

## Features

- Incorporates the ARM926EJ-S™ ARM® Thumb® Processor
  - DSP Instruction Extensions, ARM Jazelle® Technology for Java® Acceleration
  - 32-KByte Data Cache, 32-KByte Instruction Cache, Write Buffer
  - CPU Frequency 400 MHz
  - Memory Management Unit
  - EmbeddedICE™, Debug Communication Channel Support
- Additional Embedded Memories
  - One 64-KByte Internal ROM, Single-cycle Access at Maximum Matrix Speed
  - Two 16-KByte Internal SRAM, Single-cycle Access at Maximum Matrix Speed
- External Bus Interface (EBI)
  - Supports SDRAM, Static Memory, ECC-enabled NAND Flash and CompactFlash®
- USB 2.0 Full Speed (12 Mbits per second) Device Port
  - On-chip Transceiver, 2,432-byte Configurable Integrated DPRAM
- USB 2.0 Full Speed (12 Mbits per second) Host and Double Port
  - Single or Dual On-chip Transceivers
  - Integrated FIFOs and Dedicated DMA Channels
- Ethernet MAC 10/100 Base T
  - Media Independent Interface or Reduced Media Independent Interface
  - 128-byte FIFOs and Dedicated DMA Channels for Receive and Transmit
- Image Sensor Interface
  - ITU-R BT. 601/656 External Interface, Programmable Frame Capture Rate
  - 12-bit Data Interface for Support of High Sensibility Sensors
  - SAV and EAV Synchronization, Preview Path with Scaler, YCbCr Format
- Bus Matrix
  - Six 32-bit-layer Matrix
  - Boot Mode Select Option, Remap Command
- Fully-featured System Controller, including
  - Reset Controller, Shutdown Controller
  - Four 32-bit Battery Backup Registers for a Total of 16 Bytes
  - Clock Generator and Power Management Controller
  - Advanced Interrupt Controller and Debug Unit
  - Periodic Interval Timer, Watchdog Timer and Real-time Timer
- Reset Controller (RSTC)
  - Based on a Power-on Reset Cell, Reset Source Identification and Reset Output Control
- Clock Generator (CKGR)
  - Selectable 32,768 Hz Low-power Oscillator or Internal Low Power RC Oscillator on Battery Backup Power Supply, Providing a Permanent Slow Clock
  - 3 to 20 MHz On-chip Oscillator, One up to 800 MHz PLL and One up to 100 MHz PLL
- Power Management Controller (PMC)
  - Very Slow Clock Operating Mode, Software Programmable Power Optimization Capabilities
  - Two Programmable External Clock Signals
- Advanced Interrupt Controller (AIC)
  - Individually Maskable, Eight-level Priority, Vectored Interrupt Sources
  - Three External Interrupt Sources and One Fast Interrupt Source, Spurious Interrupt Protected
- Debug Unit (DBGU)
  - 2-wire UART and Support for Debug Communication Channel, Programmable ICE Access Prevention
  - Mode for General Purpose 2-wire UART Serial Communication



## AT91 ARM Thumb Microcontrollers

### AT91SAM9G20 Summary

**NOTE:** This is a summary document.  
The complete document is available on  
the Atmel website at [www.atmel.com](http://www.atmel.com).

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- Periodic Interval Timer (PIT)
  - 20-bit Interval Timer plus 12-bit Interval Counter
- Watchdog Timer (WDT)
  - Key-protected, Programmable Only Once, Windowed 16-bit Counter Running at Slow Clock
- Real-time Timer (RTT)
  - 32-bit Free-running Backup Counter Running at Slow Clock with 16-bit Prescaler
- One 4-channel 10-bit Analog-to-Digital Converter
- Three 32-bit Parallel Input/Output Controllers (PIOA, PIOB, PIOC)
  - 96 Programmable I/O Lines Multiplexed with up to Two Peripheral I/Os
  - Input Change Interrupt Capability on Each I/O Line
  - Individually Programmable Open-drain, Pull-up Resistor and Synchronous Output
  - All I/O Lines are Schmitt Trigger Inputs
- Peripheral DMA Controller Channels (PDC)
- One Two-slot MultiMedia Card Interface (MCI)
  - SDCard/SDIO and MultiMediaCard™ Compliant
  - Automatic Protocol Control and Fast Automatic Data Transfers with PDC
- One Synchronous Serial Controller (SSC)
  - Independent Clock and Frame Sync Signals for Each Receiver and Transmitter
  - I<sup>2</sup>S Analog Interface Support, Time Division Multiplex Support
  - High-speed Continuous Data Stream Capabilities with 32-bit Data Transfer
- Four Universal Synchronous/Asynchronous Receiver Transmitters (USART)
  - Individual Baud Rate Generator, IrDA® Infrared Modulation/Demodulation, Manchester Encoding/Decoding
  - Support for ISO7816 T0/T1 Smart Card, Hardware Handshaking, RS485 Support
  - Full Modem Signal Control on USART0
- Two 2-wire UARTs
- Two Master/Slave Serial Peripheral Interfaces (SPI)
  - 8- to 16-bit Programmable Data Length, Four External Peripheral Chip Selects
  - Synchronous Communications
- Two Three-channel 16-bit Timer/Counters (TC)
  - Three External Clock Inputs, Two Multi-purpose I/O Pins per Channel
  - Double PWM Generation, Capture/Waveform Mode, Up/Down Capability
  - High-Drive Capability on Outputs TIOA0, TIOA1, TIOA2
- One Two-wire Interface (TWI)
  - Compatible with Standard Two-wire Serial Memories
  - One, Two or Three Bytes for Slave Address
  - Sequential Read/Write Operations
  - Master, Multi-master and Slave Mode Operation
  - Bit Rate: Up to 400 Kbits
  - General Call Supported in Slave Mode
  - Connection to Peripheral DMA Controller (PDC) Channel Capabilities Optimizes Data Transfers in Master Mode
- IEEE® 1149.1 JTAG Boundary Scan on All Digital Pins
- Required Power Supplies
  - 0.9V to 1.1V for VDDDBU, VDDCORE, VDDPLL
  - 1.65 to 3.6V for VDDOSC
  - 1.65V to 3.6V for VDDIOP (Peripheral I/Os)
  - 3.0V to 3.6V for VDDUSB
  - 3.0V to 3.6V VDDANA (Analog-to-digital Converter)
  - Programmable 1.65V to 1.95V or 3.0V to 3.6V for VDDIOM (Memory I/Os)
- Available in a 217-ball LFBGA and 247-ball TFBGA RoHS-compliant Package

## 1. Description

The AT91SAM9G20 is based on the integration of an ARM926EJ-S processor with fast ROM and RAM memories and a wide range of peripherals.

The AT91SAM9G20 embeds an Ethernet MAC, one USB Device Port, and a USB Host controller. It also integrates several standard peripherals, such as the USART, SPI, TWI, Timer Counters, Synchronous Serial Controller, ADC and MultiMedia Card Interface.

The AT91SAM9G20 is architected on a 6-layer matrix, allowing a maximum internal bandwidth of six 32-bit buses. It also features an External Bus Interface capable of interfacing with a wide range of memory devices.

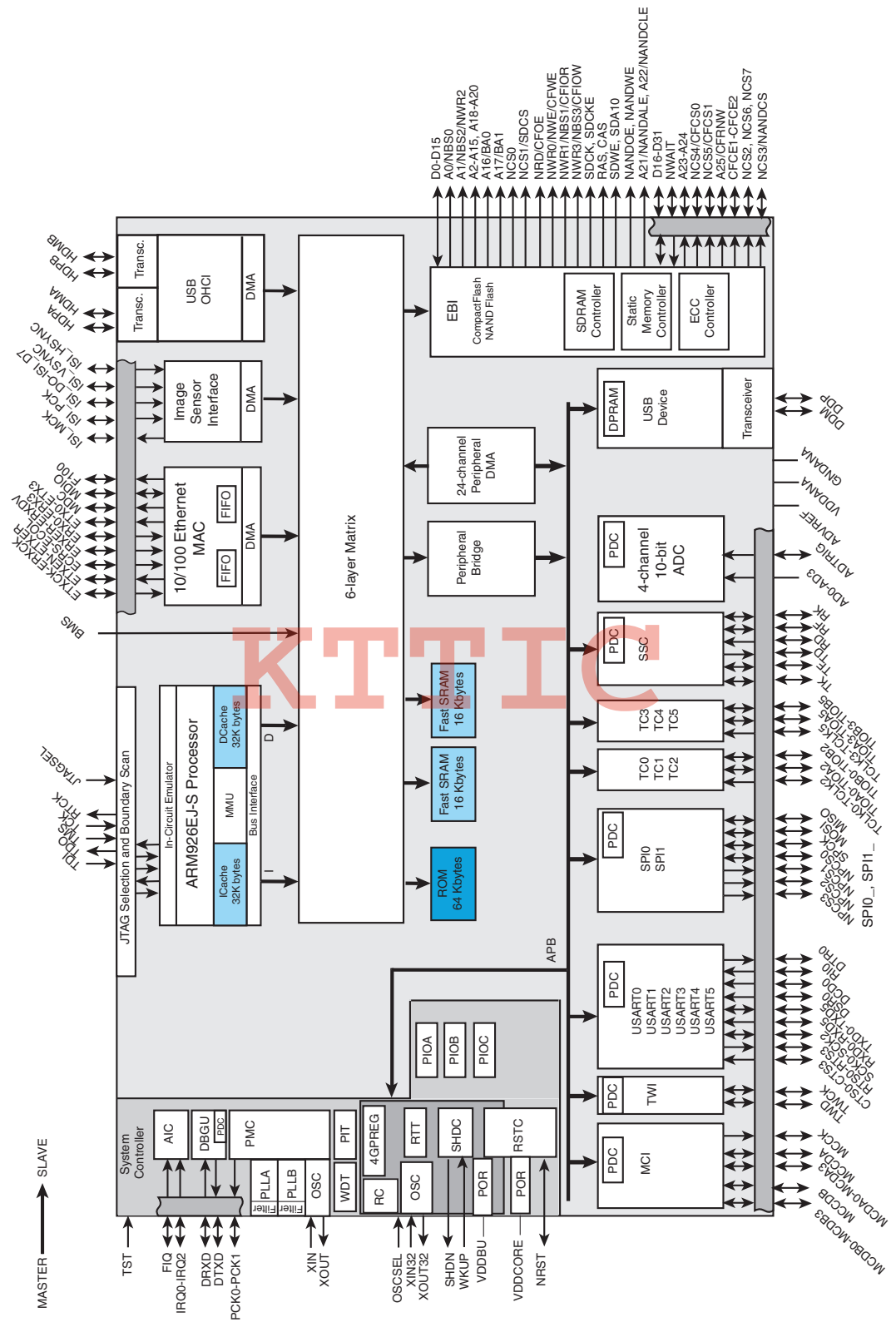
The AT91SAM9G20 is an enhancement of the AT91SAM9260 with the same peripheral features. It is pin-to-pin compatible with the exception of power supply pins. Speed is increased to reach 400 MHz on the ARM core and 133 MHz on the system bus and EBI.

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## 2. AT91SAM9G20 Block Diagram

Figure 2-1. AT91SAM9G20 Block Diagram



### 3. Signal Description

**Table 3-1.** Signal Description List (Continued)

| Signal Name                         | Function                           | Type   | Active Level | Comments   |
|-------------------------------------|------------------------------------|--------|--------------|--|
| <b>Power Supplies</b>               |                                    |        |              |  |
| VDDIOM                              | EBI I/O Lines Power Supply         | Power  |              | 1.65V to 1.95V or 3.0V to 3.6V                     |
| VDDIOP                              | Peripherals I/O Lines Power Supply | Power  |              | 1.65V to 3.6V                                      |
| VDDDBU                              | Backup I/O Lines Power Supply      | Power  |              | 0.9V to 1.1V                                       |
| VDDANA                              | Analog Power Supply                | Power  |              | 3.0V to 3.6V                                       |
| VDDPLL                              | PLL Power Supply                   | Power  |              | 0.9V to 1.1V                                       |
| VDDOSC                              | Oscillator Power Supply            | Power  |              | 1.65V to 3.6V                                      |
| VDDCORE                             | Core Chip Power Supply             | Power  |              | 0.9V to 1.1V                                       |
| VDDUSB                              | USB Power Supply                   | Power  |              | 1.65V to 3.6V                                      |
| GND                                 | Ground                             | Ground |              |  |
| GNDANA                              | Analog Ground                      | Ground |              |  |
| GNDDBU                              | Backup Ground                      | Ground |              |  |
| GNDUSB                              | USB Ground                         | Ground |              |  |
| GNDPLL                              | PLL Ground                         | Ground |              |  |
| <b>Clocks, Oscillators and PLLs</b> |                                    |        |              |  |
| XIN                                 | Main Oscillator Input              | Input  |              |  |
| XOUT                                | Main Oscillator Output             | Output |              |  |
| XIN32                               | Slow Clock Oscillator Input        | Input  |              |  |
| XOUT32                              | Slow Clock Oscillator Output       | Output |              |  |
| OSCSEL                              | Slow Clock Oscillator Selection    | Input  |              | Accepts between 0V and VDDDBU.                     |
| PCK0 - PCK1                         | Programmable Clock Output          | Output |              |  |
| <b>Shutdown, Wakeup Logic</b>       |                                    |        |              |  |
| SHDN                                | Shutdown Control                   | Output |              |  |
| WKUP                                | Wake-up Input                      | Input  |              | Accepts between 0V and VDDDBU.                     |
| <b>ICE and JTAG</b>                 |                                    |        |              |  |
| NTRST                               | Test Reset Signal                  | Input  | Low          | Pull-up resistor                                   |
| TCK                                 | Test Clock                         | Input  |              | No pull-up resistor                                |
| TDI                                 | Test Data In                       | Input  |              | No pull-up resistor                                |
| TDO                                 | Test Data Out                      | Output |              |  |
| TMS                                 | Test Mode Select                   | Input  |              | No pull-up resistor                                |
| JTAGSEL                             | JTAG Selection                     | Input  |              | Pull-down resistor. Accepts between 0V and VDDDBU. |
| RTCK                                | Return Test Clock                  | Output |              |  |

