Mini-K7

Ver 1.5 5/23/16

Windows/Linux Embedded Computer with Kintex7 FPGA, FMC I/O Site, Integrated Timing Support

FEATURES

- Combines an industry-standard COM Express CPU module with a single FMC I/O module in an extremely compact, stand alone design
- Programmable Kintex 7 325/410 and Spartan 6 FPGAs
- Small form factor: 4_H x 7_W x 10_D
- Conduction cooled design: Fins or cold-plate
- Stand-alone operation: Able to operate headless, booting from SSD
- Windows, Linux OS support. RTOS availability.
- VITA 57 FMC IO module site. Add anything from RF receivers to industrial control modules. Delivers >3000MB/s to CPU memory**
- Integrated timing and triggering support for IO includes GPS, IEEE1588 or IRIG -disciplined clock
- Supports Innovative and third-party FMC modules for private data channels, triggering and timing features
- USB 3.0 x2/2.0 x2, Gb Ethernet, SATA x4, DisplayPort, Touch Screen
- Up to 2 removable SSD (1.8 in) plus 2 eSATA
- AC or DC operation

APPLICATIONS

- Embedded instrumentation
- Remote, autonomous IO
- Mobile instrumentation
- Distributed data acquisition

SOFTWARE

- Windows and Linux compatible
- Runs standard desktop applications
- MSVC / GNU C++ Developers Kit supporting IO integration and customization
- Device drivers, example software and support applets supplied for all peripherals

** Data rate dependent on the COM Express module capabilities

Mini-K7: Rugged, Compact FPGA SBC with FMC I/O

DESCRIPTION

The Mini-K7 is a user-customizable, turnkey embedded instrument that includes a full Windows/Linux PC and supports a wide assortment of ultimate-performance FMC modules. With its modular I/O, scalable performance, and easy to use PC architecture, the Mini-K7 reduces time-to-market while providing the performance you need.

Distributed Data Acquisition ¯ Put the Mini-K7 at the data source and reduce system errors and complexity. Optional GPS or IEEE1588-synchronized timing, triggering and sample control is available for remote I/O. Limitless expansion via multiple nodes. Up to 2 SSD for data logging.

Uniquely customizable ¯ single FMC site for IO, user-programmable FPGA for IO interfaces, triggering and timing control, USB ports.

Remote or Local Operation - Continuous data streaming up to 3200 MB/s to SSD or Gb/s Ethernet. Optional, stand-alone, autonomous operation with GPS-synchronized sampling.

Rugged ¯ SSD boot drive support in a compact, rugged footprint that is ready for embedded operation.

8-26V DC-Only Operation - Perfect for portable or automotive data loggers or waveform generators.

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ORDERING INFORMATION

Product	Part Number	Description
Mini-K7	90600-<CFG>-<ER>	Mini-K7 – (Atom CPU) User-customizable, turnkey embedded instrument consisting of SW-K7 single-board computer with Atom™ E3845 1.91 GHz 542/792 (Turbo) 10W (4C/1333), 8 GB DDR3 RAM, 1333 MHz FSB, 2 SATA 600, 2 USB 3.0, 8-26V DC power supply, rugged enclosure with integrated heat spreaders, AC to DC Power adapter included (specify locale). No boot drive or OS, order separately. <CFG> is one of the available FPGA type and speed configurations. <ER> is environmental rating L0..L3, per this table. For a complete list of operating system, SSD storage, GPS timing and all other options, visit the Mini-K7 online quotation page here.
Analog (RF) expansion tray	30401	Optional expansion tray suitable for housing application-specific tuners, attenuators, amplifiers, GPS or VLF circuitry, etc. All signals from optional FMC module are routed via internal cabling into this tray. Tray walls may be machined to expose application-specific connectors as needed. 3D models provided. Standard tray exposes one N-type, one BNC and one SMA connectors.
LCD tray	30402	Optional rugged aluminum expansion tray including 800x480 resolution touch-screen, PCAP, backlight power supply and display power switch. Steel mesh grid attaches to bezel magnetically to allow display use while installed or removed.
FMC-1000	80325	FMC Module with 2x 1250 MSPS 14-bit A/D, 2x 1250 MSPS 16-bit DAC with PLL
FMC-500	80281	FMC Module with 2x 500 MSPS 14-bit A/D, 2x 1230 MSPS 16-bit DACs with PLL
FMC-310	80320	FMC Module with 4x 310 MSPS 16-bit A/D with PLL and Timing Controls
FMC-250	80315	FMC Module with 2x 250 MSPS 16-bit A/D, 2x 500 MSPS 16-bit or 1x 1GSPS DAC with PLL
FMC-Servo	80339	FMC Module w/(8) 16-bit, 500 kSPS A/D Channels · (8) 16-bit D/A Channels with onboard PLL
FMC-SFP+	80285	FMC Module with Four SFP+ Ports

