Welcome to E-XFL.COM

What is "Embedded - Microcontrollers"?

"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	ARM® Cortex®-M4
Core Size	32-Bit Single-Core
Speed	48MHz
Connectivity	I²C, IrDA, LINbus, SPI, UART/USART, USB
Peripherals	Brown-out Detect/Reset, DMA, I²S, POR, PWM, WDT
Number of I/O	48
Program Memory Size	256KB (256K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	32K x 8
Voltage - Supply (Vcc/Vdd)	1.68V ~ 3.6V
Data Converters	A/D 7x12b; D/A 1x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	64-TQFP
Supplier Device Package	64-TQFP (10x10)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/atsam4ls4ba-au

3.2 Peripheral Multiplexing on I/O lines

3.2.1 Multiplexed Signals

Each GPIO line can be assigned to one of the peripheral functions. The following tables (Section 3-1 ”100-pin GPIO Controller Function Multiplexing” on page 19 to Section 3-4 ”48-pin GPIO Controller Function Multiplexing” on page 28) describes the peripheral signals multiplexed to the GPIO lines.

Peripheral functions that are not relevant in some parts of the family are grey-shaded.

For description of differents Supply voltage source, refer to the Section 6. ”Power and Startup Considerations” on page 46.

Table 3-1. 100-pin GPIO Controller Function Multiplexing (Sheet 1 of 4)

ATSAM4LC		ATSAM4LS		Pin	GPIO	Supply	GPIO Functions						
QFN	VFBGA	QFN	VFBGA				A	B	C	D	E	F	G
5	B9	5	B9	PA00	0	VDDIO							
6	B8	6	B8	PA01	1	VDDIO							
12	A7	12	A7	PA02	2	VDDIN	SCIF GCLK0	SPI NPCS0					CATB DIS
19	B3	19	B3	PA03	3	VDDIN		SPI MISO					
24	A2	24	A2	PA04	4	VDDANA	ADCIFE AD0	USART0 CLK	EIC EXTINT2	GLOC IN1			CATB SENSE0
25	A1	25	A1	PA05	5	VDDANA	ADCIFE AD1	USART0 RXD	EIC EXTINT3	GLOC IN2	ADCIFE TRIGGER		CATB SENSE1
30	C3	30	C3	PA06	6	VDDANA	DACC VOUT	USART0 RTS	EIC EXTINT1	GLOC IN0	ACIFC ACAN0		CATB SENSE2
31	D3	31	D3	PA07	7	VDDANA	ADCIFE AD2	USART0 TXD	EIC EXTINT4	GLOC IN3	ACIFC ACAP0		CATB SENSE3
44	G2	44	G2	PA08	8	LCDA	USART0 RTS	TC0 A0	PEVC PAD EVT0	GLOC OUT0		LCDCA SEG23	CATB SENSE4
47	F5	47	F5	PA09	9	LCDA	USART0 CTS	TC0 B0	PEVC PAD EVT1	PARC PCDATA0		LCDCA COM3	CATB SENSE5
48	H2	48	H2	PA10	10	LCDA	USART0 CLK	TC0 A1	PEVC PAD EVT2	PARC PCDATA1		LCDCA COM2	CATB SENSE6
49	H3	49	H3	PA11	11	LCDA	USART0 RXD	TC0 B1	PEVC PAD EVT3	PARC PCDATA2		LCDCA COM1	CATB SENSE7
50	J2	50	J2	PA12	12	LCDA	USART0 TXD	TC0 A2		PARC PCDATA3		LCDCA COM0	CATB DIS
63	H5	63	H5	PA13	13	LCDA	USART1 RTS	TC0 B2	SPI NPCS1	PARC PCDATA4		LCDCA SEG5	CATB SENSE8
64	K7	64	K7	PA14	14	LCDA	USART1 CLK	TC0 CLK0	SPI NPCS2	PARC PCDATA5		LCDCA SEG6	CATB SENSE9
65	G5	65	G5	PA15	15	LCDA	USART1 RXD	TC0 CLK1	SPI NPCS3	PARC PCDATA6		LCDCA SEG7	CATB SENSE10

Table 3-4. 48-pin GPIO Controller Function Multiplexing (Sheet 1 of 2)

