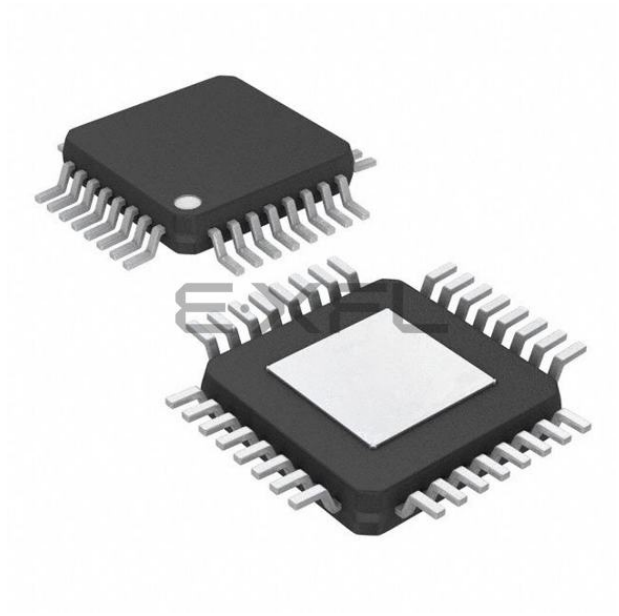

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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	ARM® Cortex®-M0+
Core Size	32-Bit Single-Core
Speed	48MHz
Connectivity	CANbus, I²C, LINbus, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, DMA, POR, WDT
Number of I/O	26
Program Memory Size	256KB (256K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	32K x 8
Voltage - Supply (Vcc/Vdd)	2.7V ~ 5.5V
Data Converters	A/D 10x12b, 1x16b; D/A 1x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	32-TQFP
Supplier Device Package	32-TQFP (7x7)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/atsamc21e18a-aut

	SAM C20N	SAM C20J	SAM C20G	SAM C20E
Peripheral Touch Controller (PTC) Number of self-capacitance channels (Y-lines)	32	32	22	16
Peripheral Touch Controller (PTC) Number of mutual-capacitance channels (X x Y lines)	256 (16x16)	256 (16x16)	121 (11x11)	64 (8x8)
Frequency Meter (FREQM) reference clock divider	Yes	Yes	Yes	Yes
Maximum CPU frequency	48 MHz			
Packages	TQFP	QFN TQFP WLCSP	QFN TQFP	QFN TQFP
Oscillators	32.768 kHz crystal oscillator (XOSC32K) 0.4-32 MHz crystal oscillator (XOSC) 32.768 kHz internal oscillator (OSC32K) 32 kHz ultra low-power internal oscillator (OSCULP32K) 48 MHz high-accuracy internal oscillator (OSC48M) 96 MHz Fractional Digital Phased Locked Loop (FDPLL96M)			
Event System channels	6	6	6	6
SW Debug Interface	Yes	Yes	Yes	Yes
Watchdog Timer (WDT)	Yes	Yes	Yes	Yes

Related Links

I/O Multiplexing and Considerations

This flag is cleared by writing a one to the flag.

This flag is set when a Peripheral Access Error occurs while accessing the peripheral associated with the respective INTFLAGD bit, and will generate an interrupt request if INTENCLR/SET.ERR is one.

Writing a zero to this bit has no effect.

Writing a one to this bit will clear the corresponding INTFLAGD interrupt flag.

Name: INTFLAGD
Offset: 0x20 [ID-00000a18]
Reset: 0x000000
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
				TC7	TC6	TC5	SERCOM7	SERCOM6
Access				R/W	R/W	R/W	R/W	R/W
Reset				0	0	0	0	0

Bits 2, 3, 4 – TC5, TC6, TC7: Interrupt Flag for TCn [n = 7..5]

Bits 0, 1 – SERCOM6, SERCOM7: Interrupt Flag for SERCOMn [n = 7..6]

11.7.10 Peripheral Write Protection Status A

Writing to this register has no effect.

Reading STATUS register returns peripheral write protection status:

Value	Description
0	Peripheral is not write protected.
1	Peripheral is write protected.

Name: STATUSA
Offset: 0x34 [ID-00000a18]
Reset: 0x000000
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
				TSENS	FREQM	EIC	RTC	WDT
Access				R	R	R	R	R
Reset				0	0	0	0	0