**Table 3-1.** Signal Description List (Continued)

| Signal Name                                | Function                       | Type   | Active Level | Comments   |
|--|--------------------------------|--------|--------------|--|
| <b>Reset/Test</b>                          |                                |        |              |  |
| NRST                                       | Microcontroller Reset          | I/O    | Low          | Pull-up resistor   |
| TST  | Test Mode Select               | Input  |              | Pull-down resistor. Accepts between 0V and VDDBU.                                |
| BMS  | Boot Mode Select               | Input  |              | No pull-up resistor<br>BMS = 0 when tied to GND.<br>BMS = 1 when tied to VDDIOP. |
| <b>Debug Unit - DBGU</b>                   |                                |        |              |  |
| DRXD                                       | Debug Receive Data             | Input  |              |  |
| DTXD                                       | Debug Transmit Data            | Output |              |  |
| <b>Advanced Interrupt Controller - AIC</b> |                                |        |              |  |
| IRQ0 - IRQ2                                | External Interrupt Inputs      | Input  |              |  |
| FIQ  | Fast Interrupt Input           | Input  |              |  |
| <b>PIO Controller - PIOA - PIOB - PIOC</b> |                                |        |              |  |
| PA0 - PA31                                 | Parallel IO Controller A       | I/O    |              | Pulled-up input at reset   |
| PB0 - PB31                                 | Parallel IO Controller B       | I/O    |              | Pulled-up input at reset   |
| PC0 - PC31                                 | Parallel IO Controller C       | I/O    |              | Pulled-up input at reset   |
| <b>External Bus Interface - EBI</b>        |                                |        |              |  |
| D0 - D31                                   | Data Bus                       | I/O    |              | Pulled-up input at reset   |
| A0 - A25                                   | Address Bus                    | Output |              | 0 at reset   |
| NWAIT                                      | External Wait Signal           | Input  | Low          |  |
| <b>Static Memory Controller - SMC</b>      |                                |        |              |  |
| NCS0 - NCS7                                | Chip Select Lines              | Output | Low          |  |
| NWR0 - NWR3                                | Write Signal                   | Output | Low          |  |
| NRD  | Read Signal                    | Output | Low          |  |
| NWE  | Write Enable                   | Output | Low          |  |
| NBS0 - NBS3                                | Byte Mask Signal               | Output | Low          |  |
| <b>CompactFlash Support</b>                |                                |        |              |  |
| CFCE1 - CFCE2                              | CompactFlash Chip Enable       | Output | Low          |  |
| CFOE                                       | CompactFlash Output Enable     | Output | Low          |  |
| CFWE                                       | CompactFlash Write Enable      | Output | Low          |  |
| CFIOR                                      | CompactFlash IO Read           | Output | Low          |  |
| CFIOW                                      | CompactFlash IO Write          | Output | Low          |  |
| CFRNW                                      | CompactFlash Read Not Write    | Output |              |  |
| CFCS0 - CFCS1                              | CompactFlash Chip Select Lines | Output | Low          |  |

Table 3-1. Signal Description List (Continued)

| Signal Name   | Function                        | Type   | Active Level | Comments |
|---|---------------------------------|--------|--------------|----------|
| <b>NAND Flash Support</b>   |                                 |        |              |          |
| NANDCS  | NAND Flash Chip Select          | Output | Low          |          |
| NANDOE  | NAND Flash Output Enable        | Output | Low          |          |
| NANDWE  | NAND Flash Write Enable         | Output | Low          |          |
| NANDALE   | NAND Flash Address Latch Enable | Output | Low          |          |
| NANDCLE   | NAND Flash Command Latch Enable | Output | Low          |          |
| <b>SDRAM Controller</b>   |                                 |        |              |          |
| SDCK  | SDRAM Clock                     | Output |              |          |
| SDCKE   | SDRAM Clock Enable              | Output | High         |          |
| SDCS  | SDRAM Controller Chip Select    | Output | Low          |          |
| BA0 - BA1   | Bank Select                     | Output |              |          |
| SDWE  | SDRAM Write Enable              | Output | Low          |          |
| RAS - CAS   | Row and Column Signal           | Output | Low          |          |
| SDA10   | SDRAM Address 10 Line           | Output |              |          |
| <b>Multimedia Card Interface MCI</b>                                  |                                 |        |              |          |
| MCK   | Multimedia Card Clock           | Output |              |          |
| MCCDA   | Multimedia Card Slot A Command  | I/O    |              |          |
| MCDA0 - MCDA3   | Multimedia Card Slot A Data     | I/O    |              |          |
| MCCDB   | Multimedia Card Slot B Command  | I/O    |              |          |
| MCDB0 - MCDB3   | Multimedia Card Slot B Data     | I/O    |              |          |
| <b>Universal Synchronous Asynchronous Receiver Transmitter USARTx</b> |                                 |        |              |          |
| SCKx  | USARTx Serial Clock             | I/O    |              |          |
| TXDx  | USARTx Transmit Data            | I/O    |              |          |
| RXDx  | USARTx Receive Data             | Input  |              |          |
| RTSx  | USARTx Request To Send          | Output |              |          |
| CTSx  | USARTx Clear To Send            | Input  |              |          |
| DTR0  | USART0 Data Terminal Ready      | Output |              |          |
| DSR0  | USART0 Data Set Ready           | Input  |              |          |
| DCD0  | USART0 Data Carrier Detect      | Input  |              |          |
| RI0   | USART0 Ring Indicator           | Input  |              |          |
| <b>Synchronous Serial Controller - SSC</b>                            |                                 |        |              |          |
| TD  | SSC Transmit Data               | Output |              |          |
| RD  | SSC Receive Data                | Input  |              |          |
| TK  | SSC Transmit Clock              | I/O    |              |          |
| RK  | SSC Receive Clock               | I/O    |              |          |
| TF  | SSC Transmit Frame Sync         | I/O    |              |          |
| RF  | SSC Receive Frame Sync          | I/O    |              |          |

**Table 3-1.** Signal Description List (Continued)

| Signal Name                                | Function                          | Type   | Active Level | Comments                   |
|--|-----------------------------------|--------|--------------|----------------------------|
| <b>Timer/Counter - TCx</b>                 |                                   |        |              |                            |
| TCLKx                                      | TC Channel x External Clock Input | Input  |              |                            |
| TIOAx                                      | TC Channel x I/O Line A           | I/O    |              |                            |
| TIOBx                                      | TC Channel x I/O Line B           | I/O    |              |                            |
| <b>Serial Peripheral Interface - SPIx_</b> |                                   |        |              |                            |
| SPIx_MISO                                  | Master In Slave Out               | I/O    |              |                            |
| SPIx_MOSI                                  | Master Out Slave In               | I/O    |              |                            |
| SPIx_SPCK                                  | SPI Serial Clock                  | I/O    |              |                            |
| SPIx_NPCS0                                 | SPI Peripheral Chip Select 0      | I/O    | Low          |                            |
| SPIx_NPCS1-SPIx_NPCS3                      | SPI Peripheral Chip Select        | Output | Low          |                            |
| <b>Two-Wire Interface</b>                  |                                   |        |              |                            |
| TWD  | Two-wire Serial Data              | I/O    |              |                            |
| TWCK                                       | Two-wire Serial Clock             | I/O    |              |                            |
| <b>USB Host Port</b>                       |                                   |        |              |                            |
| HDP A                                      | USB Host Port A Data +            | Analog |              |                            |
| HDMA                                       | USB Host Port A Data -            | Analog |              |                            |
| HDP B                                      | USB Host Port B Data +            | Analog |              |                            |
| HDMB                                       | USB Host Port B Data -            | Analog |              |                            |
| <b>USB Device Port</b>                     |                                   |        |              |                            |
| DDM  | USB Device Port Data -            | Analog |              |                            |
| DDP  | USB Device Port Data +            | Analog |              |                            |
| <b>Ethernet 10/100</b>                     |                                   |        |              |                            |
| ETXCK                                      | Transmit Clock or Reference Clock | Input  |              | MII only, REFCK in RMII    |
| ERXCK                                      | Receive Clock                     | Input  |              | MII only                   |
| ETXEN                                      | Transmit Enable                   | Output |              |                            |
| ETX0-ETX3                                  | Transmit Data                     | Output |              | ETX0-ETX1 only in RMII     |
| ETXER                                      | Transmit Coding Error             | Output |              | MII only                   |
| ERXDV                                      | Receive Data Valid                | Input  |              | RXDV in MII, CRSDV in RMII |
| ERX0-ERX3                                  | Receive Data                      | Input  |              | ERX0-ERX1 only in RMII     |
| ERXER                                      | Receive Error                     | Input  |              |                            |
| ECRS                                       | Carrier Sense and Data Valid      | Input  |              | MII only                   |
| ECOL                                       | Collision Detect                  | Input  |              | MII only                   |
| EMDC                                       | Management Data Clock             | Output |              |                            |
| EMDIO                                      | Management Data Input/Output      | I/O    |              |                            |



Table 3-1. Signal Description List (Continued)

| Signal Name                        | Function                        | Type   | Active Level | Comments                          |
|------------------------------------|---------------------------------|--------|--------------|-----------------------------------|
| <b>Image Sensor Interface</b>      |                                 |        |              |                                   |
| ISI_D0-ISI_D11                     | Image Sensor Data               | Input  |              |                                   |
| ISI_MCK                            | Image Sensor Reference Clock    | Output |              |                                   |
| ISI_HSYNC                          | Image Sensor Horizontal Synchro | Input  |              |                                   |
| ISI_VSYNC                          | Image Sensor Vertical Synchro   | Input  |              |                                   |
| ISI_PCK                            | Image Sensor Data clock         | Input  |              |                                   |
| <b>Analog to Digital Converter</b> |                                 |        |              |                                   |
| AD0-AD3                            | Analog Inputs                   | Analog |              | Digital pulled-up inputs at reset |
| ADVREF                             | Analog Positive Reference       | Analog |              |                                   |
| ADTRG                              | ADC Trigger                     | Input  |              |                                   |

Note: No PLLRCA line present on the AT91SAM9G20.

### 4. Package and Pinout

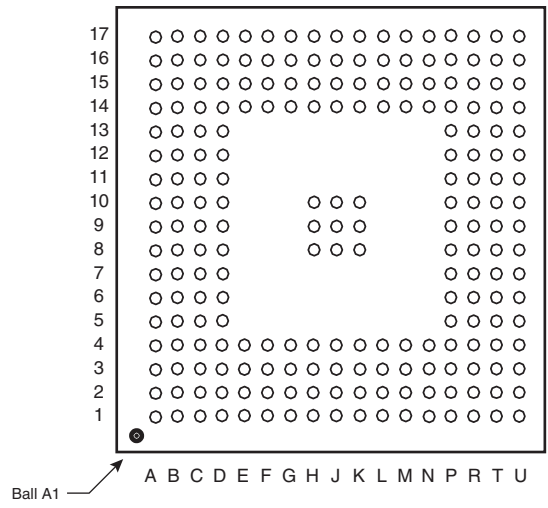
- The AT91SAM9G20 is available in a 217-ball, 15 x 15 mm, LFBGA package (0.8 mm pitch) (Figure 4-1).
- The AT91SAM9G20 is available in a 247-ball, 10 x 10 x 1.1 mm, TFBGA Green package, (0.5 mm pitch) (Figure 4-2).

#### 4.1 217-ball LFBGA Package Outline

Figure 4-1 shows the orientation of the 217-ball LFBGA package.

A detailed mechanical description is given in the section “AT91SAM9G20 Mechanical Characteristics” of the product datasheet.

