

## Features

- Eight DSPs and 24-bit Audio Router On-chip
- 32 kHz to 96 kHz Sampling Rate
- 16-bit Microcontroller On-chip
- Variety of I/Os, including SmartMedia™ and DataFlash®
- Embedded RAM for Single Chip Operation (768 Kbits)
- Warm Start Power-down
- 1µA Typical Deep Power-down, 0.5 mW/MIPS Typical Operating
- External Flash/ROM Capability
- Available in a 100-lead TQFP Package
- Ideal for Real-time Audio Applications
  - Wavetable Synthesis
  - MP3 Decoding
  - Effect Processing (Reverb, Echo, Chorus, Equalizer)
  - Filtering, Sampling Rate Conversion
- Typical Applications: Karaoke, Professional Audio, Cellular Phones, Musical Instruments, Consumer Electronics

## Description

The ATSAM3308 is a member of the new ATSAM3000 family that uses the DSP array technology. The ATSAM3308 includes eight 24-bit DSPs, a 24-bit Audio Router and a general-purpose 16-bit on-chip CISC microcontroller. Its high performance and flexibility with 8-input/8-output channels enables implementation of audio applications in professional-quality sound production such as MP3 decoding with time stretch and pitch control, concurrent Wavetable synthesis, effect processing and digital mixing. A variety of I/Os, including external Wave ROM, SmartMedia® and DataFlash® are provided. Sampling rates up to 96 kHz at 24 bits are supported.



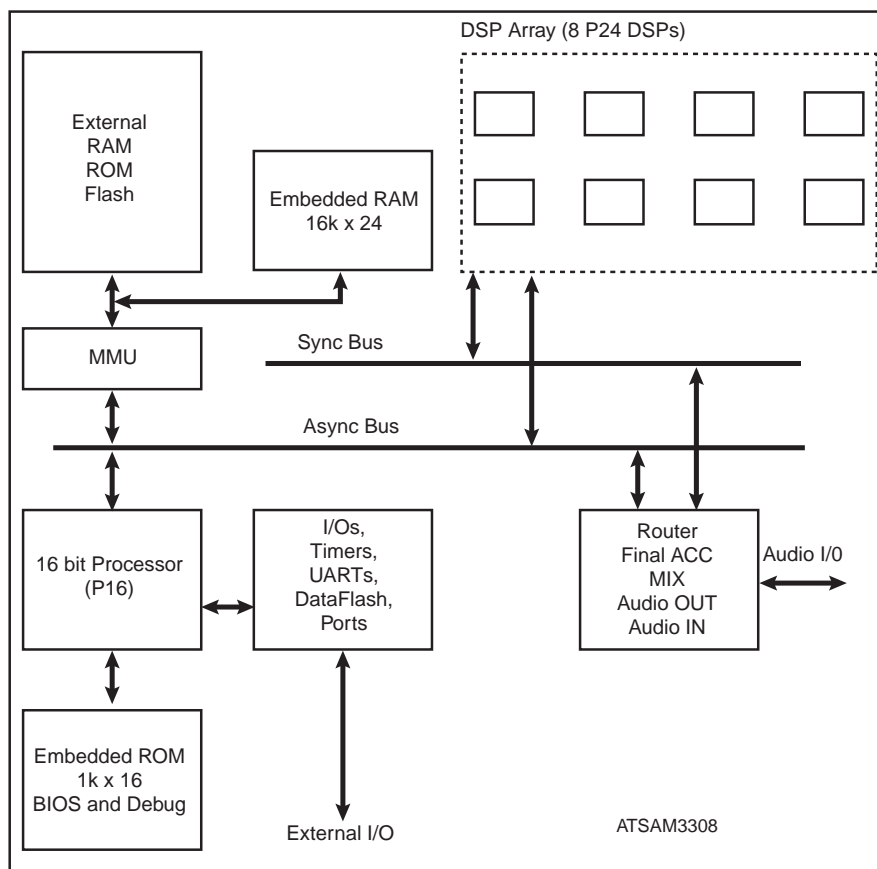
## Audio Processing

## ATSAM3308 Combined MIDI-Synthesizer and MP3 Decoder



## DSP Array Block Diagram

Figure 1. ATSAM3308 DSP Array Block Diagram



## Functional Description

### DSP Array

The ATSAM3308 includes eight on-chip DSPs.

Each DSP (P24) is built around a 2k x 24 RAM and a 1k x 24 ROM. The RAM contains both data and P24 instructions, the ROM contains typical coefficients such as FFT cosines and windowing. A P24 sends and receives audio samples through the Sync Bus. It can request external data such as compressed audio through the Async Bus. Each P24 RAM can be accessed through the Async Bus.

Each P24 is capable of typical MAC operation loops, including auto-indexing, bit reverse and butterfly (multiplication of complex numbers). It also includes specialized audio instructions such as state variable IIR filtering, envelope generation, linear interpolation and wavetable loop.

One P24 is sufficient for processing one channel of MP3 data pump, implementing a multi-tap delay line or a multi-tap transversal filter. A single P24 is also capable of generating twelve voices of wavetable sound at 32 kHz sampling rate (8 voices at 48 kHz), including sample cache, pitch control, 2nd order filter and two envelope generators.

### Sync Bus

The Sync Bus transfers data on a frame basis, typical frame rates being 32, 44.1, 48 or 96 kHz. Each frame is divided into 64 time slots. Each slot is divided into 4 bus cycles. Each P24 is assigned a hardwired time slot (8 to 63), during which it may provide 24-bit data to the bus (up to 4 data samples). Each P24 can read data on the bus at any time,

allowing inter P24 communication at the current sampling rate. Slots 0 to 7 are reserved for a specific router DSP, which also handles audio out, audio in, and remix send.

## **Async Bus**

The Async Bus has 24-bit data inside the chip and 16-bit data outside.

The P16 processor normally masters the Async Bus; it can read/write the P24 memories and the external or embedded ROM/RAM. However, each P24 can request a bus master cycle for accessing external ROM/RAM or other P24 memories. This allows efficient intercommunication between several P24s on asynchronous block basis. Specific P24 instructions FLOAT and FIX convert fixed-point DSP data to floating-point 16 bits. This allows for 20-bit audio dynamic range when using 16-bit external memory.

## **16-bit Processor**

The P16 processor is widely used in ATSAM products. Using the P16 keeps large firmware investments from the ATSAM97xx series. A built-in ROM, connected to the P16 holds basic input/output software (BIOS) for peripherals such as UART, DataFlash, SmartMedia and MPU, as well as a debugger that uses a dedicated asynchronous serial line. The firmware can reside on external parallel ROM/Flash or it can be downloaded at power-up into the built-in 16k x 24 RAM from serial EEPROM, DataFlash, SmartMedia or host.

## **MMU (Memory Management Unit)**

The MMU handles transfer requests between the external or embedded RAM/ROM, the P16 and the P24s through the Async Bus. The ATSAM3308 includes 16k x 24 RAM on chip.

## **Router: Final ACC, MIX, Audio Out, Audio In**

This block includes RAM (accessed through the Async Bus) that defines the routing from the Sync Bus to/from the Audio I/O or back to the Sync Bus (mix send). It takes care of mix and accumulation from Sync Bus samples. Eight channels of audio in and eight channels of audio out are provided (4-stereo in/out, I2S format). The stereo audio in channels may have a different sampling rate than the audio out channels. In this case, one (or more) P24 takes care of sampling rate conversion.