Bit	7	6	5	4	3	2	1	0
	GCLK	SUPC	OSC32KCTRL	OSCCTRL	RSTC	MCLK	PM	PAC
Access	R	R	R	R	R	R	R	R
Reset	0	0	0	0	0	0	0	0

Bit 12 – TSENS: Peripheral TSENS Write Protection Status

Bit 11 – FREQM: Peripheral FREQM Write Protection Status

Bit 10 – EIC: Peripheral EIC Write Protection Status

Bit 9 – RTC: Peripheral RTC Write Protection Status

Bit 8 – WDT: Peripheral WDT Write Protection Status

Bit 7 – GCLK: Peripheral GCLK Write Protection Status

Bit 6 – SUPC: Peripheral SUPC Write Protection Status

Bit 5 – OSC32KCTRL: Peripheral OSC32KCTRL Write Protection Status

Bit 4 – OSCCTRL: Peripheral OSCCTRL Write Protection Status

Bit 3 – RSTC: Peripheral RSTC Write Protection Status

Bit 2 – MCLK: Peripheral MCLK Write Protection Status

Bit 1 – PM: Peripheral PM Write Protection Status

Bit 0 – PAC: Peripheral PAC Write Protection Status

CPU Clock Domain	
Peripheral Clock	**Default State**
CLK_SERCOM1_AHB	Disabled
CLK_SERCOM2_APB	Disabled
CLK_SERCOM3_APB	Disabled
CLK_SERCOM4_APB	Disabled
CLK_SERCOM5_APB	Disabled
CLK_SERCOM6_APB	Disabled
CLK_SERCOM7_APB	Disabled
CLK_TCC0_APB	Disabled
CLK_TCC1_APB	Disabled
CLK_TCC2_APB	Disabled
CLK_TC0_APB	Disabled
CLK_TC1_APB	Disabled
CLK_TC2_APB	Disabled
CLK_TC3_APB	Disabled
CLK_TC4_APB	Disabled
CLK_TC5_APB	Disabled
CLK_TC6_APB	Disabled
CLK_TC7_APB	Disabled
CLK_TSENS_APB	Disabled
CLK_WDT_APB	Enabled

Backup Clock Domain	
Peripheral Clock	**Default State**
CLK_OSC32KCTRL_APB	Enabled
CLK_PM_APB	Enabled
CLK_SUPC_APB	Enabled
CLK_RSTC_APB	Enabled
CLK_RTC_APB	Enabled

When the APB clock is not provided to a module, its registers cannot be read or written. The module can be re-enabled later by writing the corresponding mask bit to '1'.

A module may be connected to several clock domains (for instance, AHB and APB), in which case it will have several mask bits.

19. PM – Power Manager

Related Links

Sleep Mode Operation

19.1 Overview

The Power Manager (PM) controls the sleep modes of the device.

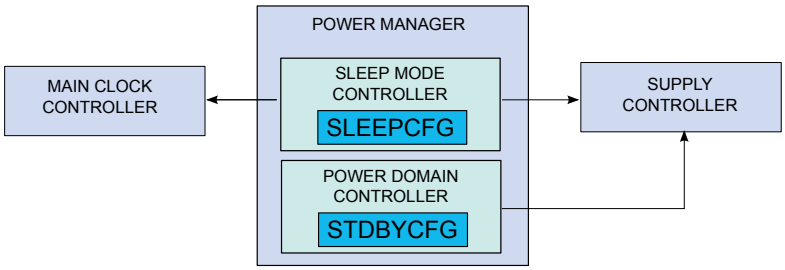
Various sleep modes are provided in order to fit power consumption requirements. This enables the PM to stop unused modules in order to save power. In active mode, the CPU is executing application code. When the device enters a sleep mode, program execution is stopped and some modules and clock domains are automatically switched off by the PM according to the sleep mode. The application code decides which sleep mode to enter and when. Interrupts from enabled peripherals and all enabled reset sources can restore the device from a sleep mode to active mode.

19.2 Features

- Power management control
  - Sleep modes: Idle, Standby

19.3 Block Diagram

Figure 19-1. PM Block Diagram



19.4 Signal Description

Not applicable.

19.5 Product Dependencies

In order to use this peripheral, other parts of the system must be configured correctly, as described below.

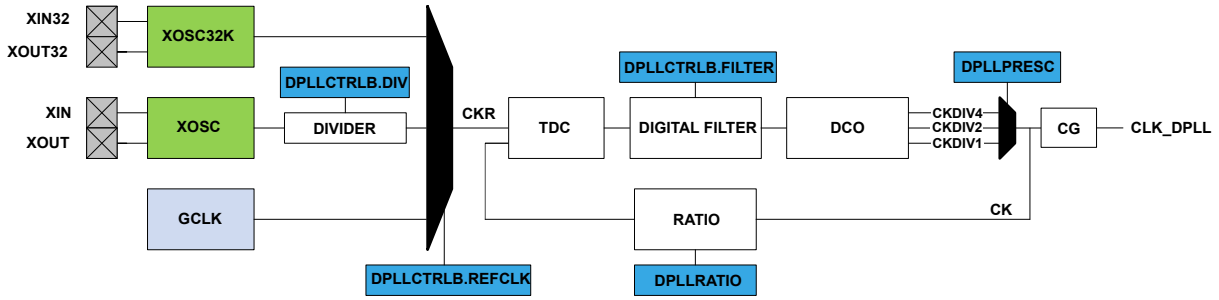
19.5.1 I/O Lines

Not applicable.

19.5.2 Clocks

The PM bus clock (CLK_PM_APB) can be enabled and disabled in the Main Clock module. If this clock is disabled, it can only be re-enabled by a system reset.

Figure 20-2. DPLL Block Diagram



When the controller is disabled, the output clock is low. If the Loop Divider Ratio Fractional part bit field in the DPLL Ratio register (DPLLRATIO.LDRFRAC) is zero, the DPLL works in integer mode. Otherwise, the fractional mode is activated. Note that the fractional part has a negative impact on the jitter of the DPLL.