ATSAM4LC	ATSAM4LS	Pin	GPIO	Supply	GPIO Functions						
					A	B	C	D	E	F	G
1	1	PA00	0	VDDIO							
2	2	PA01	1	VDDIO							
3	3	PA02	2	VDDIN	SCIF GCLK0	SPI NPCS0					CATB DIS
10	10	PA03	3	VDDIN		SPI MISO					
11	11	PA04	4	VDDANA	ADCIFE AD0	USART0 CLK	EIC EXTINT2	GLOC IN1			CATB SENSE0
12	12	PA05	5	VDDANA	ADCIFE AD1	USART0 RXD	EIC EXTINT3	GLOC IN2	ADCIFE TRIGGER		CATB SENSE1
15	15	PA06	6	VDDANA	DACC VOUT	USART0 RTS	EIC EXTINT1	GLOC IN0	ACIFC ACAN0		CATB SENSE2
16	16	PA07	7	VDDANA	ADCIFE AD2	USART0 TXD	EIC EXTINT4	GLOC IN3	ACIFC ACAP0		CATB SENSE3
20	20	PA08	8	LCDA	USART0 RTS	TC0 A0	PEVC PAD EVT0	GLOC OUT0		LCDCA SEG23	CATB SENSE4
21	21	PA09	9	LCDA	USART0 CTS	TC0 B0	PEVC PAD EVT1	PARC PCDATA0		LCDCA COM3	CATB SENSE5
22	22	PA10	10	LCDA	USART0 CLK	TC0 A1	PEVC PAD EVT2	PARC PCDATA1		LCDCA COM2	CATB SENSE6
23	23	PA11	11	LCDA	USART0 RXD	TC0 B1	PEVC PAD EVT3	PARC PCDATA2		LCDCA COM1	CATB SENSE7
24	24	PA12	12	LCDA	USART0 TXD	TC0 A2		PARC PCDATA3		LCDCA COM0	CATB DIS
32	32	PA13	13	LCDA	USART1 RTS	TC0 B2	SPI NPCS1	PARC PCDATA4		LCDCA SEG5	CATB SENSE8
33	33	PA14	14	LCDA	USART1 CLK	TC0 CLK0	SPI NPCS2	PARC PCDATA5		LCDCA SEG6	CATB SENSE9
34	34	PA15	15	LCDA	USART1 RXD	TC0 CLK1	SPI NPCS3	PARC PCDATA6		LCDCA SEG7	CATB SENSE10
35	35	PA16	16	LCDA	USART1 TXD	TC0 CLK2	EIC EXTINT1	PARC PCDATA7		LCDCA SEG8	CATB SENSE11
36	36	PA17	17	LCDA	USART2 RTS	ABDACB DAC0	EIC EXTINT2	PARC PCCK		LCDCA SEG9	CATB SENSE12
37	37	PA18	18	LCDA	USART2 CLK	ABDACB DACN0	EIC EXTINT3	PARC PCEN1		LCDCA SEG18	CATB SENSE13
38	38	PA19	19	LCDA	USART2 RXD	ABDACB DAC1	EIC EXTINT4	PARC PCEN2	SCIF GCLK0	LCDCA SEG19	CATB SENSE14
39	39	PA20	20	LCDA	USART2 TXD	ABDACB DACN1	EIC EXTINT5	GLOC IN0	SCIF GCLK1	LCDCA SEG20	CATB SENSE15
41	41	PA21	21	LCDC	SPI MISO	USART1 CTS	EIC EXTINT6	GLOC IN1	TWIM2 TWD	LCDCA SEG34	CATB SENSE16
42	42	PA22	22	LCDC	SPI MOSI	USART2 CTS	EIC EXTINT7	GLOC IN2	TWIM2 TWCK	LCDCA SEG35	CATB SENSE17
43	43	PA23	23	LCDC	SPI SCK	TWIMS0 TWD	EIC EXTINT8	GLOC IN3	SCIF GCLK IN0	LCDCA SEG38	CATB DIS

Table 3-8. Signal Descriptions List (Sheet 2 of 4)

Signal Name	Function	Type	Active Level	Comments
Inter-IC Sound (I2S) Controller - IISC				
IMCK	I2S Master Clock	Output		
ISCK	I2S Serial Clock	I/O		
ISDI	I2S Serial Data In	Input		
ISDO	I2S Serial Data Out	Output		
IWS	I2S Word Select	I/O		
LCD Controller - LCDCA				
BIASL	Bias voltage (1/3 VLCD)	Analog		
BIASH	Bias voltage (2/3 VLCD)	Analog		
CAPH	High voltage end of flying capacitor	Analog		
CAPL	Low voltage end of flying capacitor	Analog		
COM3 - COM0	Common terminals	Analog		
SEG39 - SEG0	Segment terminals	Analog		
VLCD	Bias voltage	Analog		
Parallel Capture - PARC				
PCCK	Clock	Input		
PCDATA7 - PCDATA0	Data lines	Input		
PCEN1	Data enable 1	Input		
PCEN2	Data enable 2	Input		
Peripheral Event Controller - PEVC				
PAD_EVT3 - PAD_EVT0	Event Inputs	Input		
Power Manager - PM				
RESET_N	Reset	Input	Low	
System Control Interface - SCIF				
GCLK3 - GCLK0	Generic Clock Outputs	Output		
GCLK_IN1 - GCLK_IN0	Generic Clock Inputs	Input		
XIN0	Crystal 0 Input	Analog/ Digital		
XOUT0	Crystal 0 Output	Analog		
Serial Peripheral Interface - SPI				
MISO	Master In Slave Out	I/O		
MOSI	Master Out Slave In	I/O		
NPCS3 - NPCS0	SPI Peripheral Chip Selects	I/O	Low	
SCK	Clock	I/O		
Timer/Counter - TC0, TC1				

Table 3-8. Signal Descriptions List (Sheet 4 of 4)

Signal Name	Function	Type	Active Level	Comments
PA31 - PA00	Parallel I/O Controller I/O Port A	I/O		
PB15 - PB00	Parallel I/O Controller I/O Port B	I/O		
PC31 - PC00	Parallel I/O Controller I/O Port C	I/O		

Note: 1. See "Power and Startup Considerations" section.

3.4 I/O Line Considerations

3.4.1 SW/JTAG Pins

The JTAG pins switch to the JTAG functions if a rising edge is detected on TCK low after the RESET_N pin has been released. The TMS, and TDI pins have pull-up resistors when used as JTAG pins. The TCK pin always has pull-up enabled during reset. The JTAG pins can be used as GPIO pins and multiplexed with peripherals when the JTAG is disabled. Refer to Section 3.2.3 "JTAG Port Connections" on page 29 for the JTAG port connections.

For more details, refer to Section 1.1 "Enhanced Debug Port (EDP)" on page 3.

3.4.2 RESET_N Pin

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

3.4.3 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 GPIO pins.

3.4.4 GPIO Pins

All the I/O lines integrate a pull-up/pull-down resistor and slew rate controller. Programming these features is performed independently for each I/O line through the GPIO Controllers. After reset, I/O lines default as inputs with pull-up and pull-down resistors disabled and slew rate enabled.

3.4.5 High-drive Pins

The six pins PA02, PB00, PB01, PC04, PC05 and PC06 have high-drive output capabilities. Refer to Section 9.6.2 "High-drive I/O Pin : PA02, PC04, PC05, PC06" on page 115 for electrical characteristics.

