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Features

- Core
  - ARM® Cortex®-M3 revision 2.0 running at up to 64 MHz
  - Memory Protection Unit (MPU)
  - Thumb®-2 instruction set
- Pin-to-pin compatible with AT91SAM7S legacy products (64-pin versions), SAM3S4/2/1 products
- Memories
  - 512 Kbytes Single Plane (SAM3S8) embedded Flash, 128-bit wide access, memory accelerator
  - 512 Kbytes Dual Plane (SAM3SD8) embedded Flash, 128-bit wide access, memory accelerator
  - 64 Kbytes embedded SRAM
  - 16 Kbytes ROM with embedded boot loader routines (UART, USB) and IAP routines
  - 8-bit Static Memory Controller (SMC): SRAM, PSRAM, NOR and NAND Flash support
- System
  - Embedded voltage regulator for single supply operation
  - Power-on-Reset (POR), Brown-out Detector (BOD) and Watchdog for safe operation
  - Quartz or ceramic resonator oscillators: 3 to 20 MHz main power with Failure Detection and optional low-power 32.768 kHz for RTC or device clock
  - RTC with Gregorian and Persian Calendar mode, waveform generation in low-power modes
  - RTC clock calibration circuitry for 32.768 kHz crystal frequency compensation
  - High precision 8/12 MHz factory trimmed internal RC oscillator with 4 MHz default frequency for device startup. In-application trimming access for frequency adjustment
  - Slow Clock Internal RC oscillator as permanent low-power mode device clock
  - Two PLLs up to 130 MHz for device clock and for USB
  - Temperature Sensor
  - Up to 24 peripheral DMA (PDC) channels
- Low Power Modes
  - Sleep and Backup modes, down to 1 µA in Backup mode
  - Ultra low-power RTC
- Peripherals
  - USB 2.0 Device: 12 Mbps, 2668 byte FIFO, up to 8 bidirectional Endpoints. On-Chip Transceiver
  - Up to 3 USARTs with ISO7816, IrDA®, RS-485, SPI, Manchester and Modem Mode
  - Two 2-wire UARTs
  - Up to 2 Two Wire Interface (I2C compatible), 1 SPI, 1 Serial Synchronous Controller (I2S), 1 High Speed Multimedia Card Interface (SDIO/SD Card/MMC)
  - 6 Three-Channel 16-bit Timer/Counter with capture, waveform, compare and PWM mode. Quadrature Decoder Logic and 2-bit Gray Up/Down Counter for Stepper Motor
  - 4-channel 16-bit PWM with Complementary Output, Fault Input, 12-bit Dead Time Generator Counter for Motor Control
  - 32-bit Real-time Timer and RTC with calendar and alarm features
  - Up to 15-channel, 1Msps ADC with differential input mode and programmable gain stage and auto calibration
  - One 2-channel 12-bit 1Msps DAC
  - One Analog Comparator with flexible input selection, Selectable input hysteresis
  - 32-bit Cyclic Redundancy Check Calculation Unit (CRCCU)
- I/O
  - Up to 79 I/O lines with external interrupt capability (edge or level sensitivity), debouncing, glitch filtering and on-die Series Resistor Termination
  - Three 32-bit Parallel Input/Output Controllers, Peripheral DMA assisted Parallel Capture Mode
- Packages
  - 100-lead LQFP, 14 x 14 mm, pitch 0.5 mm/100-ball TFBGA, 9 x 9 mm, pitch 0.8 mm
  - 64-lead LQFP, 10 x 10 mm, pitch 0.5 mm/64-pad QFN 9x9 mm, pitch 0.5 mm

AT91SAM ARM-based Flash MCU

SAM3S8/SD8 Series

Summary

11090BS–ATARM–22-Oct-13

1. Description

The Atmel SAM3S8/SD8 series is a member of a family of Flash microcontrollers based on the high performance 32-bit ARM Cortex-M3 RISC processor. It operates at a maximum speed of 64 MHz and features up to 512 Kbytes of Flash (dual plane on SAM3SD8) and up to 64 Kbytes of SRAM. The peripheral set includes a Full Speed USB Device port with embedded transceiver, a High Speed MCI for SDIO/SD/MMC, an External Bus Interface featuring a Static Memory Controller providing connection to SRAM, PSRAM, NOR Flash, LCD Module and NAND Flash, 2(3)x USARTs, (3 on SAM3SD8C) 2x UARTs, 2x TWIs, 3x SPI, an I2S, as well as 1 PWM timer, 6x general-purpose 16-bit timers (with stepper motor and quadrature decoder logic support), an RTC, a 12-bit ADC, a 12-bit DAC and an analog comparator.

The SAM3S8/SD8 series is ready for capacitive touch thanks to the QTouch® library, offering an easy way to implement buttons, wheels and sliders.

The SAM3S8/SD8 device is a medium range general purpose microcontroller with the best ratio in terms of reduced power consumption, processing power and peripheral set. This enables the SAM3S8/SD8 to sustain a wide range of applications including consumer, industrial control, and PC peripherals.

It operates from 1.62V to 3.6V and is available in 64- and 100-pin QFP, 64-pin QFN, and 100-pin BGA packages.

The SAM3S8/SD8 series is the ideal migration path from the SAM7S series for applications that require more performance. The SAM3S8/SD8 series is pin-to-pin compatible with the SAM7S series.

1.1 Configuration Summary

The SAM3S8/SD8 series devices differ in memory size, package and features. Table 1-1 summarizes the configurations of the device family.

Table 1-1. Configuration Summary

Feature	SAM3S8B	SAM3S8C	SAM3SD8B	SAM3SD8C
Flash	512 Kbytes	512 Kbytes	512 Kbytes	512 Kbytes
SRAM	64 Kbytes	64 Kbytes	64 Kbytes	64 Kbytes
Package	LQFP64 QFN64	LQFP100 BGA100	LQFP64 QFN64	LQFP100 BGA100
Number of PIOs	47	79	47	79
12-bit ADC	11 channels(2)	16 channels(2)	11 channels(2)	16 channels(2)
12-bit DAC	2 channels	2 channels	2 channels	2 channels
Timer Counter Channels	6	6	6	6
PDC Channels	22	22	24	24
USART/UART	2/2(1)	2/2(1)	2/2(1)	3/2(1)
HSMCI	1 port/4 bits	1 port/4 bits	1 port/4 bits	1 port/4 bits
External Bus Interface	-	8-bit data, 4 chip selects, 24-bit address	-	8-bit data, 4 chip selects, 24-bit address

Notes: 1. Full Modem support on USART1.
2. One channel is reserved for internal temperature sensor.

