SBC-K7

V 1.1 12/19/2013

Innovative Integration
... real time solutions!

Embedded PC for Instrumentation and Control with Kintex-7 FPGA core and configurable FMC IO

FEATURES

- **Embedded PC**
  - Type 6 COM Express Module
  - Runs Windows/Linux, 32/64-bit
  - High-end: i7 CPU, 4 cores, 2.1 GHz, 16 GB, Low Power: Atom CPU, 2 cores, 1.6GHz, 4GB
  - DisplayPort and Touchscreen LCD support
- **Small and Low Power**
  - 270x170x40mm carrier board size
  - Typical power consumption ~30W (Atom), ~70W (i7) excluding FMC
  - Conduction or air-cooled versions
- **FMC I/O sites**
  - Dual VITA 57 module sites (HPC and LPC)
  - Double width FMC compatible
- **FPGA Computing Core**
  - Xilinx Kintex-7 K325T or K410T
  - 2 memory banks at 800MHz clock speed: 128M x 32 DDR3 SDRAM 128M x 16 DDR3 SDRAM
- **Communications ports**
  - 2x 1Gb Ethernet
  - 2x USB 3.0 + 1x USB 2.0
  - 2x eSATA + 2x SATA
- **Timing Features**
  - IEEE-1588 and IRIG-B timing synchronization
  - Optional GPS integration
  - Clock and trigger I/O for system timing
- **Environmental ratings** for -40 to 85C and 5g vibe

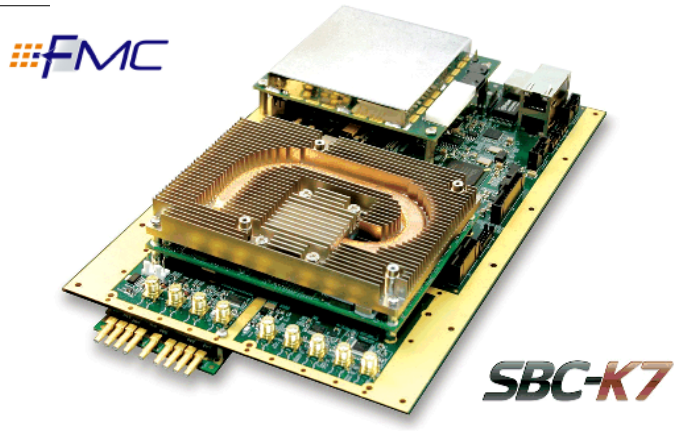
APPLICATIONS

- Embedded instrumentation and controls
- Distributed sensor processing and networks
- Remote data recording

SOFTWARE

- MATLAB/VHDL FrameWork Logic
- Microsoft and QtCreator C++ Tools
- Win 7/ Linux

MATLAB XILINX



DESCRIPTION

The SBC-K7 is an ideal platform for embedded instrumentation that combines an i7 or Atom processor based PC running Windows/Linux with a Xilinx Kintex-7 FPGA and an industry-compliant FMC IO site (HPC) plus a second FMC-compatible (LPC) site. A double width FMC module can also be accomodated.

The CPU is a COM Express Type 6 module featuring a quad-core i7 or a dual-core Intel Atom processor. Even optimized for the low power Atom CPU based COM Express modules, consuming as little as 9W, support 1Gb Ethernet, USB 3.0, SATA 3, DisplayPort, Touchscreen LCD, and PCI Express connectivity. The COM Express module is industry-standard, multi-sourced with a range of performance/power choices.

The FPGA computing core features the Xilinx Kintex-7 FPGA family, either K325T or K410T. The K410T provides 1540 DSP MAC elements operating at up to 500 MHz and 400K logic cells. The FPGA core has two memory banks, 128M x 32-bit, 800 MHz DDR3 supporting bidirectional streaming data flow plus a 128M x 16-bit, 800 MHz DDR3 for use by an optional uBlaze core.