3.4.6 USB Pins

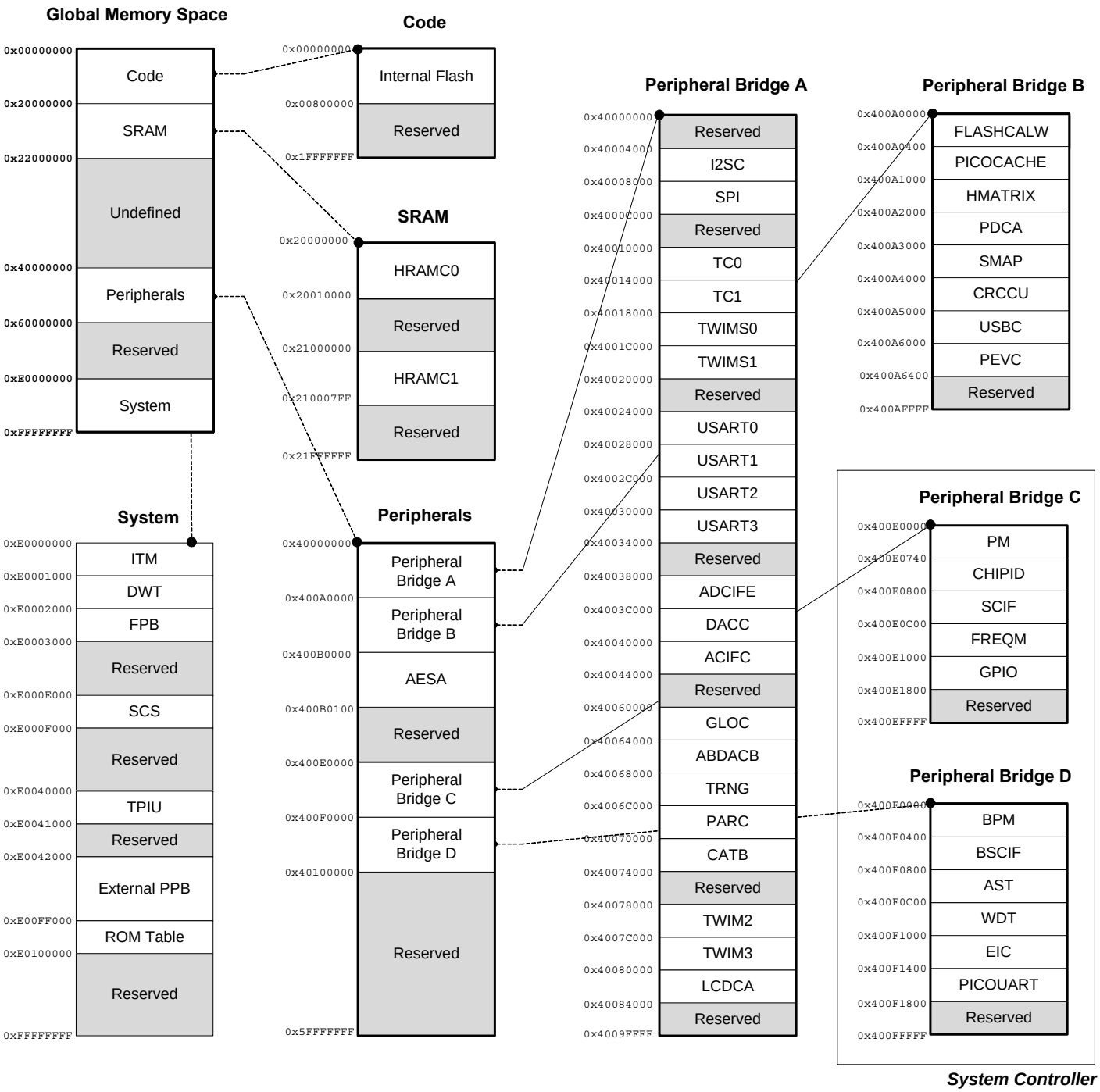
When these pins are used for USB, the pins are behaving according to the USB specification. When used as GPIO pins or used for other peripherals, the pins have the same behavior as other normal I/O pins, but the characteristics are different. Refer to Section 9.6.3 "USB I/O Pin : PA25, PA26" on page 116 for electrical characteristics.

These pins are compliant to USB standard only when VDDIO power supply is 3.3V nominal.

5. Memories

5.1 Product Mapping

Figure 5-1. ATSAM4L8/L4/L2 Product Mapping

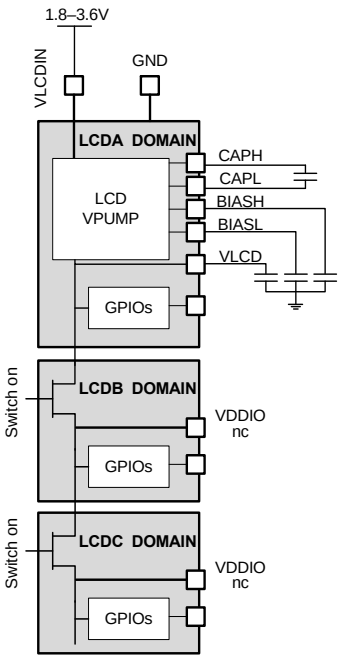


connected to an external voltage source (1.8-3.6V). LCDB cluster is not available in 64 and 48 pin packages

