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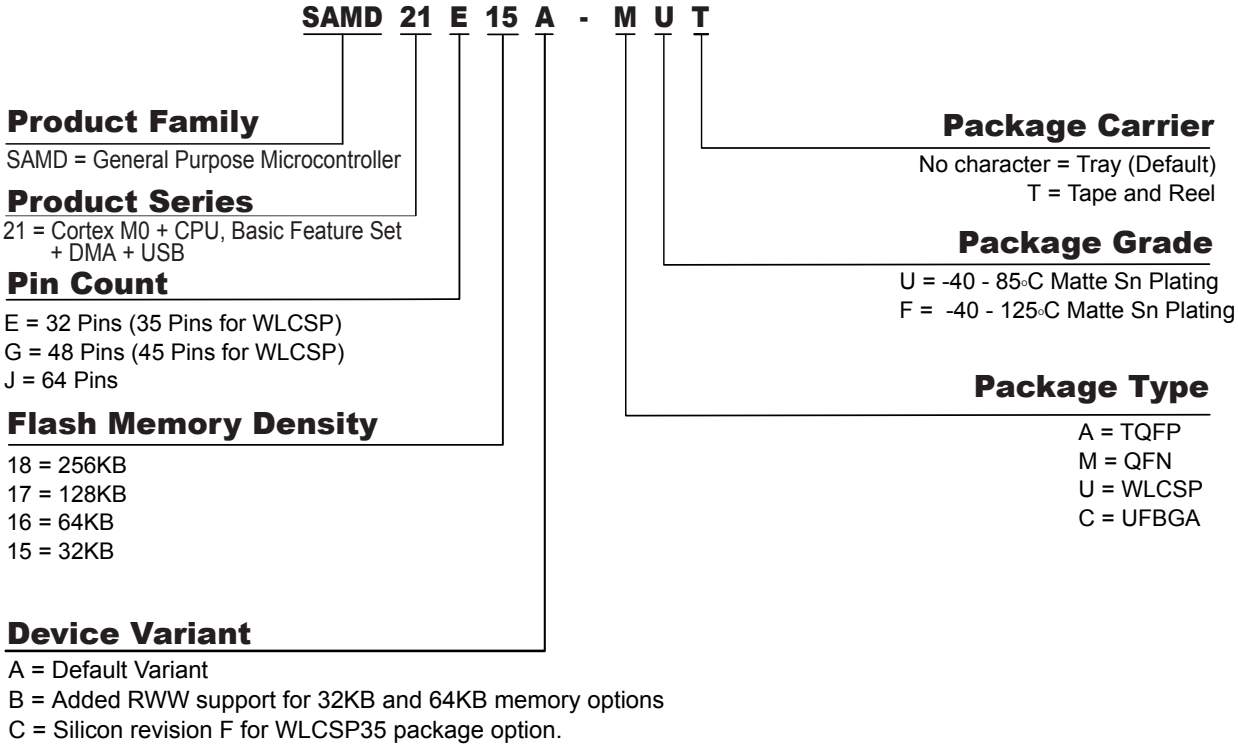
"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" 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, USB
Peripherals	Brown-out Detect/Reset, DMA, I²S, POR, PWM, WDT
Number of I/O	52
Program Memory Size	64KB (64K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	8K x 8
Voltage - Supply (Vcc/Vdd)	1.62V ~ 3.6V
Data Converters	A/D 20x12b; 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/atsamd21j16b-aut

3. Ordering Information



3.1 SAM D21E

Table 3-1. Device Variant A

Ordering Code	FLASH (bytes)	SRAM (bytes)	Package	Carrier Type
ATSAMD21E15A-AU	32K	4K	TQFP32	Tray
ATSAMD21E15A-AUT				Tape & Reel
ATSAMD21E15A-AF				Tray
ATSAMD21E15A-AFT				Tape & Reel
ATSAMD21E15A-MU			QFN32	Tray
ATSAMD21E15A-MUT				Tape & Reel
ATSAMD21E15A-MF				Tray
ATSAMD21E15A-MFT				Tape & Reel

