Cost Benefits of FPGA and FMC for Embedded Systems Development

Overview

The FPGA Mezzanine Card (FMC) as defined by industry standard VITA 57.1 can be used to greatly improve project risk management and bring products to market faster due to its flexibility and performance. FMCs are very effective for system upgrades and technology insertion, and using them makes it easier to incorporate new technologies such as higher resolution A/Ds and D/As as they become available. FMCs offer the flexibility to reuse carrier cards, firmware, and software on new projects. They also enable a standardized engineering knowledge base, which can decrease spin-up time on new projects and programs. Their compact size of 69mm x 76.5mm adapts well to a variety of configurations and compliments other common mezzanine formats such as PMC and XMC. The format is an excellent choice for such applications as intelligence gathering systems, RADAR/SONAR, real-time video processing, and wireless telecommunications.

Technical Benefits

The FMC form factor emerged to address the need for different front panel I/O configurations for systems development. FPGA carrier cards in 3U and 6U form factors rely on fixed front panel connectivity designed for particular functions, so it can be necessary to replace the card to change the front panel I/O. While PMC and XMC modules can be used to reconfigure the front panel I/O, their size uses a large portion of the FPGA card area. The combination of FPGA carrier cards with FMC daughter cards is the perfect choice for optimal performance and flexibility because these smaller modules address the bandwidth, latency, and connectivity limitations of PMC and XMC formats. FMC modules are half the size of XMC modules and typically produce less than 12W of heat.

FMCs provide a standard form factor and modular interface to the FPGA carrier card. A simplified I/O interface design is made possible by decoupling the I/O interfaces from the FPGA which maximizes the reuse potential of carrier cards. The FMC form factor offers the best I/O approach outside of a monolithic solution. They can serve in a number of roles such as analog-to-digital conversion, digital-to-analog conversion radio frequency transceiver, optical communication, clock distribution, and DSP.

The FMC format offers additional advantages over other configurations in the areas of data throughput, latency, and system overhead. The format supports 80 LVDS pairs and 10 high speed transceiver lanes, thus offering an aggregate bandwidth of 300Gbps between the mezzanine and carrier cards. By removing protocol overhead, it is also possible to eliminate latency and enable deterministic data delivery by using FMCs.

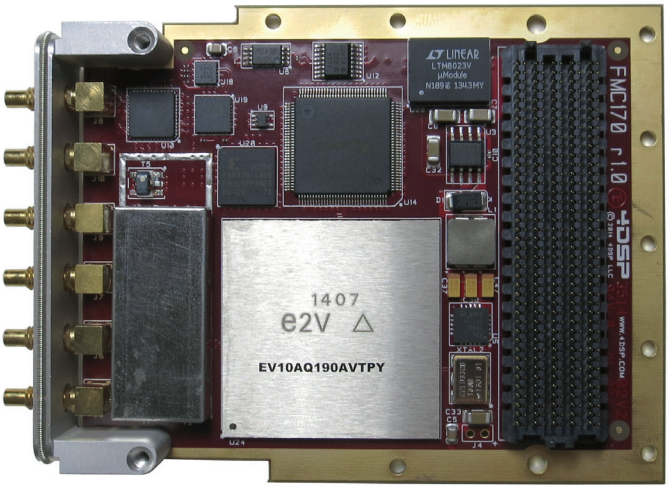

Figure 1: 4DSP FMC170 (Actual Size)

Small Form Factor Carrier Cards

Embedded system designs are increasingly turning to small form factor (SFF) architectures to reduce size, weight, and power (SWaP) requirements. FMC modules bring compact high-performance signal processing and versatile I/O capabilities to embedded systems when used with SFF carrier cards based on such open standards as PCI Express (PCIe), VPX, CompactPCI, and MicroTCA.

PCIe is a high-speed, point-to-point computer serial interface that supports chip-to-chip connectivity, backplanes, and chassis-to-chassis connections. It is scalable and can provide more bandwidth through both higher speeds and additional lanes. It offers improvements over older serial expansion bus standards, including higher throughput, lower I/O pin count, smaller physical footprint, better performance-scaling, and better error detection and reporting.

