Features

- High-performance, Low-power 8/16-bit Atmel® AVR® XMEGA™ Microcontroller
- Non-volatile Program and Data Memories
  - 64K - 256K Bytes of In-System Self-Programmable Flash
  - 4K - 8K Bytes Boot Code Section with Independent Lock Bits
  - 2K - 4K Bytes EEPROM
  - 4K - 16K Bytes Internal SRAM
- Peripheral Features
  - Four-channel Event System
  - Five 16-bit Timer/Counters
    - Four Timer/Counters with 4 Output Compare or Input Capture channels
    - One Timer/Counters with 2 Output Compare or Input Capture channels
    - High Resolution Extensions on two Timer/Counters
    - Advanced Waveform Extension on one Timer/Counter
  - Three USARTs
    - IrDA Extension on 1 USART
  - Two Two-Wire Interfaces with dual address match(I^2C and SMBus compatible)
  - Two SPI (Serial Peripheral Interfaces)
  - 16-bit Real Time Counter with Separate Oscillator
  - One Sixteen-channel, 12-bit, 200ksps Analog to Digital Converter
  - Two Analog Comparators with Window compare function
  - External Interrupts on all General Purpose I/O pins
  - Programmable Watchdog Timer with Separate On-chip Ultra Low Power Oscillator
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal and External Clock Options with PLL
  - Programmable Multi-level Interrupt Controller
  - Sleep Modes: Idle, Power-down, Standby, Power-save, Extended Standby
  - Advanced Programming, Test and Debugging Interface
    - PDI (Program and Debug Interface) for programming, test and debugging
- I/O and Packages
  - 50 Programmable I/O Lines
  - 64-lead TQFP
  - 64-pad QFN
- Operating Voltage
  - 1.6 – 3.6V
- Speed performance
  - 0 – 12 MHz @ 1.6 – 3.6V
  - 0 – 32 MHz @ 2.7 – 3.6V

Typical Applications

- Industrial control
- Factory automation
- Building control
- Board control
- White Goods
- Climate control
- ZigBee
- Motor control
- Networking
- Optical
- Hand-held battery applications
- Power tools
- HVAC
- Metering
- Medical Applications

8/16-bit AVR® XMEGA D3 Microcontroller

ATxmega256D3
ATxmega192D3
ATxmega128D3
ATxmega64D3

8134I–AVR–12/10

1. Ordering Information

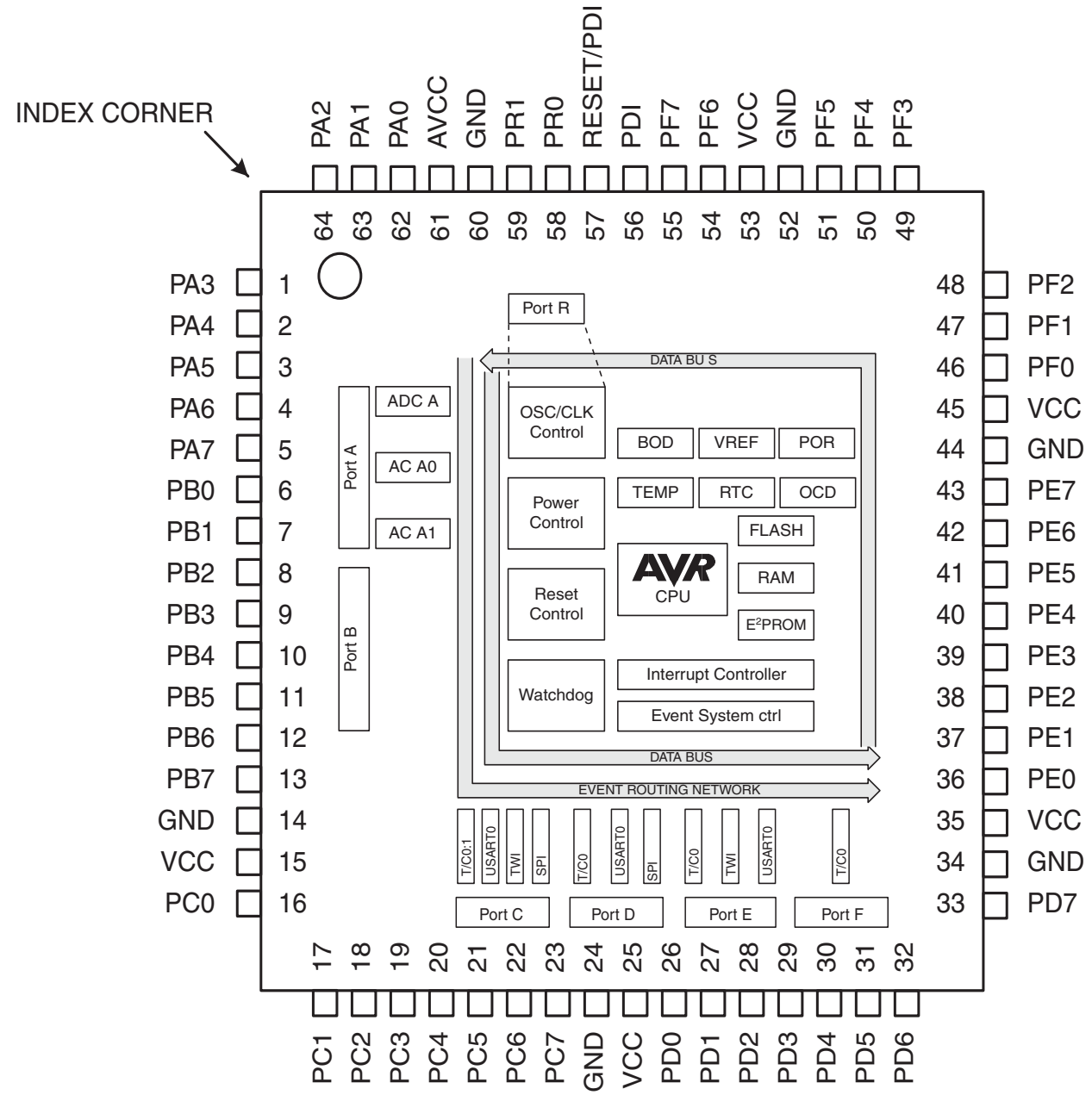
Ordering Code	Flash (B)	E^2 (B)	SRAM (B)	Speed (MHz)	Power Supply	Package[1][2][3]	Temp
ATxmega256D3-AU	256K + 8K	4K	16K	32	1.6 - 3.6V	64A	-40° - 85°C
ATxmega192D3-AU	192K + 8K	2K	16K	32	1.6 - 3.6V		
ATxmega128D3-AU	128K + 8K	2K	8K	32	1.6 - 3.6V		
ATxmega64D3-AU	64K + 4K	2K	4K	32	1.6 - 3.6V		
ATxmega256D3-MH	256K + 8K	4K	16K	32	1.6 - 3.6V	64M2	
ATxmega192D3-MH	192K + 8K	2K	16K	32	1.6 - 3.6V		
ATxmega128D3-MH	128K + 8K	2K	8K	32	1.6 - 3.6V		
ATxmega64D3-MH	64K + 4K	2K	4K	32	1.6 - 3.6V		

Notes:
1. This device can also be supplied in wafer form. Please contact your local Atmel sales office for detailed ordering information.
2. Pb-free packaging, complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.
3. For packaging information, see "Packaging information" on page 86.

Package Type	
64A	64-lead, 14 x 14 mm Body Size, 1.0 mm Body Thickness, 0.8 mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP)
64M2	64-pad, 9 x 9 x 1.0 mm Body, Lead Pitch 0.50 mm, 7.65 mm Exposed Pad, Quad Flat No-Lead Package (QFN)

2. Pinout/ Block Diagram

Figure 2-1. Block diagram and pinout



Notes: 1. For full details on pinout and alternate pin functions refer to "Pinout and Pin Functions" on page 46.
2. The large center pad underneath the QFN/MLF package should be soldered to ground on the board to ensure good mechanical stability.

3. Overview

The Atmel® AVR® XMEGA D3 is a family of low power, high performance and peripheral rich CMOS 8/16-bit microcontrollers based on the AVR® enhanced RISC architecture. By execug powerful instructions in a single clock cycle, the XMEGA D3 achieves throughputs approaching 1 Million Instructions Per Second (MIPS) per MHz allowing the system designer to optimize power consumption versus processing speed.

The AVR CPU combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction, executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs many times faster than conventional single-accumulator or CISC based microcontrollers.

The XMEGA D3 devices provide the following features: In-System Programmable Flash with Read-While-Write capabilities, Internal EEPROM and SRAM, four-channel Event System, Programmable Multi-level Interrupt Controller, 50 general purpose I/O lines, 16-bit Real Time Counter (RTC), five flexible 16-bit Timer/Counters with compare modes and PWM, three USARTs, two Two-Wire Interface (TWIs), two Serial Peripheral Interfaces (SPIs), one 16-channel 12-bit ADC with optional differential input with programmable gain, two analog comparators with window mode, programmable Watchdog Timer with separate Internal Oscillator, accurate internal oscillators with PLL and prescaler and programmable Brown-Out Detection.

The Program and Debug Interface (PDI), a fast 2-pin interface for programming and debugging, is available.

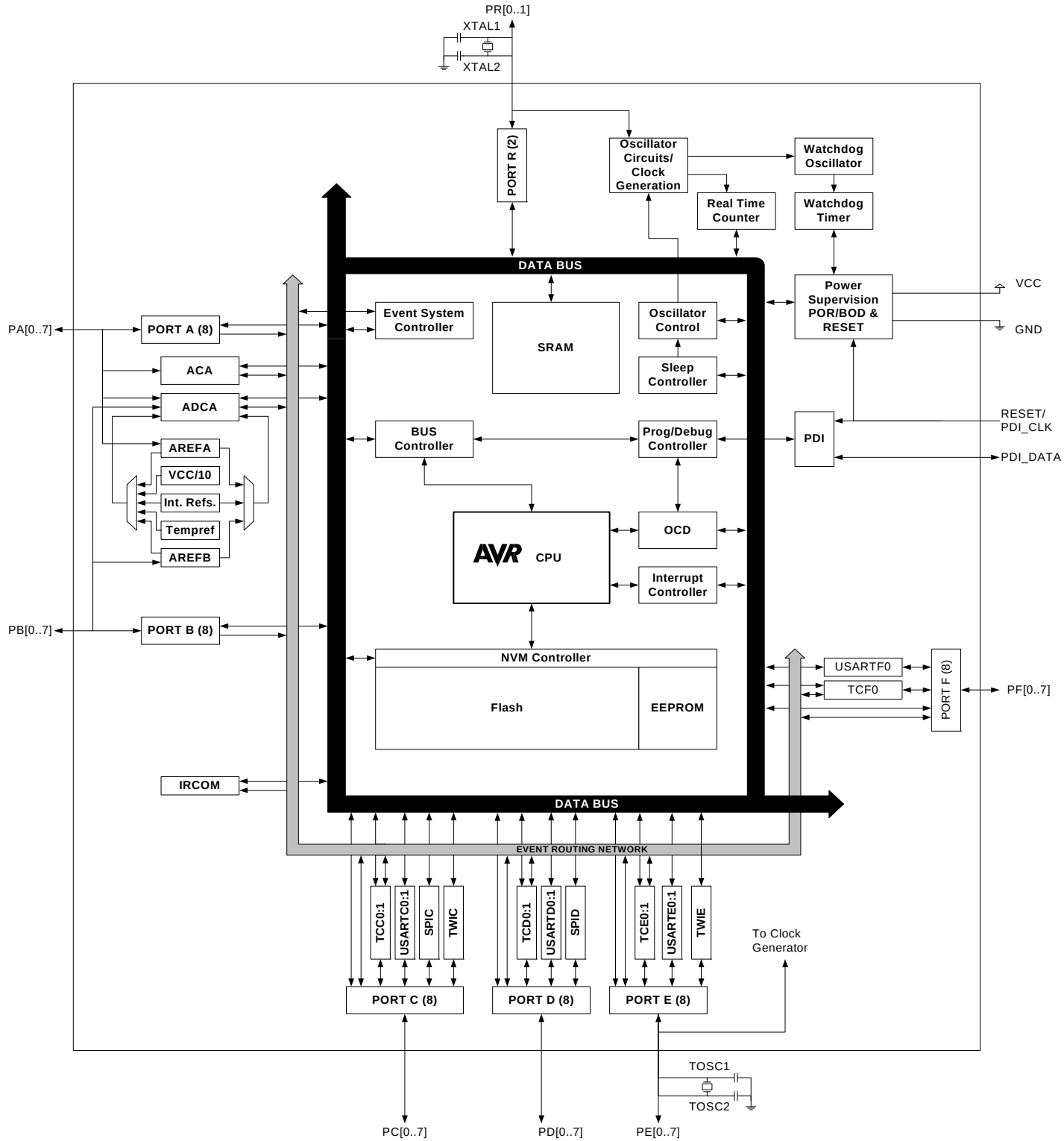
The XMEGA D3 devices have five software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Event System, Interrupt Controller and all peripherals to continue functioning. The Power-down mode saves the SRAM and register contents but stops the oscillators, disabling all other functions until the next TWI or pin-change interrupt, or Reset. In Power-save mode, the asynchronous Real Time Counter continues to run, allowing the application to maintain a timer base while the rest of the device is sleeping. In Standby mode, the Crystal/Resonator Oscillator is kept running while the rest of the device is sleeping. This allows very fast start-up from external crystal combined with low power consumption. In Extended Standby mode, both the main Oscillator and the Asynchronous Timer continue to run. To further reduce power consumption, the peripheral clock for each individual peripheral can optionally be stopped in Active mode and Idle sleep mode.

The device is manufactured using Atmel's high-density nonvolatile memory technology. The program Flash memory can be reprogrammed in-system through the PDI. A Bootloader running in the device can use any interface to download the application program to the Flash memory. The Bootloader software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8/16-bit RISC CPU with In-System Self-Programmable Flash, the Atmel XMEGA D3 is a powerful microcontroller family that provides a highly flexible and cost effective solution for many embedded applications.

The XMEGA D3 devices are supported with a full suite of program and system development tools including: C compilers, macro assemblers, program debugger/simulators, programmers, and evaluation kits.

3.1 Block Diagram

Figure 3-1. XMEGA D3 Block Diagram



4. Resources

A comprehensive set of development tools, application notes and datasheets are available for download on http://www.atmel.com/avr.

4.1 Recommended reading

- Atmel® AVR® XMEGA™ D Manual
- XMEGA Application Notes

This device data sheet only contains part specific information and a short description of each peripheral and module. The XMEGA D Manual describes the modules and peripherals in depth. The XMEGA application notes contain example code and show applied use of the modules and peripherals.

The XMEGA Manual and Application Notes are available from http://www.atmel.com/avr.

5. Disclaimer

For devices that are not available yet, typical values contained in this datasheet are based on simulations and characterization of other AVR XMEGA microcontrollers manufactured on the same process technology. Min. and Max values will be available after the device is characterized.

6. AVR CPU

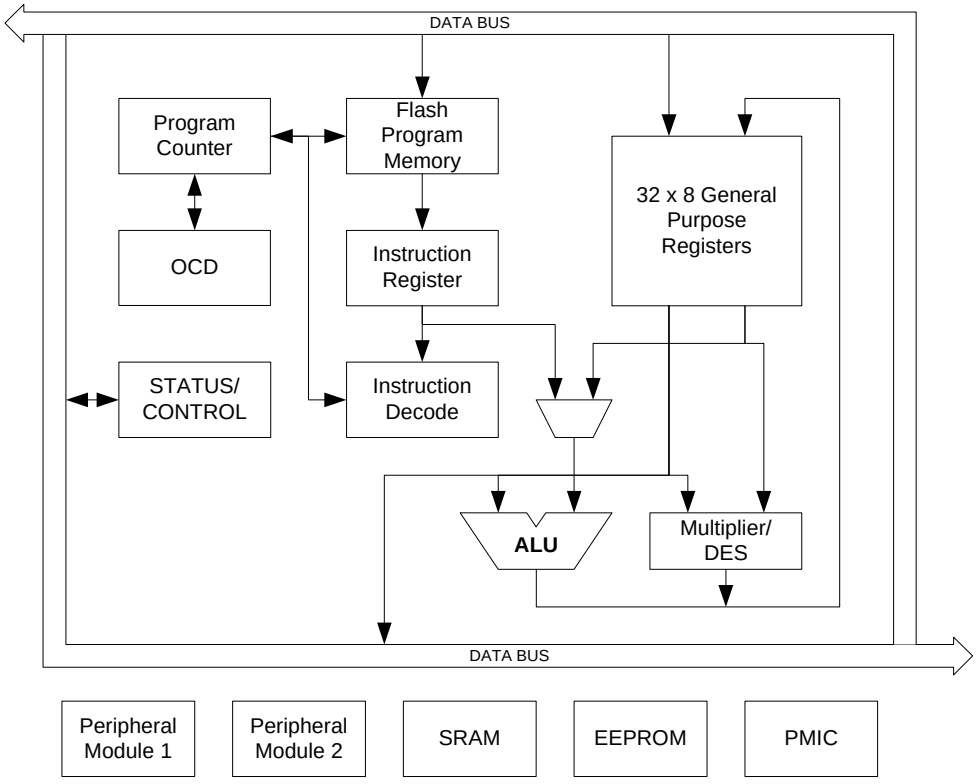
6.1 Features

- 8/16-bit high performance AVR RISC Architecture
  - 138 instructions
  - Hardware multiplier
- 32x8-bit registers directly connected to the ALU
- Stack in RAM
- Stack Pointer accessible in I/O memory space
- Direct addressing of up to 16M bytes of program and data memory
- True 16/24-bit access to 16/24-bit I/O registers
- Support for 8-, 16- and 32-bit Arithmetic
- Configuration Change Protection of system critical features

6.2 Overview

The Atmel® AVR® XMEGA™ D3 uses the 8/16-bit AVR CPU. The main function of the AVR CPU is to ensure correct program execution. The CPU must therefore be able to access memories, perform calculations and control peripherals. Interrupt handling is described in a separate section. Figure 6-1 on page 7 shows the CPU block diagram.

Figure 6-1. CPU block diagram



The AVR uses a Harvard architecture - with separate memories and buses for program and data. Instructions in the program memory are executed with a single level pipeline. While one instruction is being executed, the next instruction is pre-fetched from the program memory.

This concept enables instructions to be executed in every clock cycle. The program memory is In-System Re-programmable Flash memory.

6.3 Register File

The fast-access Register File contains 32 x 8-bit general purpose working registers with a single clock cycle access time. This allows single-cycle Arithmetic Logic Unit (ALU) operation. In a typical ALU operation, two operands are output from the Register File, the operation is executed, and the result is stored back in the Register File - in one clock cycle.

Six of the 32 registers can be used as three 16-bit indirect address register pointers for Data Space addressing - enabling efficient address calculations. One of these address pointers can also be used as an address pointer for look up tables in Flash program memory.

6.4 ALU - Arithmetic Logic Unit

The high performance Arithmetic Logic Unit (ALU) supports arithmetic and logic operations between registers or between a constant and a register. Single register operations can also be executed. Within a single clock cycle, arithmetic operations between general purpose registers or between a register and an immediate are executed. After an arithmetic or logic operation, the Status Register is updated to reflect information about the result of the operation.

The ALU operations are divided into three main categories – arithmetic, logical, and bit-functions. Both 8- and 16-bit arithmetic is supported, and the instruction set allows for easy implementation of 32-bit arithmetic. The ALU also provides a powerful multiplier supporting both signed and unsigned multiplication and fractional format.

6.5 Program Flow

When the device is powered on, the CPU starts to execute instructions from the lowest address in the Flash Program Memory ‘0’. The Program Counter (PC) addresses the next instruction to be fetched. After a reset, the PC is set to location ‘0’.

Program flow is provided by conditional and unconditional jump and call instructions, capable of addressing the whole address space directly. Most AVR instructions use a 16-bit word format, while a limited number uses a 32-bit format.

During interrupts and subroutine calls, the return address PC is stored on the Stack. The Stack is effectively allocated in the general data SRAM, and consequently the Stack size is only limited by the total SRAM size and the usage of the SRAM. After reset the Stack Pointer (SP) points to the highest address in the internal SRAM. The SP is read/write accessible in the I/O memory space, enabling easy implementation of multiple stacks or stack areas. The data SRAM can easily be accessed through the five different addressing modes supported in the AVR CPU.

7. Memories

7.1 Features

- **Flash Program Memory**
  - **One linear address space**
  - **In-System Programmable**
  - **Self-Programming and Bootloader support**
  - **Application Section for application code**
  - **Application Table Section for application code or data storage**
  - **Boot Section for application code or bootloader code**
  - **Separate lock bits and protection for all sections**
- **Data Memory**
  - **One linear address space**
  - **Single cycle access from CPU**
  - **SRAM**
  - **EEPROM**
    - **Byte and page accessible**
    - **Optional memory mapping for direct load and store**
  - **I/O Memory**
    - **Configuration and Status registers for all peripherals and modules**
    - **16 bit-accessible General Purpose Register for global variables or flags**
- **Production Signature Row Memory for factory programmed data**
  - **Device ID for each microcontroller device type**
  - **Serial number for each device**
  - **Oscillator calibration bytes**
  - **ADC and temperature sensor calibration data**
- **User Signature Row**
  - **One flash page in size**
  - **Can be read and written from software**
  - **Content is kept after chip erase**

7.2 Overview

The AVR architecture has two main memory spaces, the Program Memory and the Data Memory. In addition, the XMEGA D3 features an EEPROM Memory for non-volatile data storage. All three memory spaces are linear and require no paging. The available memory size configurations are shown in ”Ordering Information” on page 2. In addition each device has a Flash memory signature row for calibration data, device identification, serial number etc.

Non-volatile memory spaces can be locked for further write or read/write operations. This prevents unrestricted access to the application software.

7.3 In-System Programmable Flash Program Memory

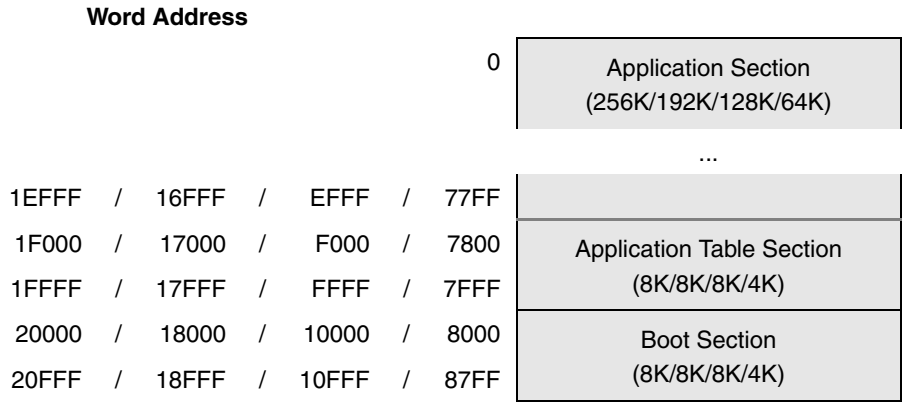
The XMEGA D3 devices contains On-chip In-System Programmable Flash memory for program storage, see Figure 7-1 on page 10. Since all AVR instructions are 16- or 32-bits wide, each Flash address location is 16 bits.

The Program Flash memory space is divided into Application and Boot sections. Both sections have dedicated Lock Bits for setting restrictions on write or read/write operations. The Store Pro-

gram Memory (SPM) instruction must reside in the Boot Section when used to write to the Flash memory.

A third section inside the Application section is referred to as the Application Table section which has separate Lock bits for storage of write or read/write protection. The Application Table section can be used for storing non-volatile data or application software.

Figure 7-1. Flash Program Memory (Hexadecimal address)

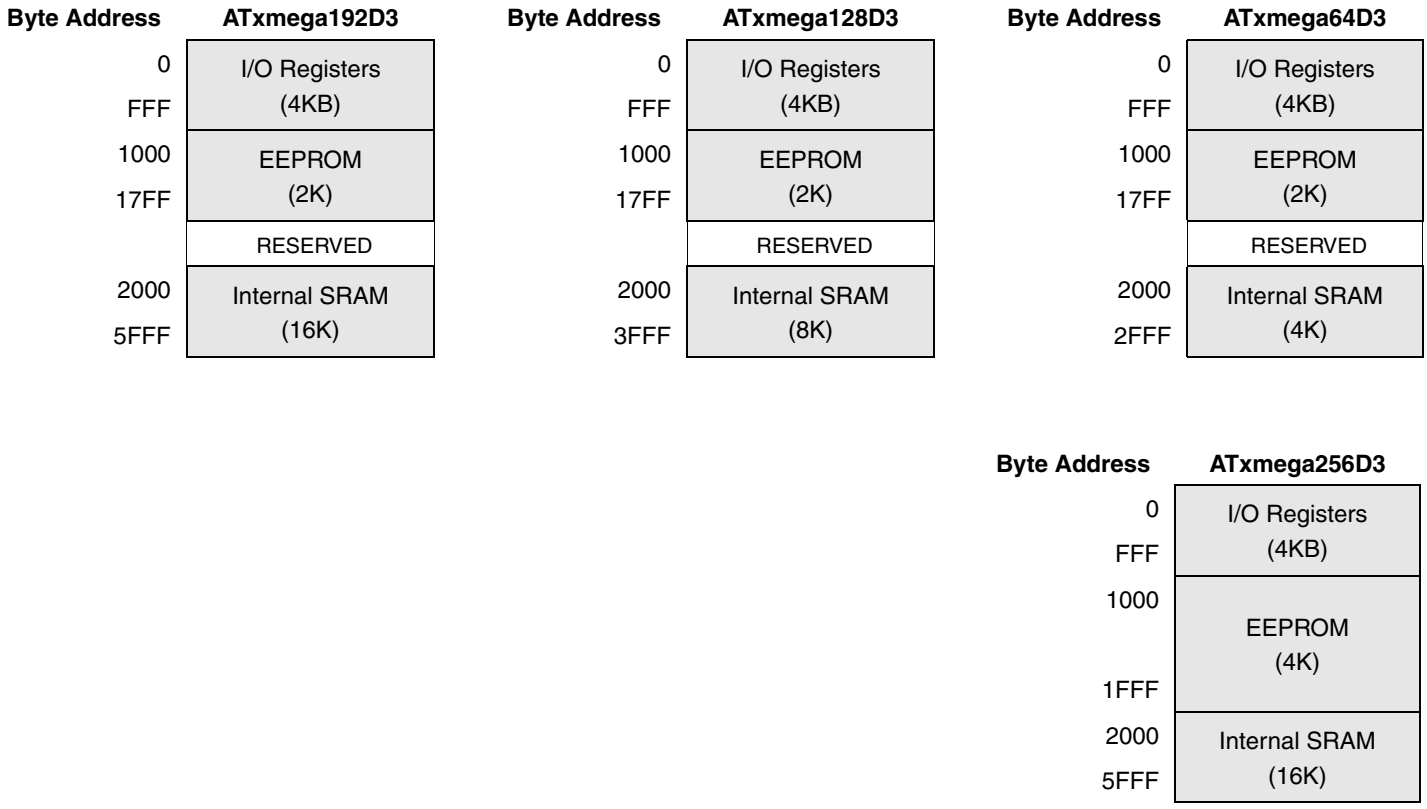


The Application Table Section and Boot Section can also be used for general application software.

7.4 Data Memory

The Data Memory consist of the I/O Memory, EEPROM and SRAM memories, all within one linear address space, see Figure 7-2 on page 11. To simplify development, the memory map for all devices in the family is identical and with empty, reserved memory space for smaller devices.

Figure 7-2. Data Memory Map (Hexadecimal address)



7.4.1 I/O Memory

All peripherals and modules are addressable through I/O memory locations in the data memory space. All I/O memory locations can be accessed by the Load (LD/LDS/LDD) and Store (ST/STS/STD) instructions, transferring data between the 32 general purpose registers in the CPU and the I/O Memory.

The IN and OUT instructions can address I/O memory locations in the range 0x00 - 0x3F directly.

I/O registers within the address range 0x00 - 0x1F are directly bit-accessible using the SBI and CBI instructions. The value of single bits can be checked by using the SBIS and SBIC instructions on these registers.

The I/O memory address for all peripherals and modules in XMEGA D3 is shown in the ”Peripheral Module Address Map” on page 51.

7.4.2 SRAM Data Memory

The XMEGA D3 devices have internal SRAM memory for data storage.

7.4.3 EEPROM Data Memory

The XMEGA D3 devices have internal EEPROM memory for non-volatile data storage. It is addressable either in a separate data space or it can be memory mapped into the normal data memory space. The EEPROM memory supports both byte and page access.

7.5 Production Signature Row

The Production Signature Row is a separate memory section for factory programmed data. It contains calibration data for functions such as oscillators and analog modules.

The production signature row also contains a device ID that identify each microcontroller device type, and a serial number that is unique for each manufactured device. The device ID for the available XMEGA D3 devices is shown in Table 7-1 on page 13. The serial number consist of the production LOT number, wafer number, and wafer coordinates for the device.

The production signature row can not be written or erased, but it can be read from both application software and external programming.

Table 7-1. Device ID bytes for XMEGA D3 devices.

Device	Device ID bytes		
	Byte 2	Byte 1	Byte 0
ATxmega64D3	4A	96	1E
ATxmega128D3	48	97	1E
ATxmega192D3	49	97	1E
ATxmega256D3	44	98	1E

7.6 User Signature Row

The User Signature Row is a separate memory section that is fully accessible (read and write) from application software and external programming. The user signature row is one flash page in size, and is meant for static user parameter storage, such as calibration data, custom serial numbers or identification numbers, random number seeds etc. This section is not erased by Chip Erase commands that erase the Flash, and requires a dedicated erase command. This ensures parameter storage during multiple program/erase session and on-chip debug sessions.

