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"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®-M0+
Core Size	32-Bit Single-Core
Speed	48MHz
Connectivity	I²C, LINbus, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, DMA, POR, WDT
Number of I/O	52
Program Memory Size	32KB (32K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	4K x 8
Voltage - Supply (Vcc/Vdd)	2.7V ~ 5.5V
Data Converters	A/D 12x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 105°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/atsamc20j15a-ant

- Device select

13.11 Functional Description

13.11.1 Principle of Operation

The DSU provides memory services such as CRC32 or MBIST that require almost the same interface. Hence, the Address, Length and Data registers (ADDR, LENGTH, DATA) are shared. These shared registers must be configured first; then a command can be issued by writing the Control register. When a command is ongoing, other commands are discarded until the current operation is completed. Hence, the user must wait for the STATUSA.DONE bit to be set prior to issuing another one.

13.11.2 Basic Operation

13.11.2.1 Initialization

The module is enabled by enabling its clocks. For more details, refer to Clocks. The DSU registers can be PAC write-protected.

Related Links

PAC - Peripheral Access Controller

13.11.2.2 Operation From a Debug Adapter

Debug adapters should access the DSU registers in the external address range 0x100 – 0x2000. If the device is protected by the NVMCTRL security bit, accessing the first 0x100 bytes causes the system to return an error. Refer to Intellectual Property Protection.

Related Links

NVMCTRL – Non-Volatile Memory Controller

Security Bit

13.11.2.3 Operation From the CPU

There are no restrictions when accessing DSU registers from the CPU. However, the user should access DSU registers in the internal address range (0x0 – 0x100) to avoid external security restrictions. Refer to Intellectual Property Protection.

13.11.3 32-bit Cyclic Redundancy Check CRC32

The DSU unit provides support for calculating a cyclic redundancy check (CRC32) value for a memory area (including Flash and AHB RAM).

When the CRC32 command is issued from:

- The internal range, the CRC32 can be operated at any memory location
- The external range, the CRC32 operation is restricted; DATA, ADDR, and LENGTH values are forced (see below)

Bit	31	30	29	28	27	26	25	24
Access								
Reset								

Bit	23	22	21	20	19	18	17	16
Access								
Reset								

Bit	15	14	13	12	11	10	9	8
Access								
Reset								

Bit	7	6	5	4	3	2	1	0
	FKBC[3:0]				JEPCC[3:0]			
Access	R	R	R	R	R	R	R	R
Reset	0	0	0	0	0	0	0	0

Bits 7:4 – FKBC[3:0]: 4KB Count
These bits will always return zero when read, indicating that this debug component occupies one 4KB block.

Bits 3:0 – JEPCC[3:0]: JEP-106 Continuation Code
These bits will always return zero when read.

13.13.15 Peripheral Identification 0

Name: PID0
Offset: 0x1FE0
Reset: 0x00000000
Property: -

16.6.5.2 Minimize Power Consumption in Standby

The following table identifies when a Clock Generator is off in Standby Mode, minimizing the power consumption:

Table 16-2. Clock Generator n Activity in Standby Mode

Request for Clock n present	GENCTRLn.RUNSTDBY	GENCTRLn.OE	Clock Generator n
yes	-	-	active
no	1	1	active
no	1	0	OFF
no	0	1	OFF
no	0	0	OFF

16.6.5.3 Entering Standby Mode

There may occur a delay when the device is put into Standby, until the power is turned off. This delay is caused by running Clock Generators: if the Run in Standby bit in the Generator Control register (GENCTRLn.RUNSTDBY) is '0', GCLK must verify that the clock is turned of properly. The duration of this verification is frequency-dependent.

Related Links

PM – Power Manager

16.6.6 Synchronization

Due to asynchronicity between the main clock domain and the peripheral clock domains, some registers need to be synchronized when written or read.

An exception is the Channel Enable bit in the Peripheral Channel Control registers (PCHCTRLm.CHEN). When changing this bit, the bit value must be read-back to ensure the synchronization is complete and to assert glitch free internal operation. Note that changing the bit value under ongoing synchronization will *not* generate an error.

The following registers are synchronized when written:

- Generic Clock Generator Control register (GENCTRLn)
- Control A register (CTRLA)

Required write-synchronization is denoted by the "Write-Synchronized" property in the register description.