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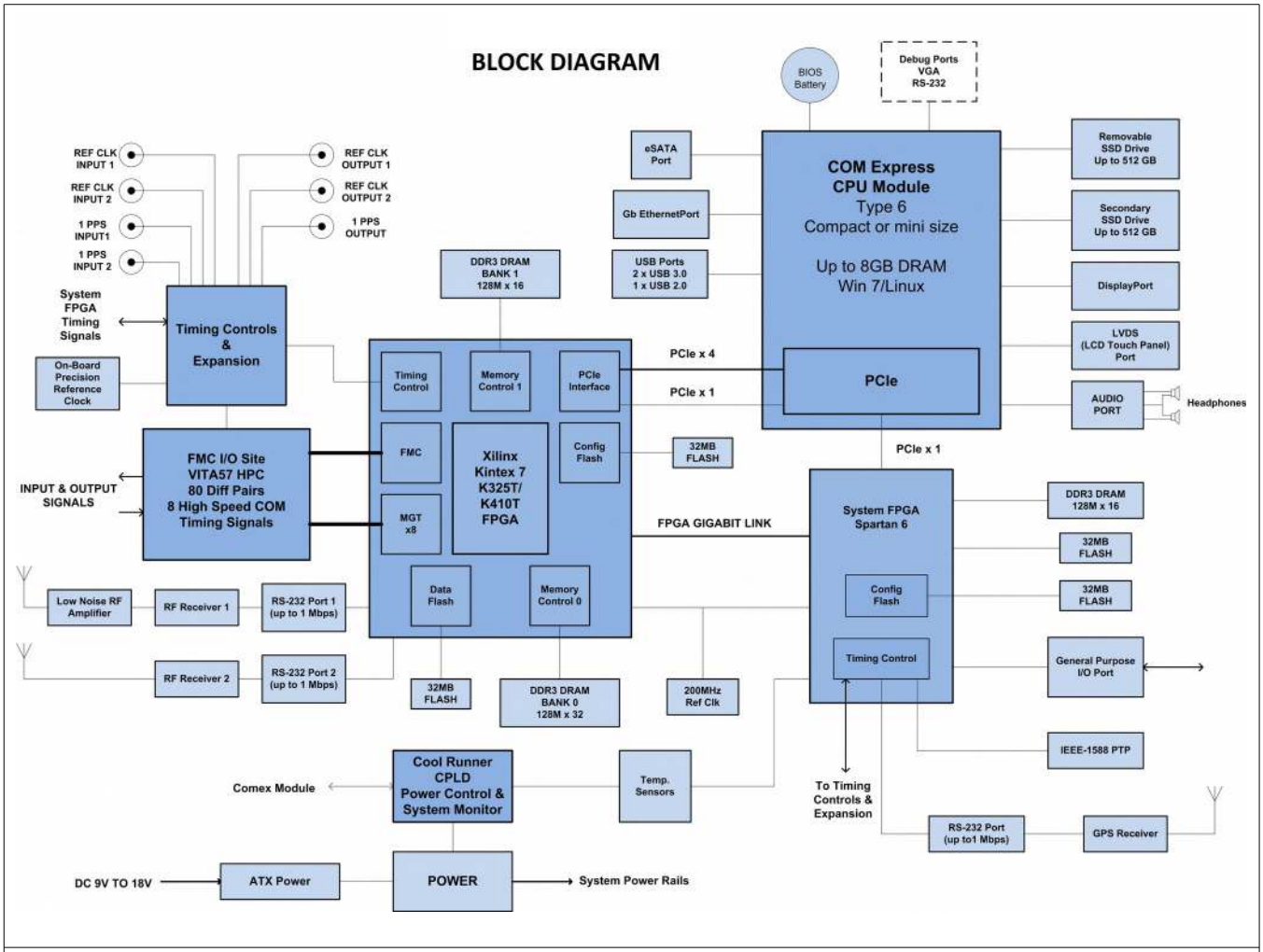

