FPGA + ARM® Cortex™- M3 + Programmable Analog
Innovative Intelligent Integration

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

SmartFusion Architecture

SmartFusion2 SoC FPGAs offer 5K–150K LEs with a 166 MHz ARM Cortex-M3 processor, including ETM and instruction cache with on-chip eSRAM and eNVM and a complete microcontroller subsystem with extensive peripherals, including CAN, TSE, and USB.

Key Benefits of SmartFusion cSoCs

- 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 setting on 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 and GNU
  - Real-time operating system (RTOS) and middleware components from Micrium, RoweBots, Emcraft and more

No-Compromise Microcontroller Subsystem(MSS)

- 32-bit ARM Cortex-M3 CPU
- Multi-layer ARM communication matrix with up to 16 Gbps throughput
- 10/100 Ethernet MAC with RMII interface
- Two of each: SPI, I2C, 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
- Based on Microsemi’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, x8, and x18 organizations
- True dual-port SRAM (including x18)
- Up to 128 FPGA I/Os supporting LVDS, PCI, PCI-X and LVTT/LVCMOS standards

Programmable Analog

- Hardware industry-standard 100 MHz, 32-bit ARM Cortex-M3 CPU
- 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 analog-to-digital conversion (ADC), digital-to-analog conversion (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

- Variable aspect ratio 4,608-bit SRAM blocks
- x1, x2, x4, x8, and x18 organizations
- True dual-port SRAM (including x18)
- Up to 128 FPGA I/Os supporting LVDS, PCI, PCI-X and LVTT/LVCMOS standards
Designing with SmartFusion cSoCs 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. Microsemi 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—Liber™ SoC Design Suite offers high productivity with its comprehensive, easy-to-learn, easy-to-adapt development tools for designing with Microsemi’s low power Flash FPGAs and SoCs. The suite integrates industry standard Synopsys Synplify Pro® synthesis and Mentor Graphics ModelSim® simulation with best-in-class constraints management and debug capabilities.

- Embedded Design—Microsemi offers FREE SoftConsole Eclipse-based IDE, which includes the GNU C/C++ compiler and GDB debugger. Microsemi 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.

SmartFusion Ecosystem

The Microsemi SoC Products Group has a long history of supplying comprehensive FPGA development tools and recognizes the benefit of partnering with industry leaders to deliver optimum usability and productivity to customers. Taking the same approach with processor development, Microsemi has partnered with key industry leaders in the microcontroller space to provide the robust SmartFusion ecosystem. Microsemi 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. Because an ARM processor was chosen for SmartFusion cSoCs, Microsemi’s customers can benefit from the extensive ARM ecosystem. By building on Microsemi supplied HAL and drivers, third party vendors can easily port RTOS and middleware for the SmartFusion devices.

Operating System

- Micrium
  - Offers their µC/OS-II™ and µC/OS-III™ to support SmartFusion devices and includes a TCP/IP stack.
  - Keil
    - Includes the RTX Kernel in their standard MDK software and sources can also be purchased in an additional module along with TCP/IP.
  - RoweBots
    - Delivers their ultra tiny Linux™-compatible RTOS Unison, consisting of a set of modular software components.
  - Emcraft
    - Developed the first uClinux™ offering for SmartFusion, along with their own embedded development platform.
  - FreeRTOS
    - Micron has ported the FreeRTOS Kernel to SmartFusion and demonstrates this as a webserver reference design, included with both the SmartFusion evaluation and development kits.

The diagram above shows the SmartFusion stack with examples of drivers, RTOS and middleware from Microsemi and partners. By leveraging the SmartFusion stack, designers can decide at which level to add their own customization to their design, thus speeding time to market and reducing overhead in the design.
Motor Control

SmartFusion devices are uniquely suited for active control of permanent magnet motors, servo motors, AC induction motors and stepper motors. A single SmartFusion cSoC can manage control of multiple electric motors in real-time, including start and stop, rotational direction, speed and torque, protection against motor overloads or faults and use of closed-loop performance algorithms.

The ARM Cortex-M3 based MSS manages high-level tasks such as communication and interface, the on-chip analog resources convert voltage and current readings to digital format for computation; the FPGA fabric provides flexibility in custom logic implementation and hardware acceleration for complex motor control algorithms. The presence of an MCU and FPGA in this integrated device enables easy partitioning of software and hardware, resulting in higher performance, lower power and efficient silicon usage.

Microsemi’s SmartFusion Dual Motor Control Kit enables demonstration and benchtop development of your motor control products, including support for a state of the art FOC algorithm. Microsemi provides multiple free reference designs for use with the kit.

Industrial Automation

The range of peripherals offered for the Cortex-M3 processor and the flexibility of SmartFusion FPGA fabric make the device ideal for industrial automation. The SmartFusion Development Kit supports Ethernet, EtherCAT, CAN, UART, I2C and SPI hardware, while firmware can be used for various other interface standards such as Modbus® and PROFINET for industrial networking. With the availability of programmable analog for sensing and analog outputs, SmartFusion cSoCs 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

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 a SmartFusion device as a system manager provides the designer maximum implementation flexibility.