Example (integer mode only): assuming F_{CKR} = 32kHz and F_{CK} = 48MHz, the multiplication ratio is 1500. It means that LDR shall be set to 1499.

Example (fractional mode): assuming F_{CKR} = 32kHz and F_{CK} = 48.006MHz, the multiplication ratio is 1500.1875 (1500 + 3/16). Thus LDR is set to 1499 and LDRFRAC to 3.

Related Links

GCLK - Generic Clock Controller

OSC32KCTRL – 32KHz Oscillators Controller

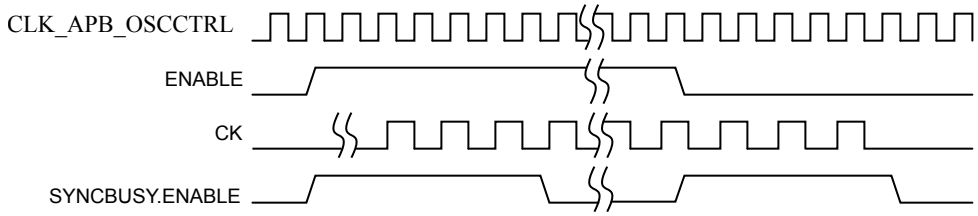
20.6.5.1 Basic Operation

Initialization, Enabling, Disabling, and Resetting

The DPLLC is enabled by writing a '1' to the Enable bit in the DPLL Control A register (DPLLCTRLA.ENABLE). The DPLLC is disabled by writing a zero to this bit.

The DPLLSYNCBUSY.ENABLE is set when the DPLLCTRLA.ENABLE bit is modified. It is cleared when the DPLL output clock CK has sampled the bit at the high level after enabling the DPLL. When disabling the DPLL, DPLLSYNCBUSY.ENABLE is cleared when the output clock is no longer running.

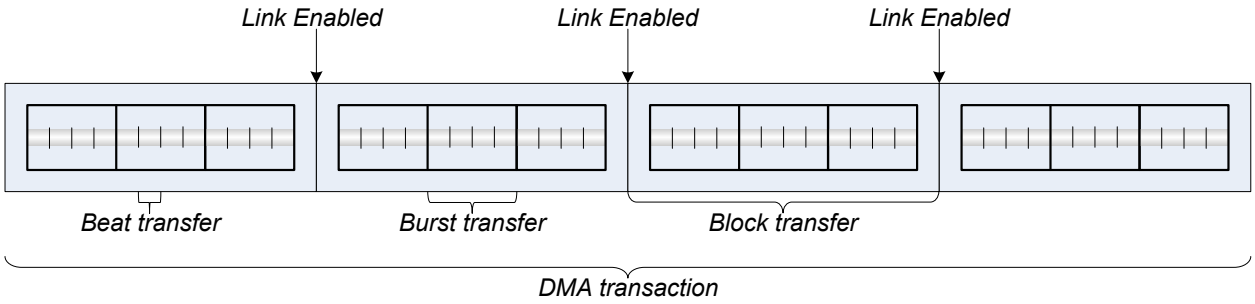
Figure 20-3. Enable Synchronization Busy Operation



The frequency of the DPLL output clock CK is stable when the module is enabled and when the Lock bit in the DPLL Status register is set (DPLLSTATUS.LOCK).

When the Lock Time bit field in the DPLL Control B register (DPLLCTRLB.LTIME) is non-zero, a user defined lock time is used to validate the lock operation. In this case the lock time is constant. If DPLLCTRLB.LTIME=0, the lock signal is linked with the status bit of the DPLL, and the lock time varies depending on the filter selection and the final target frequency.

Figure 25-2. DMA Transfer Sizes



- Beat transfer: The size of one data transfer bus access, and the size is selected by writing the Beat Size bit group in the Block Transfer Control register (BTCTRL.BEATSIZE)
- Burst transfer: Defined as n beat transfers, where n will differ from one device family to another. A burst transfer is atomic, cannot be interrupted and the length of the burst is selected by writing the Burst Length bit group in each Channel n Control A register (CHCTRLA.BURSTLEN).
- Block transfer: The amount of data one transfer descriptor can transfer, and the amount can range from 1 to 64k beats. A block transfer can be interrupted, in contrast to the burst transfer.
- Transaction: The DMAC can link several transfer descriptors by having the first descriptor pointing to the second and so forth, as shown in the figure above. A DMA transaction is the complete transfer of all blocks within a linked list.

A transfer descriptor describes how a block transfer should be carried out by the DMAC, and it must remain in SRAM. For further details on the transfer descriptor refer to Transfer Descriptors.

The figure above shows several block transfers linked together, which are called linked descriptors. For further information about linked descriptors, refer to Linked Descriptors.