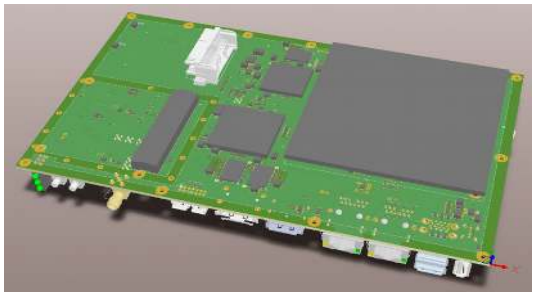

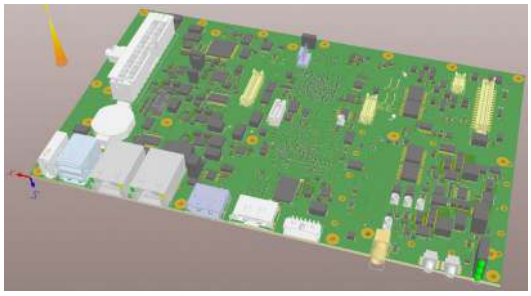

Top and bottom of SW-K7 Motherboard with Single FMC module, the heart of the Mini-K7 system

Mini-K7

Figure 1. Mini-K7 with optional signal conditioning and touch screen trays, front left

Figure 2. Mini-K7 with optional signal conditioning and touch screen trays, front right

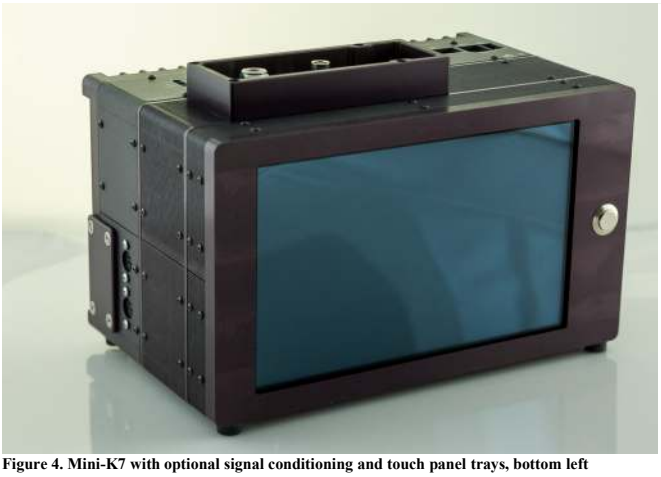

Figure 4. Mini-K7 with optional signal conditioning and touch panel trays, bottom left

Figure 3. Mini-K7 with optional signal conditioning and touch panel trays, back left. SSD access door in upper left corner

Figure 5. Optional signal conditioning tray (top), P/N 30401

Figure 6. Optional signal conditioning tray (bottom). P/N 30401

Figure 7. Optional touch screen tray (top), P/N 30402

Figure 8. Optional touch screen tray (bottom), P/N 30402

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Figure 9. Mini-K7 without optional trays, front-left

Figure 10. Mini-K7 without optional trays, front

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Standard Features

FMC Site	
Specification	VITA 57.1 FMC
High Speed Pairs	4 or 8 lanes (Tx/Rx pair) 6.5 Gbps max rate 4 lanes are shared with 10G Ethernet port
Signal Pairs	80 pairs total LA: 34 pairs (Vcco = 2.5V, Vref from FMC) HA: 24 pairs (Vcco = 2.5V, Vref from FMC) HB: 22 pairs (Vcco and Vref from FMC)
IO Standards	LA, HA : LVCMOS25, LVDS25, LVDCI2, SSTL25, HSTL25 HB: all Kintex7 IO standards supported
Power (available to module)	3.3V @ 3A 12V @ 1A 3.3V AUX @ 0.5A Vadj = 2.5V @ 4A