## **I/O**

The ATSAM3308 includes very versatile I/Os, that share common pins for reduced pin count and small IC footprint. Most I/Os, when not used for a specific function, remain available as firmware controlled general-purpose pins.

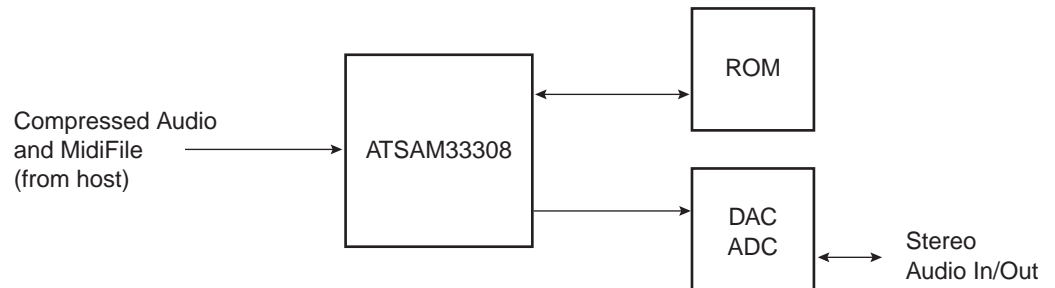
The following peripherals are included on chip:

- 2 x 8-bit timers
- 2 x 16-bit timers
- Parallel slave 8-bit port, MPU401 compatible
- Parallel master 8-bit port, for connection to SmartMedia and/or LCD display, switches, etc.
- 2 x asynchronous bidirectional serial ports
- Synchronous serial slave port (SPI type host connection).
- SPI master bidirectional port for EEPROM or DataFlash connection.
- Firmware controlled I/O pins.

## Typical Application Examples

### Host-controlled MP3 + High Quality Wavetable Player

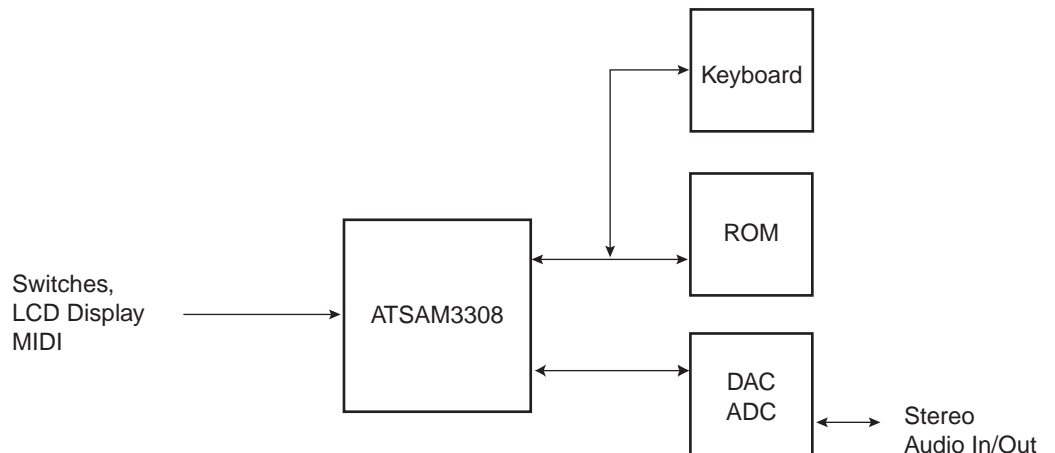
**Figure 2.** Host-controlled MP3 + High Quality Wavetable Player



- Concurrent MP3 + wavetable
- Legendary Dream high quality wavetable sound
- Typical polyphony:
  - 56 voices with effects (reverb, chorus, etc.) @48 kHz sampling rate
  - MP3 decode + 32 voices with effects @48 kHz sampling rate
- External wavetable ROM/Flash choice from 4 Mbits to 128 Mbits
- Choice of host communication interfaces
  - 8-bit parallel
  - Asynchronous serial (MIDI)
  - Synchronous serial (SPI)
- Built-in Standard Midi file player (SMF) dramatically reduces host load

### Musical Keyboard with Key Velocity

**Figure 3.** Musical Keyboard with Key Velocity



- Up to 64-voice polyphony with effects
- Choice of GM+ sampled sounds from 4 Mbits to 64 Mbits
- Maximum external memory addressing range: 128 Mbits

## DSP Capacity and I/O Configuration

### DSP Considerations

The ATSAM3308 includes 8 x P24 DSPs. Table 1 below lists the performance achievable by the P24.

**Table 1.** P24 Performance

Function	P24s Required
MP3 decode	3
12-voice wavetable synthesis @32 kHz	1
8-voice wavetable synthesis @48 kHz	1
Stereo reverb and chorus @48 kHz	1
Stereo 31-band equalizer @48 kHz	3

The ATSAM3308 runs firmware directly from an external ROM/Flash memory. It may also run firmware from local RAM, thus freeing many I/O pins, which can then be used for application dependent functions. The ATSAM3308 is the ideal choice when wavetable synthesis or many I/O pins are required.

### I/O Selection Considerations

I/Os are organized in groups, which can be mutually exclusive because they share the same IC pins (please refer to the pinout to identify the exclusions). The two main types of operation are host controlled and stand-alone.

#### Host-controlled Operation

There are three main possible ways of communication with a host processor:

- 8-bit parallel MPU type bidirectional interface signals: D7 - D0,  $\overline{CS}$ ,  $\overline{WR}$ ,  $\overline{RD}$ , A0, IRQ
- Asynchronous serial, MIDI\_IN and optionally MIDI\_OUT
- Synchronous serial signals: SDIN, SCLK, SYNC,  $\overline{INT}$

#### Stand-alone Operation

Possible stand-alone modes are:

- Firmware into external ROM or Flash memory
- Firmware into external EEPROM or DataFlash
- Firmware into external SmartMedia. In this case, the firmware should reside in the SmartMedia reserved sectors starting at sector # 1.

## Pinout

### Pin Description

In the Pin Description table below:

- Identical sharing number indicates multifunction pins.
- Pd indicates a pin with built-in pull-down resistor.
- Pu indicates a pin with built-in pull-up resistor.

**Table 2.** Pinout by Pin Name

Pin Name	Pin Number	Type	Sharing	Description
GND	9, 22, 30, 41, 56, 70, 75, 87, 97	PWR	–	Digital ground. All of these pins should be returned to a ground plane.
VC18	20, 47, 73, 99	PWR	–	Core power. All of these pins should be returned to nominal 1.8V or to PWROUT if the built-in power switch is used.
VC33	13, 50, 83	PWR	–	Periphery power. All these pins should be returned to nominal 3.3V.
PWRIN	29	PWR	–	Power switch input; should be returned to nominal 1.8V even if the power switch is not used.
PWROUT	28	PWR	–	Power switch output; should be connected to all VC18 pins if the power switch is used
D7 - D0	96, 95, 91, 90, 82, 81, 77, 76	I/O	1	Slave 8-bit interface data. Output if $\overline{CS}$ and $\overline{RD}$ are low (read from chip), input if $\overline{CS}$ and $\overline{WR}$ are low (write to chip). Type of data defined by A0 input.
I/O7 - I/O0	96, 95, 91, 90, 82, 81, 77, 76	I/O	1	SmartMedia data or other peripheral data
P0.7 - P0.0	96, 95, 91, 90, 82, 81, 77, 76	I/O	1	General-purpose I/O; can be programmed individually as input or output.
CLAD3 - 0	96, 95, 91, 90	In	1	Optional bit clocks for digital audio input. Used for sampling rate conversion for external incoming digital audio such as AES/BEU or S/Pdif.
WSAD3 - 0	82, 81, 77, 76	In	1	Optional word selects for digital audio input. Used for sampling rate conversion for external incoming digital audio such as AES/BEU or S/Pdif.
A0	98	In	2	Slave 8-bit interface address. Indicates data/status or data/ctrl transfer type ( $\overline{CS}/RD$ , low or $\overline{CS}/WR$ low)
SMPD	98	In	2	SmartMedia presence detect
P0.10	98	In	2	General-purpose input pin
SCLK	98	In	2	Serial slave synchronous interface input clock
$\overline{CS}$	100	In	3	Slave 8-bit interface chip select, active low.
P0.11	100	In	3	General-purpose input pin
SYNC	100	In	3	Serial slave synchronous interface input sync signal
$\overline{WR}$	1	In	4	Slave 8-bit interface write, active low. D7 - D0 data is sampled by chip on $\overline{WR}$ rising edge if $\overline{CS}$ is low
$\overline{SMC}$	1	In	4	SmartMedia configuration. This pin is sensed after power-up. If found low, it is assumed that a SmartMedia connector is present. The built-in firmware will wait for SmartMedia SMPD.
P0.12	1	In	4	General-purpose input pin