7.7 Flash and EEPROM Page Size

The Flash Program Memory and EEPROM data memory is organized in pages. The pages are word accessible for the Flash and byte accessible for the EEPROM.

Table 7-2 on page 14 shows the Flash Program Memory organization. Flash write and erase operations are performed on one page at the time, while reading the Flash is done one byte at the time. For Flash access the Z-pointer (Z[m:n]) is used for addressing. The most significant bits in the address (FPAGE) gives the page number and the least significant address bits (FWORD) gives the word in the page.

Table 7-2. Number of words and Pages in the Flash.

Devices	Flash Size (Bytes)	Page Size (words)	FWORD	FPAGE	Application		Boot	
					Size	No of Pages	Size	No of Pages
ATxmega64D3	64K + 4K	128	Z[7:1]	Z[16:8]	64K	256	4K	16
ATxmega128D3	128K + 8K	256	Z[8:1]	Z[17:9]	128K	256	8K	16
ATxmega192D3	192K + 8K	256	Z[8:1]	Z[18:9]	192K	384	8K	16
ATxmega256D3	256K + 8K	256	Z[8:1]	Z[18:9]	256K	512	8K	16

Table 7-3 on page 14 shows EEPROM memory organization for the XMEGA D3 devices. EEEPROM write and erase operations can be performed one page or one byte at the time, while reading the EEPROM is done one byte at the time. For EEPROM access the NVM Address Register (ADDR[m:n] is used for addressing. The most significant bits in the address (E2PAGE) gives the page number and the least significant address bits (E2BYTE) gives the byte in the page.

Table 7-3. Number of bytes and Pages in the EEPROM.

Devices	EEPROM Size (Bytes)	Page Size (Bytes)	E2BYTE	E2PAGE	No of Pages
ATxmega64D3	2K	32	ADDR[4:0]	ADDR[10:5]	64
ATxmega128D3	2K	32	ADDR[4:0]	ADDR[10:5]	64
ATxmega192D3	2K	32	ADDR[4:0]	ADDR[10:5]	64
ATxmega256D3	4K	32	ADDR[4:0]	ADDR[11:5]	128

8. Event System

8.1 Features

- Inter-peripheral communication and signalling with minimum latency
- CPU independent operation
- 4 Event Channels allows for up to 4 signals to be routed at the same time
- Events can be generated by
  - Timer/Counters (TCxn)
  - Real Time Counter (RTC)
  - Analog to Digital Converters (ADC)
  - Analog Comparators (AC)
  - Ports (PORTx)
  - System Clock (Clk_{SYS})
  - Software (CPU)
- Events can be used by
  - Timer/Counters (TCxn)
  - Analog to Digital Converters (ADC)
  - Ports (PORTx)
  - IR Communication Module (IRCOM)
- The same event can be used by multiple peripherals for synchronized timing
- Advanced Features
  - Manual Event Generation from software (CPU)
  - Quadrature Decoding
  - Digital Filtering
- Functions in Active and Idle mode

8.2 Overview

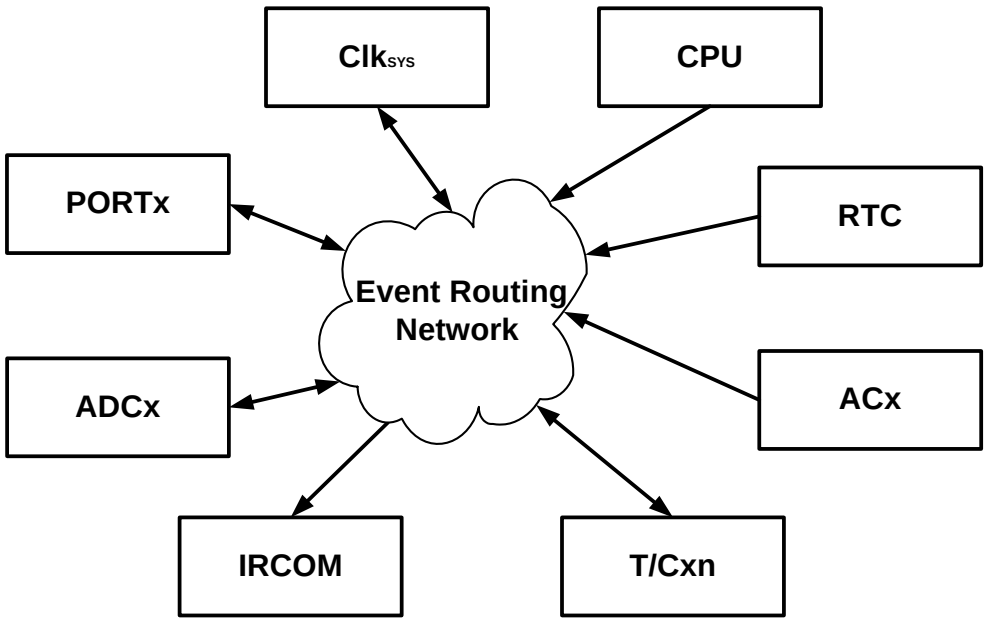
The Event System is a set of features for inter-peripheral communication. It enables the possibility for a change of state in one peripheral to automatically trigger actions in one or more peripherals. What changes in a peripheral that will trigger actions in other peripherals are configurable by software. It is a simple, but powerful system as it allows for autonomous control of peripherals without any use of interrupts or CPU resources.

The indication of a change in a peripheral is referred to as an event, and is usually the same as the interrupt conditions for that peripheral. Events are passed between peripherals using a dedicated routing network called the Event Routing Network. Figure 8-1 on page 16 shows a basic block diagram of the Event System with the Event Routing Network and the peripherals to which it is connected. This highly flexible system can be used for simple routing of signals, pin functions or for sequencing of events.

The maximum latency is two CPU clock cycles from when an event is generated in one peripheral, until the actions are triggered in one or more other peripherals.

The Event System is functional in both Active and Idle modes.

Figure 8-1. Event system block diagram.



The Event Routing Network can directly connect together ADCs, Analog Comparators (AC), I/O ports (PORTx), the Real-time Counter (RTC), Timer/Counters (T/C) and the IR Communication Module (IRCOM). Events can also be generated from software (CPU).

All events from all peripherals are always routed into the Event Routing Network. This consist of four multiplexers where each can be configured in software to select which event to be routed into that event channel. All four event channels are connected to the peripherals that can use events, and each of these peripherals can be configured to use events from one or more event channels to automatically trigger a software selectable action.

9. System Clock and Clock options

9.1 Features

- **Fast start-up time**
- **Safe run-time clock switching**
- **Internal Oscillators:**
  - **32 MHz run-time calibrated RC oscillator**
  - **2 MHz run-time calibrated RC oscillator**
  - **32.768 kHz calibrated RC oscillator**
  - **32 kHz Ultra Low Power (ULP) oscillator**
- **External clock options**
  - **0.4 - 16 MHz Crystal Oscillator**
  - **32.768 kHz Crystal Oscillator**
  - **External clock**
- **PLL with internal and external clock options with 2 to 31x multiplication**
- **Clock Prescalers with 2 to 2048x division**
- **Fast peripheral clock running at 2 and 4 times the CPU clock speed**
- **Automatic Run-Time Calibration of internal oscillators**
- **Crystal Oscillator failure detection**

9.2 Overview

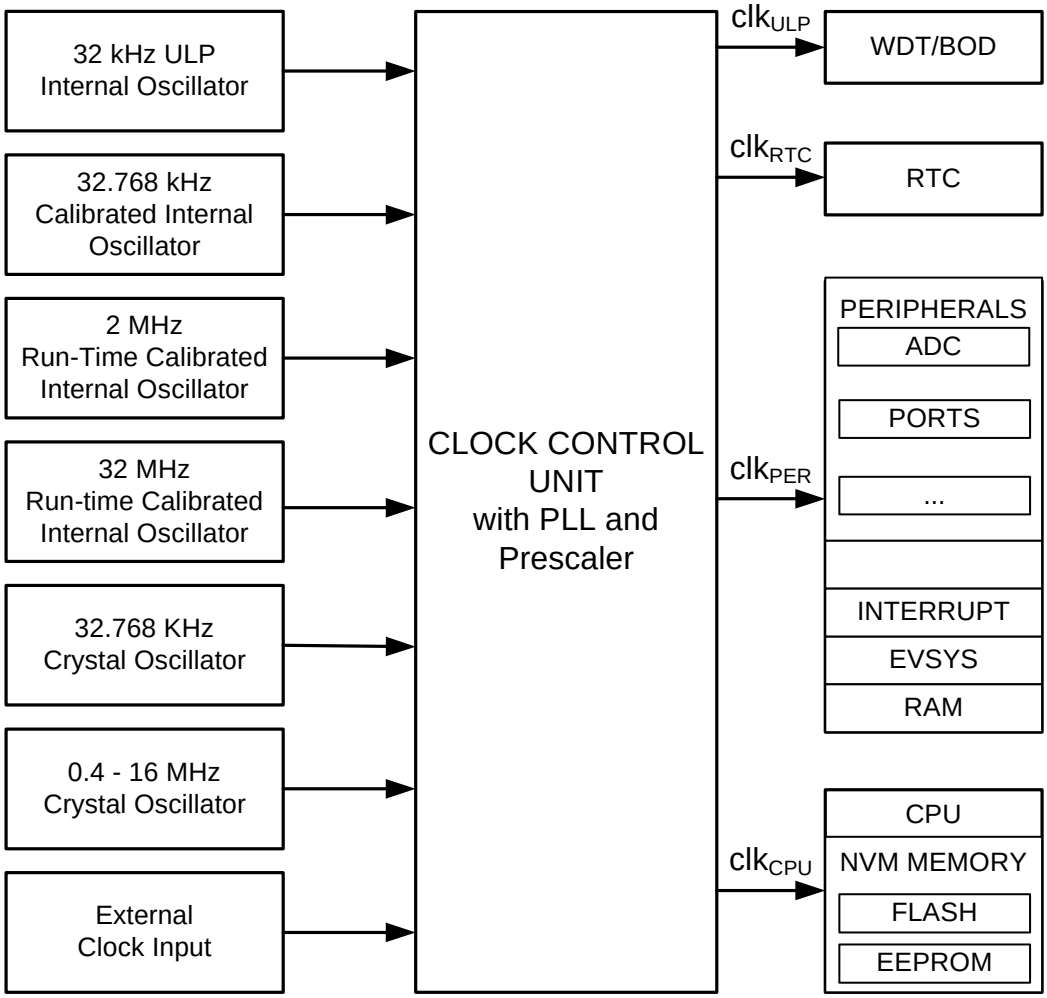
XMEGA D3 has an advanced clock system, supporting a large number of clock sources. It incorporates both integrated oscillators, external crystal oscillators and resonators. A high frequency Phase Locked Loop (PLL) and clock prescalers can be controlled from software to generate a wide range of clock frequencies from the clock source input.

It is possible to switch between clock sources from software during run-time. After reset the device will always start up running from the 2 Mhz internal oscillator.

A calibration feature is available, and can be used for automatic run-time calibration of the internal 2 MHz and 32 MHz oscillators. This reduce frequency drift over voltage and temperature.

A Crystal Oscillator Failure Monitor can be enabled to issue a Non-Maskable Interrupt and switch to internal oscillator if the external oscillator fails. Figure 9-1 on page 18 shows the principal clock system in XMEGA D3.

Figure 9-1. Clock system overview



Each clock source is briefly described in the following sub-sections.

9.3 Clock Options

9.3.1 32 kHz Ultra Low Power Internal Oscillator

The 32 kHz Ultra Low Power (ULP) Internal Oscillator is a very low power consumption clock source. It is used for the Watchdog Timer, Brown-Out Detection and as an asynchronous clock source for the Real Time Counter. This oscillator cannot be used as the system clock source, and it cannot be directly controlled from software.

9.3.2 32.768 kHz Calibrated Internal Oscillator

The 32.768 kHz Calibrated Internal Oscillator is a high accuracy clock source that can be used as the system clock source or as an asynchronous clock source for the Real Time Counter. It is calibrated during production to provide a default frequency which is close to its nominal frequency.

9.3.3 32.768 kHz Crystal Oscillator

The 32.768 kHz Crystal Oscillator is a low power driver for an external watch crystal. It can be used as system clock source or as asynchronous clock source for the Real Time Counter.

9.3.4 0.4 - 16 MHz Crystal Oscillator

The 0.4 - 16 MHz Crystal Oscillator is a driver intended for driving both external resonators and crystals ranging from 400 kHz to 16 MHz.

9.3.5 2 MHz Run-time Calibrated Internal Oscillator

The 2 MHz Run-time Calibrated Internal Oscillator is a high frequency oscillator. It is calibrated during production to provide a default frequency which is close to its nominal frequency. The oscillator can use the 32.768 kHz Calibrated Internal Oscillator or the 32 kHz Crystal Oscillator as a source for calibrating the frequency run-time to compensate for temperature and voltage drift hereby optimizing the accuracy of the oscillator.

9.3.6 32 MHz Run-time Calibrated Internal Oscillator

The 32 MHz Run-time Calibrated Internal Oscillator is a high frequency oscillator. It is calibrated during production to provide a default frequency which is close to its nominal frequency. The oscillator can use the 32.768 kHz Calibrated Internal Oscillator or the 32 kHz Crystal Oscillator as a source for calibrating the frequency run-time to compensate for temperature and voltage drift hereby optimizing the accuracy of the oscillator.

9.3.7 External Clock input

The external clock input gives the possibility to connect a clock from an external source.

9.3.8 PLL with Multiplication factor 2 - 31x

The PLL provides the possibility of multiplying a frequency by any number from 2 to 31. In combination with the prescalers, this gives a wide range of output frequencies from all clock sources.

10. Power Management and Sleep Modes

10.1 Features

- 5 sleep modes
  - Idle
  - Power-down
  - Power-save
  - Standby
  - Extended standby
- Power Reduction registers to disable clocks to unused peripherals

10.2 Overview

The XMEGA D3 provides various sleep modes tailored to reduce power consumption to a minimum. All sleep modes are available and can be entered from Active mode. In Active mode the CPU is executing application code. The application code decides when and what sleep mode to enter. Interrupts from enabled peripherals and all enabled reset sources can restore the microcontroller from sleep to Active mode.

In addition, Power Reduction registers provide a method to stop the clock to individual peripherals from software. When this is done, the current state of the peripheral is frozen and there is no power consumption from that peripheral. This reduces the power consumption in Active mode and Idle sleep mode.

10.3 Sleep Modes

10.3.1 Idle Mode

In Idle mode the CPU and Non-Volatile Memory are stopped, but all peripherals including the Interrupt Controller and Event System are kept running. Interrupt requests from all enabled interrupts will wake the device.

10.3.2 Power-down Mode

In Power-down mode all system clock sources, and the asynchronous Real Time Counter (RTC) clock source, are stopped. This allows operation of asynchronous modules only. The only interrupts that can wake up the MCU are the Two Wire Interface address match interrupts, and asynchronous port interrupts, e.g pin change.

10.3.3 Power-save Mode

Power-save mode is identical to Power-down, with one exception: If the RTC is enabled, it will keep running during sleep and the device can also wake up from RTC interrupts.

10.3.4 Standby Mode

Standby mode is identical to Power-down with the exception that all enabled system clock sources are kept running, while the CPU, Peripheral and RTC clocks are stopped. This reduces the wake-up time when external crystals or resonators are used.

10.3.5 Extended Standby Mode

Extended Standby mode is identical to Power-save mode with the exception that all enabled system clock sources are kept running while the CPU and Peripheral clocks are stopped. This reduces the wake-up time when external crystals or resonators are used.

11. System Control and Reset

11.1 Features

- **Multiple reset sources for safe operation and device reset**
  - **Power-On Reset**
  - **External Reset**
  - **Watchdog Reset**
    - **The Watchdog Timer runs from separate, dedicated oscillator**
  - **Brown-Out Reset**
    - **Accurate, programmable Brown-Out levels**
  - **PDI reset**
  - **Software reset**
- **Asynchronous reset**
  - **No running clock in the device is required for reset**
- **Reset status register**

11.2 Resetting the AVR

During reset, all I/O registers are set to their initial values. The SRAM content is not reset. Application execution starts from the Reset Vector. The instruction placed at the Reset Vector should be an Absolute Jump (JMP) instruction to the reset handling routine. By default the Reset Vector address is the lowest Flash program memory address, ‘0’, but it is possible to move the Reset Vector to the first address in the Boot Section.

The I/O ports of the AVR are immediately tri-stated when a reset source goes active.

The reset functionality is asynchronous, so no running clock is required to reset the device.

After the device is reset, the reset source can be determined by the application by reading the Reset Status Register.

11.3 Reset Sources

11.3.1 Power-On Reset

The MCU is reset when the supply voltage VCC is below the Power-on Reset threshold voltage.

11.3.2 External Reset

The MCU is reset when a low level is present on the RESET pin.

11.3.3 Watchdog Reset

The MCU is reset when the Watchdog Timer period expires and the Watchdog Reset is enabled. The Watchdog Timer runs from a dedicated oscillator independent of the System Clock. For more details see ”WDT - Watchdog Timer” on page 23.

11.3.4 Brown-Out Reset

The MCU is reset when the supply voltage VCC is below the Brown-Out Reset threshold voltage and the Brown-out Detector is enabled. The Brown-out threshold voltage is programmable.

11.3.5 PDI reset

The MCU can be reset through the Program and Debug Interface (PDI).

11.3.6 Software reset

The MCU can be reset by the CPU writing to a special I/O register through a timed sequence.

12. WDT - Watchdog Timer

12.1 Features

- **11 selectable timeout periods, from 8 ms to 8s.**
- **Two operation modes**
  - **Standard mode**
  - **Window mode**
- **Runs from the 1 kHz output of the 32 kHz Ultra Low Power oscillator**
- **Configuration lock to prevent unwanted changes**

12.2 Overview

The XMEGA D3 has a Watchdog Timer (WDT). The WDT will run continuously when turned on and if the Watchdog Timer is not reset within a software configurable time-out period, the microcontroller will be reset. The Watchdog Reset (WDR) instruction must be run by software to reset the WDT, and prevent microcontroller reset.

The WDT has a Window mode. In this mode the WDR instruction must be run within a specified period called a window. Application software can set the minimum and maximum limits for this window. If the WDR instruction is not executed inside the window limits, the microcontroller will be reset.

A protection mechanism using a timed write sequence is implemented in order to prevent unwanted enabling, disabling or change of WDT settings.

For maximum safety, the WDT also has an Always-on mode. This mode is enabled by programming a fuse. In Always-on mode, application software can not disable the WDT.

13. PMIC - Programmable Multi-level Interrupt Controller

13.1 Features

- **Separate interrupt vector for each interrupt**
- **Short, predictable interrupt response time**
- **Programmable Multi-level Interrupt Controller**
  - **3 programmable interrupt levels**
  - **Selectable priority scheme within low level interrupts (round-robin or fixed)**
  - **Non-Maskable Interrupts (NMI)**
- **Interrupt vectors can be moved to the start of the Boot Section**

13.2 Overview

XMEGA D3 has a Programmable Multi-level Interrupt Controller (PMIC). All peripherals can define three different priority levels for interrupts; high, medium or low. Medium level interrupts may interrupt low level interrupt service routines. High level interrupts may interrupt both low- and medium level interrupt service routines. Low level interrupts have an optional round robin scheme to make sure all interrupts are serviced within a certain amount of time.

The built in oscillator failure detection mechanism can issue a Non-Maskable Interrupt (NMI).

13.3 Interrupt vectors

When an interrupt is serviced, the program counter will jump to the interrupt vector address. The interrupt vector is the sum of the peripheral's base interrupt address and the offset address for specific interrupts in each peripheral. The base addresses for the XMEGA D3 devices are shown in Table 13-1. Offset addresses for each interrupt available in the peripheral are described for each peripheral in the XMEGA A manual. For peripherals or modules that have only one interrupt, the interrupt vector is shown in Table 13-1. The program address is the word address.

Table 13-1. Reset and Interrupt Vectors

Program Address (Base Address)	Source	Interrupt Description
0x000	RESET	
0x002	OSCF_INT_vect	Crystal Oscillator Failure Interrupt vector (NMI)
0x004	PORTC_INT_base	Port C Interrupt base
0x008	PORTR_INT_base	Port R Interrupt base
0x014	RTC_INT_base	Real Time Counter Interrupt base
0x018	TWIC_INT_base	Two-Wire Interface on Port C Interrupt base
0x01C	TCC0_INT_base	Timer/Counter 0 on port C Interrupt base
0x028	TCC1_INT_base	Timer/Counter 1 on port C Interrupt base
0x030	SPIC_INT_vect	SPI on port C Interrupt vector
0x032	USARTC0_INT_base	USART 0 on port C Interrupt base
0x040	NVM_INT_base	Non-Volatile Memory Interrupt base
0x044	PORTB_INT_base	Port B Interrupt base
0x056	PORTE_INT_base	Port E INT base

Table 13-1. Reset and Interrupt Vectors (Continued)

Program Address (Base Address)	Source	Interrupt Description
0x05A	TWIE_INT_base	Two-Wire Interface on Port E Interrupt base
0x05E	TCE0_INT_base	Timer/Counter 0 on port E Interrupt base
0x074	USARTE0_INT_base	USART 0 on port E Interrupt base
0x080	PORTD_INT_base	Port D Interrupt base
0x084	PORTA_INT_base	Port A Interrupt base
0x088	ACA_INT_base	Analog Comparator on Port A Interrupt base
0x08E	ADCA_INT_base	Analog to Digital Converter on Port A Interrupt base
0x09A	TCD0_INT_base	Timer/Counter 0 on port D Interrupt base
0x0AE	SPID_INT_vector	SPI D Interrupt vector
0x0B0	USARTD0_INT_base	USART 0 on port D Interrupt base
0x0D0	PORTF_INT_base	Port F Interrupt base
0x0D8	TCF0_INT_base	Timer/Counter 0 on port F Interrupt base

14. I/O Ports

14.1 Features

- Selectable input and output configuration for each pin individually
- Flexible pin configuration through dedicated Pin Configuration Register
- Synchronous and/or asynchronous input sensing with port interrupts and events
  - Sense both edges
  - Sense rising edges
  - Sense falling edges
  - Sense low level
- Asynchronous wake-up from all input sensing configurations
- Two port interrupts with flexible pin masking
- Highly configurable output driver and pull settings:
  - Totem-pole
  - Pull-up/-down
  - Wired-AND
  - Wired-OR
  - Bus-keeper
  - Inverted I/O
- Optional Slew rate control
- Configuration of multiple pins in a single operation
- Read-Modify-Write (RMW) support
- Toggle/clear/set registers for Output and Direction registers
- Clock output on port pin
- Event Channel 0 output on port pin 7
- Mapping of port registers (virtual ports) into bit accessible I/O memory space

14.2 Overview

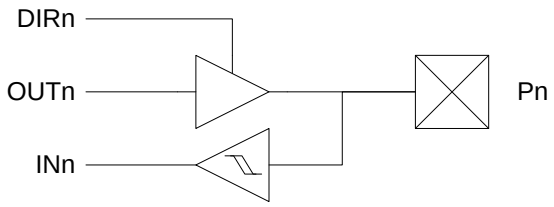
The XMEGA D3 devices have flexible General Purpose I/O Ports. A port consists of up to 8 pins, ranging from pin 0 to pin 7. The ports implement several functions, including synchronous/asynchronous input sensing, pin change interrupts and configurable output settings. All functions are individual per pin, but several pins may be configured in a single operation.

14.3 I/O configuration

All port pins (Pn) have programmable output configuration. In addition, all port pins have an inverted I/O function. For an input, this means inverting the signal between the port pin and the pin register. For an output, this means inverting the output signal between the port register and the port pin. The inverted I/O function can be used also when the pin is used for alternate functions.

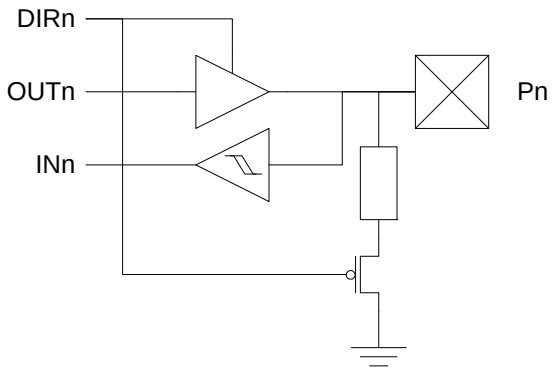
14.3.1 Push-pull

Figure 14-1. I/O configuration - Totem-pole



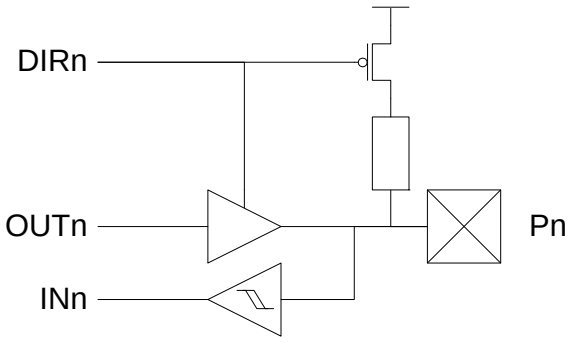
14.3.2 Pull-down

Figure 14-2. I/O configuration - Totem-pole with pull-down (on input)



14.3.3 Pull-up

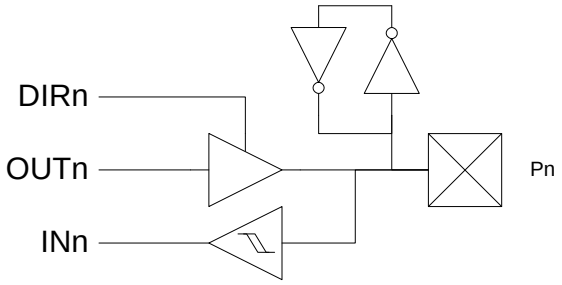
Figure 14-3. I/O configuration - Totem-pole with pull-up (on input)



14.3.4 Bus-keeper

The bus-keeper's weak output produces the same logical level as the last output level. It acts as a pull-up if the last level was '1', and pull-down if the last level was '0'.

Figure 14-4. I/O configuration - Totem-pole with bus-keeper



14.3.5 Others

Figure 14-5. Output configuration - Wired-OR with optional pull-down

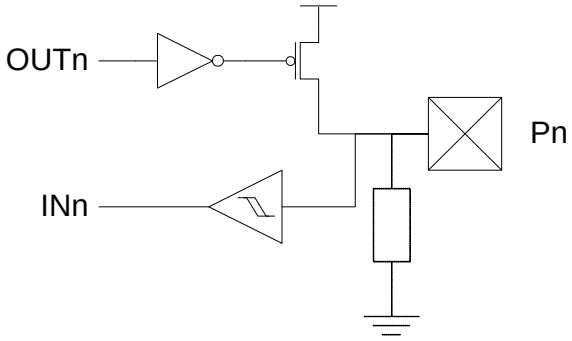
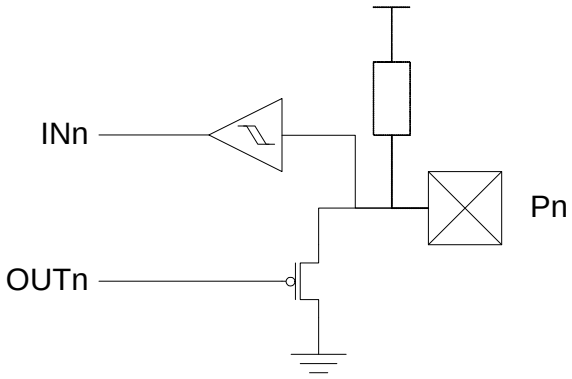


Figure 14-6. I/O configuration - Wired-AND with optional pull-up

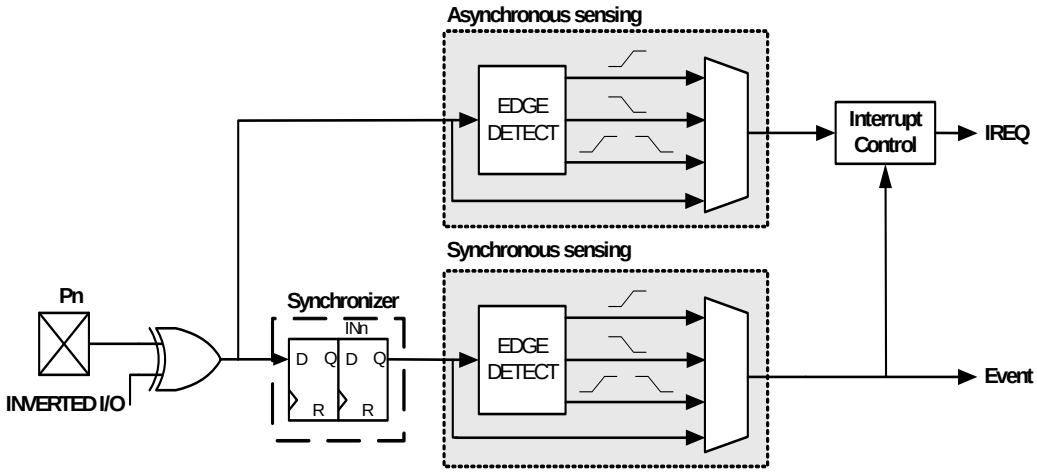


14.4 Input sensing

- **Sense both edges**
- **Sense rising edges**
- **Sense falling edges**
- **Sense low level**

Input sensing is synchronous or asynchronous depending on the enabled clock for the ports, and the configuration is shown in Figure 14-7 on page 29.