FPGA	
Device	Xilinx Kintex 7
Speed Grades	-1 (custom orders) , -2 (standard)
Sizes	K160T = ~ 47.5M gates equivalent K325T = ~ 24M gates equivalent K410T = ~ 55M gates equivalent
Flip-Flops /Slices	K160T: 202K /25K K325T: 407K /50K K410T: 508K /63K
DSP48E1 elements/ BlockRAMs	K160T: 600 K325T: 840 K410T: 1540
GTX Ports	x8 lanes total: x4 lanes FMC or 10Gb Ethernet x4 lanes @ 6.5 Gbps to FMC
Configuration	JTAG or boot from onboard flash

FPGA Memories 2 Banks Total: each pre-configured as flow-thru FIFO	
DDR3 SDRAM	128M x 16 128M x 32 clock rate: 800 MHz

FPGA IO Interfaces	
10Gb Ethernet	~1GB/s transfer rates XAUI 3.125Gbps interface to FPGA SFP+ port supports fiber optic cable Loopback and BIST modes
DIO Bits	32, arranged as 16 pairs LVCMOS (2.5V) LVDS25

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COM Express CPU and Site	
Standards	PCIMG COM.0 R2.0 COM Express
Type	6
Size	Supports 95 x 95 mm module
Verified Modules	cExpress-BT-E3845 Compact COM Express Type 6 module
CPU Types	Intel Atom quad-core processor at 1.91 GHz
COM Express Memory	Dual channel non-ECC 1333/1066 MHz DDR3L memory, 8GB in dual stacked SODIMM sockets
BIOS	AMI APTIO UEFI in 16 Mbit SPI flash

PC Peripherals	
USB	2 host ports, USB 3.0/2.0 2 client port, USB 2.0
Ethernet	Port 0: 10/100/1000 under OS control Port 1: IEEE 1588 Precision Timing Protocol RJ-45 Cu interfaces
SATA	2x SATA internal (2x removable eSATA 6 Gbps external access, but unsupported on cExpress-BT-E3845 module)
Video/Audio	Integrated graphics engine DisplayPort video port USB HD audio
CAN	AX/RX port
GPS Port	UART to GPS
Touchscreen (optional)	LVDS panel support with I2C/USB touch controller Resolution up to 1280x768 @ 60Hz 18 or 24-bit pixel color depths
Watchdog Timer	Optionally resets CPU
Temperature Monitor	CPU monitor and independent system monitoring Over-temperature shutdown

Sample Clocks and Triggering	
Clock Sources	1 SMA for FMC clocks 1 SMA for clock to FPGA
Trigger Sources	2 LVDS outputs (SATA-style connector) 2 LVDS inputs (SATA-style connector)
Timing Synchronization	2 multi-drop LVDS pairs 2 open-collector flags IDC10 connector, 2mm
GPS (option)	10MHz reference disciplined to GPS PPS timing reference input Position and UTC time reporting Support for Symmetricom GPS-500
IEEE 1588 PTP (option)	10MHz disciplined to PTP reference PPS timing reference input Software stack runs on CPU Timing resolution to <100 ns

Power	
Consumption	Atom™ E3845 1.91 GHz 542/792 (Turbo) 10W (4C/1333) K325T @ 200 MHz clock rate; DDR3 SDRAM memory, no 10GbE interface: 20W baseline power
Temperature Monitor	Software with programmable alarms Over-temperature protection
Power Control	Deep sleep mode FMC power controls
Cooling	Conduction cooled

Physicals	
Form Factor	100 x 175 x 250 mm (4 x 7 x 10 in.)
Hazardous Materials	Lead-free and RoHS compliant

ABSOLUTE MAXIMUM RATINGS

Exposure to conditions exceeding these ratings may cause damage!