Related Links

CTRLA

Register Synchronization

PCHCTRL0, PCHCTRL1, PCHCTRL2, PCHCTRL3, PCHCTRL4, PCHCTRL5, PCHCTRL6, PCHCTRL7, PCHCTRL8, PCHCTRL9, PCHCTRL10, PCHCTRL11, PCHCTRL12, PCHCTRL13, PCHCTRL14, PCHCTRL15, PCHCTRL16, PCHCTRL17, PCHCTRL18, PCHCTRL19, PCHCTRL20, PCHCTRL21, PCHCTRL22, PCHCTRL23, PCHCTRL24, PCHCTRL25, PCHCTRL26, PCHCTRL27, PCHCTRL28, PCHCTRL29, PCHCTRL30, PCHCTRL31, PCHCTRL32, PCHCTRL33, PCHCTRL34, PCHCTRL35, PCHCTRL36, PCHCTRL37, PCHCTRL38, PCHCTRL39, PCHCTRL40, PCHCTRL41, PCHCTRL42, PCHCTRL43, PCHCTRL44, PCHCTRL45

Frequencies must never exceed the specified maximum frequency for each clock domain.

Value	Name	Description
0x01	DIV1	Divide by 1
0x02	DIV2	Divide by 2
0x04	DIV4	Divide by 4
0x08	DIV8	Divide by 8
0x10	DIV16	Divide by 16
0x20	DIV32	Divide by 32
0x40	DIV64	Divide by 64
0x80	DIV128	Divide by 128
others	-	Reserved

17.8.6 AHB Mask

Note: This register is only available for SAMC2x "N" series devices.

Name: AHBMASK
Offset: 0x10 [ID-00001086]
Reset: 0x000003CFF
Property: PAC Write-Protection

Bit	31	30	29	28	27	26	25	24
Access			R	R	R	R	R	R
Reset			0	0	0	0	0	0

Bit	23	22	21	20	19	18	17	16
Access	R	R	R	R	R	R	R	R
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
						PAC	CAN1	CAN0
Access	R	R	R	R	R	R/W	R/W	R/W
Reset	0	0	0	0	1	1	0	0

Bit	7	6	5	4	3	2	1	0
	DMAC	HSRAM	NVMCTRL	HMATRIXHS	DSU	APBC	APBB	APBA
Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	1	1	1	1	1	1	1	1

Bit 13 – APBD: APBD AHB Clock Enable

Value	Description
0	The AHB clock for the APBD is stopped.
1	The AHB clock for the APBD is enabled.

Bit 12 – DIVAS: DIVAS AHB Clock Enable

24.12.10 Alarm Value in Clock/Calendar mode (CTRLA.MODE=2)

The 32-bit value of ALARM is continuously compared with the 32-bit CLOCK value, based on the masking set by MASK.SEL. When a match occurs, the Alarm n interrupt flag in the Interrupt Flag Status and Clear register (INTFLAG.ALARM) is set on the next counter cycle, and the counter is cleared if CTRLA.MATCHCLR is '1'.

Name: ALARM
Offset: 0x20
Reset: 0x00000000
Property: PAC Write-Protection, Write-Synchronized

Bit	31	30	29	28	27	26	25	24
	YEAR[5:0]						MONTH[3:2]	
Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0

Bit	23	22	21	20	19	18	17	16
	MONTH[1:0]		DAY[4:0]					HOUR[4:4]
Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
	HOUR[3:0]				MINUTE[5:2]			
Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0

Bit	7	6	5	4	3	2	1	0
	MINUTE[1:0]		SECOND[5:0]					
Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0

Bits 31:26 – YEAR[5:0]: Year
The alarm year. Years are only matched if MASK.SEL is 6

Bits 25:22 – MONTH[3:0]: Month
The alarm month. Months are matched only if MASK.SEL is greater than 4.

Bits 21:17 – DAY[4:0]: Day
The alarm day. Days are matched only if MASK.SEL is greater than 3.

Bits 16:12 – HOUR[4:0]: Hour
The alarm hour. Hours are matched only if MASK.SEL is greater than 2.

Bits 11:6 – MINUTE[5:0]: Minute
The alarm minute. Minutes are matched only if MASK.SEL is greater than 1.

Bits 5:0 – SECOND[5:0]: Second
The alarm second. Seconds are matched only if MASK.SEL is greater than 0.

The following DMAC bit is enable-protected, meaning that it can only be written when both the DMAC and CRC are disabled (CTRL.DMAENABLE=0 and CTRL.CRCENABLE=0):

- Software Reset bit in Control register (CTRL.SWRST)

The following DMA channel register is enable-protected, meaning that it can only be written when the corresponding DMA channel is disabled (CHCTRLA.ENABLE=0):

- Channel Control B (CHCTRLB) register, except the Command bit (CHCTRLB.CMD) and the Channel Arbitration Level bit (CHCTRLB.LVL)

The following DMA channel bit is enable-protected, meaning that it can only be written when the corresponding DMA channel is disabled:

- Channel Software Reset bit in Channel Control A register (CHCTRLA.SWRST)

The following CRC registers are enable-protected, meaning that they can only be written when the CRC is disabled (CTRL.CRCENABLE=0):

- CRC Control register (CRCCTRL)
- CRC Checksum register (CRCCHKSUM)

Enable-protection is denoted by the "Enable-Protected" property in the register description.