FMC I/O site 0 (HPC) has 80 LVDS pairs connected to the FPGA, plus clocks, controls, and up to x8 5.0 Gbps lanes. FMC I/O site 1 (LPC) has 54 LVDS pairs plus clocks, controls, and up to x8 PCIe lanes. Timing features include clock and trigger I/O for multi-card synchronization. GPS, IEEE-1588 PTP and IRIG-B timing references are integrated with on-card timing features for system-level timing coordination. Innovative offers a full line of FMC analog and digital IO modules; SB7-K7 can be also readily adapted to use custom modules.

For system communications the SBC-K7 includes two 1Gb Ethernet and 2x USB 3.0 ports. An additional USB 2.0 port is available for in-system use. The 1Gb Ethernet and USB ports provide instant connectivity to host PCs and networks. 10 Gb communications can be implemented via an available FMC. The 10Gb Ethernet port connects directly to the FPGA, providing sustained “wire speed” rates of ~1GB/s over a fiber optic connection.

The SBC-K7 is rugged and low power. Typical power consumption is ~30W (Atom/K325T FPGA) excluding FMC. SBC-K7 operates from a 8-36V DC input power. Air and conduction cooled versions are available, rated for -40 to +85C, with up to 5 g vibration.

The FPGA logic can be fully customized using VHDL/Verilog or Matlab using the the Frame Work Logic toolset. Real-time hardware-in-the-loop development using the graphical Simulink block diagrams is supported. IP cores for signal processing applications such down-conversion, demodulation and FFT are also available.

Software tools for host development include C++ libraries and drivers for Windows and Linux. Application examples demonstrate card use and features.

SBC-K7

ORDERING INFORMATION

Product	Part Number	Description
SBC-K7	90326-<CFG>-<ER>	SBC-K7 single board PC with Kintex-7 FPGA, Type 6 COM Express Module <CFG> is one of the available COM Express Module, FPGA type and speed configurations. <ER> is environmental rating (see following table) ** For alternate FPGAs or speed grades contact sales)
SBC-K7 FrameWork Logic	55032	SBC-K7 FrameWork Logic board support package for RTL and MATLAB. Includes technical support for one year. Check with sales for specific FMC support.
Software	57001	Malibu software installation DVD including drivers for Windows and Linux.
Power Supply	80200-13 80200-14 80200-15	80200-13, COMEX POWER SUPPLY 150w AC-DC Power Adapter, 12v 12.5, USA/Japan/Korea/Taiwan power cord 80200-14, COMEX POWER SUPPLY 150w AC-DC Power Adapter, 12v 12.5, UK/Australia/India power cord 80200-15, COMEX POWER SUPPLY 150w AC-DC Power Adapter, 12v 12.5, EU power cord

