

## Features

- High Performance, Low Power AVR<sup>®</sup>32 32-Bit Microcontroller
  - 210 DMIPS throughput at 150 MHz
  - 16 KB instruction cache and 16 KB data caches
  - Memory Management Unit enabling use of operating systems
  - Single-cycle RISC instruction set including SIMD and DSP instructions
  - Java Hardware Acceleration
- Multimedia Co-Processor
  - Vector Multiplication Unit for video acceleration through color-space conversion (YUV $\leftrightarrow$ RGB), image scaling and filtering, quarter pixel motion compensation
- Multi-hierarchy bus system
  - High-performance data transfers on separate buses for increased performance
- Data Memories
  - 32KBytes SRAM
- External Memory Interface
  - SDRAM, DataFlash<sup>™</sup>, SRAM, Multi Media Card (MMC), Secure Digital (SD),
  - Compact Flash, Smart Media, NAND Flash
- Direct Memory Access Controller
  - External Memory access without CPU intervention
- Interrupt Controller
  - Individually maskable Interrupts
  - Each interrupt request has a programmable priority and autovector address
- System Functions
  - Power and Clock Manager
  - Crystal Oscillator with Phase-Lock-Loop (PLL)
  - Watchdog Timer
  - Real-time Clock
- 6 Multifunction timer/counters
  - Three external clock inputs, I/O pins, PWM, capture and various counting capabilities
- 4 Universal Synchronous/Asynchronous Receiver/Transmitters (USART)
  - 115.2 kbps IrDA Modulation and Demodulation
  - Hardware and software handshaking
- 3 Synchronous Serial Protocol controllers
  - Supports I2S, SPI and generic frame-based protocols
- Two-Wire Interface
  - Sequential Read/Write Operations, Philips' I2C<sup>®</sup> compatible
- Image Sensor Interface
  - 12-bit Data Interface for CMOS cameras
- Universal Serial Bus (USB) 2.0 High Speed (480 Mbps) Device
  - On-chip Transceivers with physical interface
- 16-bit stereo audio DAC
  - Sample rates up to 50 kHz
- On-Chip Debug System
  - Nexus Class 3
  - Full speed, non-intrusive data and program trace
  - Runtime control and JTAG interface
- Package/Pins
  - AT32AP7001: 208-pin QFP/ 90 GPIO pins
- Power supplies
  - 1.65V to 1.95V VDDCORE
  - 3.0V to 3.6V VDDIO



## AVR<sup>®</sup>32 32-bit Microcontroller

AT32AP7001

Preliminary

Summary



## 1. Part Description

The AT32AP7001 is a complete System-on-chip application processor with an AVR32 RISC processor achieving 210 DMIPS running at 150 MHz. AVR32 is a high-performance 32-bit RISC microprocessor core, designed for cost-sensitive embedded applications, with particular emphasis on low power consumption, high code density and high application performance.

AT32AP7001 implements a Memory Management Unit (MMU) and a flexible interrupt controller supporting modern operating systems and real-time operating systems. The processor also includes a rich set of DSP and SIMD instructions, specially designed for multimedia and telecom applications.

AT32AP7001 incorporates SRAM memories on-chip for fast and secure access. For applications requiring additional memory, external 16-bit SRAM is accessible. Additionally, an SDRAM controller provides off-chip volatile memory access as well as controllers for all industry standard off-chip non-volatile memories, like Compact Flash, Multi Media Card (MMC), Secure Digital (SD)-card, SmartCard, NAND Flash and Atmel DataFlash™.

The Direct Memory Access controller for all the serial peripherals enables data transfer between memories without processor intervention. This reduces the processor overhead when transferring continuous and large data streams between modules in the MCU.

The Timer/Counters includes three identical 16-bit timer/counter channels. Each channel can be independently programmed to perform a wide range of functions including frequency measurement, event counting, interval measurement, pulse generation, delay timing and pulse width modulation.

A pixel co-processor provides color space conversions for images and video, in addition to a wide variety of hardware filter support

Synchronous Serial Controllers provide easy access to serial communication protocols, audio standards like AC'97, I2S, I2C© and various SPI modes. The modules support frame-based protocols, like VoIP SIP protocols.

The Java hardware acceleration implementation in AVR32 allows for a very high-speed Java byte-code execution. AVR32 implements Java instructions in hardware, reusing the existing RISC data path, which allows for a near-zero hardware overhead and cost with a very high performance.

The Image Sensor Interface supports cameras with up to 12-bit data buses and connects directly to the LCD interface through a separate bus.

PS2 connectivity is provided for standard input devices like mice and keyboards.

AT32AP7001 integrates a class 3 Nexus 2.0 On-Chip Debug (OCD) System, with non-intrusive real-time trace, full-speed read/write memory access in addition to basic runtime control.

The C-compiler is closely linked to the architecture and is able to utilize code optimization features, both for size and speed.



## 2.1 Processor and architecture

### 2.1.1 AVR32AP CPU

- 32-bit load/store AVR32B RISC architecture.
  - Up to 15 general-purpose 32-bit registers.
  - 32-bit Stack Pointer, Program Counter and Link Register reside in register file.
  - Fully orthogonal instruction set.
  - Privileged and unprivileged modes enabling efficient and secure Operating Systems.
  - Innovative instruction set together with variable instruction length ensuring industry leading code density.
  - DSP extension with saturating arithmetic, and a wide variety of multiply instructions.
  - SIMD extension for media applications.
- 7 stage pipeline allows one instruction per clock cycle for most instructions.
  - Java Hardware Acceleration.
  - Byte, half-word, word and double word memory access.
  - Unaligned memory access.
  - Shadowed interrupt context for INT3 and multiple interrupt priority levels.
  - Dynamic branch prediction and return address stack for fast change-of-flow.
  - Coprocessor interface.
- Full MMU allows for operating systems with memory protection.
- 16Kbyte Instruction and 16Kbyte data caches.
  - Virtually indexed, physically tagged.
  - 4-way associative.
  - Write-through or write-back.
- Nexus Class 3 On-Chip Debug system.
  - Low-cost NanoTrace supported.

### 2.1.2 Pixel Coprocessor (PiCo)

- Coprocessor coupled to the AVR32 CPU Core through the TCB Bus.
- Three parallel Vector Multiplication Units (VMU) where each unit can:
  - Multiply three pixel components with three coefficients.
  - Add the products from the multiplications together.
  - Accumulate the result or add an offset to the sum of the products.
- Can be used for accelerating:
  - Image Color Space Conversion.
    - Configurable Conversion Coefficients.
    - Supports packed and planar input and output formats.
    - Supports subsampled input color spaces (i.e 4:2:2, 4:2:0).
  - Image filtering/scaling.
    - Configurable Filter Coefficients.
    - Throughput of one sample per cycle for a 9-tap FIR filter.
    - Can use the built-in accumulator to extend the FIR filter to more than 9-taps.
    - Can be used for bilinear/bicubic interpolations.
  - MPEG-4/H.264 Quarter Pixel Motion Compensation.
- Flexible input Pixel Selector.
  - Can operate on numerous different image storage formats.
- Flexible Output Pixel Inserter.
  - Scales and saturates the results back to 8-bit pixel values.

- Supports packed and planar output formats.
- Configurable coefficients with flexible fixed-point representation.

