Actel ®
POWER MATTERS

SmartFusion™

The Intelligent Mixed Signal FPGA

SMARTFUSION™

Flash FPGA + ARM® Cortex™-M3 + Programmable Analog

Innovative Intelligent Integration

SmartFusion intelligent mixed signal FPGAs are the only devices that integrate an FPGA, an ARM® Cortex™-M3 processor and programmable analog, offering full customization, IP protection and ease-of-use. Based on Actel's proprietary flash process, SmartFusion devices are ideal for hardware and embedded designers who need a true system-on-chip (SoC) that gives more flexibility than traditional fixed-function microcontrollers without the excessive cost of soft processor cores on traditional FPGAs.

- Hard 32-bit ARM Cortex-M3 processor
- Proven ProASIC®3 FPGA fabric
- Full-featured programmable analog
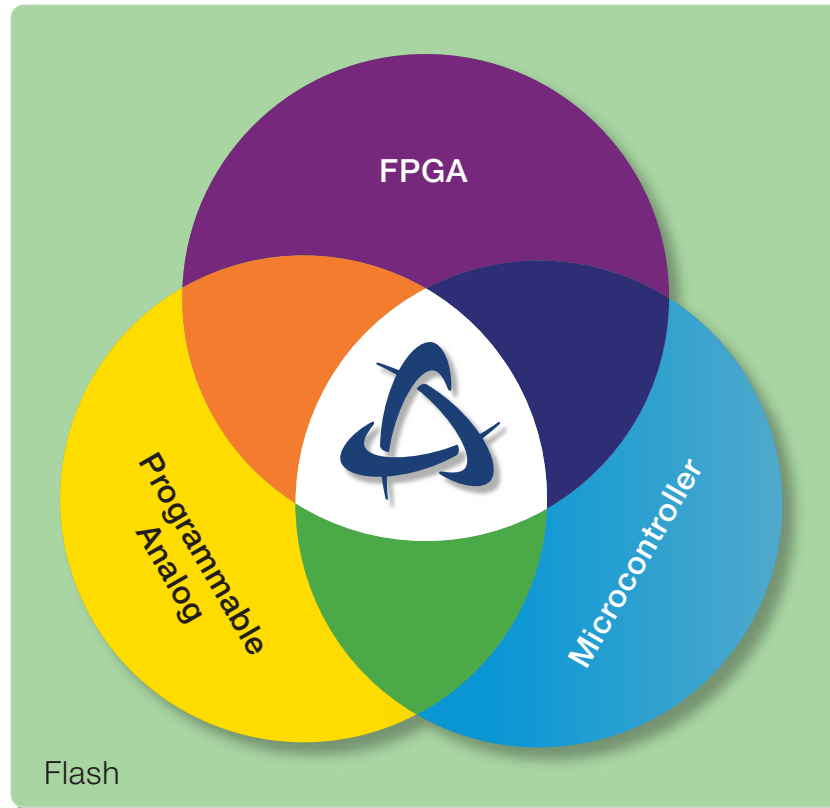
Key Benefits of SmartFusion FPGAs

Full Design Customization

- Create a product with exactly the features you need
- Innovate and differentiate for a competitive edge
- Incorporate last-minute changes with an on-chip FPGA
- In-application programming (IAP) capability for field upgrades
- Experiment with hardware acceleration for select algorithms in FPGA fabric

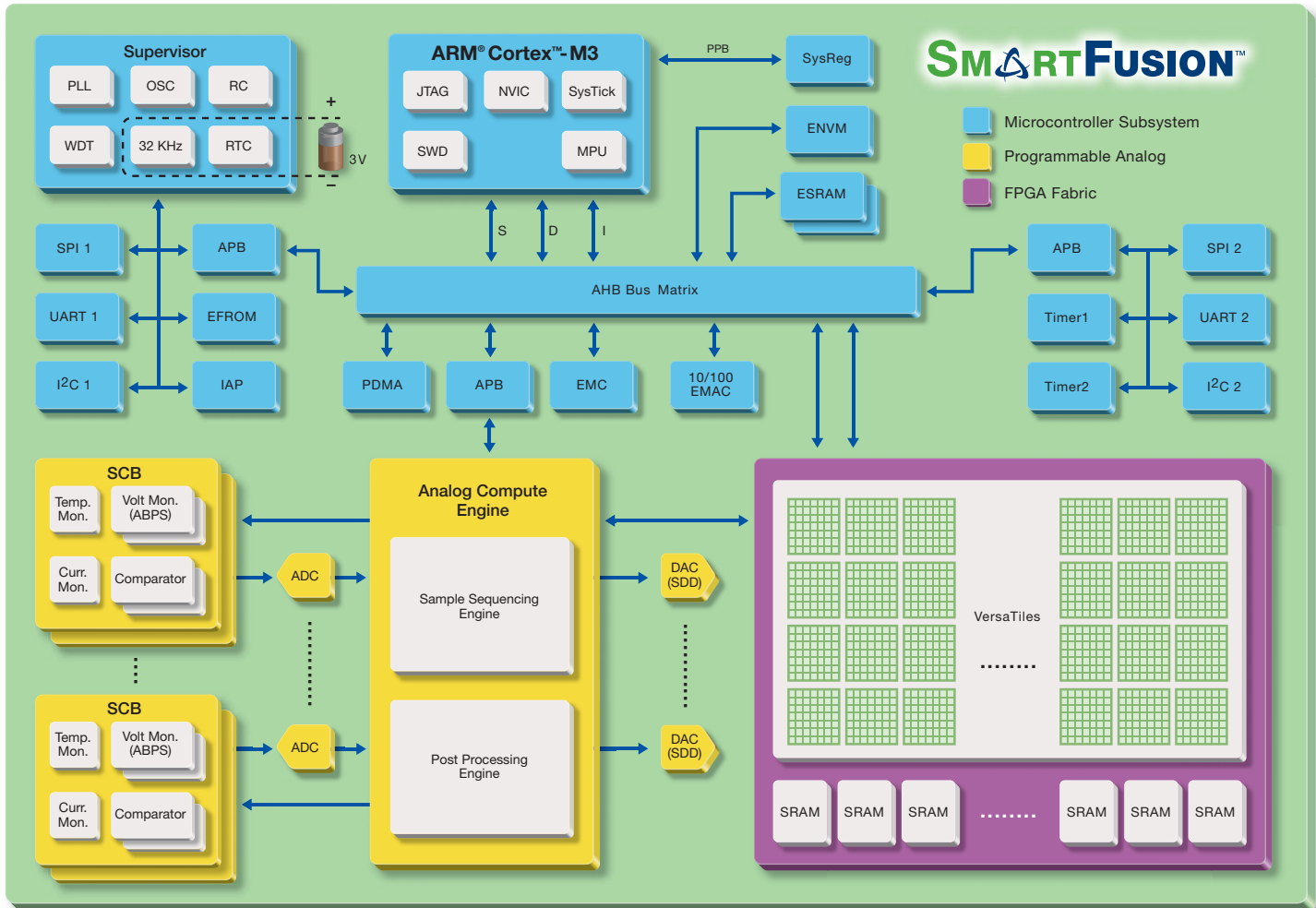### Intellectual Property (IP) Protection