Figure 14-7. Input sensing system overview



When a pin is configured with inverted I/O, the pin value is inverted before the input sensing.

14.5 Port Interrupt

Each port has two interrupts with separate priority and interrupt vector. All pins on the port can be individually selected as source for each of the interrupts. The interrupts are then triggered according to the input sense configuration for each pin configured as source for the interrupt.

14.6 Alternate Port Functions

In addition to the input/output functions on all port pins, most pins have alternate functions. This means that other modules or peripherals connected to the port can use the port pins for their functions, such as communication or pulse-width modulation. ”Pinout and Pin Functions” on page 46 shows which modules on peripherals that enable alternate functions on a pin, and which alternate functions that is available on a pin.

15. T/C - 16-bits Timer/Counter with PWM

15.1 Features

- Five 16-bit Timer/Counters
  - Four Timer/Counters of type 0
  - One Timer/Counters of type 1
- Four Compare or Capture (CC) Channels in Timer/Counter 0
- Two Compare or Capture (CC) Channels in Timer/Counter 1
- Double Buffered Timer Period Setting
- Double Buffered Compare or Capture Channels
- Waveform Generation:
  - Single Slope Pulse Width Modulation
  - Dual Slope Pulse Width Modulation
  - Frequency Generation
- Input Capture:
  - Input Capture with Noise Cancelling
  - Frequency capture
  - Pulse width capture
  - 32-bit input capture
- Event Counter with Direction Control
- Timer Overflow and Timer Error Interrupts and Events
- One Compare Match or Capture Interrupt and Event per CC Channel
- Hi-Resolution Extension (Hi-Res)
- Advanced Waveform Extension (AWEX)

15.2 Overview

XMEGA D3 has five Timer/Counters, four Timer/Counter 0 and one Timer/Counter 1. The difference between them is that Timer/Counter 0 has four Compare/Capture channels, while Timer/Counter 1 has two Compare/Capture channels.

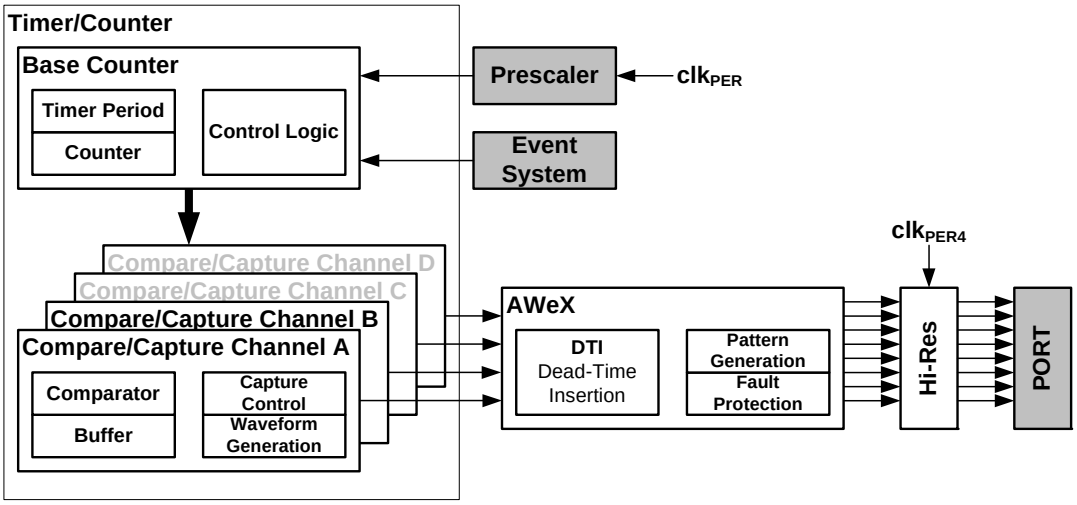
The Timer/Counters (T/C) are 16-bit and can count any clock, event or external input in the microcontroller. A programmable prescaler is available to get a useful T/C resolution. Updates of Timer and Compare registers are double buffered to ensure glitch free operation. Single slope PWM, dual slope PWM and frequency generation waveforms can be generated using the Compare Channels.

Through the Event System, any input pin or event in the microcontroller can be used to trigger input capture, hence no dedicated pins are required for this. The input capture has a noise canceller to avoid incorrect capture of the T/C, and can be used to do frequency and pulse width measurements.

A wide range of interrupt or event sources are available, including T/C Overflow, Compare match and Capture for each Compare/Capture channel in the T/C.

PORTC has one Timer/Counter 0 and one Timer/Counter1. PORTD, PORTE and PORTF each have one Timer/Counter 0. Notation of these are TCC0 (Time/Counter C0), TCC1, TCD0, TCE0, and TCF0, respectively.

Figure 15-1. Overview of a Timer/Counter and closely related peripherals



The Hi-Resolution Extension can be enabled to increase the waveform generation resolution by 2 bits (4x). This is available for all Timer/Counters. See ”Hi-Res - High Resolution Extension” on page 33 for more details.

The Advanced Waveform Extension can be enabled to provide extra and more advanced features for the Timer/Counter. This are only available for Timer/Counter 0. See ”AWEX - Advanced Waveform Extension” on page 32 for more details.

16. AWEX - Advanced Waveform Extension

16.1 Features

- **Output with complementary output from each Capture channel**
- **Four Dead Time Insertion (DTI) Units, one for each Capture channel**
- **8-bit DTI Resolution**
- **Separate High and Low Side Dead-Time Setting**
- **Double Buffered Dead-Time**
- **Event Controlled Fault Protection**
- **Single Channel Multiple Output Operation (for BLDC motor control)**
- **Double Buffered Pattern Generation**

16.2 Overview

The Advanced Waveform Extension (AWEX) provides extra features to the Timer/Counter in Waveform Generation (WG) modes. The AWEX enables easy and safe implementation of for example, advanced motor control (AC, BLDC, SR, and Stepper) and power control applications.

Any WG output from a Timer/Counter 0 is split into a complimentary pair of outputs when any AWEX feature is enabled. These output pairs go through a Dead-Time Insertion (DTI) unit that enables generation of the non-inverted Low Side (LS) and inverted High Side (HS) of the WG output with dead time insertion between LS and HS switching. The DTI output will override the normal port value according to the port override setting. Optionally the final output can be inverted by using the invert I/O setting for the port pin.

The Pattern Generation unit can be used to generate a synchronized bit pattern on the port it is connected to. In addition, the waveform generator output from Compare Channel A can be distributed to, and override all port pins. When the Pattern Generator unit is enabled, the DTI unit is bypassed.

The Fault Protection unit is connected to the Event System. This enables any event to trigger a fault condition that will disable the AWEX output. Several event channels can be used to trigger fault on several different conditions.

The AWEX is available for TCC0. The notation of this is AWEXC.

17. Hi-Res - High Resolution Extension

17.1 Features

- **Increases Waveform Generator resolution by 2-bits (4x)**
- **Supports Frequency, single- and dual-slope PWM operation**
- **Supports the AWEX when this is enabled and used for the same Timer/Counter**

17.2 Overview

The Hi-Resolution (Hi-Res) Extension is able to increase the resolution of the waveform generation output by a factor of 4. When enabled for a Timer/Counter, the Fast Peripheral clock running at four times the CPU clock speed will be as input to the Timer/Counter.

The High Resolution Extension can also be used when an AWEX is enabled and used with a Timer/Counter.

XMEGA D3 devices have one Hi-Res Extension that can be enabled for each Timer/Counters on PORTC. The notation of this is HIRESC.

18. RTC - Real-Time Counter

18.1 Features

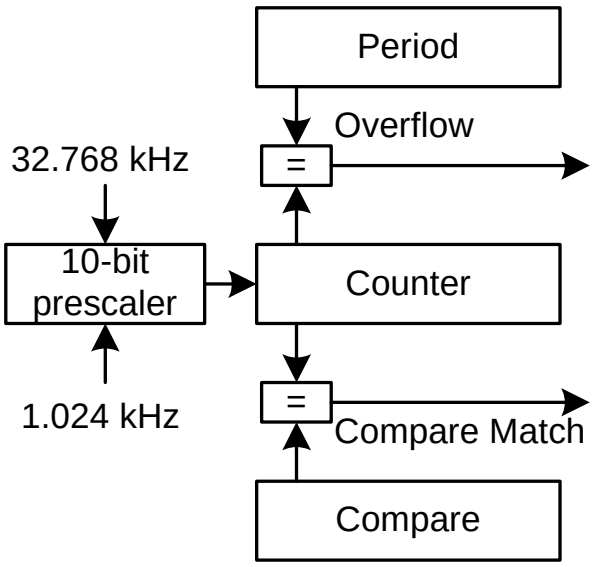
- **16-bit Timer**
- **Flexible Tick resolution ranging from 1 Hz to 32.768 kHz**
- **One Compare register**
- **One Period register**
- **Clear timer on Overflow or Compare Match**
- **Overflow or Compare Match event and interrupt generation**

18.2 Overview

The XMEGA D3 includes a 16-bit Real-time Counter (RTC). The RTC can be clocked from an accurate 32.768 kHz Crystal Oscillator, the 32.768 kHz Calibrated Internal Oscillator, or from the 32 kHz Ultra Low Power Internal Oscillator. The RTC includes both a Period and a Compare register. For details, see Figure 18-1.

A wide range of Resolution and Time-out periods can be configured using the RTC. With a maximum resolution of 30.5 µs, time-out periods range up to 2000 seconds. With a resolution of 1 second, the maximum time-out period is over 18 hours (65536 seconds).

Figure 18-1. Real-time Counter overview



19. TWI - Two Wire Interface

19.1 Features

- **Two Identical TWI peripherals**
- **Simple yet Powerful and Flexible Communication Interface**
- **Both Master and Slave Operation Supported**
- **Device can Operate as Transmitter or Receiver**
- **7-bit Address Space Allows up to 128 Different Slave Addresses**
- **Multi-master Arbitration Support**
- **Up to 400 kHz Data Transfer Speed**
- **Slew-rate Limited Output Drivers**
- **Noise Suppression Circuitry Rejects Spikes on Bus Lines**
- **Fully Programmable Slave Address with General Call Support**
- **Address Recognition Causes Wake-up when in Sleep Mode**
- **I^2C and System Management Bus (SMBus) compatible**

19.2 Overview

The Two-Wire Interface (TWI) is a bi-directional wired-AND bus with only two lines, the clock (SCL) line and the data (SDA) line. The protocol makes it possible to interconnect up to 128 individually addressable devices. Since it is a multi-master bus, one or more devices capable of taking control of the bus can be connected.

The only external hardware needed to implement the bus is a single pull-up resistor for each of the TWI bus lines. Mechanisms for resolving bus contention are inherent in the TWI protocol.

PORTC and PORTE each has one TWI. Notation of these peripherals are TWIC and TWIE, respectively.

20. SPI - Serial Peripheral Interface

20.1 Features

- **Two Identical SPI peripherals**
- **Full-duplex, Three-wire Synchronous Data Transfer**
- **Master or Slave Operation**
- **LSB First or MSB First Data Transfer**
- **Seven Programmable Bit Rates**
- **End of Transmission Interrupt Flag**
- **Write Collision Flag Protection**
- **Wake-up from Idle Mode**
- **Double Speed (CK/2) Master SPI Mode**

20.2 Overview

The Serial Peripheral Interface (SPI) allows high-speed full-duplex, synchronous data transfer between different devices. Devices can communicate using a master-slave scheme, and data is transferred both to and from the devices simultaneously.

PORTC and PORTD each has one SPI. Notation of these peripherals are SPIC and SPID, respectively.

21. USART

21.1 Features

- Three Identical USART peripherals
- Full Duplex Operation (Independent Serial Receive and Transmit Registers)
- Asynchronous or Synchronous Operation
- Master or Slave Clocked Synchronous Operation
- High-resolution Arithmetic Baud Rate Generator
- Supports Serial Frames with 5, 6, 7, 8, or 9 Data Bits and 1 or 2 Stop Bits
- Odd or Even Parity Generation and Parity Check Supported by Hardware
- Data OverRun Detection
- Framing Error Detection
- Noise Filtering Includes False Start Bit Detection and Digital Low Pass Filter
- Three Separate Interrupts on TX Complete, TX Data Register Empty and RX Complete
- Multi-processor Communication Mode
- Double Speed Asynchronous Communication Mode
- Master SPI mode for SPI communication
- IrDA support through the IRCOM module

21.2 Overview

The Universal Synchronous and Asynchronous serial Receiver and Transmitter (USART) is a highly flexible serial communication module. The USART supports full duplex communication, and both asynchronous and clocked synchronous operation. The USART can also be set in Master SPI mode to be used for SPI communication.

Communication is frame based, and the frame format can be customized to support a wide range of standards. The USART is buffered in both direction, enabling continued data transmission without any delay between frames. There are separate interrupt vectors for receive and transmit complete, enabling fully interrupt driven communication. Frame error and buffer overflow are detected in hardware and indicated with separate status flags. Even or odd parity generation and parity check can also be enabled.

One USART can use the IRCOM module to support IrDA 1.4 physical compliant pulse modulation and demodulation for baud rates up to 115.2 kbps.

PORTC, PORTD, and PORTE each has one USART. Notation of these peripherals are USARTC0, USARTD0 and USARTE0, respectively.

22. IRCOM - IR Communication Module

22.1 Features

- **Pulse modulation/demodulation for infrared communication**
- **Compatible to IrDA 1.4 physical for baud rates up to 115.2 kbps**
- **Selectable pulse modulation scheme**
  - **3/16 of baud rate period**
  - **Fixed pulse period, 8-bit programmable**
  - **Pulse modulation disabled**
- **Built in filtering**
- **Can be connected to and used by one USART at the time**

22.2 Overview

XMEGA contains an Infrared Communication Module (IRCOM) for IrDA communication with baud rates up to 115.2 kbps. This supports three modulation schemes: 3/16 of baud rate period, fixed programmable pulse time based on the Peripheral Clock speed, or pulse modulation disabled. There is one IRCOM available which can be connected to any USART to enable infrared pulse coding/decoding for that USART.

23. ADC - 12-bit Analog to Digital Converter

23.1 Features

- One ADC with 12-bit resolution
- 200 ksps sample rate
- Signed and Unsigned conversions
- 16 single ended inputs
- 8x4 differential inputs
- 3 internal inputs:
  - Integrated Temperature Sensor
  - VCC voltage divided by 10
  - Bandgap voltage
- Software selectable gain of 1, 2, 4, 8, 16, 32 or 64
- Software selectable resolution of 8- or 12-bit.
- Internal or External Reference selection
- Event triggered conversion for accurate timing
- Interrupt/Event on compare result

23.2 Overview

XMEGA D3 devices have one Analog to Digital Converters (ADC), see Figure 23-1 on page 40.

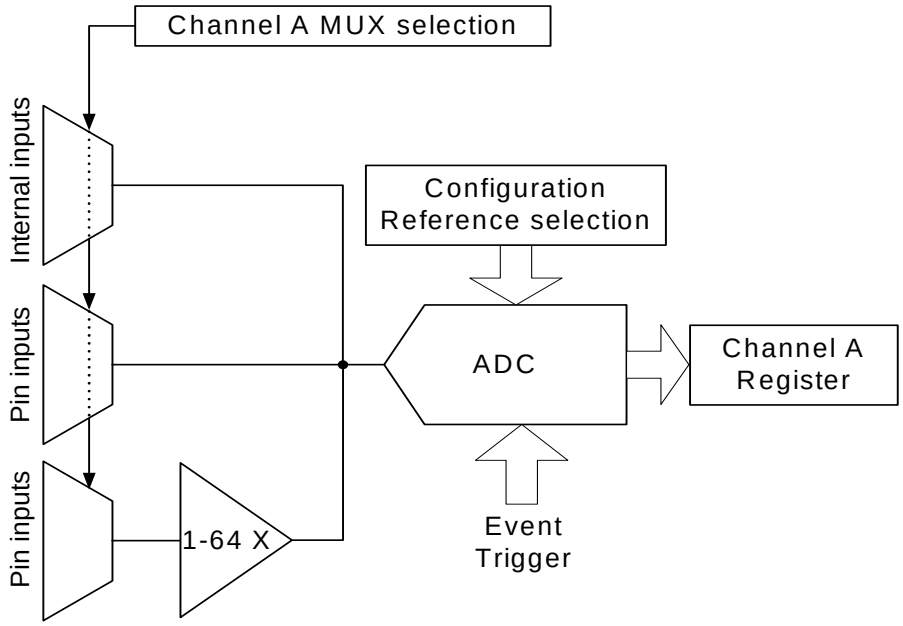
The ADC converts analog voltages to digital values. The ADC has 12-bit resolution and is capable of converting up to 200K samples per second. The input selection is flexible, and both singleended and differential measurements can be done. For differential measurements an optional gain stage is available to increase the dynamic range. In addition several internal signal inputs are available. The ADC can provide both signed and unsigned results.

ADC measurements can either be started by application software or an incoming event from another peripheral in the device. The latter ensure the ADC measurements can be started with predictable timing, and without software intervention. The ADC has one channel, meaning there is one input selection (MUX selection) and one result register available.

Both internal and external analog reference voltages can be used. A very accurate internal 1.00V reference is available.

An integrated temperature sensor is available and the output from this can be measured with the ADC. A VCC/10 signal and the Bandgap voltage can also be measured by the ADC.

Figure 23-1. ADC overview



The ADC may be configured for 8- or 12-bit result, reducing the minimum conversion time (propagation delay) from 0.5 µs for 12-bit to 3.7 µs for 8-bit result.

ADC conversion results are provided left- or right adjusted with optional ‘1’ or ‘0’ padding. This eases calculation when the result is represented as a signed integer (signed 16-bit number).

PORTA has one ADC. Notation of this peripheral is ADCA.

24. AC - Analog Comparator

24.1 Features

- **Two Analog Comparators**
- **Selectable hysteresis**
  - **No, Small or Large**
- **Analog Comparator output available on pin**
- **Flexible Input Selection**
  - **All pins on the port**
  - **Bandgap reference voltage.**
  - **Voltage scaler that can perform a 64-level scaling of the internal VCC voltage.**
- **Interrupt and event generation on**
  - **Rising edge**
  - **Falling edge**
  - **Toggle**
- **Window function interrupt and event generation on**
  - **Signal above window**
  - **Signal inside window**
  - **Signal below window**

24.2 Overview

XMEGA D3 features two Analog Comparators (AC). An Analog Comparator compares two voltages, and the output indicates which input is largest. The Analog Comparator may be configured to give interrupt requests and/or events upon several different combinations of input change.

Hysteresis can be adjusted in order to find the optimal operation for each application.

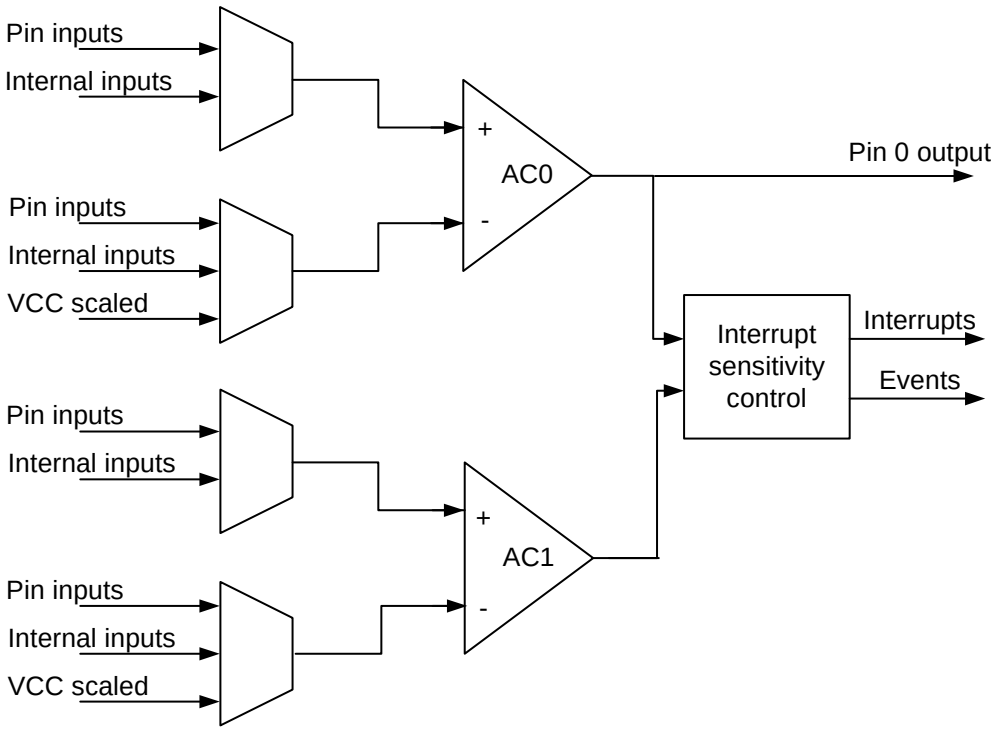
A wide range of input selection is available, both external pins and several internal signals can be used.

The Analog Comparators are always grouped in pairs (AC0 and AC1) on each analog port. They have identical behavior but separate control registers.

Optionally, the state of the comparator is directly available on a pin.

PORTA and has one AC pair. Notations of this peripheral is ACA.

Figure 24-1. Analog comparator overview



24.3 Input Selection

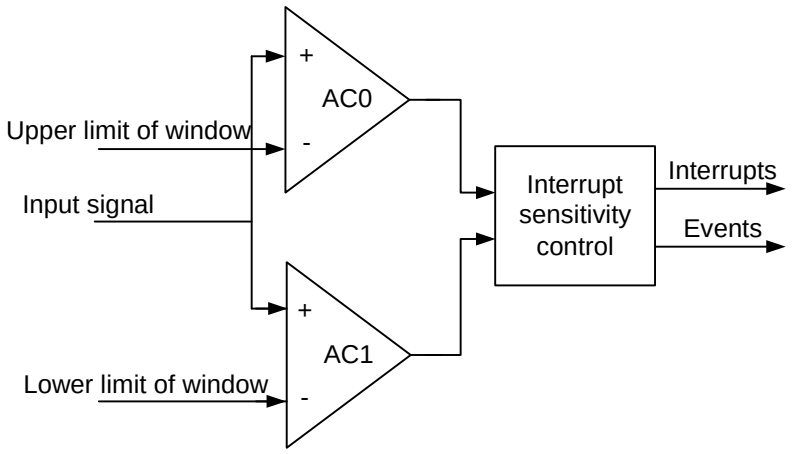
The Analog comparators have a very flexible input selection and the two comparators grouped in a pair may be used to realize a window function. One pair of analog comparators is shown in Figure 24-1 on page 42.

- **Input selection from pin**
  - **Pin 0, 1, 2, 3, 4, 5, 6 selectable to positive input of analog comparator**
  - **Pin 0, 1, 3, 5, 7 selectable to negative input of analog comparator**
- **Internal signals available on positive analog comparator inputs**
- **Internal signals available on negative analog comparator inputs**
  - **64-level scaler of the VCC, available on negative analog comparator input**
  - **Bandgap voltage reference**

24.4 Window Function

The window function is realized by connecting the external inputs of the two analog comparators in a pair as shown in Figure 24-2.

Figure 24-2. Analog comparator window function



25. OCD - On-chip Debug

25.1 Features

- Complete Program Flow Control
  - Go, Stop, Reset, Step into, Step over, Step out, Run-to-Cursor
- Debugging on C and high-level language source code level
- Debugging on Assembler and disassembler level
- 1 dedicated program address or source level breakpoint for AVR Studio / debugger
- 4 Hardware Breakpoints
- Unlimited Number of User Program Breakpoints
- Unlimited Number of User Data Breakpoints, with break on:
  - Data location read, write or both read and write
  - Data location content equal or not equal to a value
  - Data location content is greater or less than a value
  - Data location content is within or outside a range
  - Bits of a data location are equal or not equal to a value
- Non-Intrusive Operation
  - No hardware or software resources in the device are used
- High Speed Operation
  - No limitation on debug/programming clock frequency versus system clock frequency

25.2 Overview

The XMEGA D3 has a powerful On-Chip Debug (OCD) system that - in combination with Atmel's development tools - provides all the necessary functions to debug an application. It has support for program and data breakpoints, and can debug an application from C and high level language source code level, as well as assembler and disassembler level. It has full Non-Intrusive Operation and no hardware or software resources in the device are used. The ODC system is accessed through an external debugging tool which connects to the PDI interface. Refer to "PDI - Program and Debug Interface" on page 45.

26. PDI - Program and Debug Interface

26.1 Features

- **PDI - Program and Debug Interface (Atmel proprietary 2-pin interface)**
- **Access to the OCD system**
- **Programming of Flash, EEPROM, Fuses and Lock Bits**

26.2 Overview

The programming and debug facilities are accessed through the PDI interface. The PDI physical interface uses one dedicated pin together with the Reset pin, and no general purpose pins are used.

The PDI is an Atmel proprietary protocol for communication between the microcontroller and Atmel's or third party development tools.

27. Pinout and Pin Functions

The pinout of XMEGA D3 is shown in "" on page 2. In addition to general I/O functionality, each pin may have several function. This will depend on which peripheral is enabled and connected to the actual pin. Only one of the alternate pin functions can be used at time.

27.1 Alternate Pin Function Description

The tables below show the notation for all pin functions available and describe its function.

27.1.1 Operation/Power Supply

VCC	Digital supply voltage
AVCC	Analog supply voltage
GND	Ground

27.1.2 Port Interrupt functions

SYNC	Port pin with full synchronous and limited asynchronous interrupt function
ASYNC	Port pin with full synchronous and full asynchronous interrupt function

27.1.3 Analog functions

ACn	Analog Comparator input pin n
AC0OUT	Analog Comparator 0 Output
ADCn	Analog to Digital Converter input pin n
AREF	Analog Reference input pin

27.1.4 Timer/Counter and AWEX functions

OCnx	Output Compare Channel x for Timer/Counter n
$\overline{\text{OCnx}}$	Inverted Output Compare Channel x for Timer/Counter n
OCnxLS	Output Compare Channel x Low Side for Timer/Counter n
OCnxHS	Output Compare Channel x High Side for Timer/Counter n

27.1.5 Communication functions

SCL	Serial Clock for TWI
SDA	Serial Data for TWI
SCLIN	Serial Clock In for TWI when external driver interface is enabled
SCLOUT	Serial Clock Out for TWI when external driver interface is enabled
SDAIN	Serial Data In for TWI when external driver interface is enabled
SDAOUT	Serial Data Out for TWI when external driver interface is enabled
XCKn	Transfer Clock for USART n
RXDn	Receiver Data for USART n
TXDn	Transmitter Data for USART n
$\overline{SS}$	Slave Select for SPI
MOSI	Master Out Slave In for SPI
MISO	Master In Slave Out for SPI
SCK	Serial Clock for SPI

27.1.6 Oscillators, Clock and Event

TOSCn	Timer Oscillator pin n
XTALn	Input/Output for inverting Oscillator pin n
CLKOUT	Peripheral Clock Output
EVOUT	Event Channel 0 Output

27.1.7 Debug/System functions

$\overline{RESET}$	Reset pin
PDI_CLK	Program and Debug Interface Clock pin
PDI_DATA	Program and Debug Interface Data pin

27.2 Alternate Pin Functions

The tables below show the main and alternate pin functions for all pins on each port. They also show which peripheral that makes use of or enables the alternate pin function.

Table 27-1. Port A - Alternate functions

PORT A	PIN #	INTERRUPT	ADCA POS	ADCA NEG	ADAA GAINPOS	ADCA GAINNEG	ACA POS	ACA NEG	ACA OUT	REFA
GND	60									
AVCC	61									
PA0	62	SYNC	ADC0	ADC0	ADC0		AC0	AC0		AREFA
PA1	63	SYNC	ADC1	ADC1	ADC1		AC1	AC1		
PA2	64	SYNC/ASYNC	ADC2	ADC2	ADC2		AC2			
PA3	1	SYNC	ADC3	ADC3	ADC3		AC3	AC3		
PA4	2	SYNC	ADC4		ADC4	ADC4	AC4			
PA5	3	SYNC	ADC5		ADC5	ADC5	AC5	AC5		
PA6	4	SYNC	ADC6		ADC6	ADC6	AC6			
PA7	5	SYNC	ADC7		ADC7	ADC7		AC7	AC0 OUT	

Table 27-2. Port B - Alternate functions

PORT B	PIN #	INTERRUPT	ADCA POS	REFB
PB0	6	SYNC	ADC8	AREFB
PB1	6	SYNC	ADC9	
PB2	8	SYNC/ASYNC	ADC10	
PB3	9	SYNC	ADC11	
PB4	10	SYNC	ADC12	
PB5	11	SYNC	ADC13	
PB6	12	SYNC	ADC14	
PB7	13	SYNC	ADC15	
GND	14			
VCC	15			

Table 27-3. Port C - Alternate functions

PORT C	PIN #	INTERRUPT	TCC0	AWEXC	TCC1	USARTC0	SPIC	TWIC	CLOCKOUT	EVENTOUT
PC0	16	SYNC	OC0A	OC0ALS				SDA		
PC1	17	SYNC	OC0B	OC0AHS		XCK0		SCL		
PC2	18	SYNC/ASYNC	OC0C	OC0BLS		RXD0				
PC3	19	SYNC	OC0D	OC0BHS		TXD0				
PC4	20	SYNC		OC0CLS	OC1A		$\overline{SS}$			
PC5	21	SYNC		OC0CHS	OC1B		MOSI			
PC6	22	SYNC		OC0DLS			MISO			
PC7	23	SYNC		OC0DHS			SCK		CLKOUT	EVOUT
GND	24									
VCC	25									

Table 27-4. Port D - Alternate functions

PORT D	PIN #	INTERRUPT	TCD0	USARTD0	SPID	CLOCKOUT	EVENTOUT
PD0	26	SYNC	OC0A				
PD1	27	SYNC	OC0B	XCK0			
PD2	28	SYNC/ASYNC	OC0C	RXD0			
PD3	29	SYNC	OC0D	TXD0			
PD4	30	SYNC			$\overline{SS}$		
PD5	31	SYNC			MOSI		
PD6	32	SYNC			MISO		
PD7	33	SYNC			SCK	CLKOUT	EVOUT
GND	34						
VCC	35						

Table 27-5. Port E - Alternate functions

PORT E	PIN #	INTERRUPT	TCE0	USARTE0	CLOCKOUT	EVENTOUT	TOSC	TWIE
PE0	36	SYNC	OC0A					SDA
PE1	37	SYNC	OC0B	XCK0				SCL
PE2	38	SYNC/ASYNC	OC0C	RXD0				
PE3	39	SYNC	OC0D	TXD0				
PE4	40	SYNC						
PE5	41	SYNC						
PE6	42	SYNC					TOSC1	
PE7	43	SYNC			CLKOUT	EVOUT	TOSC1	
GND	44							
VCC	45							

Table 27-6. Port F - Alternate functions

PORT F	PIN #	INTERRUPT	TCF0
PF0	46	SYNC	OC0A
PF1	47	SYNC	OC0B
PF2	48	SYNC/ASYNC	OC0C
PF3	49	SYNC	OC0D
PF4	50	SYNC	
PF5	51	SYNC	
PF6	54	SYNC	
PF7	55	SYNC	
GND	52		
VCC	53		

Table 27-7. Port R - Alternate functions

PORT R	PIN #	INTERRUPT	PDI	XTAL
PDI	56		PDI_DATA	
$\overline{\text{RESET}}$	57		PDI_CLOCK	
PR0	58	SYNC		XTAL2
PR1	59	SYNC		XTAL1

28. Peripheral Module Address Map

The address maps show the base address for each peripheral and module in XMEGA D3. For complete register description and summary for each peripheral module, refer to the XMEGA A Manual.