### 2.1.3 Debug and Test system

- IEEE1149.1 compliant JTAG and boundary scan
- Direct memory access and programming capabilities through JTAG interface
- Extensive On-Chip Debug features in compliance with IEEE-ISTO 5001-2003 (Nexus 2.0) Class 3
- Auxiliary port for high-speed trace information
- Hardware support for 6 Program and 2 data breakpoints
- Unlimited number of software breakpoints supported
- Advanced Program, Data, Ownership, and Watchpoint trace supported

### 2.1.4 DMA controller

- 2 HSB Master Interfaces
- 3 Channels
- Software and Hardware Handshaking Interfaces
  - 11 Hardware Handshaking Interfaces
- Memory/Non-Memory Peripherals to Memory/Non-Memory Peripherals Transfer
- Single-block DMA Transfer
- Multi-block DMA Transfer
  - Linked Lists
  - Auto-Reloading
  - Contiguous Blocks
- DMA Controller is Always the Flow Controller
- Additional Features
  - Scatter and Gather Operations
  - Channel Locking
  - Bus Locking
  - FIFO Mode
  - Pseudo Fly-by Operation

### 2.1.5 Peripheral DMA Controller

- Transfers from/to peripheral to/from any memory space without intervention of the processor.
- Next Pointer Support, forbids strong real-time constraints on buffer management.
- Eighteen channels
  - Two for each USART
  - Two for each Serial Synchronous Controller
  - Two for each Serial Peripheral Interface

### 2.1.6 Bus system

- HSB bus matrix with 10 Masters and 8 Slaves handled
  - Handles Requests from the CPU Icache, CPU Dcache, HSB bridge, HISI, USB 2.0 Controller, DMA Controller 0, DMA Controller 1, and to internal SRAM 0, internal SRAM 1, PB A, PB B, EBI and, USB.

- Round-Robin Arbitration (three modes supported: no default master, last accessed default master, fixed default master)
- Burst Breaking with Slot Cycle Limit
- One Address Decoder Provided per Master
- 2 Peripheral buses allowing each bus to run on different bus speeds.
  - PB A intended to run on low clock speeds, with peripherals connected to the PDC.
  - PB B intended to run on higher clock speeds, with peripherals connected to the DMAC.
- HSB-HSB Bridge providing a low-speed HSB bus running at the same speed as PBA
  - Allows PDC transfers between a low-speed PB bus and a bus matrix of higher clock speeds

An overview of the bus system is given in [Figure 2-1 on page 3](#). All modules connected to the same bus use the same clock, but the clock to each module can be individually shut off by the Power Manager. The figure identifies the number of master and slave interfaces of each module connected to the HSB bus, and which DMA controller is connected to which peripheral.

Package and Pinout

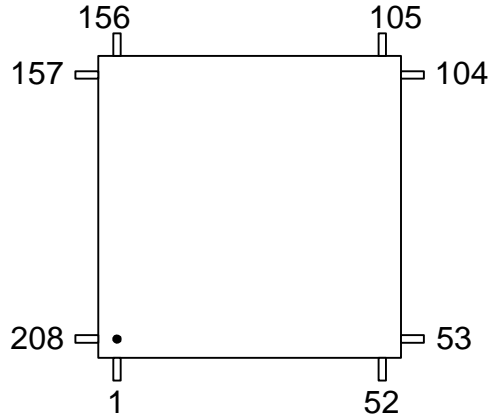


Table 3-1. QFP-208 Package Pinout

1	GND	53	GND	105	GND	157	GND
2	PE17	54	PA23	106	PX13	158	PB10
3	PE18	55	PA24	107	PX14	159	PB11
4	PX47	56	XIN1	108	PX15	160	PB12
5	PX48	57	XOUT1	109	PX16	161	PB13
6	PX49	58	AVDDUSB	110	PX17	162	PB14
7	PX50	59	AGNDUSB	111	PX34	163	PB15
8	PX51	60	VDDIO	112	PX35	164	PB16
9	VDDIO	61	FSDM	113	PX36	165	PB17
10	PX32	62	FSDP	114	PX37	166	PB18
11	PX33	63	GND	115	PX38	167	PB19
12	PX00	64	GND	116	PX18	168	PB20
13	PX01	65	HSDM	117	PX19	169	PB21
14	PX02	66	HSDP	118	PX20	170	PB22
15	PX03	67	VDDCORE	119	PX21	171	PB23
16	PX04	68	GND	120	PX22	172	VDDCORE
17	PX05	69	GND	121	PX23	173	GND
18	VDDCORE	70	VBG	122	PX24	174	GND
19	GND	71	VDDIO	123	PX25	175	PA06
20	TDO	72	PA25	124	PX26	176	PA07
21	TCK	73	PA26	125	VDDIO	177	VDDIO

**Table 3-1.** QFP-208 Package Pinout (Continued)

22	TMS		74	PA27		126	PX27		178	VDDIO
23	TDI		75	PA28		127	PX28		179	OSCEN_N
24	TRST_N		76	PA29		128	PX29		180	XIN32
25	EVTI_N		77	PA30		129	PX30		181	XOUT32
26	RESET_N		78	PA31		130	PX31		182	AGNDOSC
27	PA00		79	WAKE_N		131	VDDCORE		183	AVDDOSC
28	PA01		80	PB26		132	GND		184	PLL1
29	PA02		81	PB27		133	GND		185	XIN0
30	PA03		82	PB28		134	PE26		186	XOUT0
31	PA04		83	PX53		135	PX39		187	AGNDPLL
32	PA05		84	PX52		136	VDDCORE		188	AVDDPLL
33	PB24		85	PX41		137	GND		189	PLL0
34	PB25		86	GND		138	PX40		190	PE00
35	PA08		87	PE25		139	PX42		191	PE01
36	VDDIO		88	PE24		140	PX43		192	PE02
37	GND		89	PE23		141	PX44		193	PE03
38	PA09		90	PE22		142	PX45		194	PE04
39	PA10		91	PE21		143	PX46		195	PE05
40	PA11		92	PE20		144	PB00		196	PE06
41	PA12		93	PE19		145	PB01		197	PE07
42	PA13		94	PX06		146	PB02		198	PE08
43	PA14		95	PX07		147	PB03		199	PE09
44	PA15		96	PX08		148	PB04		200	PE10
45	PA16		97	PX09		149	PB05		201	PE11
46	PA17		98	PX10		150	PB06		202	PE12
47	PA18		99	PX11		151	PB07		203	PE13
48	PA19		100	PB29		152	PB08		204	PE14
49	PA20		101	PB30		153	PB09		205	PE15
50	PA21		102	PX12		154	PC16		206	PE16
51	PA22		103	PC00		155	PC17		207	No Connect
52	VDDIO		104	VDDIO		156	VDDIO		208	GND



## 4. Signals Description

The following table gives details on the signal name classified by peripheral. The pinout multiplexing of these signals is given in the Peripheral Muxing table in the Peripherals chapter.