Figure 4-1. 217-ball LFBGA Package (Top View)



## 4.2 217-ball LFBGA Pinout

Table 4-1. Pinout for 217-ball LFBGA Package

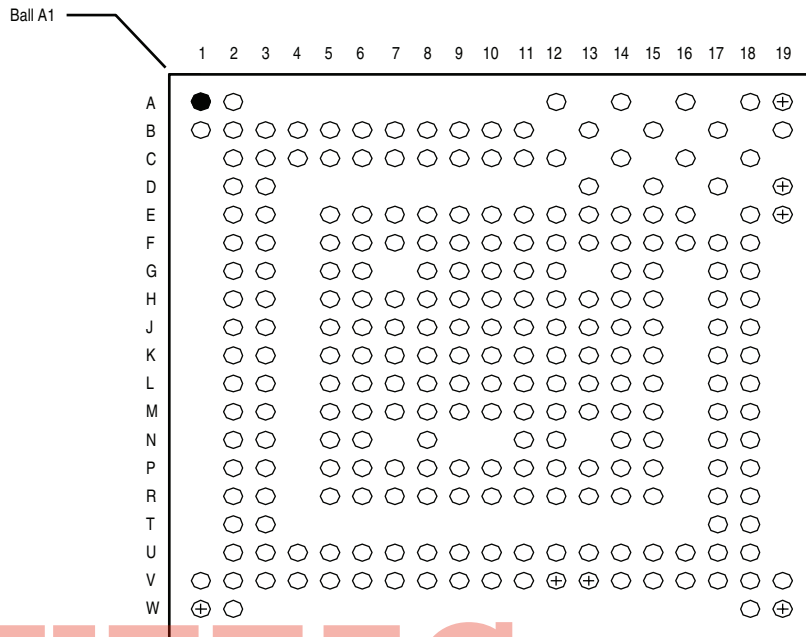
| Pin | Signal Name     | Pin | Signal Name | Pin | Signal Name | Pin | Signal Name |
|-----|-----------------|-----|-------------|-----|-------------|-----|-------------|
| A1  | CFIOW/NBS3/NWR3 | D5  | A5          | J14 | TDO         | P17 | PB5         |
| A2  | NBS0/A0         | D6  | GND         | J15 | PB19        | R1  | NC          |
| A3  | NWR2/NBS2/A1    | D7  | A10         | J16 | TDI         | R2  | GNDANA      |
| A4  | A6              | D8  | GND         | J17 | PB16        | R3  | PC29        |
| A5  | A8              | D9  | VDDCORE     | K1  | PC24        | R4  | VDDANA      |
| A6  | A11             | D10 | GNDUSB      | K2  | PC20        | R5  | PB12        |
| A7  | A13             | D11 | VDDIOM      | K3  | D15         | R6  | PB23        |
| A8  | BA0/A16         | D12 | GNDUSB      | K4  | PC21        | R7  | GND         |
| A9  | A18             | D13 | DDM         | K8  | GND         | R8  | PB26        |
| A10 | A21             | D14 | HDPB        | K9  | GND         | R9  | PB28        |
| A11 | A22             | D15 | NC          | K10 | GND         | R10 | PA0         |
| A12 | CFWE/NWE/NWR0   | D16 | VDDDBU      | K14 | PB4         | R11 | PA4         |
| A13 | CFOE/NRD        | D17 | XIN32       | K15 | PB17        | R12 | PA5         |
| A14 | NCS0            | E1  | D10         | K16 | GND         | R13 | PA10        |
| A15 | PC5             | E2  | D5          | K17 | PB15        | R14 | PA21        |
| A16 | PC6             | E3  | D3          | L1  | GND         | R15 | PA23        |
| A17 | PC4             | E4  | D4          | L2  | PC26        | R16 | PA24        |
| B1  | SDCK            | E14 | HDPA        | L3  | PC25        | R17 | PA29        |
| B2  | CFIOR/NBS1/NWR1 | E15 | HDMA        | L4  | VDDOSC      | T1  | NC          |
| B3  | SDCS/NCS1       | E16 | GNDBU       | L14 | PA28        | T2  | GNDPLL      |
| B4  | SDA10           | E17 | XOUT32      | L15 | PB9         | T3  | PC0         |
| B5  | A3              | F1  | D13         | L16 | PB8         | T4  | PC1         |
| B6  | A7              | F2  | SDWE        | L17 | PB14        | T5  | PB10        |
| B7  | A12             | F3  | D6          | M1  | VDDCORE     | T6  | PB22        |
| B8  | A15             | F4  | GND         | M2  | PC31        | T7  | GND         |
| B9  | A20             | F14 | OSCSEL      | M3  | GND         | T8  | PB29        |
| B10 | NANDWE          | F15 | BMS         | M4  | PC22        | T9  | PA2         |
| B11 | PC7             | F16 | JTAGSEL     | M14 | PB1         | T10 | PA6         |
| B12 | PC10            | F17 | TST         | M15 | PB2         | T11 | PA8         |
| B13 | PC13            | G1  | PC15        | M16 | PB3         | T12 | PA11        |
| B14 | PC11            | G2  | D7          | M17 | PB7         | T13 | VDDCORE     |
| B15 | PC14            | G3  | SDCKE       | N1  | XIN         | T14 | PA20        |
| B16 | PC8             | G4  | VDDIOM      | N2  | VDDPLL      | T15 | GND         |
| B17 | WKUP            | G14 | GND         | N3  | PC23        | T16 | PA22        |
| C1  | D8              | G15 | NRST        | N4  | PC27        | T17 | PA27        |
| C2  | D1              | G16 | RTCK        | N14 | PA31        | U1  | GNDPLL      |
| C3  | CAS             | G17 | TMS         | N15 | PA30        | U2  | ADVREF      |
| C4  | A2              | H1  | PC18        | N16 | PB0         | U3  | PC2         |
| C5  | A4              | H2  | D14         | N17 | PB6         | U4  | PC3         |
| C6  | A9              | H3  | D12         | P1  | XOUT        | U5  | PB20        |
| C7  | A14             | H4  | D11         | P2  | VDDPLL      | U6  | PB21        |
| C8  | BA1/A17         | H8  | GND         | P3  | PC30        | U7  | PB25        |
| C9  | A19             | H9  | GND         | P4  | PC28        | U8  | PB27        |
| C10 | NANDOE          | H10 | GND         | P5  | PB11        | U9  | PA12        |
| C11 | PC9             | H14 | VDDCORE     | P6  | PB13        | U10 | PA13        |
| C12 | PC12            | H15 | TCK         | P7  | PB24        | U11 | PA14        |
| C13 | DDP             | H16 | NTRST       | P8  | VDDIOP      | U12 | PA15        |
| C14 | HDMB            | H17 | PB18        | P9  | PB30        | U13 | PA19        |
| C15 | NC              | J1  | PC19        | P10 | PB31        | U14 | PA17        |
| C16 | VDDUSB          | J2  | PC17        | P11 | PA1         | U15 | PA16        |
| C17 | SHDN            | J3  | VDDIOM      | P12 | PA3         | U16 | PA18        |
| D1  | D9              | J4  | PC16        | P13 | PA7         | U17 | VDDIOP      |
| D2  | D2              | J8  | GND         | P14 | PA9         |     |             |
| D3  | RAS             | J9  | GND         | P15 | PA26        |     |             |
| D4  | D0              | J10 | GND         | P16 | PA25        |     |             |

### 4.3 247-ball TFBGA Package Outline

Figure 4-2 shows the orientation of the 247-ball TFBGA package.

A detailed mechanical description is given in the section “AT91SAM9G20 Mechanical Characteristics” of the product datasheet.

**Figure 4-2.** 247-ball TFBGA Package (Bottom View)



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#### 4.4 247-ball TFBGA Package Pinout

Table 4-2. Pinout for 247-ball TFBGA Package

| Pin | Signal Name     | Pin | Signal Name     | Pin | Signal Name | Pin | Signal Name |
|-----|-----------------|-----|-----------------|-----|-------------|-----|-------------|
| A1  | D13             | F7  | CFIOR/NBS1/NWR1 | K10 | GND         | P17 | RTCK        |
| A2  | D12             | F8  | SDA10           | K11 | VDDIOM      | P18 | PB16        |
| A12 | A9              | F9  | NBS0/A0         | K12 | GND         | R2  | GND         |
| A14 | A13             | F10 | A6              | K13 | GND         | R3  | PB29        |
| A16 | A20             | F11 | A12             | K14 | XOUT32      | R5  | PB26        |
| A18 | A22             | F12 | A15             | K15 | XIN32       | R6  | PB27        |
| A19 | NANDOE          | F13 | BA1/A17         | K17 | HDPA        | R7  | PA5         |
| B1  | D15             | F14 | PC10            | K18 | HDMA        | R8  | GND         |
| B2  | D14             | F15 | PC14            | L2  | NC          | R9  | PA12        |
| B3  | D10             | F16 | VDDUSB          | L3  | NC          | R10 | GND         |
| B4  | D9              | F17 | PC9             | L5  | ADVREF      | R11 | PA19        |
| B5  | D7              | F18 | PC12            | L6  | PC2         | R12 | PA26        |
| B6  | D3              | G2  | PC26            | L7  | GND         | R13 | PB1         |
| B7  | D2              | G3  | PC25            | L8  | GND         | R14 | GND         |
| B8  | RAS             | G5  | PC24            | L9  | GND         | R15 | PB7         |
| B9  | CAS             | G6  | PC21            | L10 | GND         | R17 | PB14        |
| B10 | NWR2/NBS2/A1    | G8  | VDDCORE         | L11 | VDDCORE     | R18 | PB9         |
| B11 | A3              | G9  | A5              | L12 | GND         | T2  | PA1         |
| B13 | A10             | G10 | VDDCORE         | L13 | OSCSSEL     | T3  | PB10        |
| B15 | A18             | G11 | VDDCORE         | L14 | GND         | T17 | PB19        |
| B17 | A21             | G12 | VDDCORE         | L15 | GND         | T18 | PB17        |
| B19 | VDDUSB          | G14 | PC13            | L17 | NRST        | U2  | GNDANA      |
| C2  | PC15            | G15 | GND             | L18 | TCK         | U3  | PB21        |
| C3  | D11             | G17 | GNDUSB          | M2  | PC0         | U4  | PB28        |
| C4  | D8              | G18 | PC11            | M3  | PC1         | U5  | PB31        |
| C5  | SDCKE           | H2  | PC31            | M5  | PC3         | U6  | PA4         |
| C6  | SDWE            | H3  | PC30            | M6  | NTRST       | U7  | PA3         |
| C7  | SDCK            | H5  | PC28            | M7  | GND         | U8  | PA9         |
| C8  | D1              | H6  | PC27            | M8  | GND         | U9  | GND         |
| C9  | SDCS/NCS1       | H7  | PC29            | M9  | GND         | U10 | PA15        |
| C10 | A2              | H8  | GND             | M10 | PA16        | U11 | PA21        |
| C11 | A7              | H9  | GND             | M11 | VDDCORE     | U12 | PA25        |
| C12 | A11             | H10 | VDDIOM          | M12 | GND         | U13 | PA29        |
| C14 | A19             | H11 | VDDIOM          | M13 | VDDIOP      | U14 | PA27        |
| C16 | GNDUSB          | H12 | GND             | M14 | TST         | U15 | PA31        |
| C18 | CFWE/NWE/NWR0   | H13 | VDDCORE         | M15 | JTAGSEL     | U16 | GND         |
| D2  | PC17            | H14 | SHDW            | M17 | PB18        | U17 | PB2         |
| D3  | PC16            | H15 | VDDBU           | M18 | TMS         | U18 | GND         |
| D13 | A14             | H17 | HDPB            | N2  | PB20        | V1  | PB12        |
| D15 | NANDWE          | H18 | HDMA            | N3  | PB13        | V2  | PB23        |
| D17 | CFOE/NRD        | J2  | VDDQSC          | N5  | PB11        | V3  | PB30        |
| D19 | NCS0            | J3  | VDDPLL          | N6  | BMS         | V4  | PA2         |
| E2  | PC18            | J5  | XOUT            | N8  | GND         | V5  | PA8         |
| E3  | PC19            | J6  | XIN             | N11 | PA17        | V6  | PA10        |
| E5  | D6              | J7  | VDDPLL          | N12 | PA23        | V7  | PA13        |
| E6  | D5              | J8  | GND             | N14 | GND         | V8  | VDDIOP      |
| E7  | D0              | J9  | VDDIOM          | N15 | VDDIOP      | V9  | PA14        |
| E8  | CFIOW/NBS3/NWR3 | J10 | VDDIOM          | N17 | TDO         | V10 | VDDIOP      |
| E9  | GND             | J11 | VDDIOM          | N18 | TDI         | V11 | PA20        |
| E10 | A4              | J12 | GND             | P2  | PB24        | V12 | PA22        |
| E11 | A8              | J13 | GND             | P3  | PB22        | V13 | VDDIOP      |
| E12 | VDDIOM          | J14 | WKUP            | P5  | GND         | V14 | PA30        |
| E13 | BA0/A16         | J15 | DDP             | P6  | GND         | V15 | PB0         |
| E14 | PC8             | J17 | DDM             | P7  | PA6         | V16 | GND         |
| E15 | PC4             | J18 | VDDIOP          | P8  | PA7         | V17 | PB4         |
| E16 | PC5             | K2  | GNDPLL          | P9  | PA11        | V18 | GND         |
| E18 | PC7             | K3  | GND             | P10 | GND         | V19 | PB6         |
| E19 | PC6             | K5  | NC              | P11 | PA18        | W1  | PB25        |
| F2  | PC22            | K6  | GNDPLL          | P12 | PA24        | W2  | PA0         |
| F3  | PC23            | K7  | VDDANA          | P13 | PA28        | W18 | PB8         |
| F5  | PC20            | K8  | GND             | P14 | PB3         | W19 | PB15        |
| F6  | D4              | K9  | GND             | P15 | PB5         |     |             |

## 5. Power Considerations

### 5.1 Power Supplies

The AT91SAM9G20 has several types of power supply pins:

- VDDCORE pins: Power the core, including the processor, the embedded memories and the peripherals; voltage ranges from 0.9V to 1.1V, 1.0V nominal.
- VDDIOM pins: Power the External Bus Interface I/O lines; voltage ranges between 1.65V and 1.95V (1.8V typical) or between 3.0V and 3.6V (3.3V nominal). The voltage range is selectable by software.
- VDDIOP pins: Power the Peripherals I/O lines; voltage ranges from 1.65V to 3.6V.
- VDDDBU pin: Powers the Slow Clock oscillator, the internal RC oscillator and a part of the System Controller; voltage ranges from 0.9V to 1.1V, 1.0V nominal.
- VDDPLL pin: Powers the PLL cells; voltage ranges from 0.9V to 1.1V.
- VDDOSC pin: Powers the Main Oscillator cells; voltage ranges from 1.65V to 3.6V
- VDDANA pin: Powers the Analog to Digital Converter; voltage ranges from 3.0V to 3.6V, 3.3V nominal.
- VDDUSB pin: Powers USB transceiver; voltage ranges from 3.0V to 3.6V.

Ground pins GND are common to VDDCORE, VDDIOM, VDDOSC and VDDIOP pins power supplies. Separated ground pins are provided for VDDDBU, VDDPLL, VDDUSB and VDDANA. These ground pins are respectively GNDBU, GNDPLL, GNDUSB and GNDANA.