Table 28-1. Peripheral Module Address Map

Base Address	Name	Description
0x0000	GPIO	General Purpose IO Registers
0x0010	VPORT0	Virtual Port 0
0x0014	VPORT1	Virtual Port 1
0x0018	VPORT2	Virtual Port 2
0x001C	VPORT3	Virtual Port 2
0x0030	CPU	CPU
0x0040	CLK	Clock Control
0x0048	SLEEP	Sleep Controller
0x0050	OSC	Oscillator Control
0x0060	DFLLRC32M	DFLL for the 32 MHz Internal RC Oscillator
0x0068	DFLLRC2M	DFLL for the 2 MHz RC Oscillator
0x0070	PR	Power Reduction
0x0078	RST	Reset Controller
0x0080	WDT	Watch-Dog Timer
0x0090	MCU	MCU Control
0x00A0	PMIC	Programmable MUltilevel Interrupt Controller
0x00B0	PORTCFG	Port Configuration
0x0180	EVSYS	Event System
0x01C0	NVM	Non Volatile Memory (NVM) Controller
0x0200	ADCA	Analog to Digital Converter on port A
0x0380	ACA	Analog Comparator pair on port A
0x0400	RTC	Real Time Counter
0x0480	TWIC	Two Wire Interface on port C
0x04A0	TWIE	Two Wire Interface on port E
0x0600	PORTA	Port A
0x0620	PORTB	Port B
0x0640	PORTC	Port C
0x0660	PORTD	Port D
0x0680	PORTE	Port E
0x06A0	PORTF	Port F
0x07E0	PORTR	Port R
0x0800	TCC0	Timer/Counter 0 on port C
0x0840	TCC1	Timer/Counter 1 on port C
0x0880	AWEXC	Advanced Waveform Extension on port C
0x0890	HIRESC	High Resolution Extension on port C
0x08A0	USARTC0	USART 0 on port C
0x08C0	SPIC	Serial Peripheral Interface on port C
0x08F8	IRCOM	Infrared Communication Module
0x0900	TCD0	Timer/Counter 0 on port D
0x09A0	USARTD0	USART 0 on port D
0x09C0	SPID	Serial Peripheral Interface on port D
0x0A00	TCE0	Timer/Counter 0 on port E
0x0A80	AWEXE	Advanced Waveform Extensionon port E
0x0AA0	USARTE0	USART 0 on port E
0x0AC0	SPIE	Serial Peripheral Interface on port E
0x0B00	TCF0	Timer/Counter 0 on port F

29. Instruction Set Summary

Mnemonics	Operands	Description	Operation	Flags	#Clocks
Arithmetic and Logic Instructions					
ADD	Rd, Rr	Add without Carry	Rd ← Rd + Rr	Z,C,N,V,S,H	1
ADC	Rd, Rr	Add with Carry	Rd ← Rd + Rr + C	Z,C,N,V,S,H	1
ADIW	Rd, K	Add Immediate to Word	Rd ← Rd + 1:Rd + K	Z,C,N,V,S	2
SUB	Rd, Rr	Subtract without Carry	Rd ← Rd - Rr	Z,C,N,V,S,H	1
SUBI	Rd, K	Subtract Immediate	Rd ← Rd - K	Z,C,N,V,S,H	1
SBC	Rd, Rr	Subtract with Carry	Rd ← Rd - Rr - C	Z,C,N,V,S,H	1
SBCI	Rd, K	Subtract Immediate with Carry	Rd ← Rd - K - C	Z,C,N,V,S,H	1
SBIW	Rd, K	Subtract Immediate from Word	Rd + 1:Rd ← Rd + 1:Rd - K	Z,C,N,V,S	2
AND	Rd, Rr	Logical AND	Rd ← Rd • Rr	Z,N,V,S	1
ANDI	Rd, K	Logical AND with Immediate	Rd ← Rd • K	Z,N,V,S	1
OR	Rd, Rr	Logical OR	Rd ← Rd v Rr	Z,N,V,S	1
ORI	Rd, K	Logical OR with Immediate	Rd ← Rd v K	Z,N,V,S	1
EOR	Rd, Rr	Exclusive OR	Rd ← Rd ⊕ Rr	Z,N,V,S	1
COM	Rd	One's Complement	Rd ← $FF - Rd	Z,C,N,V,S	1
NEG	Rd	Two's Complement	Rd ← $00 - Rd	Z,C,N,V,S,H	1
SBR	Rd,K	Set Bit(s) in Register	Rd ← Rd v K	Z,N,V,S	1
CBR	Rd,K	Clear Bit(s) in Register	Rd ← Rd • ($FFh - K)	Z,N,V,S	1
INC	Rd	Increment	Rd ← Rd + 1	Z,N,V,S	1
DEC	Rd	Decrement	Rd ← Rd - 1	Z,N,V,S	1
TST	Rd	Test for Zero or Minus	Rd ← Rd • Rd	Z,N,V,S	1
CLR	Rd	Clear Register	Rd ← Rd ⊕ Rd	Z,N,V,S	1
SER	Rd	Set Register	Rd ← $FF	None	1
MUL	Rd,Rr	Multiply Unsigned	R1:R0 ← Rd x Rr (UU)	Z,C	2
MULS	Rd,Rr	Multiply Signed	R1:R0 ← Rd x Rr (SS)	Z,C	2
MULSU	Rd,Rr	Multiply Signed with Unsigned	R1:R0 ← Rd x Rr (SU)	Z,C	2
FMUL	Rd,Rr	Fractional Multiply Unsigned	R1:R0 ← Rd x Rr<<1 (UU)	Z,C	2
FMULS	Rd,Rr	Fractional Multiply Signed	R1:R0 ← Rd x Rr<<1 (SS)	Z,C	2
FMULSU	Rd,Rr	Fractional Multiply Signed with Unsigned	R1:R0 ← Rd x Rr<<1 (SU)	Z,C	2
Branch Instructions					
RJMP	k	Relative Jump	PC ← PC + k + 1	None	2
IJMP		Indirect Jump to (Z)	PC(15:0) ← Z, PC(21:16) ← 0	None	2
EIJMP		Extended Indirect Jump to (Z)	PC(15:0) ← Z, PC(21:16) ← EIND	None	2
JMP	k	Jump	PC ← k	None	3
RCALL	k	Relative Call Subroutine	PC ← PC + k + 1	None	2 / 3(1)
ICALL		Indirect Call to (Z)	PC(15:0) ← Z, PC(21:16) ← 0	None	2 / 3(1)
EICALL		Extended Indirect Call to (Z)	PC(15:0) ← Z, PC(21:16) ← EIND	None	3(1)
CALL	k	call Subroutine	PC ← k	None	3 / 4(1)

Mnemonics	Operands	Description	Operation	Flags	#Clocks
RET		Subroutine Return	PC ← STACK	None	4 / 5[1]
RETI		Interrupt Return	PC ← STACK	I	4 / 5[1]
CPSE	Rd,Rr	Compare, Skip if Equal	if (Rd = Rr) PC ← PC + 2 or 3	None	1 / 2 / 3
CP	Rd,Rr	Compare	Rd - Rr	Z,C,N,V,S,H	1
CPC	Rd,Rr	Compare with Carry	Rd - Rr - C	Z,C,N,V,S,H	1
CPI	Rd,K	Compare with Immediate	Rd - K	Z,C,N,V,S,H	1
SBRC	Rr, b	Skip if Bit in Register Cleared	if (Rr(b) = 0) PC ← PC + 2 or 3	None	1 / 2 / 3
SBRS	Rr, b	Skip if Bit in Register Set	if (Rr(b) = 1) PC ← PC + 2 or 3	None	1 / 2 / 3
SBIC	A, b	Skip if Bit in I/O Register Cleared	if (I/O(A,b) = 0) PC ← PC + 2 or 3	None	2 / 3 / 4
SBIS	A, b	Skip if Bit in I/O Register Set	If (I/O(A,b) =1) PC ← PC + 2 or 3	None	2 / 3 / 4
BRBS	s, k	Branch if Status Flag Set	if (SREG(s) = 1) then PC ← PC + k + 1	None	1 / 2
BRBC	s, k	Branch if Status Flag Cleared	if (SREG(s) = 0) then PC ← PC + k + 1	None	1 / 2
BREQ	k	Branch if Equal	if (Z = 1) then PC ← PC + k + 1	None	1 / 2
BRNE	k	Branch if Not Equal	if (Z = 0) then PC ← PC + k + 1	None	1 / 2
BRCS	k	Branch if Carry Set	if (C = 1) then PC ← PC + k + 1	None	1 / 2
BRCC	k	Branch if Carry Cleared	if (C = 0) then PC ← PC + k + 1	None	1 / 2
BRSH	k	Branch if Same or Higher	if (C = 0) then PC ← PC + k + 1	None	1 / 2
BRLO	k	Branch if Lower	if (C = 1) then PC ← PC + k + 1	None	1 / 2
BRMI	k	Branch if Minus	if (N = 1) then PC ← PC + k + 1	None	1 / 2
BRPL	k	Branch if Plus	if (N = 0) then PC ← PC + k + 1	None	1 / 2
BRGE	k	Branch if Greater or Equal, Signed	if (N ⊕ V= 0) then PC ← PC + k + 1	None	1 / 2
BRLT	k	Branch if Less Than, Signed	if (N ⊕ V= 1) then PC ← PC + k + 1	None	1 / 2
BRHS	k	Branch if Half Carry Flag Set	if (H = 1) then PC ← PC + k + 1	None	1 / 2
BRHC	k	Branch if Half Carry Flag Cleared	if (H = 0) then PC ← PC + k + 1	None	1 / 2
BRTS	k	Branch if T Flag Set	if (T = 1) then PC ← PC + k + 1	None	1 / 2
BRTC	k	Branch if T Flag Cleared	if (T = 0) then PC ← PC + k + 1	None	1 / 2
BRVS	k	Branch if Overflow Flag is Set	if (V = 1) then PC ← PC + k + 1	None	1 / 2
BRVC	k	Branch if Overflow Flag is Cleared	if (V = 0) then PC ← PC + k + 1	None	1 / 2
BRIE	k	Branch if Interrupt Enabled	if (I = 1) then PC ← PC + k + 1	None	1 / 2
BRID	k	Branch if Interrupt Disabled	if (I = 0) then PC ← PC + k + 1	None	1 / 2
Data Transfer Instructions					
MOV	Rd, Rr	Copy Register	Rd ← Rr	None	1
MOVW	Rd, Rr	Copy Register Pair	Rd+1:Rd ← Rr+1:Rr	None	1
LDI	Rd, K	Load Immediate	Rd ← K	None	1
LDS	Rd, k	Load Direct from data space	Rd ← (k)	None	2[1][2]
LD	Rd, X	Load Indirect	Rd ← (X)	None	1[1][2]
LD	Rd, X+	Load Indirect and Post-Increment	Rd ← (X) X ← X + 1	None	1[1][2]
LD	Rd, -X	Load Indirect and Pre-Decrement	X ← X - 1, ← X - 1 Rd ← (X) ← (X)	None	2[1][2]
LD	Rd, Y	Load Indirect	Rd ← (Y) ← (Y)	None	1[1][2]
LD	Rd, Y+	Load Indirect and Post-Increment	Rd ← (Y) Y ← Y + 1	None	1[1][2]

Mnemonics	Operands	Description	Operation	Flags	#Clocks
LD	Rd, -Y	Load Indirect and Pre-Decrement	Y ← Y - 1 Rd ← (Y)	None	2[1][2]
LDD	Rd, Y+q	Load Indirect with Displacement	Rd ← (Y + q)	None	2[1][2]
LD	Rd, Z	Load Indirect	Rd ← (Z)	None	1[1][2]
LD	Rd, Z+	Load Indirect and Post-Increment	Rd ← (Z), Z ← Z+1	None	1[1][2]
LD	Rd, -Z	Load Indirect and Pre-Decrement	Z ← Z - 1, Rd ← (Z)	None	2[1][2]
LDD	Rd, Z+q	Load Indirect with Displacement	Rd ← (Z + q)	None	2[1][2]
STS	k, Rr	Store Direct to Data Space	(k) ← Rd	None	2[1]
ST	X, Rr	Store Indirect	(X) ← Rr	None	1[1]
ST	X+, Rr	Store Indirect and Post-Increment	(X) ← Rr, X ← X + 1	None	1[1]
ST	-X, Rr	Store Indirect and Pre-Decrement	X ← X - 1, (X) ← Rr	None	2[1]
ST	Y, Rr	Store Indirect	(Y) ← Rr	None	1[1]
ST	Y+, Rr	Store Indirect and Post-Increment	(Y) ← Rr, Y ← Y + 1	None	1[1]
ST	-Y, Rr	Store Indirect and Pre-Decrement	Y ← Y - 1, (Y) ← Rr	None	2[1]
STD	Y+q, Rr	Store Indirect with Displacement	(Y + q) ← Rr	None	2[1]
ST	Z, Rr	Store Indirect	(Z) ← Rr	None	1[1]
ST	Z+, Rr	Store Indirect and Post-Increment	(Z) ← Rr Z ← Z + 1	None	1[1]
ST	-Z, Rr	Store Indirect and Pre-Decrement	Z ← Z - 1	None	2[1]
STD	Z+q,Rr	Store Indirect with Displacement	(Z + q) ← Rr	None	2[1]
LPM		Load Program Memory	R0 ← (Z)	None	3
LPM	Rd, Z	Load Program Memory	Rd ← (Z)	None	3
LPM	Rd, Z+	Load Program Memory and Post-Increment	Rd ← (Z), Z ← Z + 1	None	3
ELPM		Extended Load Program Memory	R0 ← (RAMPZ:Z)	None	3
ELPM	Rd, Z	Extended Load Program Memory	Rd ← (RAMPZ:Z)	None	3
ELPM	Rd, Z+	Extended Load Program Memory and Post-Increment	Rd ← (RAMPZ:Z), Z ← Z + 1	None	3
SPM		Store Program Memory	(RAMPZ:Z) ← R1:R0	None	-
SPM	Z+	Store Program Memory and Post-Increment by 2	(RAMPZ:Z) ← R1:R0, Z ← Z + 2	None	-
IN	Rd, A	In From I/O Location	Rd ← I/O(A)	None	1
OUT	A, Rr	Out To I/O Location	I/O(A) ← Rr	None	1
PUSH	Rr	Push Register on Stack	STACK ← Rr	None	1[1]
POP	Rd	Pop Register from Stack	Rd ← STACK	None	2[1]
Bit and Bit-test Instructions					
LSL	Rd	Logical Shift Left	Rd(n+1) ← Rd(n), Rd(0) ← 0, C ← Rd(7)	Z,C,N,V,H	1
LSR	Rd	Logical Shift Right	Rd(n) ← Rd(n+1), Rd(7) ← 0, C ← Rd(0)	Z,C,N,V	1

Mnemonics	Operands	Description	Operation	Flags	#Clocks
ROL	Rd	Rotate Left Through Carry	Rd(0) ← C, Rd(n+1) ← Rd(n), C ← Rd(7)	Z,C,N,V,H	1
ROR	Rd	Rotate Right Through Carry	Rd(7) ← C, Rd(n) ← Rd(n+1), C ← Rd(0)	Z,C,N,V	1
ASR	Rd	Arithmetic Shift Right	Rd(n) ← Rd(n+1), n=0..6	Z,C,N,V	1
SWAP	Rd	Swap Nibbles	Rd(3..0) ↔ Rd(7..4)	None	1
BSET	s	Flag Set	SREG(s) ← 1	SREG(s)	1
BCLR	s	Flag Clear	SREG(s) ← 0	SREG(s)	1
SBI	A, b	Set Bit in I/O Register	I/O(A, b) ← 1	None	1
CBI	A, b	Clear Bit in I/O Register	I/O(A, b) ← 0	None	1
BST	Rr, b	Bit Store from Register to T	T ← Rr(b)	T	1
BLD	Rd, b	Bit load from T to Register	Rd(b) ← T	None	1
SEC		Set Carry	C ← 1	C	1
CLC		Clear Carry	C ← 0	C	1
SEN		Set Negative Flag	N ← 1	N	1
CLN		Clear Negative Flag	N ← 0	N	1
SEZ		Set Zero Flag	Z ← 1	Z	1
CLZ		Clear Zero Flag	Z ← 0	Z	1
SEI		Global Interrupt Enable	I ← 1	I	1
CLI		Global Interrupt Disable	I ← 0	I	1
SES		Set Signed Test Flag	S ← 1	S	1
CLS		Clear Signed Test Flag	S ← 0	S	1
SEV		Set Two's Complement Overflow	V ← 1	V	1
CLV		Clear Two's Complement Overflow	V ← 0	V	1
SET		Set T in SREG	T ← 1	T	1
CLT		Clear T in SREG	T ← 0	T	1
SEH		Set Half Carry Flag in SREG	H ← 1	H	1
CLH		Clear Half Carry Flag in SREG	H ← 0	H	1
MCU Control Instructions					
BREAK		Break	(See specific descr. for BREAK)	None	1
NOP		No Operation		None	1
SLEEP		Sleep	(see specific descr. for Sleep)	None	1
WDR		Watchdog Reset	(see specific descr. for WDR)	None	1

Notes: 1. Cycle times for Data memory accesses assume internal memory accesses, and are not valid for accesses via the external RAM interface.
2. One extra cycle must be added when accessing Internal SRAM.

30. Electrical Characteristics

All typical values are measured at T = 25°C unless other temperature condition is given. All minimum and maximum values are valid across operating temperature and voltage unless other conditions are given.

30.1 Absolute Maximum Ratings*

Operating Temperature	-55°C to +125°C
Storage Temperature	-65°C to +150°C
Voltage on any Pin with respect to Ground	-0.5V to V_{CC}+0.5V
Maximum Operating Voltage	3.6V
DC Current per I/O Pin	20.0 mA
DC Current V_{CC} and GND Pins	200.0 mA

*NOTICE: Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

30.2 DC Characteristics

Table 30-1. Current Consumption

Symbol	Parameter	Condition			Min	Typ	Max	Units
I_{CC}	Power Supply Current[1]	Active	32 kHz, Ext. Clk	V_{CC} = 1.8V		25		µA
				V_{CC} = 3.0V		71		
			1 MHz, Ext. Clk	V_{CC} = 1.8V		317		
				V_{CC} = 3.0V		697		
			2 MHz, Ext. Clk	V_{CC} = 1.8V		613	800	
				V_{CC} = 3.0V		1340	1800	
			32 MHz, Ext. Clk	V_{CC} = 3.0V		15.7	18	mA
		Idle	32 kHz, Ext. Clk	V_{CC} = 1.8V		3.6		µA
				V_{CC} = 3.0V		6.9		
			1 MHz, Ext. Clk	V_{CC} = 1.8V		112		
				V_{CC} = 3.0V		215		
			2 MHz, Ext. Clk	V_{CC} = 1.8V		224	350	
				V_{CC} = 3.0V		430	650	
			32 MHz, Ext. Clk	V_{CC} = 3.0V		6.9	8	mA
	Power-down mode	All Functions Disabled, T = 25°C		V_{CC} = 3.0V		0.1	3	µA
		All Functions Disabled, T = 85°C		V_{CC} = 3.0V		1.75	5	
		ULP, WDT, Sampled BOD, T = 25°C		V_{CC} = 1.8V		1	6	
				V_{CC} = 3.0V		1	6	
		ULP, WDT, Sampled BOD, T=85°C		V_{CC} = 3.0V		2.7	10	

Table 30-1. Current Consumption

Symbol	Parameter	Condition		Min	Typ	Max	Units
I_{CC}	Power-save mode	RTC 1 kHz from Low Power 32 kHz TOSC, T = 25°C	V_{CC} = 1.8V		0.5	4	µA
			V_{CC} = 3.0V		0.7	4	
		RTC from Low Power 32 kHz TOSC	V_{CC} = 3.0V		1.16		
	Reset Current Consumption	without Reset pull-up resistor current	V_{CC} = 3.0V		1300		
Module current consumption[2]							
I_{CC}	RC32M				460		µA
	RC32M w/DFLL	Internal 32.768 kHz oscillator as DFLL source			594		
	RC2M				101		
	RC2M w/DFLL	Internal 32.768 kHz oscillator as DFLL source			134		
	RC32K				27		
	PLL	Multiplication factor = 10x			202		
	Watchdog normal mode				1		
	BOD Continuous mode				128		
	BOD Sampled mode				1		
	Internal 1.00 V ref				80		
	Temperature reference				74		
	RTC with int. 32 kHz RC as source	No prescaling			27		
	RTC with ULP as source	No prescaling			1		
	AC				103		
	USART	Rx and Tx enabled, 9600 BAUD			5.4		
	Timer/Counter	Prescaler DIV1			20		
	Flash/EEPROM Programming	Vcc = 2V			25		mA
		Vcc = 3V			33		

Notes: 1. All Power Reduction Registers set.
2. All parameters measured as the difference in current consumption between module enabled and disabled. All data at V_{CC} = 3.0V, Clk_{SYS} = 1 MHz External clock with no prescaling.

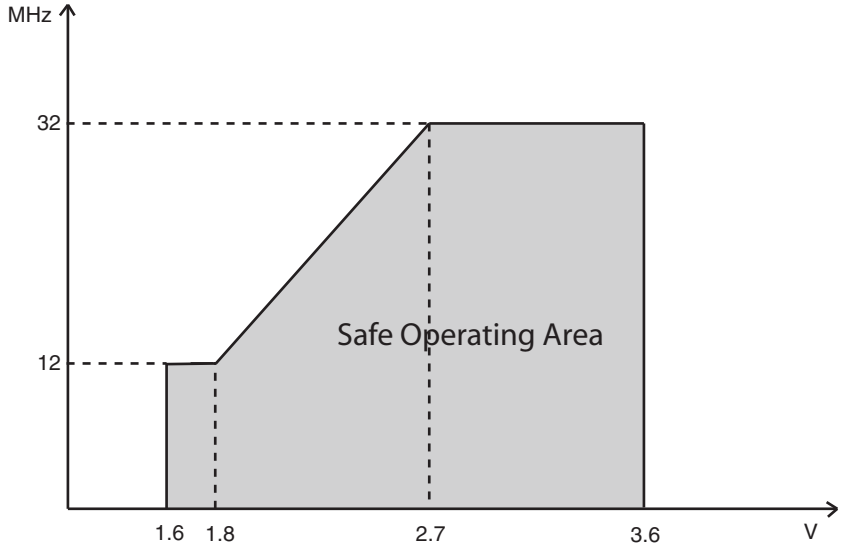
30.3 Operating Voltage and Frequency

Table 30-2. Operating voltage and frequency

Symbol	Parameter	Condition	Min	Typ	Max	Units
Clk_{CPU}	CPU clock frequency	V_{CC} = 1.6V	0		12	MHz
		V_{CC} = 1.8V	0		12	
		V_{CC} = 2.7V	0		32	
		V_{CC} = 3.6V	0		32	

The maximum CPU clock frequency of the XMEGA D3 devices is depending on V_{CC}. As shown in Figure 30-1 on page 58 the Frequency vs. V_{CC} curve is linear between 1.8V < V_{CC} < 2.7V.

Figure 30-1. Maximum Frequency vs. Vcc



30.4 Flash and EEPROM Memory Characteristics

Table 30-3. Endurance and Data Retention

Symbol	Parameter	Condition		Min	Typ	Max	Units
	Flash	Write/Erase cycles	25°C	10K			Cycle
			85°C	10K			
		Data retention	25°C	100			Year
			55°C	25			
	EEPROM	Write/Erase cycles	25°C	80K			Cycle
			85°C	30K			
		Data retention	25°C	100			Year
			55°C	25			

Table 30-4. Programming time

Symbol	Parameter	Condition	Min	Typ[1]	Max	Units
	Chip Erase	Flash, EEPROM[2] and SRAM Erase		40		ms
	Flash	Page Erase		6		
		Page Write		6		
		Page WriteAutomatic Page Erase and Write		12		
	EEPROM	Page Erase		6		
		Page Write		6		
		Page WriteAutomatic Page Erase and Write		12		

Notes: 1. Programming is timed from the internal 2 MHz oscillator.
2. EEPROM is not erased if the EESAVE fuse is programmed.

30.5 ADC Characteristics

Table 30-5. ADC Characteristics

Symbol	Parameter	Condition	Min	Typ	Max	Units
RES	Resolution	Programmable: 8/12	8	12	12	Bits
INL	Integral Non-Linearity	Differential mode, 80ksps	-5	±2	5	LSB
DNL	Differential Non-Linearity	Differential mode, 80ksps		< ±1		
	Gain Error			< ±10		mV
	Offset Error			< ±2		
ADC_{clk}	ADC Clock frequency	Max is 1/4 of Peripheral Clock			1400	kHz
	Conversion rate				200	ksps
	Conversion time (propagation delay)	(RES+2)/2+GAIN RES = 8 or 12, GAIN = 0, 1, 2 or 3	5	7	10	ADC_{clk} cycles
	Sampling Time	1/2 ADC_{clk} cycle	0.36			uS
	Conversion range		0		VREF	V
AVCC	Analog Supply Voltage		V_{cc}-0.3		V_{cc}+0.3	
VREF	Reference voltage		1.0		V_{cc}-0.6V	
	Input bandwidth					kHz
INT1V	Internal 1.00V reference(1)			1.00		V
INTVCC	Internal V_{CC}/1.6			V_{CC}/1.6		
SCALEDVCC	Scaled internal V_{CC}/10 input			V_{CC}/10		
R_{AREF}	Reference input resistance			> 10		MΩ
	Start-up time			12	24	ADC_{clk} cycles
	Internal input sampling speed	Temp. sensor, V_{CC}/10, Bandgap			100	ksps

Note: 1. Refer to "Bandgap Characteristics" on page 61 for more parameter details.

Table 30-6. ADC Gain Stage Characteristics

Symbol	Parameter	Condition		Min	Typ	Max	Units
	Gain error	1 to 64 gain			< ±1		%
	Offset error				< ±1		mV
Vrms	Noise level at input	64x gain	VREF = Int. 1V		0.12		
			VREF = Ext. 2V		0.06		
	Clock rate	Same as ADC				200	kHz

30.6 Analog Comparator Characteristics

Table 30-7. Analog Comparator Characteristics

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{off}	Input Offset Voltage	V_{CC} = 1.6 - 3.6V		<±10		mV
I_{lk}	Input Leakage Current	V_{CC} = 1.6 - 3.6V		< 1000		pA
V_{hys1}	Hysteresis, No	V_{CC} = 1.6 - 3.6V		0		mV
V_{hys2}	Hysteresis, Small	V_{CC} = 1.6 - 3.6V		20		mV
V_{hys3}	Hysteresis, Large	V_{CC} = 1.6 - 3.6V		40		
t_{delay}	Propagation delay	V_{CC} = 1.6 - 3.6V		175		ns

30.7 Bandgap Characteristics

Table 30-8. Bandgap Voltage Characteristics

Symbol	Parameter	Condition	Min	Typ	Max	Units
	Bandgap Startup Time	As reference for ADC	1 Clk_PER + 2.5µs			µs
		As input to AC or ADC		1.5		
	Bandgap voltage			1.1		V
INT1V	Internal 1.00V reference	T= 85°C, After calibration	0.99	1	1.01	
	Variation over voltage and temperature	V_{CC} = 1.6 - 3.6V, TA = -40°C to 85°C		±2		%

30.8 Brownout Detection Characteristics

Table 30-9. Brownout Detection Characteristics[1]

Symbol	Parameter	Condition	Min	Typ	Max	Units
	BOD level 0 falling Vcc	T= 85°C	1.62	1.63	1.7	V
	BOD level 1 falling Vcc			1.9		
	BOD level 2 falling Vcc			2.17		
	BOD level 3 falling Vcc			2.43		
	BOD level 4 falling Vcc			2.68		
	BOD level 5 falling Vcc			2.96		
	BOD level 6 falling Vcc			3.22		
	BOD level 7 falling Vcc			3.49		
	Hysteresis	BOD level 0-5		1		%

Note: 1. BOD is calibrated at 85°C within the BOD level 0 values, and BOD level 0 is the default level.