**Table 4-1.** Signal Description List

Signal Name	Function	Type	Active Level	Comments
<b>Power</b>				
AVDDPLL	PLL Power Supply	Power		1.65 to 1.95 V
AVDDUSB	USB Power Supply	Power		1.65 to 1.95 V
AVDDOSC	Oscillator Power Supply	Power		1.65 to 1.95 V
VDDCORE	Core Power Supply	Power		1.65 to 1.95 V
VDDIO	I/O Power Supply	Power		3.0 to 3.6V
AGNDPLL	PLL Ground	Ground		
AGNDUSB	USB Ground	Ground		
AGNDOSC	Oscillator Ground	Ground		
GND	Ground	Ground		
<b>Clocks, Oscillators, and PLL's</b>				
XIN0, XIN1, XIN32	Crystal 0, 1, 32 Input	Analog		
XOUT0, XOUT1, XOUT32	Crystal 0, 1, 32 Output	Analog		
PLL0, PLL1	PLL 0,1 Filter Pin	Analog		
<b>JTAG</b>				
TCK	Test Clock	Input		
TDI	Test Data In	Input		
TDO	Test Data Out	Output		
TMS	Test Mode Select	Input		
TRST_N	Test Reset	Input	Low	
<b>Auxiliary Port - AUX</b>				
MCKO	Trace Data Output Clock	Output		
MDO0 - MDO5	Trace Data Output	Output		
MSEO0 - MSEO1	Trace Frame Control	Output		
EVTI_N	Event In	Input	Low	

**Table 4-1.** Signal Description List

Signal Name	Function	Type	Active Level	Comments
EVTO_N	Event Out	Output	Low	
<b>Power Manager - PM</b>				
GCLK0 - GCLK4	Generic Clock Pins	Output		
OSCEN_N	Oscillator Enable	Input	Low	
RESET_N	Reset Pin	Input	Low	
WAKE_N	Wake Pin	Input	Low	
<b>External Interrupt Module - EIM</b>				
EXTINT0 - EXTINT3	External Interrupt Pins	Input		
NMI_N	Non-Maskable Interrupt Pin	Input	Low	
<b>AC97 Controller - AC97C</b>				
SCLK	AC97 Clock Signal	Input		
SDI	AC97 Receive Signal	Output		
SDO	AC97 Transmit Signal	Output		
SYNC	AC97 Frame Synchronization Signal	Input		
<b>DAC - DAC</b>				
DATA0 - DATA1	D/A Data Out	Output		
DATAN0 - DATAN1	D/A Inverted Data Out	Output		
<b>External Bus Interface - EBI</b>				
ADDR0 - ADDR25	Address Bus	Output		
CAS	Column Signal	Output	Low	
CFCE1	Compact Flash 1 Chip Enable	Output	Low	
CFCE2	Compact Flash 2 Chip Enable	Output	Low	
CFRNW	Compact Flash Read Not Write	Output		
DATA0 - DATA31	Data Bus	I/O		
NANDOE	NAND Flash Output Enable	Output	Low	
NANDWE	NAND Flash Write Enable	Output	Low	
NCS0 - NCS5	Chip Select	Output	Low	
NRD	Read Signal	Output	Low	

**Table 4-1.** Signal Description List

Signal Name	Function	Type	Active Level	Comments
NWAIT	External Wait Signal	Input	Low	
NWE0	Write Enable 0	Output	Low	
NWE1	Write Enable 1	Output	Low	
NWE3	Write Enable 3	Output	Low	
RAS	Row Signal	Output	Low	
SDA10	SDRAM Address 10 Line	Output		
SDCK	SDRAM Clock	Output		
SDCKE	SDRAM Clock Enable	Output		
SDCS	SDRAM Chip Select	Output	Low	
SDWE	SDRAM Write Enable	Output	Low	
<b>Image Sensor Interface - ISI</b>				
DATA0 - DATA11	Image Sensor Data	Input		
HSYNC	Horizontal Synchronization	Input		
PCLK	Image Sensor Data Clock	Input		
VSYSN	Vertical Synchronization	Input		
<b>Multimedia Card Interface - MMCI</b>				
CLK	Multimedia Card Clock	Output		
CMD0 - CMD1	Multimedia Card Command	I/O		
DATA0 - DATA7	Multimedia Card Data	I/O		
<b>Parallel Input/Output 2 - PIOA, PIOB, PIOC, PIOD, PIOE</b>				
PA0 - PA31	Parallel I/O Controller PIOA	I/O		
PB0 - PB30	Parallel I/O Controller PIOB	I/O		
PC0 - PC31	Parallel I/O Controller PIOC	I/O		
PD0 - PD17	Parallel I/O Controller PIOD	I/O		
PE0 - PE26	Parallel I/O Controller PIOE	I/O		
<b>PS2 Interface - PSIF</b>				
CLOCK0 - CLOCK1	PS2 Clock	Input		
DATA0 - DATA1	PS2 Data	I/O		

**Table 4-1.** Signal Description List

Signal Name	Function	Type	Active Level	Comments
<b>Serial Peripheral Interface - SPI0, SPI1</b>				
MISO	Master In Slave Out	I/O		
MOSI	Master Out Slave In	I/O		
NPCS0 - NPCS3	SPI Peripheral Chip Select	I/O	Low	
SCK	Clock	Output		
<b>Synchronous Serial Controller - SSC0, SSC1, SSC2</b>				
RX_CLOCK	SSC Receive Clock	I/O		
RX_DATA	SSC Receive Data	Input		
RX_FRAME_SYNC	SSC Receive Frame Sync	I/O		
TX_CLOCK	SSC Transmit Clock	I/O		
TX_DATA	SSC Transmit Data	Output		
TX_FRAME_SYNC	SSC Transmit Frame Sync	I/O		
<b>DMA Controller - DMAC</b>				
DMARQ0 - DMARQ3	DMA Requests	Input		
<b>Timer/Counter - TIMER0, TIMER1</b>				
A0	Channel 0 Line A	I/O		
A1	Channel 1 Line A	I/O		
A2	Channel 2 Line A	I/O		
B0	Channel 0 Line B	I/O		
B1	Channel 1 Line B	I/O		
B2	Channel 2 Line B	I/O		
CLK0	Channel 0 External Clock Input	Input		
CLK1	Channel 1 External Clock Input	Input		
CLK2	Channel 2 External Clock Input	Input		
<b>Two-wire Interface - TWI</b>				
SCL	Serial Clock	I/O		
SDA	Serial Data	I/O		
<b>Universal Synchronous Asynchronous Receiver Transmitter - USART0, USART1, USART2, USART3</b>				

**Table 4-1.** Signal Description List

Signal Name	Function	Type	Active Level	Comments
CLK	Clock	I/O		
CTS	Clear To Send	Input		
RTS	Request To Send	Output		
RXD	Receive Data	Input		
TXD	Transmit Data	Output		
<b>Pulse Width Modulator - PWM</b>				
PWM0 - PWM3	PWM Output Pins	Output		
<b>Universal Serial Bus Device - USB</b>				
DDM	USB Device Port Data -	Analog		
DDP	USB Device Port Data +	Analog		
VBG	USB bandgap	Analog		Connected to a 6810 Ohm $\pm$ 0.5% resistor to ground and a 10 pF capacitor to ground.

## 5. Power Considerations

### 5.1 Power Supplies

The AT32AP7001 has several types of power supply pins:

- **VDDCORE pins:** Power the core, memories, and peripherals. Voltage is 1.8V nominal.
- **VDDIO pins:** Power I/O lines. Voltage is 3.3V nominal.
- **VDDPLL pin:** Powers the PLL. Voltage is 1.8V nominal.
- **VDDUSB pin:** Powers the USB. Voltage is 1.8V nominal.
- **VDDOSC pin:** Powers the oscillators. Voltage is 1.8V nominal.