### 5.2 Power Consumption

The AT91SAM9G20 consumes about 4 mA of static current on VDDCORE at 25°C. This static current rises at up to 18 mA if the temperature increases to 85°C.

On VDDDBU, the current does not exceed 9 µA at 25°C. This static current rises at up to 18 µA if the temperature increases to 85°C.

For dynamic power consumption, the AT91SAM9G20 consumes a maximum of 50 mA on VDDCORE at maximum conditions (1.0V, 25°C, rises to 80mA at 85°C, processor running full-performance algorithm out of high-speed memories).

### 5.3 Programmable I/O Lines

The power supplies pins VDDIOM accept two voltage ranges. This allows the device to reach its maximum speed either out of 1.8V or 3.3V external memories.

The maximum speed is 133 MHz on the pin SDCK (SDRAM Clock) loaded with 10 pF. The other signals (control, address and data signals) do not go over 66 MHz, loaded with 30 pF for power supply at 1.8V and 50 pF for power supply at 3.3V.

The EBI I/Os accept two slew rate modes, Fast and Slow. This allows to adapt the rising and falling time on SDRAM clock, control and data to the bus load.

The voltage ranges and the slew rates are determined by programming VDDIOMSEL and IOSR bits in the Chip Configuration registers located in the Matrix User Interface.

At reset, the selected voltage defaults to 3.3V nominal and power supply pins can accept either 1.8V or 3.3V. The user must make sure to program the EBI voltage range before getting the device out of its Slow Clock Mode.

At reset, the selected slew rates defaults are Fast.

## 6. I/O Line Considerations

### 6.1 JTAG Port Pins

TMS, TDI and TCK are schmitt trigger inputs and have no pull-up resistors.

TDO and RTCK are outputs, driven at up to VDDIOP, and have no pull-up resistor.

The JTAGSEL pin is used to select the JTAG boundary scan when asserted at a high level. It integrates a permanent pull-down resistor of about 15 k $\Omega$  to GND, so that it can be left unconnected for normal operations.

The NTRST signal is described in the Reset Pins paragraph.

All the JTAG signals are supplied with VDDIOP.

### 6.2 Test Pin

The TST pin is used for manufacturing test purposes when asserted high. It integrates a permanent pull-down resistor of about 15 k $\Omega$  to GNDBU, so that it can be left unconnected for normal operations. Driving this line at a high level leads to unpredictable results.

This pin is supplied with VDDBU.

### 6.3 Reset Pins

NRST is an open-drain output integrating a non-programmable pull-up resistor. It can be driven with voltage at up to VDDIOP.

NTRST is an input which allows reset of the JTAG Test Access port. It has no action on the processor.

As the product integrates power-on reset cells, which manages the processor and the JTAG reset, the NRST and NTRST pins can be left unconnected.

The NRST and NTRST pins both integrate a permanent pull-up resistor of 100 k $\Omega$  minimum to VDDIOP.

The NRST signal is inserted in the Boundary Scan.

### 6.4 PIO Controllers

All the I/O lines are Schmitt trigger inputs and all the lines managed by the PIO Controllers integrate a programmable pull-up resistor of 75 k $\Omega$  typical with the exception of P4 - P31. For details, refer to the section "AT91SAM9G20 Electrical Characteristics". Programming of this pull-up resistor is performed independently for each I/O line through the PIO Controllers.

### 6.5 I/O Line Drive Levels

The PIO lines drive current capability is described in the DC Characteristics section of the product datasheet.

### 6.6 Shutdown Logic Pins

The SHDN pin is a tri-state output only pin, which is driven by the Shutdown Controller. There is no internal pull-up. An external pull-up to VDDBU is needed and its value must be higher than 1 M $\Omega$ . The resistor value is calculated according to the regulator enable implementation and the SHDN level.

The pin WKUP is an input-only. It can accept voltages only between 0V and VDDBU.

## 6.7 Slow Clock Selection

The AT91SAM9G20 slow clock can be generated either by an external 32768Hz crystal or the on-chip RC oscillator.

# 7. Processor and Architecture

## 7.1 ARM926EJ-S Processor

- RISC Processor Based on ARM v5TEJ Architecture with Jazelle technology for Java acceleration
- Two Instruction Sets
  - ARM High-performance 32-bit Instruction Set
  - Thumb High Code Density 16-bit Instruction Set
- DSP Instruction Extensions
- 5-Stage Pipeline Architecture:
  - Instruction Fetch (F)
  - Instruction Decode (D)
  - Execute (E)
  - Data Memory (M)
  - Register Write (W)
- 32-Kbyte Data Cache, 32-Kbyte Instruction Cache
  - Virtually-addressed 4-way Associative Cache
  - Eight words per line
  - Write-through and Write-back Operation
  - Pseudo-random or Round-robin Replacement
- Write Buffer
  - Main Write Buffer with 16-word Data Buffer and 4-address Buffer
  - DCache Write-back Buffer with 8-word Entries and a Single Address Entry
  - Software Control Drain
- Standard ARM v4 and v5 Memory Management Unit (MMU)
  - Access Permission for Sections
  - Access Permission for large pages and small pages can be specified separately for each quarter of the page
  - 16 embedded domains
- Bus Interface Unit (BIU)
  - Arbitrates and Schedules AHB Requests
  - Separate Masters for both instruction and data access providing complete Matrix system flexibility
  - Separate Address and Data Buses for both the 32-bit instruction interface and the 32-bit data interface

- On Address and Data Buses, data can be 8-bit (Bytes), 16-bit (Half-words) or 32-bit (Words)

## 7.2 Bus Matrix

- 6-layer Matrix, handling requests from 6 masters
- Programmable Arbitration strategy
  - Fixed-priority Arbitration
  - Round-Robin Arbitration, either with no default master, last accessed default master or fixed default master
- Burst Management
  - Breaking with Slot Cycle Limit Support
  - Undefined Burst Length Support
- One Address Decoder provided per Master
  - Three different slaves may be assigned to each decoded memory area: one for internal boot, one for external boot, one after remap
- Boot Mode Select
  - Non-volatile Boot Memory can be internal or external
  - Selection is made by BMS pin sampled at reset
- Remap Command
  - Allows Remapping of an Internal SRAM in Place of the Boot Non-Volatile Memory
- Allows Handling of Dynamic Exception Vectors

### 7.2.1 Matrix Masters

The Bus Matrix of the AT91SAM9G20 manages six Masters, which means that each master can perform an access concurrently with others, according the slave it accesses is available.

Each Master has its own decoder that can be defined specifically for each master. In order to simplify the addressing, all the masters have the same decodings.

**Table 7-1.** List of Bus Matrix Masters

|          |                     |
|----------|---------------------|
| Master 0 | ARM926™ Instruction |
| Master 1 | ARM926 Data         |
| Master 2 | PDC                 |
| Master 3 | ISI Controller      |
| Master 4 | Ethernet MAC        |
| Master 5 | USB Host DMA        |

### 7.2.2 Matrix Slaves

Each Slave has its own arbiter, thus allowing to program a different arbitration per Slave.

**Table 7-2.** List of Bus Matrix Slaves

|         |                          |
|---------|--------------------------|
| Slave 0 | Internal SRAM0 16 KBytes |
| Slave 1 | Internal SRAM1 16 KBytes |



**Table 7-2.** List of Bus Matrix Slaves (Continued)

|         |                         |
|---------|-------------------------|
| Slave 2 | Internal ROM            |
|         | USB Host User Interface |
| Slave 3 | External Bus Interface  |
| Slave 4 | Internal Peripherals    |

**7.2.3 Masters to Slaves Access**

All the Masters can normally access all the Slaves. However, some paths do not make sense, like as example allowing access from the Ethernet MAC to the Internal Peripherals. Thus, these paths are forbidden or simply not wired, and shown “-” in Table 7-3.

**Table 7-3.** AT91SAM9G20 Masters to Slaves Access

| Master |                         | 0 & 1                     | 2                         | 3              | 4            | 5                   |
|--------|-------------------------|---------------------------|---------------------------|----------------|--------------|---------------------|
| Slave  |                         | ARM926 Instruction & Data | Peripheral DMA Controller | ISI Controller | Ethernet MAC | USB Host Controller |
| 0      | Internal SRAM 16 Kbytes | X                         | X                         | X              | X            | X                   |
| 1      | Internal SRAM 16 Kbytes | X                         | X                         | X              | X            | X                   |
| 2      | Internal ROM            | X                         | X                         | -              | -            | -                   |
|        | UHP User Interface      | X                         | X                         | -              | -            | -                   |
| 3      | External Bus Interface  | X                         | X                         | X              | X            | X                   |
| 4      | Internal Peripherals    | X                         | X                         | -              | -            | -                   |

**7.3 Peripheral DMA Controller**

- Acting as one Matrix Master
- Allows data transfers from/to peripheral to/from any memory space without any intervention of the processor.
- Next Pointer Support, forbids strong real-time constraints on buffer management.
- Twenty-four channels
  - Two for each USART
  - Two for the Debug Unit
  - Two for the Serial Synchronous Controller
  - Two for each Serial Peripheral Interface
  - One for Multimedia Card Interface
  - One for Analog-to-Digital Converter
  - Two for the Two-wire Interface

The Peripheral DMA Controller handles transfer requests from the channel according to the following priorities (Low to High priorities):

- TWI Transmit Channel
- DBGU Transmit Channel
- USART5 Transmit Channel

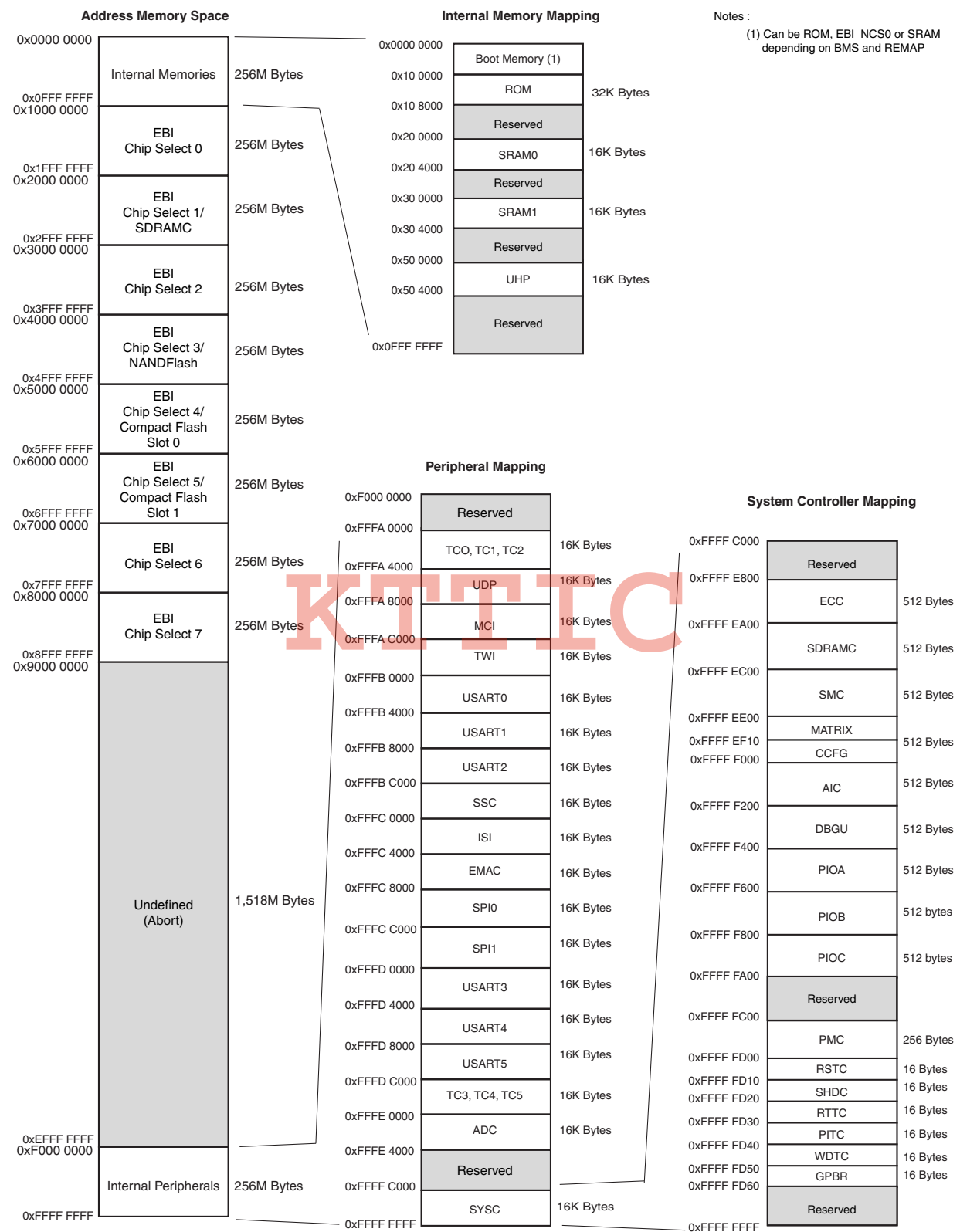
- USART4 Transmit Channel
- USART3 Transmit Channel
- USART2 Transmit Channel
- USART1 Transmit Channel
- USART0 Transmit Channel
- SPI1 Transmit Channel
- SPI0 Transmit Channel
- SSC Transmit Channel
- TWI Receive Channel
- DBGU Receive Channel
- USART5 Receive Channel
- USART4 Receive Channel
- USART3 Receive Channel
- USART2 Receive Channel
- USART1 Receive Channel
- USART0 Receive Channel
- ADC Receive Channel
- SPI1 Receive Channel
- SPI0 Receive Channel
- SSC Receive Channel
- MCI Transmit/Receive Channel

## 7.4 Debug and Test Features

- ARM926 Real-time In-circuit Emulator
  - Two real-time Watchpoint Units
  - Two Independent Registers: Debug Control Register and Debug Status Register
  - Test Access Port Accessible through JTAG Protocol
  - Debug Communications Channel
- Debug Unit
  - Two-pin UART
  - Debug Communication Channel Interrupt Handling
  - Chip ID Register
- IEEE1149.1 JTAG Boundary-scan on All Digital Pins

### 8. Memories

Figure 8-1. AT91SAM9G20 Memory Mapping



A first level of address decoding is performed by the Bus Matrix, i.e., the implementation of the Advanced High Performance Bus (AHB) for its Master and Slave interfaces with additional features.