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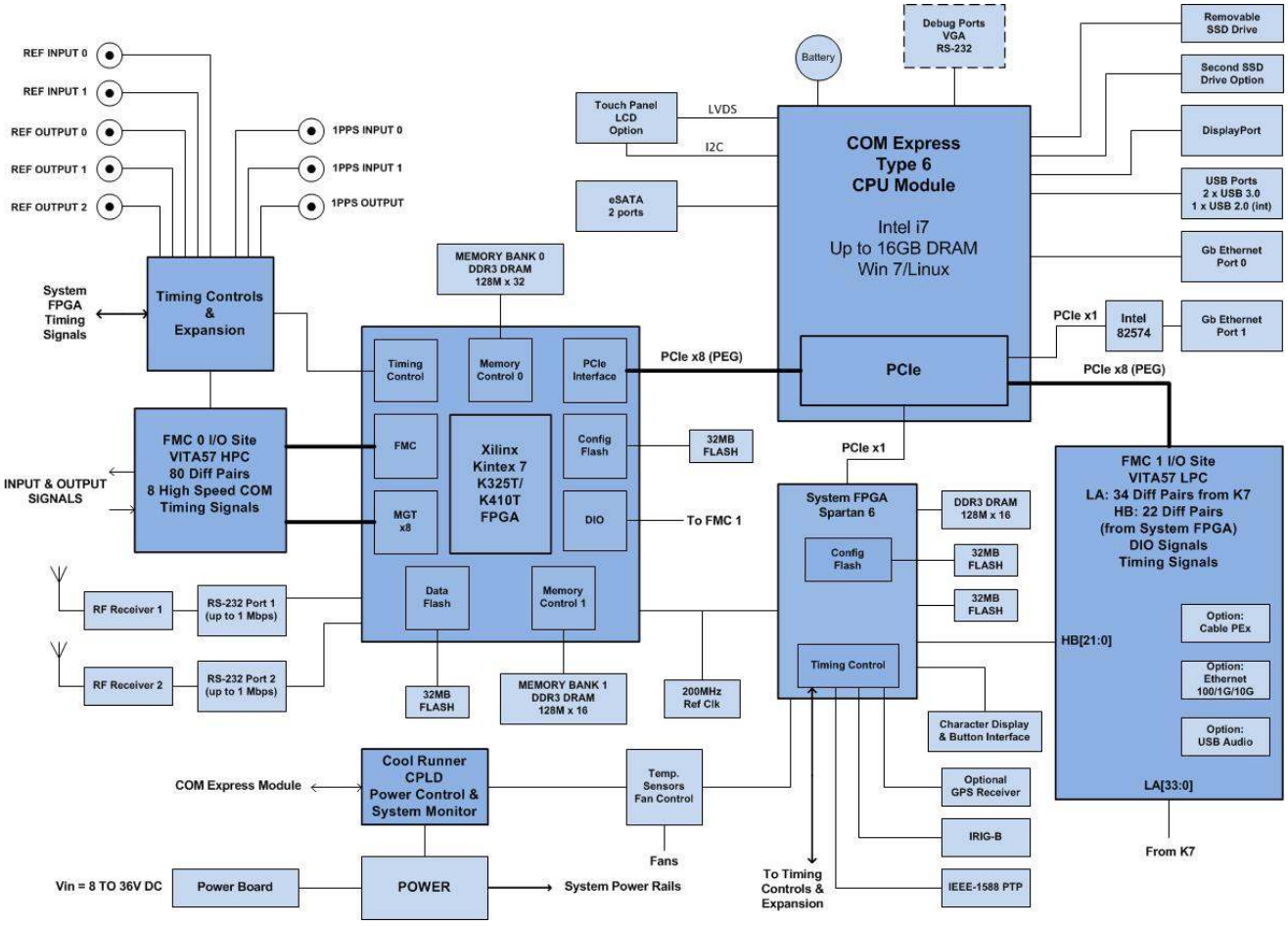

Illustration 1: SBC-K7 Functional Block Diagram in typical application

Operating Environment Ratings

The SBC-K7 and FMC modules are available for rugged applications. The cards are 100% tested for operation over the specified range.

Environment Rating <ER>	L0	L1	L2	L3
Environment	Office, controlled lab	Outdoor, stationary	Industrial	Vehicles
Applications	Lab instruments, research	Outdoor monitoring and controls	Industrial applications with moderate vibration	Manned vehicles

SBC-K7

Cooling		Forced Air	Forced Air	Conduction	Conduction
Operating Temperature		0 to +50C	-40 to +85C	-20 to +65C	-40 to +70C
Storage Temperature		-20 to +90C	-40 to +100C	-40 to +100C	-40 to +100C
Vibration	Sine	-	-	2g 20-500 Hz	5g 20-2000 Hz
	Random	-	-	0.04 g^2/Hz 20-2000 Hz	0.1 g^2/Hz 20-2000 Hz
Shock		-	-	20g, 11 ms	30g, 11 ms
Humidity		0 to 95%, non-condensing	0 to 100%	0 to 100%	0 to 100%
Conformal coating			Conformal coating	Conformal coating, extended temperature range devices	Conformal coating, extended temperature range devices, Thermal conduction assembly
Testing		Functional, Temperature cycling	Functional, Temperature cycling, Wide temperature testing	Functional, Temperature cycling, Wide temperature testing Vibration, Shock	Functional, Temperature cycling, Wide temperature testing Vibration, Shock

Minimum lot sizes and NRE charges may apply. Contact sales support for pricing and availability.

