Atmel ARM Processor-Based Flash MCU

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Presentation Outline

• Cortex-M Flash MCU Roadmap
• Technical highlights
• Applications
• Ecosystem
• Q&A
Atmel ARM Processor-Based Flash MCU Family

**SAM7**
- Flash MCU
- ARM7TDMI®
- Flash up to 512KB
- Runs up to 55MHz

**SAM3**
- Flash MCU
- ARM® Cortex™-M3
- Flash up to 512KB
- Runs up to 96MHz

**SAM4**
- Flash MCU/DSC
- ARM Cortex-M4
- Optional FPU
- Flash up to 2MB
- Runs up to 120MHz
Atmel Cortex-M roadmap

Flash
- 2MB
- 1MB
- 512KB
- 256KB
- 128KB
- 64KB
- 32KB
- 16KB
- 8KB
- 4KB

Baseline
- SAM3N
- SAM3S
- SAM3U

Connectivity
- SAM3X
- SAM3A
- SAM4S
- SAM4N 1Q 2013
- SAM4S

High-speed USB
- SAM3U

picoPower
- SAM4E 1Q 2013
- SAM4N 1Q 2013
- SAM4L 3Q 2013
- SAM4L ES Now

CM3/4 Available Now
CM4 Development
# Atmel SAM3/4 Family Overview

<table>
<thead>
<tr>
<th>Feature</th>
<th>SAM3N/SAM4N</th>
<th>SAM3S/SAM4S</th>
<th>SAM4L</th>
<th>SAM3U</th>
<th>SAM3A</th>
<th>SAM3X</th>
<th>SAM4E</th>
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<tbody>
<tr>
<td>Frequency (max)</td>
<td>80MHz</td>
<td>120MHz</td>
<td>50MHz</td>
<td>96MHz</td>
<td>84MHz</td>
<td>84MHz</td>
<td>120MHz</td>
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<tr>
<td>Flash (KB)</td>
<td>16-1024</td>
<td>64-2048</td>
<td>128-512</td>
<td>64-256</td>
<td>256-512</td>
<td>256-512</td>
<td>512-1024</td>
</tr>
<tr>
<td>SRAM (KB)</td>
<td>4-80</td>
<td>8-160</td>
<td>32-64</td>
<td>20-50</td>
<td>64-100</td>
<td>64-100</td>
<td>128</td>
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<tr>
<td>USB (embedded PHY)</td>
<td>–</td>
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<td>EMAC</td>
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<tr>
<td>Dual CAN</td>
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<td>–</td>
<td>–</td>
<td>–</td>
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<tr>
<td>DAC</td>
<td>✔</td>
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<td>✔</td>
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<tr>
<td>QTouch®</td>
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<tr>
<td>External Bus</td>
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## Common Features

- Cortex-M3/4/4F CPU
- Timer, PWM
- QFP/QFN/BGA
- 48 to 144 pins
- Extended supply 1.62-3.6V
- Up to 24 x 12-bit ADC
- Backup mode down to 0.7 μA
- USART, SPI, I2C, I2S
Technical Highlights
Dual Bank Flash
Dual Bank Flash enables Fault Tolerant Self-Programming

What Problem does it Solve?
• Provides a fail-safe method of upgrading firmware on remote networked systems
• Enables background firmware upgrade without halting application execution
• Prevents system corruption while upgrading the system software

How Does it Work?
• Safe and secure remote update:

- Normal operation from Bank 1 while simultaneously remotely programming Bank 2
- Power or comms failure cause Bank 2 program fail while Bank 1 continues to operate and requests retransmission
- Reprogramming successful, device now executes from Bank 2, Bank 1 available for next update
EBI Scrambler
Available on all SAM3/4 devices with an EBI

What Problem does it Solve?
• External memory is relatively easy for attackers to read or alter.
• The EBI scrambler conceals data without penalizing performance.

How Does it Work?
• The External Bus Interface (EBI), including the NAND flash controller, may be set to automatically scramble data to any selected external memory devices.
• There are no access penalties when reading or writing scrambled data.
Integrated High Speed USB 2.0 PHY
Reduced BOM cost and board space

What Problem does it Solve?
• Removes the need for an external USB 2.0 HS PHY (Physical Interface) companion chip.
• PCB area – and potentially overall product size - is reduced by removing need for additional PHY IC, signal routing and support components

How Does it Work?
• Atmel’s integrated USB 2.0 HS PHY completes the signal path with minimal external components.
Integrated termination resistors with debounce

Available in all SAM3 and SAM4 MCUs

What Problem Does it solve

• All system designs have to comply with EMI standards.
• GPIO switching will cause signal integrity issues that generate EMI
  • Voltage ringing, spike currents, simultaneous switching noise, ...
• On-die termination (ODT) improves signal integrity without external components
  • Reduce PCB size and BOM cost

How Does it work?