- Interface between microcontroller and FPGA not exposed at board level
- No bitstream exposed at power up
- Encrypted in-system programming (ISP) with 128-bit AES via JTAG
- FlashLock® controls access to the security settings of the device
- Protection against overbuilding with customer programmable device key

Ease-of-Use Increases Productivity

- A single platform for your entire line of products
- Integrated design environment for both FPGA and embedded designers
- Simple GUI-based configuration of complex programmable analog
- Industry leading compile and debug from Keil,™ IAR Systems® and GNU
- Micrium supports SmartFusion with RTOS and middleware components

SmartFusion Architecture

Along with microcontroller (MCU), FPGA and analog, SmartFusion intelligent mixed signal FPGAs integrate substantial flash and SRAM memory and comprehensive clock generation and management circuitry. SmartFusion architecture enables data storage and execution of code from a single monolithic device. In addition, in-application programming (IAP) enables real-time updates and reprogramming of the complete chip. Design compromises that were inevitable with traditional fixed-function microcontrollers and FPGAs are eliminated when designing with SmartFusion devices.
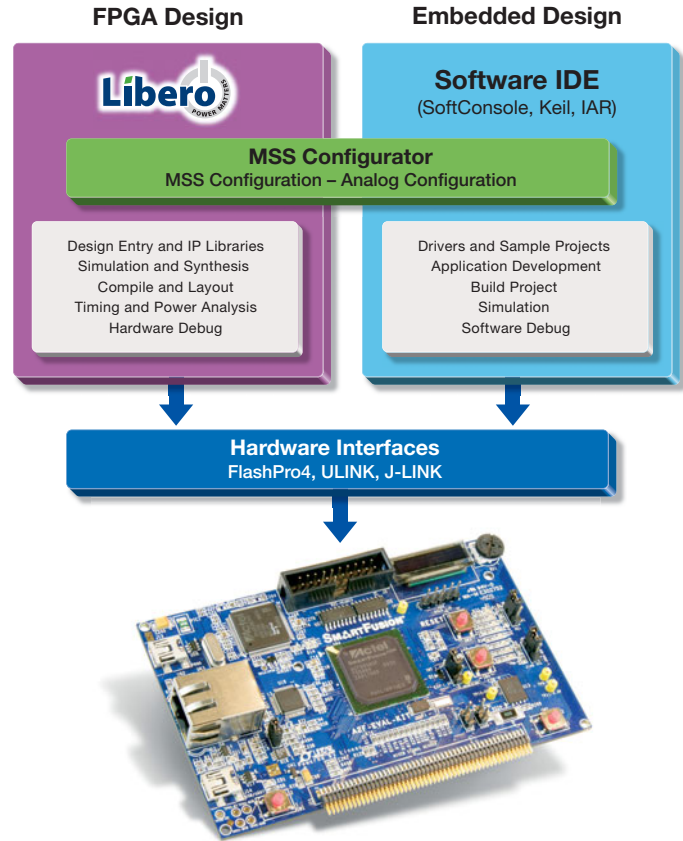

No-Compromise Microcontroller Subsystem (MSS)	Programmable Analog	No-Compromise FPGA Fabric

• Hard industry-standard 100 MHz, 32-bit ARM Cortex-M3 CPU
• Multi-layer AHB communication matrix with up to 16 Gbps throughput
• 10/100 Ethernet MAC with RMII interface
• Two of each: SPI, I^{2}C, UART, 32-bit timers
• Up to 512 KB flash and 64 KB of SRAM
• External memory controller (EMC)
• 8-channel DMA controller
• Up to 41 MSS I/Os with Schmitt Trigger inputs
  - 25 I/Os can be used as FPGA I/Os
	• High-performance analog signal conditioning blocks (SCB) with voltage, current and temperature monitors
	• Analog compute engine (ACE) offloads CPU from analog initialization and processing of ADC, DAC and SCBs
	• Integrated ADCs and DACs with 1 percent accuracy
	• 12/10/8-Bit mode ADCs with 500/550/600 Ksps sampling rate
	• Up to ten 15 ns high-speed comparators
	• Up to 32 analog inputs and 3 outputs
		• Based on Actel's proven ProASIC3 architecture
		• 60,000 to 500,000 system gates with 350 MHz system performance
		• Embedded SRAMs and FIFOs
		  - Variable aspect ratio 4,608-bit SRAM blocks
		  - x1, x2, x4, x9 and x18 organizations
		  - True dual-port SRAM (excluding x18)
		• Up to 128 FPGA I/Os supporting LVDS, PCI, PCI-X & LVTTL/LVCMOS standards

Designing with SmartFusion

Designing with SmartFusion involves three different types of design: FPGA design, embedded design and analog design. These roles can be filled by three different designers, two designers or even a single designer, depending on company structure and project complexity. Actel has developed design tools and flows to meet the needs of these three types of designers so they can work together smoothly on a single project.