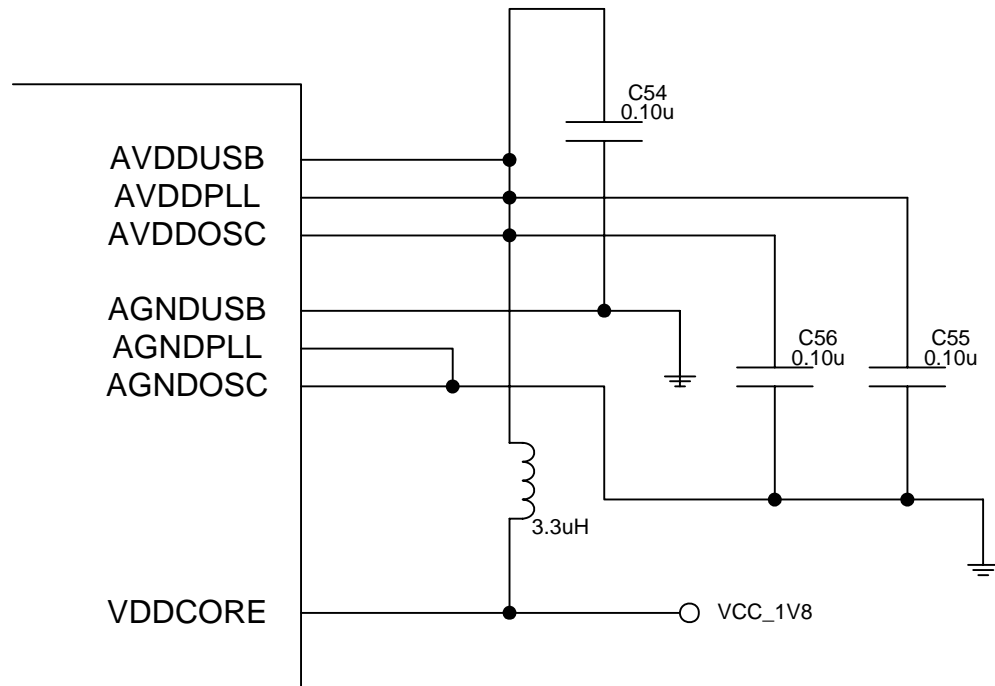
The ground pins GND are common to VDDCORE and VDDIO. The ground pin for VDDPLL is GNDPLL, and the GND pin for VDDOSC is GNDOSC.

See ["Electrical Characteristics" on page 928](#) for power consumption on the various supply pins.

### 5.2 Power Supply Connections

Special considerations should be made when connecting the power and ground pins on a PCB. [Figure 5-1](#) shows how this should be done.

**Figure 5-1.** Connecting analog power supplies



## **6. I/O Line Considerations**

### **6.1 JTAG pins**

The TMS, TDI and TCK pins have pull-up resistors. TDO is an output, driven at up to VDDIO, and have no pull-up resistor. The TRST\_N pin is used to initialize the embedded JTAG TAP Controller when asserted at a low level. It is a schmitt input and integrates permanent pull-up resistor to VDDIO, so that it can be left unconnected for normal operations.

### **6.2 WAKE\_N pin**

The WAKE\_N pin is a schmitt trigger input integrating a permanent pull-up resistor to VDDIO.

### **6.3 RESET\_N pin**

The RESET\_N pin is a schmitt input and integrates a permanent pull-up resistor to VDDIO. As the product integrates a power-on reset cell, the RESET\_N pin can be left unconnected in case no reset from the system needs to be applied to the product.

### **6.4 EVTI\_N pin**

The EVTI\_N pin is a schmitt input and integrates a non-programmable pull-up resistor to VDDIO.

### **6.5 TWI pins**

When these pins are used for TWI, the pins are open-drain outputs with slew-rate limitation and inputs with inputs with spike-filtering. When used as GPIO-pins or used for other peripherals, the pins have the same characteristics as PIO pins.

### **6.6 PIO pins**

All the I/O lines integrate a programmable pull-up resistor. Programming of this pull-up resistor is performed independently for each I/O line through the PIO Controllers. After reset, I/O lines default as inputs with pull-up resistors enabled, except when indicated otherwise in the column "Reset State" of the PIO Controller multiplexing tables.

## 7. Memories

### 7.1 Embedded Memories

- 32 Kbyte SRAM
  - Implemented as two 16Kbyte blocks
  - Single cycle access at full bus speed

### 7.2 Physical Memory Map

The system bus is implemented as an HSB bus matrix. All system bus addresses are fixed, and they are never remapped in any way, not even in boot. Note that AT32AP7001 by default uses segment translation, as described in the AVR32 Architecture Manual. The 32 bit physical address space is mapped as follows:

**Table 7-1.** AT32AP7001 Physical Memory Map

Start Address	Size	Device
0x0000_0000	64 Mbyte	EBI SRAM CS0
0x0400_0000	64 Mbyte	EBI SRAM CS4
0x0800_0000	64 Mbyte	EBI SRAM CS2
0x0C00_0000	64 Mbyte	EBI SRAM CS3
0x1000_0000	256 Mbyte	EBI SRAM/SDRAM CS1
0x2000_0000	64 Mbyte	EBI SRAM CS5
0x2400_0000	16 Kbyte	Internal SRAM 0
0x2400_4000	16 Kbyte	Internal SRAM1
0xFF00_0000	4 Kbyte	LCDC configuration
0xFF20_0000	1 KByte	DMAC configuration
0xFF30_0000	1 MByte	USB Data
0xFFE0_0000	1 MByte	PBA
0xFFFF0_0000	1 MByte	PBB

Accesses to unused areas returns an error result to the master requesting such an access.

The bus matrix has the several masters and slaves. Each master has its own bus and its own decoder, thus allowing a different memory mapping per master. The master number in the table below can be used to index the HMATRIX control registers. For example, MCFG2 is associated with the HSB-HSB bridge.



**Table 7-2.** HSB masters

Master 0	CPU Dcache
Master 1	CPU Icache
Master 2	HSB-HSB Bridge
Master 3	ISI DMA
Master 4	USB DMA
Master 5	LCD Controller DMA
Master 6	Ethernet MAC0 DMA
Master 7	Ethernet MAC1 DMA
Master 8	DMAC Master Interface 0
Master 9	DMAC Master Interface 1

Each slave has its own arbiter, thus allowing a different arbitration per slave. The slave number in the table below can be used to index the HMATRIX control registers. For example, SCFG3 is associated with PBB.