A DMA transfer is initiated by an incoming transfer trigger on one of the DMA channels. This trigger can be configured to be either a software trigger, an event trigger, or one of the dedicated peripheral triggers. The transfer trigger will result in a DMA transfer request from the specific channel to the arbiter. If there are several DMA channels with pending transfer requests, the arbiter chooses which channel is granted access to become the active channel. The DMA channel granted access as the active channel will carry out the transaction as configured in the transfer descriptor. A current transaction can be interrupted by a higher prioritized channel after each burst transfer, but will resume the block transfer when the according DMA channel is granted access as the active channel again.

For each beat transfer, an optional output event can be generated. For each block transfer, optional interrupts and an optional output event can be generated. When a transaction is completed, dependent of the configuration, the DMA channel will either be suspended or disabled.

25.6.1.2 CRC

The internal CRC engine supports two commonly used CRC polynomials: CRC-16 (CRC-CCITT) and CRC-32 (IEEE 802.3). It can be used on a selectable DMA channel, or on the I/O interface. Refer to CRC Operation for details.

25.6.2 Basic Operation

25.6.2.1 Initialization

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

- Descriptor Base Memory Address register (BASEADDR)
- Write-Back Memory Base Address register (WRBADDR)

Value	Description
0	The NMI edge detection is synchronously operated.
1	The NMI edge detection is asynchronously operated.

Bit 3 – NMIFILTEN: Non-Maskable Interrupt Filter Enable

Value	Description
0	NMI filter is disabled.
1	NMI filter is enabled.

Bits 2:0 – NMISENSE[2:0]: Non-Maskable Interrupt Sense Configuration
These bits define on which edge or level the NMI triggers.

Value	Name	Description
0x0	NONE	No detection
0x1	RISE	Rising-edge detection
0x2	FALL	Falling-edge detection
0x3	BOTH	Both-edge detection
0x4	HIGH	High-level detection
0x5	LOW	Low-level detection
0x6 - 0x7	-	Reserved

26.8.3 Non-Maskable Interrupt Flag Status and Clear

Name: NMIFLAG
Offset: 0x02
Reset: 0x0000

Bit	15	14	13	12	11	10	9	8
Access								
Reset								

Bit	7	6	5	4	3	2	1	0
								NMI
Access								RW
Reset								0

Bit 0 – NMI: Non-Maskable Interrupt
This flag is cleared by writing a '1' to it.

This flag is set when the NMI pin matches the NMI sense configuration, and will generate an interrupt request.

Writing a '0' to this bit has no effect.

26.8.4 Synchronization Busy

Bit	15	14	13	12	11	10	9	8
						LENERR	SEXTTOUT	MEXTTOUT
Access						R/W	R/W	R/W
Reset						0	0	0

Bit	7	6	5	4	3	2	1	0
	CLKHOLD	LOWTOUT	BUSSTATE[1:0]			RXNACK	ARBLOST	BUSERR
Access	R	R/W	R	R		R	R/W	R/W
Reset	0	0	0	0		0	0	0

Bit 10 – LENERR: Transaction Length Error
This bit is set when automatic length is used for a DMA transaction and the slave sends a NACK before ADDR.LEN bytes have been written by the master.

Writing '1' to this bit location will clear STATUS.LENERR. This flag is automatically cleared when writing to the ADDR register.

Writing '0' to this bit has no effect.

This bit is not write-synchronized.

Bit 9 – SEXTTOUT: Slave SCL Low Extend Time-Out
This bit is set if a slave SCL low extend time-out occurs.

This bit is automatically cleared when writing to the ADDR register.

Writing '1' to this bit location will clear SEXTTOUT. Normal use of the I^2C interface does not require the SEXTTOUT flag to be cleared by this method.

Writing '0' to this bit has no effect.

This bit is not write-synchronized.

Bit 8 – MEXTTOUT: Master SCL Low Extend Time-Out
This bit is set if a master SCL low time-out occurs.

Writing '1' to this bit location will clear STATUS.MEXTTOUT. This flag is automatically cleared when writing to the ADDR register.

Writing '0' to this bit has no effect.

This bit is not write-synchronized.

Bit 7 – CLKHOLD: Clock Hold
This bit is set when the master is holding the SCL line low, stretching the I^2C clock. Software should consider this bit when INTFLAG.SB or INTFLAG.MB is set.

This bit is cleared when the corresponding interrupt flag is cleared and the next operation is given.

Writing '0' to this bit has no effect.

Writing '1' to this bit has no effect.

This bit is not write-synchronized.

Bit 6 – LOWTOUT: SCL Low Time-Out
This bit is set if an SCL low time-out occurs.

Value	Description
0	Interrupt disabled.
1	Interrupt enabled.

Bit 17 – MRAFE: Message RAM Access Failure Interrupt Enable

Value	Description
0	Interrupt disabled.
1	Interrupt enabled.

Bit 16 – TSWE: Timestamp Wraparound Interrupt Enable

Value	Description
0	Interrupt disabled.
1	Interrupt enabled.

Bit 15 – TEFLE: Tx Event FIFO Event Lost Interrupt Enable

Value	Description
0	Interrupt disabled.
1	Interrupt enabled.

Bit 14 – TEFFE: Tx Event FIFO Full Interrupt Enable

Value	Description
0	Interrupt disabled.
1	Interrupt enabled.