- FPGA Design—Libero® Integrated Design Environment (IDE) is Actel's comprehensive software toolset for designing with all Actel FPGAs. Libero IDE includes industry-leading synthesis, simulation and debug tools from Synopsys® and Mentor Graphics®, as well as innovative timing and power optimization and analysis.

- Embedded Design—Actel offers FREE SoftConsole Eclipse-based IDE, which includes the GNU C/C++ compiler and GDB debugger. Actel also offers evaluation versions of software from Keil and IAR, with full versions available from respective suppliers.

- Analog Design—The MSS configurator provides graphical configuration for current, voltage and temperature monitors, sample sequencing setup and post-processing configuration, as well as DAC output.

The MSS configurator creates a bridge between the FPGA and embedded designers so device configuration can be easily shared between multiple developers.

FPGA Design

Embedded Design

Libero

POWER MATTERS

Software IDE
(SoftConsole, Keil, IAR)

MSS Configurator
MSS Configuration – Analog Configuration

Design Entry and IP Libraries
Simulation and Synthesis
Compile and Layout
Timing and Power Analysis
Hardware Debug

Drivers and Sample Projects
Application Development
Build Project
Simulation
Software Debug

Hardware Interfaces
FlashPro4, ULINK, J-LINK

MSS Configurator

- Configure the MSS peripherals and I/Os during embedded system design.
- Create or view hardware configuration in FPGA design flow.
- Create or import hardware configuration in embedded design flow.
- Automatically generate drivers for peripherals or soft IP.
- Configure programmable analog components.
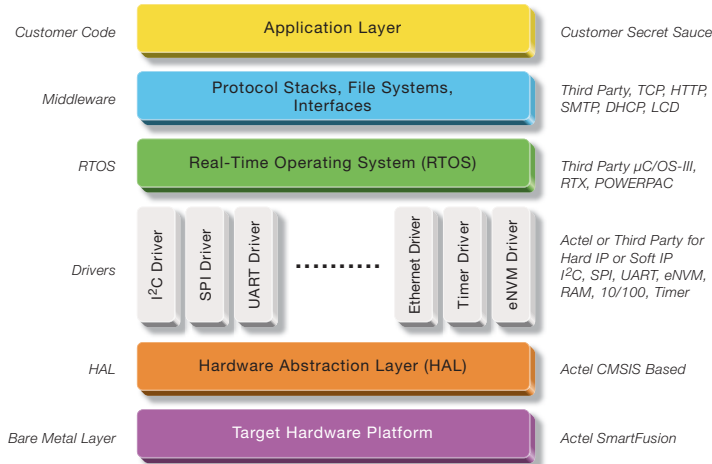- Connect FPGA fabric designs and IP to MSS.
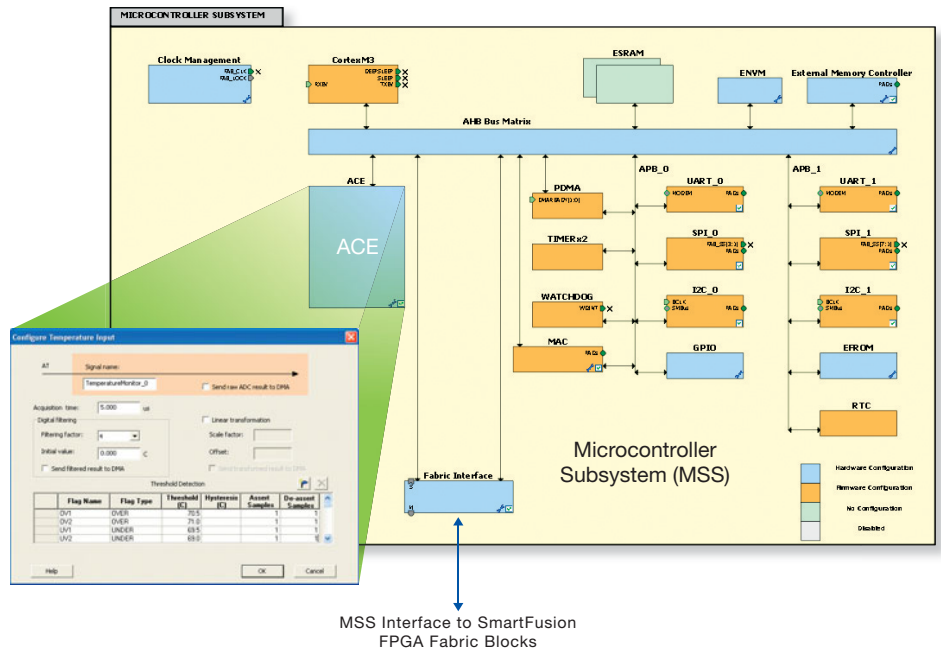
MSS Interface to SmartFusion
FPGA Fabric Blocks

SmartFusion Ecosystem

Actel has a long history of supplying comprehensive FPGA development tools and recognizes the benefit of partnering with industry leaders to deliver the optimum usability and productivity to customers. Taking the same approach with processor development, Actel has partnered with key industry leaders in the microcontroller space to provide the robust SmartFusion ecosystem.

Actel is partnering with Keil and IAR to provide Software IDE support to SmartFusion system designers. The result is a robust solution that can be easily adopted by existing embedded developers. The learning path is straightforward for FPGA designers.

Customer Code	**Application Layer**	*Customer Secret Sauce*
Middleware	**Protocol Stacks, File Systems, Interfaces**	*Third Party, TCP, HTTP, SMTP, DHCP, LCD*
RTOS	**Real-Time Operating System (RTOS)**	*Third Party µC/OS-III, RTX, POWERPAC*
Drivers	I²C Driver · SPI Driver · UART Driver .... Ethernet Driver · Timer Driver · eNVM Driver	*Actel or Third Party for Hard IP or Soft IP I²C, SPI, UART, eNVM, RAM, 10/100, Timer*
HAL	**Hardware Abstraction Layer (HAL)**	*Actel CMSIS Based*
Bare Metal Layer	**Target Hardware Platform**	*Actel SmartFusion*

The diagram above represents support for the Actel device and ecosystem resources. At the foundation is the SmartFusion hardware platform. Built on it is the hardware abstraction layer (HAL), which is based on the ARM Cortex Microcontroller Software Interface Standard (CMSIS). Each of the peripherals has its own driver, whether it is hard IP or soft IP added in the FPGA fabric. Above the drivers is a real-time operating system (RTOS) with protocol stacks and interfaces, provided by third party vendors. The designer can add secret sauce or custom applications involving all or none of the layers below.