Parameter	Min	Max	Units	Conditions
Input Voltage Range	8	26	V	High and Ultra performance COM Express modules
Operating Temperature	-20	60	C	Non-condensing, TBD CFM convective air flow or cold plate required
Storage Temperature	-65	+150	C	
ESD Rating	-	1k	V	Human Body Model
Vibration	-	5	g	9-200 Hz, Class 3.3 per ETSI EN 300 019-1-3 V2.1.2 (2003-04)
Shock	-	30g, 11 mS	g peak	Class 3.3 per ETSI EN 300 019-1-3 V2.1.2 (2003-04)

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Architecture and Features

The Mini-K7 combines a Windows/Linux compatible embedded PC with integrated, user- Kintex 7 FPGA and one FMC IO module plus supporting peripherals to create a customizable instrument for a variety of applications.

Embedded PC

The Mini-K7 architecture is Windows/Linux compatible – it runs the same applications as a desktop computer. The COM Express CPU module is a PC on a module and provides the computing engine, available with the advanced Intel i7 processors.

COM Express Advantages

- Intel compatible PC runs Windows, Linux
- Scalable performance
- Latest technologies: PCI Express 2.0, Gb Ethernet, USB 3.0
- Upgradeable as requirements change and evolve
- Compact 95 x 95 mm form-factor
- Industry-standard, multi-vendor

The COM Express module provides the PCI Express bus that links the FMC module to the CPU. FMC modules install just like PCI Express add-in cards on the PC and are software compatible with PC applications. The PCI Express bus tightly couples the CPU to the FMC module and outperforms previous generation systems by 2 to 4 times. Data transfer rates to CPU memory at 3200 MB/s to dedicated peripherals on the FMC site.

The Mini-K7 provides familiar PC interfaces for expansion and connectivity: Gigabit Ethernet, USB ports, and SATA HDD.

The DisplayPort video port and USB keyboard/mouse make operating the Mini-K7 to operate just like any PC. Standard PC screens supporting Displayport up to 2048x1536 are supported. "Headless" operation is also supported for truly embedded applications without keyboard/monitor/mouse attached. In the headless mode, the Mini-K7 can be remotely controlled and accessed over Ethernet.

FMC I/O Site

A single FMC I/O module site enables the Mini-K7 to be configured to address a wide variety of I/O -intensive applications. The FMC site is for PCI Express mezzanine cards conforming to VITA 57.1 standard, which are 75 x 75 mm modules. Each module site has a heat frame routed directly under the module to support efficient conduction.

XMC Modules for IO

- Flexible, modular IO
- Industry-standard VITA 57.1
- PCI Express with up to 3.2 GB/s transfer rates
- Innovative modules for SDR, IF Rx and Tx and digital communications
- Third party modules with wide I/O complement
- Industry-standard, multi-vendor

The Innovative FMC module family offers a range of analog performance mated to the state-of-the-art performance of the Kintex7 FPGA computing core. Innovative's Velocia architecture data packet system allows these modules to stream data continuously to system memory at rates up to 3.2 GB/s – making the Mini-K7 well suited for data logging and playback functions. When configured with a four SSD RAID0 array (2 internal SATA+2 external eSATA), sustained rates to 2000 MB/s are achievable.

Importantly, all Innovative FMC modules for the Mini-K7 support simultaneous sampling, triggering, controls and private inter-module communications. System triggers and matched reference clocks from the baseboard provide simultaneous sampling for the two modules. The FMC modules are interconnected via the Spartan6, so they can communicate bidirectionally for real-time applications demanding low latency and deterministic performance.

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Optional Signal Conditioning Tray

The Mini-K7 mechanical design incorporates convenient stackable modules. These additional "trays" can be used to house application-specific signal conditioning electronics, such as RF receivers/down-converters, filters, GPS receivers, or amplifiers/programmable attenuators. Cabling enters the front of the tray via bulkhead connections and routes directly to the FMC module or SW-K7 carrier. Additional stackable modules are available to provide a touch-screen interface, to allow creation of module instrumentation.

Illustration 1: SW-K7 atop optional RF receiver and touch screen trays.