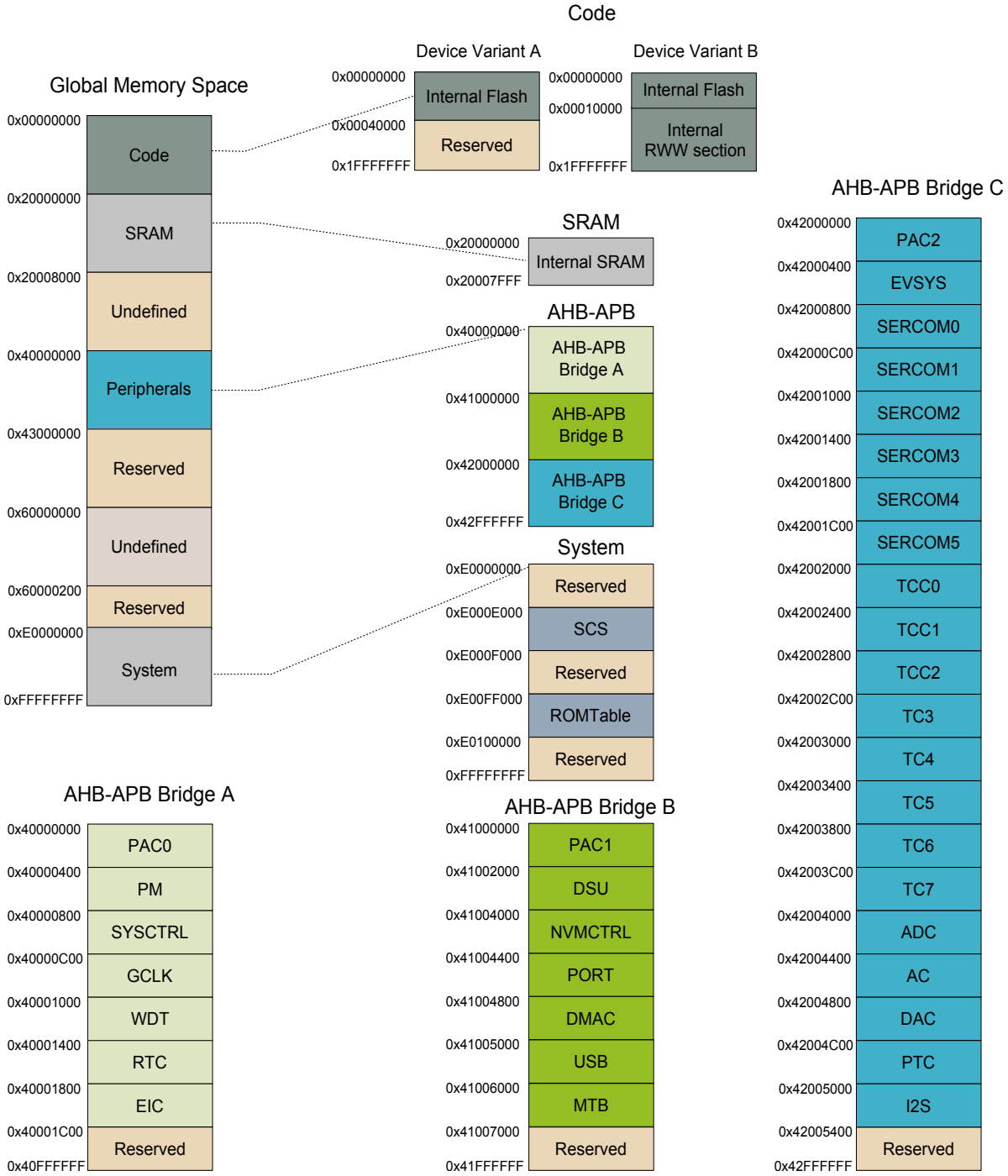
3.3 SAM D21J

Table 3-6. Device Variant A

Ordering Code	FLASH (bytes)	SRAM (bytes)	Package	Carrier Type
ATSAMD21J15A-AU	32K	4K	TQFP64	Tray
ATSAMD21J15A-AUT				Tape & Reel
ATSAMD21J15A-AF				Tray
ATSAMD21J15A-AFT				Tape & Reel
ATSAMD21J15A-MU			QFN64	Tray
ATSAMD21J15A-MUT				Tape & Reel
ATSAMD21J15A-MF				Tray
ATSAMD21J15A-MFT				Tape & Reel
ATSAMD21J16A-AU	64K	8K	TQFP64	Tray
ATSAMD21J16A-AUT				Tape & Reel
ATSAMD21J16A-AF				Tray
ATSAMD21J16A-AFT				Tape & Reel
ATSAMD21J16A-MU			QFN64	Tray
ATSAMD21J16A-MUT				Tape & Reel
ATSAMD21J16A-MF				Tray
ATSAMD21J16A-MFT				Tape & Reel
ATSAMD21J16A-CU			UFBGA64	Tray
ATSAMD21J16A-CUT				Tape & Reel
ATSAMD21J17A-AU	128K	16K	TQFP64	Tray
ATSAMD21J17A-AUT				Tape & Reel
ATSAMD21J17A-AF				Tray
ATSAMD21J17A-AFT				Tape & Reel
ATSAMD21J17A-MU			QFN64	Tray
ATSAMD21J17A-MUT				Tape & Reel
ATSAMD21J17A-MF				Tray
ATSAMD21J17A-MFT				Tape & Reel
ATSAMD21J17A-CU			UFBGA64	Tray
ATSAMD21J17A-CUT				Tape & Reel

9. Product Mapping

Figure 9-1. SAM D21 Product Mapping



This figure represents the full configuration of the SAM D21 with maximum flash and SRAM capabilities and a full set of peripherals. Refer to the Configuration Summary for details.

13.13 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.

13.13.1 Control

Name: CTRL
Offset: 0x0000
Reset: 0x00
Property: PAC Write-Protection

Bit	7	6	5	4	3	2	1	0
				CE	MBIST	CRC		SWRST
Access				W	W	W		W
Reset				0	0	0		0

Bit 4 – CE: Chip-Erase
Writing a '0' to this bit has no effect.

Writing a '1' to this bit starts the Chip-Erase operation.

Bit 3 – MBIST: Memory Built-In Self-Test
Writing a '0' to this bit has no effect.

Writing a '1' to this bit starts the memory BIST algorithm.

Bit 2 – CRC: 32-bit Cyclic Redundancy Check
Writing a '0' to this bit has no effect.

Writing a '1' to this bit starts the cyclic redundancy check algorithm.

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

Writing a '1' to this bit resets the module.

13.13.2 Status A

Name: STATUSA
Offset: 0x0001
Reset: 0x00
Property: PAC Write-Protection

Note: Optional write-protection is indicated by the "PAC Write-Protection" property in the register description.

When the CPU is halted in debug mode, all write-protection is automatically disabled. Write-protection does not apply for accesses through an external debugger.

17.5.7 Analog Connections

When used, the 32.768kHz crystal must be connected between the XIN32 and XOUT32 pins, and the 0.4-32MHz crystal must be connected between the XIN and XOUT pins, along with any required load capacitors. For details on recommended oscillator characteristics and capacitor load, refer to the *Electrical Characteristics* for details.

Related Links

Electrical Characteristics

17.6 Functional Description

17.6.1 Principle of Operation

XOSC, XOSC32K, OSC32K, OSCULP32K, OSC8M, DFLL48M, FDPLL96M, BOD33, BOD12, and VREF are configured via SYSCTRL control registers. Through this interface, the sub-peripherals are enabled, disabled or have their calibration values updated.

The Power and Clocks Status register gathers different status signals coming from the sub-peripherals controlled by the SYSCTRL. The status signals can be used to generate system interrupts, and in some cases wake up the system from standby mode, provided the corresponding interrupt is enabled.