Before the DMAC is enabled it must be configured, as outlined by the following steps:

- The SRAM address of where the descriptor memory section is located must be written to the Description Base Address (BASEADDR) register
- The SRAM address of where the write-back section should be located must be written to the Write-Back Memory Base Address (WRBADDR) register
- Priority level x of the arbiter can be enabled by setting the Priority Level x Enable bit in the Control register (CTRL.LVLENx=1)

Before a DMA channel is enabled, the DMA channel and the corresponding first transfer descriptor must be configured, as outlined by the following steps:

- DMA channel configurations
  - The channel number of the DMA channel to configure must be written to the Channel ID (CHID) register
  - Trigger action must be selected by writing the Trigger Action bit group in the Channel Control B register (CHCTRLB.TRIGACT)
  - Trigger source must be selected by writing the Trigger Source bit group in the Channel Control B register (CHCTRLB.TRIGSRC)
- Transfer Descriptor
  - The size of each access of the data transfer bus must be selected by writing the Beat Size bit group in the Block Transfer Control register (BTCTRL.BEATSIZE)
  - The transfer descriptor must be made valid by writing a one to the Valid bit in the Block Transfer Control register (BTCTRL.VALID)
  - Number of beats in the block transfer must be selected by writing the Block Transfer Count (BTCNT) register
  - Source address for the block transfer must be selected by writing the Block Transfer Source Address (SRCADDR) register
  - Destination address for the block transfer must be selected by writing the Block Transfer Destination Address (DSTADDR) register

Name: CHID
Offset: 0x3F [ID-00001ece]
Reset: 0x00
Property: -

Bit	7	6	5	4	3	2	1	0
					ID[3:0]			
Access					R/W	R/W	R/W	R/W
Reset					0	0	0	0

Bits 3:0 – ID[3:0]: Channel ID
These bits define the channel number that will be affected by the channel registers (CH*). Before reading or writing a channel register, the channel ID bit group must be written first.

25.8.18 Channel Control A

This register affects the DMA channel that is selected in the Channel ID register (CHID.ID).

Name: CHCTRLA
Offset: 0x40 [ID-00001ece]
Reset: 0x00
Property: PAC Write-Protection, Enable-Protected

Bit	7	6	5	4	3	2	1	0
		RUNSTDBY					ENABLE	SWRST
Access	R	R/W	R	R	R	R	R/W	R/W
Reset	0	0	0	0	0	0	0	0

Bit 6 – RUNSTDBY: Channel run in standby
This bit is used to keep the DMAC channel running in standby mode.

This bit is not enable-protected.

Value	Description
0	The DMAC channel is halted in standby.
1	The DMAC channel continues to run in standby.

Bit 1 – ENABLE: Channel Enable
Writing a '0' to this bit during an ongoing transfer, the bit will not be cleared until the internal data transfer buffer is empty and the DMA transfer is aborted. The internal data transfer buffer will be empty once the ongoing burst transfer is completed.

Writing a '1' to this bit will enable the DMA channel.

This bit is not enable-protected.

Value	Description
0	DMA channel is disabled.
1	DMA channel is enabled.

Bit 0 – SWRST: Channel Software Reset
Writing a '0' to this bit has no effect.

Name: INTFLAG
Offset: 0x14 [ID-00000b2c]
Reset: 0x00
Property: –

Bit	7	6	5	4	3	2	1	0
							ERROR	READY
Access							R/W	R
Reset							0	0

Bit 1 – ERROR: Error
This flag is set on the occurrence of an NVME, LOCKE or PROGE error.

This bit can be cleared by writing a '1' to its bit location.

Value	Description
0	No errors have been received since the last clear.
1	At least one error has occurred since the last clear.

Bit 0 – READY: NVM Ready

Value	Description
0	The NVM controller is busy programming or erasing.
1	The NVM controller is ready to accept a new command.

27.8.7 Status

Name: STATUS
Offset: 0x18 [ID-00000b2c]
Reset: 0x0X00
Property: –

Bit	15	14	13	12	11	10	9	8
								SB
Access								R
Reset								x

Bit	7	6	5	4	3	2	1	0
				NVME	LOCKE	PROGE	LOAD	PRM
Access				R/W	R/W	R/W	R/W	R
Reset				0	0	0	0	0

Bit 8 – SB: Security Bit Status

Value	Description
0	The Security bit is inactive.
1	The Security bit is active.