2. Block Diagram

Figure 2-1. SAM3S8/SD8 100-pin version Block Diagram

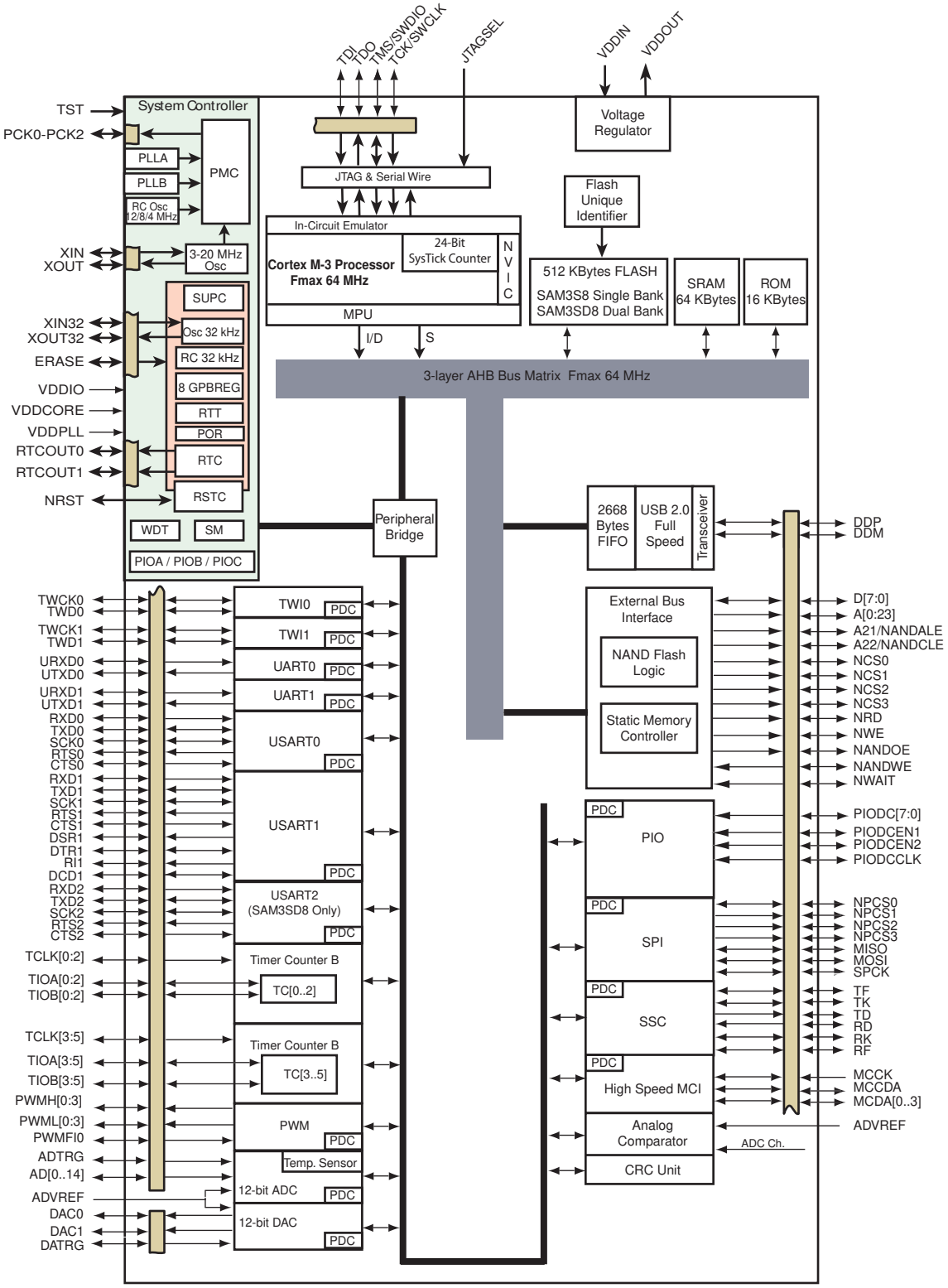
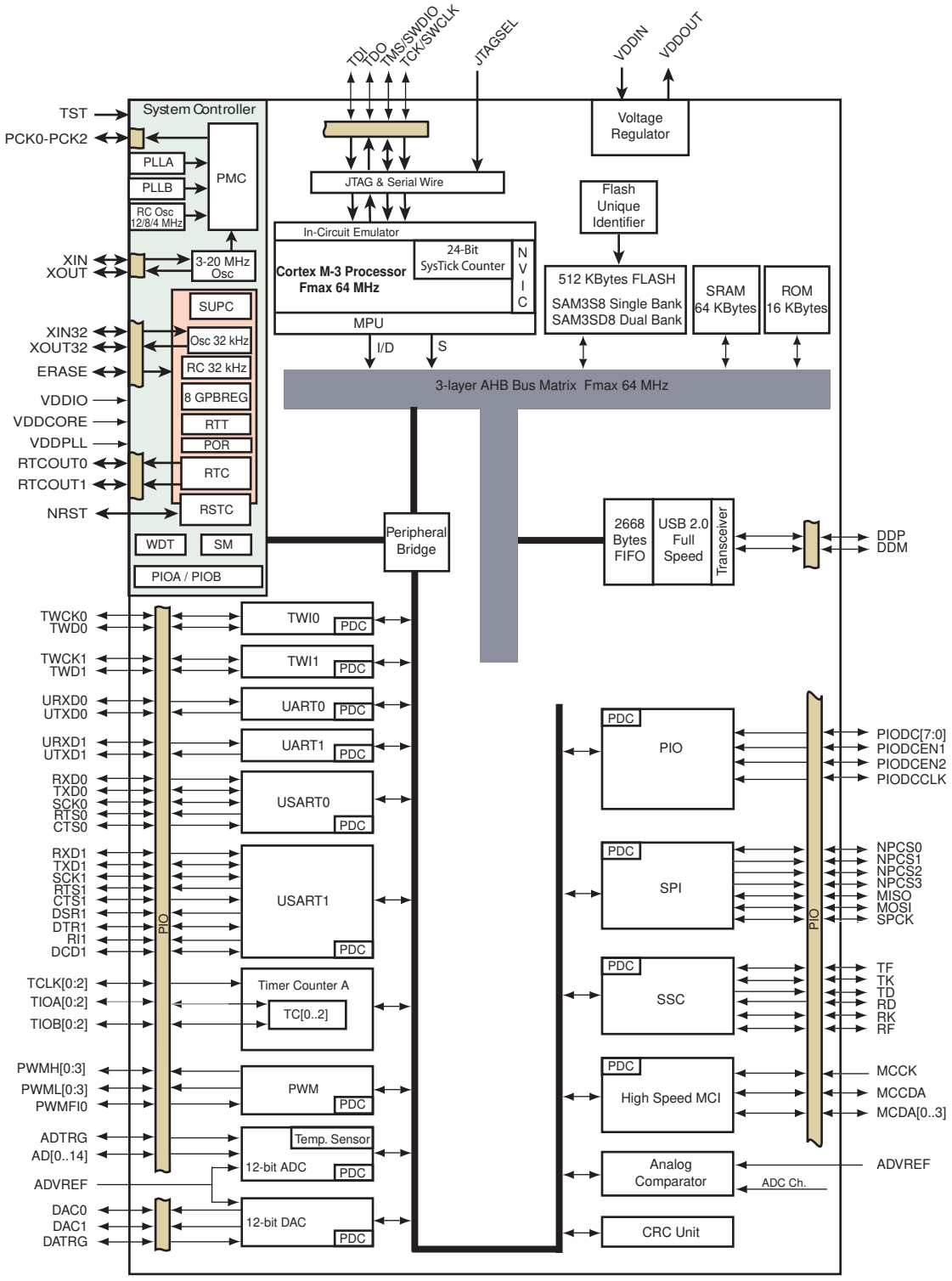


Figure 2-2. SAM3S8/SD8 64-pin version Block Diagram



3. Signal Description

Table 3-1 gives details on signal names classified by peripheral.