The oscillator must be enabled to run. The oscillator is enabled by writing a one to the ENABLE bit in the respective oscillator control register, and disabled by writing a zero to the oscillator control register. In idle mode, the default operation of the oscillator is to run only when requested by a peripheral. In standby mode, the default operation of the oscillator is to stop. This behavior can be changed by the user, see below for details.

The behavior of the oscillators in the different sleep modes is shown in the table below.

Table 17-1. Behavior of the Oscillators

Oscillator	Idle 0, 1, 2	Standby
XOSC	Run on request	Stop
XOSC32K	Run on request	Stop
OSC32K	Run on request	Stop
OSCULP32K	Run	Run
OSC8M	Run on request	Stop
DFLL48M	Run on request	Stop
FDPLL96M	Run on request	Stop

To force an oscillator to always run in idle mode, and not only when requested by a peripheral, the oscillator ONDEMAND bit must be written to zero. The default value of this bit is one, and thus the default operation in idle mode is to run only when requested by a peripheral.

Value	Description
0	The DFLL Lock Fine interrupt is disabled.
1	The DFLL Lock Fine interrupt is enabled, and an interrupt request will be generated when the DFLL Lock Fine Interrupt flag is set.

Bit 5 – DFLLOOB: DFLL Out Of Bounds Interrupt Enable
Writing a zero to this bit has no effect.

Writing a one to this bit will set the DFLL Out Of Bounds Interrupt Enable bit, which enables the DFLL Out Of Bounds interrupt.

Value	Description
0	The DFLL Out Of Bounds interrupt is disabled.
1	The DFLL Out Of Bounds interrupt is enabled, and an interrupt request will be generated when the DFLL Out Of Bounds Interrupt flag is set.

Bit 4 – DFLLRDY: DFLL Ready Interrupt Enable
Writing a zero to this bit has no effect.

Writing a one to this bit will set the DFLL Ready Interrupt Enable bit, which enables the DFLL Ready interrupt and set the corresponding interrupt request.

Value	Description
0	The DFLL Ready interrupt is disabled.
1	The DFLL Ready interrupt is enabled, and an interrupt request will be generated when the DFLL Ready Interrupt flag is set.

Bit 3 – OSC8MRDY: OSC8M Ready Interrupt Enable
Writing a zero to this bit has no effect.

Writing a one to this bit will set the OSC8M Ready Interrupt Enable bit, which enables the OSC8M Ready interrupt.

Value	Description
0	The OSC8M Ready interrupt is disabled.
1	The OSC8M Ready interrupt is enabled, and an interrupt request will be generated when the OSC8M Ready Interrupt flag is set.

Bit 2 – OSC32KRDY: OSC32K Ready Interrupt Enable
Writing a zero to this bit has no effect.

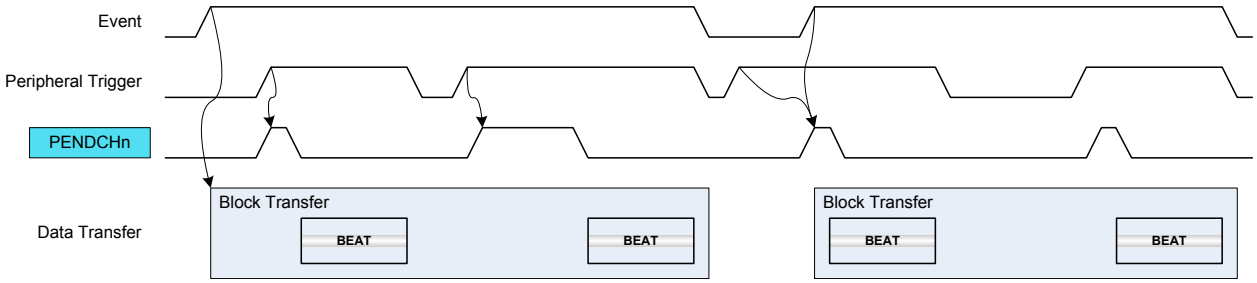
Writing a one to this bit will set the OSC32K Ready Interrupt Enable bit, which enables the OSC32K Ready interrupt.

Value	Description
0	The OSC32K Ready interrupt is disabled.
1	The OSC32K Ready interrupt is enabled, and an interrupt request will be generated when the OSC32K Ready Interrupt flag is set.

Bit 1 – XOSC32KRDY: XOSC32K Ready Interrupt Enable
Writing a zero to this bit has no effect.

Writing a one to this bit will set the XOSC32K Ready Interrupt Enable bit, which enables the XOSC32K Ready interrupt.

Figure 20-14. Conditional Block Transfer with Beat Peripheral Triggers



Channel Suspend

The event input is used to suspend an ongoing channel operation. The event is acknowledged when the current AHB access is completed. For further details on Channel Suspend, refer to Channel Suspend.

Channel Resume

The event input is used to resume a suspended channel operation. The event is acknowledged as soon as the event is received and the Channel Suspend Interrupt Flag (CHINTFLAG.SUSP) is cleared. For further details refer to Channel Suspend.

Skip Next Block Suspend

This event can be used to skip the next block suspend action. If the channel is suspended before the event rises, the channel operation is resumed and the event is acknowledged. If the event rises before a suspend block action is detected, the event is kept until the next block suspend detection. When the block transfer is completed, the channel continues the operation (not suspended) and the event is acknowledged.

Related Links

USER

20.6.3.5 Event Output Selection

Event output selection is available only for the least significant DMA channels. The pulse width of an event output from a channel is one AHB clock cycle.

The output of channel events is enabled by writing a '1' to the Channel Event Output Enable bit in the Control B register (CHCTRLB.EVOE). The event output cause is selected by writing to the Event Output Selection bits in the Block Transfer Control register (BTCTRL.EVOSEL). It is possible to generate events after each block transfer (BTCTRL.EVOSEL=0x1) or beat transfer (BTCTRL.EVOSEL=0x3). To enable an event being generated when a transaction is complete, the block event selection must be set in the last transfer descriptor only.