Triggering and Sample Clocks

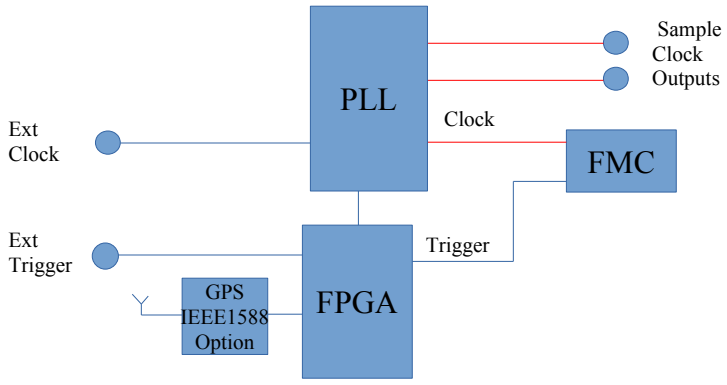
The Mini-K7 has unique clocking and triggering features for its FMC module site. The site receives two triggers from the Spartan 6 application FPGA and two clock inputs through its mezzanine connector. Innovative FMC modules can use these to support simultaneous sampling and unique trigger scenarios using the Kintex7 application FPGA.

Sample clocks for the FMC modules can be generated using an on-card PLL or from an external clock input. The PLL can use either the external clock input or an GPS/IEEE1588 -disciplined clock as a reference. The disciplined clock allows multiple, remote instruments to sample simultaneously and act cooperatively. Position and time data is also available when either of these options are installed.

Remote Operation

Mini-K7 can be operated using Ethernet as a remote computer or embedded instrument. For pure embedded operation, the Mini-K7 can operate "headless" without monitor, keyboard or mouse. The system boots from a SATA SSD.

Sample Controls and Clocking



Application FPGA

The Kintex7 application FPGA allows the Mini-K7 to be customized for many IO functions, such as triggering and control features. The FPGA is a PCIe bus peripheral to the COM Express CPU. New functions can added to the system as PCI devices by adding them to the FPGA design. FPGA logic is provided in the FrameWork Logic tools, which includes the standard functionality that can be modified or used as an example.

The Kintex 7 logic is loaded from an on-card ROM that is field-reprogrammable. Development uses a Xilinx USB JTAG cable and Xilinx ISE development tools (download at www. xilinx.com).

Software Tools

Software development tools for the Mini-K7 provide comprehensive support application development including device drivers, peripheral configuration and control, and utilities that allow developers to be productive from the start. Software classes provide C++ developers a powerful, high-level interface to the system devices that makes system integration and achieving real-time, high speed data acquisition easier.

Software for data logging and analysis are provided with every Innovative FMC module. Data can be logged to system memory at full rate or to disk drives at rates supported by the drive and controller. Triggering and sample rate controls are

provided to support data acquisition applications without writing code. Innovative software applets include *Binview* which provides data viewing, analysis and import to MATLAB for large data files.

Support for MS Visual C++ or QtCreator GNU C++is provided. Supported OSes include Windows, Linux (including real-time variants). For more information, the software tools User Guide and on-line help may be downloaded.

Logic Tools

Customized IO interfaces, triggering and other unique features may be added to the Mini-K7 by modifying the FPGA logic. The FrameWork Logic tools provide support for VHDL/Verilog developments. Application logic can be modified by building upon the Innovative components for hardware interfaces and system functions. Each design is provided as a Xilinx ISE project with VHDL source for top level logic with a ModelSim testbench illustrating logic functionality.

FMC Modules

Plug FMC modules into the Mini-K7 to build your custom, turnkey embedded instrument. Innovative Integration offers an array of ultra-performance, FMC modules to create your solution.

Innovative FMC modules feature analog and digital IO which is directly controlled by the Kintex 7 FPGA located on the SW-K7 motherboard, which functions as a FPGA computing engine connected to the host via a high performance PCI Express bus. The FrameWork Logic development tools allow you to design in MATLAB and VHDL and rapidly implement high speed signal processing on the FMC.

FMC-250	FMC-SFP+	FMC-500M
FMC Module with 2x 250 MSPS 16-bit A/D, 2x 500 MSPS 16-bit or 1x 1GSPS DAC with PLL and Timing Controls **P/N 80315**	**FMC Module with Four SFP+ Ports** **P/N 80285**	**FMC Module with 2x 500 MSPS 14-bit A/D, 2x 500 MSPS 16-bit or 1x 1GSPS DAC with PLL and Timing Controls** **P/N 80281**
		

See the selection of FMC IO modules here.

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