By selecting an ARM processor, Actel's customers can benefit from the extensive ARM ecosystem. By building on Actel supplied HAL and drivers, third party vendors can easily port RTOS and middleware for the SmartFusion devices.

Micrium

Micrium is consistently recognized as a leader in embedded software components. The company's flagship µC/OS family is recognized for a variety of features and benefits, including unparalleled reliability, performance, dependability, impeccable source code and vast documentation. Micrium supports the following products for SmartFusion and continues to work with Actel on additional projects.

- µC/OS-III,™ Micrium's newest RTOS, is designed to save time on your next embedded project and puts greater control of the software in your hands.

- µC/TCP-IP™ is a compact, reliable and high-performance stack built from the ground up by Micrium and has the quality, scalability and reliability that translates into a rapid configuration of network options, remarkable ease-of-use and rapid time-to-market.

- µC/Probe™ is one of the most useful tools in embedded systems design and puts you in the driver's seat, allowing you to take charge of virtually any variable, memory location and I/O port in your embedded product, while your system is running—there's no need to stop.

Software IDE Choices

|	CMSIS COMPLIANT	Actel® POWER MATTERS	KEIL™ An ARM® Company	IAR SYSTEMS
Software IDE		SoftConsole	Keil MDK	Embedded Workbench
Free Versions from Actel		Free with Libero IDE	32 K Code Limited	32 K Code Limited
Available from Vendor		N/A	Full version	Full Version
Compiler		GNU GCC	RealView C/C++	IAR ARM Compiler
Debugger		GDB Debug	µVision Debugger	C-SPY Debugger
Instruction Set Simulator		No	µVision Simulator	Yes
Debug Hardware		FlashPro4	ULINK2 or ULINK-ME	J-LINK or J-LINK Lite

→ For more information regarding software ecosystem, refer to **www.actel.com/products/smartfusion/ecosystem.aspx**.

Motor Control

SmartFusion intelligent mixed signal FPGAs are uniquely suited to active motor control for permanent magnet motors, servo motors, series motors, separately excited motors and alternating current induction motors. A SmartFusion FPGA can actively manage multiple electric motors, including start and stop, control of rotational direction, speed and torque, protection against motor overloads or faults and active control using closed loop performance algorithms. SmartFusion on-chip resources allow you to monitor motor performance in real time with or without dedicated encoders, applying corrective control signals to maintain commanded direction, speed and torque and deliver precise motor position control.

Actel's motor control partner, Power and Control Design, Inc., has produced a SmartFusion Motor Control Development Kit that enables demonstration and benchtop development of your world-class permanent magnet motor control products. The kit includes five reference designs with source files:

- Trapezoidal using Hall effect sensor feedback
- Sinusoidal using Hall effect sensor feedback
- Sinusoidal with encoder feedback
- Sensorless trapezoidal with back-EMF feedback
- Ethernet interactive control of motors
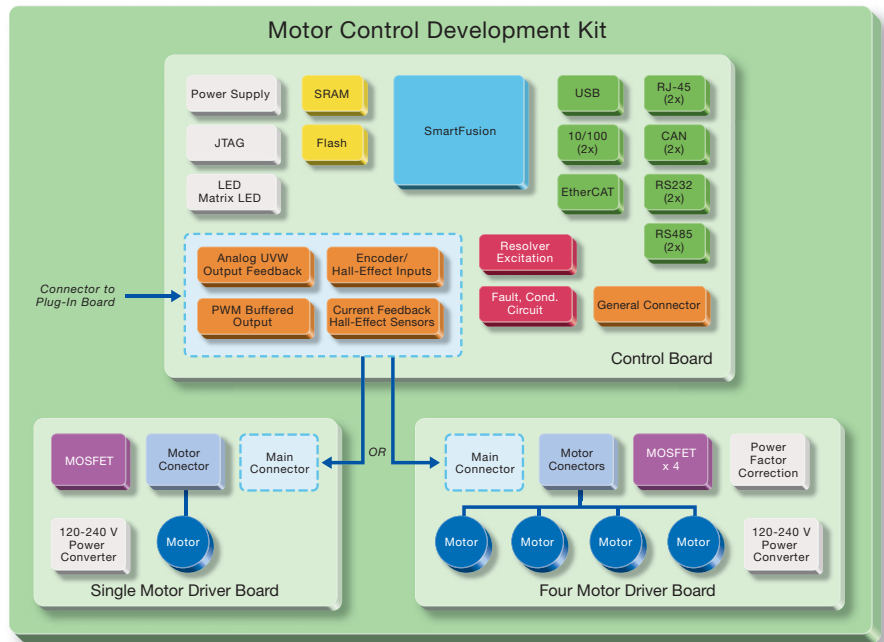
Industrial Automation