Decoding breaks up the 4G bytes of address space into 16 banks of 256 Mbytes. The banks 1 to 7 are directed to the EBI that associates these banks to the external chip selects EBI\_NCS0 to EBI\_NCS7. Bank 0 is reserved for the addressing of the internal memories, and a second level of decoding provides 1 Mbyte of internal memory area. Bank 15 is reserved for the peripherals and provides access to the Advanced Peripheral Bus (APB).

Other areas are unused and performing an access within them provides an abort to the master requesting such an access.

Each Master has its own bus and its own decoder, thus allowing a different memory mapping per Master. However, in order to simplify the mappings, all the masters have a similar address decoding.

Regarding Master 0 and Master 1 (ARM926 Instruction and Data), three different Slaves are assigned to the memory space decoded at address 0x0: one for internal boot, one for external boot, one after remap. Refer to [Table 8-1, "Internal Memory Mapping," on page 20](#) for details.

A complete memory map is presented in [Figure 8-1 on page 19](#).

## 8.1 Embedded Memories

- 64-KByte ROM
  - Single Cycle Access at full matrix speed
- Two 16-Kbyte Fast SRAM
  - Single Cycle Access at full matrix speed

### 8.1.1 Boot Strategies

[Table 8-1](#) summarizes the Internal Memory Mapping for each Master, depending on the Remap status and the BMS state at reset.

**Table 8-1.** Internal Memory Mapping

| Address     | REMAP = 0               |          | REMAP = 1 |
|-------------|-------------------------|----------|-----------|
|             | BMS = 1                 | BMS = 0  |           |
| 0x0000 0000 | ROM                     | EBI_NCS0 | SRAM0 16K |
| 0x0010 0000 | ROM                     |          |           |
| 0x0020 0000 | SRAM0 16K               |          |           |
| 0x0030 0000 | SRAM1 16K               |          |           |
| 0x0050 0000 | USB Host User Interface |          |           |

The system always boots at address 0x0. To ensure a maximum number of possibilities for boot, the memory layout can be configured with two parameters.

REMAP allows the user to lay out the first internal SRAM bank to 0x0 to ease development. This is done by software once the system has booted. When REMAP = 1, BMS is ignored. Refer to the Bus Matrix Section for more details.

When REMAP = 0, BMS allows the user to lay out to 0x0, at his convenience, the ROM or an external memory. This is done via hardware at reset.

Note: Memory blocks not affected by these parameters can always be seen at their specified base addresses. See the complete memory map presented in [Figure 8-1 on page 19](#).

The AT91SAM9G20 matrix manages a boot memory that depends on the level on the BMS pin at reset. The internal memory area mapped between address 0x0 and 0x000F FFFF is reserved for this purpose.

If BMS is detected at 1, the boot memory is the embedded ROM.

If BMS is detected at 0, the boot memory is the memory connected on the Chip Select 0 of the External Bus Interface.

#### 8.1.1.1 *BMS = 1, Boot on Embedded ROM*

The system boots using the Boot Program.

- Boot on slow clock (On-chip RC or 32,768 Hz)
- Auto baudrate detection
- Downloads and runs an application from external storage media into internal SRAM
- Downloaded code size depends on embedded SRAM size
- Automatic detection of valid application
- Bootloader on a non-volatile memory
  - SDCard (boot ROM does not support high capacity SDCards.)
  - NAND Flash
  - SPI DataFlash<sup>®</sup> and Serial Flash connected on NPCS0 and NPCS1 of the SPI0
  - EEPROM on TWI
- SAM-BA<sup>®</sup> Boot in case no valid program is detected in external NVM, supporting
  - Serial communication on a DBGU
  - USB Device HS Port

#### 8.1.1.2 *BMS = 0, Boot on External Memory*

- Boot on slow clock (On-chip RC or 32,768 Hz)
- Boot with the default configuration for the Static Memory Controller, byte select mode, 16-bit data bus, Read/Write controlled by Chip Select, allows boot on 16-bit non-volatile memory.

The customer-programmed software must perform a complete configuration.

To speed up the boot sequence when booting at 32 kHz EBI CS0 (BMS=0), the user must take the following steps:

1. Program the PMC (main oscillator enable or bypass mode).
2. Program and start the PLL.
3. Reprogram the SMC setup, cycle, hold, mode timings registers for CS0 to adapt them to the new clock.
4. Switch the main clock to the new value.

## 8.2 External Memories

The external memories are accessed through the External Bus Interface. Each Chip Select line has a 256-Mbyte memory area assigned.

Refer to the memory map in [Figure 8-1 on page 19](#).

### 8.2.1 External Bus Interface

- Integrates three External Memory Controllers
  - Static Memory Controller
  - SDRAM Controller
  - ECC Controller
- Additional logic for NAND Flash
- Full 32-bit External Data Bus
- Up to 26-bit Address Bus (up to 64MBytes linear)
- Up to 8 chip selects, Configurable Assignment:
  - Static Memory Controller on NCS0
  - SDRAM Controller or Static Memory Controller on NCS1
  - Static Memory Controller on NCS2
  - Static Memory Controller on NCS3, Optional NAND Flash support
  - Static Memory Controller on NCS4 - NCS5, Optional CompactFlash support
  - Static Memory Controller on NCS6-NCS7

### 8.2.2 Static Memory Controller

- 8-, 16- or 32-bit Data Bus
- Multiple Access Modes supported
  - Byte Write or Byte Select Lines
  - Asynchronous read in Page Mode supported (4- up to 32-byte page size)
- Multiple device adaptability
  - Compliant with LCD Module
  - Control signals programmable setup, pulse and hold time for each Memory Bank
- Multiple Wait State Management
  - Programmable Wait State Generation
  - External Wait Request
  - Programmable Data Float Time
- Slow Clock mode supported

### 8.2.3 SDRAM Controller

- Supported devices
  - Standard and Low-power SDRAM (Mobile SDRAM)
- Numerous configurations supported
  - 2K, 4K, 8K Row Address Memory Parts
  - SDRAM with two or four Internal Banks
  - SDRAM with 16- or 32-bit Datapath
- Programming facilities
  - Word, half-word, byte access
  - Automatic page break when Memory Boundary has been reached

- Multibank Ping-pong Access
- Timing parameters specified by software
- Automatic refresh operation, refresh rate is programmable
- Energy-saving capabilities
  - Self-refresh, power down and deep power down modes supported
- Error detection
  - Refresh Error Interrupt
- SDRAM Power-up Initialization by software
- CAS Latency of 1, 2 and 3 supported
- Auto Precharge Command not used

#### 8.2.4 Error Corrected Code Controller

- Hardware Error Corrected Code (ECC) Generation
  - Detection and Correction by Software
- Supports NAND Flash and SmartMedia™ Devices with 8- or 16-bit Data Path.
- Supports NAND Flash/SmartMedia with Page Sizes of 528, 1056, 2112 and 4224 Bytes, Specified by Software
- Supports 1 bit correction for a page of 512,1024,2048 and 4096 Bytes with 8- or 16-bit Data Path
- Supports 1 bit correction per 512 bytes of data for a page size of 512, 2048 and 4096 Bytes with 8-bit Data Path
- Supports 1 bit correction per 256 bytes of data for a page size of 512, 2048 and 4096 Bytes with 8-bit Data Path

## 9. System Controller

The System Controller is a set of peripherals, which allow handling of key elements of the system, such as power, resets, clocks, time, interrupts, watchdog, etc.

The System Controller User Interface embeds also the registers allowing to configure the Matrix and a set of registers for the chip configuration. The chip configuration registers allows configuring:

- EBI chip select assignment and Voltage range for external memories

The System Controller's peripherals are all mapped within the highest 16 Kbytes of address space, between addresses 0xFFFF E800 and 0xFFFF FFFF.

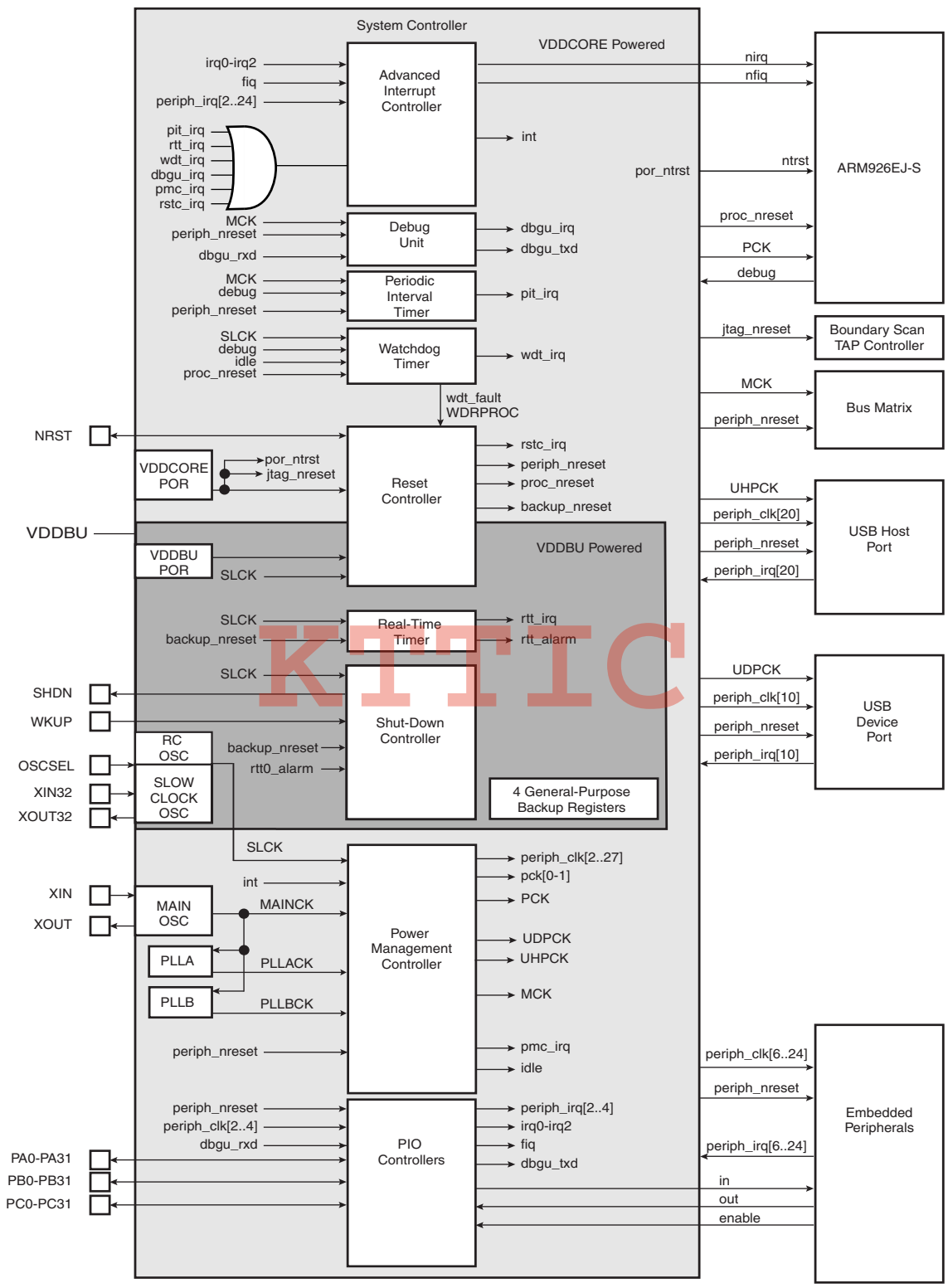
However, all the registers of System Controller are mapped on the top of the address space. All the registers of the System Controller can be addressed from a single pointer by using the standard ARM instruction set, as the Load/Store instruction has an indexing mode of  $\pm 4$  Kbytes.

[Figure 9-1 on page 24](#) shows the System Controller block diagram.

[Figure 8-1 on page 19](#) shows the mapping of the User Interfaces of the System Controller peripherals.

