

#### Description

The Atmel® | SMART™ SAM D09 is a series of low-power microcontrollers using the 32-bit ARM® Cortex®-M0+ processor, and ranging from 14- to 24-pins with up to 16KB Flash and 4KB of SRAM. The SAM D09 devices operate at a maximum frequency of 48MHz and reach 2.46 Coremark/MHz. They are designed for simple and intuitive migration with identical peripheral modules, hex compatible code, identical linear address map and pin compatible migration paths between all devices in the product series. All devices include intelligent and flexible peripherals, Atmel Event System for inter-peripheral signaling, and support for capacitive touch button, slider and wheel user interfaces. The SAM D09 series is compatible to the other product series in the SAM D family, enabling easy migration to larger device with added features.

The Atmel SAM D09 devices provide the following features: In-system programmable Flash, six-channel direct memory access (DMA) controller, 6 channel Event System, programmable interrupt controller, up to 22 programmable I/O pins, 32-bit real-time clock and calendar, two 16-bit Timer/Counters (TC), where each TC can be configured to perform frequency and waveform generation, accurate program execution timing or input capture with time and frequency measurement of digital signals. The TCs can operate in 8- or 16-bit mode, selected TCs can be cascaded to form a 32-bit TC, and one timer/counter has extended functions optimized for motor, lighting and other control applications. The series provide two Serial Communication Modules (SERCOM) that each can be configured to act as an USART, UART, SPI, I<sup>2</sup>C, SMBus, PMBus and LIN slave; up to 10-channel 350ksps 12-bit ADC with programmable gain and optional oversampling and decimation supporting up to 16-bit resolution, programmable Watchdog Timer, brown-out detector and power-on reset and two-pin Serial Wire Debug (SWD) program and debug interface.

All devices have accurate and low-power external and internal oscillators. All oscillators can be used as a source for the system clock. Different clock domains can be independently configured to run at different frequencies, enabling power saving by running each peripheral at its optimal clock frequency, and thus maintaining a high CPU frequency while reducing power consumption.

The SAM D09 devices have two software-selectable sleep modes, idle and standby. In idle mode the CPU is stopped while all other functions can be kept running. In standby all clocks and functions are stopped except those selected to continue running. The device supports SleepWalking. This feature allows the peripheral to wake up from sleep based on predefined conditions, and thus allows the CPU to wake up only when needed, e.g. when a threshold is crossed or a result is ready. The Event System supports synchronous and asynchronous events, allowing peripherals to receive, react to and send events even in standby mode.

The Flash program memory can be reprogrammed in-system through the SWD interface. The same interface can be used for non-intrusive on-chip debug and trace of application code. A boot loader running in the device can use any communication interface to download and upgrade the application program in the Flash memory.

The Atmel SAM D09 devices are supported with a full suite of program and system development tools, including C compilers, macro assemblers, program debugger/simulators, programmers and evaluation kits.

## Features

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- Processor
  - ARM Cortex-M0+ CPU running at up to 48MHz
    - Single-cycle hardware multiplier
    - Micro Trace Buffer
- Memories
  - 8/16KB in-system self-programmable Flash
  - 4KB SRAM Memory
- System
  - Power-on reset (POR) and brown-out detection (BOD)
  - Internal and external clock options with 48MHz Digital Frequency Locked Loop (DFLL48M) and 48MHz to 96MHz Fractional Digital Phase Locked Loop (FDPLL96M)
  - External Interrupt Controller (EIC)
  - 8 external interrupts
  - One non-maskable interrupt
  - Two-pin Serial Wire Debug (SWD) programming, test and debugging interface
- Low Power
  - Idle and standby sleep modes
  - SleepWalking peripherals
- Peripherals
  - 6-channel Direct Memory Access Controller (DMAC)
  - 6-channel Event System
  - Two 16-bit Timer/Counters (TC), configurable as either:
    - One 16-bit TC with compare/capture channels
    - One 8-bit TC with compare/capture channels
    - One 32-bit TC with compare/capture channels, by using two TCs
  - 32-bit Real Time Counter (RTC) with clock/calendar function
  - Watchdog Timer (WDT)
  - CRC-32 generator
  - Two Serial Communication Interfaces (SERCOM), each configurable to operate as either:
    - USART with full-duplex and single-wire half-duplex configuration
    - I<sup>2</sup>C Bus
    - SMBUS/PMBUS
    - SPI
    - LIN slave
  - 12-bit, 350ksps Analog-to-Digital Converter (ADC) with up to 10 channels
    - Differential and single-ended input
    - 1/2x to 16x programmable gain stage
    - Automatic offset and gain error compensation
    - Oversampling and decimation in hardware to support 13-, 14-, 15- or 16-bit resolution
- I/O
  - Up to 22 programmable I/O pins
- Packages
  - 24-pin QFN
  - 14-pin SOIC
- Operating Voltage
  - 2.4V – 3.63V