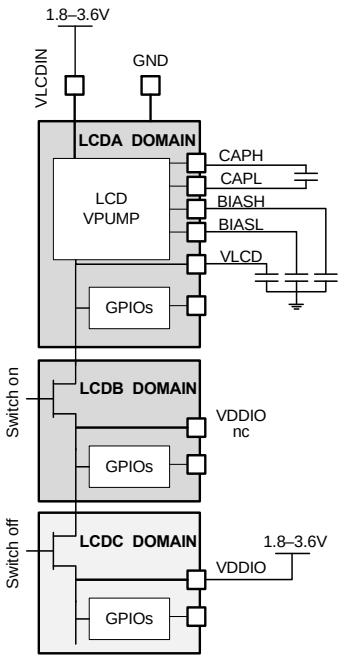
Table 6-1. LCD powering when using the internal voltage pump

Package	Segments in use	VDDIO LCDB	VDDIO LCDC
100-pin packages	[1,24]	1.8-3.6V	1.8-3.6V
	[1, 32]	nc	1.8-3.6V
	[1, 40]	nc	nc
64-pin packages	[1,15]	-	1.8-3.6V
	[1, 23]	-	nc
48-pin packages	[1,9]	-	1.8-3.6V
	[1,13]	-	nc

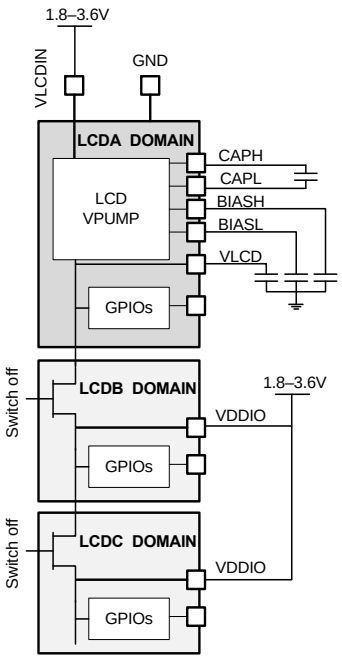
Up to 4x40 segments
No GPIO in LCD clusters



Up to 4x32 segments
Up to 8 GPIOs in LCDC clusters



Up to 4x24 segments
Up to 16 GPIOs in LCDB & LCDC clusters



mechanism can be useful for applications that only require the processor to run when an interrupt occurs.

Before entering the SLEEP mode, the user must configure:

- the SLEEP mode configuration field (BPM.PMCON.SLEEP), Refer to Table 7-1.
- the SCR.SLEEPDEEP bit to 0. (See the Power Management section in the ARM Cortex-M4 Processor chapter).
- the BPM.PMCON.RET bit to 0.
- the BPM.PMCON.BKUP bit to 0.

7.1.1.2 Exiting SLEEP mode

The NVIC wakes the system up when it detects any non-masked interrupt with sufficient priority to cause exception entry. The system goes back to the RUN mode from which the SLEEP mode was entered. The CPU and affected modules are restarted. Note that even if an interrupt is enabled in SLEEP mode, it will not trigger if the source module is not clocked.

7.1.2 WAIT Mode and RETENTION Mode

The WAIT and RETENTION modes allow achieving very low power consumption while maintaining the Core domain powered-on. Internal SRAM and registers contents of the Core domain are preserved.

In these modes, all clocks are stopped except the 32kHz clocks (OSC32K, RC32K) which are kept running if enabled.

In RETENTION mode, the SleepWalking feature is not supported and must not be used.

7.1.2.1 Entering WAIT or RETENTION Mode

The WAIT or RETENTION modes are entered by executing the WFI instruction with the following settings:

- set the SCR.SLEEPDEEP bit to 1. (See the Power Management section in the ARM Cortex-M4 Processor chapter).
- set the BPM.PSAVE.BKUP bit to 0.
- set the BPM.PMCON.RET bit to RETENTION or WAIT mode.

SLEEPONEXIT feature is also available. See ”Entering SLEEP mode” on page 56.

7.1.2.2 Exiting WAIT or RETENTION Mode

In WAIT or RETENTION modes, synchronous clocks are stopped preventing interrupt sources from triggering. To wakeup the system, asynchronous wake up sources (AST, EIC, USBC ...) should be enabled in the peripheral (refer to the documentation of the peripheral). The PM.AWEN (Asynchronous Wake Up Enable) register should also be enabled for all peripheral except for EIC and AST.

When the enabled asynchronous wake up event occurs and the system is waken-up, it will generate either:

- an interrupt on the PM WAKE interrupt line if enabled (Refer to Section 9. ”Power Manager (PM)” on page 677). In that case, the PM.WCAUSE register indicates the wakeup source.
- or an interrupt directly from the peripheral if enabled (Refer to the section of the peripheral).

When waking up, the system goes back to the RUN mode mode from which the WAIT or RETENTION mode was entered.

8.5 Product dependencies

8.5.1 I/O Lines

Refer to Section 1.1.5.1 ”I/O Lines” on page 5.

8.5.2 Power management

Refer to Section 1.1.5.2 ”Power Management” on page 5.

8.5.3 Clocks

Refer to Section 1.1.5.3 ”Clocks” on page 5.