### 9.1 System Controller Block Diagram

Figure 9-1. AT91SAM9G20 System Controller Block Diagram





## 9.2 Reset Controller

- Based on two Power-on-Reset cell
  - one on VDDDBU and one on VDDCORE
- Status of the last reset
  - Either general reset (VDDDBU rising), wake-up reset (VDDCORE rising), software reset, user reset or watchdog reset
- Controls the internal resets and the NRST pin output
  - Allows shaping a reset signal for the external devices

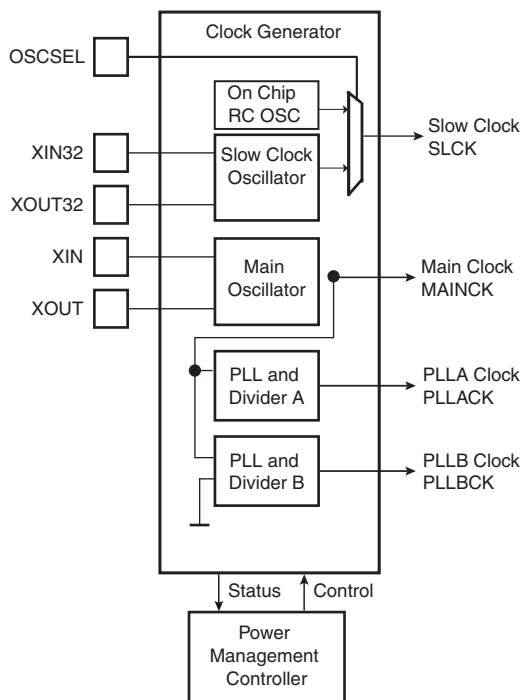
## 9.3 Shutdown Controller

- Shutdown and Wake-Up logic
  - Software programmable assertion of the SHDWN pin
  - Deassertion Programmable on a WKUP pin level change or on alarm

## 9.4 Clock Generator

- Embeds a Low Power 32768 Hz Slow Clock Oscillator and a Low power RC oscillator selectable with OSCSEL signal
  - Provides the permanent Slow Clock SLCK to the system
- Embeds the Main Oscillator
  - Oscillator bypass feature
  - Supports 3 to 20 MHz crystals
- Embeds 2 PLLs
  - The PLL A outputs 400-800 MHz clock
  - The PLL B outputs 100 MHz clock
  - Both integrate an input divider to increase output accuracy
  - PLL A and PLL B embed their own filters

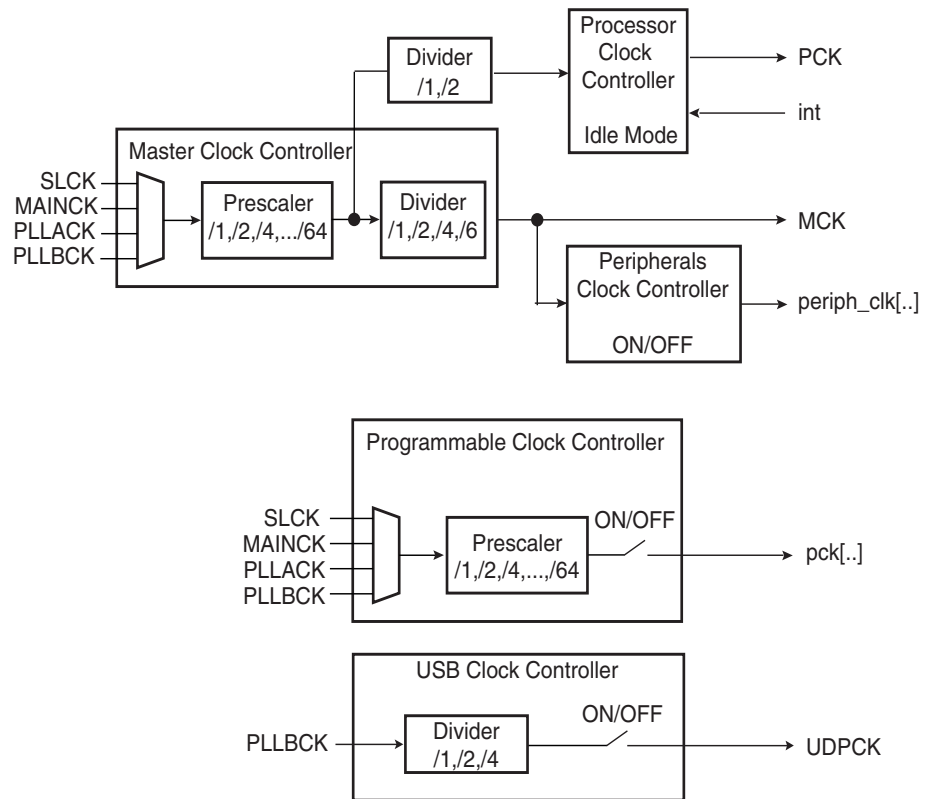
**Figure 9-2.** Clock Generator Block Diagram



## 9.5 Power Management Controller

- Provides:
  - the Processor Clock PCK
  - the Master Clock MCK, in particular to the Matrix and the memory interfaces. The MCK divider can be 1,2,4,6
  - the USB Device Clock UDPCK
  - independent peripheral clocks, typically at the frequency of MCK
  - 2 programmable clock outputs: PCK0, PCK1
- Five flexible operating modes:
  - Normal Mode, processor and peripherals running at a programmable frequency
  - Idle Mode, processor stopped waiting for an interrupt
  - Slow Clock Mode, processor and peripherals running at low frequency
  - Standby Mode, mix of Idle and Backup Mode, peripheral running at low frequency, processor stopped waiting for an interrupt
  - Backup Mode, Main Power Supplies off, VDDBU powered by a battery

Figure 9-3. AT91SAM9G20 Power Management Controller Block Diagram



## 9.6 Periodic Interval Timer

- Includes a 20-bit Periodic Counter, with less than 1  $\mu$ s accuracy
- Includes a 12-bit Interval Overlay Counter
- Real Time OS or Linux®/Windows CE® compliant tick generator

## 9.7 Watchdog Timer

- 16-bit key-protected only-once-Programmable Counter
- Windowed, prevents the processor being in a dead-lock on the watchdog access

## 9.8 Real-time Timer

- Real-time Timer 32-bit free-running back-up Counter
- Integrates a 16-bit programmable prescaler running on slow clock
- Alarm Register capable of generating a wake-up of the system through the Shutdown Controller

## 9.9 General-purpose Back-up Registers

- Four 32-bit backup general-purpose registers

## 9.10 Advanced Interrupt Controller

- Controls the interrupt lines (nIRQ and nFIQ) of the ARM Processor
- Thirty-two individually maskable and vectored interrupt sources

- Source 0 is reserved for the Fast Interrupt Input (FIQ)
- Source 1 is reserved for system peripherals
- Programmable Edge-triggered or Level-sensitive Internal Sources
- Programmable Positive/Negative Edge-triggered or High/Low Level-sensitive
- Three External Sources plus the Fast Interrupt signal
- 8-level Priority Controller
  - Drives the Normal Interrupt of the processor
  - Handles priority of the interrupt sources 1 to 31
  - Higher priority interrupts can be served during service of lower priority interrupt
- Vectoring
  - Optimizes Interrupt Service Routine Branch and Execution
  - One 32-bit Vector Register per interrupt source
  - Interrupt Vector Register reads the corresponding current Interrupt Vector
- Protect Mode
  - Easy debugging by preventing automatic operations when protect models are enabled
- Fast Forcing
  - Permits redirecting any normal interrupt source on the Fast Interrupt of the processor

## 9.11 Debug Unit

- Composed of two functions:
  - Two-pin UART
  - Debug Communication Channel (DCC) support
- Two-pin UART
  - Implemented features are 100% compatible with the standard Atmel<sup>®</sup> USART
  - Independent receiver and transmitter with a common programmable Baud Rate Generator
  - Even, Odd, Mark or Space Parity Generation
  - Parity, Framing and Overrun Error Detection
  - Automatic Echo, Local Loopback and Remote Loopback Channel Modes
  - Support for two PDC channels with connection to receiver and transmitter
- Debug Communication Channel Support
  - Offers visibility of and interrupt trigger from COMMRX and COMMTX signals from the ARM Processor's ICE Interface

## 9.12 Chip Identification

- Chip ID: 0x019905A1
- JTAG ID: 0x05B2403F
- ARM926 TAP ID: 0x0792603F

## 10. Peripherals

### 10.1 User Interface

The peripherals are mapped in the upper 256 Mbytes of the address space between the addresses 0xFFFA 0000 and 0xFFFC FFFF. Each User Peripheral is allocated 16 Kbytes of address space. A complete memory map is presented in [Figure 8-1 on page 19](#).

### 10.2 Identifiers

[Table 10-1](#) defines the Peripheral Identifiers of the AT91SAM9G20. A peripheral identifier is required for the control of the peripheral interrupt with the Advanced Interrupt Controller and for the control of the peripheral clock with the Power Management Controller.

**Table 10-1.** AT91SAM9G20 Peripheral Identifiers (Continued)

| Peripheral ID | Peripheral Mnemonic | Peripheral Name               | External Interrupt |
|---------------|---------------------|-------------------------------|--------------------|
| 0             | AIC                 | Advanced Interrupt Controller | FIQ                |
| 1             | SYSC                | System Controller Interrupt   |                    |
| 2             | PIOA                | Parallel I/O Controller A     |                    |
| 3             | PIOB                | Parallel I/O Controller B     |                    |
| 4             | PIOC                | Parallel I/O Controller C     |                    |
| 5             | ADC                 | Analog to Digital Converter   |                    |
| 6             | US0                 | USART 0                       |                    |
| 7             | US1                 | USART 1                       |                    |
| 8             | US2                 | USART 2                       |                    |
| 9             | MCI                 | Multimedia Card Interface     |                    |
| 10            | UDP                 | USB Device Port               |                    |
| 11            | TWI                 | Two-wire Interface            |                    |
| 12            | SPI0                | Serial Peripheral Interface 0 |                    |
| 13            | SPI1                | Serial Peripheral Interface 1 |                    |
| 14            | SSC                 | Synchronous Serial Controller |                    |
| 15            | -                   | Reserved                      |                    |
| 16            | -                   | Reserved                      |                    |
| 17            | TC0                 | Timer/Counter 0               |                    |
| 18            | TC1                 | Timer/Counter 1               |                    |
| 19            | TC2                 | Timer/Counter 2               |                    |
| 20            | UHP                 | USB Host Port                 |                    |
| 21            | EMAC                | Ethernet MAC                  |                    |
| 22            | ISI                 | Image Sensor Interface        |                    |
| 23            | US3                 | USART 3                       |                    |
| 24            | US4                 | USART 4                       |                    |
| 25            | US5                 | USART 5                       |                    |
| 26            | TC3                 | Timer/Counter 3               |                    |
| 27            | TC4                 | Timer/Counter 4               |                    |
| 28            | TC5                 | Timer/Counter 5               |                    |

**Table 10-1.** AT91SAM9G20 Peripheral Identifiers (Continued)

| Peripheral ID | Peripheral Mnemonic | Peripheral Name               | External Interrupt |
|---------------|---------------------|-------------------------------|--------------------|
| 29            | AIC                 | Advanced Interrupt Controller | IRQ0               |
| 30            | AIC                 | Advanced Interrupt Controller | IRQ1               |
| 31            | AIC                 | Advanced Interrupt Controller | IRQ2               |

Note: Setting AIC, SYSC, UHP, ADC and IRQ0-2 bits in the clock set/clear registers of the PMC has no effect. The ADC clock is automatically started for the first conversion. In Sleep Mode the ADC clock is automatically stopped after each conversion.

## 10.2.1 Peripheral Interrupts and Clock Control

### 10.2.1.1 System Interrupt

The System Interrupt in Source 1 is the wired-OR of the interrupt signals coming from:

- the SDRAM Controller
- the Debug Unit
- the Periodic Interval Timer
- the Real-time Timer
- the Watchdog Timer
- the Reset Controller
- the Power Management Controller

The clock of these peripherals cannot be deactivated and Peripheral ID 1 can only be used within the Advanced Interrupt Controller.

### 10.2.1.2 External Interrupts

All external interrupt signals, i.e., the Fast Interrupt signal FIQ or the Interrupt signals IRQ0 to IRQ2, use a dedicated Peripheral ID. However, there is no clock control associated with these peripheral IDs.

## 10.3 Peripheral Signal Multiplexing on I/O Lines

The AT91SAM9G20 features 3 PIO controllers (PIOA, PIOB, PIOC) that multiplex the I/O lines of the peripheral set.

Each PIO Controller controls up to 32 lines. Each line can be assigned to one of two peripheral functions, A or B. [Table 10-2 on page 31](#), [Table 10-3 on page 32](#) and [Table 10-4 on page 33](#) define how the I/O lines of the peripherals A and B are multiplexed on the PIO Controllers. The two columns “Function” and “Comments” have been inserted in this table for the user’s own comments; they may be used to track how pins are defined in an application.

Note that some peripheral functions which are output only might be duplicated within both tables.

The column “Reset State” indicates whether the PIO Line resets in I/O mode or in peripheral mode. If I/O appears, the PIO Line resets in input with the pull-up enabled, so that the device is maintained in a static state as soon as the reset is released. As a result, the bit corresponding to the PIO Line in the register PIO\_PSR (Peripheral Status Register) resets low.

If a signal name appears in the “Reset State” column, the PIO Line is assigned to this function and the corresponding bit in PIO\_PSR resets high. This is the case of pins controlling memories, in particular the address lines, which require the pin to be driven as soon as the reset is released. Note that the pull-up resistor is also enabled in this case.