30.9 PAD Characteristics

Table 30-10. PAD Characteristics

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{IH}	Input High Voltage	V_{CC} = 2.4 - 3.6V	0.7*V_{CC}		V_{CC}+0.5	V
		V_{CC} = 1.6 - 2.4V	0.8*V_{CC}		V_{CC}+0.5	
V_{IL}	Input Low Voltage	V_{CC} = 2.4 - 3.6V	-0.5		0.3*V_{CC}	
		V_{CC} = 1.6 - 2.4V	-0.5		0.2*V_{CC}	
V_{OL}	Output Low Voltage GPIO	I_{OH} = 8 mA, V_{CC} = 3.3V		0.4	0.76	
		I_{OH} = 5 mA, V_{CC} = 3.0V		0.3	0.64	
		I_{OH} = 3 mA, V_{CC} = 1.8V		0.2	0.46	
V_{OH}	Output High Voltage GPIO	I_{OH} = -4 mA, V_{CC} = 3.3V	2.6	2.9		
		I_{OH} = -3 mA, V_{CC} = 3.0V	2.1	2.7		
		I_{OH} = -1 mA, V_{CC} = 1.8V	1.4	1.6		
I_{IL}	Input Leakage Current I/O pin			<0.001	1	µA
I_{IH}	Input Leakage Current I/O pin			<0.001	1	
R_P	I/O pin Pull/Buss keeper Resistor			20		kΩ
R_{RST}	Reset pin Pull-up Resistor			20		
	Input hysteresis			0.5		V

30.10 POR Characteristics

Table 30-11. Power-on Reset Characteristics

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{POT-}	POR threshold voltage falling V_{CC}	V_{CC} falls faster than 1V/ms	0.4	0.8		V
		V_{CC} falls at 1V/ms or slower	0.8	1.3		
V_{POT+}	POR threshold voltage rising V_{CC}			1.3	1.59	

30.11 Reset Characteristics

Table 30-12. Reset Characteristics

Symbol	Parameter	Condition	Min	Typ	Max	Units
	Minimum reset pulse width			90	1000	ns
	Reset threshold voltage	V_{CC} = 2.7 - 3.6V		0.45*V_{CC}		V
		V_{CC} = 1.6 - 2.7V		0.42*V_{CC}		

30.12 Oscillator Characteristics

Table 30-13. Internal 32.768kHz Oscillator Characteristics

Symbol	Parameter	Condition	Min	Typ	Max	Units
	Accuracy	T = 85°C, V_{CC} = 3V, After production calibration	-0.5		0.5	%

Table 30-14. Internal 2MHz Oscillator Characteristics

Symbol	Parameter	Condition	Min	Typ	Max	Units
	Accuracy	T = 85°C, V_{CC} = 3V, After production calibration	-1.5		1.5	%
	DFLL Calibration step size	T = 25°C, V_{CC} = 3V		0.15		

Table 30-15. Internal 32MHz Oscillator Characteristics

Symbol	Parameter	Condition	Min	Typ	Max	Units
	Accuracy	T = 85°C, V_{CC} = 3V, After production calibration	-1.5		1.5	%
	DFLL Calibration stepsize	T = 25°C, V_{CC} = 3V		0.2		

Table 30-16. Internal 32kHz, ULP Oscillator Characteristics

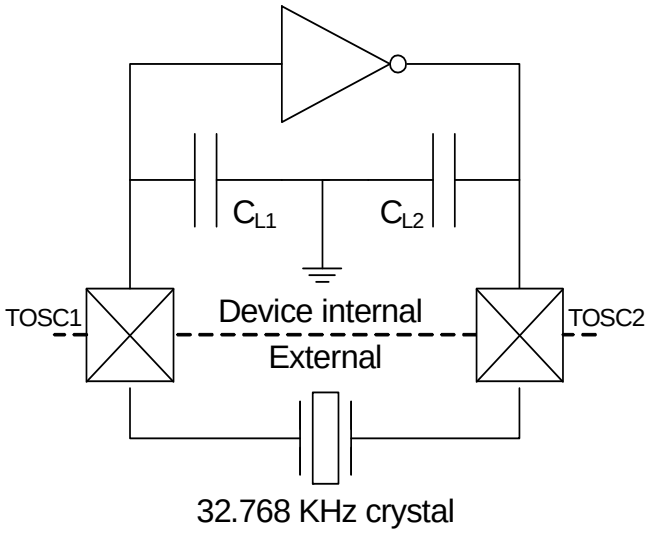
Symbol	Parameter	Condition	Min	Typ	Max	Units
	Output frequency 32 kHz ULP OSC	T = 85°C, V_{CC} = 3.0V		26		kHz

Table 30-17. External 32.768kHz Crystal Oscillator and TOSC characteristics

Symbol	Parameter	Condition	Min	Typ	Max	Units
SF	Safety factor	Capacitive load matched to crystal specification	3			
ESR/R_1	Recommended crystal equivalent series resistance (ESR)	Crystal load capacitance 6.5pF			60	kΩ
		Crystal load capacitance 9.0pF			35	
C_{IN_TOSC}	Input capacitance between TOSC pins	Normal mode		1.7		pF
		Low power mode		2.2		

Note: 1. See Figure 30-2 on page 64 for definition

Figure 30-2. TOSC input capacitance



The input capacitance between the TOSC pins is CL1 + CL2 in series as seen from the crystal when oscillating without external capacitors.

Table 30-18. Device wake-up time from sleep

Symbol	Parameter	Condition[1]	Min	Typ[2]	Max	Units
	Idle Sleep, Standby and Extended Standby sleep mode	Int. 32.768 kHz RC		130		µS
		Int. 2 MHz RC		2		
		Ext. 2 MHz Clock		2		
		Int. 32 MHz RC		0.17		
	Power-save and Power-down Sleep mode	Int. 32.768 kHz RC		320		
		Int. 2 MHz RC		10.3		
		Ext. 2 MHz Clock		4.5		
		Int. 32 MHz RC		5.8		

Notes: 1. Non-prescaled System Clock source.
2. Time from pin change on external interrupt pin to first available clock cycle. Additional interrupt response time is minimum 5 system clock source cycles.

31. Typical Characteristics

31.1 Active Supply Current

Figure 31-1. Active Supply Current vs. Frequency
f_{SYS} = 0 - 1.0 MHz External clock, T = 25°C

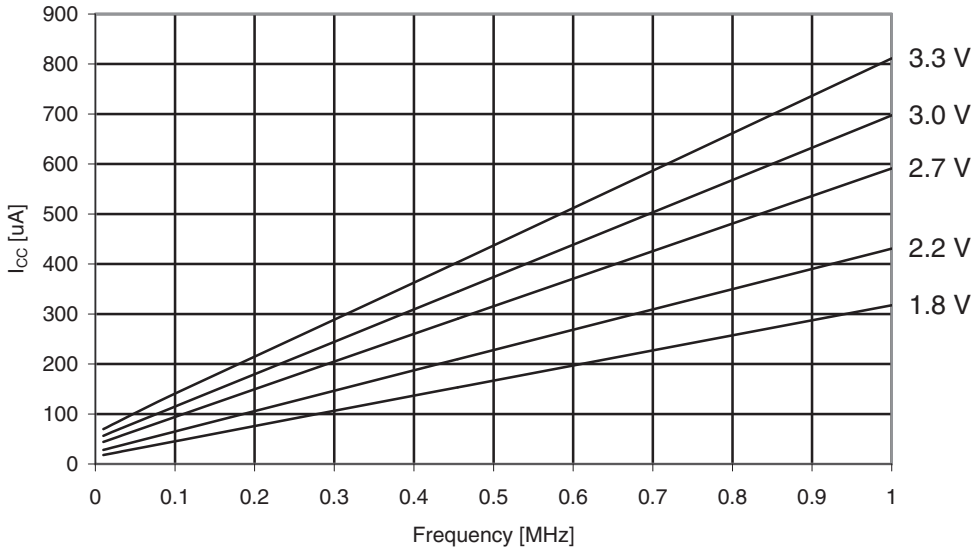


Figure 31-2. Active Supply Current vs. Frequency
f_{SYS} = 1 - 32 MHz External clock, T = 25°C

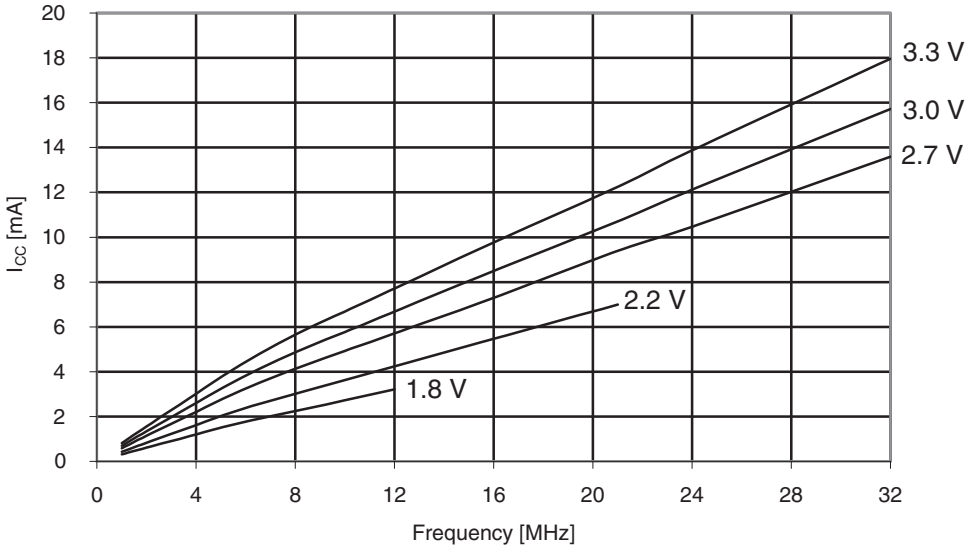


Figure 31-3. Active Supply Current vs. Vcc

f_{SYS} = 1.0 MHz External Clock

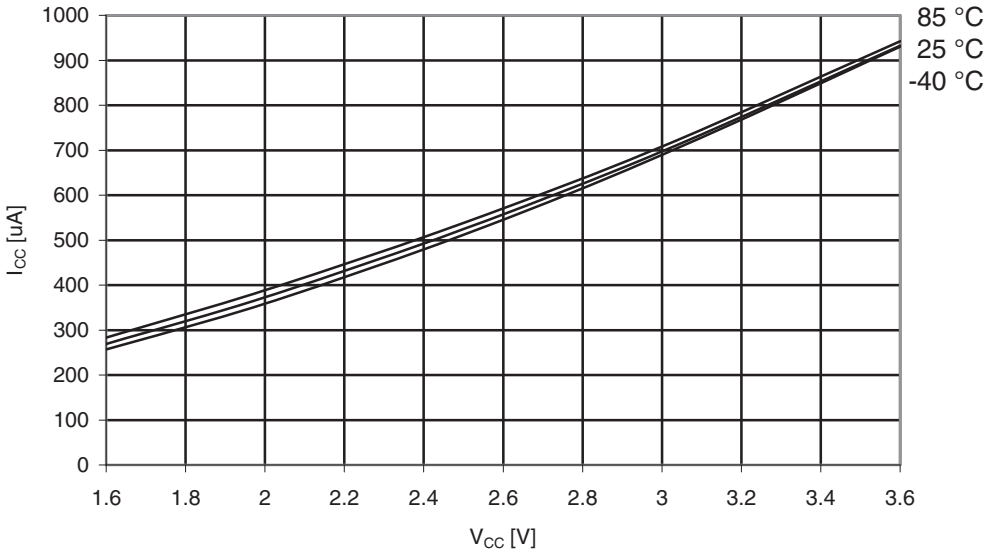


Figure 31-4. Active Supply Current vs. VCC

f_{SYS} = 32.768 kHz internal RC

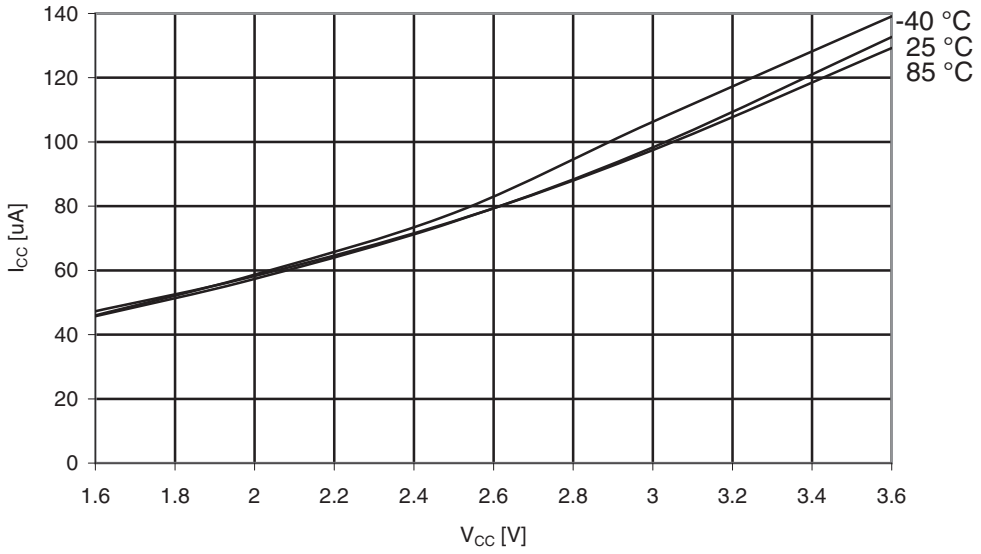


Figure 31-5. Active Supply Current vs. Vcc

f_{SYS} = 2.0 MHz internal RC

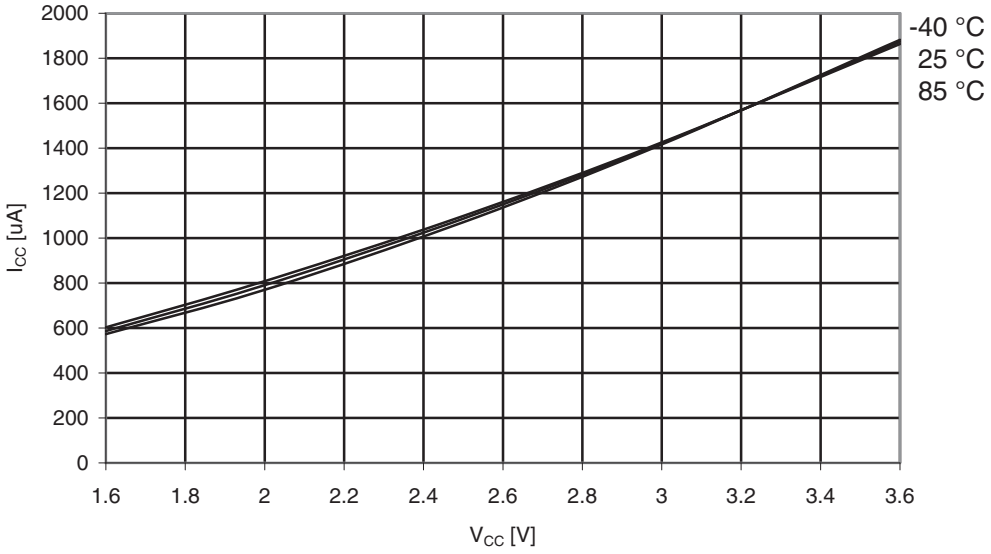


Figure 31-6. Active Supply Current vs. Vcc

f_{SYS} = 32 MHz internal RC prescaled to 8 MHz

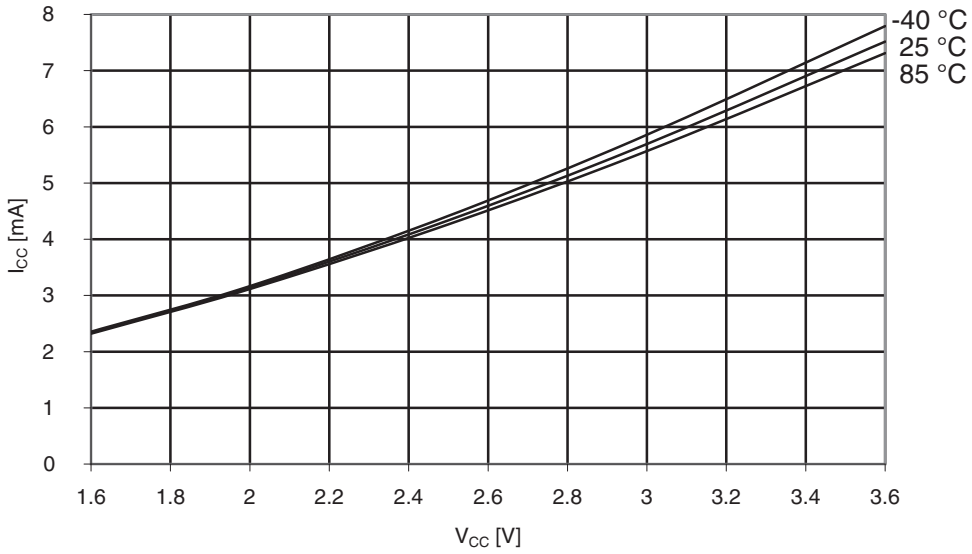
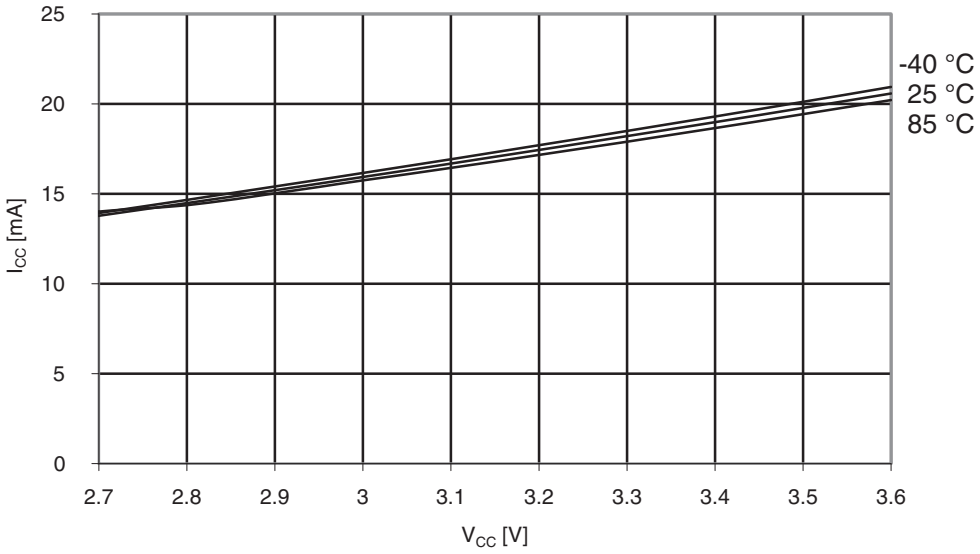


Figure 31-7. Active Supply Current vs. Vcc

f_{SYS} = 32 MHz internal RC



31.2 Idle Supply Current

Figure 31-8. Idle Supply Current vs. Frequency

f_{SYS} = 0 - 1.0 MHz, T = 25°C

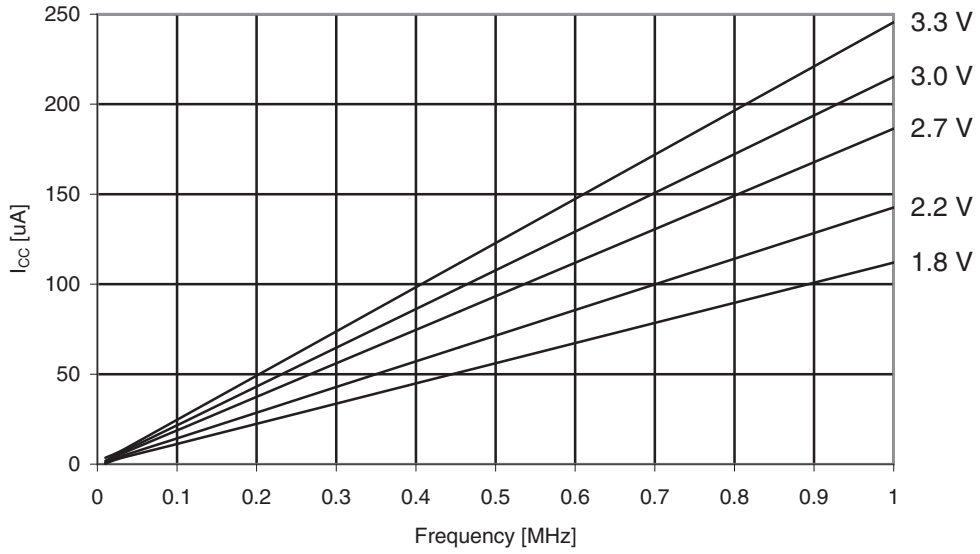


Figure 31-9. Idle Supply Current vs. Frequency

f_{SYS} = 1 - 32 MHz, T = 25°C

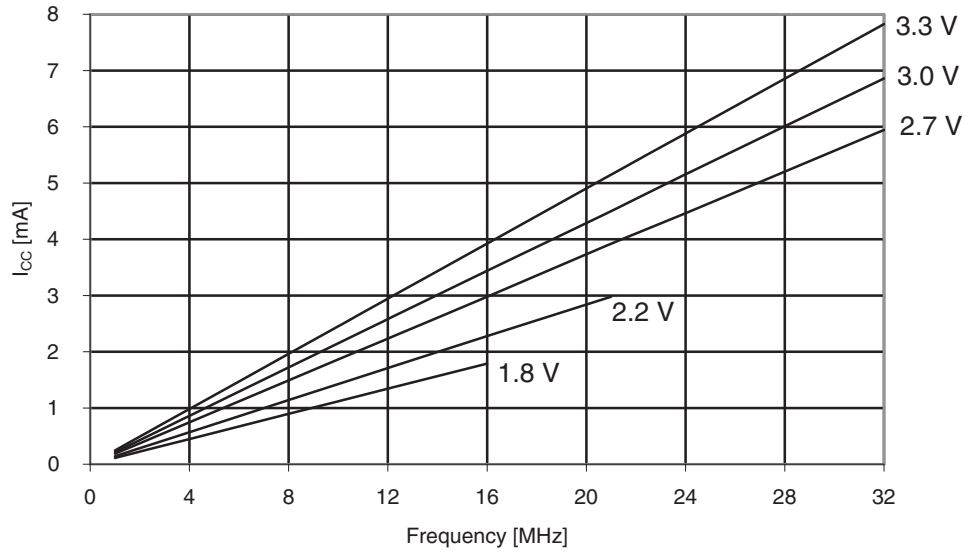


Figure 31-10. Idle Supply Current vs. Vcc

f_{SYS} = 1.0 MHz External Clock

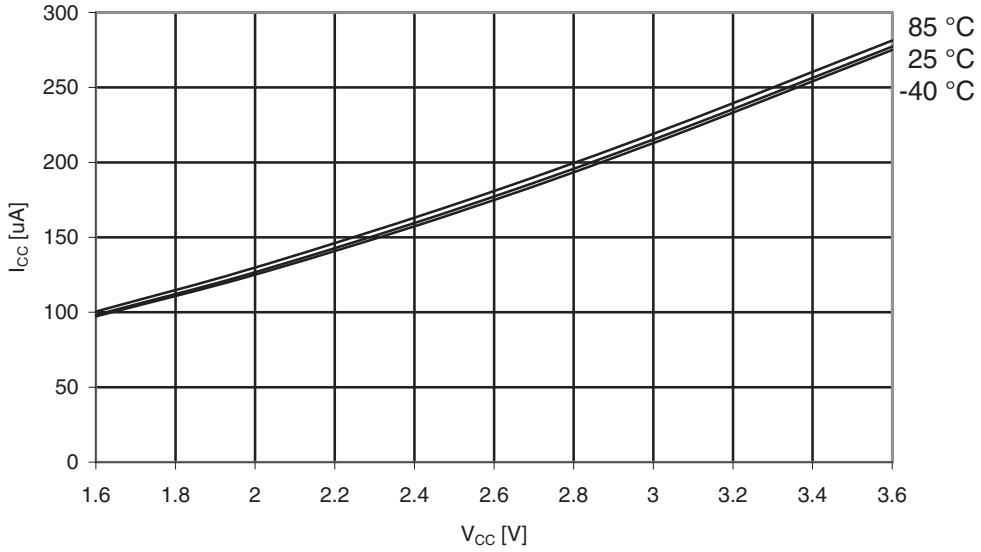


Figure 31-11. Idle Supply Current vs. Vcc

f_{SYS} = 32.768 kHz internal RC

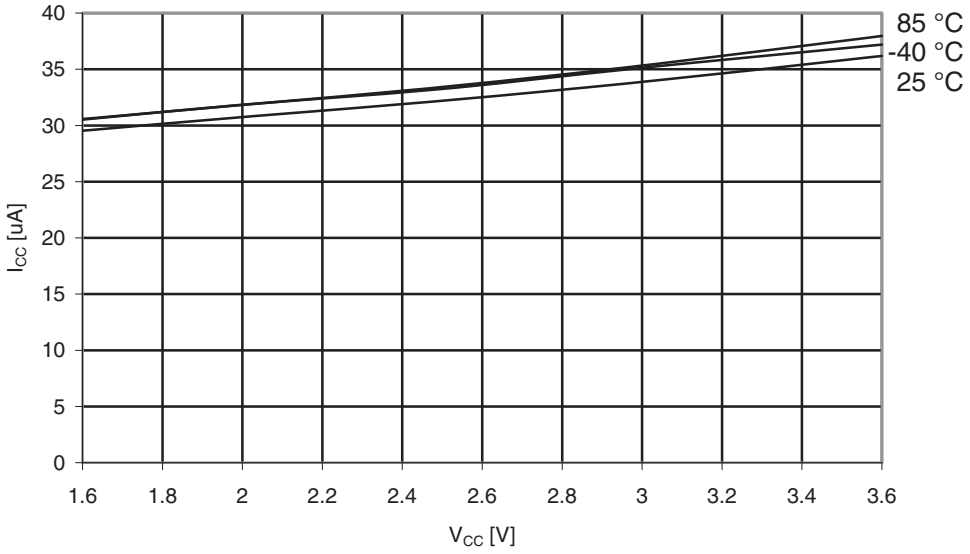


Figure 31-12. Idle Supply Current vs. Vcc

f_{SYS} = 2.0 MHz internal RC

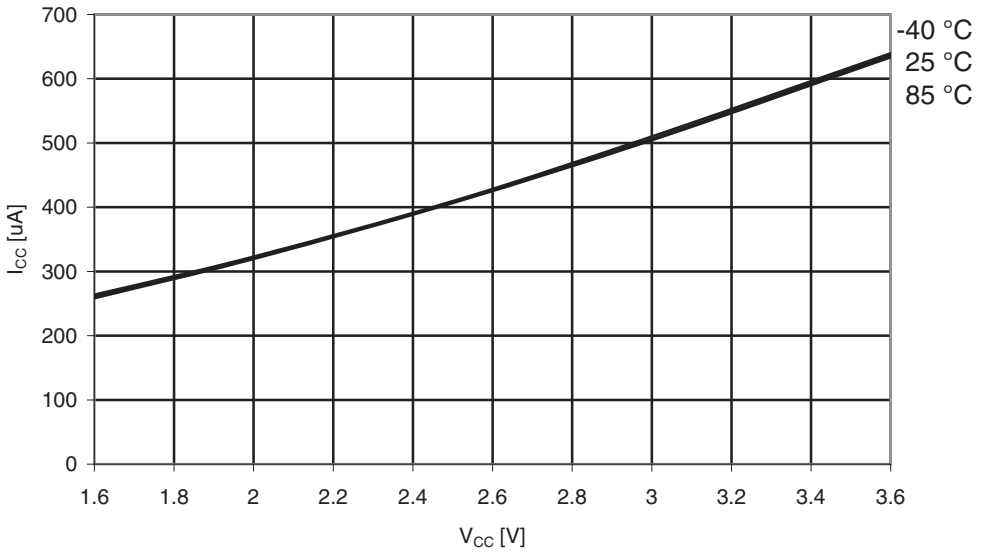


Figure 31-13. Idle Supply Current vs. Vcc

f_{SYS} = 32 MHz internal RC prescaled to 8 MHz

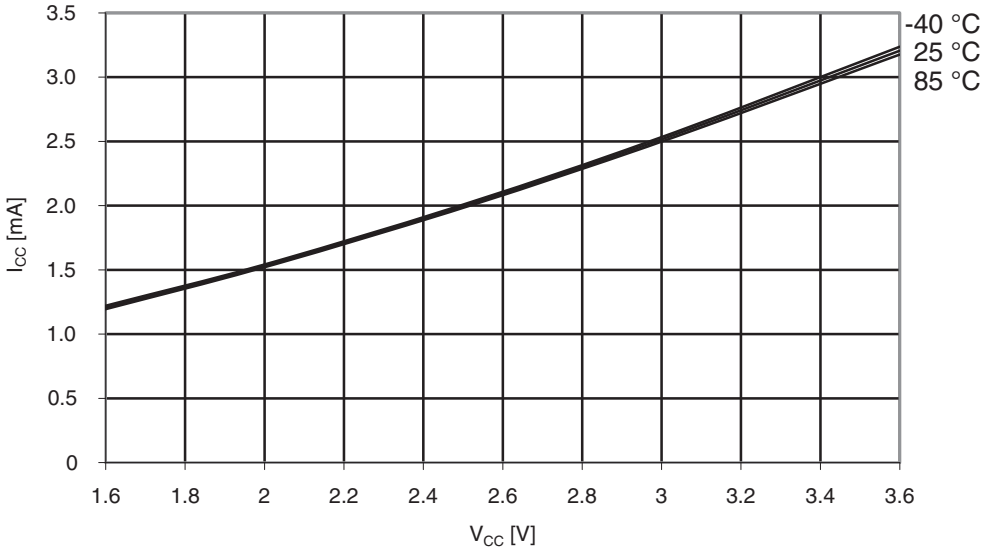
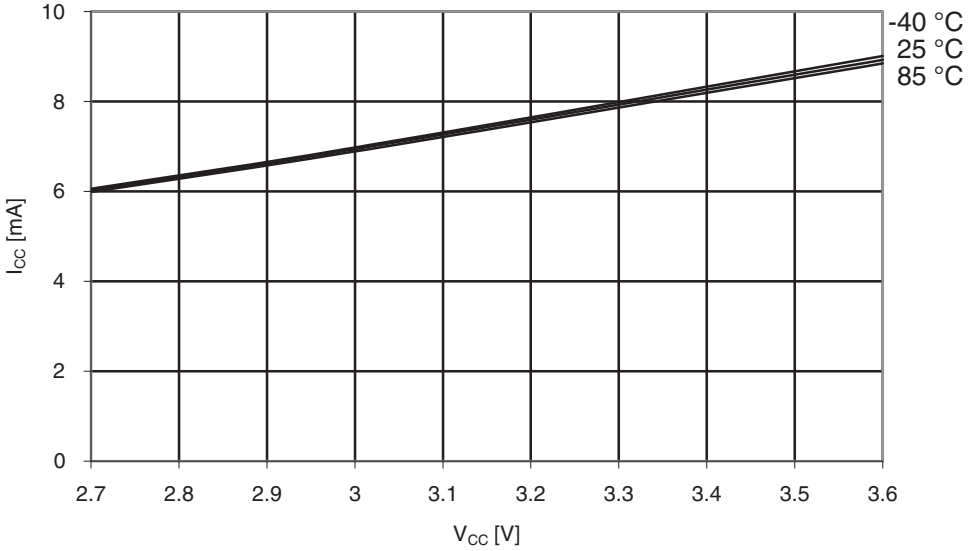