The VPX standard (VITA 46) uses a switched architecture that is similar to commercial PCIe cards, but it is designed specifically for defense applications. VPX enables rugged COTS computing applications particularly for data-intensive military programs that require high-frequency signal processing. It was developed as a more robust and higher-performance extension of VME standards and retains the 3U and 6U Eurocard form factor. A great advantage of VPX is its significantly increased total I/O capability.

CompactPCI is an industrialized computer bus interconnect that combines a Eurocard-type connector and PCI signaling and protocols in standardized 3U and 6U sizes. Originally designed to support the PCI protocol, CompactPCI has evolved to include other technologies such as switched Ethernet. It is used in a wide variety of applications in the industrial, commercial, aerospace, military, and telecom fields.

MicroTCA provides a high-performance, versatile, and compact architecture with such benefits as robust system management and high reliability. Originally designed for telecommunications applications, this modular COTS format is also more interoperable and comes at a lower cost than other standards. It has expanded to include ruggedized versions used for mobile, military, and avionics applications.

Reducing Costs and Risk

The simplicity of the FMC standard reduces risk in system development by minimizing power requirements, lowering IP core costs, reducing material costs, and shortening engineering times partly because expertise in protocol standards such as PCI, PCIe, or Serial RapidIO is not required. FMCs enable cost-effective project budget management because it is possible to repurpose existing designs for new I/O requirements simply by changing the FMC module and tweaking the FPGA design.

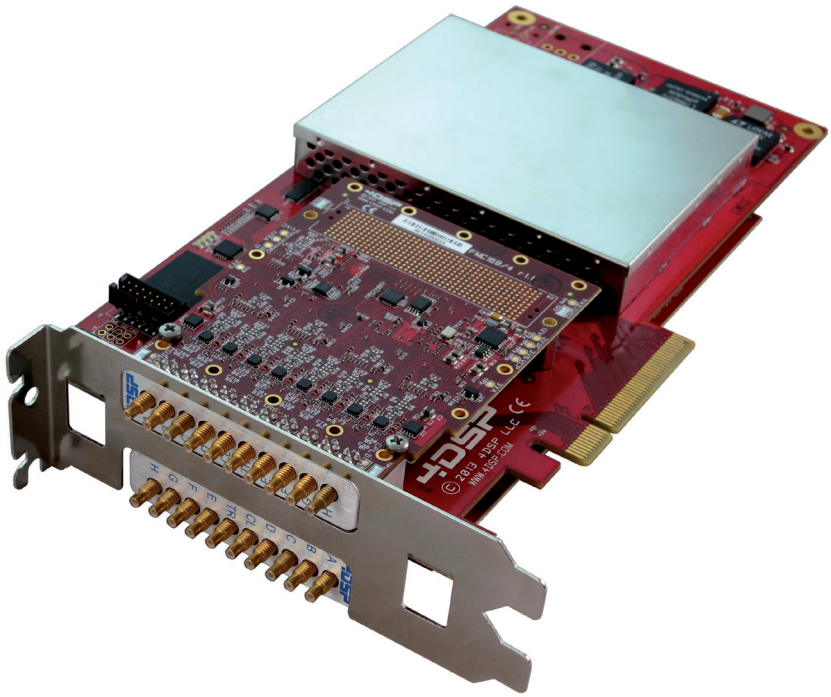

Figure 2: 4DSP's PC720 PCIe card with two FMC168s mounted

An FPGA development kit combined with an FMC translates into project savings when factored into a typical solution budget. The ability to reuse the FMC as-is in the final product reduces risk significantly while cutting down development costs and giving firmware and software engineers access to a functional platform early in the project cycle. For example, a complementary DAQ platform can be centered on a Xilinx Kintex UltraScale FPGA KCU105 evaluation kit installed in a PCIe slot of a desktop PC or connected to a laptop via Ethernet. The functionality of the card can be extended by adding daughter boards such as the 4DSP FMC116 analog-to-digital converter module with sixteen channels able to digitize signals at a rate of 125Msps each. The use of such a platform during the early stages of system integration lowers engineering overhead by reducing the time spent on software and firmware integration and testing. It also allows the process to begin weeks or months earlier in the schedule by using readily available hardware.