The range of peripherals SmartFusion offers for the Cortex-M3 processor and the flexibility of its FPGA fabric make the device ideal for industrial automation. The SmartFusion Development Kit supports Ethernet, EtherCAT, CAN, UART, I^2C and SPI hardware, while firmware can be used for various other interface standards such as Modbus® and PROFIBUS for industrial networking. With the use of the programmable analog for sensing and analog outputs, SmartFusion can also be used in industrial control applications, including gateways, sensing, actuators and I/O devices. The list below describes how the various sections of the device could be used in industrial automation.
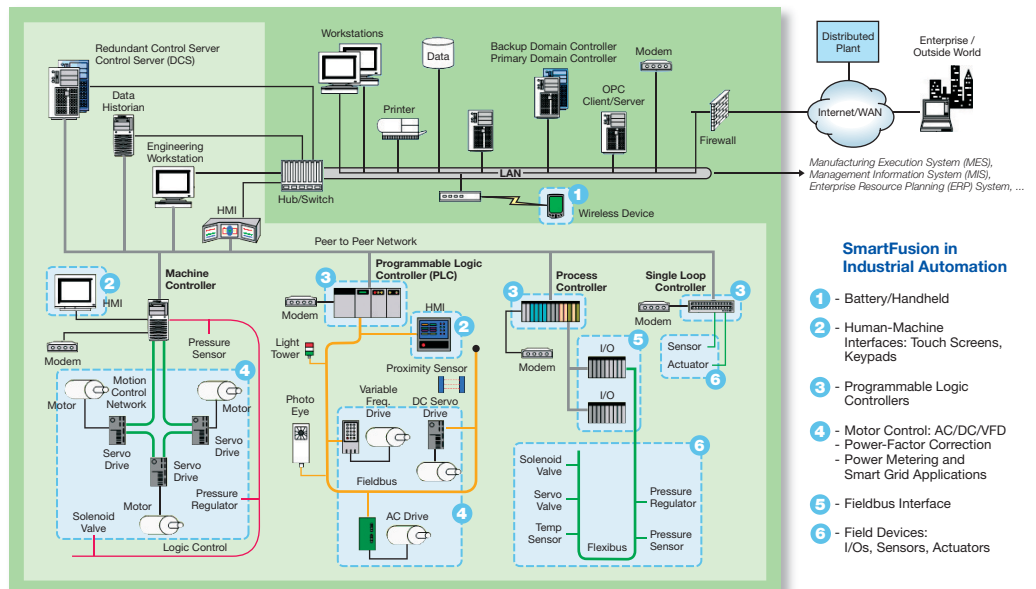
Microcontroller Subsystem

- ARM Cortex-M3 running Fieldbus protocol stack
- Ethernet MAC – standard protocols

FPGA Fabric

- Multiple RS485 capable UARTs
  - PROFIBUS, Modbus, WorldFIP, P-NET
- High Speed Manchester Encoding/Decoding
- CAN

Analog

- ADC for sensing
- DAC for excitation

Source: NIST

System Management

System management continues to gain importance in the design of all electronic systems, since smaller process geometries drive more multi-volt devices and are more susceptible to voltage and temperature fluctuations. System management tasks focus on maximizing system uptime, identifying and communicating alert conditions and logging data and alarm conditions. This can be combined with in-system diagnostics and prognostics, not only to help debug systems that have failed, but also to identify potential failures before they arise. Thus, using SmartFusion as a system manager provides the designer maximum implementation flexibility.

- Use the sample sequence engine in the ACE to manage system health data collection.
- Use the post-processing engine in the ACE to manage alert condition flag generation.
- Cortex-M3 only needs to make requests to the ACE and respond to interrupts, no processing cycles needed.
- Use FPGA gates for control algorithms when needed.
- Communicate through I2C, UART, SPI or Ethernet for updates and reporting.

Leveraging the considerable processing power of the ACE leaves the Cortex-M3 and FPGA gates available for running the actual application or communicating with the outside world. This not only eliminates the need for multiple ASSP devices to perform system management, but prevents system management from being an unnecessary burden on the bill-of-materials (BOM) cost. Selecting SmartFusion devices for system management provides flexibility and reliability at the lowest total cost of ownership (TCO).

Typical Board Using Traditional System Management Solution

Typical System Management Solution Using SmartFusion
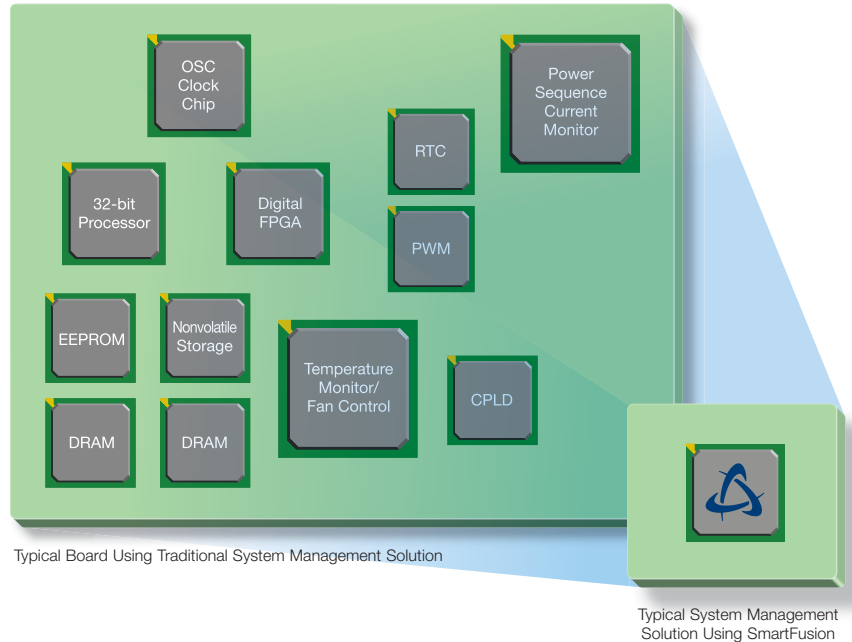
Power Management

SmartFusion Mixed Signal Power Manager (MPM) enables designers to integrate intelligent configurable power management with their own Cortex-M3 firmware and FPGA design using SmartFusion devices.

SmartFusion MPM is a complete power management example design that demonstrates power rail monitoring, power sequencing, closed-loop trimming, power-up and power-down control and event data logging for up to 32 individual power supplies.