Figure 31-14. Idle Supply Current vs. Vcc

f_{SYS} = 32 MHz internal RC



31.3 Power-down Supply Current

Figure 31-15. Power-down Supply Current vs. Temperature

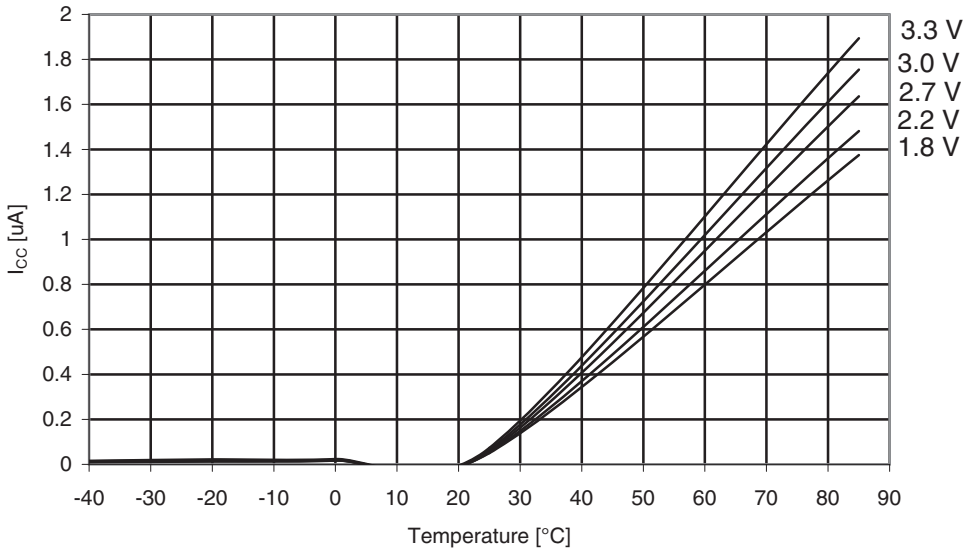
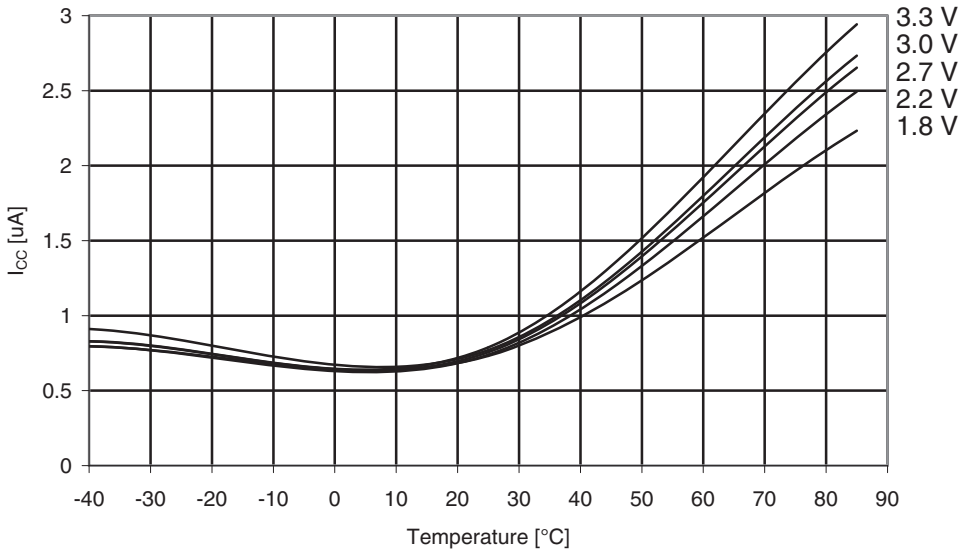


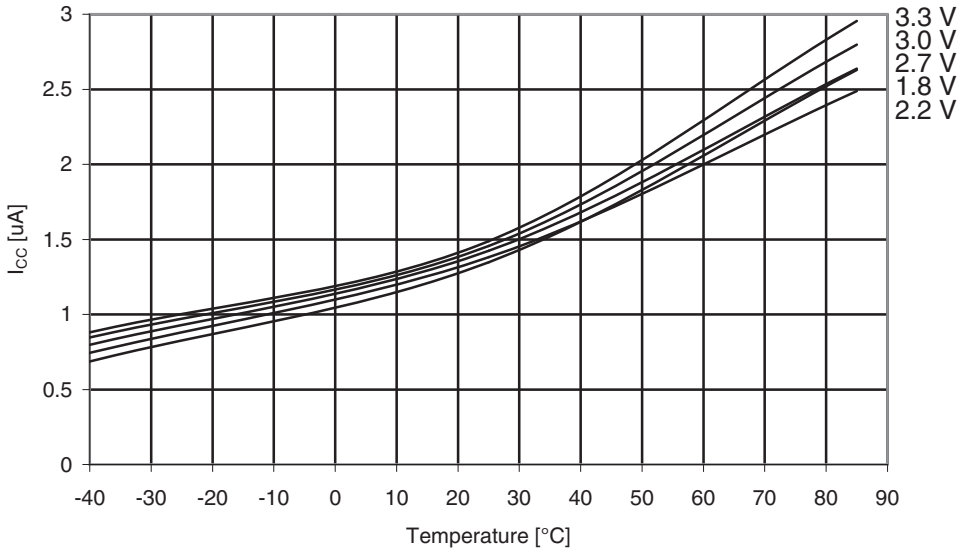
Figure 31-16. Power-down Supply Current vs. Temperature

With WDT and sampled BOD enabled.



31.4 Power-save Supply Current

Figure 31-17. Power-save Supply Current vs. Temperature
With WDT, sampled BOD and RTC from ULP enabled



31.5 Pin Pull-up

Figure 31-18. Reset Pull-up Resistor Current vs. Reset Pin Voltage
V_{CC} = *1.8V*

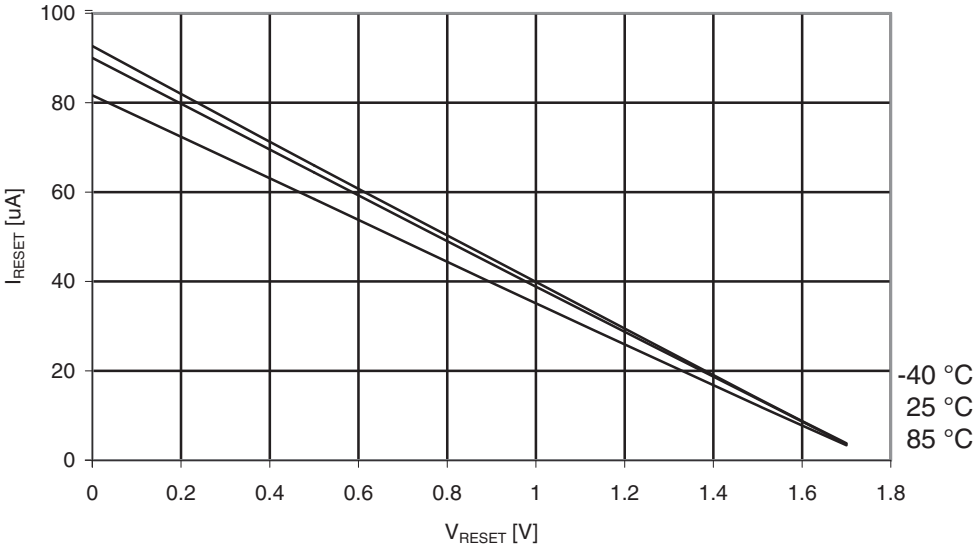


Figure 31-19. Reset Pull-up Resistor Current vs. Reset Pin Voltage

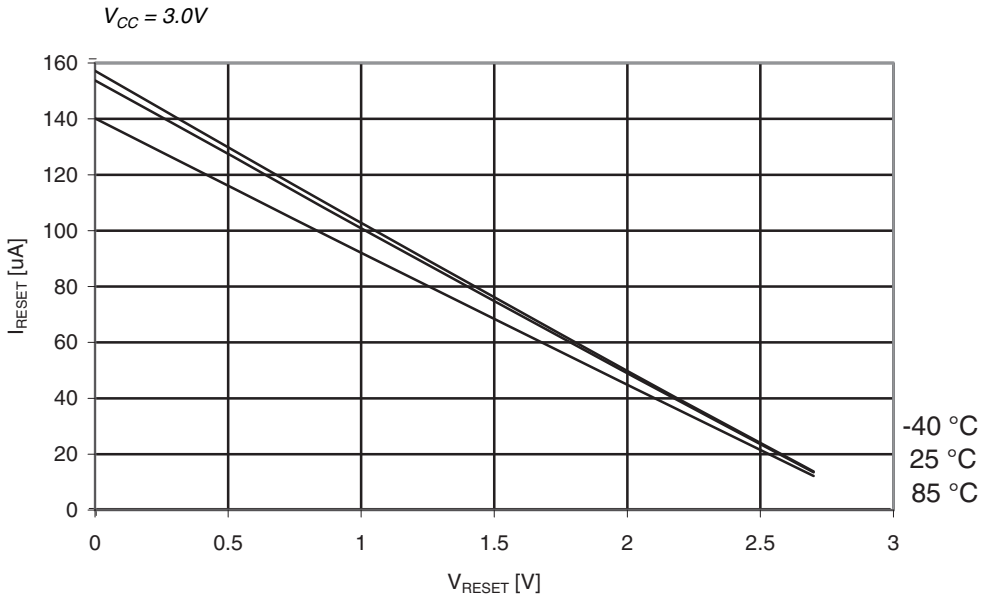
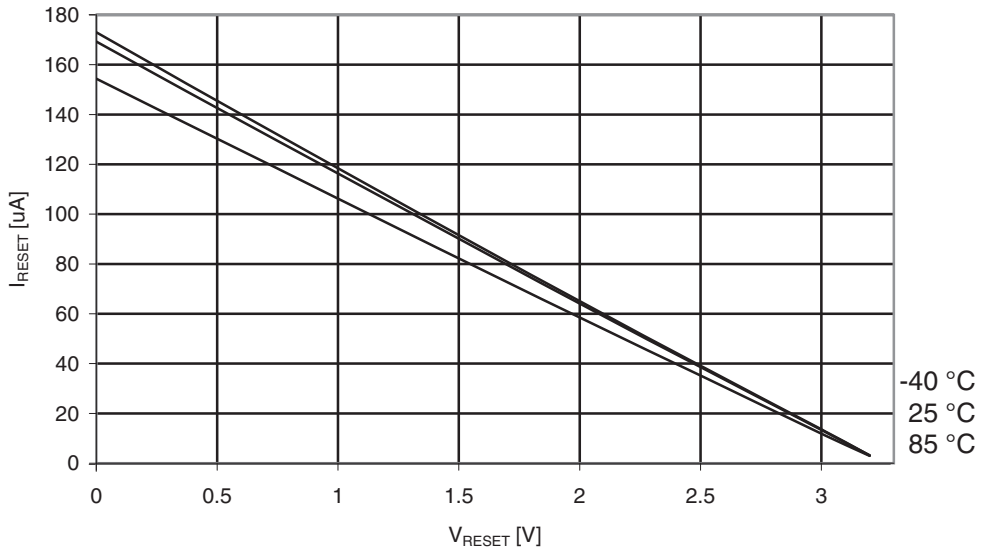


Figure 31-20. Reset Pull-up Resistor Current vs. Reset Pin Voltage



31.6 Pin Output Voltage vs. Sink/Source Current

Figure 31-21. I/O Pin Output Voltage vs. Source Current

Vcc = 1.8V

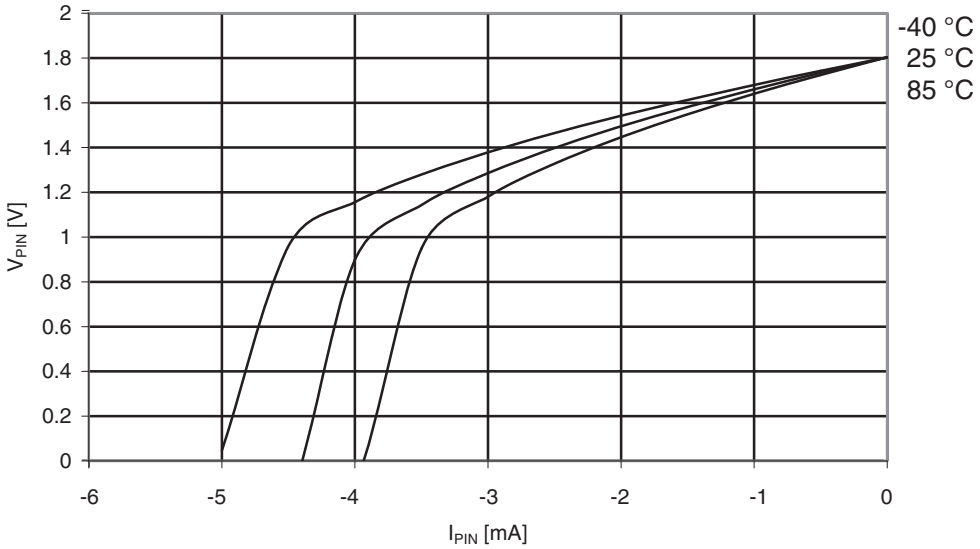


Figure 31-22. I/O Pin Output Voltage vs. Source Current

Vcc = 3.0V

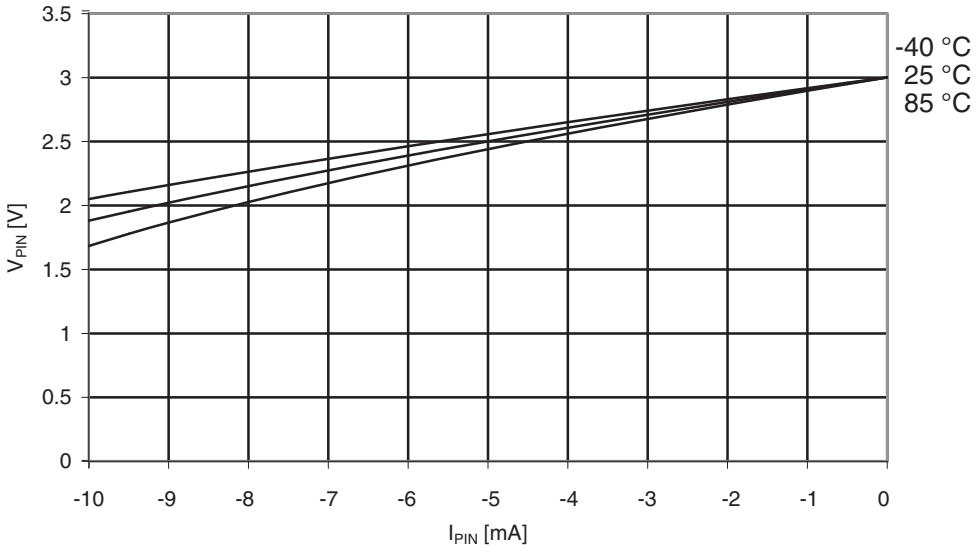


Figure 31-23. I/O Pin Output Voltage vs. Source Current

Vcc = 3.3V

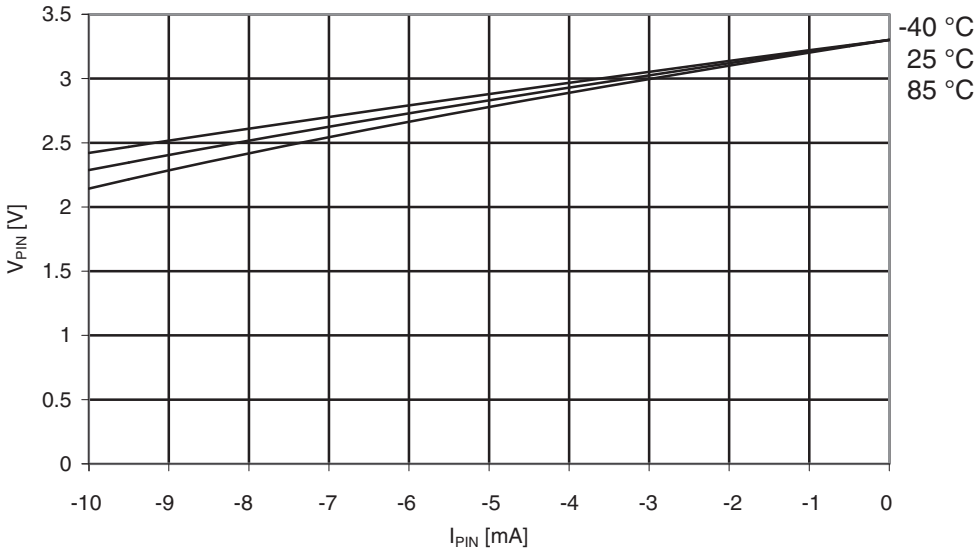


Figure 31-24. I/O Pin Output Voltage vs. Sink Current

Vcc = 1.8V

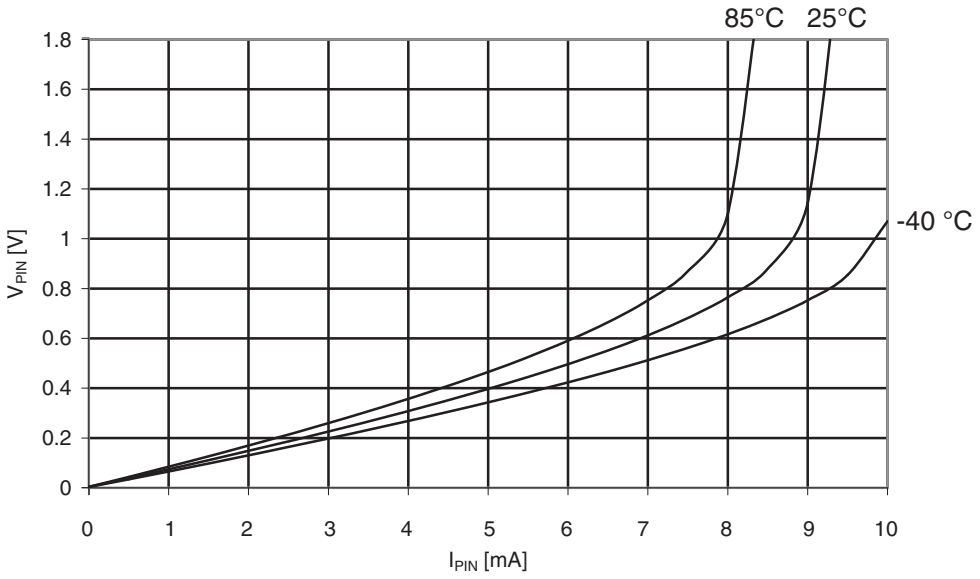


Figure 31-25. I/O Pin Output Voltage vs. Sink Current

Vcc = 3.0V

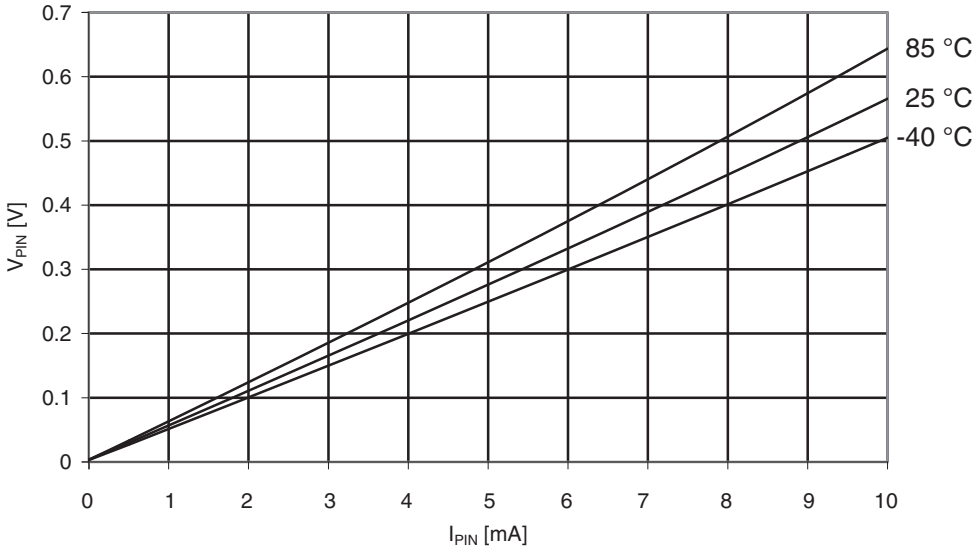
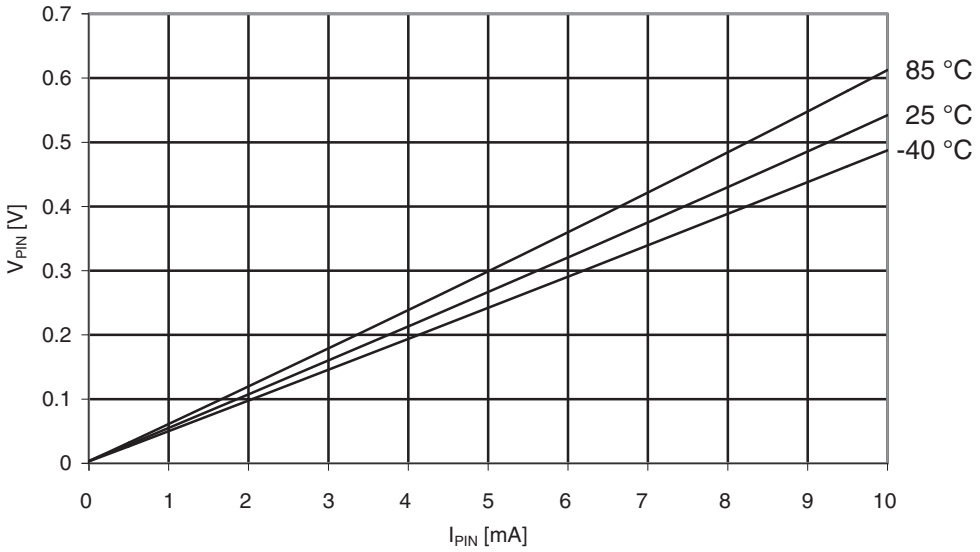


Figure 31-26. I/O Pin Output Voltage vs. Sink Current

Vcc = 3.3V



31.7 Pin Thresholds and Hysteresis

Figure 31-27. I/O Pin Input Threshold Voltage vs. V_{CC}

V_{IH} - I/O Pin Read as "1"

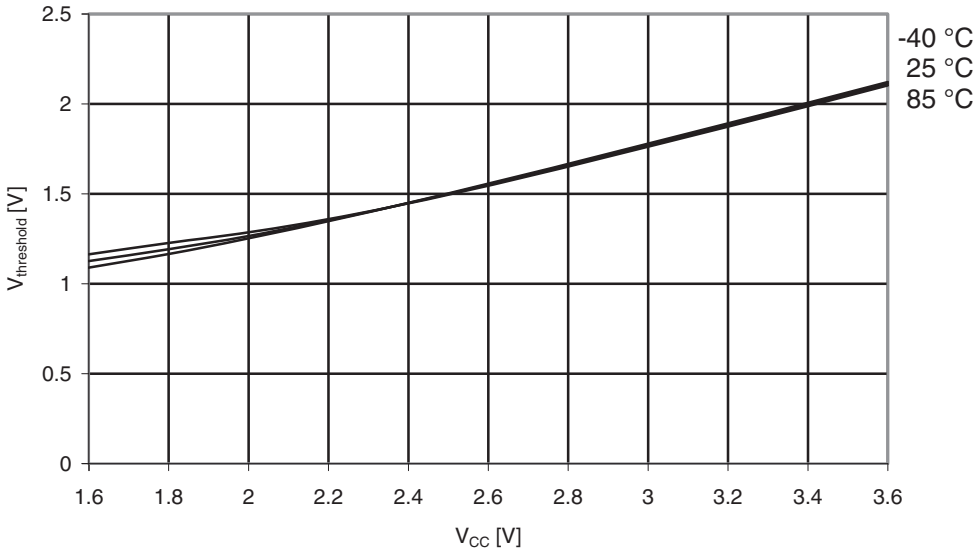


Figure 31-28. I/O Pin Input Threshold Voltage vs. V_{CC}

V_{IL} - I/O Pin Read as "0"

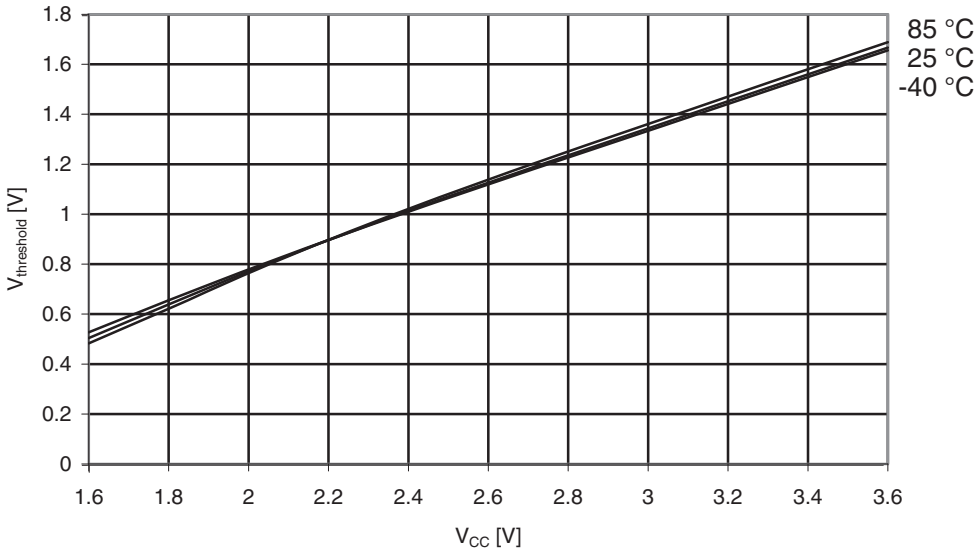


Figure 31-29. I/O Pin Input Hysteresis vs. V_{CC}

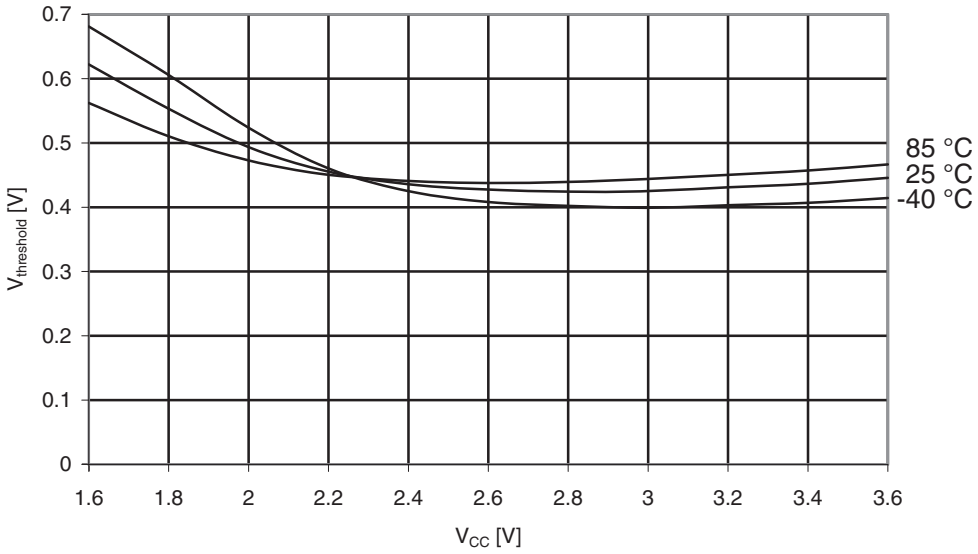


Figure 31-30. Reset Input Threshold Voltage vs. V_{CC}

V_{IH} - I/O Pin Read as "1"