• ODT more closely matches the impedance of the output of the device to the PCB trace.
• This matching minimizes the reflection factor, resulting in lower switching currents and reduced ringing (signal overshoot and undershoot).
Integrated termination resistors with debounce

Available in all SAM3 and SAM4 MCUs

- SAM3/4 devices therefore offer better signal integrity without adding extra components.
Parallel Input/Output Controller (PIO) - Parallel Capture Mode

Easily connect external asynchronous devices such as CMOS sensors

What Problem does it Solve?

- PIO controller can capture asynchronous data at speeds greater than 25MHz and can be configured for up to 32-bit data
- Processor can execute other code or sleep while transfer takes place

How Does it Work?

- Parallel Capture can be triggered from external asynchronous clock at up to half Master Clock speed
- PIO can be configured to read 8-, 16- or 32-bit of parallel data
- Built-in Peripheral DMA can transfer data to RAM in 2 Master Clocks
**SAM4 Cache system**

Zero Wait State access at full speed

- 2Kbytes of 4-way consecutive cache with monitor system

- Coremark results:
  - 370 coremark @ 120MHz
  - 3 Coremark/Mhz

- Advantage
  - Compensate wait state penalty at high frequency
  - Reduce power consumption

- Drawback
  - Not suitable if Deterministic tasks to be executed (i.e. : Real Time Applications)
SAM3 Power Modes

**Run**
- 450µA/MHz
- CPU
- SRAM
- RTC

**Wait**
- 8µA*
- CPU: Not clocked
- SRAM
- RTC
- 10µs wake up time
- 16 wake up inputs + Timers + USB
- IOs level kept

**Back up**
- 1.2µA
- CPU
- SRAM
- RTC
- 100µs wake up time
- 16 wake up inputs + Timers
- IOs level kept

* External regulator
SAM4 Power Modes

- **Run**: 200µA/MHz
  - CPU
  - SRAM
  - RTC

- **Wait**: 20µA*
  - CPU (Not clocked)
  - SRAM
  - RTC
  - 10µs wake up time
  - 16 wake up inputs + Timers + USB IOs level kept
  - * External regulator

- **Back up**: 1µA
  - CPU
  - SRAM
  - RTC
  - 100µs wake up time
  - 16 wake up inputs + Timers IOs level kept
# SAM3/4 Technical Highlights

<table>
<thead>
<tr>
<th>Feature</th>
<th>SAM3/4N</th>
<th>SAM3/4S</th>
<th>SAM4E</th>
<th>SAM4L</th>
<th>SAM3U</th>
<th>SAM3A</th>
<th>SAM3X</th>
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<tbody>
<tr>
<td>Dual Bank Flash</td>
<td>-</td>
<td>√</td>
<td>-</td>
<td>-</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>EBI scrambling</td>
<td>-</td>
<td>√</td>
<td>-</td>
<td>-</td>
<td>√</td>
<td>-</td>
<td>√</td>
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<tr>
<td>USB HS Phy</td>
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<td>-</td>
<td>-</td>
<td>√</td>
<td>√</td>
<td>√</td>
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<tr>
<td>On-Die Termination</td>
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<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>PIO capture mode (camera int.)</td>
<td>-</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>ECC on Embedded Flash</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
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<tr>
<td>Cache</td>
<td>-</td>
<td>SAM4S</td>
<td>√</td>
<td>√</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Active power consumption (/MHz)</td>
<td>200µA</td>
<td>200µA</td>
<td>200µA</td>
<td>Down to 90 µA</td>
<td>350µA</td>
<td>350µA</td>
<td>350µA</td>
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<tr>
<td>2MB of Flash</td>
<td>-</td>
<td>SAM4S</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
</tbody>
</table>
Applications
Application: PIR Motion Activated Camera

Target Application

• What:
  • An electronic device not just to detect but also to identify intruder with image captures, delivering better security through visual verification of alarms.

• Key Design Considerations of the Product:
  • False Alarm Immunity
    • To eliminate the service cost due to false alarms
  • Extended Battery Life (3V AA or Coin Batteries)
    • It is battery powered for easy installation and mounted on the wall usually out of reach of power supply
  • Low BOM Cost
Application: PIR Motion Activated Camera

Atmel Offerings

• Hardware System Components:
  • Complete Wireless PIR Reference Design (SAM4S-WPIR-RD) with application note
  • ATSAM4S16 Cortex-M4 based MCU
  • AT86RF231/232/233 RF Transceiver or ATZigBit RF Module (FCC certified)

• Development Tools & Software:
  • SAM4S-EK full-featured kit and SAM4S software package for fast development and code evaluation
  • Atmel Studio 6 & Atmel Software Framework (ASF) supporting all Atmel 8-bit and 32-bit MCUs:
    • FREE IDE with Complier
    • FREE Software Libraries of Production-ready Source Code
    • Common APIs for Project Portability
Application: Sports Watch

Target Application

• What:
  • A battery powered wristwatch with special features to keep track of running or workout performance, typically including:
    • Sensors (temp, acceleration, pressure, compass, ...)
    • RF interface to biosensors or shoe sensors
    • Geo-positioning system
    • a Bluetooth and/or USB interface to import and export data from and to a PC.