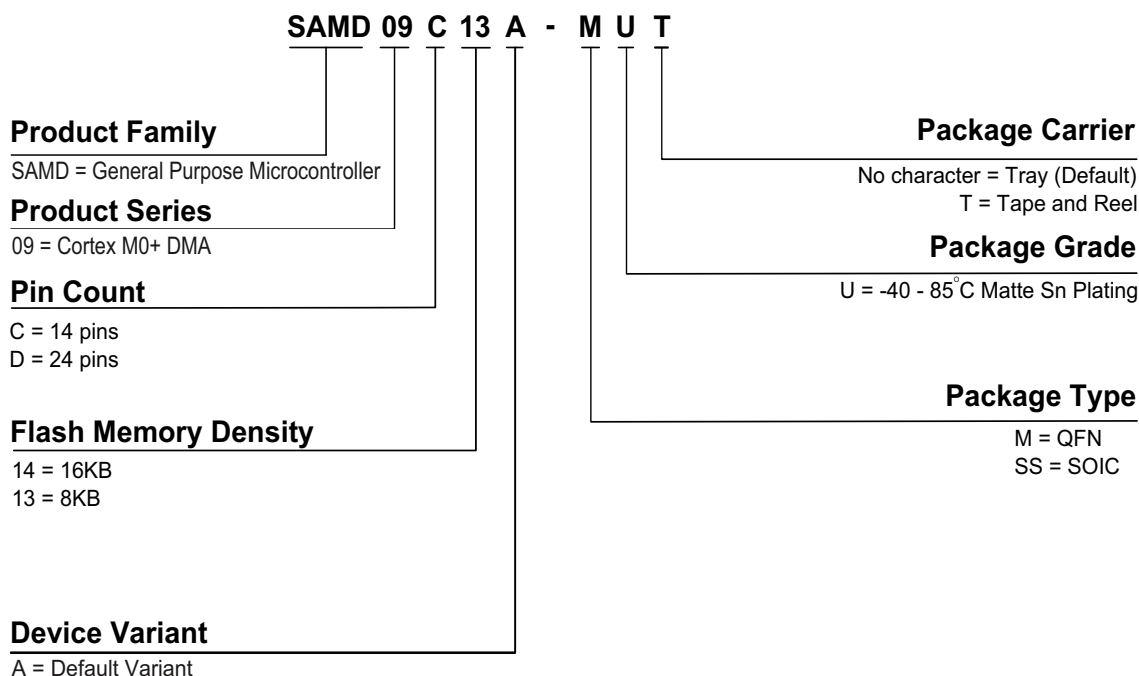
# 1. Configuration Summary

**Table 1-1. Configuration Summary**

|                                            | SAM D09D – 24-pin QFN                                                                                                                                                                                                                                                                                                                         | SAM D09C – 14-pin SOIC               |
|--------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| Pins                                       | 24                                                                                                                                                                                                                                                                                                                                            | 14                                   |
| General Purpose I/O-pins (GPIOs)           | 22                                                                                                                                                                                                                                                                                                                                            | 12                                   |
| Flash                                      | 16KB                                                                                                                                                                                                                                                                                                                                          | 8KB                                  |
| SRAM                                       | 4KB                                                                                                                                                                                                                                                                                                                                           | 4KB                                  |
| Timer Counter (TC)                         | 2                                                                                                                                                                                                                                                                                                                                             | 2 <sup>(1)</sup>                     |
| Waveform output channels for TC            | 2                                                                                                                                                                                                                                                                                                                                             | 2                                    |
| DMA channels                               | 6                                                                                                                                                                                                                                                                                                                                             | 6                                    |
| Serial Communication Interface (SERCOM)    | 2                                                                                                                                                                                                                                                                                                                                             | 2                                    |
| Analog-to-Digital Converter (ADC) channels | 10                                                                                                                                                                                                                                                                                                                                            | 5                                    |
| Real-Time Counter (RTC)                    | Yes                                                                                                                                                                                                                                                                                                                                           | Yes                                  |
| RTC alarms                                 | 1                                                                                                                                                                                                                                                                                                                                             | 1                                    |
| RTC compare values                         | 1 32-bit value or<br>2 16-bit values                                                                                                                                                                                                                                                                                                          | 1 32-bit value or<br>2 16-bit values |
| External Interrupt lines                   | 8                                                                                                                                                                                                                                                                                                                                             | 8                                    |
| Maximum CPU frequency                      | 48MHz                                                                                                                                                                                                                                                                                                                                         | 48MHz                                |
| Packages                                   | QFN                                                                                                                                                                                                                                                                                                                                           | SOIC                                 |
| Oscillators                                | 32.768kHz crystal oscillator (XOSC32K)<br>0.4-32MHz crystal oscillator (XOSC)<br>32.768kHz internal oscillator (OSC32K)<br>32kHz ultra-low-power internal oscillator (OSCULP32K)<br>8MHz high-accuracy internal oscillator (OSC8M)<br>48MHz Digital Frequency Locked Loop (DFLL48M)<br>96MHz Fractional Digital Phased Locked Loop (FDPLL96M) |                                      |
| Event System channels                      | 6                                                                                                                                                                                                                                                                                                                                             | 6                                    |
| SW Debug Interface                         | Yes                                                                                                                                                                                                                                                                                                                                           | Yes                                  |
| Watchdog Timer (WDT)                       | Yes                                                                                                                                                                                                                                                                                                                                           | Yes                                  |