SBC-K7

Standard Features

FMC Sites	
Specification	VITA 57 FMC, HPC (FMC site 0) and LPC (FMC site 1). Double width FMC card supported
High Speed Pairs	8 lanes (Tx/Rx pair) 6.5 Gbps max rate
Signal Pairs	**FMC 0 (HPC)** - 80 diff pairs total LA: 34 diff pairs (K7 FPGA) HA: 24 diff pairs (K7 FPGA) HB: 22 diff pairs (K7 FPGA) **FMC 1 (LPC)** - 56 diff pairs total LA: 34 pairs (K7 FPGA) HB: 22 diff pairs (Spartan-6)
IO Standards	**FMC 0** LA, HA : LVCMOS25, LVDS25, LVDCI2, SSTL25, HSTL25 HB: all Kintex-7 IO standards supported **FMC 1** LA: LVCMOS25, LVDS25, LVDCI2, SSTL25, HSTL25 HB: All Spartan-6 IO standards supported
Power (available to each module)	3.3V @ 3A 12V @ 1A 3.3V AUX @ 0.5A Vadj = 2.5V @ 4A

FPGA	
Device	Xilinx Kintex-7
Speed Grades	-1, -2
Logic Cells	K325T: 326K K410T: 406K
Flip-Flops /Slices	K325T: 407K /50K K410T: 508K /63K
DSP48E1 elements/ BlockRAMs	K325T: 840 K410T: 1540
GTX 12.5 Gb/s Transceivers	16 available
Configuration	JTAG or on-board Flash NVRAM In-System reprogrammable

FPGA Memories 2 Banks Total	
DDR3 SDRAM	1x 128MB x 16 1x 128MB x 32 clock rate 800 MHz

FPGA IO Interfaces	
PCI Express	Supports PCI Express Base 2.1 specification at Gen1 and Gen2 data rates

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COM Express CPU and Site	
Standards	PCIMG COM.0 COM Express Rev 2.0
Type	6
Size	Supports Basic (125 x 95 mm) or Compact (95 x 95 mm) module sizes
Verified Modules	Radisys CEQM77HDE-3612-0 Adlink Express-IBR-i7-R-3612QE Adlink Express-GFC-T56N
CPU Types	Core™ i7 3612QE - 2.1GHz, 4 Core, 6M Cache, HDGraphics 4000, TPM, ECC, 0C to 60C processor at 2.1GHz 6MB L3 cache with QM67 chipset Intel i7 processor at 2.1 GHz (High Performance) Express-GFC-T56N Compact COM Express Type 6 module with AMD Fusion G-T56N dual-core processor at 1.65 GHz and A55M Controller Hub (Low Power)
COM Express Memory	16 GB (i7), 6M cache 8 GB (AMD Fusion), 2x 512KB Cache
BIOS	AMI APTIO UEFI

PC Peripherals	
USB	2x USB 3.0/2.0 ports 2x USB 2.0 for internal in-system use
Ethernet	2x 10/100/1000 ports IEEE-1588 Precision Timing Protocol on dedicated port
SATA	2 SATA/2 eSATA (4x 6 Gb/s or 2x 6 Gb/s + 2x 3 Gb/s depending on the COM Express module used
Video/Audio	DisplayPort video port
Serial/CAN	RS232 and/or AX/RX port depending on the COM Express module used
GPS Port	UART (RS232) to GPS
Storage	SSD boot drive; removable SSD drive (4 total SATA ports are supported)
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	2x SMA for FMC external reference clocks; On-board high-precision crystal based reference clock
Time stamping/ Trigger Sources	2x SMA for 1 PPS external sources. Can be also used for FMC triggering
GPS (option)	10MHz reference disciplined to GPS signal 1 PPS timing reference input Position and UTC time reporting Support for Jackson Labs CSAC/ Symmetricom GPS-500 and similar units
IEEE-1588 PTP (option)	10MHz disciplined to PTP reference 1 PPS timing reference input Software stack runs on CPU Timing resolution to <100 ns