**Table 7-3.** HSB slaves

Slave 0	Internal SRAM 0
Slave 1	Internal SRAM1
Slave 2	PBA
Slave 3	PBB
Slave 4	EBI
Slave 5	USB data
Slave 6	LCDC configuration
Slave 7	DMAC configuration

## 8. Peripherals

### 8.1 Peripheral address map

**Table 8-1.** Peripheral Address Mapping

Address		Peripheral Name	Bus
0xFF200000	DMAC	DMA Controller Slave Interface- DMAC	HSB
0xFF300000	USB	USB 2.0 Slave Interface - USB	HSB
0xFFE00000	SPI0	Serial Peripheral Interface - SPI0	PB A
0xFFE00400	SPI1	Serial Peripheral Interface - SPI1	PB A
0xFFE00800	TWI	Two-wire Interface - TWI	PB A
0xFFE00C00	USART0	Universal Synchronous Asynchronous Receiver Transmitter - USART0	PB A
0xFFE01000	USART1	Universal Synchronous Asynchronous Receiver Transmitter - USART1	PB A
0xFFE01400	USART2	Universal Synchronous Asynchronous Receiver Transmitter - USART2	PB A
0xFFE01800	USART3	Universal Synchronous Asynchronous Receiver Transmitter - USART3	PB A
0xFFE01C00	SSC0	Synchronous Serial Controller - SSC0	PB A
0xFFE02000	SSC1	Synchronous Serial Controller - SSC1	PB A
0xFFE02400	SSC2	Synchronous Serial Controller - SSC2	PB A
0xFFE02800	PIOA	Parallel Input/Output 2 - PIOA	PB A
0xFFE02C00	PIOB	Parallel Input/Output 2 - PIOB	PB A
0xFFE03000	PIOC	Parallel Input/Output 2 - PIOC	PB A
0xFFE03400	PIOD	Parallel Input/Output 2 - PIOD	PB A
0xFFE03800	PIOE	Parallel Input/Output 2 - PIOE	PB A

**Table 8-1.** Peripheral Address Mapping (Continued)

Address	Peripheral Name	Bus
0xFFE03C00	PSIF PS2 Interface - PSIF	PB A
0xFFFF0000	SM System Manager - SM	PB B
0xFFFF00400	INTC Interrupt Controller - INTC	PB B
0xFFFF00800	HMATRIX HSB Matrix - HMATRIX	PB B
0xFFFF00C00	TC0 Timer/Counter - TC0	PB B
0xFFFF01000	TC1 Timer/Counter - TC1	PB B
0xFFFF01400	PWM Pulse Width Modulation Controller - PWM	PB B
0xFFFF02000	DAC DAC - Audio DAC	PB B
0xFFFF02400	MCI Multimedia Card Interface - MCI	PB B
0xFFFF02800	AC97C AC97 Controller - AC97C	PB B
0xFFFF02C00	ISI Image Sensor Interface - ISI	PB B
0xFFFF03000	USB USB 2.0 Configuration Interface - USB	PB B
0xFFFF03400	SMC Static Memory Controller - SMC	PB B
0xFFFF03800	SDRAMC SDRAM Controller - SDRAMC	PB B
0xFFFF03C00	ECC Error Correcting Code Controller - ECC	PB B

## 8.2 Interrupt Request Signal Map

The various modules may output interrupt request signals. These signals are routed to the Interrupt Controller (INTC). The Interrupt Controller supports up to 64 groups of interrupt requests. Each group can have up to 32 interrupt request signals. All interrupt signals in the same group share the same autovector address and priority level. Refer to the documentation for the individual submodules for a description of the semantic of the different interrupt requests.

The interrupt request signals in AT32AP7001 are connected to the INTC as follows:

**Table 8-2.** Interrupt Request Signal Map

Group	Line	Signal
0	0	COUNT-COMPARE match
	1	Performance Counter Overflow
2	0	DMAC BLOCK
	1	DMAC DSTT
	2	DMAC ERR
	3	DMAC SRCT
	4	DMAC TFR
3	0	SPI 0
4	0	SPI 1
5	0	TWI
6	0	USART0
7	0	USART1
8	0	USART2
9	0	USART3
10	0	SSC0
11	0	SSC1
12	0	SSC2
13	0	PIOA
14	0	PIOB
15	0	PIOC
16	0	PIOD
17	0	PIOE
18	0	PSIF
19	0	EIM0
	1	EIM1
	2	EIM2
	3	EIM3
20	0	PM
21	0	RTC
22	0	TC00
	1	TC01
	2	TC02
23	0	TC10
	1	TC11
	2	TC12

**Table 8-2.** Interrupt Request Signal Map

Group	Line	Signal
24	0	PWM
27	0	DAC
28	0	MCI
29	0	AC97C
30	0	ISI
31	0	USB
32	0	EBI

### 8.3 DMAC Handshake Interface Map

The following table details the hardware handshake map between the DMAC and the peripherals attached to it :

**Table 8-3.** Hardware Handshaking Connection

Request	Hardware Handshaking Interface
MCI RX	0
MCI TX	1
DAC TX	2
AC97C CHANNEL A RX	3
AC97C CHANNEL A TX	4
AC97C CHANNEL B RX	5
AC97C CHANNEL B TX	6
EXTERNAL DMA REQUEST 0	7
EXTERNAL DMA REQUEST 1	8
EXTERNAL DMA REQUEST 2	9
EXTERNAL DMA REQUEST 3	10

## 8.4 Clock Connections

### 8.4.1 Timer/Counters

Each Timer/Counter channel can independently select an internal or external clock source for its counter:

**Table 8-4.** Timer/Counter clock connections

Timer/Counter	Source	Name	Connection
0	Internal	TIMER_CLOCK1	clk_slow
		TIMER_CLOCK2	clk_pbb / 4
		TIMER_CLOCK3	clk_pbb / 8
		TIMER_CLOCK4	clk_pbb / 16
		TIMER_CLOCK5	clk_pbb / 32
	External	XC0	See <a href="#">Section 8.7</a>
		XC1	
		XC2	
1	Internal	TIMER_CLOCK1	clk_slow
		TIMER_CLOCK2	clk_pbb / 4
		TIMER_CLOCK3	clk_pbb / 8
		TIMER_CLOCK4	clk_pbb / 16
		TIMER_CLOCK5	clk_pbb / 32
	External	XC0	See <a href="#">Section 8.7</a>
		XC1	
		XC2	

### 8.4.2 USARTs

Each USART can be connected to an internally divided clock:

**Table 8-5.** USART clock connections

USART	Source	Name	Connection
0	Internal	CLK_DIV	clk_pba / 8
1			
2			
3			

## 8.4.3 SPIs

Each SPI can be connected to an internally divided clock:

**Table 8-6.** SPI clock connections

SPI	Source	Name	Connection
0	Internal	CLK_DIV	clk_pba / 32
1			

## 8.5 External Interrupt Pin Mapping

External interrupt requests are connected to the following pins::

**Table 8-7.** External Interrupt Pin Mapping

Source	Connection
NMI_N	PB24
EXTINT0	PB25
EXTINT1	PB26
EXTINT2	PB27
EXTINT3	PB28

## 8.6 Nexus OCD AUX port connections

If the OCD trace system is enabled, the trace system will take control over a number of pins, irrespectively of the PIO configuration. Two different OCD trace pin mappings are possible, depending on the configuration of the OCD AXS register. For details, see the *AVR32 AP Technical Reference Manual*.

**Table 8-8.** Nexus OCD AUX port connections

Pin	AXS=0	AXS=1
EVTI_N	EVTI_N	EVTI_N
MDO[5]	PB09	PC18
MDO[4]	PB08	PC14
MDO[3]	PB07	PC12
MDO[2]	PB06	PC11
MDO[1]	PB05	PC06
MDO[0]	PB04	PC05
EVTO_N	PB03	PB28
MCKO	PB02	PC02
MSEO[1]	PB01	PC01
MSEO[0]	PB00	PC00

## 8.7 Peripheral Multiplexing on IO lines

The AT32AP7001 features five PIO controllers, PIOA to PIOE, that multiplex the I/O lines of the peripheral set. Each PIO Controller controls up to thirty-two lines.

Each line can be assigned to one of two peripheral functions, A or B. The tables in the following pages define how the I/O lines of the peripherals A and B are multiplexed on the PIO Controllers.