10.3.1 PIO Controller A Multiplexing

Table 10-2. Multiplexing on PIO Controller A

| PIO Controller A |              |              |          |             | Application Usage |          |          |
|------------------|--------------|--------------|----------|-------------|-------------------|----------|----------|
| I/O Line         | Peripheral A | Peripheral B | Comments | Reset State | Power Supply      | Function | Comments |
| PA0              | SPI0_MISO    | MCDB0        |          | I/O         | VDDIOP            |          |          |
| PA1              | SPI0_MOSI    | MCCDB        |          | I/O         | VDDIOP            |          |          |
| PA2              | SPI0_SPCK    |              |          | I/O         | VDDIOP            |          |          |
| PA3              | SPI0_NPCS0   | MCDB3        |          | I/O         | VDDIOP            |          |          |
| PA4              | RTS2         | MCDB2        |          | I/O         | VDDIOP            |          |          |
| PA5              | CTS2         | MCDB1        |          | I/O         | VDDIOP            |          |          |
| PA6              | MCDA0        |              |          | I/O         | VDDIOP            |          |          |
| PA7              | MCCDA        |              |          | I/O         | VDDIOP            |          |          |
| PA8              | MCCK         |              |          | I/O         | VDDIOP            |          |          |
| PA9              | MCDA1        |              |          | I/O         | VDDIOP            |          |          |
| PA10             | MCDA2        | ETX2         |          | I/O         | VDDIOP            |          |          |
| PA11             | MCDA3        | ETX3         |          | I/O         | VDDIOP            |          |          |
| PA12             | ETX0         |              |          | I/O         | VDDIOP            |          |          |
| PA13             | ETX1         |              |          | I/O         | VDDIOP            |          |          |
| PA14             | ERX0         |              |          | I/O         | VDDIOP            |          |          |
| PA15             | ERX1         |              |          | I/O         | VDDIOP            |          |          |
| PA16             | ETXEN        |              |          | I/O         | VDDIOP            |          |          |
| PA17             | ERXDV        |              |          | I/O         | VDDIOP            |          |          |
| PA18             | ERXER        |              |          | I/O         | VDDIOP            |          |          |
| PA19             | ETXCK        |              |          | I/O         | VDDIOP            |          |          |
| PA20             | EMDC         |              |          | I/O         | VDDIOP            |          |          |
| PA21             | EMDIO        |              |          | I/O         | VDDIOP            |          |          |
| PA22             | ADTRG        | ETXER        |          | I/O         | VDDIOP            |          |          |
| PA23             | TWD          | ETX2         |          | I/O         | VDDIOP            |          |          |
| PA24             | TWCK         | ETX3         |          | I/O         | VDDIOP            |          |          |
| PA25             | TCLK0        | ERX2         |          | I/O         | VDDIOP            |          |          |
| PA26             | TIOA0        | ERX3         |          | I/O         | VDDIOP            |          |          |
| PA27             | TIOA1        | ERXCK        |          | I/O         | VDDIOP            |          |          |
| PA28             | TIOA2        | ECRS         |          | I/O         | VDDIOP            |          |          |
| PA29             | SCK1         | ECOL         |          | I/O         | VDDIOP            |          |          |
| PA30             | SCK2         | RXD4         |          | I/O         | VDDIOP            |          |          |
| PA31             | SCK0         | TXD4         |          | I/O         | VDDIOP            |          |          |

### 10.3.2 PIO Controller B Multiplexing

**Table 10-3.** Multiplexing on PIO Controller B

| PIO Controller B |              |              |          |             | Application Usage |          |          |
|------------------|--------------|--------------|----------|-------------|-------------------|----------|----------|
| I/O Line         | Peripheral A | Peripheral B | Comments | Reset State | Power Supply      | Function | Comments |
| PB0              | SPI1_MISO    | TIOA3        |          | I/O         | VDDIOP            |          |          |
| PB1              | SPI1_MOSI    | TIOB3        |          | I/O         | VDDIOP            |          |          |
| PB2              | SPI1_SPCK    | TIOA4        |          | I/O         | VDDIOP            |          |          |
| PB3              | SPI1_NPCS0   | TIOA5        |          | I/O         | VDDIOP            |          |          |
| PB4              | TXD0         |              |          | I/O         | VDDIOP            |          |          |
| PB5              | RXD0         |              |          | I/O         | VDDIOP            |          |          |
| PB6              | TXD1         | TCLK1        |          | I/O         | VDDIOP            |          |          |
| PB7              | RXD1         | TCLK2        |          | I/O         | VDDIOP            |          |          |
| PB8              | TXD2         |              |          | I/O         | VDDIOP            |          |          |
| PB9              | RXD2         |              |          | I/O         | VDDIOP            |          |          |
| PB10             | TXD3         | ISI_D8       |          | I/O         | VDDIOP            |          |          |
| PB11             | RXD3         | ISI_D9       |          | I/O         | VDDIOP            |          |          |
| PB12             | TXD5         | ISI_D10      |          | I/O         | VDDIOP            |          |          |
| PB13             | RXD5         | ISI_D11      |          | I/O         | VDDIOP            |          |          |
| PB14             | DRXD         |              |          | I/O         | VDDIOP            |          |          |
| PB15             | DTXD         |              |          | I/O         | VDDIOP            |          |          |
| PB16             | TK0          | TCLK3        |          | I/O         | VDDIOP            |          |          |
| PB17             | TF0          | TCLK4        |          | I/O         | VDDIOP            |          |          |
| PB18             | TD0          | TIOB4        |          | I/O         | VDDIOP            |          |          |
| PB19             | RD0          | TIOB5        |          | I/O         | VDDIOP            |          |          |
| PB20             | RK0          | ISI_D0       |          | I/O         | VDDIOP            |          |          |
| PB21             | RF0          | ISI_D1       |          | I/O         | VDDIOP            |          |          |
| PB22             | DSR0         | ISI_D2       |          | I/O         | VDDIOP            |          |          |
| PB23             | DCD0         | ISI_D3       |          | I/O         | VDDIOP            |          |          |
| PB24             | DTR0         | ISI_D4       |          | I/O         | VDDIOP            |          |          |
| PB25             | RI0          | ISI_D5       |          | I/O         | VDDIOP            |          |          |
| PB26             | RTS0         | ISI_D6       |          | I/O         | VDDIOP            |          |          |
| PB27             | CTS0         | ISI_D7       |          | I/O         | VDDIOP            |          |          |
| PB28             | RTS1         | ISI_PCK      |          | I/O         | VDDIOP            |          |          |
| PB29             | CTS1         | ISI_VSYNC    |          | I/O         | VDDIOP            |          |          |
| PB30             | PCK0         | ISI_HSYNC    |          | I/O         | VDDIOP            |          |          |
| PB31             | PCK1         | ISI_MCK      |          | I/O         | VDDIOP            |          |          |



10.3.3 PIO Controller C Multiplexing

Table 10-4. Multiplexing on PIO Controller C

| PIO Controller C |              |              |          |             | Application Usage |          |          |
|------------------|--------------|--------------|----------|-------------|-------------------|----------|----------|
| I/O Line         | Peripheral A | Peripheral B | Comments | Reset State | Power Supply      | Function | Comments |
| PC0              |              | SCK3         | AD0      | I/O         | VDDANA            |          |          |
| PC1              |              | PCK0         | AD1      | I/O         | VDDANA            |          |          |
| PC2              |              | PCK1         | AD2      | I/O         | VDDANA            |          |          |
| PC3              |              | SPI1_NPCS3   | AD3      | I/O         | VDDANA            |          |          |
| PC4              | A23          | SPI1_NPCS2   |          | A23         | VDDIOM            |          |          |
| PC5              | A24          | SPI1_NPCS1   |          | A24         | VDDIOM            |          |          |
| PC6              | TIOB2        | CFCE1        |          | I/O         | VDDIOM            |          |          |
| PC7              | TIOB1        | CFCE2        |          | I/O         | VDDIOM            |          |          |
| PC8              | NCS4/CFCS0   | RTS3         |          | I/O         | VDDIOM            |          |          |
| PC9              | NCS5/CFCS1   | TIOB0        |          | I/O         | VDDIOM            |          |          |
| PC10             | A25/CFRNW    | CTS3         |          | A25         | VDDIOM            |          |          |
| PC11             | NCS2         | SPI0_NPCS1   |          | I/O         | VDDIOM            |          |          |
| PC12             | IRQ0         | NCS7         |          | I/O         | VDDIOM            |          |          |
| PC13             | FIQ          | NCS6         |          | I/O         | VDDIOM            |          |          |
| PC14             | NCS3/NANDCS  | IRQ2         |          | I/O         | VDDIOM            |          |          |
| PC15             | NWAIT        | IRQ1         |          | I/O         | VDDIOM            |          |          |
| PC16             | D16          | SPI0_NPCS2   |          | I/O         | VDDIOM            |          |          |
| PC17             | D17          | SPI0_NPCS3   |          | I/O         | VDDIOM            |          |          |
| PC18             | D18          | SPI1_NPCS1   |          | I/O         | VDDIOM            |          |          |
| PC19             | D19          | SPI1_NPCS2   |          | I/O         | VDDIOM            |          |          |
| PC20             | D20          | SPI1_NPCS3   |          | I/O         | VDDIOM            |          |          |
| PC21             | D21          |              |          | I/O         | VDDIOM            |          |          |
| PC22             | D22          | TCLK5        |          | I/O         | VDDIOM            |          |          |
| PC23             | D23          |              |          | I/O         | VDDIOM            |          |          |
| PC24             | D24          |              |          | I/O         | VDDIOM            |          |          |
| PC25             | D25          |              |          | I/O         | VDDIOM            |          |          |
| PC26             | D26          |              |          | I/O         | VDDIOM            |          |          |
| PC27             | D27          |              |          | I/O         | VDDIOM            |          |          |
| PC28             | D28          |              |          | I/O         | VDDIOM            |          |          |
| PC29             | D29          |              |          | I/O         | VDDIOM            |          |          |
| PC30             | D30          |              |          | I/O         | VDDIOM            |          |          |
| PC31             | D31          |              |          | I/O         | VDDIOM            |          |          |

## 10.4 Embedded Peripherals

### 10.4.1 Serial Peripheral Interface

- Supports communication with serial external devices
  - Four chip selects with external decoder support allow communication with up to 15 peripherals
  - Serial memories, such as DataFlash and 3-wire EEPROMs
  - Serial peripherals, such as ADCs, DACs, LCD Controllers, CAN Controllers and Sensors
  - External co-processors
- Master or slave serial peripheral bus interface
  - 8- to 16-bit programmable data length per chip select
  - Programmable phase and polarity per chip select
  - Programmable transfer delays between consecutive transfers and between clock and data per chip select
  - Programmable delay between consecutive transfers
  - Selectable mode fault detection
- Very fast transfers supported
  - Transfers with baud rates up to MCK
  - The chip select line may be left active to speed up transfers on the same device

### 10.4.2 Two-wire Interface

- Compatibility with standard two-wire serial memory
- One, two or three bytes for slave address
- Sequential read/write operations
- Supports either master or slave modes
- Compatible with standard two-wire serial memories
- Master, multi-master and slave mode operation
- Bit rate: up to 400 Kbits
- General Call supported in slave mode
- Connection to Peripheral DMA Controller (PDC) capabilities optimizes data transfers in master mode only
  - One channel for the receiver, one channel for the transmitter
  - Next buffer support

### 10.4.3 USART

- Programmable Baud Rate Generator
- 5- to 9-bit full-duplex synchronous or asynchronous serial communications
  - 1, 1.5 or 2 stop bits in Asynchronous Mode or 1 or 2 stop bits in Synchronous Mode
  - Parity generation and error detection
  - Framing error detection, overrun error detection
  - MSB- or LSB-first
  - Optional break generation and detection

- By 8 or by-16 over-sampling receiver frequency
- Hardware handshaking RTS-CTS
- Optional modem signal management DTR-DSR-DCD-RI
- Receiver time-out and transmitter timeguard
- Optional Multi-drop Mode with address generation and detection
- Optional Manchester Encoding
- RS485 with driver control signal
- ISO7816, T = 0 or T = 1 Protocols for interfacing with smart cards
  - NACK handling, error counter with repetition and iteration limit
- IrDA modulation and demodulation
  - Communication at up to 115.2 Kbps
- Test Modes
  - Remote Loopback, Local Loopback, Automatic Echo

The USART contains features allowing management of the Modem Signals DTR, DSR, DCD and RI. In the AT91SAM9G20, only the USART0 implements these signals, named DTR0, DSR0, DCD0 and RI0.

The USART1 and USART2 do not implement all the modem signals. Only RTS and CTS (RTS1 and CTS1, RTS2 and CTS2, respectively) are implemented in these USARTs for other features.

Thus, programming the USART1, USART2 or the USART3 in Modem Mode may lead to unpredictable results. In these USARTs, the commands relating to the Modem Mode have no effect and the status bits relating the status of the modem signals are never activated.

#### 10.4.4 Serial Synchronous Controller

- Provides serial synchronous communication links used in audio and telecom applications (with CODECs in Master or Slave Modes, I<sup>2</sup>S, TDM Buses, Magnetic Card Reader, etc.)
- Contains an independent receiver and transmitter and a common clock divider
- Offers a configurable frame sync and data length
- Receiver and transmitter can be programmed to start automatically or on detection of different event on the frame sync signal
- Receiver and transmitter include a data signal, a clock signal and a frame synchronization signal

#### 10.4.5 Timer Counter

- Two blocks of three 16-bit Timer Counter channels
- Each channel can be individually programmed to perform a wide range of functions including:
  - Frequency Measurement
  - Event Counting
  - Interval Measurement
  - Pulse Generation
  - Delay Timing
  - Pulse Width Modulation
  - Up/down Capabilities
- Each channel is user-configurable and contains:

- Three external clock inputs
  - Five internal clock inputs
  - Two multi-purpose input/output signals
  - Each block contains two global registers that act on all three TC Channels
- Note: TC Block 0 (TC0, TC1, TC2) and TC Block 1 (TC3, TC4, TC5) have identical user interfaces. See [Figure 8-1, “AT91SAM9G20 Memory Mapping,”](#) on page 19 for TC Block 0 and TC Block 1 base addresses.