Table 3-1. Signal Description List

Signal Name	Function	Type	Active Level	Voltage reference	Comments
Power Supplies					
VDDIO	Peripherals I/O Lines and USB transceiver Power Supply	Power			1.62V to 3.6V
VDDIN	Voltage Regulator Input, ADC, DAC and Analog Comparator Power Supply	Power			1.8V to 3.6V(4)
VDDOUT	Voltage Regulator Output	Power			1.8V Output
VDDPLL	Oscillator and PLL Power Supply	Power			1.62 V to 1.95V
VDDCORE	Power the core, the embedded memories and the peripherals	Power			1.62V to 1.95V
GND	Ground	Ground			
Clocks, Oscillators and PLLs					
XIN	Main Oscillator Input	Input		VDDIO	Reset State: - PIO Input - Internal Pull-up disabled - Schmitt Trigger enabled(1)
XOUT	Main Oscillator Output	Output			
XIN32	Slow Clock Oscillator Input	Input			
XOUT32	Slow Clock Oscillator Output	Output			
PCK0 - PCK2	Programmable Clock Output	Output			Reset State: - PIO Input - Internal Pull-up enabled - Schmitt Trigger enabled(1)
Real Time Clock					
RTCOUT0	Programmable RTC waveform output	Output		VDDIO	Reset State: - PIO Input - Internal Pull-up disabled - Schmitt Trigger enabled(1)
RTCOUT1	Programmable RTC waveform output	Output			
Serial Wire/JTAG Debug Port - SWJ-DP					
TCK/SWCLK	Test Clock/Serial Wire Clock	Input		VDDIO	Reset State: - SWJ-DP Mode - Internal pull-up disabled(5) - Schmitt Trigger enabled(1)
TDI	Test Data In	Input			
TDO/TRACESWO	Test Data Out / Trace Asynchronous Data Out	Output			
TMS/SWDIO	Test Mode Select /Serial Wire Input/Output	Input / I/O			
JTAGSEL	JTAG Selection	Input	High		Permanent Internal pull-down

Table 3-1. Signal Description List (Continued)

Signal Name	Function	Type	Active Level	Voltage reference	Comments
Flash Memory					
ERASE	Flash and NVM Configuration Bits Erase Command	Input	High	VDDIO	Reset State: - Erase Input - Internal pull-down enabled - Schmitt Trigger enabled[1]
Reset/Test					
NRST	Synchronous Microcontroller Reset	I/O	Low	VDDIO	Permanent Internal pull-up
TST	Test Select	Input			Permanent Internal pull-down
Universal Asynchronous Receiver Transceiver - UARTx					
URXDx	UART Receive Data	Input			
UTXDx	UART Transmit Data	Output			
PIO Controller - PIOA - PIOB - PIOC					
PA0 - PA31	Parallel IO Controller A	I/O		VDDIO	Reset State: - PIO or System IOs[2] - Internal pull-up enabled - Schmitt Trigger enabled[1]
PB0 - PB14	Parallel IO Controller B	I/O			
PC0 - PC31	Parallel IO Controller C	I/O			
PIO Controller - Parallel Capture Mode					
PIODC0-PIODC7	Parallel Capture Mode Data	Input		VDDIO	
PIODCCLK	Parallel Capture Mode Clock	Input			
PIODCEN1-2	Parallel Capture Mode Enable	Input			
External Bus Interface					
D0 - D7	Data Bus	I/O			
A0 - A23	Address Bus	Output			
NWAIT	External Wait Signal	Input	Low		
Static Memory Controller - SMC					
NCS0 - NCS3	Chip Select Lines	Output	Low		
NRD	Read Signal	Output	Low		
NWE	Write Enable	Output	Low		
NAND Flash Logic					
NANDOE	NAND Flash Output Enable	Output	Low		
NANDWE	NAND Flash Write Enable	Output	Low		
High Speed Multimedia Card Interface - HSMCI					
MCCK	Multimedia Card Clock	I/O			
MCCDA	Multimedia Card Slot A Command	I/O			
MCDA0 - MCDA3	Multimedia Card Slot A Data	I/O			

Table 3-1. Signal Description List (Continued)

Signal Name	Function	Type	Active Level	Voltage reference	Comments
Universal Synchronous Asynchronous Receiver Transmitter USARTx					
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			
DTR1	USART1 Data Terminal Ready	I/O			
DSR1	USART1 Data Set Ready	Input			
DCD1	USART1 Data Carrier Detect	Output			
RI1	USART1 Ring Indicator	Input			
Synchronous Serial Controller - SSC					
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			
Timer/Counter - TC					
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			
Pulse Width Modulation Controller- PWMC					
PWMHx	PWM Waveform Output High for channel x	Output			
PWMLx	PWM Waveform Output Low for channel x	Output			only output in complementary mode when dead time insertion is enabled.
PWMFI0	**PWM Fault Input**	Input			
Serial Peripheral Interface - SPI					
MISO	Master In Slave Out	I/O			
MOSI	Master Out Slave In	I/O			
SPCK	SPI Serial Clock	I/O			
SPI_NPCS0	SPI Peripheral Chip Select 0	I/O	Low		
SPI_NPCS1 - SPI_NPCS3	SPI Peripheral Chip Select	Output	Low		

Table 3-1. Signal Description List (Continued)

Signal Name	Function	Type	Active Level	Voltage reference	Comments
Two-Wire Interface- TWI					
TWDx	TWIx Two-wire Serial Data	I/O			
TWCKx	TWIx Two-wire Serial Clock	I/O			
Analog					
ADVREF	ADC, DAC and Analog Comparator Reference	Analog			
12-bit Analog-to-Digital Converter - ADC					
AD0-AD14	Analog Inputs	Analog, Digital			
ADTRG	ADC Trigger	Input		VDDIO	
12-bit Digital-to-Analog Converter - DAC					
DAC0 - DAC1	Analog output	Analog, Digital			
DACTRG	DAC Trigger	Input		VDDIO	
Fast Flash Programming Interface - FFPI					
PGMEN0-PGMEN2	Programming Enabling	Input		VDDIO	
PGMM0-PGMM3	Programming Mode	Input		VDDIO	
PGMD0-PGMD15	Programming Data	I/O			
PGMRDY	Programming Ready	Output	High		
PGMNVALID	Data Direction	Output	Low		
PGMNOE	Programming Read	Input	Low		
PGMCK	Programming Clock	Input			
PGMNCMD	Programming Command	Input	Low		
USB Full Speed Device					
DDM	USB Full Speed Data -	Analog, Digital		VDDIO	Reset State: - USB Mode - Internal Pull-down(3)
DDP	USB Full Speed Data +				

Note:
1. Schmitt Triggers can be disabled through PIO registers.
2. Some PIO lines are shared with System I/Os.
3. Refer to USB Section of the product Electrical Characteristics for information on Pull-down value in USB Mode.
4. See “Typical Powering Schematics” Section for restrictions on voltage range of Analog Cells.
5. TDO pin is set in input mode when the Cortex-M3 Core is not in debug mode. Thus the internal pull-up corresponding to this PIO line must be enabled to avoid current consumption due to floating input.

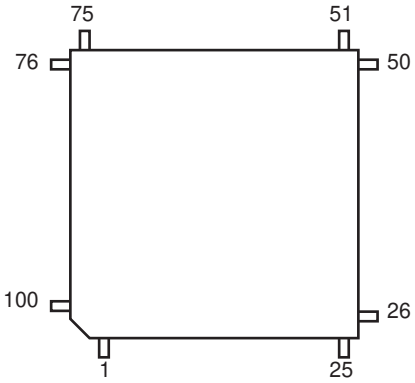
4. Package and Pinout

SAM3S8/SD8 devices are pin-to-pin compatible with AT91SAM7S legacy products for 64-pin version. Furthermore, SAM3S8/SD8 products have new functionalities referenced in italic in Table 4-1, Table 4-3.