**Table 2.** Pinout by Pin Name (Continued)

Pin Name	Pin Number	Type	Sharing	Description
$\overline{RD}$	2	In	5	Slave 8-bit interface read, active low. D7 - D0 data is output when $\overline{RD}$ goes low and $\overline{CS}$ is low
$\overline{R\overline{B}}$	2	In	5	SmartMedia Ready Busy/ status
P0.13	2	In	5	General-purpose input pin
IRQ	8	Out	6	Slave 8-bit interface interrupt request. High when data is ready to be transferred from chip to host. Reset by a read from host ( $\overline{CS} = 0$ and $\overline{RD} = 0$ )
$\overline{SMRE}$	8	Out	6	SmartMedia read enable ( $\overline{RE}$ ), active low
FS0	8	In	6	Frequency sense, sensed at power up. Together with FS1, allows the firmware to know the operating frequency of the chip (see FS1).
P0.8	8	I/O	6	General-purpose I/O pin
$\overline{INT}$	8	Out	6	Serial slave synchronous interface data request, active low.
MIDI_IN	17	In	7	Serial MIDI in
P0.14	17	In	7	General-purpose input pin
SDIN	17	In	7	Serial slave synchronous interface input data
MIDI_OUT	18	Out	8	Serial MIDI out
FS1	18	In	8	Frequency sense, sensed at power up. FS1/FS0 allow firmware to know operating frequency of chip as follows: 00 6.9552 MHz 01 9.6 MHz 10 11.2896 MHz 11 12.288 MHz
P0.9	18	I/O	8	General-purpose I/O
DABD3 - 0	67, 66, 65, 64	Out	-	Four stereo channels of digital audio output, I2S format
CLBD	6	Out	-	Audio bit clock for DABD3 - 0. Audio bit clock for DAAD3 - 0 if the corresponding CLAD3 - 0 is not used.
WSBD	7	Out	-	Audio left/right channel select for DABD3 - 0. Audio left/right channel for DAAD3 - 0 if the corresponding WSAD3 - 0 is not used.
CKOUT	5	Out	-	External DAC/Codec master clock. Same frequency as X2 pin. Can be programmed to be 128xFs, 192xFs, 256xFs, 384xFs, where Fs is the DAC/Codec sampling rate.
DAAD0	54	In	9	Stereo audio data input, I2S format. Can operate on CLBD master rate or CLAD0 external rate when sampling rate conversion is requested.
P0.15	54	In	9	General-purpose input pin
DAAD3 - 1	60, 59, 55	In Pd	-	Three additional channels of stereo audio input, I2S format. Can individually operate on CLBD master rate or corresponding CLAD3 - 1 when sampling rate conversion is requested. DAAD3 - 1 have built-in pull-downs. They may be left open if not used.
MUTE	19	I/O	10	External DAC/Codec Mute. Sensed at power up. If found high, then MUTE becomes an active high output. If found low, then MUTE becomes an active low output.
P1.6	19	I/O	10	General-purpose I/O pin
WA21	45	Out	11	External memory address bit, extension to 64 Mbits

**Table 2.** Pinout by Pin Name (Continued)

Pin Name	Pin Number	Type	Sharing	Description
$\overline{\text{SMCE}}$	45	Out	11	SmartMedia chip enable ( $\overline{\text{CE}}$ ), active low
P1.5	45	I/O	11	General-purpose I/O pin
WA20	44	Out	12	External memory address bit, extension to 32 Mbits
SMALE	44	Out	12	SmartMedia address latch enable (ALE)
P1.4	44	I/O	12	General-purpose I/O pin
WA19	43	Out	13	External memory address bit, extension to 16 Mbits
$\overline{\text{SMWE}}$	43	Out	13	SmartMedia write enable ( $\overline{\text{WE}}$ ), active low
P1.3	43	I/O	13	General-purpose I/O pin
WA18	42	Out	14	External memory address bit, extension to 8 Mbits
SMCLE	42	Out	14	SmartMedia command latch enable (CLE)
P1.2	42	I/O	14	General-purpose I/O pin
WA17 – WA16	58, 57	Out	15	External memory address bits, extension to 2 and 4 Mbits
P1.1 – P1.0	58, 57	I/O	15	General-purpose I/O pins
WA15 – WA0	53, 51, 40, 39, 38, 37, 36, 27, 26, 21, 16, 15, 14, 12, 11, 10	Out	16	External memory address bits, up to 1 Mbits (64K x 16)
P2.15 – P2.0	53, 51, 40, 39, 38, 37, 36, 27, 26, 21, 16, 15, 14, 12, 11, 10	I/O	16	General-purpose I/O pins
WD15 – WD0	94, 93, 92, 89, 88, 86, 85, 84, 80, 79, 78, 69, 68, 63, 62, 61	I/O	17	External memory data
P3.15 – P3.0	94, 93, 92, 89, 88, 86, 85, 84, 80, 79, 78, 69, 68, 63, 62, 61	I/O	17	General-purpose I/O pins
$\overline{\text{WCS1}}$	3	Out	18	External memory chip select 1, active low. Pre-decode for an external RAM/Flash/ROM at address 200:0000H.
P1.10	3	I/O	18	General-purpose I/O pin
$\overline{\text{WCS0}}$	4	Out	19	External memory chip select 2, active low. Pre-decode for an external RAM/Flash/ROM at address 000:0000H
P1.9	4	I/O	19	General-purpose I/O pin
$\overline{\text{WOE}}$	48	Out	20	External memory output enable, active low
P1.8	48	I/O	20	General-purpose I/O pin
$\overline{\text{WWE}}$	49	Out	21	External memory write enable, active low
P1.7	49	I/O	21	General-purpose I/O pin
$\overline{\text{DFCS}}$	23	Out	-	DataFlash chip select
DFSI	25	Out	-	DataFlash serial input (to DataFlash)
DFSO	32	In Pd	-	DataFlash serial output (from DataFlash). This pin has a built-in pull-down. It may be left open if not used.
DFSCK	24	Out	-	DataFlash data clock