Power	
Consumption	30W typical baseline power (K325T @ 200 MHz clock rate, Atom CPU based COM Express module, FMC power not included)
Temperature Monitor	Software with programmable alarms Over-temperature protection
Power Control	Deep sleep mode FMC power controls
Cooling	Forced air or Conduction cooled

Physicals	
Form Factor	250 x 160 x 75 mm (10 x 5.5 x 3 in.)
Hazardous Materials	Lead-free and RoHS compliant

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Architecture and Features

The SBC-K7 is a carrier card that integrates an embedded PC, Xilinx Kintex-7 FPGA computing core with a pair of FMC IO modules on a single card. The architecture tightly couples the FPGA to the FMC and enables the card to perform real-time signal processing with low latency and extremely high rates, while providing all the ease-of-use and convenience of a PC.

Embedded PC

The SBC-K7 architecture is Windows/Linux compatible – it runs the same applications as a desktop computer. The COM Express CPU Type 6 module is a PC on a module and provides the computing engine, available with the advanced high-end multi-core Intel i7 processors as well as a low-power Atom CPU.

COM Express Advantages

- Intel compatible PC runs Windows, Linux
- Scalable performance
- Latest technologies: PCI Express 2.0, Gb Ethernet, USB 3.0, SATA 3.
- Upgradeable as requirements change and evolve
- Compact 95 x 125 mm form-factor
- Industry-standard, multi-vendor

The modularity of the COM Express module allows the SBC-K7 to be configured for the performance and power that is right for the application. When newer processors are available or the system requirements change, the COM Express module can be changed without changing the system architecture or software. Leveraging this industry standard also means that there are many vendors and varieties to choose from.

The COM Express module provides the PCI Express bus that links the FMC modules to the CPU. The PCI Express bus tightly couples the CPU to the FMC modules and outperforms previous generation systems by 2 to 4 times. Data transfer rates to CPU memory are at 3200 MB/s for both FMC sites.

The SBC-K7 provides familiar PC interfaces for expansion and connectivity: Gigabit Ethernet, USB ports, and SATA. The boot image can be stored on a rugged low power Solid State Drive (SSD). The SBC-K7 may also be booted from USB or Ethernet. Dual eSATA ports provide expansion to additional SSD or HDD for data storage.

The SBC-K7 operates either “headless” for embedded applications or supports a monitor, keyboard and mouse over the USB and DisplayPort. Standard PC DisplayPort screens with up to 2048x1536 resolution are supported. Support for touchscreen LCD panel makes standalone instruments easier to use while leveraging the PC development environment. In the headless mode, the ePC-K7 can be remotely controlled and accessed over Ethernet.

The CPU core connects to the FPGA over a x8 PCI Express link. This link supports up to ~3200 MB/s sustained transfer rates and is used as the primary data path between the CPU and FPGA (write-host is 3200 bidirectional and host-FMC card is 3100 unidirectional) Software and firmware support high speed DMA transfers to the CPU, enabling data logging and signal processing on the CPU.

FMC IO Sites

Dual FMC IO module sites enable the ePC-K7 to be configured with a wide variety of IO modules. The FMC sites are for PCI Express mezzanine cards conforming to VITA 57.1 standard. Each FMC site has a heat frame routed directly under the module to support efficient conduction cooling. FMC Site 0 supports HPC (High Pin Count) modules; FMC Site 1 supports LPC (Low Pin Count) modules. Double width FMC module is also supported.

The Innovative FMC module families offer a range of analog performance mated to the state-of-the-art performance of the Kintex-7 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 SBC-K7 well suited for data logging and playback functions. When configured with a four SSD RAID0 array, sustained rates to 2000MB/s are achievable.

SBC-K7

Importantly, all Innovative FMC modules for the SBC-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 Spartan-6 FPGA, so they can communicate bidirectionally for real-time applications demanding low latency and deterministic performance.

Triggering and Sample Clocks

The SBC-K7 has unique clocking and triggering features for the FMC modules. Each module receives two triggers from 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 Kintex-7 application FPGA.