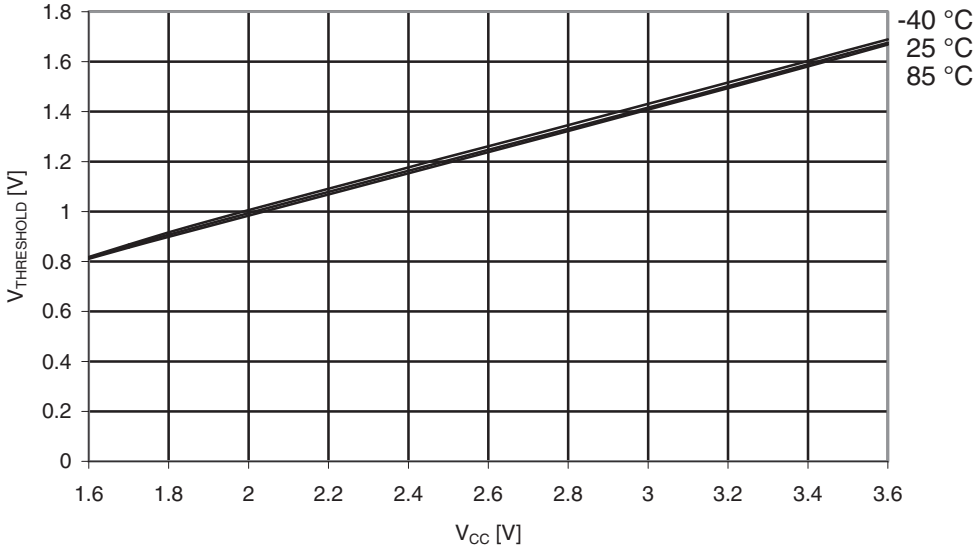
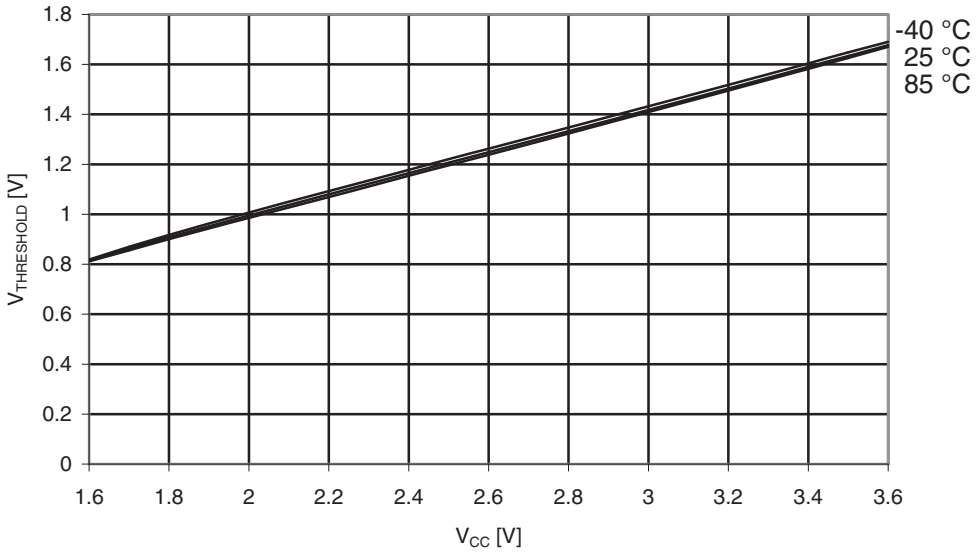


Figure 31-31. Reset Input Threshold Voltage vs. V_{CC}

V_{IL} - I/O Pin Read as "0"



31.8 Bod Thresholds

Figure 31-32. BOD Thresholds vs. Temperature

BOD Level = 1.6V

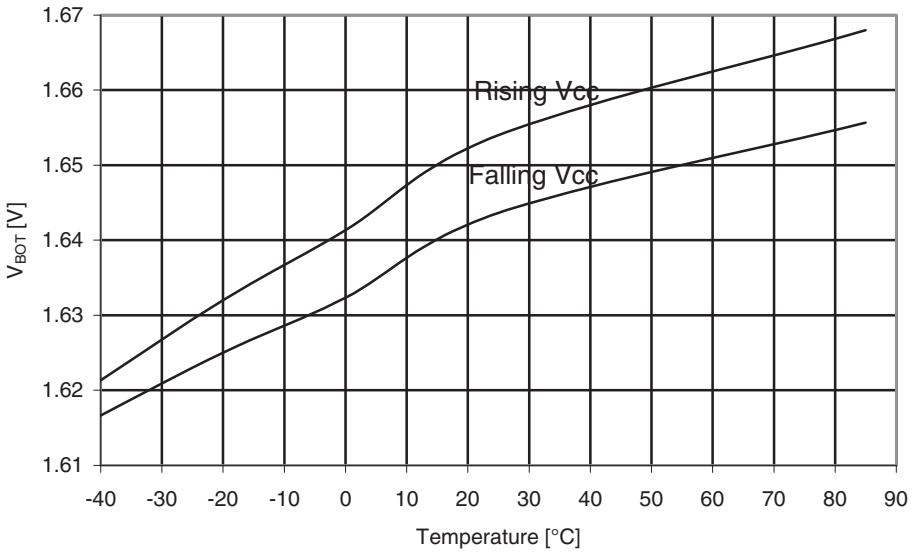
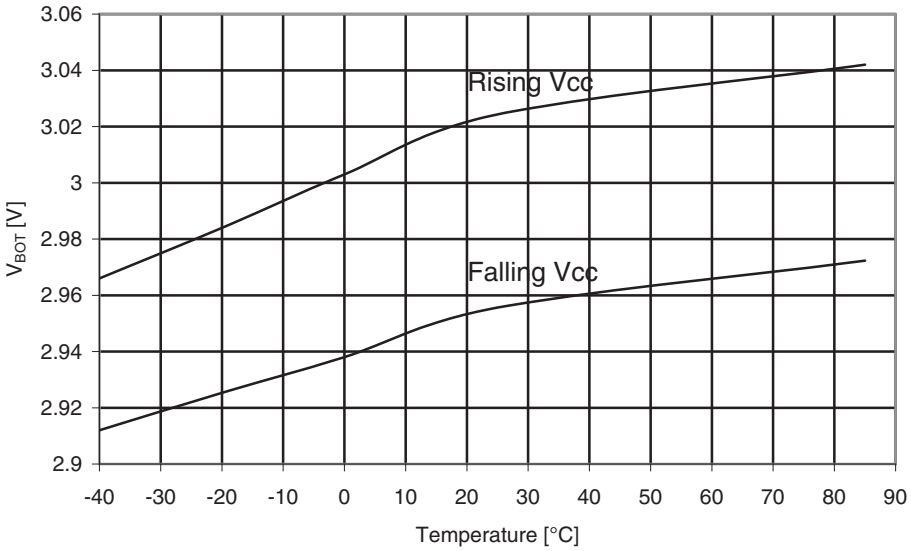


Figure 31-33. BOD Thresholds vs. Temperature

BOD Level = 2.9V

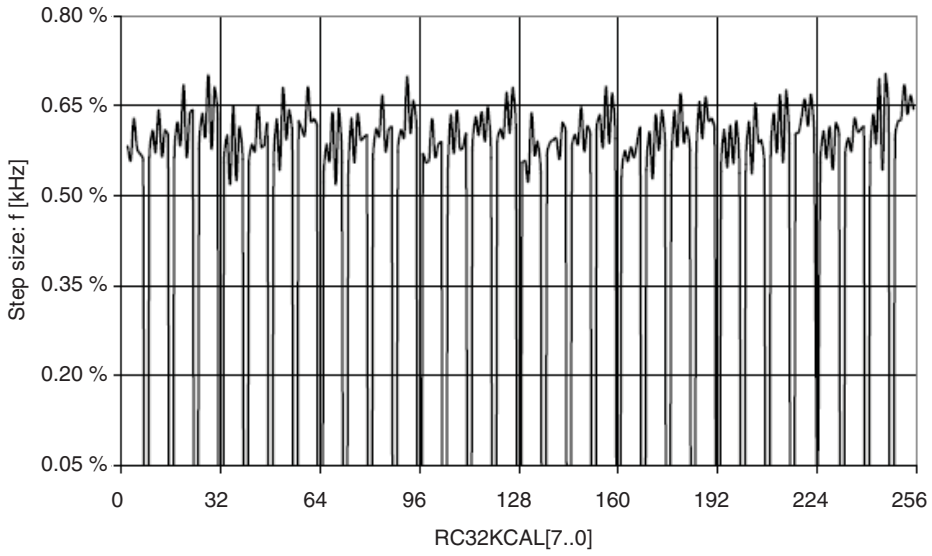


31.9 Oscillators and Wake-up Time

31.9.1 Internal 32.768 kHz Oscillator

Figure 31-34. Internal 32.768 kHz Oscillator Calibration Step Size

T = -40 to 85°C, V_{CC} = 3V



31.9.2 Internal 2 MHz Oscillator

Figure 31-35. Internal 2 MHz Oscillator CALA Calibration Step Size

T = -40 to 85°C, V_{CC} = 3V

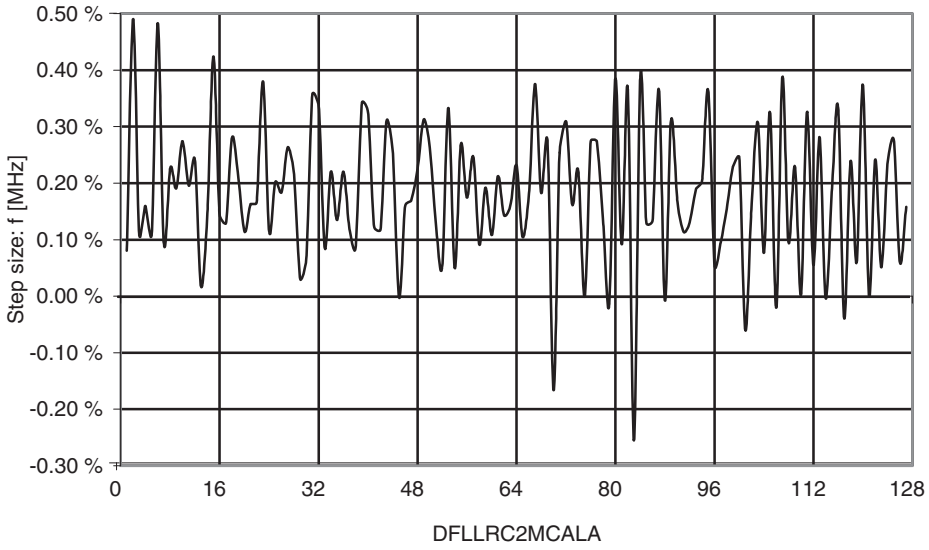
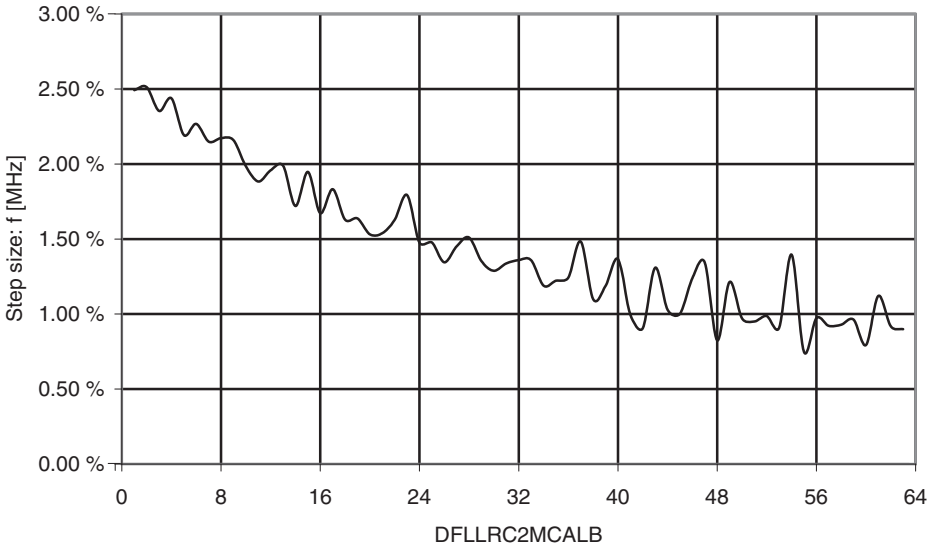


Figure 31-36. Internal 2 MHz Oscillator CALB Calibration Step Size

T = -40 to 85°C, V_{CC} = 3V



31.9.3 Internal 32 MHZ Oscillator

Figure 31-37. Internal 32 MHz Oscillator CALA Calibration Step Size

T = -40 to 85°C, V_{CC} = 3V

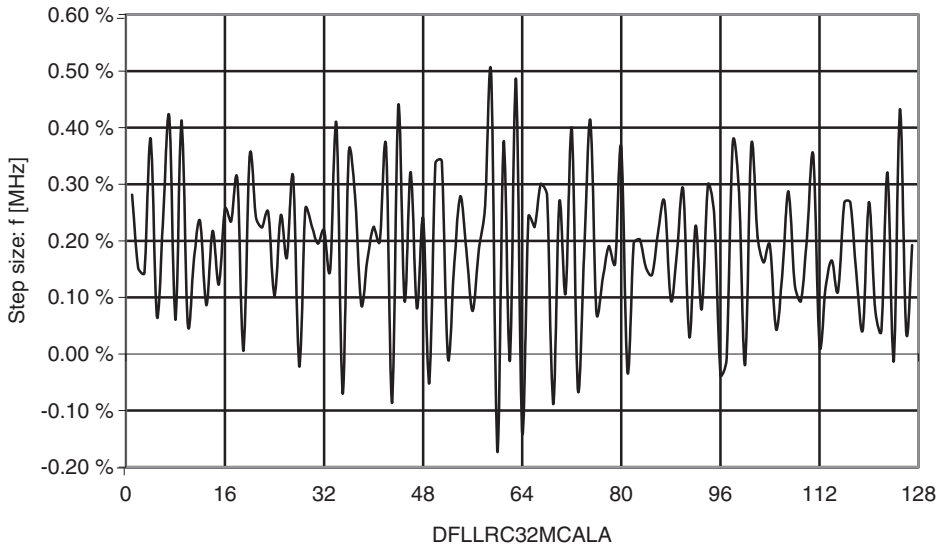
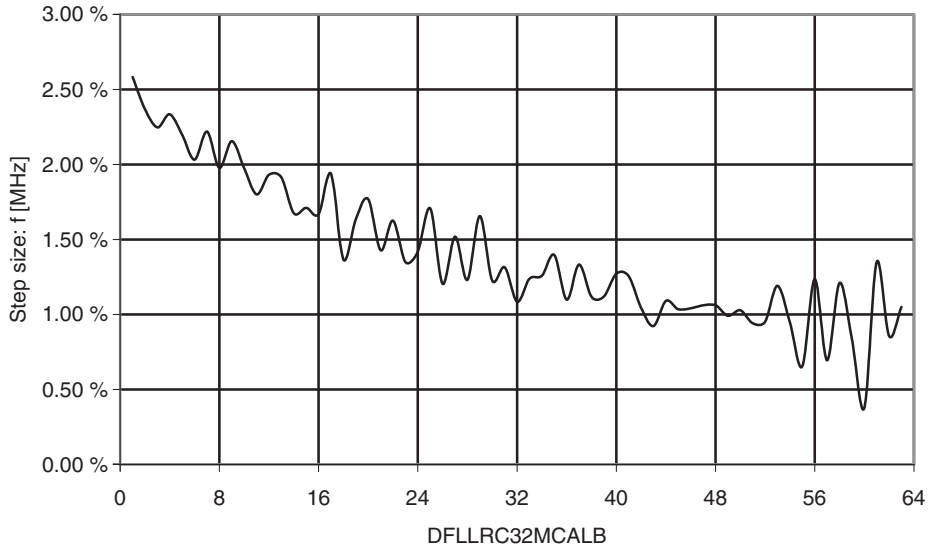


Figure 31-38. Internal 32 MHz Oscillator CALB Calibration Step Size

T = -40 to 85°C, V_{CC} = 3V



31.10 Module current consumption

Figure 31-39. AC current consumption vs. Vcc

Low-power Mode

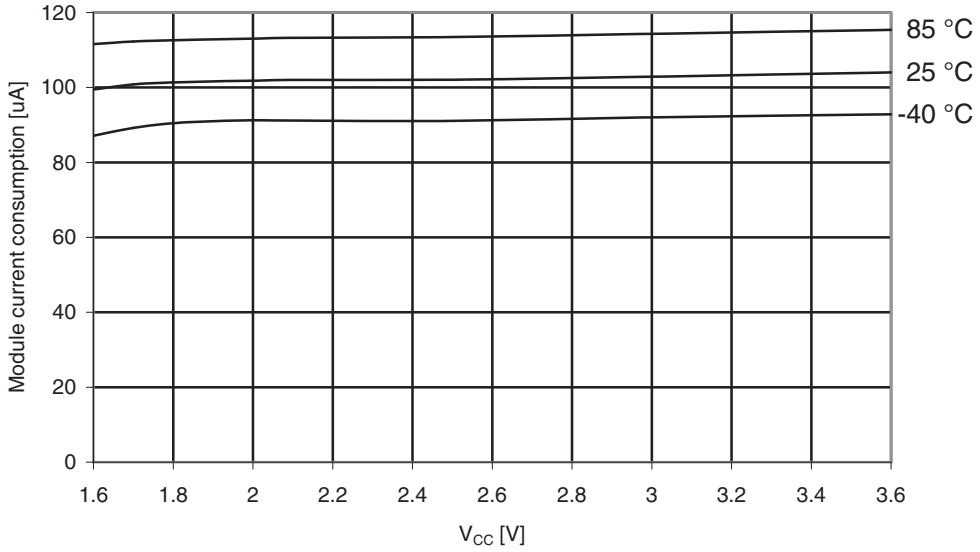
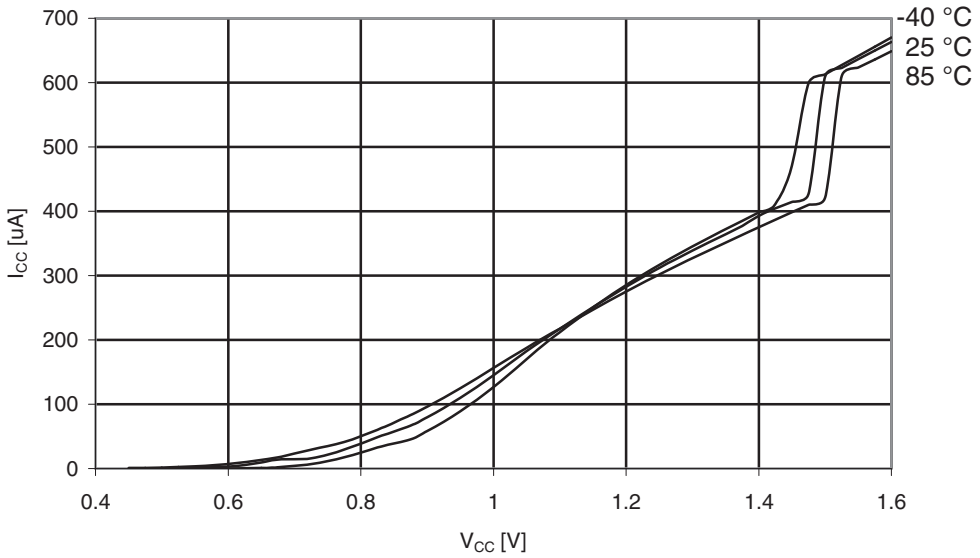
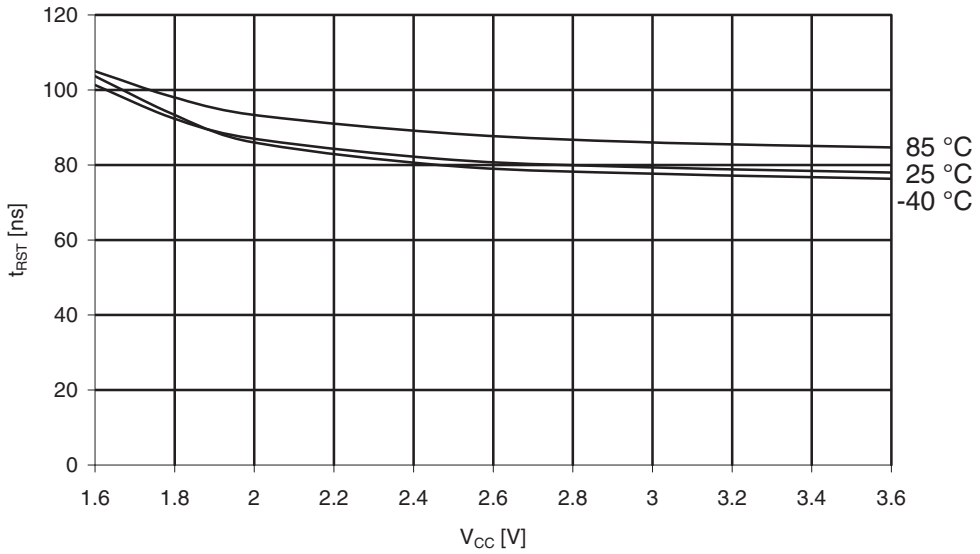


Figure 31-40. Power-up current consumption vs. Vcc



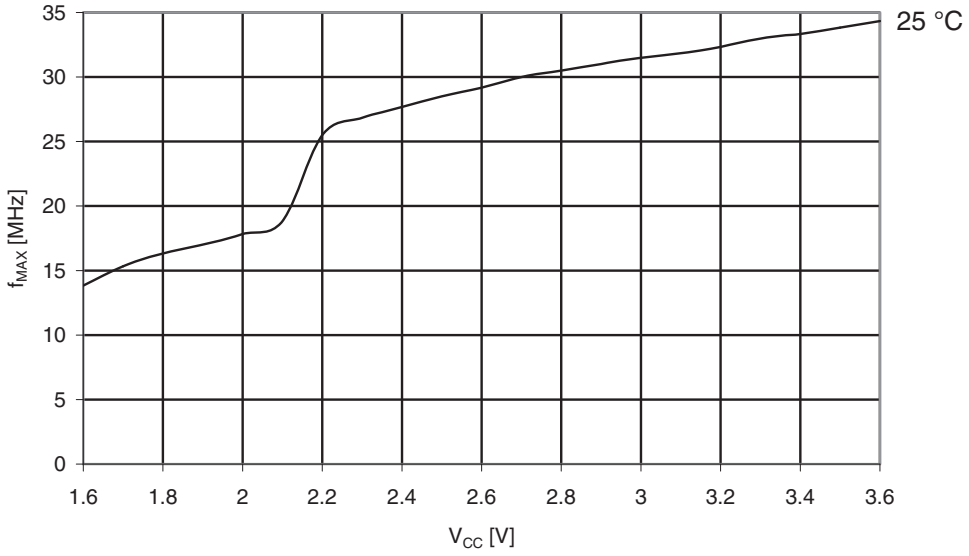
31.11 Reset Pulsewidth

Figure 31-41. Minimum Reset Pulse Width vs. Vcc



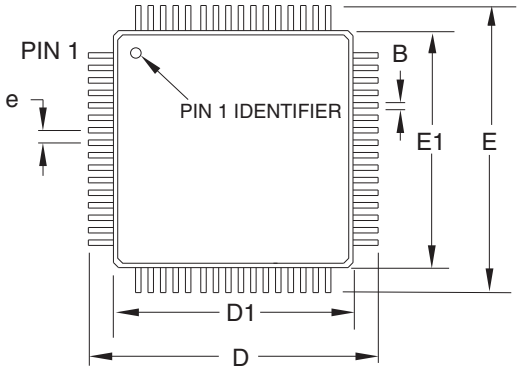
31.12 PDI Speed

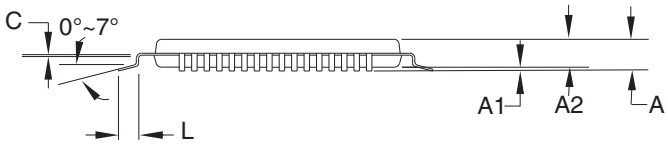
Figure 31-42. PDI Speed vs. Vcc



32. Packaging information

32.1 64A





COMMON DIMENSIONS
(Unit of Measure = mm)

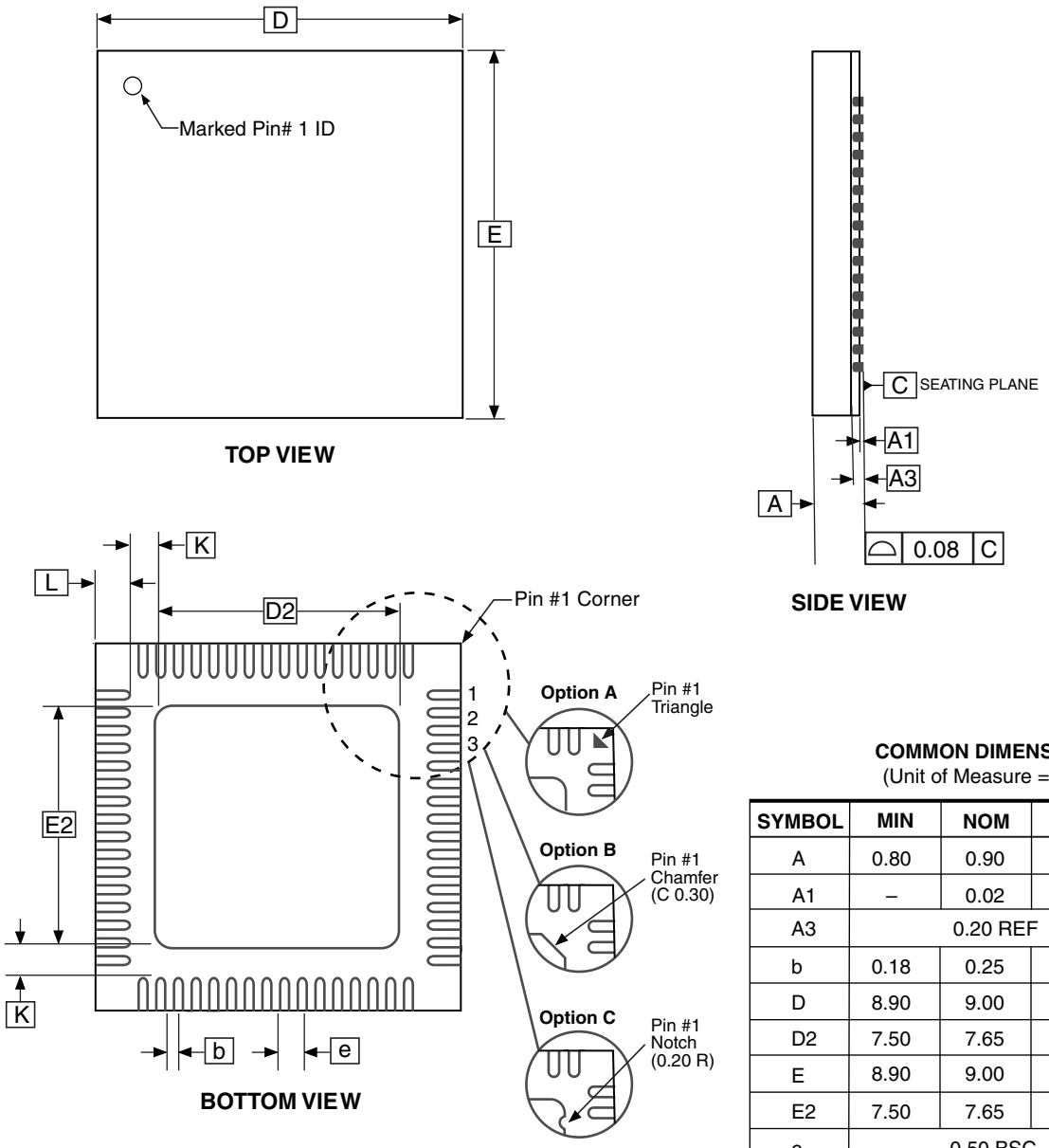
SYMBOL	MIN	NOM	MAX	NOTE
A	–	–	1.20	
A1	0.05	–	0.15	
A2	0.95	1.00	1.05	
D	15.75	16.00	16.25	
D1	13.90	14.00	14.10	Note 2
E	15.75	16.00	16.25	
E1	13.90	14.00	14.10	Note 2
B	0.30	–	0.45	
C	0.09	–	0.20	
L	0.45	–	0.75	
e	0.80 TYP			

Notes:
1. This package conforms to JEDEC reference MS-026, Variation AEB.
2. Dimensions D1 and E1 do not include mold protrusion. Allowable protrusion is 0.25 mm per side. Dimensions D1 and E1 are maximum plastic body size dimensions including mold mismatch.
3. Lead coplanarity is 0.10 mm maximum.