Note: 1. The signals for TC2 are not routed out on the 14-pin package.

## 2. Ordering Information



### 2.1 SAM D09C – 14-pin SOIC

| Ordering Code     | FLASH (bytes) | SRAM (bytes) | Package | Carrier Type |
|-------------------|---------------|--------------|---------|--------------|
| ATSAMD09C13A-SSUT | 8K            | 4K           | SOIC14  | Tape & Reel  |

### 2.2 SAM D09D – 24-pin QFN

| Ordering Code    | FLASH (bytes) | SRAM (bytes) | Package | Carrier Type |
|------------------|---------------|--------------|---------|--------------|
| ATSAMD09D14A-MUT | 16K           | 4K           | QFN24   | Tape & Reel  |

### 2.3 Device Identification

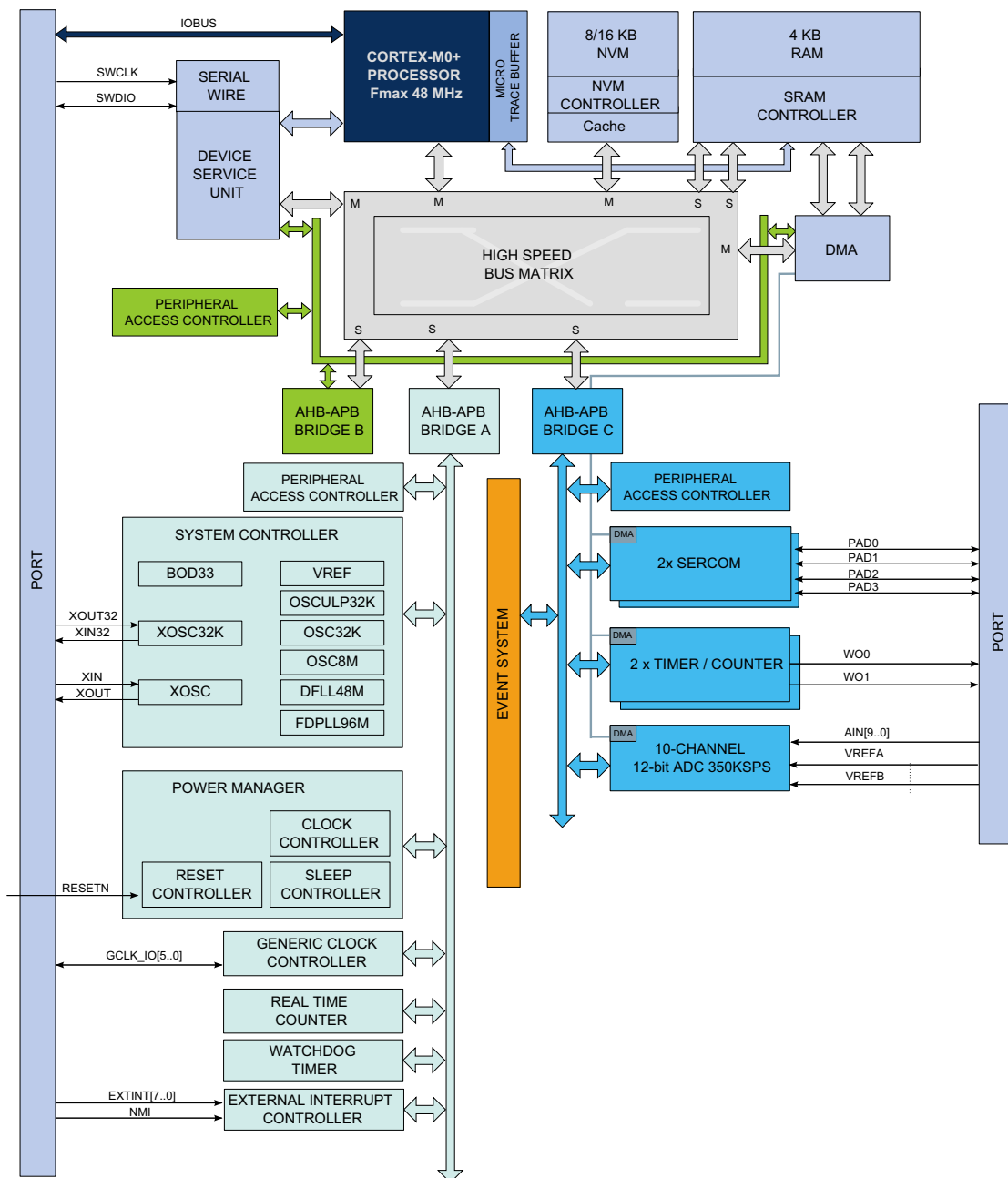
The DSU - Device Service Unit peripheral provides the Device Selection bits in the Device Identification register (DID.DEVSEL) in order to identify the device by software. The device variants have a reset value of DID=0x1001drxx, with the LSB identifying the die number ('d'), the die revision ('r') and the device selection ('xx').