The figure Figure 20-15 shows an example where the event output generation is enabled in the first block transfer, and disabled in the second block.

Offset	Name	Bit Pos.								
0x10	INTFLAG	7:0	EXTINT7	EXTINT6	EXTINT5	EXTINT4	EXTINT3	EXTINT2	EXTINT1	EXTINT0
0x11		15:8	EXTINT15	EXTINT14	EXTINT13	EXTINT12	EXTINT11	EXTINT10	EXTINT9	EXTINT8
0x12		23:16							EXTINT17	EXTINT16
0x13		31:24								
0x14	WAKEUP	7:0	WAKEUPEN7	WAKEUPEN6	WAKEUPEN5	WAKEUPEN4	WAKEUPEN3	WAKEUPEN2	WAKEUPEN1	WAKEUPEN0
0x15		15:8	WAKEUPEN15	WAKEUPEN14	WAKEUPEN13	WAKEUPEN12	WAKEUPEN11	WAKEUPEN10	WAKEUPEN9	WAKEUPEN8
0x16		23:16							WAKEUPEN17	WAKEUPEN16
0x17		31:24								
0x18	CONFIG0	7:0	FILTEN1	SENSE1[2:0]			FILTEN0	SENSE0[2:0]		
0x19		15:8	FILTEN3	SENSE3[2:0]			FILTEN2	SENSE2[2:0]		
0x1A		23:16	FILTEN5	SENSE5[2:0]			FILTEN4	SENSE4[2:0]		
0x1B		31:24	FILTEN7	SENSE7[2:0]			FILTEN6	SENSE6[2:0]		
0x1C	CONFIG1	7:0	FILTEN9	SENSE9[2:0]			FILTEN8	SENSE8[2:0]		
0x1D		15:8	FILTEN11	SENSE11[2:0]			FILTEN10	SENSE10[2:0]		
0x1E		23:16	FILTEN13	SENSE13[2:0]			FILTEN12	SENSE12[2:0]		
0x1F		31:24	FILTEN15	SENSE15[2:0]			FILTEN14	SENSE14[2:0]		
0x20	CONFIG2	7:0	FILTEN25	SENSE25[2:0]			FILTEN24	SENSE24[2:0]		
0x21		15:8	FILTEN27	SENSE27[2:0]			FILTEN26	SENSE26[2:0]		
0x22		23:16	FILTEN29	SENSE29[2:0]			FILTEN28	SENSE28[2:0]		
0x23		31:24	FILTEN31	SENSE31[2:0]			FILTEN30	SENSE30[2:0]		

21.8 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 require synchronization when read and/or written. Synchronization is denoted by the "Read-Synchronized" and/or "Write-Synchronized" property in each individual register description.

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

21.8.1 Control

Name: CTRL
Offset: 0x00
Reset: 0x00
Property: Write-Protected, Write-Synchronized

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

This bit will always read as zero.

Bit 16 – PMUXEN: Peripheral Multiplexer Enable
This bit determines the new value written to PINCFGy.PMUXEN for all pins selected by the WRCONFIG.PINMASK and WRCONFIG.HWSEL bits, when the WRCONFIG.WRPINCFG bit is set.

This bit will always read as zero.

Bits 15:0 – PINMASK[15:0]: Pin Mask for Multiple Pin Configuration
These bits select the pins to be configured within the half-word group selected by the WRCONFIG.HWSEL bit.

These bits will always read as zero.

Value	Description
0	The configuration of the corresponding I/O pin in the half-word group will be left unchanged.
1	The configuration of the corresponding I/O pin in the half-word PORT group will be updated.

23.8.12 Peripheral Multiplexing n

There are up to 16 Peripheral Multiplexing registers in each group, one for every set of two subsequent I/O lines. The n denotes the number of the set of I/O lines.

Name: PMUXn
Offset: 0x30 + n*0x01 [n=0..15]
Reset: 0x00
Property: PAC Write-Protection

Bit	7	6	5	4	3	2	1	0
	PMUXO[3:0]				PMUXE[3:0]			
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 7:4 – PMUXO[3:0]: Peripheral Multiplexing for Odd-Numbered Pin
These bits select the peripheral function for odd-numbered pins (2*n + 1) of a PORT group, if the corresponding PINCFGy.PMUXEN bit is '1'.

Not all possible values for this selection may be valid. For more details, refer to the *I/O Multiplexing and Considerations*.

PMUXO[3:0]	Name	Description
0x0	A	Peripheral function A selected
0x1	B	Peripheral function B selected
0x2	C	Peripheral function C selected
0x3	D	Peripheral function D selected
0x4	E	Peripheral function E selected
0x5	F	Peripheral function F selected
0x6	G	Peripheral function G selected
0x7	H	Peripheral function H selected

Figure 25-3. Baud Rate Generator

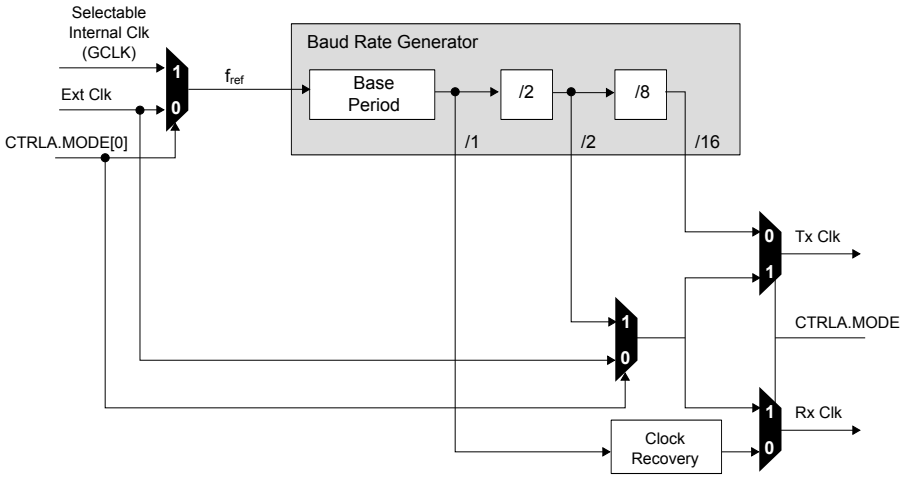


Table 25-2 contains equations for the baud rate (in bits per second) and the BAUD register value for each operating mode.