Bit 13 – TEFWE: Tx Event FIFO Watermark Reached Interrupt Enable

Value	Description
0	Interrupt disabled.
1	Interrupt enabled.

Bit 12 – TEFNE: Tx Event FIFO New Entry Interrupt Enable

Value	Description
0	Interrupt disabled.
1	Interrupt enabled.

Bit 11 – TFEE: Tx FIFO Empty Interrupt Enable

Value	Description
0	Interrupt disabled.
1	Interrupt enabled.

Bit 10 – TCFE: Transmission Cancellation Finished Interrupt Enable

Value	Description
0	Interrupt disabled.
1	Interrupt enabled.

Bit 9 – TCE: Transmission Completed Interrupt Enable

Bit	31	30	29	28	27	26	25	24
	PERBUF[31:24]							
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
	PERBUF[23:16]							
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
	PERBUF[15:8]							
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
	PERBUF[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	1

Bits 31:0 – PERBUF[31:0]: Period Buffer Value
These bits hold the value of the period buffer register. The value is copied to PER register on UPDATE condition.

35.7.3.17 Channel x Compare Buffer Value, 32-bit Mode

Name: CCBUFx
Offset: 0x30 + x*0x04 [x=0..1]
Reset: 0x00000000
Property: Write-Synchronized

Bits 13:12 – PRESCYNC[1:0]: Prescaler and Counter Synchronization
These bits select if on re-trigger event, the Counter is cleared or reloaded on either the next GCLK_TCCx clock, or on the next prescaled GCLK_TCCx clock. It is also possible to reset the prescaler on re-trigger event.

These bits are not synchronized.

Value	Name	Description	
		Counter Reloaded	Prescaler
0x0	GCLK	Reload or reset Counter on next GCLK	-
0x1	PRESC	Reload or reset Counter on next prescaler clock	-
0x2	RESYNC	Reload or reset Counter on next GCLK	Reset prescaler counter
0x3	Reserved		

Bit 11 – RUNSTDBY: Run in Standby
This bit is used to keep the TCC running in standby mode.

This bit is not synchronized.

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

Bits 10:8 – PRESCALER[2:0]: Prescaler
These bits select the Counter prescaler factor.

These bits are not synchronized.

Value	Name	Description
0x0	DIV1	Prescaler: GCLK_TCC
0x1	DIV2	Prescaler: GCLK_TCC/2
0x2	DIV4	Prescaler: GCLK_TCC/4
0x3	DIV8	Prescaler: GCLK_TCC/8
0x4	DIV16	Prescaler: GCLK_TCC/16
0x5	DIV64	Prescaler: GCLK_TCC/64
0x6	DIV256	Prescaler: GCLK_TCC/256
0x7	DIV1024	Prescaler: GCLK_TCC/1024

Bits 6:5 – RESOLUTION[1:0]: Dithering Resolution
These bits increase the TCC resolution by enabling the dithering options.

These bits are not synchronized.

Value	Description
0	The Non-Recoverable Fault x interrupt is disabled.
1	The Non-Recoverable Fault x interrupt is enabled.

Bit 13 – FAULTB: Recoverable Fault B Interrupt Enable
Writing a '0' to this bit has no effect.

Writing a '1' to this bit will clear the Recoverable Fault B Interrupt Disable/Enable bit, which disables the Recoverable Fault B interrupt.

Value	Description
0	The Recoverable Fault B interrupt is disabled.
1	The Recoverable Fault B interrupt is enabled.

Bit 12 – FAULTA: Recoverable Fault A Interrupt Enable
Writing a '0' to this bit has no effect.

Writing a '1' to this bit will clear the Recoverable Fault A Interrupt Disable/Enable bit, which disables the Recoverable Fault A interrupt.

Value	Description
0	The Recoverable Fault A interrupt is disabled.
1	The Recoverable Fault A interrupt is enabled.

Bit 11 – DFS: Non-Recoverable Debug Fault Interrupt Enable
Writing a '0' to this bit has no effect.

Writing a '1' to this bit will clear the Debug Fault State Interrupt Disable/Enable bit, which disables the Debug Fault State interrupt.

Value	Description
0	The Debug Fault State interrupt is disabled.
1	The Debug Fault State interrupt is enabled.

Bit 10 – UFS: Non-Recoverable Update Fault Interrupt Enable
Writing a zero to this bit has no effect.

Writing a one to this bit will clear the Non-Recoverable Update Fault Interrupt Disable/Enable bit, which disables the Non-Recoverable Update Fault interrupt.

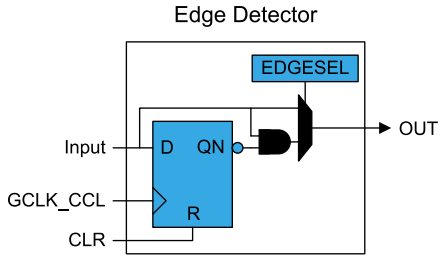
Value	Description
0	The Non-Recoverable Update Fault interrupt is disabled.
1	The Non-Recoverable Update Fault interrupt is enabled.

Bit 3 – ERR: Error Interrupt Enable
Writing a '0' to this bit has no effect.