Sample clocks for the FMC modules can be generated using an on-card PLL or from an external reference clock input. The PLL can use either the internal FMC generated clock or the external clock input from the baseboard, which can be selected from a few available options - GPS/IRIG/IEEE-1588 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 from the GPS when installed.

Remote Operation

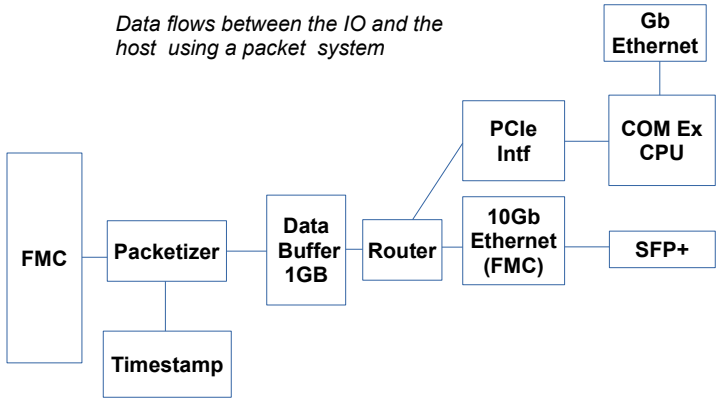
SBC-K7 can be operated using Ethernet as a remote computer or embedded instrument. For pure embedded operation, the SBC-K7 can operate "headless" without monitor, keyboard or mouse. The system boots from a SATA SSD or HDD.

FPGA Core

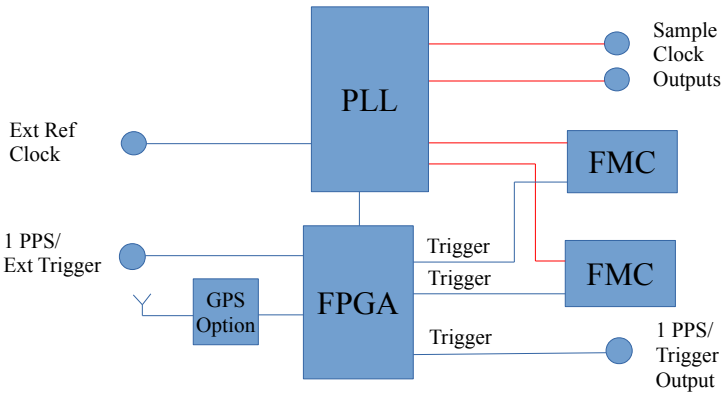
The SBC-K7 family has a Kintex-7 application FPGA and memory at its core for DSP and control. The completely flexible architecture of FPGAs supports fully parallel processing, delivering DSP performance of over 1 Tera MACs using the K410T operating at 500 MHz. In addition to the raw processing power, the FPGA fabric integrates logic, memory and connectivity features that make the SBC-K7 capable performing very demanding real-time signal processing.

FMC 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



Sample Controls and Clocking



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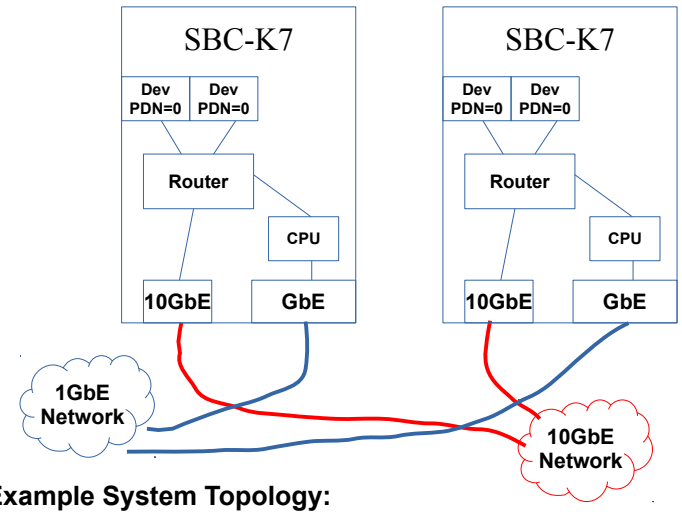
The FPGA is a PCIe bus peripheral to the COM Express CPU. New functions can be added to the system as PCIe devices by adding them to the FPGA design. The FPGA has direct access to two DDR3 SDRAM memory banks. These memories allow the FPGA working space for computation, required by DSP functions like FFTs, and bulk data storage needed for system data buffering and algorithms like large FFTs. Memory controller cores implement queuing, pattern generation, or flexible interfaces that supports their use for system data buffering and algorithm memory.