**Table 2.** Pinout by Pin Name (Continued)

Pin Name	Pin Number	Type	Sharing	Description
P1.15	46	I/O Pu	-	General-purpose I/O pin. This pin has built-in pull-up. It may be left open if not used.
X1 – X2	72,71	-	-	External crystal connection. Standard frequencies are 6.9552 MHz, 9.6 MHz, 11.2896 MHz, 12.288 MHz. Max frequency is 12.5 MHz. An external clock (max. 1.8 V <sub>pp</sub> ) can be connected to X1 using AC coupling (22 pF). A built-in PLL multiplies the clock frequency by 4 for internal use.
LFT	74	-	-	PLL decoupling RCR filter
RESET	33	In	-	Master reset Schmitt trigger input, active low. RESET should be held low during at least 5 ms after power is applied. On the rising edge of RESET, the chip enters an initialization routine, which may involve firmware download from an external SmartMedia, DataFlash or host.
STIN	34	In Pd	-	Serial test input. This is a 57.6 Kbaud asynchronous input used for firmware debugging. This pin is tested at power-up. The built-in debugger starts if STIN is found high. STIN has a built-in pull-down. It should be grounded or left open for normal operation.
STOUT	35	Out	-	Serial test output. 57.6 Kbaud async output used for firmware debugging.
PDWN	31	In	-	Power down input, active low. High level on this pin is typ. VC18. When PDWN is low, the oscillator and PLL are stopped, the power switch opens, and the chip enters a deep sleep mode (1 µA typ. consumption when power switch is used). To exit from power down, PDWN has to be set high then RESET applied. Alternate programmable power-downs are available which allow warm restart of the chip.
TEST	52	In Pd	-	Test input. Should be grounded or left open.

## Pinout by Pin Number

**Table 3.** ATSAM3308 Pinout by Pin Number

Pin #	Pin Name	Pin #	Pin Name	Pin #	Pin Name	Pin #	Pin Name
1	WR SMC P0.12	26	WA7 P2.7	51	WA14 P2.14	76	D0 I/O0 P0.0 WSAD0
2	RD R/B P0.13	27	WA8 P2.8	52	TEST	77	D1 I/O1 P0.1 WSAD1
3	WCS1 P1.10	28	PWROUT	53	WA15 P2.15	78	WD5 P3.5
4	WCS0 P1.9	29	PWRIN	54	DAAD0 P0.15	79	WD6 P3.6
5	CKOUT	30	GND	55	DAAD1	80	WD7 P3.7
6	CLBD	31	PDWN	56	GND	81	D2 I/O2 P0.2 WSAD2
7	WSBD	32	DFSO	57	WA16 P1.0	82	D3 I/O3 P0.3 WSAD3
8	IRQ	33	RESET	58	WA17 P1.1	83	VC33
9	GND	34	STIN	59	DAAD2	84	WD8 P3.8
10	WA0 P2.0	35	STOUT	60	DAAD3	85	WD9 P3.9
11	WA1 P2.1	36	WA9 P2.9	61	WD0 P3.0	86	WD10 P3.10
12	WA2 P2.2	37	WA10 P2.10	62	WD1 P3.1	87	GND
13	VC3	38	WA11 P2.11	63	WD2 P3.2	88	WD11 P3.11
14	WA3 P2.3	39	WA12 P2.12	64	DABD0	89	WD12 P3.12
15	WA4 P2.4	40	WA13 P2.13	65	DABD1	90	D4 I/O4 P0.4 CLAD0
16	WA5 P2.5	41	GND	66	DABD2	91	D5 I/O5 P0.5 CLAD1
17	MIDI_IN P0.14 SDIN	42	WA18 SMCLE P1.2	67	DABD3	92	WD13 P3.13
18	MIDI_OUT FS1 P0.9	43	WA19 SMWE P1.3	68	WD3 P3.3	93	WD14 P3.14
19	MUTE P1.6	44	WA20 SMALE P1.4	69	WD4 P3.4	94	WD15 P3.15
20	VC18	45	WA21 SMCE P1.5	70	GND	95	D6 I/O6 P0.6 CLAD2
21	WA6 P2.6	46	P1.15	71	X2	96	D7 I/O7 P0.7 CLAD3
22	GND	47	VC18	72	X1	97	GND
23	DFCS	48	WOE P1.8	73	VC18	98	A0 SMPD P0.10 SCLK
24	DFSCK	49	WWE P1.7	74	LFT	99	VC18
25	DFSI	50	VC33	75	GND	100	CS P0.11 SYNC

## Mechanical Dimensions

Figure 4. Thin Plastic 100-lead Quad Flat Pack (TQFP100B)

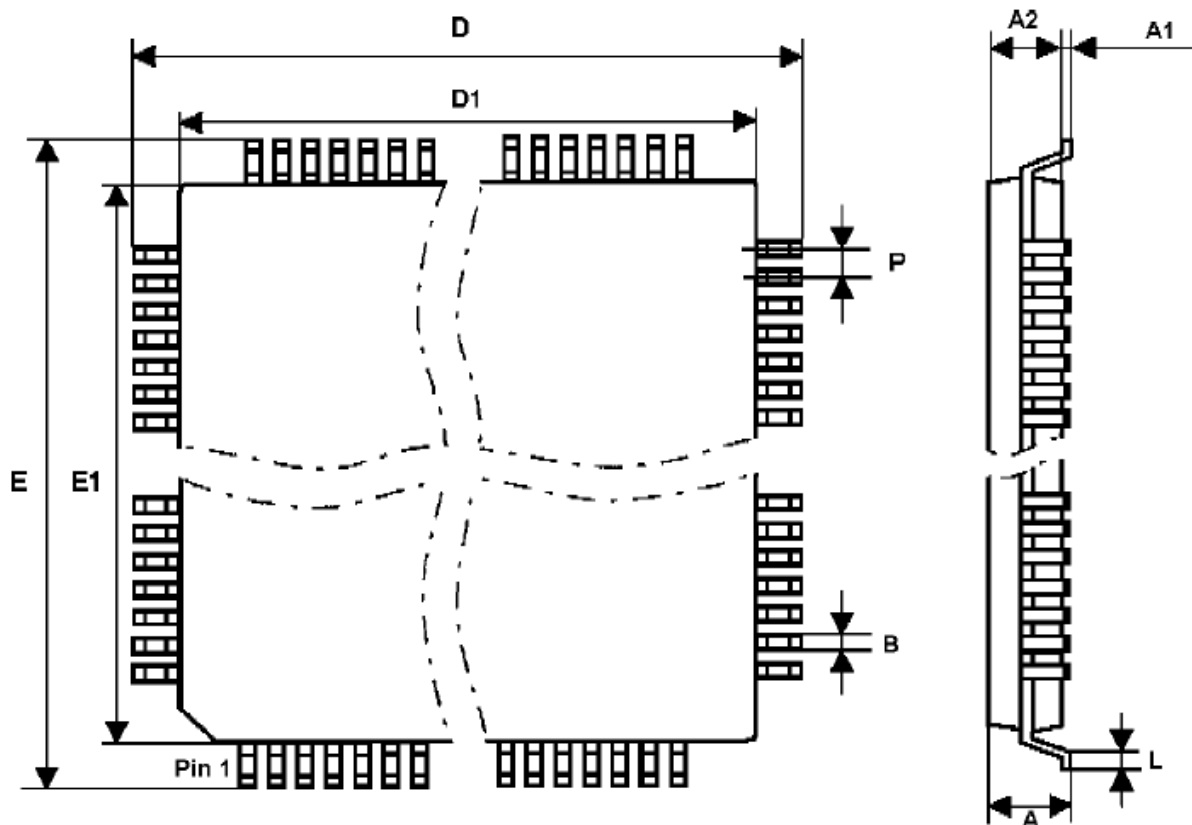


Table 4. Package Dimensions in mm

Denomination	Min	Nom	Max
A	1.40	1.50	1.60
A1	0.05	0.10	0.15
A2	1.35	1.40	1.45
L	0.45	0.60	0.75
D		14.00	
D1		12.00	
E		14.00	
E1		12.00	
P		0.40	
B	0.13	0.18	0.23