**Table 2-1. Device Identification Values**

| Device Variant | DID.DEVSEL  | Device ID (DID) |
|----------------|-------------|-----------------|
| SAMD09D14AM    | 0x00        | 0x10040r00      |
| Reserved       | 0x01 - 0x06 |                 |
| SAMD09C13A     | 0x07        | 0x10040r07      |

Note: The device variant (last letter of the ordering number) is independent of the die revision (DSU.DID.REVISION): The device variant denotes functional differences, whereas the die revision marks evolution of the die. The device variant denotes functional differences, whereas the die revision marks evolution of the die

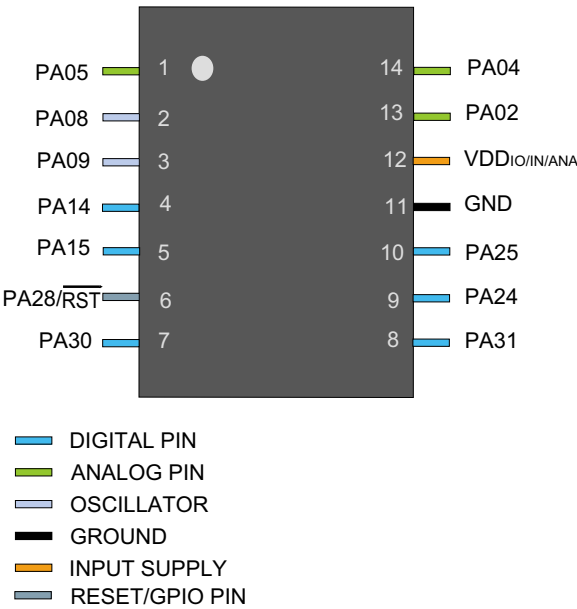
### 3. Block Diagram



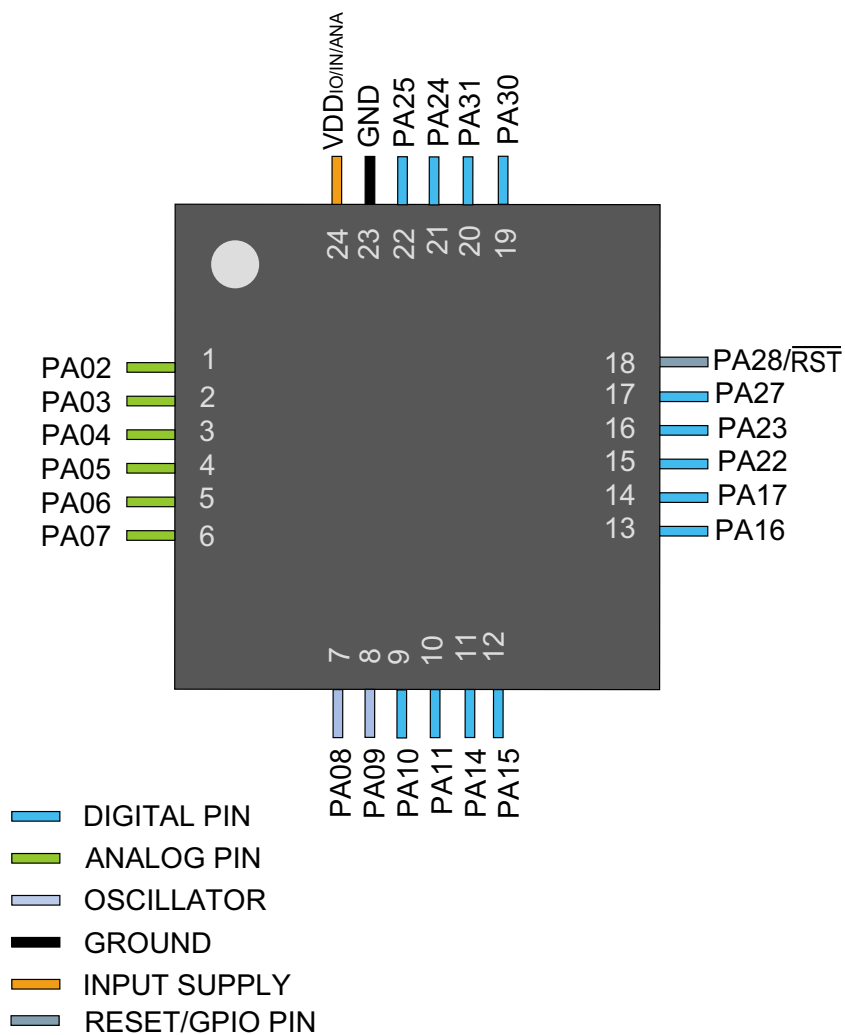
2. Some products have different number of SERCOM instances and ADC signals.