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

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

Figure 37-13. Edge Detector



37.6.2.7 Sequential Logic

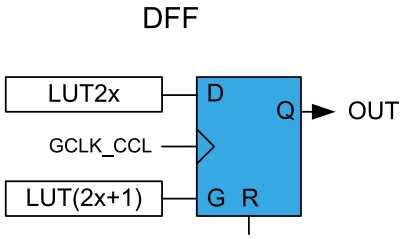
Each LUT pair can be connected to the internal sequential logic which can be configured to work as D flip flop, JK flip flop, gated D-latch or RS-latch by writing the Sequential Selection bits on the corresponding Sequential Control x register (SEQCTRLx.SEQSEL). Before using sequential logic, the GCLK_CCL clock and optionally each LUT filter or edge detector must be enabled.

Note: While configuring the sequential logic, the even LUT must be disabled. When configured the even LUT must be enabled.

Gated D Flip-Flop (DFF)

When the DFF is selected, the D-input is driven by the even LUT output (LUT0 and LUT2), and the G-input is driven by the odd LUT output (LUT1 and LUT3), as shown in Figure 37-14.

Figure 37-14. D Flip Flop



When the even LUT is disabled (LUTCTRL0.ENABLE=0 / LUTCTRL2.ENABLE=0), the flip-flop is asynchronously cleared. The reset command (R) is kept enabled for one APB clock cycle. In all other cases, the flip-flop output (OUT) is refreshed on rising edge of the GCLK_CCL, as shown in Table 37-2.

Table 37-2. DFF Characteristics

R	G	D	OUT
1	X	X	Clear
0	1	1	Set
		0	Clear
	0	X	Hold state (no change)

JK Flip-Flop (JK)

When this configuration is selected, the J-input is driven by the even LUT output (LUT0 and LUT2), and the K-input is driven by the odd LUT output (LUT1 and LUT3), as shown in Figure 37-15.

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

38.7 Register Summary

Offset	Name	Bit Pos.								
0x00	CTRLA	7:0	ONDEMAND	RUNSTDBY	SLAVEEN				ENABLE	SWRST
0x01	CTRLB	7:0						PRESCALER[2:0]		
0x02	REFCTRL	7:0	REFCOMP				REFSEL[3:0]			
0x03	EVCTRL	7:0			WINMONEO	RESRDYEO	STARTINV	FLUSHINV	STARTEI	FLUSHEI
0x04	INTENCLR	7:0						WINMON	OVERRUN	RESRDY
0x05	INTENSET	7:0						WINMON	OVERRUN	RESRDY
0x06	INTFLAG	7:0						WINMON	OVERRUN	RESRDY
0x07	SEQSTATUS	7:0	SEQBUSY			SEQSTATE[4:0]				
0x08	INPUTCTRL	7:0				MUXPOS[4:0]				
0x09		15:8				MUXNEG[4:0]				
0x0A	CTRLC	7:0	R2R		RESSEL[1:0]		CORREN	FREERUN	LEFTADJ	DIFFMODE
0x0B		15:8			DUALSEL[1:0]			WINMODE[2:0]		
0x0C	AVGCTRL	7:0		ADJRES[2:0]			SAMPLENUM[3:0]			
0x0D	SAMPCTRL	7:0	OFFCOMP		SAMPLEN[5:0]					
0x0E	WINLT	7:0	WINLT[7:0]							
0x0F		15:8	WINLT[15:8]							
0x10	WINUT	7:0	WINUT[7:0]							
0x11		15:8	WINUT[15:8]							
0x12	GAINCORR	7:0	GAINCORR[7:0]							
0x13		15:8					GAINCORR[11:8]			
0x14	OFFSETCORR	7:0	OFFSETCORR[7:0]							
0x15		15:8					OFFSETCORR[11:8]			
0x16 ... 0x17	Reserved									
0x18	SWTRIG	7:0							START	FLUSH
0x19 ... 0x1B	Reserved									
0x1C	DBGCTRL	7:0								DBGRUN
0x1D ... 0x1F	Reserved									
0x20	SYNCBUSY	7:0	WINUT	WINLT	SAMPCTRL	AVGCTRL	CTRLC	INPUTCTRL	ENABLE	SWRST
0x21		15:8						SWTRIG	OFFSETCOR R	GAINCORR
0x22 ... 0x23	Reserved									
0x24	RESULT	7:0	RESULT[7:0]							
0x25		15:8	RESULT[15:8]							
0x26 ... 0x27	Reserved									
0x28	SEQCTRL	7:0	SEQENn	SEQENn	SEQENn	SEQENn	SEQENn	SEQENn	SEQENn	SEQENn

Bit 5 – WINLT: Window Monitor Upper Threshold Synchronization Busy
This bit is cleared when the synchronization of WINLT register between the clock domains is complete.

This bit is set when the synchronization of WINLT register between clock domains is started.

Bit 4 – WINCTRL: Window Monitor Control Synchronization Busy
This bit is cleared when the synchronization of WINCTRL register between the clock domains is complete.

This bit is set when the synchronization of WINCTRL register between clock domains is started.