## Electrical Characteristics

### Absolute Maximum Ratings (\*)

Ambient Temperature (power applied).....	-40°C to 85°C	<b>*NOTICE:</b> Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the Recommended Operating Conditions of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
Storage Temperature .....	-65°C to 150°C	
Voltage on any pin		
X1, LFT .....	-0.3 to $V_{C18} + 0.3V$	
Others .....	-0.3 to $V_{C33} + 0.3V$	
Supply Voltage.....		
$V_{C18}$ .....	-0.3V to 1.95V	
$V_{C3}$ .....	-0.3V to 3.6V	
Maximum IOL per I/O pin.....	4 mA	

### Recommended Operating Conditions

**Table 5.** Recommended Operating Conditions

Symbol	Parameter	Min	Typ	Max	Unit
$V_{C18}$	Supply voltage	1.65	1.8	1.95	V
$V_{C33}$	Supply voltage <sup>(1)</sup>	3	3.3	$V_{C18} + 1.5$ 3.6	V
PWRIN	Supply voltage PWRIN pin	1.75	1.9	1.95	V
$T_A$	Operating ambient temperature	0	-	70	°C

Note: 1. Operation at lower  $V_{C33}$  values down to  $V_{C18}$  is possible, however external timing may be impaired. Contact Atmel in case of use of these circuits with  $V_{C33}$  outside the recommended operating range.

## DC Characteristics

**Table 6.** DC Characteristics ( $T_A = 25^\circ\text{C}$ ,  $V_{C18} = 1.8\text{V} \pm 10\%$ ,  $V_{C33} = 3.3\text{V} \pm 10\%$ )

Symbol	Parameter	Min	Typ	Max	Unit
$V_{IL}$	Low level input voltage	-0.3	-	1.0	V
$V_{IH}$	High level input voltage, except X1, $\overline{\text{PDWN}}$	2.3	-	$V_{C33} + 0.3$	V
$V_{IH}$	High level input voltage X1, $\overline{\text{PDWN}}$	1.2	-	$V_{C18} + 0.3$	V
$V_{OL}$	Low level output voltage $I_{OL} = -2\text{ mA}$	-	-	0.4	V
$V_{OH}$	High level output voltage $I_{OH} = 2\text{ mA}$	2.9	-	-	V
$I_{CC1}$	VC18 power supply current (crystal freq.=11.2896 MHz, all 8 P24s running)	-	63	-	mA
$I_{CC2}$	VC18 power supply current (crystal freq. = 11.2896 MHz, all P24s stopped)	-	22	-	mA
$I_{CC3}$	VC18 power supply current (crystal freq. = 11.2896 MHz, all P24 stopped, warm start power-down active)	-	4	-	mA
$I_{CC4}$	VC18 deep power down supply current (using power switch)	-	1	10	$\mu\text{A}$
PU/PD	Built-in pull-up/pull-down resistor	10	-	56	$\text{k}\Omega$

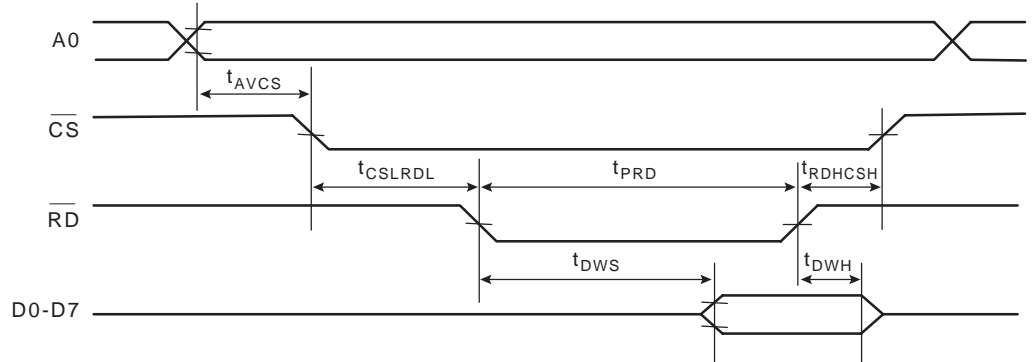
## Peripherals and Timings

### 8-bit Slave Parallel Interface

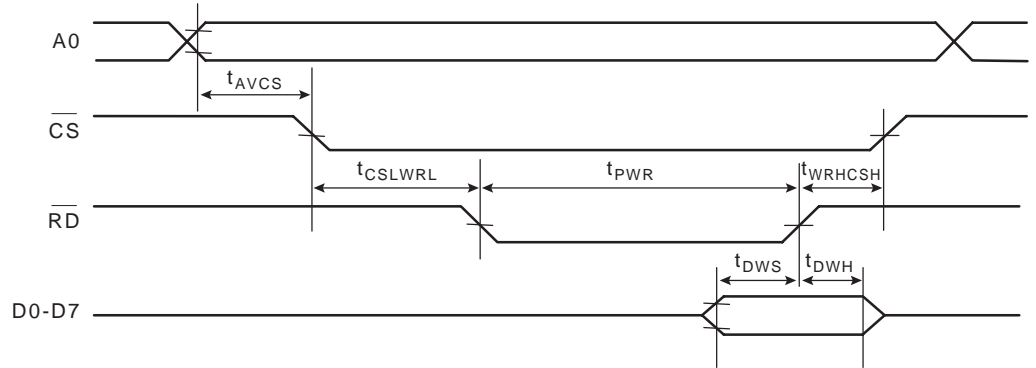
The Slave Parallel Interface is typically used to connect the chip to a host processor.  
Pins used: D7 - D0 (I/O), A0 (Input),  $\overline{WR}$  (Input),  $\overline{RD}$  (Input), IRQ (Output).

#### Timings

**Figure 5.** Host Interface Read Cycle



**Figure 6.** Host Interface Write Cycle



**Table 7.** Timing Parameters

Symbol	Parameter	Min	Typ	Max	Unit
$t_{AVCS}$	Address valid to chip select low	0	-	-	ns
$t_{CSLRDL}$	Chip select low to $\overline{RD}$ low	5	-	-	ns
$t_{RDHCSH}$	$\overline{RD}$ high to $\overline{CS}$ high	5	-	-	ns
$t_{PRD}$	$\overline{RD}$ pulse width	50	-	-	ns
$t_{RDLDV}$	Data out valid from $\overline{RD}$	-	-	20	ns
$t_{DRH}$	Data out hold from $\overline{RD}$	5	-	10	ns
$t_{CSLWRL}$	Chip select low to $\overline{WR}$ low	5	-	-	ns
$t_{WRHCSH}$	$\overline{WR}$ high to $\overline{CS}$ high	5	-	-	ns
$t_{PWR}$	$\overline{WR}$ pulse width	50	-	-	ns
$t_{DWS}$	Write data setup time	10	-	-	ns
$t_{DWH}$	Write data hold time	0	-	-	ns

## IO Status Register

7	6	5	4	3	2	1	0
TE	RF	X	X	X	X	X	X

Status register is read when  $A0 = 1$ ,  $\overline{RD} = 0$ ,  $\overline{CS} = 0$ .