The SBC-K7 uses the Kintex-7 FPGA as a system-on-chip to integrate all the features for highest performance. As such, all IO, memory and host interfaces connect directly to the FPGA – providing direct connection to the data and control for maximum flexibility and performance. Firmware for the FPGA completely defines the data flow, signal processing, controls and host interfaces, allowing complete customization of the functionality. FPGA logic is provided in the FrameWork Logic tools, which includes the standard functionality that can be modified or used as an example.

Ethernet Communications

Ethernet ports on the SBC-K7 are integrated with the Velocia packet system. The packet system provides a simple and efficient way to move real-time data. It is extensible in your design to to efficiently handle data transfers between multiple, independent data sources on the SBC-K7 and other cards. Data is packetized, using packet sizes from 32 bytes to 64MB per packet, stamped with a packet ID and destination, and then routed to other devices in the system. The Velocia packet system is completely defined by the logic firmware, giving complete flexibility to create any packet routing necessary to meet system latency and transfer rate requirements.

Real-time system architectures using Velocia packet system for data flow management



Example System Topology:
SBC-K7 nodes on 10G and 1G Ethernet networks

The SBC-K7 can be used with an optional FMC module in site 1 featuring a 10Gb Ethernet port as a high speed data pipe. The port provides over 1 GB/S sustained data transfer rates over a fiber optic link, allowing the SBC-K7 to integrate with high speed data networks for sensors and other instruments. A 10Gb Ethernet MAC interface using UDP protocol in the FPGA supports continuous "line-rate" transfers, streaming data to the network. Long or short reach fiber optic connections are supported through the SFP+ port. SFP+ module is sold separately.

A set of logic components for packets is provided in the FrameWork Logic including packetizer, depacketizer, router and buffer memory controls. Packetizing includes timestamping per VITA 49. Data within the packets may be any format.

Card Management Features

The SBC-K7 has power and system health monitoring to protect from failures. Independent monitoring of the FPGA die temperature can shut down the card to prevent damage from overheating. The COM Express CPU has independent temperature monitoring as well. The FPGA also has watchdog timer functionality that may be used to prevent runaway operation. In air-cooled applications advanced fan speed management is provided.

FPGA Configuration

The FPGA image is stored in on-board NVRAM. Configuration time depends on the FPGA size; it is ~2 seconds for the K325T. The CPU can reprogram the FPGA at any time.