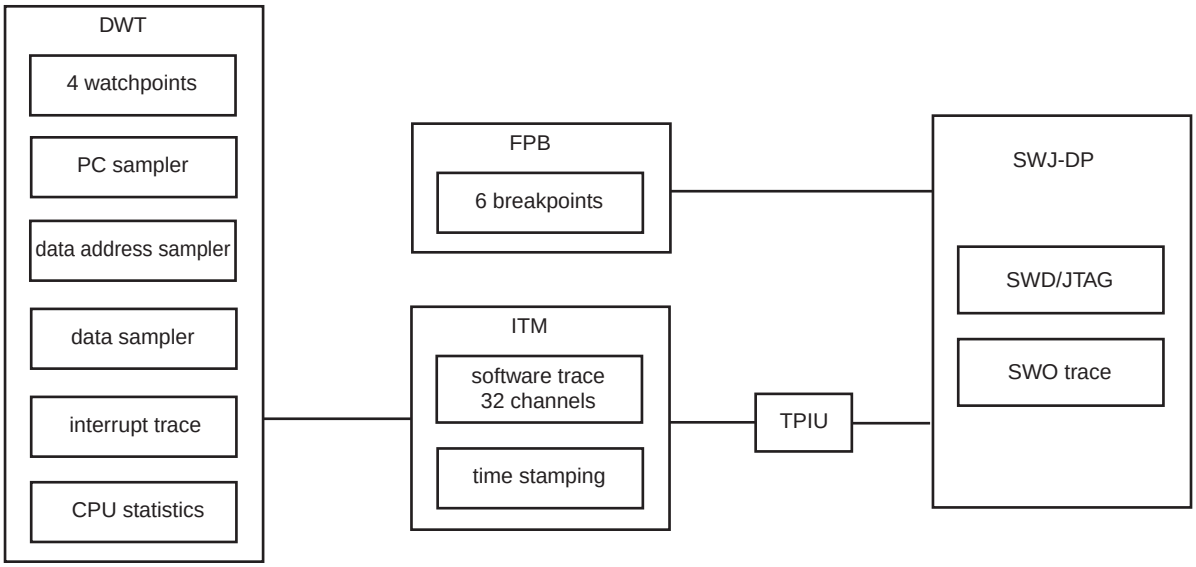
8.6 Core debug

Figure 8-2 shows the Debug Architecture used in the SAM4L. The Cortex-M4 embeds four functional units for debug:

- FPB (Flash Patch Breakpoint)
- DWT (Data Watchpoint and Trace)
- ITM (Instrumentation Trace Macrocell)
- TPIU (Trace Port Interface Unit)

The debug architecture information that follows is mainly dedicated to developers of SWJ-DP Emulators/Probes and debugging tool vendors for Cortex-M4 based microcontrollers. For further details on SWJ-DP see the Cortex-M4 technical reference manual.

Figure 8-2. Debug Architecture



8.6.1 FPB (Flash Patch Breakpoint)

The FPB:

- Implements hardware breakpoints
- Patches (on the fly) code and data being fetched by the Cortex-M4 core from code space with data in the system space. Definition of code and system spaces can be found in the System Address Map section of the ARMv7-M Architecture Reference Manual.

  - Fix the ATB ID to 1
- Write 0x1 into the Trace Enable Register:
  - Enable the Stimulus port 0
- Write 0x1 into the Trace Privilege Register:
  - Stimulus port 0 only accessed in privileged mode (Clearing a bit in this register will result in the corresponding stimulus port being accessible in user mode.)
- Write into the Stimulus port 0 register: TPIU (Trace Port Interface Unit)

  The TPIU acts as a bridge between the on-chip trace data and the Instruction Trace Macrocell (ITM).

  The TPIU formats and transmits trace data off-chip at frequencies asynchronous to the core.

Asynchronous Mode:

The TPIU is configured in asynchronous mode, trace data are output using the single TRACESWO pin. The TRACESWO signal is multiplexed with the TDO signal of the JTAG Debug Port. As a consequence, asynchronous trace mode is only available when the Serial Wire Debug mode is selected since TDO signal is used in JTAG debug mode.

Two encoding formats are available for the single pin output:

- Manchester encoded stream. This is the reset value.
- NRZ_based UART byte structure

5.4.3. How to Configure the TPIU

This example only concerns the asynchronous trace mode.

- Set the TRCENA bit to 1 into the Debug Exception and Monitor Register (0xE000EDFC) to enable the use of trace and debug blocks.
- Write 0x2 into the Selected Pin Protocol Register
  - Select the Serial Wire Output – NRZ
- Write 0x100 into the Formatter and Flush Control Register
- Set the suitable clock prescaler value into the Async Clock Prescaler Register to scale the baud rate of the asynchronous output (this can be done automatically by the debugging tool).

8.7 Enhanced Debug Port (EDP)

Rev.: 1.0.0.0

8.7.1 Features

- **IEEE1149.1 compliant JTAG debug port**
- **Serial Wire Debug Port**
- **Boundary-Scan chain on all digital pins for board-level testing**
- **Debugger Hot-Plugging**
- **SMAP core reset request source**

8.7.2 Overview

The enhanced debug port embeds a standard ARM debug port plus some specific hardware intended for testability and activation of the debug port features. All the information related to the ARM Debug Interface implementation can be found in the ARM Debug Interface v5.1 Architecture Specification document.

It features:

- A single Debug Port (SWJ-DP), that provides the external physical connection to the interface and supports two DP implementations:
  - the JTAG Debug Port (JTAG-DP)
  - the Serial Wire Debug Port (SW-DP)
- A supplementary JTAG TAP (BSCAN-TAP) connected in parallel with the JTAG-DP that implements the boundary scan instructions detailed in
- A JTAG-FILTER module that monitors TCK and RESET_N pins to handle specific features like the detection of a debugger hot-plugging and the request of reset of the Cortex-M4 at startup.

The JTAG-FILTER module detects the presence of a debugger. When present, JTAG pins are automatically assigned to the Enhanced Debug Port(EDP). If the SWJ-DP is switched to the SW mode, then TDI and TDO alternate functions are released. The JTAG-FILTER also implements a CPU halt mechanism. When triggered, the Cortex-M4 is maintained under reset after the external reset is released to prevent any system corruption during later programmation operations.

8.7.13 Security Restrictions

The SAM4L provide a security restrictions mechanism to lock access to the device. The device in the protected state when the Flash Security Bit is set. Refer to section Flash Controller for more details.

When the device is in the protected state the AHB-AP is locked. Full access to the AHB-AP is re-enabled when the protected state is released by issuing a Chip Erase command. Note that the protected state will read as programmed only after the system has been reseted.