2010-10-20

	TITLE	DRAWING NO.	REV.
2325 Orchard Parkway San Jose, CA 95131	**64A,** 64-lead, 14 x 14 mm Body Size, 1.0 mm Body Thickness, 0.8 mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP)	64A	C

32.2 64M2



COMMON DIMENSIONS
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	0.80	0.90	1.00	
A1	–	0.02	0.05	
A3		0.20 REF		
b	0.18	0.25	0.30	
D	8.90	9.00	9.10	
D2	7.50	7.65	7.80	
E	8.90	9.00	9.10	
E2	7.50	7.65	7.80	
e		0.50 BSC		
L	0.35	0.40	0.45	
K	0.20	0.27	0.40	

Notes: 1. JEDEC Standard MO-220, (SAW Singulation) Fig. 1, VMMD.
2. Dimension and tolerance conform to ASMEY14.5M-1994.

2010-10-20

	TITLE	DRAWING NO.	REV.
2325 Orchard Parkway San Jose, CA 95131	**64M2**, 64-pad, 9 x 9 x 1.0 mm Body, Lead Pitch 0.50 mm, 7.65 mm Exposed Pad, Micro Lead Frame Package (MLF)	64M2	E

33. Errata

33.1 ATxmega256D3, ATxmega192D3, ATxmega128D3, ATxmega64D3

33.1.1 rev. E

- **Bandgap voltage input for the ACs can not be changed when used for both ACs simultaneously**
- **VCC voltage scaler for AC is non-linear**
- **ADC gain stage cannot be used for single conversion**
- **ADC has increased INL error for some operating conditions**
- **ADC gain stage output range is limited to 2.4 V**
- **ADC Event on compare match non-functional**
- **ADC propagation delay is not correct when 8x -64x gain is used**
- **Bandgap measurement with the ADC is non-functional when VCC is below 2.7V**
- **Accuracy lost on first three samples after switching input to ADC gain stage**
- **Configuration of PGM and CWCM not as described in XMEGA A Manual**
- **PWM is not restarted properly after a fault in cycle-by-cycle mode**
- **BOD will be enabled at any reset**
- **EEPROM page buffer always written when NVM DATA0 is written**
- **Pending full asynchronous pin change interrupts will not wake the device**
- **Pin configuration does not affect Analog Comparator Output**
- **NMI Flag for Crystal Oscillator Failure automatically cleared**
- **Crystal start-up time required after power-save even if crystal is source for RTC**
- **RTC Counter value not correctly read after sleep**
- **Pending asynchronous RTC-interrupts will not wake up device**
- **TWI Transmit collision flag not cleared on repeated start**
- **Clearing TWI Stop Interrupt Flag may lock the bus**
- **TWI START condition at bus timeout will cause transaction to be dropped**
- **TWI Data Interrupt Flag (DIF) erroneously read as set**
- **WDR instruction inside closed window will not issue reset**
- **TWIE is not available**

1. **Bandgap voltage input for the ACs cannot be changed when used for both ACs simultaneously**

   If the Bandgap voltage is selected as input for one Analog Comparator (AC) and then selected/deselected as input for another AC, the first comparator will be affected for up to 1 µs and could potentially give a wrong comparison result.

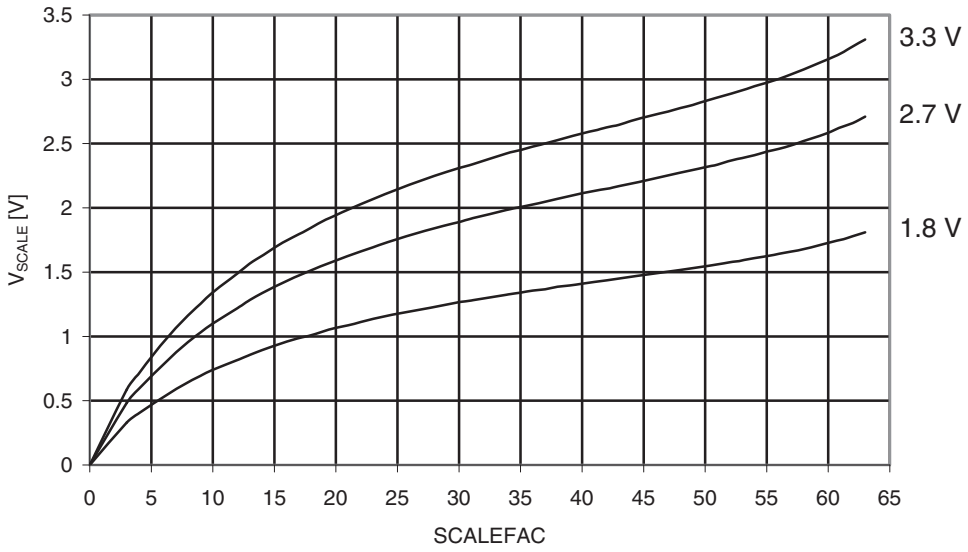
   Problem fix/Workaround

   If the Bandgap is required for both ACs simultaneously, configure the input selection for both ACs before enabling any of them.

2. **VCC voltage scaler for AC is non-linear**

   The 6-bit VCC voltage scaler in the Analog Comparators is non-linear.

Figure 33-1. Analog Comparator Voltage Scaler vs. Scalefac
T = 25°C



Problem fix/Workaround
Use external voltage input for the analog comparator if accurate voltage levels are needed

3. **ADC gain stage cannot be used for single conversion**
The ADC gain stage will not output correct result for single conversion that is triggered and started from software or event system.

Problem fix/Workaround
When the gain stage is used, the ADC must be set in free running mode for correct results.

4. **ADC has increased INL error for some operating conditions**
Some ADC configurations or operating condition will result in increased INL error.

In signed mode INL is increased to:

– 6LSB for sample rates above 130ksps, and up to 8LSB for 200ksps sample rate.
– 6LSB for reference voltage below 1.1V when VCC is above 3.0V.
– 20LSB for ambient temperature below 0 degree C and reference voltage below 1.3V.

In unsigned mode, the INL error cannot be guaranteed, and this mode should not be used.

Problem fix/Workaround

None, avoid using the ADC in the above configurations in order to prevent increased INL error. Use the ADC in signed mode also for single ended measurements.

5. **ADC gain stage output range is limited to 2.4 V**
The amplified output of the ADC gain stage will never go above 2.4 V, hence the differential input will only give correct output when below 2.4 V/gain. For the available gain settings, this gives a differential input range of:

- 1x gain: 2.4 V
- 2x gain: 1.2 V
- 4x gain: 0.6 V
- 8x gain: 300 mV
- 16x gain: 150 mV
- 32x gain: 75 mV
- 64x gain: 38 mV

Problem fix/Workaround

Keep the amplified voltage output from the ADC gain stage below 2.4 V in order to get a correct result, or keep ADC voltage reference below 2.4 V.

6. **ADC Event on compare match non-functional**

   ADC signalling event will be given at every conversion complete even if Interrupt mode (INTMODE) is set to BELOW or ABOVE.

   Problem fix/Workaround

   Enable and use interrupt on compare match when using the compare function.

7. **ADC propagation delay is not correct when 8x -64x gain is used**

   The propagation delay will increase by only one ADC clock cycle for 8x and 16x gain setting, and 32x and 64x gain settings.

   Problem fix/Workaround

   None

8. **Bandgap measurement with the ADC is non-functional when VCC is below 2.7V**

   The ADC can not be used to do bandgap measurements when VCC is below 2.7V.

   Problem fix/Workaround

   None.

9. **Accuracy lost on first three samples after switching input to ADC gain stage**

   Due to memory effect in the ADC gain stage, the first three samples after changing input channel must be disregarded to achieve 12-bit accuracy.

   Problem fix/Workaround

   Run three ADC conversions and discard these results after changing input channels to ADC gain stage.

10. **Configuration of PGM and CWCM not as described in XMEGA A Manual**

    Enabling Common Waveform Channel Mode will enable Pattern generation mode (PGM), but not Common Waveform Channel Mode.

    Enabling Pattern Generation Mode (PGM) and not Common Waveform Channel Mode (CWCM) will enable both Pattern Generation Mode and Common Waveform Channel Mode.

Problem fix/Workaround

Table 33-1. Configure PWM and CWCM according to this table:

PGM	CWCM	Description
0	0	PGM and CWCM disabled
0	1	PGM enabled
1	0	PGM and CWCM enabled
1	1	PGM enabled

11. PWM is not restarted properly after a fault in cycle-by-cycle mode

When the AWeX fault restore mode is set to cycle-by-cycle, the waveform output will not return to normal operation at first update after fault condition is no longer present.

Problem fix/Workaround

Do a write to any AWeX I/O register to re-enable the output.

12. BOD will be enabled after any reset

If any reset source goes active, the BOD will be enabled and keep the device in reset if the VCC voltage is below the programmed BOD level. During Power-On Reset, reset will not be released until VCC is above the programmed BOD level even if the BOD is disabled.

Problem fix/Workaround

Do not set the BOD level higher than VCC even if the BOD is not used.

13. EEPROM page buffer always written when NVM DATA0 is written

If the EEPROM is memory mapped, writing to NVM DATA0 will corrupt data in the EEPROM page buffer.

Problem fix/Workaround

Before writing to NVM DATA0, for example when doing software CRC or flash page buffer write, check if EEPROM page buffer active loading flag (EELOAD) is set. Do not write NVM DATA0 when EELOAD is set.

14. Pending full asynchronous pin change interrupts will not wake the device

Any full asynchronous pin-change Interrupt from pin 2, on any port, that is pending when the sleep instruction is executed, will be ignored until the device is woken from another source or the source triggers again. This applies when entering all sleep modes where the System Clock is stopped.

Problem fix/Workaround

None.

15. Pin configuration does not affect Analog Comparator output

The Output/Pull and inverted pin configuration does not affect the Analog Comparator output.

Problem fix/Workaround

None for Output/Pull configuration.

For inverted I/O, configure the Analog Comparator to give an inverted result (i.e. connect positive input to the negative AC input and vice versa), or use and external inverter to change polarity of Analog Comparator output.

16. NMI Flag for Crystal Oscillator Failure automatically cleared

NMI flag for Crystal Oscillator Failure (XOSCFDIF) will be automatically cleared when executing the NMI interrupt handler.

Problem fix/Workaround

This device revision has only one NMI interrupt source, so checking the interrupt source in software is not required.

17. Crystal start-up time required after power-save even if crystal is source for RTC

Even if 32.768 kHz crystal is used for RTC during sleep, the clock from the crystal will not be ready for the system before the specified start-up time. See "XOSCSEL[3:0]: Crystal Oscillator Selection" in XMEGA A Manual. If BOD is used in active mode, the BOD will be on during this period (0.5s).

Problem fix/Workaround

If faster start-up is required, go to sleep with internal oscillator as system clock.

18. RTC Counter value not correctly read after sleep

If the RTC is set to wake up the device on RTC Overflow and bit 0 of RTC CNT is identical to bit 0 of RTC PER as the device is entering sleep, the value in the RTC count register can not be read correctly within the first prescaled RTC clock cycle after wakeup. The value read will be the same as the value in the register when entering sleep.

The same applies if RTC Compare Match is used as wake-up source.

Problem fix/Workaround

Wait at least one prescaled RTC clock cycle before reading the RTC CNT value.

19. Pending asynchronous RTC-interrupts will not wake up device

Asynchronous Interrupts from the Real-Time-Counter that is pending when the sleep instruction is executed, will be ignored until the device is woken from another source or the source triggers again.

Problem fix/Workaround

None.

20. TWI Transmit collision flag not cleared on repeated start

The TWI transmit collision flag should be automatically cleared on start and repeated start, but is only cleared on start.

Problem fix/Workaround

Clear the flag in software after address interrupt.

21. Clearing TWI Stop Interrupt Flag may lock the bus

If software clears the STOP Interrupt Flag (APIF) on the same Peripheral Clock cycle as the hardware sets this flag due to a new address received, CLKHOLD is not cleared and the SCL line is not released. This will lock the bus.

Problem fix/Workaround

Check if the bus state is IDLE. If this is the case, it is safe to clear APIF. If the bus state is not IDLE, wait for the SCL pin to be low before clearing APIF.

Code:

```
/* Only clear the interrupt flag if within a "safe zone". */
while ( /* Bus not IDLE: */
```

```
        ((COMMS_TWI.MASTER.STATUS & TWI_MASTER_BUSSTATE_gm) !=
          TWI_MASTER_BUSSTATE_IDLE_gc)) &&
          /* SCL not held by slave: */
          !(COMMS_TWI.SLAVE.STATUS & TWI_SLAVE_CLKHOLD_bm)
      )
{
    /* Ensure that the SCL line is low */
    if ( !(COMMS_PORT.IN & PIN1_bm) )
        if ( !(COMMS_PORT.IN & PIN1_bm) )
            break;
}
/* Check for an pending address match interrupt */
if ( !(COMMS_TWI.SLAVE.STATUS & TWI_SLAVE_CLKHOLD_bm) )
{
    /* Safely clear interrupt flag */
    COMMS_TWI.SLAVE.STATUS |= (uint8_t)TWI_SLAVE_APIF_bm;
}
```

22. TWI START condition at bus timeout will cause transaction to be dropped

If Bus Timeout is enabled and a timeout occurs on the same Peripheral Clock cycle as a START is detected, the transaction will be dropped.

Problem fix/Workaround

None.

23. TWI Data Interrupt Flag erroneously read as set

When issuing the TWI slave response command CMD=0b11, it takes 1 Peripheral Clock cycle to clear the data interrupt flag (DIF). A read of DIF directly after issuing the command will show the DIF still set.

Problem fix/Workaround

Add one NOP instruction before checking DIF.

24. WDR instruction inside closed window will not issue reset

When a WDR instruction is execute within one ULP clock cycle after updating the window control register, the counter can be cleared without giving a system reset.

Problem fix/Workaround

Wait at least one ULP clock cycle before executing a WDR instruction.

25. TWIE is not available

The TWI module on PORTE, TWIE is not available

Problem fix/Workaround

Use the identical TWI module on PORTC, TWIC instead.

33.1.2 rev. B

- **Bandgap voltage input for the ACs can not be changed when used for both ACs simultaneously**
- **VCC voltage scaler for AC is non-linear**
- **ADC gain stage cannot be used for single conversion**
- **ADC has increased INL error for some operating conditions**
- **ADC gain stage output range is limited to 2.4 V**
- **ADC Event on compare match non-functional**
- **ADC propagation delay is not correct when 8x -64x gain is used**
- **Bandgap measurement with the ADC is non-functional when VCC is below 2.7V**
- **Accuracy lost on first three samples after switching input to ADC gain stage**
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- **TWI Transmit collision flag not cleared on repeated start**
- **Clearing TWI Stop Interrupt Flag may lock the bus**
- **TWI START condition at bus timeout will cause transaction to be dropped**
- **TWI Data Interrupt Flag (DIF) erroneously read as set**
- **WDR instruction inside closed window will not issue reset**
- **TWIE is not available**

1. **Bandgap voltage input for the ACs cannot be changed when used for both ACs simultaneously**

   If the Bandgap voltage is selected as input for one Analog Comparator (AC) and then selected/deselected as input for another AC, the first comparator will be affected for up to 1 µs and could potentially give a wrong comparison result.

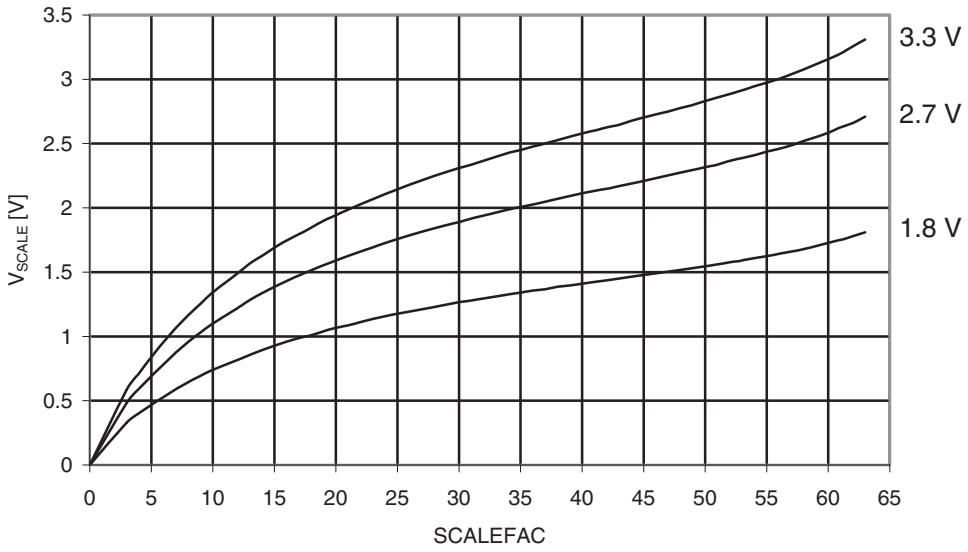
   Problem fix/Workaround

   If the Bandgap is required for both ACs simultaneously, configure the input selection for both ACs before enabling any of them.

2. **VCC voltage scaler for AC is non-linear**

   The 6-bit VCC voltage scaler in the Analog Comparators is non-linear.

Figure 33-2. Analog Comparator Voltage Scaler vs. Scalefac
T = 25°C



Problem fix/Workaround
Use external voltage input for the analog comparator if accurate voltage levels are needed

3. **ADC gain stage cannot be used for single conversion**
The ADC gain stage will not output correct result for single conversion that is triggered and started from software or event system.

Problem fix/Workaround
When the gain stage is used, the ADC must be set in free running mode for correct results.

4. **ADC has increased INL error for some operating conditions**
Some ADC configurations or operating condition will result in increased INL error.

In signed mode INL is increased to:

– 6LSB for sample rates above 130ksps, and up to 8LSB for 200ksps sample rate.
– 6LSB for reference voltage below 1.1V when VCC is above 3.0V.
– 20LSB for ambient temperature below 0 degree C and reference voltage below 1.3V.

In unsigned mode, the INL error cannot be guaranteed, and this mode should not be used.

Problem fix/Workaround

None, avoid using the ADC in the above configurations in order to prevent increased INL error. Use the ADC in signed mode also for single ended measurements.

5. **ADC gain stage output range is limited to 2.4 V**
The amplified output of the ADC gain stage will never go above 2.4 V, hence the differential input will only give correct output when below 2.4 V/gain. For the available gain settings, this gives a differential input range of:

- 1x gain: 2.4 V
- 2x gain: 1.2 V
- 4x gain: 0.6 V
- 8x gain: 300 mV
- 16x gain: 150 mV
- 32x gain: 75 mV
- 64x gain: 38 mV

Problem fix/Workaround

Keep the amplified voltage output from the ADC gain stage below 2.4 V in order to get a correct result, or keep ADC voltage reference below 2.4 V.

6. **ADC Event on compare match non-functional**

   ADC signalling event will be given at every conversion complete even if Interrupt mode (INTMODE) is set to BELOW or ABOVE.

   Problem fix/Workaround

   Enable and use interrupt on compare match when using the compare function.

7. **ADC propagation delay is not correct when 8x -64x gain is used**

   The propagation delay will increase by only one ADC clock cycle for 8x and 16x gain setting, and 32x and 64x gain settings.

   Problem fix/Workaround

   None

8. **Bandgap measurement with the ADC is non-functional when VCC is below 2.7V**

   The ADC can not be used to do bandgap measurements when VCC is below 2.7V.

   Problem fix/Workaround

   None.

9. **Accuracy lost on first three samples after switching input to ADC gain stage**

   Due to memory effect in the ADC gain stage, the first three samples after changing input channel must be disregarded to achieve 12-bit accuracy.

   Problem fix/Workaround

   Run three ADC conversions and discard these results after changing input channels to ADC gain stage.

10. **Configuration of PGM and CWCM not as described in XMEGA A Manual**

    Enabling Common Waveform Channel Mode will enable Pattern generation mode (PGM), but not Common Waveform Channel Mode.

    Enabling Pattern Generation Mode (PGM) and not Common Waveform Channel Mode (CWCM) will enable both Pattern Generation Mode and Common Waveform Channel Mode.

Problem fix/Workaround

Table 33-2. Configure PWM and CWCM according to this table:

PGM	CWCM	Description
0	0	PGM and CWCM disabled
0	1	PGM enabled
1	0	PGM and CWCM enabled
1	1	PGM enabled

11. PWM is not restarted properly after a fault in cycle-by-cycle mode

When the AWeX fault restore mode is set to cycle-by-cycle, the waveform output will not return to normal operation at first update after fault condition is no longer present.

Problem fix/Workaround

Do a write to any AWeX I/O register to re-enable the output.

12. BOD will be enabled after any reset

If any reset source goes active, the BOD will be enabled and keep the device in reset if the VCC voltage is below the programmed BOD level. During Power-On Reset, reset will not be released until VCC is above the programmed BOD level even if the BOD is disabled.

Problem fix/Workaround

Do not set the BOD level higher than VCC even if the BOD is not used.

13. EEPROM page buffer always written when NVM DATA0 is written

If the EEPROM is memory mapped, writing to NVM DATA0 will corrupt data in the EEPROM page buffer.

Problem fix/Workaround

Before writing to NVM DATA0, for example when doing software CRC or flash page buffer write, check if EEPROM page buffer active loading flag (EELOAD) is set. Do not write NVM DATA0 when EELOAD is set.

14. Pending full asynchronous pin change interrupts will not wake the device

Any full asynchronous pin-change Interrupt from pin 2, on any port, that is pending when the sleep instruction is executed, will be ignored until the device is woken from another source or the source triggers again. This applies when entering all sleep modes where the System Clock is stopped.

Problem fix/Workaround

None.

15. Pin configuration does not affect Analog Comparator output

The Output/Pull and inverted pin configuration does not affect the Analog Comparator output.

Problem fix/Workaround

None for Output/Pull configuration.

For inverted I/O, configure the Analog Comparator to give an inverted result (i.e. connect positive input to the negative AC input and vice versa), or use and external inverter to change polarity of Analog Comparator output.

16. **NMI Flag for Crystal Oscillator Failure automatically cleared**

    NMI flag for Crystal Oscillator Failure (XOSCFDIF) will be automatically cleared when executing the NMI interrupt handler.

    Problem fix/Workaround

    This device revision has only one NMI interrupt source, so checking the interrupt source in software is not required.

17. **Writing EEPROM or Flash while reading any of them will not work**

    The EEPROM and Flash cannot be written while reading EEPROM or Flash, or while executing code in Active mode.

    Problem fix/Workaround

    Enter IDLE sleep mode within 2.5 µs (Five 2 MHz clock cycles and 80 32 MHz clock cycles) after starting an EEPROM or flash write operation. Wake-up source must either be EEPROM ready or NVM ready interrupt. Alternatively set up a Timer/Counter to give an overflow interrupt 7 ms after the erase or write operation has started, or 13 ms after atomic erase-and-write operation has started, and then enter IDLE sleep mode.

18. **Crystal start-up time required after power-save even if crystal is source for RTC**

    Even if 32.768 kHz crystal is used for RTC during sleep, the clock from the crystal will not be ready for the system before the specified start-up time. See "XOSCSEL[3:0]: Crystal Oscillator Selection" in XMEGA A Manual. If BOD is used in active mode, the BOD will be on during this period (0.5s).

    Problem fix/Workaround

    If faster start-up is required, go to sleep with internal oscillator as system clock.

19. **RTC Counter value not correctly read after sleep**

    If the RTC is set to wake up the device on RTC Overflow and bit 0 of RTC CNT is identical to bit 0 of RTC PER as the device is entering sleep, the value in the RTC count register can not be read correctly within the first prescaled RTC clock cycle after wakeup. The value read will be the same as the value in the register when entering sleep.

    The same applies if RTC Compare Match is used as wake-up source.

    Problem fix/Workaround

    Wait at least one prescaled RTC clock cycle before reading the RTC CNT value.

20. **Pending asynchronous RTC-interrupts will not wake up device**

    Asynchronous Interrupts from the Real-Time-Counter that is pending when the sleep instruction is executed, will be ignored until the device is woken from another source or the source triggers again.

    Problem fix/Workaround

    None.

21. **TWI Transmit collision flag not cleared on repeated start**

    The TWI transmit collision flag should be automatically cleared on start and repeated start, but is only cleared on start.

    Problem fix/Workaround

    Clear the flag in software after address interrupt.

22. Clearing TWI Stop Interrupt Flag may lock the bus

If software clears the STOP Interrupt Flag (APIF) on the same Peripheral Clock cycle as the hardware sets this flag due to a new address received, CLKHOLD is not cleared and the SCL line is not released. This will lock the bus.

Problem fix/Workaround

Check if the bus state is IDLE. If this is the case, it is safe to clear APIF. If the bus state is not IDLE, wait for the SCL pin to be low before clearing APIF.

Code:

```
/* Only clear the interrupt flag if within a "safe zone". */
while ( /* Bus not IDLE: */
       ((COMMS_TWI.MASTER.STATUS & TWI_MASTER_BUSSTATE_gm) !=
         TWI_MASTER_BUSSTATE_IDLE_gc)) &&
         /* SCL not held by slave: */
         !(COMMS_TWI.SLAVE.STATUS & TWI_SLAVE_CLKHOLD_bm)
      )
{
    /* Ensure that the SCL line is low */
    if ( !(COMMS_PORT.IN & PIN1_bm) )
        if ( !(COMMS_PORT.IN & PIN1_bm) )
            break;
}
/* Check for an pending address match interrupt */
if ( !(COMMS_TWI.SLAVE.STATUS & TWI_SLAVE_CLKHOLD_bm) )
{
    /* Safely clear interrupt flag */
    COMMS_TWI.SLAVE.STATUS |= (uint8_t)TWI_SLAVE_APIF_bm;
}
```

23. TWI START condition at bus timeout will cause transaction to be dropped

If Bus Timeout is enabled and a timeout occurs on the same Peripheral Clock cycle as a START is detected, the transaction will be dropped.

Problem fix/Workaround

None.

24. TWI Data Interrupt Flag erroneously read as set

When issuing the TWI slave response command CMD=0b11, it takes 1 Peripheral Clock cycle to clear the data interrupt flag (DIF). A read of DIF directly after issuing the command will show the DIF still set.

Problem fix/Workaround

Add one NOP instruction before checking DIF.

25. WDR instruction inside closed window will not issue reset

When a WDR instruction is execute within one ULP clock cycle after updating the window control register, the counter can be cleared without giving a system reset.

Problem fix/Workaround

Wait at least one ULP clock cycle before executing a WDR instruction.

26. TWIE is not available

The TWI module on PORTE, TWIE is not available

Problem fix/Workaround

Use the identical TWI module on PORTC, TWIC instead.

33.1.3 All rev. A

Not sampled.

34. Datasheet Revision History

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

34.1 8134I – 12/10

1. Datasheet status changed to complete: Preliminary removed from front page.
2. Updated all tables in the “Electrical Characteristics” .
3. Replaced Table 30-11 on page 62
4. Replaced Table 30-17 on page 63 and added the figure ”TOSC input capacitance” on page 64
5. Added ERRATA ”rev. E” on page 88.
6. Updated ERRATA for ADC (ADC has increased INL error for some operating conditions).
7 Updated ERRATA ”rev. B” on page 94 with TWIE (TWIE is not available).
8. Updated the last page by Atmel new Brand Style Guide.

34.2 8134H – 09/10

1. Updated ”Errata” on page 88.

34.3 8134G – 08/10

1. Updated the Footnote 3 of ”Ordering Information” on page 2.
2. All references to CRC removed. Updated Figure 3-1 on page 5.
3. Updated ”Features” on page 26. Event Channel 0 output on port pin 7.
4. Updated ”DC Characteristics” on page 56 by adding Icc for Flash/EEPROM Programming.
5. Added AVCC in ”ADC Characteristics” on page 60.
6. Updated Start up time in ”ADC Characteristics” on page 60.
7. Updated and fixed typo in “Errata” section.

34.4 8134F – 02/10

1. Added ”PDI Speed” on page 85.

34.5 8134E – 01/10

1. Updated the device pin-out Figure 2-1 on page 3. PDI_CLK and PDI_DATA renamed only PDI.
2. Updated ”ADC - 12-bit Analog to Digital Converter” on page 39.
3. Updated Figure 23-1 on page 40.
4. Updated ”Alternate Pin Function Description” on page 46.
5. Updated ”Alternate Pin Functions” on page 48.
6. Updated ”Timer/Counter and AWEX functions” on page 46.
7. Added Table 30-17 on page 63.
8. Added Table 30-18 on page 64.
9. Changed Internal Oscillator Speed to ”Oscillators and Wake-up Time” on page 81.
10. Updated ”Errata” on page 88.

34.6 8134D – 11/09

1. Added Table 30-3 on page 59, Endurance and Data Retention.
2. Updated Table 30-10 on page 62, Input hysteresis is in V and not in mV.
3. Added ”Errata” on page 88.
4. Editing updates.

34.7 8134C – 10/09

1. Updated ”Features” on page 1 with Two Two-Wire Interfaces.
2. Updated ”Block diagram and pinout” on page 3.
3. Updated ”Overview” on page 4.
4. Updated ”XMEGA D3 Block Diagram” on page 5.
5. Updated Table 13-1 on page 24.
6. Updated ”Overview” on page 35.
7. Updated Table 27-5 on page 49.
8. Updated ”Peripheral Module Address Map” on page 51.

34.8 8134B – 08/09

1. Added ”Electrical Characteristics” on page 56.
2. Added ”Typical Characteristics” on page 65.

34.9 8134A – 03/09

1. Initial revision.

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