For asynchronous operation, there are two different modes: In *arithmetic mode*, the BAUD register value is 16 bits (0 to 65,535). In *fractional mode*, the BAUD register is 13 bits, while the fractional adjustment is 3 bits. In this mode the BAUD setting must be greater than or equal to 1.

For synchronous operation, the BAUD register value is 8 bits (0 to 255).

Table 25-2. Baud Rate Equations

Operating Mode	Condition	Baud Rate (Bits Per Second)	BAUD Register Value Calculation
Asynchronous Arithmetic	$f_{BAUD} \leq \frac{f_{ref}}{S}$	$f_{BAUD} = \frac{f_{ref}}{S}\left(1 - \frac{BAUD}{65536}\right)$	$BAUD = 65536 \cdot \left(1 - S \cdot \frac{f_{BAUD}}{f_{ref}}\right)$
Asynchronous Fractional	$f_{BAUD} \leq \frac{f_{ref}}{S}$	$f_{BAUD} = \frac{f_{ref}}{S \cdot \left(BAUD + \frac{FP}{8}\right)}$	$BAUD = \frac{f_{ref}}{S \cdot f_{BAUD}} - \frac{FP}{8}$
Synchronous	$f_{BAUD} \leq \frac{f_{ref}}{2}$	$f_{BAUD} = \frac{f_{ref}}{2 \cdot (BAUD + 1)}$	$BAUD = \frac{f_{ref}}{2 \cdot f_{BAUD}} - 1$

S - Number of samples per bit. Can be 16, 8, or 3.

The Asynchronous Fractional option is used for auto-baud detection.

The baud rate error is represented by the following formula:

$$\text{Error} = 1 - \left(\frac{\text{ExpectedBaudRate}}{\text{ActualBaudRate}}\right)$$

Asynchronous Arithmetic Mode BAUD Value Selection

The formula given for f_{BAUD} calculates the average frequency over 65536 f_{ref} cycles. Although the BAUD register can be set to any value between 0 and 65536, the actual average frequency of f_{BAUD} over a single frame is more granular. The BAUD register values that will affect the average frequency over a single frame lead to an integer increase in the cycles per frame (CPF)

$$CPF = \frac{f_{ref}}{f_{BAUD}}(D + S)$$

where

Transaction Diagram Symbols

Bus Driver

	Master driving bus
	Slave driving bus
	Either Master or Slave driving bus

Special Bus Conditions

S	START condition
Sr	repeated START condition
P	STOP condition

Data Package Direction

R '1'	Master Read
$\overline{W}$ '0'	Master Write

Acknowledge

A '0'	Acknowledge (ACK)
$\overline{A}$ '1'	Not Acknowledge (NACK)

28.6.2 Basic Operation

28.6.2.1 Initialization

The following registers are enable-protected, meaning they can be written only when the I^2C interface is disabled (CTRLA.ENABLE is ‘0’):

- Control A register (CTRLA), except Enable (CTRLA.ENABLE) and Software Reset (CTRLA.SWRST) bits
- Control B register (CTRLB), except Acknowledge Action (CTRLB.ACKACT) and Command (CTRLB.CMD) bits
- Baud register (BAUD)
- Address register (ADDR) in slave operation.

When the I^2C is enabled or is being enabled (CTRLA.ENABLE=1), writing to these registers will be discarded. If the I^2C is being disabled, writing to these registers will be completed after the disabling.

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

Before the I^2C is enabled it must be configured as outlined by the following steps:

1. Select I^2C Master or Slave mode by writing 0x4 or 0x5 to the Operating Mode bits in the CTRLA register (CTRLA.MODE).
2. If desired, select the SDA Hold Time value in the CTRLA register (CTRLA.SDAHOLD).
3. If desired, enable smart operation by setting the Smart Mode Enable bit in the CTRLB register (CTRLB.SMEN).
4. If desired, enable SCL low time-out by setting the SCL Low Time-Out bit in the Control A register (CTRLA.LOWTOUT).
5. In Master mode:
    5.1. Select the inactive bus time-out in the Inactive Time-Out bit group in the CTRLA register (CTRLA.INACTOUT).
    5.2. Write the Baud Rate register (BAUD) to generate the desired baud rate.

    In Slave mode:

Bit	15	14	13	12	11	10	9	8
	DATA[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
	DATA[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

Bits 31:0 – DATA[31:0]: Sample Data

This register is used to transfer data from the Rx Serializer.

Data samples received by Rx Serializer will be available for reading from RXDATA register, through the Receive Formatting Unit, according to formatting information for Rx Serializer in the RXCTRL register.

Offset: 0x28
Reset: 0x00000000
Property: PAC Write-Protection

Bit	31	30	29	28	27	26	25	24
Access								
Reset								

Bit	23	22	21	20	19	18	17	16
					MC3	MC2	MC1	MC0
Access					R/W	R/W	R/W	R/W
Reset					0	0	0	0

Bit	15	14	13	12	11	10	9	8
	FAULT1	FAULT0	FAULTB	FAULTA	DFS			
Access	R/W	R/W	R/W	R/W	R/W			
Reset	0	0	0	0	0			

Bit	7	6	5	4	3	2	1	0
					ERR	CNT	TRG	OVF
Access					R/W	R/W	R/W	R/W
Reset					0	0	0	0

Bits 19,18,17,16 – MCx: Match or Capture Channel x Interrupt Enable
Writing a '0' to this bit has no effect.

Writing a '1' to this bit will set the corresponding Match or Capture Channel x Interrupt Disable/Enable bit, which enables the Match or Capture Channel x interrupt.