8.7.13.1 Notation

Table 8-4 on page 73 shows bit patterns to be shifted in a format like "**p01**". Each character corresponds to one bit, and eight bits are grouped together for readability. The least significant bit is always shifted first, and the most significant bit shifted last. The symbols used are shown in Table 8-3.

Table 8-3. Symbol Description

Symbol	Description
0	Constant low value - always reads as zero.
1	Constant high value - always reads as one.
p	The chip protected state.
x	A don't care bit. Any value can be shifted in, and output data should be ignored.
e	An error bit. Read as one if an error occurred, or zero if not.
b	A busy bit. Read as one if the SMAP was busy, or zero if it was not.
s	Startup done bit. Read as one if the system has started-up correctly.

In many cases, it is not required to shift all bits through the data register. Bit patterns are shown using the full width of the shift register, but the suggested or required bits are emphasized using **bold** text. I.e. given the pattern "**01010101** xxxxxxxx xxxxxxxx xxxxxxxx", the shift register is 32 bits, but the test or debug unit may choose to shift only 8 bits "**01010101**".

The following describes how to interpret the fields in the instruction description tables:

Table 8-4. Instruction Description

Instruction	Description
IR input value	Shows the bit pattern to shift into IR in the Shift-IR state in order to select this instruction. The pattern is show both in binary and in hexadecimal form for convenience. Example: **1000** (0x8)
IR output value	Shows the bit pattern shifted out of IR in the Shift-IR state when this instruction is active. Example: p00s

8.7.14.4 CLAMP

This instruction selects the Bypass register as Data Register. The device output pins are driven from the boundary-scan chain.

Starting in Run-Test/Idle, the CLAMP instruction is accessed the following way:

1. Select the IR Scan path.
2. In Capture-IR: The IR output value is latched into the shift register.
3. In Shift-IR: The instruction register is shifted by the TCK input.
4. In Update-IR: The data from the boundary-scan chain is applied to the output pins.
5. Return to Run-Test/Idle.
6. Select the DR Scan path.
7. In Capture-DR: A logic ‘0’ is loaded into the Bypass Register.
8. In Shift-DR: Data is scanned from TDI to TDO through the Bypass register.
9. Return to Run-Test/Idle.

Table 8-8. CLAMP Details

Instructions	Details
IR input value	**0101** (0x5)
IR output value	p00s
DR Size	1
DR input value	x
DR output value	x

Table 9-3. Supply Rise Rates and Order [1]

VDDIO, VDDIN and VDDANA must be connected together and as a consequence, rise synchronously

Symbol	Parameter	Rise Rate			
		Min	Max	Unit	Comment
V_{VDDIO}	DC supply peripheral I/Os	0.0001	2.5	V/µs	
V_{VDDIN}	DC supply peripheral I/Os and internal regulator	0.0001	2.5	V/µs	
V_{VDDANA}	Analog supply voltage	0.0001	2.5	V/µs	

1. These values are based on characterization. These values are not covered by test limits in production.

Table 9-5. Maximum Clock Frequencies in Power Scaling Mode 1 and RUN Mode

Symbol	Parameter	Description	Max	Units
f_{CPU}	CPU clock frequency		12	MHz
f_{PBA}	PBA clock frequency		12	
f_{PBB}	PBB clock frequency		12	
f_{PBC}	PBC clock frequency		12	
f_{PBD}	PBD clock frequency		12	
f_{GCLK0}	GCLK0 clock frequency	DFLLIF main reference, GCLK0 pin	16.6	
f_{GCLK1}	GCLK1 clock frequency	DFLLIF dithering and SSGreference, GCLK1 pin	16.6	
f_{GCLK2}	GCLK2 clock frequency	AST, GCLK2 pin	6.6	
f_{GCLK3}	GCLK3 clock frequency	CATB, GCLK3 pin	17.3	
f_{GCLK4}	GCLK4 clock frequency	FLO and AESA	16.6	
f_{GCLK5}	GCLK5 clock frequency	GLOC, TC0 and RC32KIFB_REF	26.6	
f_{GCLK6}	GCLK6 clock frequency	ABDACB and IISC	16.6	
f_{GCLK7}	GCLK7 clock frequency	USBC	16.6	
f_{GCLK8}	GCLK8 clock frequency	TC1 and PEVC[0]	16.6	
f_{GCLK9}	GCLK9 clock frequency	PLL0 and PEVC[1]	16.6	
f_{GCLK10}	GCLK10 clock frequency	ADCIFE	16.6	
f_{GCLK11}	GCLK11 clock frequency	Master generic clock. Can be used as source for other generic clocks	51.2	
f_{OSC0}	OSC0 output frequency	Oscillator 0 in crystal mode	16	
		Oscillator 0 in digital clock mode	16	
f_{PLL}	PLL output frequency	Phase Locked Loop	N/A	
f_{DFLL}	DFLL output frequency	Digital Frequency Locked Loop	N/A	
f_{RC80M}	RC80M output frequency	Internal 80MHz RC Oscillator	N/A	

Table 9-7. ATSAM4L8 Current consumption and Wakeup time for power scaling mode 0 and 2

Mode	Conditions	T_A	Typical Wakeup Time	Typ	Max (1)	Unit
SLEEP0	Switching mode	25°C	9 * Main clock cycles	3817	4033	µA
		85°C		4050	4507	
SLEEP1	Switching mode	25°C	9 * Main clock cycles + 500ns	2341	2477	
		85°C		2525	2832	
SLEEP2	Switching mode	25°C	9 * Main clock cycles + 500ns	1758	1862	
		85°C		1925	1971	
SLEEP3	Linear mode	25°C		51	60	
WAIT	OSC32K and AST running Fast wake-up enable		1.5µs	6.7		
	OSC32K and AST stopped Fast wake-up enable			5.5		
RETENTION	OSC32K running AST running at 1kHz		1.5µs	3.9		
	AST and OSC32K stopped			3.0		
BACKUP	OSC32K running AST running at 1kHz			1.5	3.1	
	AST and OSC32K stopped			0.9	1.7	