# 4. Pinout

## 4.1 SAM D09C 14-pin SOIC

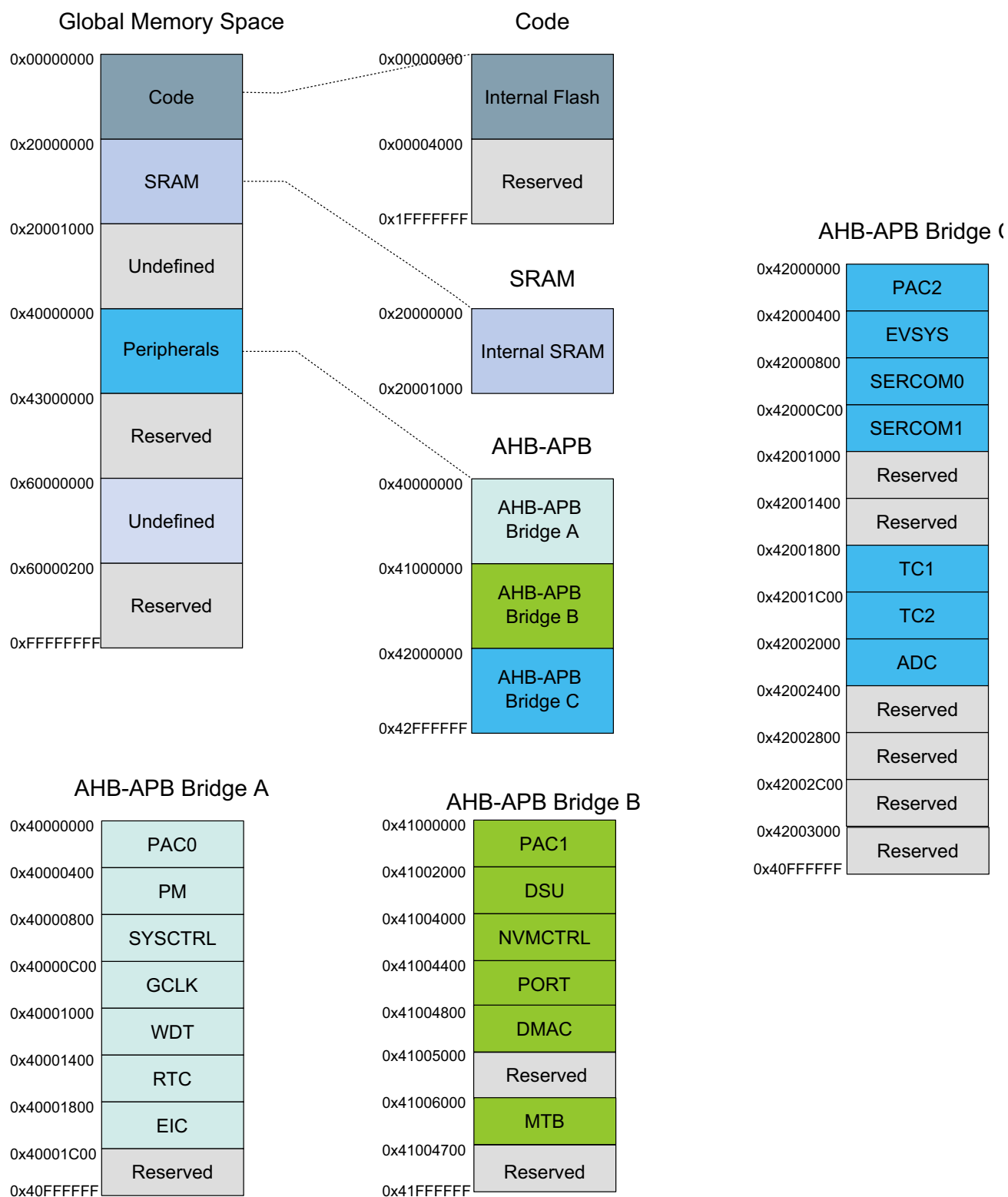


## 4.2 SAM D09D 24-pin QFN



## 5. Product Mapping

Figure 5-1. Atmel SAM D09 Product Mapping



## 6. Processor And Architecture

### 6.1 Cortex M0+ Processor

The Atmel SAM D09 implements the ARM® Cortex™-M0+ processor, which is based on the ARMv6 Architecture and Thumb®-2 ISA. The Cortex M0+ is 100% instruction set compatible with its predecessor, the Cortex-M0 processor, and upward compatible to Cortex-M3 and M4 processors.

For more information refer to [www.arm.com](http://www.arm.com).

#### 6.1.1 Cortex M0+ Configuration

| Features                         | Configuration option         | Atmel SAM D09 configuration |
|----------------------------------|------------------------------|-----------------------------|
| Interrupts                       | External interrupts 0-32     | 32                          |
| Data endianness                  | Little-endian or big-endian  | Little-endian               |
| SysTick timer                    | Present or absent            | Present                     |
| Number of watchpoint comparators | 0, 1, 2                      | 2                           |
| Number of breakpoint comparators | 0, 1, 2, 3, 4                | 4                           |
| Halting debug support            | Present or absent            | Present                     |
| Multiplier                       | Fast or small                | Fast (single cycle)         |
| Single-cycle I/O port            | Present or absent            | Present                     |
| Wake-up interrupt controller     | Supported or not supported   | Not supported               |
| Vector Table Offset Register     | Present or absent            | Present                     |
| Unprivileged/Privileged support  | Present or absent            | Absent <sup>(1)</sup>       |
| Memory Protection Unit           | Not present or 8-region      | Not present                 |