Value	Description
0	The Match or Capture Channel x interrupt is disabled.
1	The Match or Capture Channel x interrupt is enabled.

Bits 15,14 – FAULTx: Non-Recoverable Fault x Interrupt Enable
Writing a '0' to this bit has no effect.

Writing a '1' to this bit will set the Non-Recoverable Fault x Interrupt Disable/Enable bit, which enables the Non-Recoverable Fault x interrupt.

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 set the Recoverable Fault B Interrupt Disable/Enable bit, which enables the Recoverable Fault B interrupt.

Value	Description
0	Comparison will not start on any incoming event.
1	Comparison will start on any incoming event.

Bit 4 – WINEO0: Window 0 Event Output Enable
These bits indicate whether the window 0 function can generate a peripheral event or not.

Value	Description
0	Window 0 Event is disabled.
1	Window 0 Event is enabled.

Bits 1,0 – COMPEOx: Comparator x Event Output Enable
These bits indicate whether the comparator x output can generate a peripheral event or not.

Value	Description
0	COMPx event generation is disabled.
1	COMPx event generation is enabled.

34.8.4 Interrupt Enable Clear

This register allows the user to disable an interrupt without doing a read-modify-write operation. Changes in this register will also be reflected in the Interrupt Enable Set register (INTENSET).

Name: INTENCLR
Offset: 0x04
Reset: 0x00
Property: PAC Write-Protection

Bit	7	6	5	4	3	2	1	0
				WIN0			COMP1	COMP0
Access				R/W			R/W	R/W
Reset				0			0	0

Bit 4 – WIN0: Window 0 Interrupt Enable
Reading this bit returns the state of the Window 0 interrupt enable.

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

Writing a '1' to this bit disables the Window 0 interrupt.

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

Bits 1,0 – COMPx: Comparator x Interrupt Enable
Reading this bit returns the state of the Comparator x interrupt enable.

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

Writing a '1' to this bit disables the Comparator x interrupt.

Value	Description
0	The Comparator x interrupt is disabled.
1	The Comparator x interrupt is enabled.

Bit 7 – SYNCBUSY: Synchronization Busy
This bit is cleared when the synchronization of registers between the clock domains is complete.

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

Bits 1,0 – READYx: Comparator x Ready
This bit is cleared when the comparator x output is not ready.
This bit is set when the comparator x output is ready.

34.8.9 Status A

Name: STATUSC
Offset: 0x0A
Reset: 0x00
Property: –

Bit	7	6	5	4	3	2	1	0
			WSTATE0[1:0]				STATE1	STATE0
Access			R	R			R	R
Reset			0	0			0	0

Bits 5:4 – WSTATE0[1:0]: Window 0 Current State
These bits show the current state of the signal if the window 0 mode is enabled.

Value	Name	Description
0x0	ABOVE	Signal is above window
0x1	INSIDE	Signal is inside window
0x2	BELOW	Signal is below window
0x3		Reserved

Bits 1,0 – STATEx: Comparator x Current State
This bit shows the current state of the output signal from COMPx. STATEx is valid only when STATUSB.READYx is one.

34.8.10 Window Control

Name: WINCTRL
Offset: 0x0C
Reset: 0x00
Property: PAC Write-Protection, Write-Synchronized

Bit	7	6	5	4	3	2	1	0
						WINTSEL0[1:0]		WEN0
Access						R/W	R/W	R/W
Reset						0	0	0

Bits 2:1 – WINTSEL0[1:0]: Window 0 Interrupt Selection
These bits configure the interrupt mode for the comparator window 0 mode.

36. PTC - Peripheral Touch Controller

36.1 Overview

The Peripheral Touch Controller (PTC) acquires signals in order to detect touch on capacitive sensors. The external capacitive touch sensor is typically formed on a PCB, and the sensor electrodes are connected to the analog front end of the PTC through the I/O pins in the device. The PTC supports both self- and mutual-capacitance sensors.

In mutual-capacitance mode, sensing is done using capacitive touch matrices in various X-Y configurations, including indium tin oxide (ITO) sensor grids. The PTC requires one pin per X-line and one pin per Y-line.

In self-capacitance mode, the PTC requires only one pin (Y-line) for each touch sensor.

The number of available pins and the assignment of X- and Y-lines is depending on both package type and device configuration. Refer to the Configuration Summary and I/O Multiplexing table for details.

Related Links

I/O Multiplexing and Considerations

Configuration Summary

36.2 Features

- Low-power, high-sensitivity, environmentally robust capacitive touch buttons, sliders, wheels
- Supports wake-up on touch from Standby sleep mode
- Supports mutual capacitance and self-capacitance sensing
  - 6/10/16 buttons in self-capacitance mode, for 32-/48-/64- pins respectively
  - 60/120/256 buttons in mutual-capacitance mode, for 32-/48-/64- pins respectively
  - Mix-and-match mutual-and self-capacitance sensors
- One pin per electrode – no external components
- Load compensating charge sensing
  - Parasitic capacitance compensation and adjustable gain for superior sensitivity
- Zero drift over the temperature and V_{DD} range
  - Auto calibration and re-calibration of sensors
- Single-shot and free-running charge measurement
- Hardware noise filtering and noise signal de-synchronization for high conducted immunity
- Selectable channel change delay allows choosing the settling time on a new channel, as required
- Acquisition-start triggered by command or through auto-triggering feature
- Low CPU utilization through interrupt on acquisition-complete
- Supported by the Atmel® QTouch® Composer development tools. See also Atmel|Start and Atmel Studio documentation.