• Key Design Considerations of the Product:
  • Ultra Low System Power Consumption as the product is portable and battery-powered
  • High System Integration for lower BOM cost and small form factor, as well as for more design flexibility and product features
  • Connectivity to external sensors, display, buzzer, memory, and computer
Application: Sports Watch

Atmel Offerings

• Hardware System Components:
  • AT91SAM4S8/16 Cortex M4-based MCU
  • AT86RF231/232 RF Transceiver
  • AT25DF DataFlash
  • AT30TSE Serial EEPROM with Temp Sensor
  • ATtiny or AT42QT Touch device

• Atmel Studio 6 & Atmel Software Framework (ASF):
  • Free IDE with Compiler
  • FREE Software Libraries of Production-ready Source Code and Drivers
Ecosystem
Atmel Studio 6 Advantages

Atmel Studio Saves You Time and Money

• Develop => Free, Professional IDE
• Design  => +1000 Project Examples
• Migrate  => +300 Atmel ARM and AVR MCUs
• Create  => Touch Applications
Atmel Software Framework

Library of C source code

• Drivers for All Peripherals
  • DMA support
  • Interrupt handlers

• Stacks and Middleware
  • USB, TCP/IP, Wi-Fi and Bluetooth
  • Numerous USB classes
  • DHCP and Wi-Fi encryption
  • Image formats, file system & GUI library

• Application Software
  • Driver examples
  • Reference applications
  • Full documentation

• Free Of Charge
  • Maintained by Atmel

• Atmel Studio Integrated
# Atmel Gallery

## Features and benefits

- Industry’s first integrated app store for tools and embedded software
  - Delivers extensions for Atmel Studio
  - Includes free and commercial extensions
  - Easy to download and purchase

- Integrated tools for development with Atmel MCUs
  - Development tools
  - Embedded software
  - From 3rd party partners and Atmel
  - Moderated by Atmel for content quality

- Easy access
  - Built into Studio 6: Extension Manager
  - From Atmel web site: gallery.atmel.com

## Features Table

<table>
<thead>
<tr>
<th>Category</th>
<th>Extension</th>
<th>Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toolchain</td>
<td>Keil ARM Compiler plug-in</td>
<td>KEIL</td>
</tr>
<tr>
<td></td>
<td>CodeVision Compiler plug-in</td>
<td>AT</td>
</tr>
<tr>
<td>Code Editing</td>
<td>vi Emulator</td>
<td>KEIL</td>
</tr>
<tr>
<td>Analysis/Visualization</td>
<td>Goanna Studio static code analysis</td>
<td>Goanna</td>
</tr>
<tr>
<td>Tools</td>
<td>FreeRTOS+Trace RTOS visualization</td>
<td>Percep</td>
</tr>
<tr>
<td>Configuration</td>
<td>CodeWizard AVR peripheral config.</td>
<td>Atmel</td>
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<tr>
<td>Application Tools</td>
<td>Wireless Composer</td>
<td>Atmel</td>
</tr>
<tr>
<td>System modeling</td>
<td>Proteus VSM (coming soon)</td>
<td>Labctr</td>
</tr>
<tr>
<td>RTOS</td>
<td>FreeRTOS ASF integration</td>
<td>Micrmp</td>
</tr>
</tbody>
</table>
ASF Layers

Architecture split into 5 layers

1. **Applications**
   - Examples and complex apps

2. **Services**
   - Protocol Stack, high and application level

3. **External Components**
   - Software for external components

4. **Internal peripherals**
   - Device drivers, low-level

5. **Board definition**
   - Hardware board abstraction
Evaluation Kit for Each Series

SAM3S-EK
SAM4S-EK
SAM3U-EK
SAM3X-EK
SAM3N-EK
SAM4SXPLAINED
SAM4S-WPIR-RD
SAM4L-EK
SAM3 & SAM4, the right choice for your application

+150 devices for Scalability

Flash: 16kB to 2MB
Package: 48 to 144 pins

System integration
- HS USB with PHY
- Dual CAN controller
- Ethernet MAC
- CMOS interface
- Segment LCD
- HW capacitive touch
- On Die Termination
- ISP (USB, UART, IAP) in ROM
- External Bus scrambling

High Performance
- CPU Up to 120MHz
- 128-bit Flash access
- Internal DMA
- 2KB of Cache
- High speed com: SPI Up to 38Mbps
- USB Up to 480Mbps

Low Power
- 1.62V to 3.6V
- 90µA/MHz active
- 1.5µA SRAM retention
- 0.7 µA Back up (RTC On)

Safety
- ECC on Flash
- Independent watchdog source clock
- Dual bank flash
- Clock failure detection
- Key based Write Protection register

Ecosystem
- Atmel Studio 6 (IDE) / ASF / 3rd Party (IDE, Stack, RTOS, Tools) / Technical Support
Outcome

Atmel your preferred ARM-based MCU supplier

• Extensive Cortex-M MCU offering
  • First 2MB flash Cortex-M4 flash MCU
  • Taking the lead in low power
  • Unsurpassed offering providing migration path in Baseline series

• Unrivaled Ease of use with Atmel Studio 6
  • Free of charge professional IDE
  • Extensive software framework
  • Save developers time and money