- **TE: Transmit Empty**

If 0, data from ATSAM3308 to host is pending and IRQ is high. Reading the data at  $A0 = 0$  will set TE to 1 and clear IRQ.

- **RF: Receiver full.**

If 0, then ATSAM3308 is ready to accept DATA from host.

Note: If status bit RF is not checked by host, write cycle time should not be lower than 3  $\mu$ s.

## SmartMedia and Other Peripheral Interfaces

The SmartMedia and Other Peripheral Interface is a master 8-bit parallel interface that provides connection to SmartMedia or other peripherals such as LCD screens.

Pins used: I/O7 - I/O0 (I/O), SMPD (input)  $\overline{SMCE}$ , SMALE, SMCLE,  $\overline{SMRE}$ ,  $\overline{SMWE}$  (outputs)

All of these pins are fully under firmware control, therefore timing compatibility is ensured by firmware only.

## EEPROM/DataFlash Interface

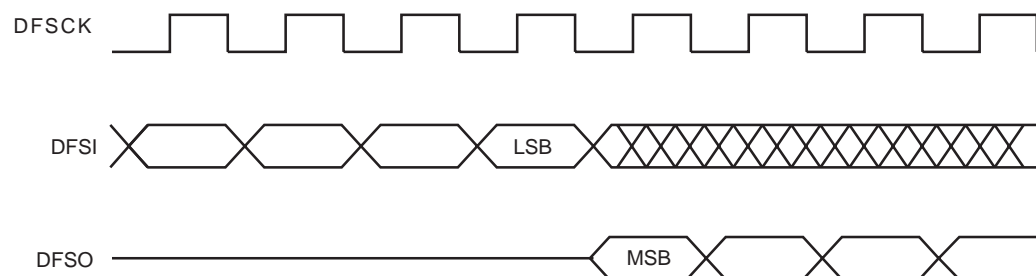
The EEPROM/DataFlash interface is a master synchronous serial interface, operating in SPI mode 0.

Pins used:  $\overline{DFCS}$ , DFSI, DFSCCK (outputs), DFSO (input)

The DFSCCK frequency is firmware programmable from fck to fck/64, where fck is the crystal frequency. Thus a large variety of EEPROM/DataFlash devices can be accommodated.

Please refer to Atmel DataFlash datasheets for accurate SPI mode 0 timing.

**Figure 7.** DataFlash Interface Typical Timing



## Serial Slave Synchronous Interface

The ATSAM3308 can be controlled by an external host processor through this unidirectional serial interface. However, no firmware can be downloaded at power-up through this interface. Therefore an external ROM/Flash/EEPROM is required.

Pins used: SCLK, SYNC, SDIN (input)  $\overline{\text{INT}}$  (output)

Data is shifted into MSB first. The IC samples an incoming SDIN bit on the rising edge of SCLK, therefore the host should change SDIN on the negative SCLK edge.

SYNC allows initial synchronization. The rising edge of SYNC, which should occur with SCLK low, indicates that SDIN will hold MSB data on the next rising SCLK.

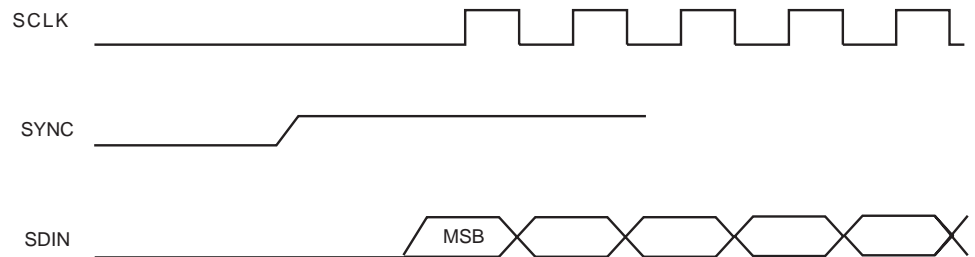
The data is stored internally into a 256 byte FIFO.

When the FIFO count is below 64, the  $\overline{\text{INT}}$  output goes low. This allows the host processor to send data in burst mode.

The maximum SCLK frequency is  $f_{\text{ck}}$  ( $f_{\text{ck}}$  being the crystal frequency). The minimum time between two bytes is 64  $f_{\text{ck}}$  periods.

The contents of the SDIN data are defined by the firmware.

**Figure 8.** Serial Slave Interface Typical Timing



## Digital Audio

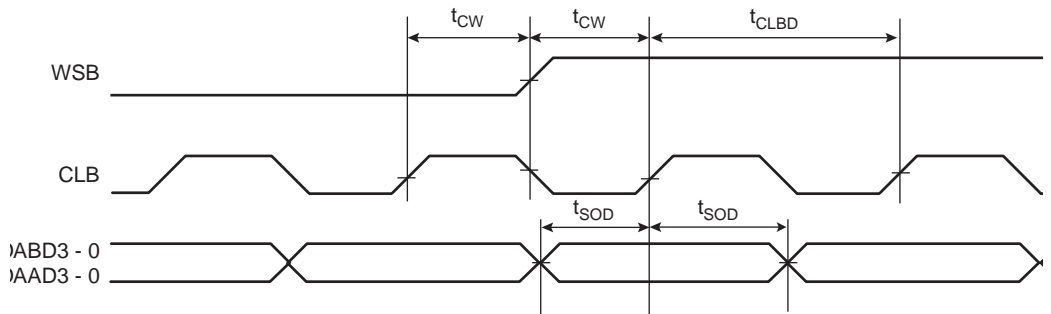
Pins used: CLBD (output), WSBD (output) DABD3 - 0 (outputs) DAAD3 - 0 (inputs)

Optionally: CLAD3 - 0 (inputs), WSAD3 - 0 (inputs)

The ATSAM3308 allows for 8 digital audio output channels and 8 digital audio input channels. All audio channels are normally synchronized on single clocks CLBD, WSBD which are derived from the IC crystal oscillator. However, as a firmware option, the DAAD3 - 0 inputs can be synchronized with incoming CLAD3 - 0 and WSAD3 - 0 signals. In this case, the incoming sampling frequencies must be lower or equal to the chip sampling frequency.

The digital audio timing follows the I2S standard, with up to 24 bits per sample

**Figure 9.** Digital Audio Timing





**Table 8.** Digital Audio Timing Parameters

Symbol	Parameter	Min	Typ	Max	Unit
$t_{CW}$	CLBD rising to WSBD change	$t_C - 10$	-	-	ns
$t_{SOD}$	DABD valid prior/after CLBD rising	$t_C - 10$	-	-	ns
$t_{CLBD}$	CLBD cycle time	-	$2 * t_C$	-	ns