Bit 4 – NVME: NVM Error
This bit can be cleared by writing a '1' to its bit location.

29.6.2.9 The Overrun Channel n Interrupt

The Overrun Channel n interrupt flag in the Interrupt Flag Status and Clear register (INTFLAG.OVRn) will be set, and the optional interrupt will be generated in the following cases:

- One or more event users on channel n is not ready when there is a new event.
- An event occurs when the previous event on channel m has not been handled by all event users connected to that channel.

The flag will only be set when using resynchronized paths. In the case of asynchronous path, the INTFLAG.OVRn is always read as zero.

29.6.2.10 The Event Detected Channel n Interrupt

The Event Detected Channel n interrupt flag in the Interrupt Flag Status and Clear register (INTFLAG.EVDn) is set when an event coming from the event generator configured on channel n is detected.

The flag will only be set when using a resynchronized path. In the case of asynchronous path, the INTFLAG.EVDn is always zero.

29.6.2.11 Channel Status

The Channel Status register (CHSTATUS) shows the status of the channels when using a synchronous or resynchronized path. There are two different status bits in CHSTATUS for each of the available channels:

- The CHSTATUS.CHBUSYn bit will be set when an event on the corresponding channel n has not been handled by all event users connected to that channel.
- The CHSTATUS.USRRDYn bit will be set when all event users connected to the corresponding channel are ready to handle incoming events on that channel.

29.6.2.12 Software Event

A software event can be initiated on a channel by setting the Channel n bit in the Software Event register (SWEVT.CHANNELn) to ‘1’. Then the software event can be serviced as any event generator; i.e., when the bit is set to ‘1’, an event will be generated on the respective channel.

29.6.3 Interrupts

The EVSYS has the following interrupt sources:

- Overrun Channel n interrupt (OVRn): for details, refer to The Overrun Channel n Interrupt.
- Event Detected Channel n interrupt (EVDn): for details, refer to The Event Detected Channel n Interrupt.

These interrupts events are asynchronous wake-up sources. See *Sleep Mode Controller*. Each interrupt source has an interrupt flag which is in the Interrupt Flag Status and Clear (INTFLAG) register. The flag is set when the interrupt is issued. Each interrupt event can be individually enabled by setting a ‘1’ to the corresponding bit in the Interrupt Enable Set (INTENSET) register, and disabled by setting a ‘1’ to the corresponding bit in the Interrupt Enable Clear (INTENCLR) register. An interrupt event is generated when the interrupt flag is set and the corresponding interrupt is enabled. The interrupt event works until the interrupt flag is cleared, the interrupt is disabled, or the Event System is reset. See INTFLAG for details on how to clear interrupt flags.

All interrupt events from the peripheral are ORed together on system level to generate one combined interrupt request to the NVIC. Refer to the *Nested Vector Interrupt Controller* for details. The event user must read the INTFLAG register to determine what the interrupt condition is.

Note that interrupts must be globally enabled for interrupt requests to be generated. Refer to *Nested Vector Interrupt Controller* for details.

Related Links

Bit	31	30	29	28	27	26	25	24
Access								
Reset								

Bit	23	22	21	20	19	18	17	16
							RXEN	
Access							R/W	
Reset							0	

Bit	15	14	13	12	11	10	9	8
	AMODE[1:0]		MSSEN				SSDE	
Access	R/W	R/W	R/W				R/W	
Reset	0	0	0				0	

Bit	7	6	5	4	3	2	1	0
		PLOADEN				CHSIZE[2:0]		
Access		R/W				R/W	R/W	R/W
Reset		0				0	0	0

Bit 17 – RXEN: Receiver Enable

Writing '0' to this bit will disable the SPI receiver immediately. The receive buffer will be flushed, data from ongoing receptions will be lost and STATUS.BUFOVF will be cleared.

Writing '1' to CTRLB.RXEN when the SPI is disabled will set CTRLB.RXEN immediately. When the SPI is enabled, CTRLB.RXEN will be cleared, SYNCBUSY.CTRLB will be set and remain set until the receiver is enabled. When the receiver is enabled CTRLB.RXEN will read back as '1'.

Writing '1' to CTRLB.RXEN when the SPI is enabled will set SYNCBUSY.CTRLB, which will remain set until the receiver is enabled, and CTRLB.RXEN will read back as '1'.

This bit is not enable-protected.

Value	Description
0	The receiver is disabled or being enabled.
1	The receiver is enabled or it will be enabled when SPI is enabled.

Bits 15:14 – AMODE[1:0]: Address Mode

These bits set the slave addressing mode when the frame format (CTRLA.FORM) with address is used. They are unused in master mode.