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).

Power management

Microsemi’s system management solution significantly reduces the cost and complexity of board-level power management by integrating power converter functions including sequencing, trimming, marging, monitoring and control as well as system management functions like reset generation, event logging and ‘green’ power algorithm support. Targeted to the Microsemi SmartFusion cSoC, there is an abundance of uncommitted analog and FPGA resources available to the user allowing the creation of a true custom solution.

Microsemi’s Mixed Signal Power Manager (MPM) reference design version 4.0 further distances itself from the competition by now including support for PMBus based POL converters. No other power management solution seamlessly supports a mix of analog and PMBus based power converters. Now you can sequence, monitor and manage a mixed set of DC/DC converters including LDO’s, analog style and the highly efficient PMBus based converters from a single management device.

- Manage up to 64 DC/DC Converters
- Full support for analog and digital POL converters
- Sequence, monitor, margin, trim converters

General Purpose Solutions (continued)
Hardware Platform management

Pigeon Point Systems, a Microsemi partner, helped refine the architecture of SmartFusion devices for hardware platform management. The following SmartFusion-based Board Management Reference (BMR) solutions for the ATCA and µTCA board and module controller are examples of offerings from Pigeon Point Systems:

- BMR-A2F-ATCA: IPM Controllers (IPMs) for ATCA boards
- BMR-A2F-µTCA: Carrier IPMs for µTCA AMC carrier boards
- BMR-A2F-µTCA: Module Management Controllers for AMC modules
- BMR-A2F-MCMC: MicroTCA Carrier Management Controllers

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 programmable analog
- Complete offloading from the Cortex-M3 of xTCA-aware analog threshold processing via ACE
- Integration of flexible power management functions eliminating the use of external power devices
- Benchtop implementations for familiarization and as a known good reference during bring-up of a new xTCA board or module

Medical Systems

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- Manage up to 64 DC/DC Converters
- Full support for analog and digital POL converters
- Sequence, monitor, margin, trim converters

Design and Data Security

Microsemi’s flash cSoCs and FPGAs have always been known for their design security and IP protection. SmartFusion devices bring an even higher level of security to embedded systems.

- Microcontroller and FPGA interface not exposed at board level
- No bitstream to transfer at boot-up
- FlashLock protects against tampering and reprogramming
- AES-encrypted in-system programming
- Protects against overbuilding with programmable device key

Microsemi is the first major FPGA company to address the threats caused by side-channel analysis. Side-channel attacks such as differential power analysis (DPA) can endanger the security of the design IP configured into a cSoC or FPGA and the security of the end application itself.

Microsemi has obtained a license from Cryptograph Research, Inc. (CRI) for the DPA patent portfolio, consisting of more than fifty patents. Contact Microsemi sales to order devices that include a license to implement IP based on these patents.

For a more complete description of Microsemi’s security solutions and partner IP blocks related to DPA and design security, refer to: www.microsemi.com/soc/products/solutions/security.

Intellectual Property for SmartFusion cSoCs

SmartFusion devices are composed of hard intellectual property (IP) blocks, such as an ARM Cortex-M3 processor, UART, SPI, I2C and 10/100 Ethernet interface, as well as standard peripherals, such as ADC, DAC, timers, watchdog timer and RTC. Beyond these hard core blocks you can select from Microsemi’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. Microsemi has more than 180 intellectual property products designed and optimized to support communications, consumer, military, industrial, automotive and aerospace markets. Microsemi 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 Microsemi SoC Products Group website: www.microsemi.com/soc.

<table>
<thead>
<tr>
<th>Core</th>
<th>Cryptography</th>
<th>Communication</th>
<th>MIL-STD-1553B</th>
<th>dsp IP Core</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core M500</td>
<td>CoreUART</td>
<td>CoreAES128</td>
<td>CorePCF</td>
<td>Core15289M</td>
</tr>
<tr>
<td>CoreGPO</td>
<td>CoreDES</td>
<td>CoreDES</td>
<td>Core2539DR</td>
<td>Core15289T</td>
</tr>
<tr>
<td>CoreTimer</td>
<td>CoreSPI</td>
<td>CoreS32</td>
<td>CoreAES128</td>
<td>Core429</td>
</tr>
<tr>
<td>CoreSDR</td>
<td>CorePMB</td>
<td>Fast 394o 256x 64x</td>
<td>In-C472</td>
<td>Core15289C</td>
</tr>
</tbody>
</table>

1. For more information, see the Nixion Technology partner page: www.microsemi.com/soc/products/partners/comparisons/nixion-tech.
2. For more information, see the Incus Core partner page: www.microsemi.com/boo/products/partners/comparisons/incus-core.