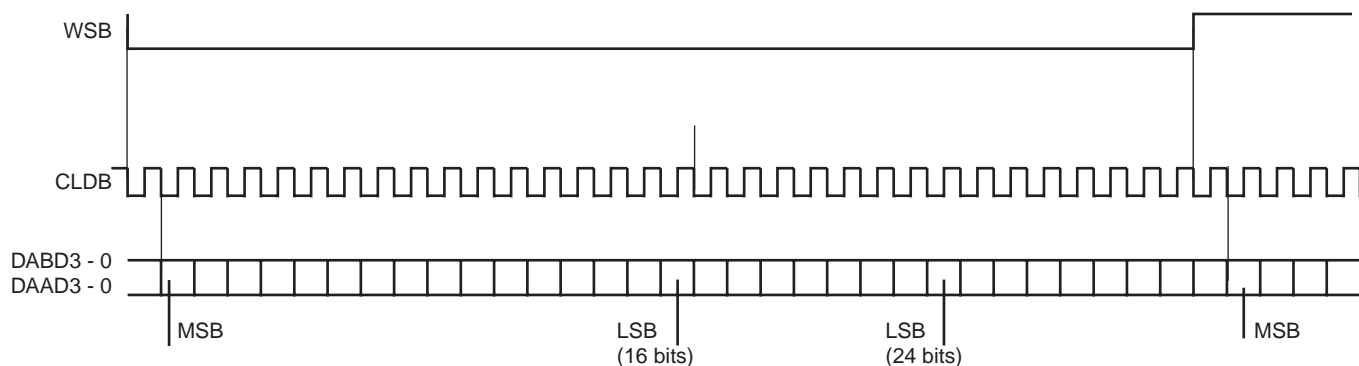
$t_C$  is related to  $t_{CK}$ , the crystal period at X1 as follows:

**Table 9.** Sample Frequency

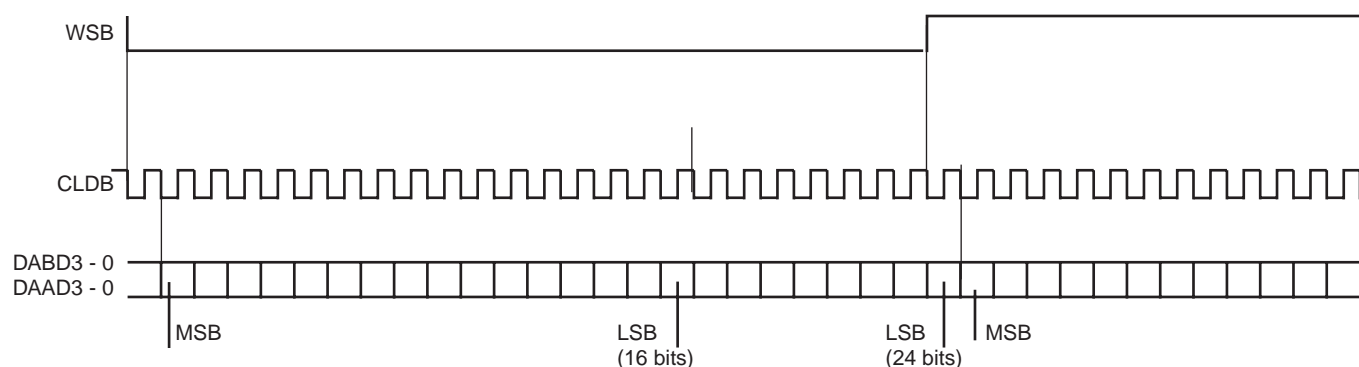
Sample Frequency WSBD	Typical Sample Frequency	$t_C$	CLBD/WSBD Frequency Ratio
$1/(t_{CK} * 128)$	96 kHz	$t_{CK}$	64
$1/(t_{CK} * 192)$	64 kHz	$2 * t_{CK}$	48
$1/(t_{CK} * 256)$	48 kHz	$2 * t_{CK}$	64
$1/(t_{CK} * 384)$	32 kHz	$4 * t_{CK}$	48

The choice of sample frequency is done by firmware.

**Figure 10.** Digital Audio Frame Format, 128 x  $F_s$  and 256 x  $F_s$  Modes



**Figure 11.** 192 x  $F_s$  and 384 x  $F_s$  Modes



## Serial MIDI\_IN and MIDI\_OUT

The serial MIDI IN and OUT signals are asynchronous signals following the MIDI transmission standard:

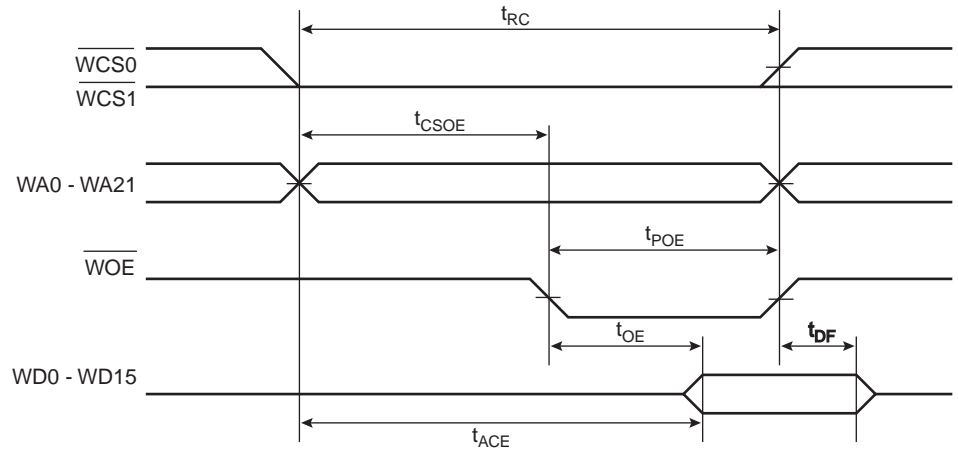
- Baud rate: 31.25 kHz
- Format: start, 8 data bits, 1 stop

## External Memory

Pins used: WA21 - WA0 (address out), WD15 - WD0 (data bi-directional)  $\overline{WCS0}$ ,  $\overline{WCS1}$  (pre-decodes out)  $\overline{WOE}$  (output enable)  $\overline{WWE}$  (write)

When using all address bits, the maximum addressing range is two pages ( $\overline{WCS0}$ ,  $\overline{WCS1}$ ) of 4M words (total = 16 Mbytes).

**Figure 12.** ROM/Flash Read Cycle

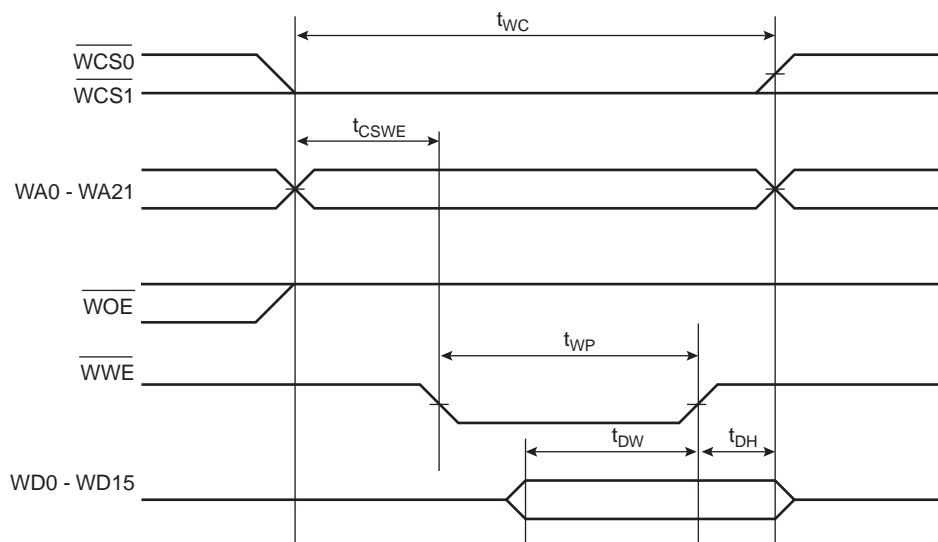


**Table 10.** External Memory Parameters

Symbol	Parameter	Min	Typ	Max	Unit
$t_{RC}$	Read cycle time	$5 * p_{LCK}$	-	$6 * p_{LCK}$	ns
$t_{CSOE}$	Chip select low/address valid to $\overline{WOE}$ low	$2 * p_{LCK} - 5$	-	$3 * p_{LCK} + 5$	ns
$t_{POE}$	Output enable pulse width	-	$3 * p_{LCK}$	-	ns
$t_{ACE}$	Chip select/address access time	$5 * p_{LCK} - 5$	-	-	ns
$t_{OE}$	Output enable access time	$3 * p_{LCK} - 5$	-	-	ns
$t_{DF}$	Chip select or $\overline{WOE}$ high to input data Hi-Z	0	-	$2 * p_{LCK} - 5$	ns