Related Links

I/O Multiplexing and Considerations

Configuration Summary

Name	Description	Mode	VDD=1.8V			VDD=3.3V			Units
			Min.	Typ.	Max	Min.	Typ.	Max.	
d_{M_MCKI}	I2S MCK duty cycle	Master mode, pin is input (1b)		50			50		%
t_{M_SCKOR}	I2S SCK rise time(3)	Master mode / Capacitive load CL = 15 pF			9			4.6	ns
t_{M_SCKOF}	I2S SCK fall time(3)	Master mode / Capacitive load CL = 15 pF			9.7			4.5	ns
d_{M_SCKO}	I2S SCK duty cycle	Master mode	45.6		50	45.6		50	%
f_{M_SCKO},1/ t_{M_SCKO}	I2S SCK frequency	Master mode,Supposing external device response delay is 30ns			8			9.5	MHz
f_{S_SCKI},1/ t_{S_SCKI}	I2S SCK frequency	Slave mode,Supposing external device response delay is 30ns			14.4			14.8	MHz
d_{S_SCKO}	I2S SCK duty cycle	Slave mode		50			50		%
t_{M_FSOV}	FS valid time	Master mode			4.1			4	ns
t_{M_FSOH}	FS hold time	Master mode	-0.9			-0.9			ns
t_{S_FSIS}	FS setup time	Slave mode	2.3			1.5			ns
t_{S_FSIH}	FS hold time	Slave mode	0			0			ns
t_{M_SDIS}	Data input setup time	Master mode	34.7			24.5			ns
t_{M_SDIH}	Data input hold time	Master mode	-8.2			-8.2			ns
t_{S_SDIS}	Data input setup time	Slave mode	4.6			3.9			ns
t_{S_SDIH}	Data input hold time	Slave mode	1.2			1.2			ns
t_{M_SDOV}	Data output valid time	Master transmitter			5.6			4.8	ns
t_{M_SDOH}	Data output hold time	Master transmitter	-0.5			-0.5			ns
t_{S_SDOV}	Data output valid time	Slave transmitter			36.2			25.9	ns
t_{S_SDOH}	Data output hold time	Slave transmitter	36			25.7			ns
t_{PDM2LS}	Data input setup time	Master mode PDM2 Left	34.7			24.5			ns
t_{PDM2LH}	Data input hold time	Master mode PDM2 Left	-8.2			-8.2			ns

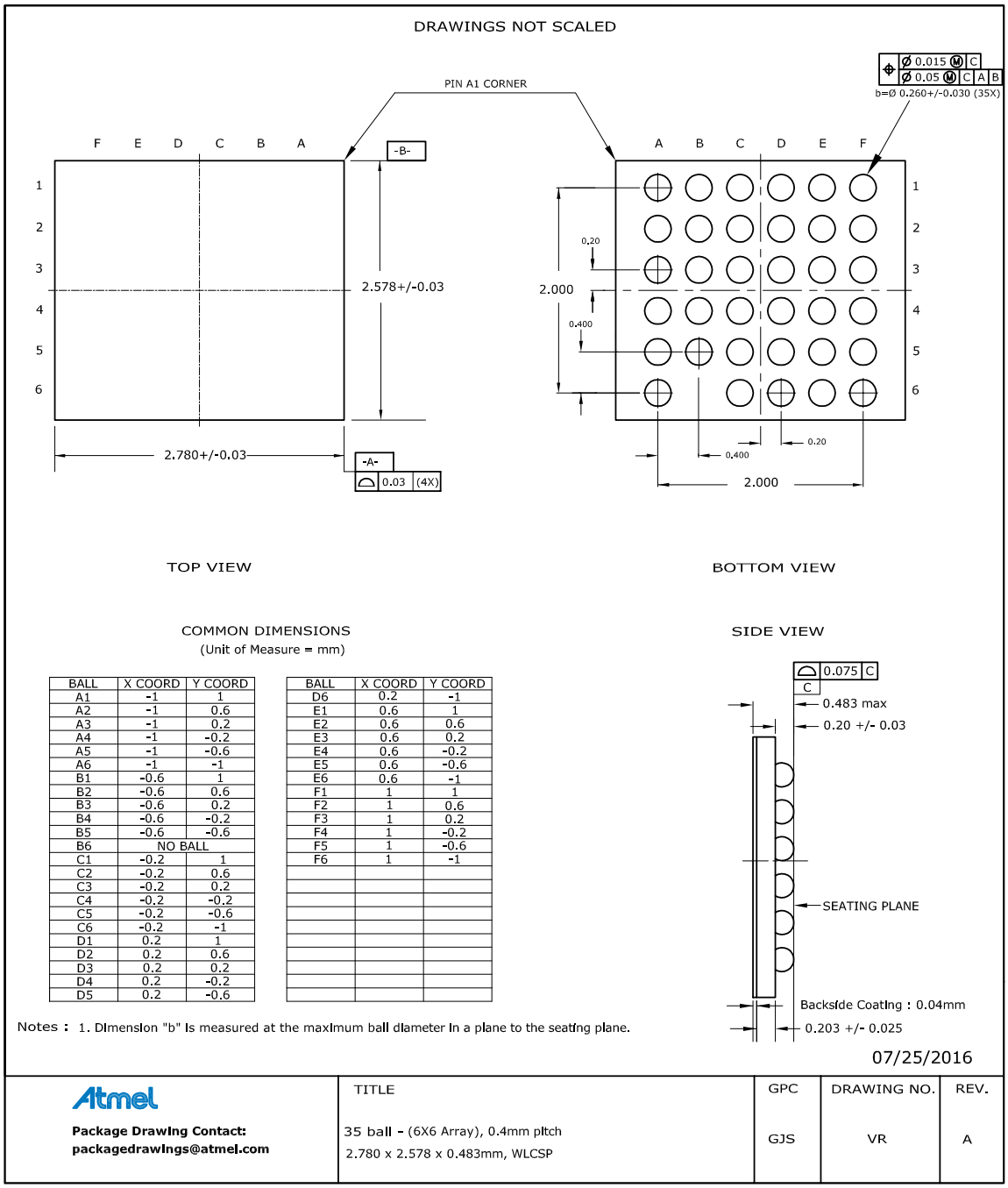
Table 38-27. Package Characteristics

Moisture Sensitivity Level	MSL1

Table 38-28. Package Reference

JEDEC Drawing Reference	MO-220
JESD97 Classification	E1

38.2.10 35 ball WLCSP (Device Variant C)