Note that some output only peripheral functions might be duplicated within the tables.

### 8.7.1 PIO Controller A Multiplexing

**Table 8-9.** PIO Controller A Multiplexing

I/O Line	Peripheral A	Peripheral B
PA00	SPI0 - MISO	SSC1 - RX_FRAME_SYNC
PA01	SPI0 - MOSI	SSC1 - TX_FRAME_SYNC
PA02	SPI0 - SCK	SSC1 - TX_CLOCK
PA03	SPI0 - NPCS[0]	SSC1 - RX_CLOCK
PA04	SPI0 - NPCS[1]	SSC1 - TX_DATA
PA05	SPI0 - NPCS[2]	SSC1 - RX_DATA
PA06	TWI - SDA	USART0 - RTS
PA07	TWI - SCL	USART0 - CTS
PA08	PSIF - CLOCK	USART0 - RXD
PA09	PSIF - DATA	USART0 - TXD
PA10	MCI - CLK	USART0 - CLK
PA11	MCI - CMD	TC0 - CLK0
PA12	MCI - DATA[0]	TC0 - A0
PA13	MCI - DATA[1]	TC0 - A1
PA14	MCI - DATA[2]	TC0 - A2
PA15	MCI - DATA[3]	TC0 - B0
PA16	USART1 - CLK	TC0 - B1
PA17	USART1 - RXD	TC0 - B2
PA18	USART1 - TXD	TC0 - CLK2
PA19	USART1 - RTS	TC0 - CLK1
PA20	USART1 - CTS	SPI0 - NPCS[3]
PA21	SSC0 - RX_FRAME_SYNC	PWM - PWM[2]
PA22	SSC0 - RX_CLOCK	PWM - PWM[3]
PA23	SSC0 - TX_CLOCK	TC1 - A0
PA24	SSC0 - TX_FRAME_SYNC	TC1 - A1
PA25	SSC0 - TX_DATA	TC1 - B0
PA26	SSC0 - RX_DATA	TC1 - B1
PA27	SPI1 - NPCS[3]	TC1 - CLK0
PA28	PWM - PWM[0]	TC1 - A2



**Table 8-9.** PIO Controller A Multiplexing

PA29	PWM - PWM[1]	TC1 - B2
PA30	SM - GCLK[0]	TC1 - CLK1
PA31	SM - GCLK[1]	TC1 - CLK2

## 8.7.2 PIO Controller B Multiplexing

**Table 8-10.** PIO Controller B Multiplexing

I/O Line	Peripheral A	Peripheral B
PB00	ISI - DATA[0]	SPI1 - MISO
PB01	ISI - DATA[1]	SPI1 - MOSI
PB02	ISI - DATA[2]	SPI1 - NPCS[0]
PB03	ISI - DATA[3]	SPI1 - NPCS[1]
PB04	ISI - DATA[4]	SPI1 - NPCS[2]
PB05	ISI - DATA[5]	SPI1 - SCK
PB06	ISI - DATA[6]	MCI - CMD[1]
PB07	ISI - DATA[7]	MCI - DATA[4]
PB08	ISI - HSYNC	MCI - DATA[5]
PB09	ISI - VSYNC	MCI - DATA[6]
PB10	ISI - PCLK	MCI - DATA[7]
PB11	PSIF - CLOCK[1]	ISI - DATA[8]
PB12	PSIF - DATA[1]	ISI - DATA[9]
PB13	SSC2 - TX_DATA	ISI - DATA[10]
PB14	SSC2 - RX_DATA	ISI - DATA[11]
PB15	SSC2 - TX_CLOCK	USART3 - CTS
PB16	SSC2 - TX_FRAME_SYNC	USART3 - RTS
PB17	SSC2 - RX_FRAME_SYNC	USART3 - TXD
PB18	SSC2 - RX_CLOCK	USART3 - RXD
PB19	SM - GCLK[2]	USART3 - CLK
PB20	DAC - DATA[1]	AC97C - SDO
PB21	DAC - DATA[0]	AC97C - SYNC
PB22	DAC - DATAN[1]	AC97C - SCLK
PB23	DAC - DATAN[0]	AC97C - SDI
PB24	NMI_N	DMAC - DMARQ[0]
PB25	EXTINT0	DMAC - DMARQ[1]
PB26	EXTINT1	USART2 - RXD
PB27	EXTINT2	USART2 - TXD
PB28	EXTINT3	USART2 - CLK
PB29	SM - GCLK[3]	USART2 - CTS
PB30	SM - GCLK[4]	USART2 - RTS

**Table 8-11.** PIO Controller C Multiplexing

PC16		
PC17		

**Table 8-12.** PIO Controller E Multiplexing

<b>I/O Line</b>	<b>Peripheral A</b>	<b>Peripheral B</b>
PE00	EBI - DATA[16]	
PE01	EBI - DATA[17]	
PE02	EBI - DATA[18]	
PE03	EBI - DATA[19]	
PE04	EBI - DATA[20]	
PE05	EBI - DATA[21]	
PE06	EBI - DATA[22]	
PE07	EBI - DATA[23]	
PE08	EBI - DATA[24]	
PE09	EBI - DATA[25]	
PE10	EBI - DATA[26]	
PE11	EBI - DATA[27]	
PE12	EBI - DATA[28]	
PE13	EBI - DATA[29]	
PE14	EBI - DATA[30]	
PE15	EBI - DATA[31]	
PE16	EBI - ADDR[23]	
PE17	EBI - ADDR[24]	
PE18	EBI - ADDR[25]	
PE19	EBI - CFCE1	
PE20	EBI - CFCE2	
PE21	EBI - NCS[4]	
PE22	EBI - NCS[5]	
PE23	EBI - CFRNW	
PE24	EBI - NWAIT	
PE25	EBI - NCS[2]	
PE26	EBI - SDCS	

## 8.7.5 IO Pins Without Multiplexing

Many of the external EBI pins are not controlled by the PIO modules, but directly driven by the EBI. These pins have programmable pullup resistors. These resistors are controlled by Special Function Register 4 (SFR4) in the HMATRIX. The pullup on the lines multiplexed with PIO is controlled by the appropriate PIO control register.

This SFR can also control CompactFlash, SmartMedia or NandFlash Support, see the EBI chapter for details

### 8.7.5.1 HMatrix SFR4 EBI Control Register

**Name:** HMATRIX\_SFR4

**Access Type:** Read/Write

31	30	29	28	27	26	25	24
-	-	-	-	-	-	-	-
23	22	21	20	19	18	17	16
-	-	-	-	-	-	-	-
15	14	13	12	11	10	9	8
-	-	-	-	-	-	-	EBI_DBPUC
7	6	5	4	3	2	1	0
-	-	EBI_CS5A	EBI_CS4A	EBI_CS3A	-	EBI_CS1A	-

- **CS1A: Chip Select 1 Assignment**

0 = Chip Select 1 is assigned to the Static Memory Controller.

1 = Chip Select 1 is assigned to the SDRAM Controller.

- **CS3A: Chip Select 3 Assignment**

0 = Chip Select 3 is only assigned to the Static Memory Controller and NCS3 behaves as defined by the SMC.

1 = Chip Select 3 is assigned to the Static Memory Controller and the NAND Flash/SmartMedia Logic is activated.