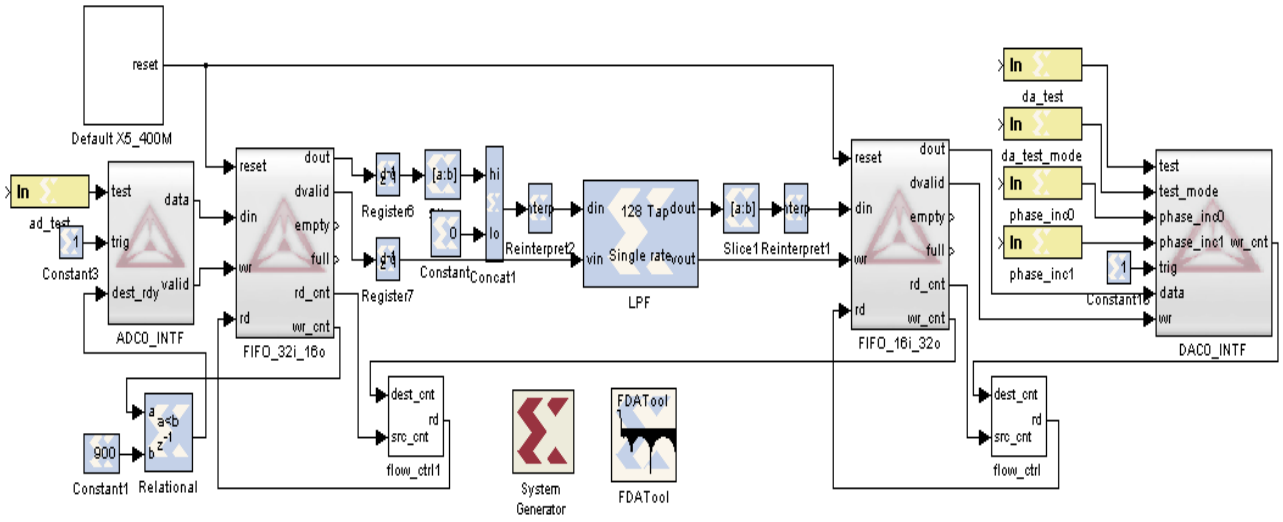
During development, the JTAG interface to the FPGA is used. This allows the FPGA image to be downloaded over the cable for debugging and test. Tools such as ChipScope and MATLAB provide assistance in development work. The FPGA JTAG connector is fully compatible with Xilinx Platform USB II JTAG Cable.

Software Tools

Software development tools for the SBC-K7 provide comprehensive support including device drivers, data buffering, card controls, and utilities that allow developers to be productive from the start. At the most fundamental level, the software tools deliver data buffers to your application without the burden of low-level real-time control of the cards. Software classes provide C++ developers a powerful, high-level interface to the card that makes real-time, high speed data acquisition easier to integrate into applications.

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 with FFT function, analysis and import to MATLAB for large data files.

Support for MS Visual C++ is provided. Supported OSes include Windows and Linux (including real-time variants). Download the software tools User Guide and on-line help for more information.



MATLAB Simulink for Logic Design

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Logic Tools

High speed DSP, analysis, customized triggering and other unique features may be added by modifying the logic. The FrameWork Logic tools provide support for RTL and MATLAB developments, providing the basic hardware interfaces, data paths and controls. The standard logic provides a hardware interface layer that allows designers to concentrate on the application-specific portions of the design. Designer can build upon the Innovative components for packet handling, hardware interfaces and system functions, the Xilinx IP core library, and third party IP. RTL source for the FrameWork Logic is provided for customization. Each design is provided as a Xilinx ISE project, with a ModelSim testbench illustrating logic functionality.

The MATLAB Board Support Package (BSP) allows logic development using Simulink and Xilinx System Generator. These tools provide a graphical design environment that integrates the logic into MATLAB Simulink for complete hardware-in-the-loop testing and development. This is an extremely powerful design methodology, since MATLAB can be used to generate, analyze and display the signals in the logic real-time in the system. Once the development is complete, the logic can be embedded in the FrameWork logic using the RTL tools.

IP for Kintex-7 FPGA

Innovative provides many IP cores for signal processing functions such as up/down-conversion, modulation/demodulation, OFDM receiver and transmit to name a few.

The DDC channelizers are offered in channel densities from 4 to 256. The four channel DDC offers complete flexibility and independence in the channels, while the 128 and 256 channel cores offer higher density for uniform channel width applications. The DDC cores are highly configurable and include programmable channel filters, decimation rates, tuning and gain controls. An integrated power meter allows the DDC to measure any channel power for AGC controls. Multiple cores can be used for higher channel counts.

Each IP core is provided with a MATLAB simulation model that shows bit-true, cycle-true functionality. Signal processing designers can then use this model for channel design and performance studies. Filter coefficients and other parameters from the MATLAB simulation can be directly loaded to the hardware for verification.

A complete list of available IP is listed here (http://www.innovative-dsp.com/products.php?product=IP%20Cores).

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