| Reset all registers              | Present or absent            | Absent                      |
| Instruction fetch width          | 16-bit only or mostly 32-bit | 32-bit                      |

Note: 1. All software run in privileged mode only

The ARM Cortex-M0+ core has two bus interfaces:

- Single 32-bit AMBA®-3 AHB-Lite™ system interface that provides connections to peripherals and all system memory, including flash and RAM
- Single 32-bit I/O port bus interfacing to the PORT with one-cycle loads and stores

## 7. Packaging Information

### 7.1 Thermal Considerations

#### 7.1.1 Thermal Resistance Data

[Table 6-1 on page 13](#) summarizes the thermal resistance data depending on the package.

**Table 7-1. Thermal Resistance Data**

| Package Type | $\theta_{JA}$ | $\theta_{JC}$ | Units |
|--------------|---------------|---------------|-------|
| 24-pin QFN   | 61.7          | 25.4          | °C/W  |
| 14-pin SOIC  | 58.5          | 26.3          | °C/W  |

#### 7.1.2 Junction Temperature

The average chip-junction temperature,  $T_J$ , in °C can be obtained from the following:

*Equation 1*

$$T_J = T_A + (P_D \times \theta_{JA})$$

*Equation 2*

$$T_J = T_A + (P_D \times (\theta_{HEATSINK} + \theta_{JC}))$$

where:

- $\theta_{JA}$  = package thermal resistance, Junction-to-ambient (°C/W), provided in [Table 6-1 on page 13](#).
- $\theta_{JC}$  = package thermal resistance, Junction-to-case thermal resistance (°C/W), provided in [Table 6-1 on page 13](#).
- $\theta_{HEATSINK}$  = cooling device thermal resistance (°C/W), provided in the device datasheet.
- $P_D$  = device power consumption (W).
- $T_A$  = ambient temperature (°C).

From the *Equation 1*, the user can derive the estimated lifetime of the chip and decide if a cooling device is necessary or not. If a cooling device is to be fitted on the chip, the second equation should be used to compute the resulting average chip-junction temperature  $T_J$  in °C.