4.1 SAM3S8C/8DC Package and Pinout

4.1.1 100-Lead LQFP Package Outline

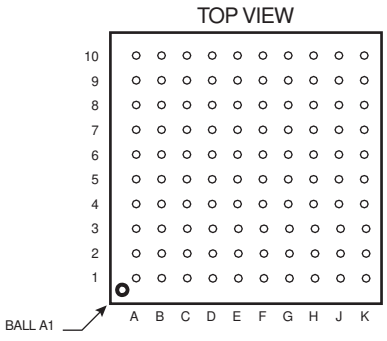
Figure 4-1. Orientation of the 100-lead LQFP Package



4.1.2 100-ball TFBGA Package Outline

The 100-Ball TFBGA package has a 0.8 mm ball pitch and respects Green Standards. Its dimensions are 9 x 9 x 1.1 mm. Figure 4-2 shows the orientation of the 100-ball TFBGA Package.

Figure 4-2. Orientation of the 100-ball TFBGA Package



4.1.3 100-Lead LQFP Pinout

Table 4-1. SAM3S8C/SD8C 100-lead LQFP pinout

1	ADVREF	26	GND	51	TDI/PB4	76	TDO/TRACESWO/ PB5
2	GND	27	VDDIO	52	PA6/PGMNOE	77	JTAGSEL
3	PB0/AD4	28	PA16/PGMD4	53	PA5/PGMRDY	78	PC18
4	PC29/AD13	29	PC7	54	PC28	79	TMS/SWDIO/PB6
5	PB1/AD5	30	PA15/PGMD3	55	PA4/PGMNCMD	80	PC19
6	PC30/AD14	31	PA14/PGMD2	56	VDDCORE	81	PA31
7	PB2/AD6	32	PC6	57	PA27/PGMD15	82	PC20
8	PC31	33	PA13/PGMD1	58	PC8	83	TCK/SWCLK/PB7
9	PB3/AD7	34	PA24/PGMD12	59	PA28	84	PC21
10	VDDIN	35	PC5	60	NRST	85	VDDCORE
11	VDDOUT	36	VDDCORE	61	TST	86	PC22
12	PA17/PGMD5/AD0	37	PC4	62	PC9	87	ERASE/PB12
13	PC26	38	PA25/PGMD13	63	PA29	88	DDM/PB10
14	PA18/PGMD6/AD1	39	PA26/PGMD14	64	PA30	89	DDP/PB11
15	PA21/PGMD9/AD8	40	PC3	65	PC10	90	PC23
16	VDDCORE	41	PA12/PGMD0	66	PA3	91	VDDIO
17	PC27	42	PA11/PGMM3	67	PA2/PGMEN2	92	PC24
18	PA19/PGMD7/AD2	43	PC2	68	PC11	93	PB13/DAC0
19	PC15/AD11	44	PA10/PGMM2	69	VDDIO	94	PC25
20	PA22/PGMD10/AD 9	45	GND	70	GND	95	GND
21	PC13/AD10	46	PA9/PGMM1	71	PC14	96	PB8/XOUT
22	PA23/PGMD11	47	PC1	72	PA1/PGMEN1	97	PB9/*PGMCK/XIN*
23	PC12/AD12	48	PA8/XOUT32/ PGMM0	73	PC16	98	VDDIO
24	PA20/PGMD8/AD3	49	PA7/XIN32/ PGMNVALID	74	PA0/PGMEN0	99	PB14/DAC1
25	PC0	50	VDDIO	75	PC17	100	VDDPLL

4.1.4 100-Ball TFBGA Pinout

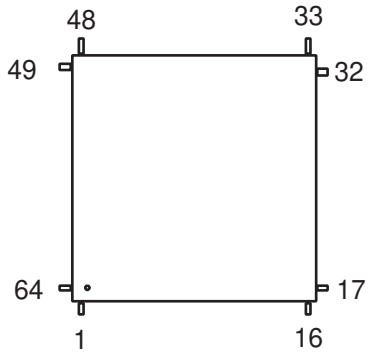
Table 4-2. SAM3S8C/SD8C 100-ball TFBGA pinout

A1	PB1/AD5	C6	TCK/SWCLK/PB7	F1	PA18/PGMD6/AD1	H6	PC4
A2	PC29	C7	PC16	F2	PC26	H7	PA11/PGMM3
A3	VDDIO	C8	PA1/PGMEN1	F3	VDDOUT	H8	PC1
A4	PB9/PGMCK/XIN	C9	PC17	F4	GND	H9	PA6/PGMNOE
A5	PB8/XOUT	C10	PA0/PGMEN0	F5	VDDIO	H10	TDI/PB4
A6	PB13/DAC0	D1	PB3/AD7	F6	PA27/PGMD15	J1	PC15/AD11
A7	DDP/PB11	D2	PB0/AD4	F7	PC8	J2	PC0
A8	DDM/PB10	D3	PC24	F8	PA28	J3	PA16/PGMD4
A9	TMS/SWDIO/PB6	D4	PC22	F9	TST	J4	PC6
A10	JTAGSEL	D5	GND	F10	PC9	J5	PA24/PGMD12
B1	PC30	D6	GND	G1	PA21/PGMD9/AD8	J6	PA25/PGMD13
B2	ADVREF	D7	VDDCORE	G2	PC27	J7	PA10/PGMM2
B3	GNDANA	D8	PA2/PGMEN2	G3	PA15/PGMD3	J8	GND
B4	PB14/DAC1	D9	PC11	G4	VDDCORE	J9	VDDCORE
B5	PC21	D10	PC14	G5	VDDCORE	J10	VDDIO
B6	PC20	E1	PA17/PGMD5/AD0	G6	PA26/PGMD14	K1	PA22/PGMD10/AD9
B7	PA31	E2	PC31	G7	PA12/PGMD0	K2	PC13/AD10
B8	PC19	E3	VDDIN	G8	PC28	K3	PC12/AD12
B9	PC18	E4	GND	G9	PA4/PGMNCMD	K4	PA20/PGMD8/AD3
B10	TDO/TRACESWO/PB5	E5	GND	G10	PA5/PGMRDY	K5	PC5
C1	PB2/AD6	E6	NRST	H1	PA19/PGMD7/AD2	K6	PC3
C2	VDDPLL	E7	PA29/AD13	H2	PA23/PGMD11	K7	PC2
C3	PC25	E8	PA30/AD14	H3	PC7	K8	PA9/PGMM1
C4	PC23	E9	PC10	H4	PA14/PGMD2	K9	PA8/XOUT32/PGMM0
C5	ERASE/PB12	E10	PA3	H5	PA13/PGMD1	K10	PA7/XIN32/PGMNVALID