BALL	X COORD	Y COORD
A1	-1	1
A2	-1	0.6
A3	-1	0.2
A4	-1	-0.2
A5	-1	-0.6
A6	-1	-1
B1	-0.6	1
B2	-0.6	0.6
B3	-0.6	0.2
B4	-0.6	-0.2
B5	-0.6	-0.6
B6	NO BALL	
C1	-0.2	1
C2	-0.2	0.6
C3	-0.2	0.2
C4	-0.2	-0.2
C5	-0.2	-0.6
C6	-0.2	-1
D1	0.2	1
D2	0.2	0.6
D3	0.2	0.2
D4	0.2	-0.2
D5	0.2	-0.6

BALL	X COORD	Y COORD
D6	0.2	-1
E1	0.6	1
E2	0.6	0.6
E3	0.6	0.2
E4	0.6	-0.2
E5	0.6	-0.6
E6	0.6	-1
F1	1	1
F2	1	0.6
F3	1	0.2
F4	1	-0.2
F5	1	-0.6
F6	1	-1

Notes : 1. Dimension "b" is measured at the maximum ball diameter in a plane to the seating plane.

6 – In two ramp mode, two events will be generated per cycle, one on each ramp's end. EVCTRL.CNTSEL.END cannot be used to identify the end of a double ramp cycle.
Errata reference: 12224
Fix/Workaround:
None

7 – If an input event triggered STOP action is performed at the same time as the counter overflows, the first pulse width of the subsequent counter start can be altered with one prescaled clock cycle.
Errata reference: 12107
Fix/Workaround:
None

8 – When the RUNSTDBY bit is written after the TCC is enabled, the respective TCC APB bus is stalled and the RUNDSTBY bit in the TCC CTRLA register is not enabled-protected.
Errata reference: 12477
Fix/Workaround:
None.

9 – TCC fault filtering on inverted fault is not working.
Errata reference: 12512
Fix/Workaround:
Use only non-inverted faults.

10 – When waking up from the STANDBY power save mode, the SYNCBUSY.CTRLB, SYNCBUSY.STATUS, SYNCBUSY.COUNT, SYNCBUSY.PATT, SYNCBUSY.WAVE, SYNCBUSY.PER and SYNCBUSY.CCx bits may be locked to 1.
Errata reference: 12227
Fix/Workaround:
After waking up from STANDBY power save mode, perform a software reset of the TCC if you are using the SYNCBUSY.CTRLB, SYNCBUSY.STATUS, SYNCBUSY.COUNT, SYNCBUSY.PATT, SYNCBUSY.WAVE, SYNCBUSY.PER or SYNCBUSY.CCx bits

11 – When the Peripheral Access Controller (PAC) protection is enabled, writing to WAVE or WAVEB registers will not cause a hardware exception.
Errata reference: 11468
Fix/Workaround:
None

12 – If the MCx flag in the INTFLAG register is set when enabling the DMA, this will trigger an immediate DMA transfer and overwrite the current buffered value in the TCC register.
Errata reference: 12155
Fix/Workaround:
None

40.1.4.14 PTC

1 – WCOMP interrupt flag is not stable. The WCOMP interrupt flag will not always be set as described in the datasheet.
Errata reference: 12860

Table 44-47. Internal 8MHz RC Oscillator Characteristics (Device Variant B)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
f_{OUT}	Output frequency	Calibrated against a 8MHz reference at 25°C, over [-40, +85]°C, over [1.62, 3.63]V	7.54	8	8.19	MHz
		Calibrated against a 8MHz reference at 25°C, at V_{DD}=3.3V	7.94	8	8.06	
		Calibrated against a 8MHz reference at 25°C, over [1.62, 3.63]V	7.92	8	8.06	
I_{OSC8M}	Current consumption	IIDLEIDLE2 on OSC32K versus IDLE2 on calibrated OSC8M enabled at 8MHz (FRANGE=1, PRESC=0)		64	96	µA
$t_{STARTUP}$	Startup time		-	2.4	3.3	µs
Duty	Duty cycle		-	50	-	%

44.8.7 Fractional Digital Phase Locked Loop (FDPLL96M) Characteristics

Table 44-48. FDPLL96M Characteristics(1) (Device Variant A)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
f_{IN}	Input frequency		32	-	2000	KHz
f_{OUT}	Output frequency		48	-	96	MHz
$I_{FDPLL96M}$	Current consumption	f_{IN}= 32 kHz, f_{OUT}= 48 MHz	-	500	700	µA
		f_{IN}= 32 kHz, f_{OUT}= 96 MHz	-	900	1200	
J_p	Period jitter	f_{IN}= 32 kHz, f_{OUT}= 48 MHz	-	1.5	2.0	%
		f_{IN}= 32 kHz, f_{OUT}= 96 MHz	-	3.0	10.0	
		f_{IN}= 2 MHz, f_{OUT}= 48 MHz	-	1.3	2.0	
		f_{IN}= 2 MHz, f_{OUT}= 96 MHz	-	3.0	7.0	
t_{LOCK}	Lock Time	After start-up, time to get lock signal. f_{IN}= 32 kHz, f_{OUT}= 96 MHz	-	1.3	2	ms
		f_{IN}= 2 MHz, f_{OUT}= 96 MHz	-	25	50	µs
Duty	Duty cycle		40	50	60	%

Table 44-49. FDPLL96M Characteristics(1) (Device Variant B, Die Revision E)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
f_{IN}	Input frequency		32	-	2000	KHz
f_{OUT}	Output frequency		48	-	96	MHz
$I_{FDPLL96M}$	Current consumption	f_{IN}= 32 kHz, f_{OUT}= 48 MHz	-	500	740	µA
		f_{IN}= 32 kHz, f_{OUT}= 96 MHz	-	900	1262	