7.2 Package Drawings

7.2.1 24-pin QFN

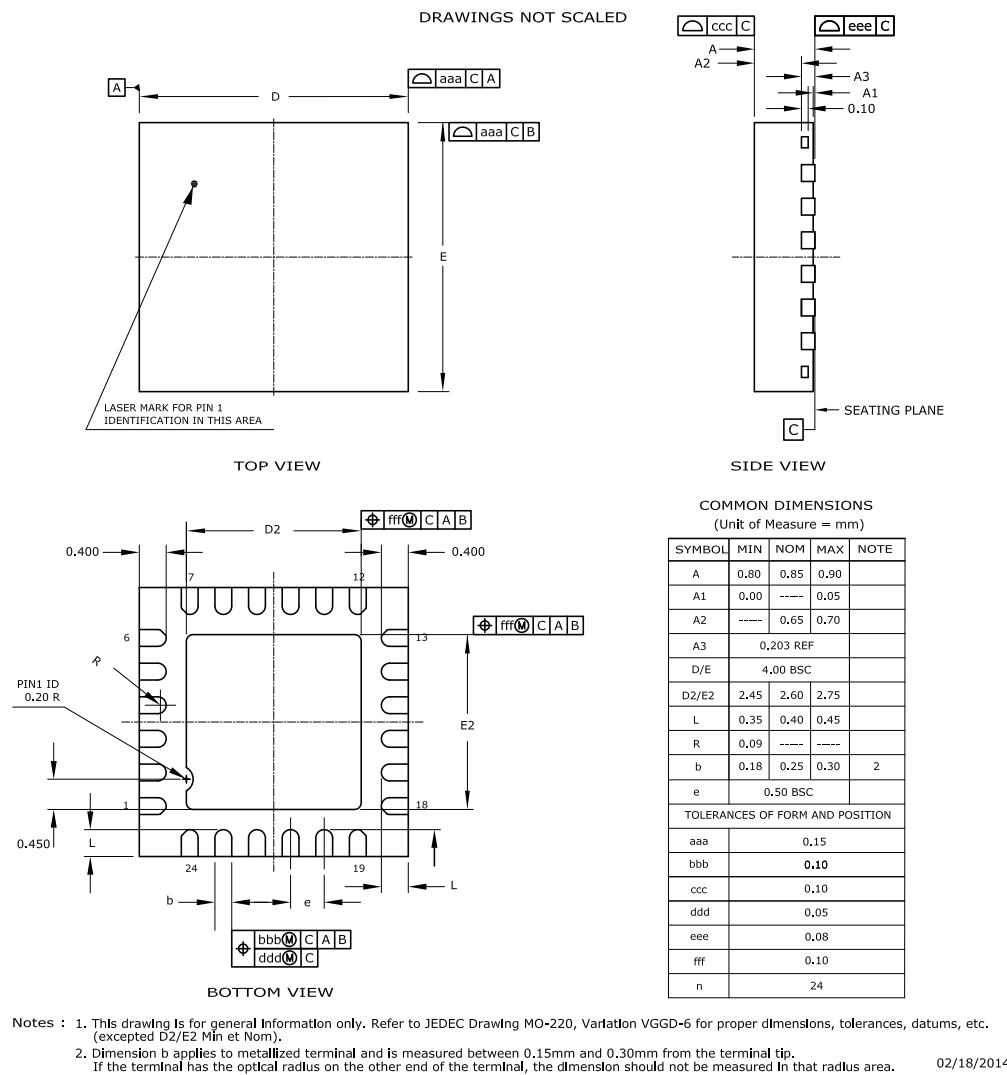


Table 7-2. Device and Package Maximum Weight

|    |    |
|----|----|
| 44 | mg |
|----|----|

Table 7-3. Package Characteristics

|                            |      |
|----------------------------|------|
| Moisture Sensitivity Level | MSL3 |
|----------------------------|------|

Table 7-4. Package Reference

|                         |        |
|-------------------------|--------|
| JEDEC Drawing Reference | MO-220 |
| JESD97 Classification   | E3     |

Table 7-5.