AMODE[1:0]	Name	Description
0x0	MASK	ADDRMASK is used as a mask to the ADDR register
0x1	2_ADDRS	The slave responds to the two unique addresses in ADDR and ADDRMASK
0x2	RANGE	The slave responds to the range of addresses between and including ADDR and ADDRMASK. ADDR is the upper limit
0x3	-	Reserved

Bit 13 – MSSEN: Master Slave Select Enable

This bit enables hardware slave select ($\overline{SS}$) control.

Name: INTENCLR
Offset: 0x14 [ID-00000e74]
Reset: 0x00
Property: PAC Write-Protection

Bit	7	6	5	4	3	2	1	0
	ERROR				SSL	RXC	TXC	DRE
Access	R/W				R/W	R/W	R/W	R/W
Reset	0				0	0	0	0

Bit 7 – ERROR: Error Interrupt Enable
Writing '0' to this bit has no effect.

Writing '1' to this bit will clear the Error Interrupt Enable bit, which disables the Error interrupt.

Value	Description
0	Error interrupt is disabled.
1	Error interrupt is enabled.

Bit 3 – SSL: Slave Select Low Interrupt Enable
Writing '0' to this bit has no effect.

Writing '1' to this bit will clear the Slave Select Low Interrupt Enable bit, which disables the Slave Select Low interrupt.

Value	Description
0	Slave Select Low interrupt is disabled.
1	Slave Select Low interrupt is enabled.

Bit 2 – RXC: Receive Complete Interrupt Enable
Writing '0' to this bit has no effect.

Writing '1' to this bit will clear the Receive Complete Interrupt Enable bit, which disables the Receive Complete interrupt.

Value	Description
0	Receive Complete interrupt is disabled.
1	Receive Complete interrupt is enabled.

Bit 1 – TXC: Transmit Complete Interrupt Enable
Writing '0' to this bit has no effect.

Writing '1' to this bit will clear the Transmit Complete Interrupt Enable bit, which disable the Transmit Complete interrupt.

Value	Description
0	Transmit Complete interrupt is disabled.
1	Transmit Complete interrupt is enabled.

Bit 0 – DRE: Data Register Empty Interrupt Enable
Writing '0' to this bit has no effect.

Writing '1' to this bit will clear the Data Register Empty Interrupt Enable bit, which disables the Data Register Empty interrupt.

33. SERCOM I²C – SERCOM Inter-Integrated Circuit

33.1 Overview

The inter-integrated circuit (I²C) interface is one of the available modes in the serial communication interface (SERCOM).

The I²C interface uses the SERCOM transmitter and receiver configured as shown in Figure 33-1. Labels in capital letters are registers accessible by the CPU, while lowercase labels are internal to the SERCOM.

A SERCOM instance can be configured to be either an I²C master or an I²C slave. Both master and slave have an interface containing a shift register, a transmit buffer and a receive buffer. In addition, the I²C master uses the SERCOM baud-rate generator, while the I²C slave uses the SERCOM address match logic.

Related Links

SERCOM – Serial Communication Interface

33.2 Features

SERCOM I²C includes the following features:

- Master or slave operation
- Can be used with DMA
- Philips I²C compatible
- SMBus™ compatible
- PMBus compatible
- Support of 100kHz and 400kHz, 1MHz and 3.4MHz I²C mode
- 4-Wire operation supported
- Physical interface includes:
  - Slew-rate limited outputs
  - Filtered inputs
- Slave operation:
  - Operation in all sleep modes
  - Wake-up on address match
  - 7-bit and 10-bit Address match in hardware for:
  -
    - Unique address and/or 7-bit general call address
    - Address range
    - Two unique addresses can be used with DMA

Related Links

Features

Bit	31	30	29	28	27	26	25	24
					FILTERVAL[3:0]			
Access					R/W	R/W	R/W	R/W
Reset					0	0	0	0

Bit	23	22	21	20	19	18	17	16
	BLANKVAL[7:0]							
Access	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0

Bit	15	14	13	12	11	10	9	8
		CAPTURE[2:0]			CHSEL[1:0]		HALT[1:0]	
Access		R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset		0	0	0	0	0	0	0

Bit	7	6	5	4	3	2	1	0
	RESTART	BLANK[1:0]		QUAL	KEEP		SRC[1:0]	
Access	R/W	R/W	R/W	R/W	R/W		R/W	R/W
Reset	0	0	0	0	0		0	0

Bits 27:24 – FILTERVAL[3:0]: Recoverable Fault n Filter Value
These bits define the filter value applied on MCEx (x=0,1) event input line. The value must be set to zero when MCEx event is used as synchronous event.

Bits 23:16 – BLANKVAL[7:0]: Recoverable Fault n Blanking Value
These bits determine the duration of the blanking of the fault input source. Activation and edge selection of the blank filtering are done by the BLANK bits (FCTRLn.BLANK).