4.2 SAM3S8B/D8B Package and Pinout

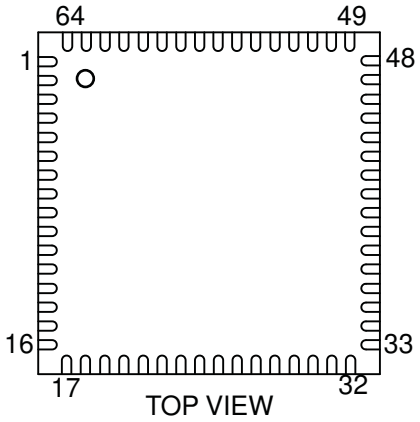
4.2.1 64-Lead LQFP Package Outline

Figure 4-3. Orientation of the 64-lead LQFP Package



4.2.2 64-lead QFN Package Outline

Figure 4-4. Orientation of the 64-lead QFN Package



4.2.3 64-Lead LQFP and QFN Pinout

Table 4-3. 64-pin SAM3S8B/D8B pinout

1	ADVREF	17	GND	33	TDI/PB4	49	TDO/TRACESWO/ PB5
2	GND	18	VDDIO	34	PA6/PGMNOE	50	JTAGSEL
3	PB0/AD4	19	PA16/PGMD4	35	PA5/PGMRDY	51	TMS/SWDIO/PB6
4	PB1/AD5	20	PA15/PGMD3	36	PA4/PGMNCMD	52	PA31
5	PB2/AD6	21	PA14/PGMD2	37	PA27/PGMD15	53	TCK/SWCLK/PB7
6	PB3/AD7	22	PA13/PGMD1	38	PA28	54	VDDCORE
7	VDDIN	23	PA24/PGMD12	39	NRST	55	ERASE/PB12
8	VDDOUT	24	VDDCORE	40	TST	56	DDM/PB10
9	PA17/PGMD5/ AD*0*	25	PA25/PGMD13	41	PA29	57	DDP/PB11
10	PA18/PGMD6/ AD1	26	PA26/PGMD14	42	PA30	58	VDDIO
11	PA21/PGMD9/ AD8	27	PA12/PGMD0	43	PA3	59	PB13/DAC0
12	VDDCORE	28	PA11/PGMM3	44	PA2/PGMEN2	60	GND
13	PA19/PGMD7/ AD2	29	PA10/PGMM2	45	VDDIO	61	XOUT/PB8
14	PA22/PGMD10/ AD9	30	PA9/PGMM1	46	GND	62	XIN/PGMCK/PB9
15	PA23/PGMD11	31	PA8/*XOUT32*/ PGMM0	47	PA1/PGMEN1	63	PB14/DAC1
16	PA20/PGMD8/ AD3	32	PA7/*XIN32*/ PGMNVALID	48	PA0/PGMEN0	64	VDDPLL

Note: The bottom pad of the QFN package must be connected to ground.

5. Power Considerations

5.1 Power Supplies

The SAM3S8/SD8 has several types of power supply pins:

- VDDCORE pins: Power the core, the embedded memories and the peripherals. Voltage ranges from 1.62V to 1.95V.
- VDDIO pins: Power the Peripherals I/O lines (Input/Output Buffers), USB transceiver, Backup part, 32 kHz crystal oscillator and oscillator pads. Voltage ranges from 1.62V to 3.6V.
- VDDIN pin: Voltage Regulator Input, ADC, DAC and Analog Comparator Power Supply. Voltage ranges from 1.8V to 3.6V.
- VDDPLL pin: Powers the PLLA, PLLB, the Fast RC and the 3 to 20 MHz oscillator. Voltage ranges from 1.62V to 1.95V.

5.2 Voltage Regulator

The SAM3S8/SD8 embeds a voltage regulator that is managed by the Supply Controller.

This internal regulator is designed to supply the internal core of SAM3S8/SD8. It features two operating modes:

- In Normal mode, the voltage regulator consumes less than 700 µA static current and draws 80 mA of output current. Internal adaptive biasing adjusts the regulator quiescent current depending on the required load current. In Wait Mode quiescent current is only 7 µA.
- In Backup mode, the voltage regulator consumes less than 1 µA while its output (VDDOUT) is driven internally to GND. The default output voltage is 1.80V and the start-up time to reach Normal mode is less than 100 µs.

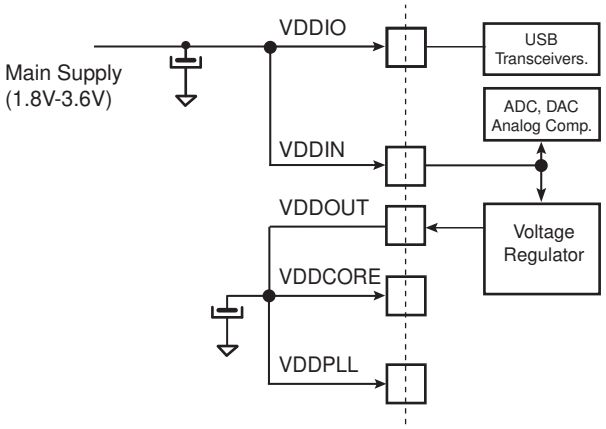
For adequate input and output power supply decoupling/bypassing, refer to the “Voltage Regulator” section in the “Electrical Characteristics” section of the datasheet.

5.3 Typical Powering Schematics

The SAM3S8/SD8 supports a 1.62V-3.6V single supply mode. The internal regulator input connected to the source and its output feeds VDDCORE. Figure 5-1 below shows the power schematics.

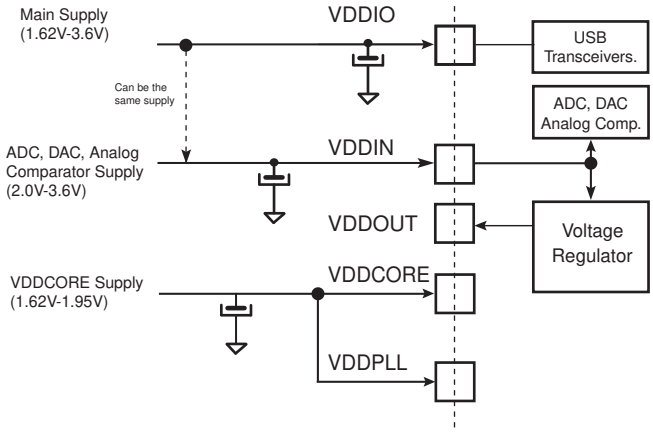
As VDDIN powers the voltage regulator, the ADC, DAC and the analog comparator, when the user does not want to use the embedded voltage regulator, it can be disabled by software via the SUPC (note that this is different from Backup mode).

Figure 5-1. Single Supply



Note: Restrictions
With Main Supply < 2.0 V, USB and ADC/DAC and Analog comparator are not usable.
With Main Supply ≥ 2.0V and < 3V, USB is not usable.
With Main Supply ≥ 3V, all peripherals are usable.

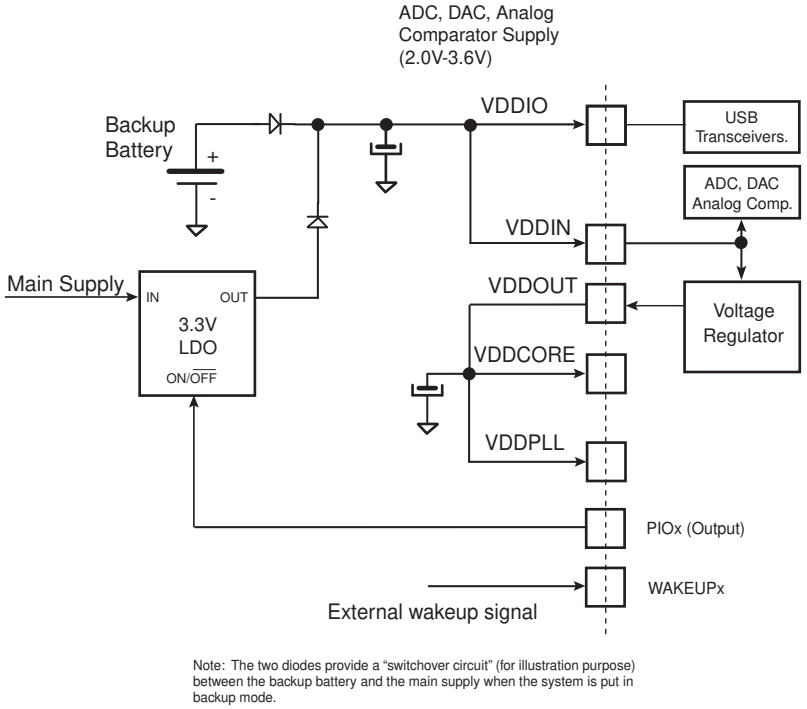
Figure 5-2. Core Externally Supplied



Note: Restrictions
With Main Supply < 2.0V, USB is not usable.
With VDDIN < 2.0V, ADC, DAC and Analog comparator are not usable.
With Main Supply ≥ 2.0V and < 3V, USB is not usable.
With Main Supply and VDDIN ≥ 3V, all peripherals are usable.