- **CS4A: Chip Select 4 Assignment**

0 = Chip Select 4 is assigned to the Static Memory Controller and NCS4, NCS5 and NCS6 behave as defined by the SMC.

1 = Chip Select 4 is assigned to the Static Memory Controller and the CompactFlash Logic is activated.

- **CS5A: Chip Select 5 Assignment**

0 = Chip Select 5 is assigned to the Static Memory Controller and NCS4, NCS5 and NCS6 behave as defined by the SMC.

1 = Chip Select 5 is assigned to the Static Memory Controller and the CompactFlash Logic is activated.

Accessing the address space reserved to NCS5 and NCS6 may lead to an unpredictable outcome.

- **EBI\_DBPUC: EBI Data Bus Pull-up Control**

0: EBI D[15:0] are internally pulled up to the VDDIO power supply. The pull-up resistors are enabled after reset.

1: EBI D[15:0] are not internally pulled up.

**Table 8-13.** IO Pins without multiplexing

I/O Line	Function
PX00	EBI - DATA[0]
PX01	EBI - DATA[1]
PX02	EBI - DATA[2]
PX03	EBI - DATA[3]
PX04	EBI - DATA[4]
PX05	EBI - DATA[5]
PX06	EBI - DATA[6]
PX07	EBI - DATA[7]
PX08	EBI - DATA[8]
PX09	EBI - DATA[9]
PX10	EBI - DATA[10]
PX11	EBI - DATA[11]
PX12	EBI - DATA[12]
PX13	EBI - DATA[13]
PX14	EBI - DATA[14]
PX15	EBI - DATA[15]
PX16	EBI - ADDR[0]
PX17	EBI - ADDR[1]
PX18	EBI - ADDR[2]
PX19	EBI - ADDR[3]
PX20	EBI - ADDR[4]
PX21	EBI - ADDR[5]
PX22	EBI - ADDR[6]
PX23	EBI - ADDR[7]
PX24	EBI - ADDR[8]
PX25	EBI - ADDR[9]
PX26	EBI - ADDR[10]
PX27	EBI - ADDR[11]
PX28	EBI - ADDR[12]
PX29	EBI - ADDR[13]
PX30	EBI - ADDR[14]
PX31	EBI - ADDR[15]

**Table 8-13.** IO Pins without multiplexing (Continued)

PX32	EBI - ADDR[16]
PX33	EBI - ADDR[17]
PX34	EBI - ADDR[18]
PX35	EBI - ADDR[19]
PX36	EBI - ADDR[20]
PX37	EBI - ADDR[21]
PX38	EBI - ADDR[22]
PX39	EBI - NCS[0]
PX40	EBI - NCS[1]
PX41	EBI - NCS[3]
PX42	EBI - NRD
PX43	EBI - NWE0
PX44	EBI - NWE1
PX45	EBI - NWE3
PX46	EBI - SDCK
PX47	EBI - SDCKE
PX48	EBI - RAS
PX49	EBI - CAS
PX50	EBI - SDWE
PX51	EBI - SDA10
PX52	EBI - NANDOE
PX53	EBI - NANDWE

## 8.8 Peripheral overview

### 8.8.1 External Bus Interface

- Optimized for Application Memory Space support
- Integrates Three External Memory Controllers:
  - Static Memory Controller
  - SDRAM Controller
  - ECC Controller
- Additional Logic for NAND Flash/SmartMedia™ and CompactFlash™ Support
  - SmartMedia support: 8-bit as well as 16-bit devices are supported
  - CompactFlash support: all modes (Attribute Memory, Common Memory, I/O, True IDE) are supported but the signals \_IOIS16 (I/O and True IDE modes) and \_ATA SEL (True IDE mode) are not handled.
- Optimized External Bus:
  - 16- or 32-bit Data Bus
  - Up to 26-bit Address Bus, Up to 64-Mbytes Addressable
  - Optimized pin multiplexing to reduce latencies on External Memories
- Up to 6 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/SmartMedia™ Support
  - Static Memory Controller on NCS4 - NCS5, Optional CompactFlash™ Support

### 8.8.2 Static Memory Controller

- 6 Chip Selects Available
- 64-Mbyte Address Space per Chip Select
- 8-, 16- or 32-bit Data Bus
- Word, Halfword, Byte Transfers
- Byte Write or Byte Select Lines
- Programmable Setup, Pulse And Hold Time for Read Signals per Chip Select
- Programmable Setup, Pulse And Hold Time for Write Signals per Chip Select
- Programmable Data Float Time per Chip Select
- Compliant with LCD Module
- External Wait Request
- Automatic Switch to Slow Clock Mode
- Asynchronous Read in Page Mode Supported: Page Size Ranges from 4 to 32 Bytes

### 8.8.3 SDRAM Controller

- Numerous Configurations Supported
  - 2K, 4K, 8K Row Address Memory Parts
  - SDRAM with Two or Four Internal Banks
  - SDRAM with 16- or 32-bit Data Path
- 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 Modes Supported
  - Supports Mobile SDRAM Devices
- Error Detection
  - Refresh Error Interrupt
- SDRAM Power-up Initialization by Software
- CAS Latency of 1, 2, 3 Supported
- Auto Precharge Command Not Used

## 8.8.4 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

## 8.8.5 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

## 8.8.6 Two-wire Interface

- Compatibility with standard two-wire serial memory
- One, two or three bytes for slave address
- Sequential read/write operations



**8.8.7 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
  - 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 46
  - Remote Loopback, Local Loopback, Automatic Echo

**8.8.8 Serial Synchronous Controller**

- Provides serial synchronous communication links used in audio and telecom applications (with CODECs in Master or Slave Modes, I2S, 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

**8.8.9 AC97 Controller**

- Compatible with AC97 Component Specification V2.2
- Capable to Interface with a Single Analog Front end
- Three independent RX Channels and three independent TX Channels
  - One RX and one TX channel dedicated to the AC97 Analog Front end control
  - One RX and one TX channel for data transfers, connected to the DMAC
  - One RX and one TX channel for data transfers, connected to the DMAC
- Time Slot Assigner allowing to assign up to 12 time slots to a channel
- Channels support mono or stereo up to 20 bit sample length - Variable sampling rate AC97 Codec Interface (48KHz and below)

## 8.8.10 Audio DAC

- Digital Stereo DAC
- Oversampled D/A conversion architecture
  - Oversampling ratio fixed 128x
  - FIR equalization filter
  - Digital interpolation filter: Comb4
  - 3rd Order Sigma-Delta D/A converters
- Digital bitstream outputs
- Parallel interface
- Connected to DMA Controller for background transfer without CPU intervention

## 8.8.11 Timer Counter

- Three 16-bit Timer Counter Channels
- 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
- Two global registers that act on all three TC Channels

## 8.8.12 Pulse Width Modulation Controller

- 4 channels, one 16-bit counter per channel
- Common clock generator, providing Thirteen Different Clocks
  - A Modulo n counter providing eleven clocks
  - Two independent Linear Dividers working on modulo n counter outputs
- Independent channel programming
  - Independent Enable Disable Commands
  - Independent Clock
  - Independent Period and Duty Cycle, with Double Bufferization
  - Programmable selection of the output waveform polarity
  - Programmable center or left aligned output waveform