Bit 3 – MUXCTRL: Mux Control Synchronization Busy
This bit is cleared when the synchronization of MUXCTRL register between the clock domains is complete.

This bit is set when the synchronization of MUXCTRL register between clock domains is started.

Bit 2 – CTRLC: Control C Synchronization Busy
This bit is cleared when the synchronization of CTRLC register between the clock domains is complete.

This bit is set when the synchronization of CTRLC register between clock domains is started.

Bit 1 – ENABLE: ENABLE Synchronization Busy
This bit is cleared when the synchronization of ENABLE register between the clock domains is complete.

This bit is set when the synchronization of ENABLE register between clock domains is started.

Bit 0 – SWRST: SWRST Synchronization Busy
This bit is cleared when the synchronization of SWRST register between the clock domains is complete.

This bit is set when the synchronization of SWRST register between clock domains is started

39.8.19 Result

Name: RESULT
Offset: 0x24 [ID-0000243d]
Reset: 0x00000000
Property: -

Figure 49-4. External Analog Reference Schematic With One Reference

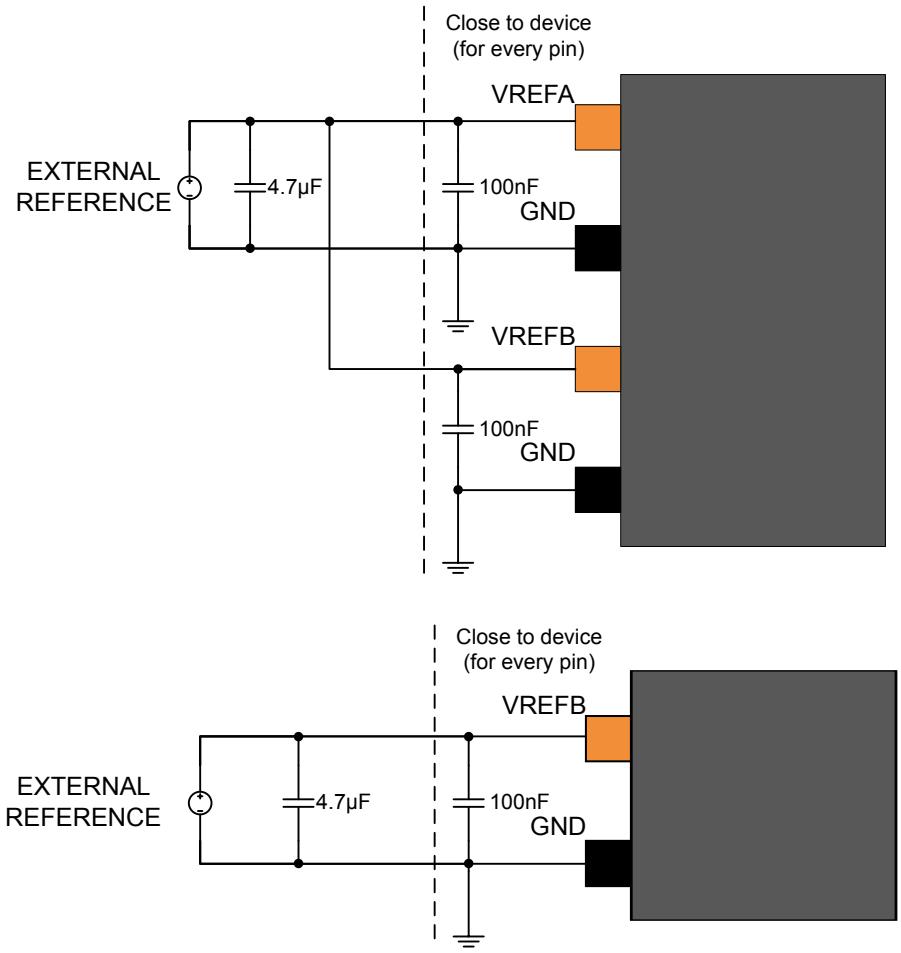


Table 49-2. External Analog Reference Connections

Signal Name	Recommended Pin Connection	Description
VREFA	2.0V to V_{DDANA} - 0.6V for ADC 1.0V to V_{DDANA} - 0.6V for DAC Decoupling/filtering capacitors: 100nF(1)(2) and 4.7µF(1)	External reference from VREFA pin on the analog port.
VREFB	1.0V to 5.5V for SDADC Decoupling/filtering capacitors: 100nF(1)(2) and 4.7µF(1)	External reference from VREFB pin on the analog port.
GND		Ground