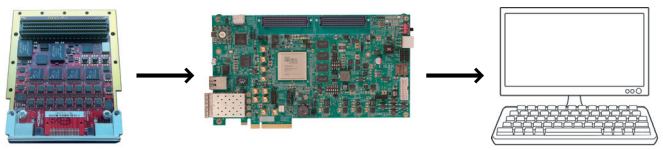

Figure 3: FMC116 and KCU105 development solution

Trends in the Embedded Industry

The FMC format continues to gain momentum. As compatibility increases, it becomes easier to integrate FMCs with carrier cards from different vendors under VITA 57.2. As of 2015, the VITA product directory lists 16 vendors providing a wide variety of FMC modules (100+), FPGA carrier cards, or combinations of both. FMC sites are now available on most development boards from FPGA industry leaders Xilinx and Altera. Indeed, FMCs are fueling the growth of FPGA-based solutions much as the PMC and XMC formats did for embedded CPU-based systems. FPGAs have established themselves as an effective high-performance option because their attributes make them ideal for overcoming the inherent SWaP constraints for embedded DSP applications. System solutions based on user-programmable FPGAs offer advantages that cannot be overlooked, and the industry has responded accordingly. In recent years, most COTS board suppliers have rolled out new FPGA products for the embedded space.

There are several technical reasons for this growth, such as big gains in logic cell counts, serial transceiver rates, channel counts, embedded ARM processors, and DSP capabilities. FPGA suppliers have also shifted their focus from a target market of hardware designers and HDL developers to software engineers and systems integrators. Additionally, design automation tools are improving. This has increased the number of FPGA system developers by giving a broader range of engineers the means to more quickly develop effective FPGA firmware. These trends benefit COTS board suppliers and system integrators by reducing time to market and lowering development costs.

Consequently, top FPGA suppliers Xilinx and Altera have seen their sales rise as many developers turn away from the competing ASIC approach due to the prohibitive expense. Programmable chip makers have recognized this growth opportunity and have worked to displace ASIC technologies for high-performance computing applications in such areas as military and aerospace (RADAR, intelligence surveillance and reconnaissance), telecommunications (wired and wireless), and test & measurement (data centers).

As the selection of FPGAs broadens, the number of FPGA-based carrier cards multiplies, enabling previously unseen solutions with dramatically expanded functionality and an attractive combination of performance and power efficiency. Additionally, significantly more flexible logic and onboard IP allow FPGAs to support the creative engineering necessary to deliver differentiated and competitively advantaged embedded systems when coupled with innovative FMC designs.

4DSP's full range of FPGA-based carrier cards and FMCs can be found at www.4dsp.com.

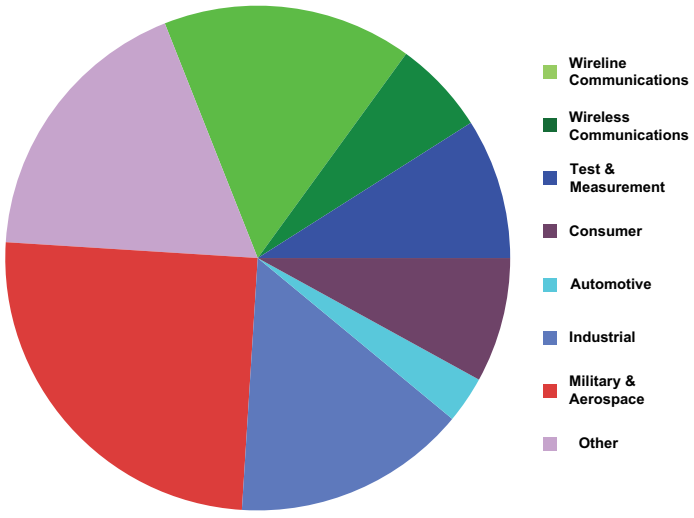

Figure 4:
FPGA Use by Industry Sector (National Microelectronics Institute)