- Manages up to 32 power regulators
- 8 configurable PWM trimming outputs
- 32 general purpose digital outputs
- Data logging to eNVM of critical events
- I2C and JTAG configuration updates
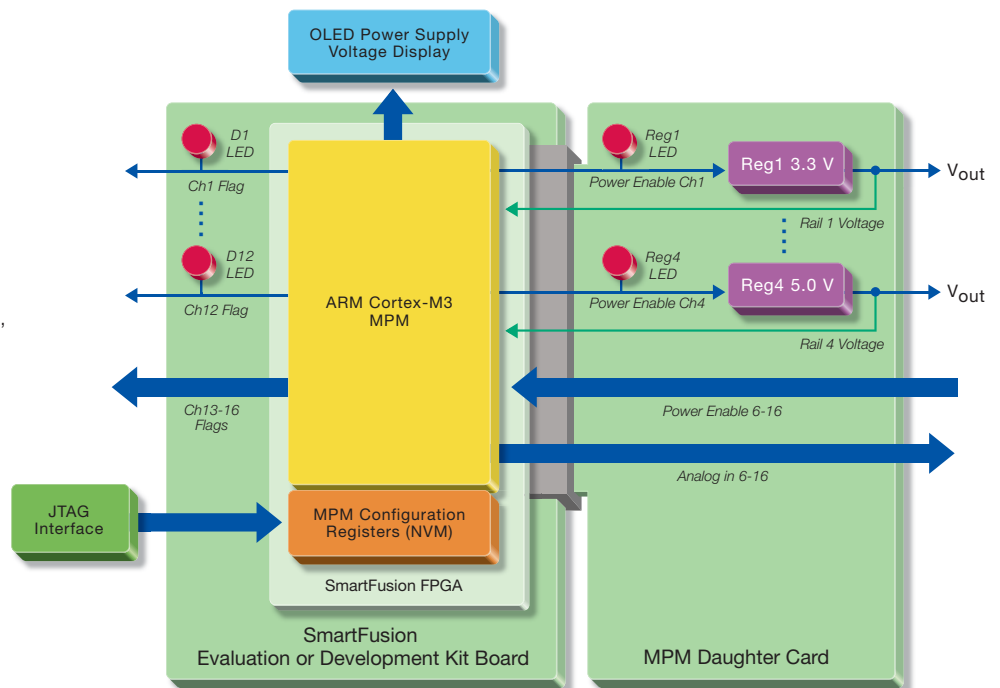
Hardware Platform Management

World-class management solutions for xTCA™ platforms

Pigeon Point Systems, an Actel company, helped refine the architecture of SmartFusion for hardware platform management and is now beginning to deliver SmartFusion-based Board Management Reference (BMR) solutions for the xTCA board and module controller types. The first of these are controller solutions for AdvancedTCA® (ATCA) and AdvancedMC™ (AMC) systems:

Benchtop Board for SmartFusion IPMC and Carrier IPMC

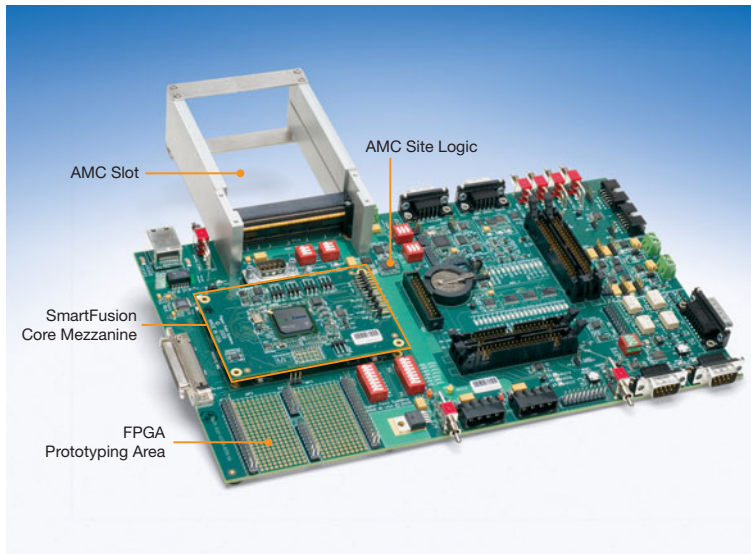- BMR-A2F-ATCA: IPM Controllers (IPMCs) for ATCA boards
- BMR-A2F-AMCc: Carrier IPMCs for ATCA AMC carrier boards
- BMR-A2F-AMCm: Module Management Controllers for AMC modules

Pigeon Point Systems is the dominant supplier of hardware and firmware solutions for the mandatory hardware platform management controllers that are part of every Telecommunications Computing Architecture (xTCA) board or module. Key features of these solutions include:

- Advanced Ethernet attachment via built-in Ethernet MAC, supporting serial port access and fast firmware upgrades over LAN
- Optimizations for xTCA management via the flash FPGA fabric, with the option to integrate additional board- and module-specific functionality
- Advanced analog monitoring using SmartFusion's programmable analog
- Complete off-loading from the Cortex-M3 of xTCA-aware analog threshold processing via ACE
- Benchtop implementations for familiarization and as a known good reference during bringup of a new xTCA board or module

Intellectual Property for SmartFusion

SmartFusion devices are composed of hard intellectual property (IP) blocks such as an ARM Cortex-M3 processor, UART, SPI, I^{2}C and 10/100 Ethernet interfaces, as well as standard peripherals, such as ADC, DAC, timers, watchdog timer and RTC. Beyond these hard cores you can select from Actel's IP Catalog within SmartDesign to add additional free IP to the FPGA fabric of your SmartFusion device, or choose from a wide range of partner cores. Actel has more than 180 intellectual property products designed and optimized to support communications, consumer, military, industrial, automotive and aerospace markets. Actel IP solutions streamline your designs, enable faster time-to-market and minimize design costs and risk. The table below shows some examples of the IP available. A complete list of cores is available on the Actel website.

General Purpose		Cryptography	Communication	MIL-STD-1553B	DSP IP Cores
Core16550	CoreUART	CoreAES128	CorePCIF	Core1553BRM	CoreFFT
CoreGPIO	CoreI2C	CoreDES	CoreSDR/DDR	Core1553BRT	CoreFIR
CoreTimer	CoreSPI	Core3DES	Core429	Core1553BRT-EBR	CoreDDS
CoreSDR	CorePWM	Fast SHA-256 Hash[1]	IniCAN[2]	Core1553BBC	—

Note:
1. Fore more information, see the Helion Technology partner page: www.actel.com/products/partners/companioncore/helion.aspx.
2. Fore more information, see the Inicore partner page: www.actel.com/products/partners/companioncore/inicore.aspx.

Actel IP cores can be accessed through the Actel Libero IDE via the SmartDesign IP catalog. Drivers for the processor supported IP cores are available through the Firmware Catalog and are extracted automatically for SmartFusion designs through the MSS Configurator dialog.