**8.8.13 Multimedia Card Interface**

- 2 double-channel Multimedia Card Interface, allowing concurrent transfers with 2 cards
- Compatibility with MultiMedia Card Specification Version 2.2
- Compatibility with SD Memory Card Specification Version 1.0
- Compatibility with SDIO Specification Version V1.0.
- Cards clock rate up to Master Clock divided by 2
- Embedded power management to slow down clock rate when not used
- Each MCI has two slot, 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

**8.8.14 PS/2 Keyboard Interface**

- Peripheral Bus slave
- PS/2 Host
- Receive and transmit capability
- Parity generation and error detection
- Overrun error detection

**8.8.15 USB Device Port**

- USB V2.0 high-speed compliant, 480 Mbits per second
- Embedded USB V2.0 high-speed transceiver
- Embedded 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, Endpoint 3: 8 bytes, no ping-pong mode
  - Endpoint 1, Endpoint 2: 64 bytes, ping-pong mode
  - Endpoint 4, Endpoint 5: 256 bytes, ping-pong mode

- 

**8.8.16 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\*480
- Support for packed data formatting for YCbCr 4:2:2 formats
- Preview scaler to generate smaller size image 50
- Programmable frame capture rate

## 9. Boot Sequence

This chapter summarizes the boot sequence of the AT32AP7001. The behaviour after power-up is controlled by the Power Manager.

### 9.1 Starting of clocks

After power-up, the device will be held in a reset state by the Power-On Reset circuitry, until the power has stabilized throughout the device. Once the power has stabilized, the device will use the XIN0 pin as clock source. XIN0 can be connected either to an external clock, or a crystal. The OSCEN\_N pin is connected either to VDD or GND to inform the Power Manager on how the XIN0 pin is connected. If XIN0 receives a signal from a crystal, dedicated circuitry in the Power Manager keeps the part in a reset state until the oscillator connected to XIN0 has settled. If XIN0 receives an external clock, no such settling delay is applied.

On system start-up, the PLLs are disabled. All clocks to all modules are running. No clocks have a divided frequency, all parts of the system receive a clock with the same frequency as the XIN0 clock.

### 9.2 Fetching of initial instructions

After reset has been released, the AVR32AP CPU starts fetching instructions from the reset address, which is 0xA000\_0000. This address lies in the P2 segment, which is non-translated, non-cacheable, and permanently mapped to the physical address range 0x0000\_0000 to 0x2000\_0000. This means that the instruction being fetched from virtual address 0xA000\_0000 is being fetched from physical address 0x0000\_0000. Physical address 0x0000\_0000 is mapped to EBI SRAM CS0. This is the external memory the device boots from.

The code read from the SRAM CS0 memory is free to configure the system to use for example the PLLs, to divide the frequency of the clock routed to some of the peripherals, and to gate the clocks to unused peripherals.

## 10. Ordering Information

**Figure 10-1.** Ordering Information

Ordering Code	Package	Package Type	Packing	Temperature Operating Range
AT32AP7001-ALUT	QFP208	Green	Tray	Industrial (-40°C to 85°C)

## 11. Errata

### 11.1 Rev. C

#### 1. SPI FDIV option does not work

Selecting clock signal using FDIV = 1 does not work as specified.

##### Fix/Workaround

Do not set FDIV = 1.

#### 2. SPI Chip Select 0 BITS field overrides other Chip Selects

The BITS field for Chip Select 0 overrides BITS fields for other Chip selects.

##### Fix/Workaround

Update Chip Select 0 BITS field to the relevant settings before transmitting with Chip Selects other than 0.

#### 3. SPI LASTXFER may be overwritten

When Peripheral Select (PS) = 0, the LASTXFER-bit in the Transmit Data Register (TDR) should be internally discarded. This fails and may cause problems during DMA transfers. Transmitting data using the PDC when PS=0, the size of the transferred data is 8- or 16-bits. The upper 16 bits of the TDR will be written to a random value. If Chip Select Active After Transfer (CSAAT) = 1, the behavior of the Chip Select will be unpredictable.

##### Fix/Workaround

- Do not use CSAAT = 1 if PS = 0
- Use GPIO to control Chip Select lines
- Select PS=1 and store data for PCS and LASTXFER for each data in transmit buffer.

#### 4. SPI LASTXFER overrides Chip Select

The LASTXFER bit overrides Chip Select input when PS = 0 and CSAAT is used.

##### Fix/Workaround

- Do not use the CSAAT
- Use GPIO as Chip Select input
- Select PS = 1. Transfer 32-bit with correct LASTXFER settings.

#### 5. MMC data write operation with less than 12 bytes is impossible.

The Data Write operation with a number of bytes less than 12 is impossible

##### Fix/Workaround

The PDC counters must always be equal to 12 bytes for data transfers lower than 12 bytes. The BLKLEN or BCNT field are used to specify the real count number.

#### 6. MMC SDIO interrupt only works for slot A

If 1-bit data bus width and on other slots than slot A, the SDIO interrupt can not be captured.

##### Fix/Workaround

Use slot A.

## 7. PSIF TXEN/RXEN may disable the transmitter/receiver

Writing a '0' to RXEN will disable the receiver. Writing '0' to TXEN will disable the transmitter.

### Fix/Workaround

When accessing the PS/2 Control Register always write '1' to RXEN to keep the receiver enabled, and write '1' to TXEN to keep the transmitter enabled.

## 8. PSIF TXRDY interrupt corrupts transfers

When writing to the Transmit Holding Register (THR), the data will be transferred to the data shift register immediately, regardless of the state of the data shift register. If a transfer is ongoing, it will be interrupted and a new transfer will be started with the new data written to THR.

### Fix/Workaround

Use the TXEMPTY-interrupt instead of the TXRDY-interrupt to update the THR. This ensures that a transfer is completed.

## 9. PWN counter restarts at 0x0001

The PWN counter restarts at 0x0001 and not 0x0000 as specified. Because of this the first PWM period has one more clock cycle.

### Fix/Workaround

- The first period is 0x0000, 0x0001, ..., period
- Consecutive periods are 0x0001, 0x0002, ..., period

## 10. PWM channel interrupt enabling triggers an interrupt

When enabling a PWM channel that is configured with center aligned period (CALG=1), an interrupt is signalled.

### Fix/Workaround

When using center aligned mode, enable the channel and read the status before channel interrupt is enabled.

## 11. PWM update period to a 0 value does not work

It is impossible to update a period equal to 0 by the using the PWM update register (PWM\_CUPD).

### Fix/Workaround

Do not update the PWM\_CUPD register with a value equal to 0.

## 12. PWM channel status may be wrong if disabled before a period has elapsed

Before a PWM period has elapsed, the read channel status may be wrong. The CHIDx-bit for a PWM channel in the PWM Enable Register will read '1' for one full PWM period even if the channel was disabled before the period elapsed. It will then read '0' as expected.

### Fix/Workaround

Reading the PWM channel status of a disabled channel is only correct after a PWM period

## 13. TWI transfer error without ACK

If the TWI does not receive an ACK from a slave during the address+R/W phase, no bits in the status register will be set to indicate this. Hence, the transfer will never complete.

**Fix/Workaround**

To prevent errors due to missing ACK, the software should use a timeout mechanism to terminate the transfer if this happens.

**11.2 Rev. B**

Not sampled.

**11.3 Rev. A**

Not sampled.



## **12. Datasheet Revision History**

Please note that the referring page numbers in this section are referred to this document. The referring revision in this section are referring to the document revision.

### **12.1 Rev. A 02/07**

1. Initial revision.

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