Figure 5-3 below provides an example of the powering scheme when using a backup battery. Since the PIO state is preserved when in backup mode, any free PIO line can be used to switch off the external regulator by driving the PIO line at low level (PIO is input, pull-up enabled after backup reset). External wake-up of the system can be from a push button or any signal. See Section 5.6 “Wake-up Sources” for further details.

Figure 5-3. Backup Battery



Note: The two diodes provide a "switchover circuit" (for illustration purpose) between the backup battery and the main supply when the system is put in backup mode.

5.4 Active Mode

Active mode is the normal running mode with the core clock running from the fast RC oscillator, the main crystal oscillator or the PLLA. The power management controller can be used to adapt the frequency and to disable the peripheral clocks.

5.5 Low-power Modes

The various low-power modes of the SAM3S8/SD8 are described below:

5.5.1 Backup Mode

The purpose of backup mode is to achieve the lowest power consumption possible in a system which is performing periodic wake-ups to perform tasks but not requiring fast startup time (<0.1ms). Total current consumption is 1.5 µA typical.

The Supply Controller, zero-power power-on reset, RTT, RTC, Backup registers and 32 kHz oscillator (RC or crystal oscillator selected by software in the Supply Controller) are running. The regulator and the core supply are off.

Backup mode is based on the Cortex-M3 deep sleep mode with the voltage regulator disabled.

The SAM3S8/SD8 can be awakened from this mode through WUP0-15 pins, the supply monitor (SM), the RTT or RTC wake-up event.

Backup mode is entered by using WFE instructions with the SLEEPDEEP bit in the Cortex-M3 System Control Register set to 1. (See the Power management description in The ARM Cortex-M3 Processor section of the product datasheet).

Exit from Backup mode happens if one of the following enable wake up events occurs:

- WKUPEN0-15 pins (level transition, configurable debouncing)

- Supply Monitor alarm
- RTC alarm
- RTT alarm

5.5.2 Wait Mode

The purpose of the wait mode is to achieve very low power consumption while maintaining the whole device in a powered state for a startup time of less than 10 µs. Current Consumption in Wait mode is typically 15 µA (total current consumption) if the internal voltage regulator is used or 8 µA if an external regulator is used.

In this mode, the clocks of the core, peripherals and memories are stopped. However, the core, peripherals and memories power supplies are still powered. From this mode, a fast start up is available.

This mode is entered via Wait for Event (WFE) instructions with LPM = 1 (Low Power Mode bit in PMC_FSMR). The Cortex-M3 is able to handle external events or internal events in order to wake-up the core (WFE). This is done by configuring the external lines WUP0-15 as fast startup wake-up pins (refer to Section 5.7 “Fast Startup”). RTC or RTT Alarm and USB wake-up events can be used to wake up the CPU (exit from WFE).

Entering Wait Mode:

- Select the 4/8/12 MHz fast RC oscillator as Main Clock
- Set the LPM bit in the PMC Fast Startup Mode Register (PMC_FSMR)
- Execute the Wait-For-Event (WFE) instruction of the processor

Note: Internal Main clock resynchronization cycles are necessary between the writing of MOSCRCEN bit and the effective entry in Wait mode. Depending on the user application, waiting for MOSCRCEN bit to be cleared is recommended to ensure that the core will not execute undesired instructions.

5.5.3 Sleep Mode

The purpose of sleep mode is to optimize power consumption of the device versus response time. In this mode, only the core clock is stopped. The peripheral clocks can be enabled. The current consumption in this mode is application dependent.

This mode is entered via Wait for Interrupt (WFI) or Wait for Event (WFE) instructions with LPM = 0 in PMC_FSMR.

The processor can be awakened from an interrupt if WFI instruction of the Cortex M3 is used, or from an event if the WFE instruction is used to enter this mode.

5.5.4 Low Power Mode Summary Table

The modes detailed above are the main low-power modes. Each part can be set to on or off separately and wake up sources can be individually configured. Table 5-1 below shows a summary of the configurations of the low-power modes.

Table 5-1. Low-power Mode Configuration Summary

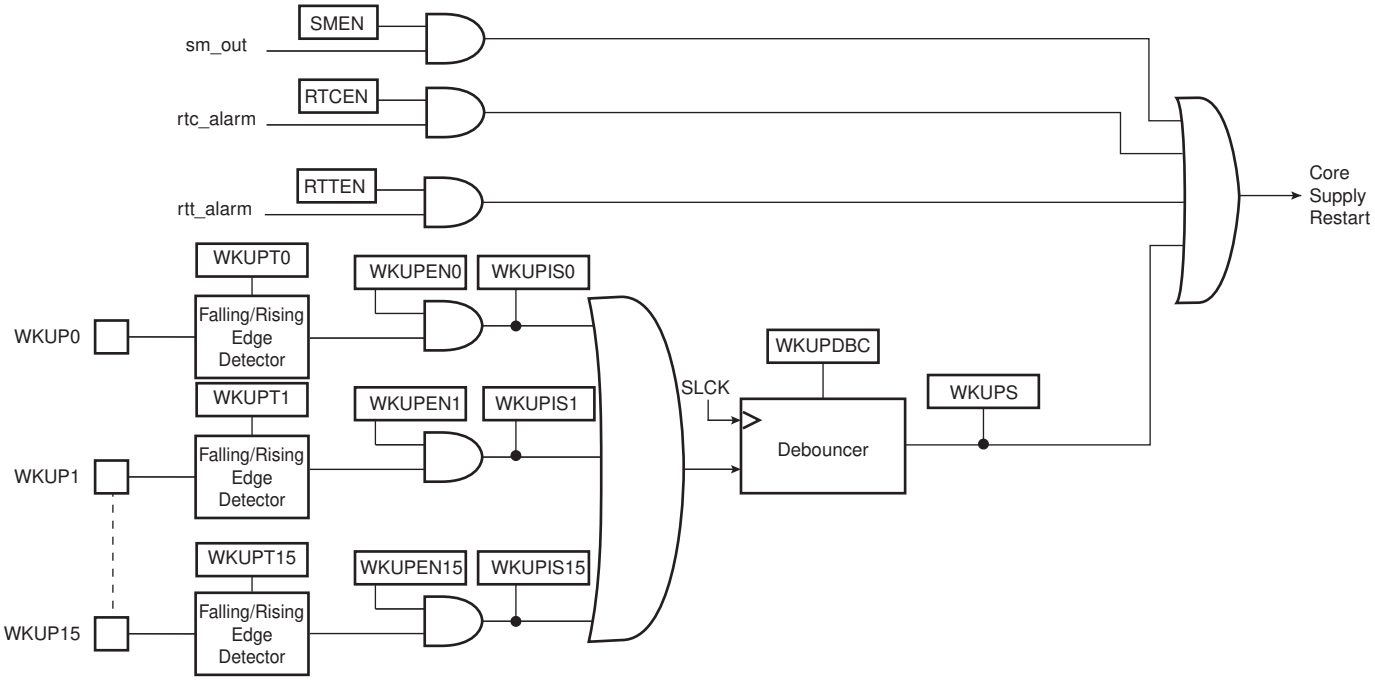
Mode	SUPC, 32 kHz Oscillator, RTC, RTT Backup Registers, POR (Backup Region)	Regulator	Core Memory Peripherals	Mode Entry	Potential Wake Up Sources	Core at Wake Up	PIO State while in Low Power Mode	PIO State at Wake Up	Consumption (2) (3)	Wake-up Time(1)
Backup Mode	ON	OFF	OFF (Not powered)	WFE +SLEEPDEEP bit = 1	WUP0-15 pins SM alarm RTC alarm RTT alarm	Reset	Previous state saved	PIOA & PIOB & PIOC Inputs with pull ups	1.5 µA typ(4)	< 0.1 ms
Wait Mode	ON	ON	Powered (Not clocked)	WFE +SLEEPDEEP bit = 0 +LPM bit = 1	Any Event from: Fast startup through WUP0-15 pins RTC alarm RTT alarm USB wake-up	Clocked back	Previous state saved	Unchanged	5 µA/15 µA (5)	< 10 µs
Sleep Mode	ON	ON	Powered(7) (Not clocked)	WFE or WFI +SLEEPDEEP bit = 0 +LPM bit = 0	Entry mode =WFI Interrupt Only; Entry mode =WFE Any Enabled Interrupt and/or Any Event from: Fast start-up through WUP0-15 pins RTC alarm RTT alarm USB wake-up	Clocked back	Previous state saved	Unchanged	(6)	(6)