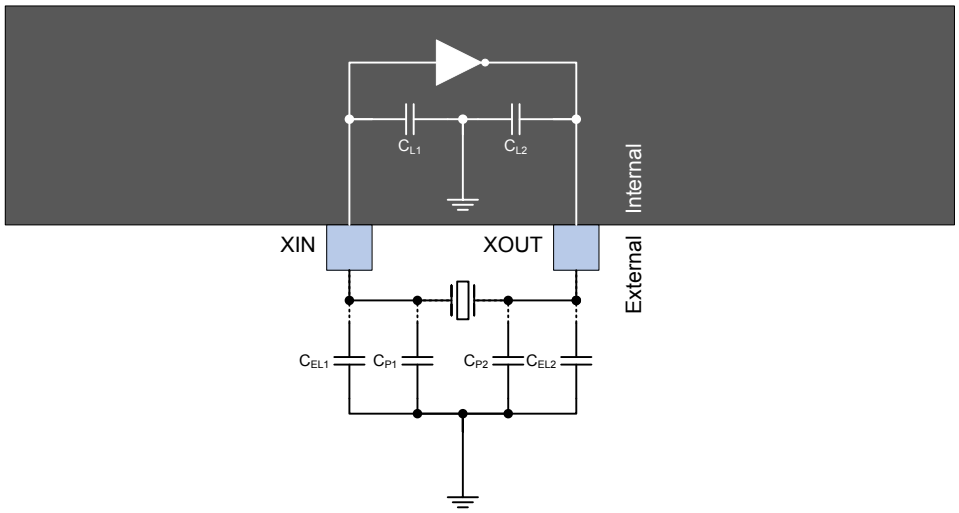
Note:

1. These values are given as a typical example.
2. Decoupling capacitor should be placed close to the device for each supply pin pair in the signal group.

49.7.4 Calculating the Correct Crystal Decoupling Capacitor

The model shown in Figure 49-10 can be used to calculate correct load capacitor for a given crystal. This model includes internal capacitors C_{Ln}, external parasitic capacitance C_{ELn} and external load capacitance C_{Pn}.

Figure 49-10. Crystal Circuit With Internal, External and Parasitic Capacitance



Using this model the total capacitive load for the crystal can be calculated as shown in the equation below:

$$\sum C_{\text{tot}} = \frac{(C_{L1} + C_{P1} + C_{\text{EL1}})(C_{L2} + C_{P2} + C_{\text{EL2}})}{C_{L1} + C_{P1} + C_{\text{EL1}} + C_{L2} + C_{P2} + C_{\text{EL2}}}$$

where C_{tot} is the total load capacitance seen by the crystal. This value should be equal to the load capacitance value found in the crystal manufacturer datasheet.

The parasitic capacitance C_{ELn} can in most applications be disregarded as these are usually very small. If accounted for, these values are dependent on the PCB material and PCB layout.

For some crystal the internal capacitive load provided by the device itself can be enough. To calculate the total load capacitance in this case. C_{ELn} and C_{Pn} are both zero, $C_{L1} = C_{L2} = C_L$, and the equation reduces to the following:

$$\sum C_{\text{tot}} = \frac{C_L}{2}$$

See the related links for equivalent internal pin capacitance values.

Related Links

Crystal Oscillator Characteristics

49.8 Programming and Debug Ports

For programming and/or debugging the SAM C20/C21 the device should be connected using the Serial Wire Debug (SWD) interface. Currently the SWD interface is supported by several Microchip and third party programmers and debuggers, like the SAM-ICE, JTAGICE3 or SAM C21 Xplained Pro (SAM C21 evaluation kit) Embedded Debugger.

Electrical Characteristics 85°C (SAM C20/C21 E/G/J)	• Digital to Analog Converter (DAC) Characteristics: Clock and timing conversion rate conditions updated: Rload > 5kW corrected to Rload > 5kΩ. • Added Temperature Sensor Characteristics.
Electrical Characteristics 105°C (SAM C20/C21 E/G/J)	Added Analog Characteristics.

50.7 Rev G - 04/2015

Ordering Information	Added Device Identification.
I/O Multiplexing and Considerations	New sections added: • SERCOM I2C Pins: Information moved from the "Type" column in Table 6-2 into separate table. • Updated CCL column. • GPIO Clusters: Moved from Absolute Maximum Ratings. • TCC Configurations: Moved from TCC – Timer/Counter for Control Applications.
Memories	• Updated Table 9-4. • Updated Table 9-1.
PAC - Peripheral Access Controller	Register bit correction: INTFLAGAHB, INTFLAGA, INTFLAGB, INTFLAGC, STATUSA, STATUSB and STATUSC
DSU - Device Service Unit	Table 13-6 updated: MBIST is not available when the device is protected from the external address space.
GCLK - Generic Clock Controller	• Block Diagram: GCLK_MAIN goes into the MCLK, not the PM. • Signal Description: Available signals are GCLK_IO[7:0].
MCLK – Main Clock	• Updated block diagram in Selecting the Synchronous Clock Division Ratio.
OSCCTRL – Oscillators Controller	Added OSC48M Calibration (CAL48M) register added (only available for Rev D silicon).
SUPC – Supply Controller	• Updated VREF.SEL bit selection table. • Removed references to BODCORE register and bit descriptions and updated description in VDDCORE Brown-Out Detector (BODCORE).
PM – Power Manager	• Sleep modes: Removed references to IDLE0 and IDLE1. Renamed IDLE2 to IDLE.
DMAC – Direct Memory Access Controller	CTRL.CRCENABLE bit added in bit position 2.
NVMCTRL – Non-Volatile Memory Controller	CTRLB.CACHEDIS: Updated from one bit in postion 18 to two bits in position 19:18. Updated bit description and bit value settings.