- Note:
1. A built-in PLL multiplies the crystal clock frequency by 4 for internal use.  $p_{LCK}$  is the period of the internal clock generated by PLL.  $p_{LCK} = t_{CK}/4$ . Typical value with crystal 12.288 MHz is  $p_{LCK} = 20$  ns.
  2. Memory access time should be lower than  $t_{ACE}$  min. Typical value with crystal 12.288 MHz is 90 ns.

**Figure 13.** External RAM/Flash Write Timing



**Table 11.** External Flash Timing Parameters

Symbol	Parameter	Min	Typ	Max	Unit
$t_{WC}$	Write cycle time	$5 * p_{LCK}$	-	$6 * p_{LCK}$	ns
$t_{CSWE}$	Write enable low from $\overline{CS}$ or Address or $\overline{WOE}$	$2 * p_{LCK} - 10$	-	-	ns
$t_{WP}$	Write pulse width	-	$4 * p_{LCK}$	-	ns
$t_{DW}$	Data out setup time	$4 * p_{LCK} - 10$	-	-	ns
$t_{DH}$	Data out hold time	10	-	-	ns

## Reset and Power-down

During power up, the  $\overline{\text{RESET}}$  input should be held low until the crystal oscillator and PLL are stabilized, which takes max. 10 ms.

After the low to high transition of  $\overline{\text{RESET}}$ , the following happens:

- All P24s enter an idle state.
- P16 program execution starts in built-in ROM.

The power-up sequence is as follows:

- STIN is sensed. If HIGH, then the built-in debugger is started.
  - Addresses 0 & 1 from external ROM are checked. If "DR" is read, then control is transferred to address 400H from external ROM.
  - $\overline{\text{SMC}}$  is sensed. If LOW, then the built-in loader waits for SmartMedia presence detect (SMPD). When detected, the firmware is down loaded from SmartMedia reserved sector 1 and started.
  - An attempt is made to read the first two bytes of an external EEPROM or DataFlash. If "DR" is read, then the built-in loader loads the firmware from the external EEPROM/DataFlash and starts it.
  - Firmware download from a host processor is assumed.
1. The 0ACh byte is written to the host, this raises IRQ. The host can recognize that the chip is ready to accept program download. Higher speed transfer can be reached by polling the parallel interface status ( $\overline{\text{CS}} = 0$ ,  $\text{A0} = 1$ ,  $\overline{\text{RD}} = 0$ ).
  2. The host sends the firmware size (in words) on two bytes (Low byte first).
  3. The host sends the ATSAM3308 firmware. The firmware should begin with string "DR".
  4. The 0ACh byte is written to the host, this raises IRQ. The host can recognize that the chip has accepted the firmware.
  5. ATSAM3308 starts the firmware.

If  $\overline{\text{PDWN}}$  is asserted low, then the crystal oscillator and PLL will be stopped. If the power switch is used, then the chip enters a deep power down sleep mode, as power is removed from the core. To exit power down,  $\overline{\text{PDWN}}$  has to be asserted high, then  $\overline{\text{RESET}}$  applied.

Other power reduction features allowing warm restart are controlled by firmware:

- P24s can be individually stopped.
- The clock frequency can be internally divided by 256.

## Recommended Board Layout

Like all HCMOS high integration ICs, following simple rules of board layout is mandatory for reliable operations:

- GND, VC33, VC18 distribution, decoupling

All GND, VC33, VC18 pins should be connected. A GND plane is strongly recommended. The board GND + VC33 distribution should be in grid form.

Recommended VC18 decoupling is 0.1  $\mu$ F at each corner of the IC with an additional 10  $\mu$ F decoupling close to the crystal. VC33 requires a single 0.1  $\mu$ F decoupling.

- Crystal, LFT

The paths between the crystal, the crystal compensation capacitors, the LFT filter R-C-R and the IC should be short and shielded. The ground return from the compensation capacitors and LFT filter should be the GND plane from the IC.

- Buses

Parallel layout from D0 - D7 and WA0 - WA21/WD0 - WD15 should be avoided. The D0 - D7 bus is an asynchronous type bus. Even on short distances, it can induce pulses on WA0 - WA21/WD0 - WD15 which can corrupt address and/or data on these buses.

A ground plane should be implemented below the D0 - D7 bus that connects both to the host and to the IC GND.

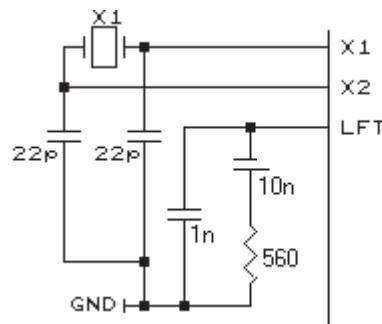
A ground plane should be implemented below the WA0 - WA21/WD0 - WD15 bus that connects both to the ROM/Flash grounds and to the IC.

- Analog Section

A specific AGND ground plane should be provided, which connects by a single trace to the GND ground. No digital signals should cross the AGND plane. Refer to the Codec vendor recommended layout for correct implementation of the analog section.

## Recommended Crystal Compensation and LFT Filter

Figure 14. Recommended Crystal Compensation and LFT Filter



## **Product Development and Debugging**

Atmel provides an integrated product development and debugging tool SamVS. SamVS runs under Windows® (98, ME, 2000, XP). Within the environment, it is possible to:

- Edit
- Assemble
- Debug on real target (In-circuit Emulation)
- Program Flash, Dataflash, EEPROM, SmartMedia on target.

Two dedicated IC pins, STIN and STOUT allow running firmware directly into the target using standard PC COM port communication at 57.6 Kbauds. Thus time-to-market is optimized by testing directly on the final prototype.

A library of frequently used functions is available, such as:

- Wavetable synthesis
- Reverb/Chorus
- MP3 decode
- 31-band equalizer
- Parametric equalizer

Atmel engineers are available to study customer-specific applications.



## **Atmel Corporation**

2325 Orchard Parkway  
San Jose, CA 95131, USA  
Tel: 1(408) 441-0311  
Fax: 1(408) 487-2600

## **Regional Headquarters**

### **Europe**

Atmel Sarl  
Route des Arsenaux 41  
Case Postale 80  
CH-1705 Fribourg  
Switzerland  
Tel: (41) 26-426-5555  
Fax: (41) 26-426-5500

### **Asia**

Room 1219  
Chinachem Golden Plaza  
77 Mody Road Tsimshatsui  
East Kowloon  
Hong Kong  
Tel: (852) 2721-9778  
Fax: (852) 2722-1369

### **Japan**

9F, Tonetsu Shinkawa Bldg.  
1-24-8 Shinkawa  
Chuo-ku, Tokyo 104-0033  
Japan  
Tel: (81) 3-3523-3551  
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## **Atmel Operations**

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