Microsemi IP cores can be accessed through Libero SoC 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.

For more details on the Microsemi IP Core offerings, please refer IP DirectCores webpage: https://www.microsemi.com/products/fpga-soc/design-resources/ip-cores/direct-cores
SmartFusion Family Product Table

<table>
<thead>
<tr>
<th>Device</th>
<th>A2F060</th>
<th>A2F200</th>
<th>A2F500</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPGA Fabrics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tilt (D-flip-flops)</td>
<td>1,530</td>
<td>4,050</td>
<td>11,520</td>
</tr>
<tr>
<td>RAM Blocks (K:80 bits)</td>
<td>8</td>
<td>8</td>
<td>24</td>
</tr>
<tr>
<td>Flash (Mbits)</td>
<td>128</td>
<td>256</td>
<td>512</td>
</tr>
<tr>
<td>SWAP (Plays)</td>
<td>16</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td>Cortex-M3 with Memory Protection Unit (MPU)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>10/100 Ethernet MAC</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>External Memory Controller (EMC)</td>
<td>24-bit address, 16-bit data</td>
<td>24-bit address, 16-bit data</td>
<td>24-bit address, 16-bit data</td>
</tr>
<tr>
<td>DMA</td>
<td>8 Ch</td>
<td>8 Ch</td>
<td>8 Ch</td>
</tr>
<tr>
<td>SPI</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>CSRF</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>SPI</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>PLL</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>100 MHz On-Chip RC Oscillator</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Main Oscillator (32 kHz to 20 MHz)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ADCs (8-to-12-bit SAR)</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>DACs (12-bit sinus-delta)</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Signal Conditioning Blocks (SCBs)</td>
<td>1</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Comparators</td>
<td>2</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Current Monitors</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Temperature Monitors</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Bipolar High Voltage Monitors</td>
<td>2</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>

1. Not available on A2F500 for the PQ208 package.
2. Two PLLs are available in CS288 and FG484 (one PLL in FG256 and PQ208).
3. These functions share 10 pins and may not all be available at the same time.
4. Available on FG256 only. DG208, FG302, and CS288 packages offer the same programmable analog capabilities as A2F200.

Package I/Os: MSS + FPGA I/Os

<table>
<thead>
<tr>
<th>Device</th>
<th>A2F060</th>
<th>A2F200</th>
<th>A2F500</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO14</td>
<td>CS288</td>
<td>FG256</td>
<td>FG484</td>
</tr>
<tr>
<td>FG256</td>
<td>CS288</td>
<td>FG484</td>
<td></td>
</tr>
<tr>
<td>FG484</td>
<td>FG256</td>
<td>CS288</td>
<td></td>
</tr>
<tr>
<td>Digital Anioing Input</td>
<td>11</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Shared Analog Input</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Total Analog Input</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Total Analog Output</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>MSS Input</td>
<td>21</td>
<td>28</td>
<td>24</td>
</tr>
<tr>
<td>MSS Output</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Temperature Grade</td>
<td>C1, C2, C3, C4</td>
<td>C1, C2, C3, C4</td>
<td></td>
</tr>
</tbody>
</table>

1. These pins are shared between digital input and output in the FSC and voltage/current temperature monitors.
2. If MSS IOs are multiplied and can be used as FPGA I/Os, if not needed for the MSS. These IOs support Schmitt triggers and support only LVTL and LVCMOS (1.5 / 1.8 / 2.5, 3.3 V) standards.
3. If MSS IOs are primary for 10/100 Ethernet MAC and are also multiplied and can be used as FPGA I/Os if Ethernet MAC is not used in a design. These IOs support Schmitt triggers and support only LVTL and LVCMOS (1.5 / 1.8 / 2.5, 3.3 V) standards.
4. CS288 Ethernet MAC is not available on A2F500.
5. EMC is not available on the A2F500 PQ208 package.

6. Military temperature grade (-55°C to +125°C) devices are offered in some density and package combinations as noted.
Microsemi is continually adding new products to its industry-leading portfolio.

For the most recent updates to our product line and for detailed information and specifications, please call/email us, or visit our website:

Toll-free: 800-713-4113
sales.support@microsemi.com
www.microsemi.com

Microsemi Corporation (Nasdaq: MSCC) offers a comprehensive portfolio of semiconductor and system solutions for aerospace & defense, communications, data center and industrial markets. Products include high-performance and radiation-hardened analog mixed-signal integrated circuits, FPGAs, SoCs and ASICs; power management products; timing and synchronization devices and precise time solutions, setting the world’s standard for time; voice processing devices; RF solutions; discrete components; enterprise storage and communication solutions, security technologies and scalable anti-tamper products; Ethernet solutions; Power-over-Ethernet ICs and midspans; as well as custom design capabilities and services. Microsemi is headquartered in Aliso Viejo, California and has approximately 4,800 employees globally. Learn more at www.microsemi.com.