1. These values are based on characterization. These values are not covered by test limits in production.

9.5.2 Power Scaling 1

The values in Table 34-7 are measured values of power consumption under the following conditions, except where noted:

- Operating conditions for power scaling mode 1
  - V_{VDDIN} = 3.3V
- Wake up time from low power modes is measured from the edge of the wakeup signal to the first instruction fetched in flash.
- Oscillators
  - OSC0 (crystal oscillator) and OSC32K (32kHz crystal oscillator) stopped
  - RCFAST Running at 12MHz
- Clocks
  - RCFAST used as main clock source
  - CPU, AHB clocks undivided
  - APBC and APBD clocks divided by 4
  - APBA and APBB bridges off
  - The following peripheral clocks running
    - PM, SCIF, AST, FLASHCALW, APBC and APBD bridges

9.5.3 Peripheral Power Consumption in Power Scaling mode 0 and 2

The values in Table 9-11 are measured values of power consumption under the following conditions:

- Operating conditions, internal core supply (Figure 9-2)
  - V_{VDDIN} = 3.3V
  - $V_{VDDCORE}$ supplied by the internal regulator in switching mode
- T_A = 25°C
- Oscillators
  - OSC0 (crystal oscillator) stopped
  - OSC32K (32KHz crystal oscillator) running with external 32KHz crystal
  - DFLL running at 48MHz with OSC32K as reference clock
- Clocks
  - DFLL used as main clock source
  - CPU, AHB, and PB clocks undivided
- I/Os are inactive with internal pull-up
- Flash enabled in high speed mode
- CPU in SLEEP0 mode
- BOD18 and BOD33 disabled

Consumption active is the added current consumption when the module clock is turned on.

9.7.7 1MHz RC Oscillator (RC1M) Characteristics

Table 9-30. RC1M Oscillator Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{OUT}	Output frequency (1)		0.91	1	1.12	MHz
I_{RC1M}	Current consumption (2)			35		µA
Duty	Duty cycle(1)		48.6	49.9	54.4	%

1. These values are based on characterization. These values are not covered by test limits in production.
2. These values are based on simulation. These values are not covered by test limits in production or characterization.

9.7.8 4/8/12MHz RC Oscillator (RCFAST) Characteristics

Table 9-31. RCFAST Oscillator Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
f_{OUT}	Output frequency (1)	Calibrated, FRANGE=0	4	4.3	4.6	MHz
		Calibrated, FRANGE=1	7.8	8.2	8.5	
		Calibrated, FRANGE=2	11.3	12	12.3	
I_{RCFAST}	Current consumption (2)	Calibrated, FRANGE=0		90	110	µA
		Calibrated, FRANGE=1		130	150	
		Calibrated, FRANGE=2		180	205	
Duty	Duty cycle(1)	Calibrated, FRANGE=0	48.8	49.6	50.1	%
		Calibrated, FRANGE=1	47.8	49.2	50.1	
		Calibrated, FRANGE=2	46.7	48.8	50.0	
$t_{STARTUP}$	Startup time(1)	Calibrated, FRANGE=2	0.1	0.31	0.71	µs

1. These values are based on characterization. These values are not covered by test limits in production.
2. These values are based on simulation. These values are not covered by test limits in production or characterization.

9.10.3 SPI Timing

9.10.3.1 Master mode

Figure 9-12. SPI Master Mode with (CPOL= NCPHA= 0) or (CPOL= NCPHA= 1)

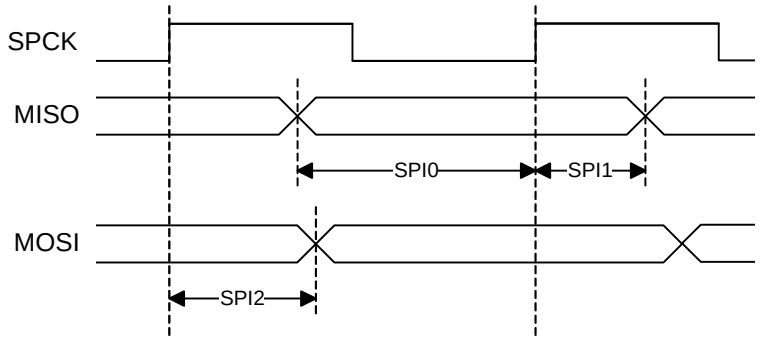


Figure 9-13. SPI Master Mode with (CPOL= 0 and NCPHA= 1) or (CPOL= 1 and NCPHA= 0)

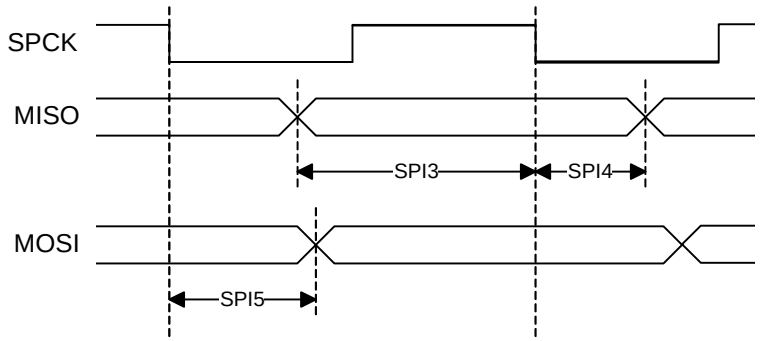


Table 9-62. SPI Timing, Master Mode[1]

Symbol	Parameter	Conditions	Min	Max	Units
SPI0	MISO setup time before SPCK rises	V_{VDDIO} from 2.85V to 3.6V, maximum external capacitor = 40pF	9		ns
SPI1	MISO hold time after SPCK rises		0		
SPI2	SPCK rising to MOSI delay		9	21	
SPI3	MISO setup time before SPCK falls		7.3		
SPI4	MISO hold time after SPCK falls		0		
SPI5	SPCK falling to MOSI delay		9	22	

Note: 1. These values are based on simulation. These values are not covered by test limits in production.