Libero IDE Licenses	Gold (FREE)	Platinum	Platinum Evaluation	Standalone
Device Support	Up to 1,500,000 gates	All devices	All devices	All devices
Actel IP	Obfuscated	RTL	Obfuscated	Obfuscated

➡ **For a complete list of Actel IP cores and partner CompanionCores, refer to: www.actel.com/products/ip.**

SmartFusion Evaluation Kit

Labels on board image: SmartFusion Device, RVI - Header, OLED Display, USB Program and Debug Interface, 10/100 Ethernet Interface, Regulators, USB Power and USB-UART Interface, 5 Debug I/Os, Reset Switch, Debug Select, 8 User LEDs, JTAG Select, PUB Switch, SPI-Flash Memory, Potentiometer, User SW1, Mixed Signal Header, 20 MHz Crystal, 32.768 KHz Crystal, VRPSM Voltage Option, User SW2
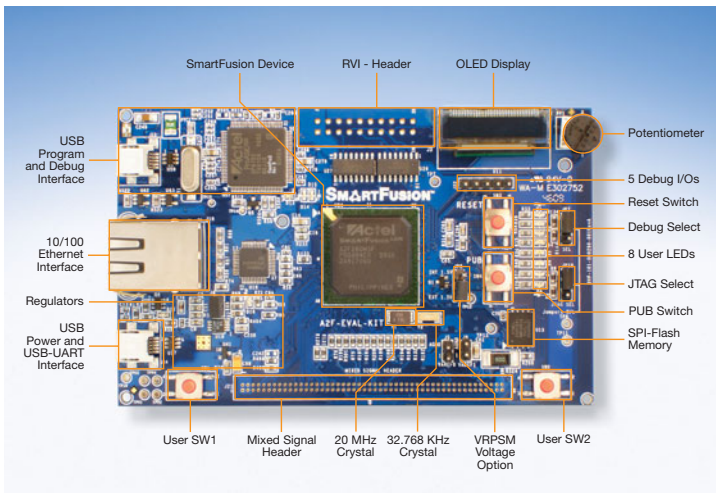
- **Supports SmartFusion evaluation, including ARM Cortex-M3, FPGA and programmable analog**
- **Free one-year Libero Integrated Design Environment (IDE) software and Gold license with SoftConsole for program and debug**
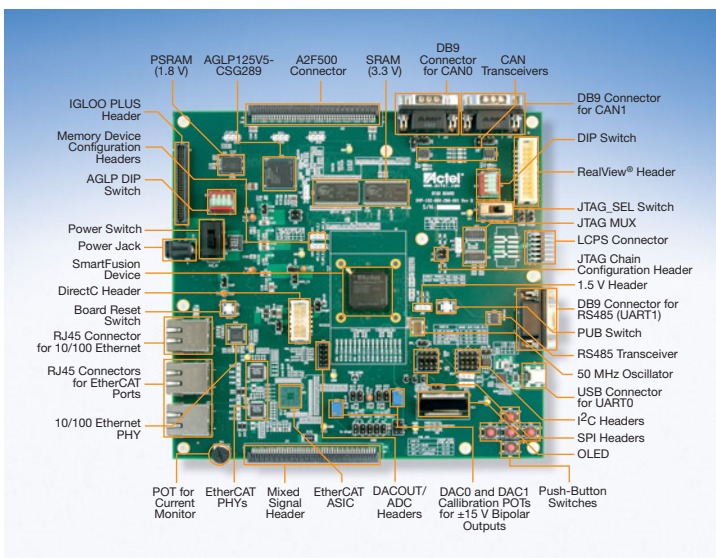- **Two USB cables**
- **User's guide, tutorial and design examples**
- **Printed circuit board (PCB) schematics, layout files and bill-of-materials (BOM)**

- **Board features**
  - Ethernet interface
  - USB port for power and HyperTerminal
  - USB port for programming and debug
  - J-Link header for debug
  - Mixed signal header
  - SPI flash – off-chip memory
  - Reset and 2 user switches, 8 LEDs
  - POT for voltage / current monitor
  - Temperature monitor
  - Organic light-emitting diode (OLED)

Ordering Code	Supported Device	Price
A2F-EVAL-KIT	A2F200M3F-FGG484	$ 99

SmartFusion Development Kit

Labels on board image: PSRAM (1.8 V), AGLP125V5-CSG289, A2F500 Connector, SRAM (3.3 V), DB9 Connector for CAN0, CAN Transceivers, IGLOO PLUS Header, Memory Device Configuration Headers, AGLP DIP Switch, Power Switch, Power Jack, SmartFusion Device, DirectC Header, Board Reset Switch, RJ45 Connector for 10/100 Ethernet, RJ45 Connectors for EtherCAT Ports, 10/100 Ethernet PHY, DB9 Connector for CAN1, DIP Switch, RealView® Header, JTAG_SEL Switch, JTAG MUX, LCPS Connector, JTAG Chain Configuration Header, 1.5 V Header, DB9 Connector for RS485 (UART1), PUB Switch, RS485 Transceiver, 50 MHz Oscillator, USB Connector for UART0, I2C Headers, SPI Headers, OLED, POT for Current Monitor, EtherCAT PHYs, Mixed Signal Header, EtherCAT ASIC, DACOUT/ADC Headers, DAC0 and DAC1 Callibration POTs for ±15 V Bipolar Outputs, Push-Button Switches
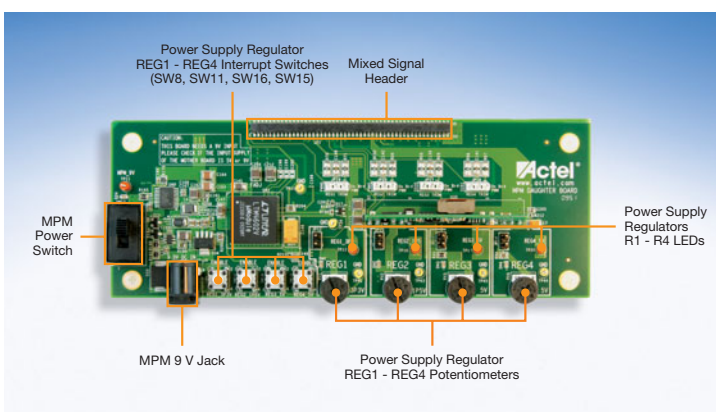
- **Supports SmartFusion development, including ARM Cortex-M3, FPGA and programmable analog**
- **Free one-year Libero IDE software and Gold license with SoftConsole for program and debug**
- **5 V power supply and international adapters**
- **Two USB cables**
- **User's guide, tutorial and design examples**
- **PCB schematics, layout files and BOM**