#### 10.4.6 Multimedia Card Interface

- One double-channel MultiMedia Card Interface
- Compatibility with MultiMedia Card Specification Version 3.11
- Compatibility with SD Memory Card Specification Version 1.1
- Compatibility with SDIO Specification Version V1.0.
- Card clock rate up to Master Clock divided by 2
- Embedded power management to slow down clock rate when not used
- MCI has two slots, each supporting
  - One slot for one MultiMediaCard bus (up to 30 cards) or
  - One SD Memory Card
- Support for stream, block and multi-block data read and write

#### 10.4.7 USB Host Port

- Compliance with Open HCI Rev 1.0 Specification
- Compliance with USB V2.0 Full-speed and Low-speed Specification
- Supports both Low-Speed 1.5 Mbps and Full-speed 12 Mbps devices
- Root hub integrated with two downstream USB ports in the 217-LFBGA package
- Two embedded USB transceivers
- Supports power management
- Operates as a master on the Matrix

#### 10.4.8 USB Device Port

- USB V2.0 full-speed compliant, 12 Mbits per second
- Embedded USB V2.0 full-speed transceiver
- Embedded 2,432-byte dual-port RAM for endpoints
- Suspend/Resume logic
- Ping-pong mode (two memory banks) for isochronous and bulk endpoints
- Six general-purpose endpoints
  - Endpoint 0 and 3: 64 bytes, no ping-pong mode
  - Endpoint 1 and 2: 64 bytes, ping-pong mode
  - Endpoint 4 and 5: 512 bytes, ping-pong mode
- Embedded pad pull-up

#### 10.4.9 Ethernet 10/100 MAC

- Compatibility with IEEE Standard 802.3
- 10 and 100 MBits per second data throughput capability
- Full- and half-duplex operations
- MII or RMII interface to the physical layer
- Register Interface to address, data, status and control registers
- DMA Interface, operating as a master on the Memory Controller
- Interrupt generation to signal receive and transmit completion
- 28-byte transmit and 28-byte receive FIFOs
- Automatic pad and CRC generation on transmitted frames
- Address checking logic to recognize four 48-bit addresses
- Support promiscuous mode where all valid frames are copied to memory
- Support physical layer management through MDIO interface

#### 10.4.10 Image Sensor Interface

- ITU-R BT. 601/656 8-bit mode external interface support
- Support for ITU-R BT.656-4 SAV and EAV synchronization
- Vertical and horizontal resolutions up to 2048 x 2048
- Preview Path up to 640 x 480 in RGMB mode, 2048 x 2048 in grayscale mode
- Support for packed data formatting for YCbCr 4:2:2 formats
- Preview scaler to generate smaller size image
- Programmable frame capture rate

#### 10.4.11 Analog-to-Digital Converter

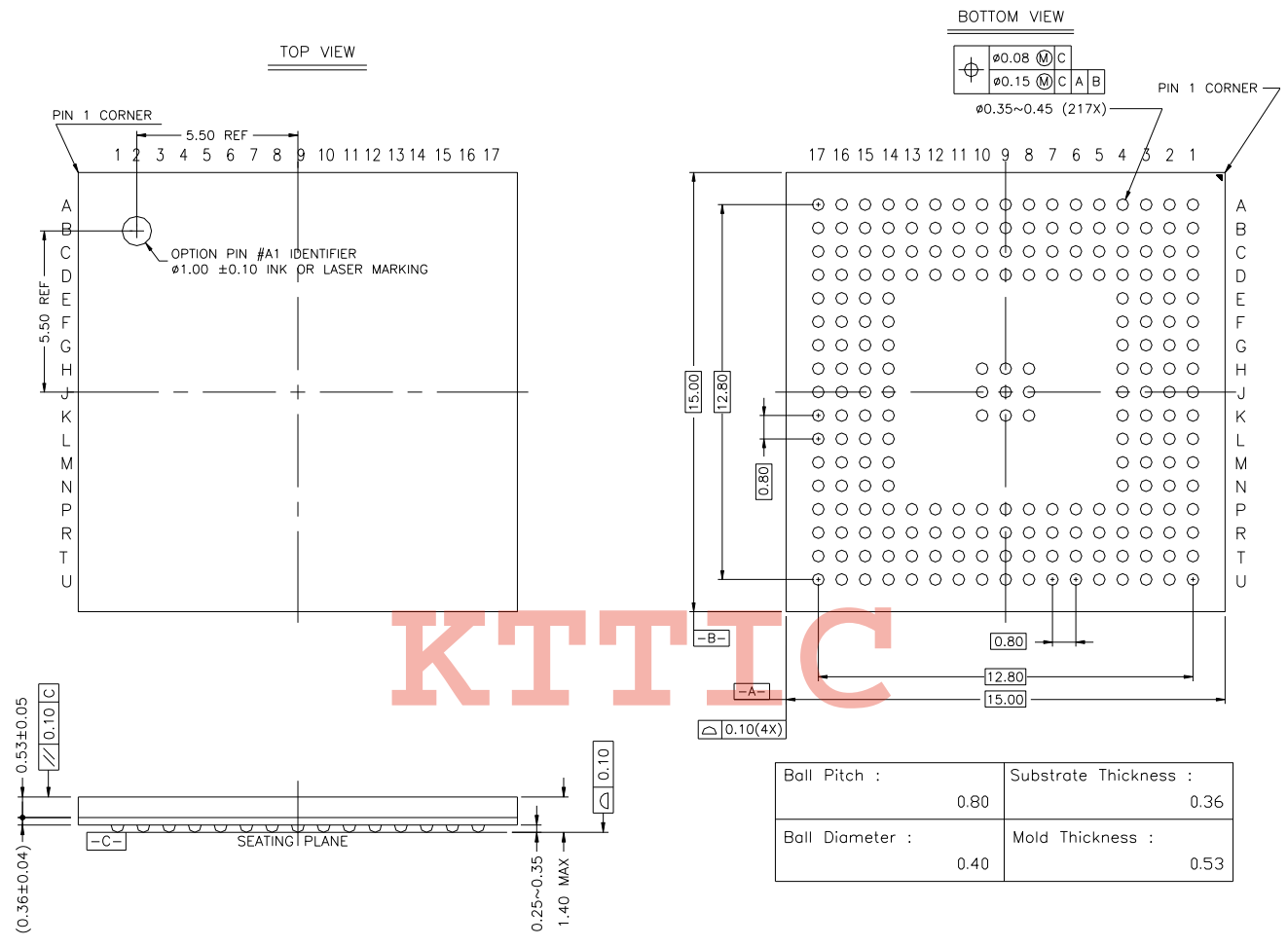
- 4-channel ADC
- 10-bit 312K samples/sec. Successive Approximation Register ADC
- -2/+2 LSB Integral Non Linearity, -1/+1 LSB Differential Non Linearity
- Individual enable and disable of each channel
- External voltage reference for better accuracy on low voltage inputs
- Multiple trigger source – Hardware or software trigger – External trigger pin – Timer Counter 0 to 2 outputs TIOA0 to TIOA2 trigger
- Sleep Mode and conversion sequencer – Automatic wakeup on trigger and back to sleep mode after conversions of all enabled channels
- Four analog inputs shared with digital signals



# 11. Pacakge Drawing

## 11.1 217-ball LFBA Package

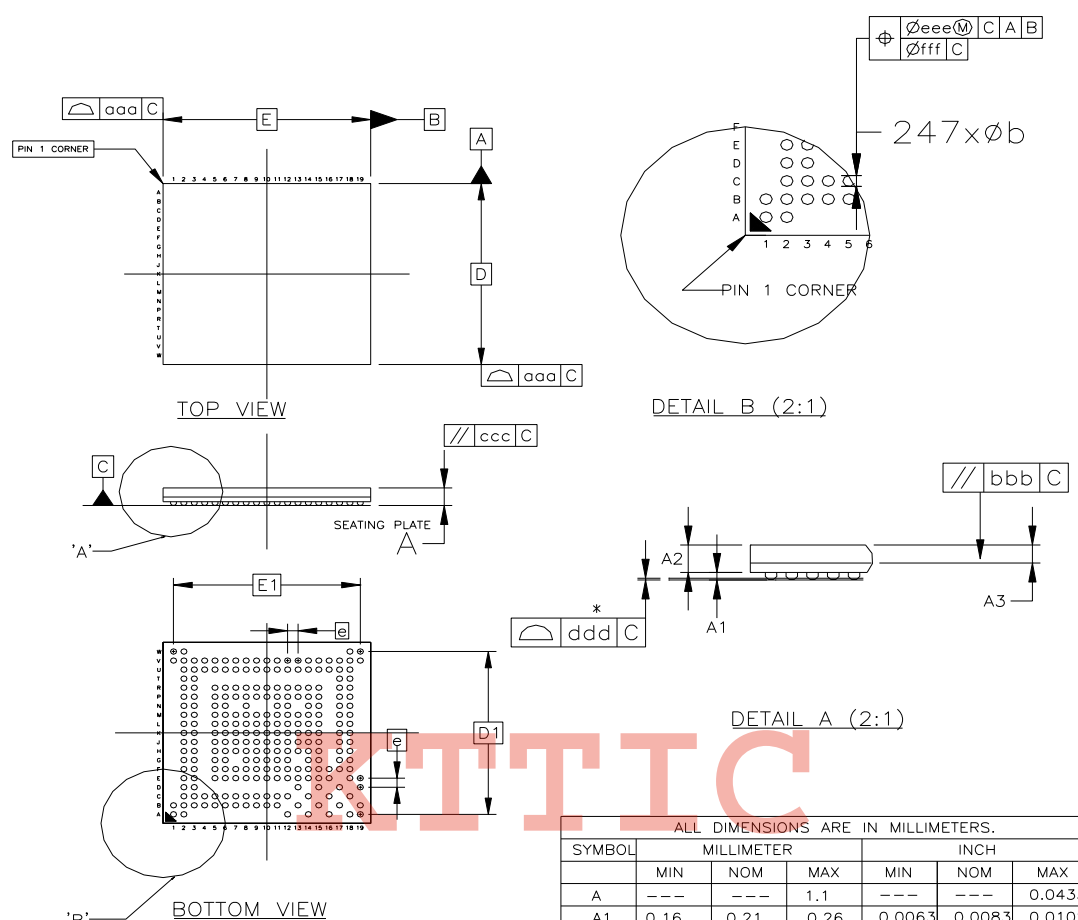
Figure 11-1. 217-ball LFBGA Package Drawing



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11.2 247-ball TFBGA Package

Figure 11-2. 247-ball TFBGA Package Drawing



ALL DIMENSIONS ARE IN MILLIMETERS.

| SYMBOL | MILLIMETER |       |       | INCH         |        |        |
|--------|------------|-------|-------|--------------|--------|--------|
|        | MIN        | NOM   | MAX   | MIN          | NOM    | MAX    |
| A      | ---        | ---   | 1.1   | ---          | ---    | 0.0433 |
| A1     | 0.16       | 0.21  | 0.26  | 0.0063       | 0.0083 | 0.0102 |
| A2     | 0.71       | 0.76  | 0.81  | 0.0280       | 0.0299 | 0.0319 |
| A3     | 0.50 BASIC |       |       | 0.0197BASIC  |        |        |
| D      | 9.90       | 10.00 | 10.10 | 0.3898       | 0.3937 | 0.3976 |
| D1     | 9 BASIC    |       |       | 0.3543BASIC  |        |        |
| E      | 9.90       | 10.00 | 10.10 | 0.3898       | 0.3937 | 0.3976 |
| E1     | 9 BASIC    |       |       | 0.3543BASIC  |        |        |
| e      | 0.5 BASIC  |       |       | 0.0197 BASIC |        |        |
| b      | 0.25       | 0.3   | 0.35  | 0.0098       | 0.0118 | 0.0138 |
| aaa    | 0.15       |       |       | 0.0059       |        |        |
| bbb    | 0.20       |       |       | 0.0078       |        |        |
| ccc    | 0.20       |       |       | 0.0079       |        |        |
| ddd    | 0.08       |       |       | 0.0031       |        |        |
| eee    | 0.15       |       |       | 0.0059       |        |        |
| fff    | 0.05       |       |       | 0.0020       |        |        |



## 12. AT91SAM9G20 Ordering Information

Table 12-1. AT91SAM9G20 Ordering Information


| MRL A Ordering Code | MRL B Ordering Code | Package | Package Type | Temperature Operating Range |
|---------------------|---------------------|---------|--------------|-----------------------------|
| AT91SAM9G20-CU      | AT91SAM9G20B-CU     | BGA217  | Green        | Industrial -40°C to 85°C    |
| -                   | AT91SAM9G20B-CFU    | BGA247  | Green        | Industrial -40°C to 85°C    |

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## Revision History

| Doc. Rev  | Comments   | Change Request Ref.  |
|---|--|----------------------|
| 6348CS  | "Features", Section 4.3 "247-ball TFBGA Package Outline", Section 4.4 "247-ball TFBGA Package Pinout", added 247-ball TFBGA package information.   | 6079                 |
|   | Section 10.4.6 "Multimedia Card Interface", compatibility with MultiMedia Card spec v3.11, SD Memory Card spec v1.1.   | 6080                 |
|   | Signal Description, Table 3-1, added GNDPLL to table   | 6022                 |
|   | Table 3-1, Signal Description and Section 10-4 "Multiplexing on PIO Controller C", EF100 removed.  | 6148                 |
|   | <b>Section 11. "Package Drawing":</b><br>Section 11.2 "247-ball TFBGA Package", added to summary.  | 6079                 |
| <b>Section 12. "AT91SAM9G20 Ordering Information"</b><br>Table 12-1, "AT91SAM9G20 Ordering Information," MLR B ordering information added to summary. | 6079   |                      |
| 6384BS  | <b>Overview</b><br>"Features" on page 1, Debug Unit (DBGU) updated.<br>Section 10.4.3 "USART", "Optional Manchester Encoding" added to list of USART features.<br>Section 8.1.1.1 "BMS = 1, Boot on Embedded ROM",<br>– SDCard, (boot ROM does not support high capacity SDCards) clarification added. | 5846<br>5931<br>5935 |
|   |  Section 6.6 "Shutdown Logic Pins", updated with external pull-up requirement.  | rfo                  |
| 6384AS  | First issue  |                      |

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