Maximum SPI Frequency, Master Output

Figure 9-16. SPI Slave Mode, NPCS Timing

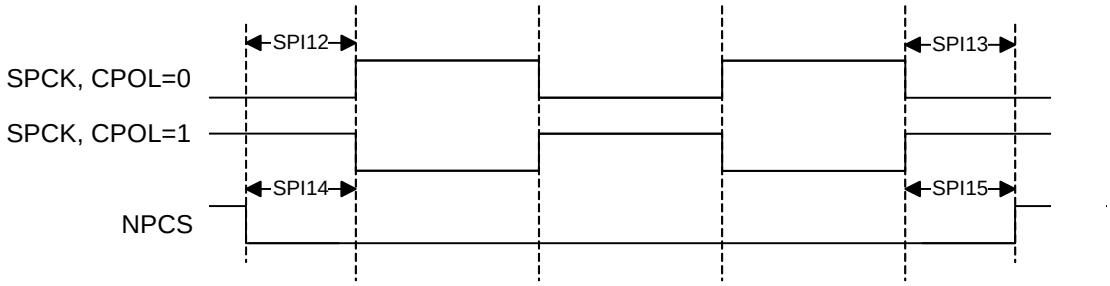


Table 9-63. SPI Timing, Slave Mode[1]

Symbol	Parameter	Conditions	Min	Max	Units
SPI6	SPCK falling to MISO delay	V_{VDDIO} from 2.85V to 3.6V, maximum external capacitor = 40pF	19	47	ns
SPI7	MOSI setup time before SPCK rises		0		
SPI8	MOSI hold time after SPCK rises		5.4		
SPI9	SPCK rising to MISO delay		19	46	
SPI10	MOSI setup time before SPCK falls		0		
SPI11	MOSI hold time after SPCK falls		5.3		
SPI12	NPCS setup time before SPCK rises		4		
SPI13	NPCS hold time after SPCK falls		2.5		
SPI14	NPCS setup time before SPCK falls		6		
SPI15	NPCS hold time after SPCK rises		1.1		

Note: 1. These values are based on simulation. These values are not covered by test limits in production.

Maximum SPI Frequency, Slave Input Mode

The maximum SPI slave input frequency is given by the following formula:

$$f_{SPCKMAX} = MIN(f_{CLKSPI}, \frac{1}{SPIn})$$

Where $SPIn$ is the MOSI setup and hold time, SPI7 + SPI8 or SPI10 + SPI11 depending on CPOL and NCPHA. f_{CLKSPI} is the maximum frequency of the CLK_SPI. Refer to the SPI chapter for a description of this clock.

Maximum SPI Frequency, Slave Output Mode

The maximum SPI slave output frequency is given by the following formula:

$$f_{SPCKMAX} = MIN(f_{PINMAX}, \frac{1}{SPIn + t_{SETUP}})$$

11. Ordering Information

Table 11-1. ATSAM4LC8 Sub Serie Ordering Information

Ordering Code	Flash (Kbytes)	RAM (Kbytes)	Package	Conditioning	Package Type	Temperature Operating Range
ATSAM4LC8CA-AU	512	64	TQFP100	Tray	Green	Industrial -40°C to 85°C
ATSAM4LC8CA-AUR				Reel		
ATSAM4LC8CA-CFU			VFBGA100	Tray		
ATSAM4LC8CA-CFUR				Reel		
ATSAM4LC8BA-AU			TQFP64	Tray		
ATSAM4LC8BA-AUR				Reel		
ATSAM4LC8BA-MU			QFN64	Tray		
ATSAM4LC8BA-MUR				Reel		
ATSAM4LC8BA-UUR			WLCSP64	Reel		
ATSAM4LC8AA-MU			QFN48	Tray		
ATSAM4LC8AA-MUR				Reel		

Table 11-2. ATSAM4LC4 Sub Serie Ordering Information

Ordering Code	Flash (Kbytes)	RAM (Kbytes)	Package	Conditioning	Package Type	Temperature Operating Range
ATSAM4LC4CA-AU-ES	256	32	TQFP100	ES	Green	N/A
ATSAM4LC4CA-AU				Tray		Industrial -40°C to 85°C
ATSAM4LC4CA-AUR				Reel		
ATSAM4LC4CA-CFU			VFBGA100	Tray		Industrial -40°C to 85°C
ATSAM4LC4CA-CFUR				Reel		
ATSAM4LC4BA-AU-ES			TQFP64	ES		N/A
ATSAM4LC4BA-AU				Tray		Industrial -40°C to 85°C
ATSAM4LC4BA-AUR				Reel		
ATSAM4LC4BA-MU-ES			QFN64	ES		N/A
ATSAM4LC4BA-MU				Tray		Industrial -40°C to 85°C
ATSAM4LC4BA-MUR				Reel		
ATSAM4LC4BA-UUR			WLCSP64	Reel		Industrial -40°C to 85°C
ATSAM4LC4AA-AU-ES			TQFP48	ES		N/A
ATSAM4LC4AA-AU				Tray		Industrial -40°C to 85°C
ATSAM4LC4AA-AUR				Reel		
ATSAM4LC4AA-MU-ES			QFN48	ES		N/A
ATSAM4LC4AA-MU				Tray		Industrial -40°C to 85°C
ATSAM4LC4AA-MUR				Reel		