Notes:
1. When considering wake-up time, the time required to start the PLL is not taken into account. Once started, the device works with the 4/8/12 MHz fast RC oscillator. The user has to add the PLL start-up time if it is needed in the system. The wake-up time is defined as the time taken for wake up until the first instruction is fetched.
2. The external loads on PIOs are not taken into account in the calculation.
3. Supply Monitor current consumption is not included.
4. Total Current consumption.
5. 5 µA on VDDCORE, 15 µA for total current consumption (using internal voltage regulator), 8 µA for total current consumption (without using internal voltage regulator).
6. Depends on MCK frequency.
7. In this mode the core is supplied and not clocked but some peripherals can be clocked.

5.6 Wake-up Sources

The wake-up events allow the device to exit the backup mode. When a wake-up event is detected, the Supply Controller performs a sequence which automatically reenables the core power supply and the SRAM power supply, if they are not already enabled.

Figure 5-4. Wake-up Source

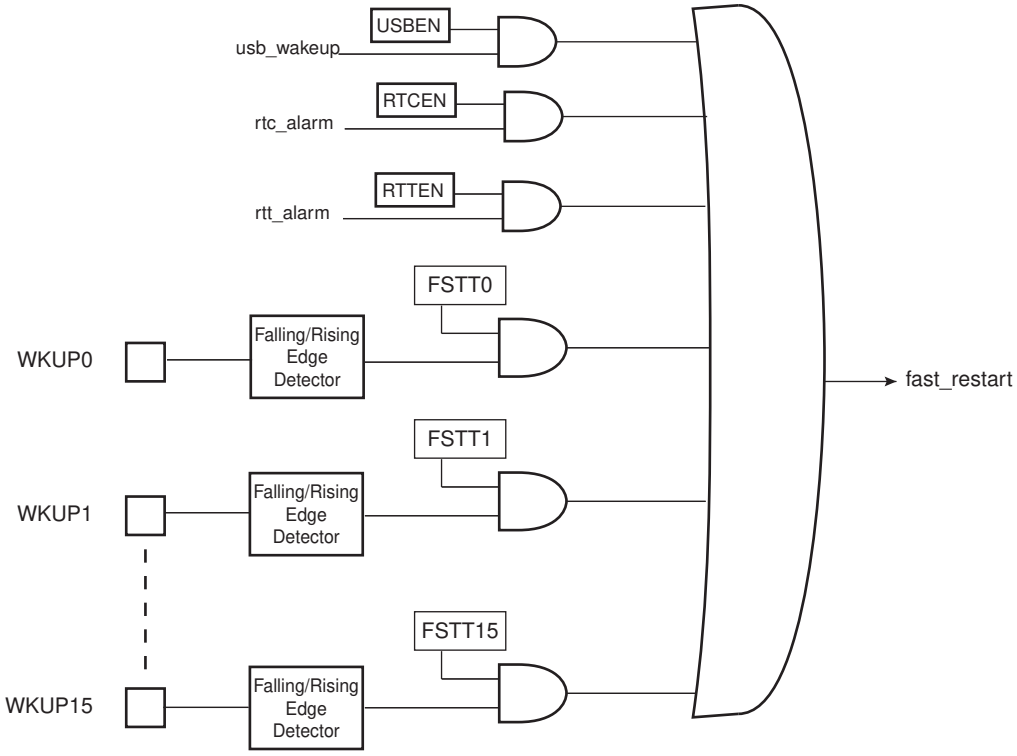


5.7 Fast Startup

The SAM3S8/SD8 allows the processor to restart in a few microseconds while the processor is in wait mode or in sleep mode. A fast start up can occur upon detection of a low level on one of the 19 wake-up inputs (WKUP0 to 15 + SM + RTC + RTT).

The fast restart circuitry, as shown in Figure 5-5, is fully asynchronous and provides a fast start-up signal to the Power Management Controller. As soon as the fast start-up signal is asserted, the PMC automatically restarts the embedded 4 MHz Fast RC oscillator, switches the master clock on this 4MHz clock and reenables the processor clock.

Figure 5-5. Fast Start-Up Sources



6. Input/Output Lines

The SAM3S8/SD8 has several kinds of input/output (I/O) lines such as general purpose I/Os (GPIO) and system I/Os. GPIOs can have alternate functionality due to multiplexing capabilities of the PIO controllers. The same PIO line can be used whether in I/O mode or by the multiplexed peripheral. System I/Os include pins such as test pins, oscillators, erase or analog inputs.

6.1 General Purpose I/O Lines

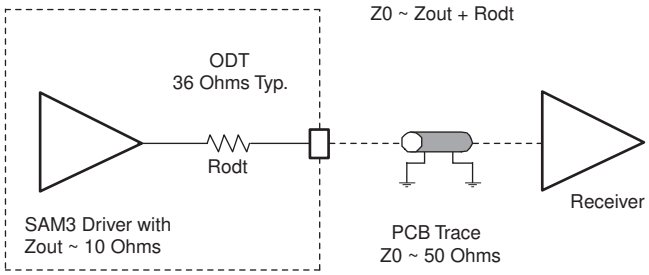
GPIO Lines are managed by PIO Controllers. All I/Os have several input or output modes such as pull-up or pull-down, input Schmitt triggers, multi-drive (open-drain), glitch filters, debouncing or input change interrupt. Programming of these modes is performed independently for each I/O line through the PIO controller user interface. For more details, refer to the product “PIO Controller” section.

The input/output buffers of the PIO lines are supplied through VDDIO power supply rail.

The SAM3S8/SD8 embeds high speed pads able to handle up to 32 MHz for HSMCI (MCK/2), 45 MHz for SPI clock lines and 35 MHz on other lines. See AC Characteristics Section of the datasheet for more details. Typical pull-up and pull-down value is 100 kΩ for all I/Os.

Each I/O line also embeds an ODT (On-Die Termination), (see Figure 6-1 below). It consists of an internal series resistor termination scheme for impedance matching between the driver output (SAM3S8/SD8) and the PCB trace impedance preventing signal reflection. The series resistor helps to reduce IOs switching current (di/dt) thereby reducing in turn, EMI. It also decreases overshoot and undershoot (ringing) due to inductance of interconnect between devices or between boards. In conclusion ODT helps diminish signal integrity issues.