When enabled, the fault input source is internally disabled for BLANKVAL* prescaled GCLK_TCC periods after the detection of the waveform edge.

Bits 14:12 – CAPTURE[2:0]: Recoverable Fault n Capture Action
These bits select the capture and Fault n interrupt/event conditions.

Table 36-8. Fault n Capture Action

Value	Name	Description
0x0	DISABLE	Capture on valid recoverable Fault n is disabled
0x1	CAPT	On rising edge of a valid recoverable Fault n, capture counter value on channel selected by CHSEL[1:0]. INTFLAG.FAULTn flag rises on each new captured value.
0x2	CAPTMIN	On rising edge of a valid recoverable Fault n, capture counter value on channel selected by CHSEL[1:0], if COUNT value is lower than the last stored capture value (CC). INTFLAG.FAULTn flag rises on each local minimum detection.
0x3	CAPTMAX	On rising edge of a valid recoverable Fault n, capture counter value on channel selected by CHSEL[1:0], if COUNT value is higher than the last stored capture value (CC).

Bit 12 – FAULTA: Recoverable Fault A State
This bit is set by hardware as soon as recoverable Fault A condition occurs.

This bit can be clear by hardware when Fault A action is resumed, or by writing a '1' to this bit when the corresponding FAULTAIN bit is low. If software halt command is enabled (FAULTA.HALT=SW), clearing this bit will release the timer/counter.

Bit 11 – FAULT1IN: Non-Recoverable Fault 1 Input
This bit is set while an active Non-Recoverable Fault 1 input is present.

Bit 10 – FAULT0IN: Non-Recoverable Fault 0 Input
This bit is set while an active Non-Recoverable Fault 0 input is present.

Bit 9 – FAULTBIN: Recoverable Fault B Input
This bit is set while an active Recoverable Fault B input is present.

Bit 8 – FAULTAIN: Recoverable Fault A Input
This bit is set while an active Recoverable Fault A input is present.

Bit 7 – PERBUFV: Period Buffer Valid
This bit is set when a new value is written to the PERBUF register. This bit is automatically cleared by hardware on UPDATE condition when CTRLB.LUPD is set, or by writing a '1' to this bit.

Bit 6 – WAVEBUFV: Waveform Control Buffer Valid
This bit is set when a new value is written to the WAVEBUF register. This bit is automatically cleared by hardware on UPDATE condition when CTRLB.LUPD is set, or by writing a '1' to this bit.

Bit 5 – PATTBUFV: Pattern Generator Value Buffer Valid
This bit is set when a new value is written to the PATTBUF register. This bit is automatically cleared by hardware on UPDATE condition when CTRLB.LUPD is set, or by writing a '1' to this bit.

Bit 4 – SLAVE: Slave
This bit is set when TCC is set in Slave mode. This bit follows the CTRLA.MSYNC bit state.

Bit 3 – DFS: Debug Fault State
This bit is set by hardware in debug mode when DDBGCTRL.FDDBD bit is set. The bit is cleared by writing a '1' to this bit and when the TCC is not in debug mode.

When the bit is set, the counter is halted and the waveforms state depend on DRVCTRL.NRE and DRVCTRL.NRV registers.

Bit 2 – UFS: Non-recoverable Update Fault State
This bit is set by hardware when the RAMP index changes and the Lock Update bit is set (CTRLBSET.LUPD). The bit is cleared by writing a one to this bit.

When the bit is set, the waveforms state depend on DRVCTRL.NRE and DRVCTRL.NRV registers.

Bit 1 – IDX: Ramp Index
In RAMP2 and RAMP2A operation, the bit is cleared during the cycle A and set during the cycle B. In RAMP1 operation, the bit always reads zero. For details on ramp operations, refer to Ramp Operations.

37.7 Register Summary

Offset	Name	Bit Pos.								
0x00	CTRL	7:0		RUNSTDBY					ENABLE	SWRST
0x01 ... 0x03	Reserved									
0x04	SEQCTRL0	7:0					SEQSEL[3:0]			
0x05	SEQCTRL1	7:0					SEQSEL[3:0]			
0x06 ... 0x07	Reserved									
0x08	LUTCTRL0	7:0	EDGESEL		FILTSEL[1:0]				ENABLE	
0x09		15:8	INSELx[3:0]				INSELx[3:0]			
0x0A		23:16		LUTEO	LUTEI	INVEI	INSELx[3:0]			
0x0B		31:24	TRUTH[7:0]							
0x0C	LUTCTRL1	7:0	EDGESEL		FILTSEL[1:0]				ENABLE	
0x0D		15:8	INSELx[3:0]				INSELx[3:0]			
0x0E		23:16		LUTEO	LUTEI	INVEI	INSELx[3:0]			
0x0F		31:24	TRUTH[7:0]							
0x10	LUTCTRL2	7:0	EDGESEL		FILTSEL[1:0]				ENABLE	
0x11		15:8	INSELx[3:0]				INSELx[3:0]			
0x12		23:16		LUTEO	LUTEI	INVEI	INSELx[3:0]			
0x13		31:24	TRUTH[7:0]							
0x14	LUTCTRL3	7:0	EDGESEL		FILTSEL[1:0]				ENABLE	
0x15		15:8	INSELx[3:0]				INSELx[3:0]			
0x16		23:16		LUTEO	LUTEI	INVEI	INSELx[3:0]			
0x17		31:24	TRUTH[7:0]							