## 7.2.2 14-pin SOIC

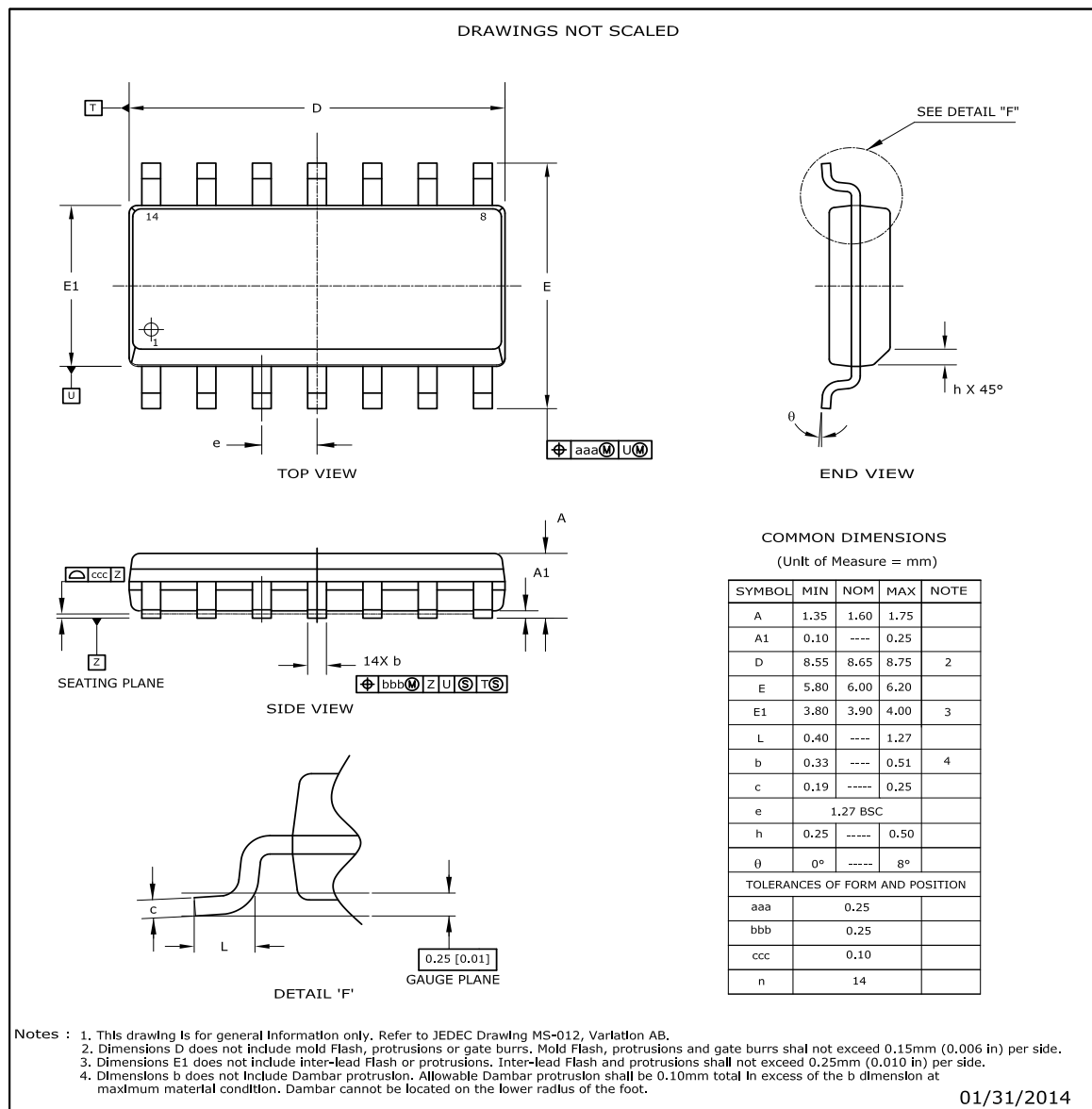


Table 7-6. Device and Package Maximum Weight

|     |    |
|-----|----|
| 230 | mg |
|-----|----|

Table 7-7. Package Characteristics

|                            |      |
|----------------------------|------|
| Moisture Sensitivity Level | MSL3 |
|----------------------------|------|

Table 7-8. Package Reference

|                         |        |
|-------------------------|--------|
| JEDEC Drawing Reference | MS-012 |
| JESD97 Classification   | E3     |

## 7.3 Soldering Profile

The following table gives the recommended soldering profile from J-STD-20.

| Profile Feature                            | Green Package |
|--------------------------------------------|---------------|
| Average Ramp-up Rate (217°C to peak)       | 3°C/s max     |
| Preheat Temperature 175°C +/-25°C          | 150-200°C     |
| Time Maintained Above 217°C                | 60-150s       |
| Time within 5°C of Actual Peak Temperature | 30s           |
| Peak Temperature Range                     | 260°C         |
| Ramp-down Rate                             | 6°C/s max     |
| Time 25°C to Peak Temperature              | 8 minutes max |

A maximum of three reflow passes is allowed per component.

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