3U and 6U cards with the front panels aligned. It refers to these host cards as carriers, and assumes an FPGA with reprogrammable IO exists on the carrier. The FMC modules come in two standard sizes, with a high-density 400-pin connector interfacing to the carrier card. By standardizing on the mechanical footprint and electrical interface, FMC cards can host a wide range of analog, digital, RF, and IO functions to then be deployed onto more generic carriers, which may also span several standards.

PXI and FMC standards can be combined into a single product by creating an FMC-compatible PXI carrier card that allows the insertion of FMC modules. In this case, the
user will end up with a fully PXI-compatible module, but with the raw measurement function defined by the FMC. Additional processing can be done by the FPGA on the carrier, on another PXI module, or by the PC software, to customize the measurement functions.

An example of exactly this approach comes from Sundance DSP, with their PXie700 FPGA PXIe Carrier Module. The PXie700 is a completely standard 3U PXI Express module with a FMC “site” where an arbitrary FMC module can be inserted. The mechanical positioning of the site aligns the faceplate of the FMC module with the faceplate of the PXI card, making it one integrated PXI device. Photos of the PXie700 with and without an FMC module are shown below.

Figure 1. The image on the left shows the Sundance PXIe700 FPGA Carrier without any FMC inserted. The large black connector is the electrical interface to the FMC, while the faceplate houses an opening for the FMC’s front panel. The image to the right shows the same PXI carrier, but with an FMC inserted, specifically the Sundance FMC-DAQ2p5. Note how the front panels align.
The PXIe700 carrier supports PXI control, trigger, and clocks to the backplane, including four-lane Gen 2 PCIe communications. It also supports the HPC (High Pin Count) connector to the FMC, including 10 GTX transceivers at 12.5Gb/s each, as well as 144 single ended IOs or 72 differential IOs.

All of this is made possible by the onboard Xilinx Kintex7 FPGA, which connects between the PXI backplane and the FMC HPC connector. This can be seen in the block diagram below. FMC, by its very name, is intended to interface directly with the IO pins of an FPGA. This makes for a very high-performance low-latency interface.

Figure 2 shows the block diagram of the PXIe-700 carrier. The embedded Xilinx FPGA contains the IP for all PXI operations to the right, as well the interfaces to the FMC on the left. The user programs the FPGA to access and control the specific FMC functions they desire.

The module also includes two banks of DDR3 memory and a 128 MB FLASH. The FPGA can be programmed using Simulink from Mathworks, coupled with Sundance’s own IP cores. Sundance is expanding the options available to include C programming of the FPGA. The product may be controlled by either a Windows or Linux controller. PXI offers a large number of embedded controllers and external interfaces, so the choice of controller is practically endless. A subsequent article will explore all the options available for FPGA customization.

Applications

The combination of a high performance PXI carrier with any of the hundreds of FMC modules allows a wide set of applications to be addressed. Though PXI was conceived as
a test and measurement platform, its small rugged form factor has also allowed it to be deployed as an embedded application in industrial, medical, and military markets.

An example is using the PXIe-700 with the FMC-DAQ2P5 mezzanine to address radar applications. The FMC-DAQ2P5 hosts a 12-bit 2.7Gs/s ADC (analog to digital converter), two 16-bit 2.8Gs/s DACs (digital to analog converters), and a number of single ended and differential IO lines. This is a good example of the high performance instrumentation that can be hosted on an FMC module. In this case, IP is downloaded into the Xilinx FPGA that both analyzes and generates the high frequency signals used in radar applications. Using Mathworks Simulink, the user can add their own custom algorithms. These signals may be wideband baseband signals, which can be coupled to microwave downconverters, and upconverters available in the PXI format to address the spectrum of interest. Using PXI plus FMC, a small, powerful radar system can be prototyped in a small PXI chassis.

FMC also fills an important role in PXI systems- customization. In many systems standard PXI modules need to be augmented with custom tailored instrumentation or signal conditioning. FMC allows a user to design their own custom printed circuit board that then is deployed in a PXI system via the PXIe-700. If more board space is needed than available on a standard FMC module, a custom design can be created that is nearly the size of a PXI module. As long as the custom board places the FMC HPC connector correctly, the new daughter card acts as a supersized FMC. If power dissipation is a concern, the new FMC can extend into the space of an adjacent slot, where the PXI chassis will supply ample cooling.

Sundance was not the first organization to deploy PXI plus FMC. CERN did as well, in a very sophisticated data acquisition and control system. The possible applications are only limited by the measurement functionality of FMC modules, which is growing rapidly. The combination expands PXI’s addressable market from primarily test and measurement to data acquisition and control, embedded, and prototyping applications. It is also an effective method for a user to add their own custom card to a PXI system.

PXI metrology grade instrumentation coupled with the growing number of analog, digital, and RF products from FMC is a powerful combination. PXI has addressed a wide set of applications in numerous industries. Over 1500 modules are available from over 50 vendors. With PXI-based FMC carriers, the new applications are nearly endless.