37.8 Register Description

Registers can be 8, 16, or 32 bits wide. Atomic 8-, 16- and 32-bit accesses are supported. In addition, the 8-bit quarters and 16-bit halves of a 32-bit register, and the 8-bit halves of a 16-bit register can be accessed directly.

Some registers are optionally write-protected by the Peripheral Access Controller (PAC). Optional PAC write-protection is denoted by the "PAC Write-Protection" property in each individual register description. For details, refer to Register Access Protection.

Some registers are enable-protected, meaning they can only be written when the peripheral is disabled. Enable-protection is denoted by the "Enable-Protected" property in each individual register description.

37.8.1 Control

38. ADC – Analog-to-Digital Converter

38.1 Overview

The Analog-to-Digital Converter (ADC) converts analog signals to digital values. The ADC has up to 12-bit resolution, and is capable of a sampling rate of up to 1MSPS. The input selection is flexible, and both differential and single-ended measurements can be performed. In addition, several internal signal inputs are available. The ADC can provide both signed and unsigned results.

ADC measurements can be started by either application software or an incoming event from another peripheral in the device. ADC measurements can be started with predictable timing, and without software intervention.

Both internal and external reference voltages can be used.

An integrated temperature sensor is available for use with the ADC. The bandgap voltage as well as the scaled I/O and core voltages can also be measured by the ADC.

The ADC has a compare function for accurate monitoring of user-defined thresholds, with minimum software intervention required.

The ADC can be configured for 8-, 10- or 12-bit results. ADC conversion results are provided left- or right-adjusted, which eases calculation when the result is represented as a signed value. It is possible to use DMA to move ADC results directly to memory or peripherals when conversions are done.

The SAM C20/C21 has two ADC instances, ADC0 and ADC1. The two inputs can be sampled simultaneously, as each ADC includes sample and hold circuits.
Note: When the Peripheral Touch Controller (PTC) is enabled, ADC0 is serving the PTC exclusively. In this case, ADC0 cannot be used by the user application.

38.2 Features

- Two Analog to Digital Converters (ADC) ADC0 and ADC1
- 8-, 10- or 12-bit resolution
- Up to 1,000,000 samples per second (1MSPS)
- Differential and single-ended inputs
  - Up to 12 analog inputs per ADC (20 unique channels total)
    16 positive and 7 negative, including internal and external
- Internal inputs:
  - Bandgap voltage
  - Scaled core supply
  - Scaled I/O supply
  - DAC
- Single, continuous and sequencing options
- Windowing monitor with selectable channel
- Conversion range: V_{ref} = [2.0V to VDD_{ANA}]
- Built-in internal reference and external reference options
- Event-triggered conversion for accurate timing (one event input)
- Optional DMA transfer of conversion settings or result

Bit	7	6	5	4	3	2	1	0
	ONREFBUF		REFRANGE[1:0]				REFSEL[1:0]	
Access	R/W		R/W	R/W			R/W	R/W
Reset	0		0	0			0	0

Bit 7 – ONREFBUF: Reference Buffer On
Turning on the buffer increases the impedance seen on the external reference, so that the current load reduces from 5µA to 0.10µA. This needs to be matched with whatever type of reference circuit is used.

Value	Description
0	Reference Buffer Off
1	Reference Buffer On

Bits 5:4 – REFRANGE[1:0]: Reference Range

REFRANGE[1:0]	Reference Voltage
0x0	Vref < 1.4V
0x1	1.4V < Vref < 2.4V
0x2	2.4 < Vref < 3.6V
0x3	Vref > 3.6V

Bits 1:0 – REFSEL[1:0]: Reference Selection
These bits select the reference for the ADC.

Note: The reference buffer should be enabled (ONREFBUF=1) when using the internal bandgap or DAC output as reference.