- **Board features**
  - Ethernet, EtherCAT, CAN, UART, I^2C and SPI interfaces
  - USB port for HyperTerminal
  - USB port for programming and debug
  - J-Link header for debug
  - Mixed signal and A2F500 digital expansion header
  - Extensive off-chip memory
  - See the Actel website for a full list of features

Ordering Codes	Supported Devices	Price
A2F-DEV-KIT	A2F200M3F-FGG484	$ 999
A2F500-DEV-KIT*	A2F500M3G-FGG484	$ 999

Note:
* Targeted for release Q3 2010

MPM Daughter Card

Labels on board image: Power Supply Regulator REG1 - REG4 Interrupt Switches (SW8, SW11, SW16, SW15), Mixed Signal Header, MPM Power Switch, Power Supply Regulators R1 - R4 LEDs, MPM 9 V Jack, Power Supply Regulator REG1 - REG4 Potentiometers

- **Supports power management design with the SmartFusion Evaluation Kit and SmartFusion Development Kit**
- **MPM design example implements configurable power management in SmartFusion**
- **Graphical configuration dialog**
- **In-system reconfigurable**
- **9 V power supply**

- **Board features**
  - 4 power supply regulators
  - 4 potentiometers to control regulators
  - 4 power supply regulator interrupt switches
  - 4 power supply regulator status LEDs
  - Mixed signal header connector connects to SmartFusion board

Ordering Code	Supported Device	Price
MPM-DC-KIT	No Actel device	$299

SmartFusion Family Product Table

SmartFusion Devices		A2F060[1]	A2F200	A2F500
FPGA Fabric	System Gates	60,000	200,000	500,000
	Tiles (D-flip-flops)	1,536	4,608	11,520
	RAM Blocks (4,608 bits)	8	8	24
Microcontroller Subsystem (MSS)	Flash (Kbytes)	128	256	512
	SRAM (Kbytes)	16	64	64
	Cortex-M3 with Memory Protection Unit (MPU)	Yes	Yes	Yes
	10/100 Ethernet MAC	No	Yes	Yes
	External Memory Controller (EMC)	26-bit address, 16-bit data	26-bit address, 16-bit data	26-bit address, 16-bit data
	DMA	8 Ch	8 Ch	8 Ch
	I^2C	2	2	2
	SPI	2	2	2
	16550 UART	2	2	2
	32-Bit Timer	2	2	2
	PLL	1	1	2
	32 KHz Low Power Oscillator	1	1	1
	100 MHz On-Chip RC Oscillator	1	1	1
	Main Oscillator (32 KHz to 20 MHz)	1	1	1
Programmable Analog	ADCs (8-/10-/12-bit SAR)	1	2	3
	DACs (12-bit sigma-delta)	1	2	3
	Signal Conditioning Blocks (SCBs)	1	4	5
	Comparators[2]	2	8	10
	Current Monitors[2]	1	4	5
	Temperature Monitors[2]	1	4	5
	Bipolar High Voltage Monitors[2]	2	8	10

Note:
1. Under definition. Subject to change.
2. These functions share I/O pins and may not all be available at the same time.

Package I/Os: MSS + FPGA I/Os

Device	A2F060[1]	A2F200		A2F500	
	FG256	FG256	FG484	FG256	FG484
Direct Analog Input	8	8	8	8	12
Total Analog Input	12	24	24	24	32
Total Analog Output	1	2	2	2	3
MSS I/Os[2,3]	25	25	41	25	41
FPGA I/Os	66	66	94	66	128
Total I/Os	104	117	161	117	204

Notes:
1. Under definition. Subject to change.
2. 16 MSS I/Os are multiplexed and can be used as FPGA I/Os, if not needed for the MSS. These I/Os support Schmitt triggers and support only LVTTL and LVCMOS (1.5 / 1.8 / 2.5, 3.3 V) standards.
3. 9 MSS I/Os are primarily for 10/00 Ethernet MAC and are also multiplexed and can be used as FPGA I/Os if Ethernet MAC is not used in a design. These I/Os support Schmitt triggers and support only LVTTL and LVCMOS (1.5 / 1.8 / 2.5, 3.3 V) standards.

➡ **For detailed device information, refer to the SmartFusion datasheet: www.actel.com/products/smartfusion/docs.aspx.**

For more information regarding Actel's SmartFusion solutions, refer to their respective web pages:

Motor Control: www.actel.com/products/solutions/motorcontrol
Industrial Automation: www.actel.com/products/solutions/industrial
System Management: www.actel.com/products/solutions/systemmgt
Power Management: www.actel.com/products/solutions/powermgt
Hardware Platform Management: www.actel.com/products/solutions/xtca
SmartFusion Evaluation Kit: www.actel.com/products/hardware/devkits_boards/smartfusion_eval.aspx
SmartFusion Development Kit: www.actel.com/products/hardware/devkits_boards/smartfusion.aspx

You may also be interested in:

Corporate Overview Brochure: www.actel.com/documents/CorpBro_PIB.pdf
Product Catalog: www.actel.com/documents/ProdCat_PIB.pdf
Solutions and IP Catalog: www.actel.com/documents/IPPIB.pdf
Pigeon Point Systems Brochure: www.actel.com/documents/PPS_PIB.pdf

For more information regarding Actel products, please contact your local Actel sales representative.

Actel is the leader in low power FPGAs and mixed signal FPGAs and offers the most comprehensive portfolio of system- and power-management solutions. Power Matters. Learn more at www.actel.com.

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