Figure 6-1. On-Die Termination



6.2 System I/O Lines

System I/O lines are pins used by oscillators, test mode, reset and JTAG to name but a few. Described below in Table 6-1are the SAM3S8/SD8 system I/O lines shared with PIO lines.

These pins are software configurable as general purpose I/O or system pins. At startup the default function of these pins is always used.

Table 6-1. System I/O Configuration Pin List.

SYSTEM_IO bit number	Default function after reset	Other function	Constraints for normal start	Configuration
12	ERASE	PB12	Low Level at startup(1)	In Matrix User Interface Registers (Refer to the System I/O Configuration Register in the "Bus Matrix" section of the datasheet.)
10	DDM	PB10	-	
11	DDP	PB11	-	
7	TCK/SWCLK	PB7	-	
6	TMS/SWDIO	PB6	-	
5	TDO/TRACESWO	PB5	-	
4	TDI	PB4	-	
-	PA7	XIN32	-	See footnote (2) below
-	PA8	XOUT32	-	
-	PB9	XIN	-	See footnote (3) below
-	PB8	XOUT	-	

Notes: 1. If PB12 is used as PIO input in user applications, a low level must be ensured at startup to prevent Flash erase before the user application sets PB12 into PIO mode,
2. In the product Datasheet Refer to: "Slow Clock Generator" of the "Supply Controller" section.
3. In the product Datasheet Refer to: "3 to 20 MHZ Crystal Oscillator" information in the "PMC" section.

6.2.1 Serial Wire JTAG Debug Port (SWJ-DP) Pins

The SWJ-DP pins are TCK/SWCLK, TMS/SWDIO, TDO/SWO, TDI and commonly provided on a standard 20-pin JTAG connector defined by ARM. For more details about voltage reference and reset state, refer to Table 3-1 on page 5.

At startup, SWJ-DP pins are configured in SWJ-DP mode to allow connection with debugging probe. Please refer to the "Debug and Test" Section of the product datasheet.

SWJ-DP pins can be used as standard I/Os to provide users more general input/output pins when the debug port is not needed in the end application. Mode selection between SWJ-DP mode (System IO mode) and general IO mode is performed through the AHB Matrix Special Function Registers (MATRIX_SFR). Configuration of the pad for pull-up, triggers, debouncing and glitch filters is possible regardless of the mode.

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 kΩ to GND, so that it can be left unconnected for normal operations.

By default, the JTAG Debug Port is active. If the debugger host wants to switch to the Serial Wire Debug Port, it must provide a dedicated JTAG sequence on TMS/SWDIO and TCK/SWCLK which disables the JTAG-DP and enables the SW-DP. When the Serial Wire Debug Port is active, TDO/TRACESWO can be used for trace.

The asynchronous TRACE output (TRACESWO) is multiplexed with TDO. So the asynchronous trace can only be used with SW-DP, not JTAG-DP. For more information about SW-DP and JTAG-DP switching, please refer to the "Debug and Test" Section.

6.3 Test Pin

The TST pin is used for JTAG Boundary Scan Manufacturing Test or Fast Flash programming mode of the SAM3S8/SD8 series. The TST pin integrates a permanent pull-down resistor of about 15 kΩ to GND, so that it can be left unconnected for normal operations. To enter fast programming mode, see the Fast Flash Programming Interface (FFPI) section. For more on the manufacturing and test mode, refer to the “Debug and Test” section of the product datasheet.

6.4 NRST Pin

The NRST pin is bidirectional. It is handled by the on-chip reset controller and can be driven low to provide a reset signal to the external components or asserted low externally to reset the microcontroller. It will reset the Core and the peripherals except the Backup region (RTC, RTT and Supply Controller). There is no constraint on the length of the reset pulse and the reset controller can guarantee a minimum pulse length. The NRST pin integrates a permanent pull-up resistor to VDDIO of about 100 kΩ. By default, the NRST pin is configured as an input.

6.5 ERASE Pin

The ERASE pin is used to reinitialize the Flash content (and some of its NVM bits) to an erased state (all bits read as logic level 1). It integrates a pull-down resistor of about 100 kΩ to GND, so that it can be left unconnected for normal operations.

This pin is debounced by SCLK to improve the glitch tolerance. When the ERASE pin is tied high during less than 100 ms, it is not taken into account. The pin must be tied high during more than 220 ms to perform a Flash erase operation.

The ERASE pin is a system I/O pin and can be used as a standard I/O. At startup, the ERASE pin is not configured as a PIO pin. If the ERASE pin is used as a standard I/O, startup level of this pin must be low to prevent unwanted erasing. Refer to Section 10.17 “Peripheral Signal Multiplexing on I/O Lines” on page 40. Also, if the ERASE pin is used as a standard I/O output, asserting the pin to low does not erase the Flash.

7. Processor and Architecture

7.1 ARM Cortex-M3 Processor

- Version 2.0
- Thumb-2 (ISA) subset consisting of all base Thumb-2 instructions, 16-bit and 32-bit.
- Harvard processor architecture enabling simultaneous instruction fetch with data load/store.
- Three-stage pipeline.
- Single cycle 32-bit multiply.
- Hardware divide.
- Thumb and Debug states.
- Handler and Thread modes.
- Low latency ISR entry and exit.

7.2 APB/AHB bridge

The SAM3S8/SD8 embeds One Peripheral bridge:

The peripherals of the bridge are clocked by MCK.

7.3 Matrix Masters

The Bus Matrix of the SAM3S8/SD8 manages 4 masters, which means that each master can perform an access concurrently with others, to an available slave.

Each master has its own decoder, which is 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	Cortex-M3 Instruction/Data
Master 1	Cortex-M3 System
Master 2	Peripheral DMA Controller (PDC)
Master 3	CRC Calculation Unit

7.4 Matrix Slaves

The Bus Matrix of the SAM3S8/SD8 manages 5 slaves. Each slave has its own arbiter, allowing a different arbitration per slave.

Table 7-2. List of Bus Matrix Slaves

Slave 0	Internal SRAM
Slave 1	Internal ROM
Slave 2	Internal Flash
Slave 3	External Bus Interface
Slave 4	Peripheral Bridge

7.5 Master to Slave Access

All the Masters can normally access all the Slaves. However, some paths do not make sense, for example allowing access from the Cortex-M3 S Bus to the Internal ROM. Thus, these paths are forbidden or simply not wired, and shown as “-” in the following table.

Table 7-3. SAM3S8_SD8 Master to Slave Access

Slaves	Masters	0	1	2	3
		Cortex-M3 I/D Bus	Cortex-M3 S Bus	PDC	CRCCU
0	Internal SRAM	-	X	X	X
1	Internal ROM	X	-	X	X
2	Internal Flash	X	-	-	X
3	External Bus Interface	-	X	X	X
4	Peripheral Bridge	-	X	X	-

7.6 Peripheral DMA Controller

- Handles data transfer between peripherals and memories
- Low bus arbitration overhead
  - One Master Clock cycle needed for a transfer from memory to peripheral
  - Two Master Clock cycles needed for a transfer from peripheral to memory
- Next Pointer management for reducing interrupt latency requirement

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

Table 7-4. Peripheral DMA Controller

Instance name	Channel T/R
USART2	Transmit
USART2	Receive
PWM	Transmit
TWI1	Transmit
TWI0	Transmit
UART1	Transmit
UART0	Transmit
USART1	Transmit
USART0	Transmit
DACC	Transmit
SPI	Transmit