Value	Name	Description
0x0	Internal bandgap	Internal 1.024V, 2.048V, 4.096V
0x1	VREFB pin	External 1-5.5V
0x2	DAC output	Internal 1-5.5V
0x3	VDDANA	Supply 2.7-5.5V

39.8.3 Control B

Name: CTRLB
Offset: 0x02 [ID-0000243d]
Reset: 0x0000
Property: PAC Write-Protection, Enable-Protected

Bit 1 – OVERRUN: Overrun
This flag is cleared by writing a one to the flag.

This flag is set if RESULT is written before the previous value has been read by CPU, and an interrupt request will be generated if INTENCLR/SET.OVERRUN is one.

Writing a zero to this bit has no effect.

Writing a one to this bit clears the Overrun interrupt flag.

Bit 0 – RESRDY: Result Ready
This flag is cleared by writing a one to the flag or by reading the RESULT register.

This flag is set when the conversion result is available, and an interrupt will be generated if INTENCLR/SET.RESRDY is one.

Writing a zero to this bit has no effect.

Writing a one to this bit clears the Result Ready interrupt flag.

39.8.8 Sequence Status

Name: SEQSTATUS
Offset: 0x08 [ID-0000243d]
Reset: 0x00
Property: -

Bit	7	6	5	4	3	2	1	0
	SEQBUSY				SEQSTATE[3:0]			
Access	R				R	R	R	R
Reset	0				0	0	0	0

Bit 7 – SEQBUSY: Sequence busy
This bit is set when the sequence start.

This bit is clear when the last conversion in a sequence is done.

Bits 3:0 – SEQSTATE[3:0]: Sequence State
This bit field is the pointer of sequence. This value identifies the last conversion done in the sequence.

39.8.9 Input Control

Name: INPUTCTRL
Offset: 0x09 [ID-0000243d]
Reset: 0x00
Property: PAC Write-Protection, Write-Synchronized

41.8.10 Synchronization Busy

Name: SYNCBUSY
Offset: 0x10 [ID-00000bc7]
Reset: 0x00000000
Property: -

Bit	31	30	29	28	27	26	25	24
Access								
Reset								

Bit	23	22	21	20	19	18	17	16
Access								
Reset								

Bit	15	14	13	12	11	10	9	8
Access								
Reset								

Bit	7	6	5	4	3	2	1	0
					DATABUF	DATA	ENABLE	SWRST
Access					R	R	R	R
Reset					0	0	0	0

Bit 3 – DATABUF: Data Buffer DAC0
This bit is set when DATABUF register is written.

This bit is cleared when DATABUF synchronization is completed.

Value	Description
0	No ongoing synchronized access.
1	Synchronized access is ongoing.

Bit 2 – DATA: Data
This bit is set when DATA register is written.

This bit is cleared when DATA synchronization is completed.

Value	Description
0	No ongoing synchronized access.
1	Synchronized access is ongoing.

Bit 1 – ENABLE: DAC Enable Status
This bit is set when CTRLA.ENABLE bit is written.

This bit is cleared when CTRLA.ENABLE synchronization is completed.

48. Packaging Information

48.1 Thermal Considerations

48.1.1 Thermal Resistance Data

The following table summarizes the thermal resistance data depending on the package.

Table 48-1. Thermal Resistance Data

Package Type	θ_{JA}	θ_{JC}
32-pin TQFP	63.1°C/W	14.3°C/W
48-pin TQFP	62.7°C/W	11.6°C/W
64-pin TQFP	56.3°C/W	11.1°C/W
100-pin TQFP	55.0°C/W	11.1°C/W
32-pin QFN	40.5°C/W	16.0°C/W
48-pin QFN	30.9°C/W	10.4°C/W
64-pin QFN	31.4°C/W	10.2°C/W
56-ball WLCSP	37.5°C/W	5.48°C/W

48.1.2 Junction Temperature

The average chip-junction temperature, T_J, in °C can be obtained from the following:

1. $T_J = T_A + (P_D \times \theta_{JA})$
2. $T_J = T_A + (P_D \times (\theta_{HEATSINK} + \theta_{JC}))$

where:

- θ_{JA} = Package thermal resistance, Junction-to-ambient (°C/W), see Thermal Resistance Data
- θ_{JC} = Package thermal resistance, Junction-to-case thermal resistance (°C/W), see Thermal Resistance Data
- $\theta_{HEATSINK}$ = Thermal resistance (°C/W) specification of the external cooling device
- P_D = Device power consumption (W)
- T_A = Ambient temperature (°C)

From the first equation, the user can derive the estimated lifetime of the chip and decide if a cooling device is necessary or not. If a cooling device is to be fitted on the chip, the second equation should be used to compute the resulting average chip-junction temperature T_J in °C.

48.2 Package Drawings

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging.