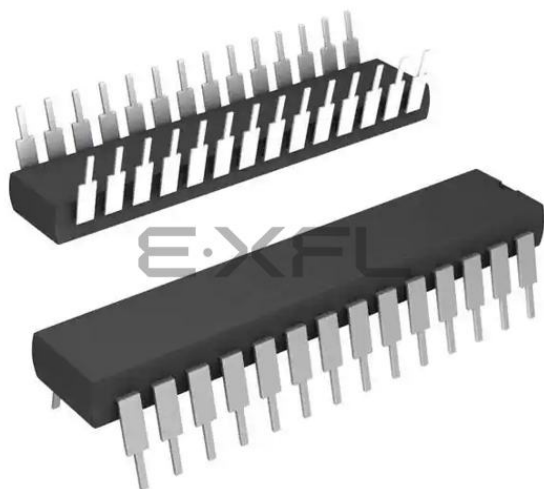




Welcome to [E-XFL.COM](http://E-XFL.COM)

### What is "[Embedded - Microcontrollers](#)"?

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

### Applications of "[Embedded - Microcontrollers](#)"

#### Details

|                            |                                                                                                                                                               |
|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Product Status             | Active                                                                                                                                                        |
| Core Processor             | AVR                                                                                                                                                           |
| Core Size                  | 8-Bit                                                                                                                                                         |
| Speed                      | 20MHz                                                                                                                                                         |
| Connectivity               | I <sup>2</sup> C, SPI, UART/USART                                                                                                                             |
| Peripherals                | Brown-out Detect/Reset, POR, PWM, WDT                                                                                                                         |
| Number of I/O              | 23                                                                                                                                                            |
| Program Memory Size        | 16KB (8K x 16)                                                                                                                                                |
| Program Memory Type        | FLASH                                                                                                                                                         |
| EEPROM Size                | 512 x 8                                                                                                                                                       |
| RAM Size                   | 1K x 8                                                                                                                                                        |
| Voltage - Supply (Vcc/Vdd) | 1.8V ~ 5.5V                                                                                                                                                   |
| Data Converters            | A/D 6x10b                                                                                                                                                     |
| Oscillator Type            | Internal                                                                                                                                                      |
| Operating Temperature      | -40°C ~ 85°C (TA)                                                                                                                                             |
| Mounting Type              | Through Hole                                                                                                                                                  |
| Package / Case             | 28-DIP (0.300", 7.62mm)                                                                                                                                       |
| Supplier Device Package    | 28-PDIP                                                                                                                                                       |
| Purchase URL               | <a href="https://www.e-xfl.com/product-detail/microchip-technology/atmega168a-pu">https://www.e-xfl.com/product-detail/microchip-technology/atmega168a-pu</a> |

- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Six PWM Channels
  - 8-channel 10-bit ADC in TQFP and QFN/MLF package
    - Temperature Measurement
  - 6-channel 10-bit ADC in PDIP Package
    - Temperature Measurement
  - Two Master/Slave SPI Serial Interface
  - One Programmable Serial USART
  - One Byte-oriented 2-wire Serial Interface (Philips I<sup>2</sup>C compatible)
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - One On-chip Analog Comparator
  - Interrupt and Wake-up on Pin Change
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby
- I/O and Packages
  - 23 Programmable I/O Lines
  - 28-pin PDIP, 32-lead TQFP, 28-pad QFN/MLF and 32-pad QFN/MLF
- Operating Voltage:
  - 1.8 - 5.5V
- Temperature Range:
  - -40°C to 85°C
- Speed Grade:
  - 0 - 4MHz @ 1.8 - 5.5V
  - 0 - 10MHz @ 2.7 - 5.5V
  - 0 - 20MHz @ 4.5 - 5.5V
- Power Consumption at 1MHz, 1.8V, 25°C
  - Active Mode: 0.2mA
  - Power-down Mode: 0.1µA
  - Power-save Mode: 0.75µA (Including 32kHz RTC)

## Table of Contents

---

|                                   |    |
|-----------------------------------|----|
| Introduction.....                 | 1  |
| Feature.....                      | 1  |
| 1. Description.....               | 4  |
| 2. Configuration Summary.....     | 5  |
| 3. Ordering Information .....     | 6  |
| 3.1. ATmega48A.....               | 6  |
| 3.2. ATmega88A .....              | 7  |
| 3.3. ATmega168A .....             | 8  |
| 4. Block Diagram.....             | 9  |
| 5. Pin Configurations.....        | 10 |
| 5.1. Pin-out.....                 | 10 |
| 5.2. Pin Descriptions.....        | 14 |
| 6. I/O Multiplexing.....          | 16 |
| 7. Resources.....                 | 18 |
| 8. Data Retention.....            | 19 |
| 9. About Code Examples.....       | 20 |
| 10. Capacitive Touch Sensing..... | 21 |
| 10.1. QTouch Library.....         | 21 |
| 11. Packaging Information.....    | 22 |
| 11.1. 32-pin 32A.....             | 22 |
| 11.2. 32-pin 32M1-A.....          | 23 |
| 11.3. 32-pin 32CC1.....           | 24 |
| 11.4. 28-pin 28M1.....            | 25 |
| 11.5. 28-pin 28P3.....            | 26 |

## 2. Configuration Summary

| Features                                        | ATmega48A/88A/168A |
|-------------------------------------------------|--------------------|
| Pin Count                                       | 28/32              |
| Flash (Bytes)                                   | 4K/8K/16K          |
| SRAM (Bytes)                                    | 512/1K/1K          |
| EEPROM (Bytes)                                  | 256/512/512        |
| Interrupt Vector Size (instruction word/vector) | 1/1/2              |
| General Purpose I/O Lines                       | 23                 |
| SPI                                             | 2                  |
| TWI (I <sup>2</sup> C)                          | 1                  |
| USART                                           | 1                  |
| ADC                                             | 10-bit 15kSPS      |
| ADC Channels                                    | 8                  |
| 8-bit Timer/Counters                            | 2                  |
| 16-bit Timer/Counters                           | 1                  |

ATmega88A and ATmega168A support a real Read-While-Write Self-Programming mechanism. There is a separate Boot Loader Section, and the SPM instruction can only execute from there. In ATmega48A, there is no Read-While-Write support and no separate Boot Loader Section. The SPM instruction can execute from the entire Flash.

### 3. Ordering Information

#### 3.1. ATmega48A

| Speed [MHz] <sup>(3)</sup> | Power Supply [V] | Ordering Code <sup>(2)</sup>                                                                                                                                                                                                       | Package <sup>(1)</sup>                                                   | Operational Range             |
|----------------------------|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------|
| 20                         | 1.8 - 5.5        | ATmega48A-AU<br>ATmega48A-AUR <sup>(4)</sup><br>ATmega48A-CCU<br>ATmega48A-CCUR <sup>(4)</sup><br>ATmega48A-MMH <sup>(5)</sup><br>ATmega48A-MMHR <sup>(4)(5)</sup><br>ATmega48A-MU<br>ATmega48A-MUR <sup>(4)</sup><br>ATmega48A-PU | 32A<br>32A<br>32CC1<br>32CC1<br>28M1<br>28M1<br>32M1-A<br>32M1-A<br>28P3 | Industrial<br>(-40°C to 85°C) |

**Note:**

1. This device can also be supplied in wafer form. Please contact your local Atmel sales office for detailed ordering information and minimum quantities.
2. Pb-free packaging, complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.
3. Please refer to *Speed Grades* for Speed vs.  $V_{CC}$
4. Tape & Reel.
5. NiPdAu Lead Finish.

| Package Type |                                                                                                   |
|--------------|---------------------------------------------------------------------------------------------------|
| 28M1         | 28-pad, 4 x 4 x 1.0 body, Lead Pitch 0.45mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)  |
| 28P3         | 28-lead, 0.300" Wide, Plastic Dual Inline Package (PDIP)                                          |
| 32M1-A       | 32-pad, 5 x 5 x 1.0 body, Lead Pitch 0.50mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)  |
| 32A          | 32-lead, Thin (1.0mm) Plastic Quad Flat Package (TQFP)                                            |
| 32CC1        | 32-ball, 4 x 4 x 0.6mm package, ball pitch 0.5mm, Ultra Thin, Fine-Pitch Ball Grill Array (UFBGA) |

### 3.3. ATmega168A

| Speed [MHz] <sup>(3)</sup> | Power Supply [V] | Ordering Code <sup>(2)</sup>                                                                                                                                                                                                                | Package <sup>(1)</sup>                                                   | Operational Range             |
|----------------------------|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------|
| 20                         | 1.8 - 5.5        | ATmega168A-AU<br>ATmega168A-AUR <sup>(5)</sup><br>ATmega168A-CCU<br>ATmega168A-CCUR <sup>(5)</sup><br>ATmega168A-MMH <sup>(4)</sup><br>ATmega168A-MMHR <sup>(4)(5)</sup><br>ATmega168A-MU<br>ATmega168A-MUR <sup>(5)</sup><br>ATmega168A-PU | 32A<br>32A<br>32CC1<br>32CC1<br>28M1<br>28M1<br>32M1-A<br>32M1-A<br>28P3 | Industrial<br>(-40°C to 85°C) |

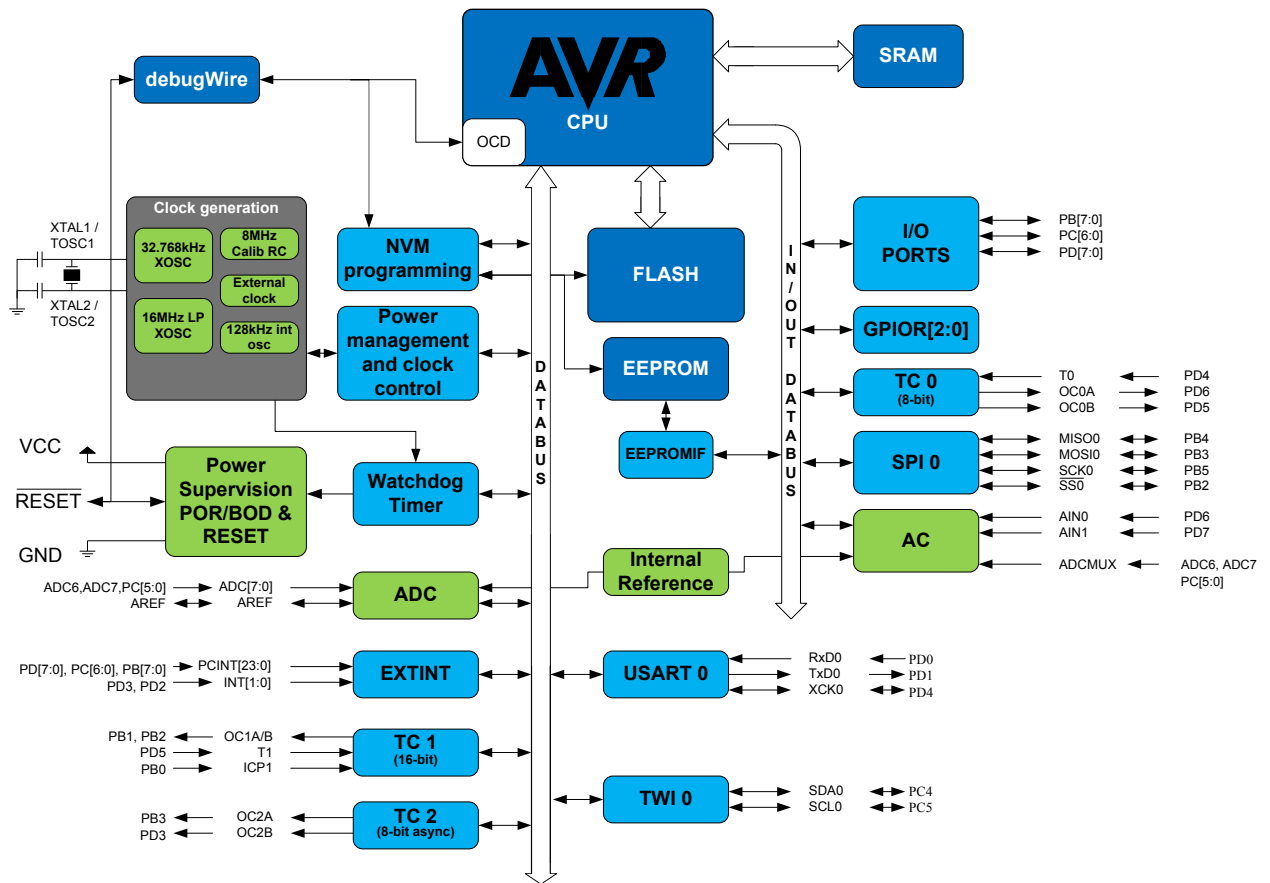
**Note:**

1. This device can also be supplied in wafer form. Please contact your local Atmel sales office for detailed ordering information and minimum quantities.
2. Pb-free packaging, complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.
3. Please refer to *Speed Grades* for Speed vs.  $V_{CC}$
4. Tape & Reel.
5. NiPdAu Lead Finish.

| Package Type |                                                                                                   |
|--------------|---------------------------------------------------------------------------------------------------|
| 28M1         | 28-pad, 4 x 4 x 1.0 body, Lead Pitch 0.45mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)  |
| 28P3         | 28-lead, 0.300" Wide, Plastic Dual Inline Package (PDIP)                                          |
| 32M1-A       | 32-pad, 5 x 5 x 1.0 body, Lead Pitch 0.50mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)  |
| 32A          | 32-lead, Thin (1.0mm) Plastic Quad Flat Package (TQFP)                                            |
| 32CC1        | 32-ball, 4 x 4 x 0.6mm package, ball pitch 0.5mm, Ultra Thin, Fine-Pitch Ball Grill Array (UFBGA) |

## 4. Block Diagram

Figure 4-1. Block Diagram



## 5. Pin Configurations

### 5.1. Pin-out

Figure 5-1. 28-pin PDIP

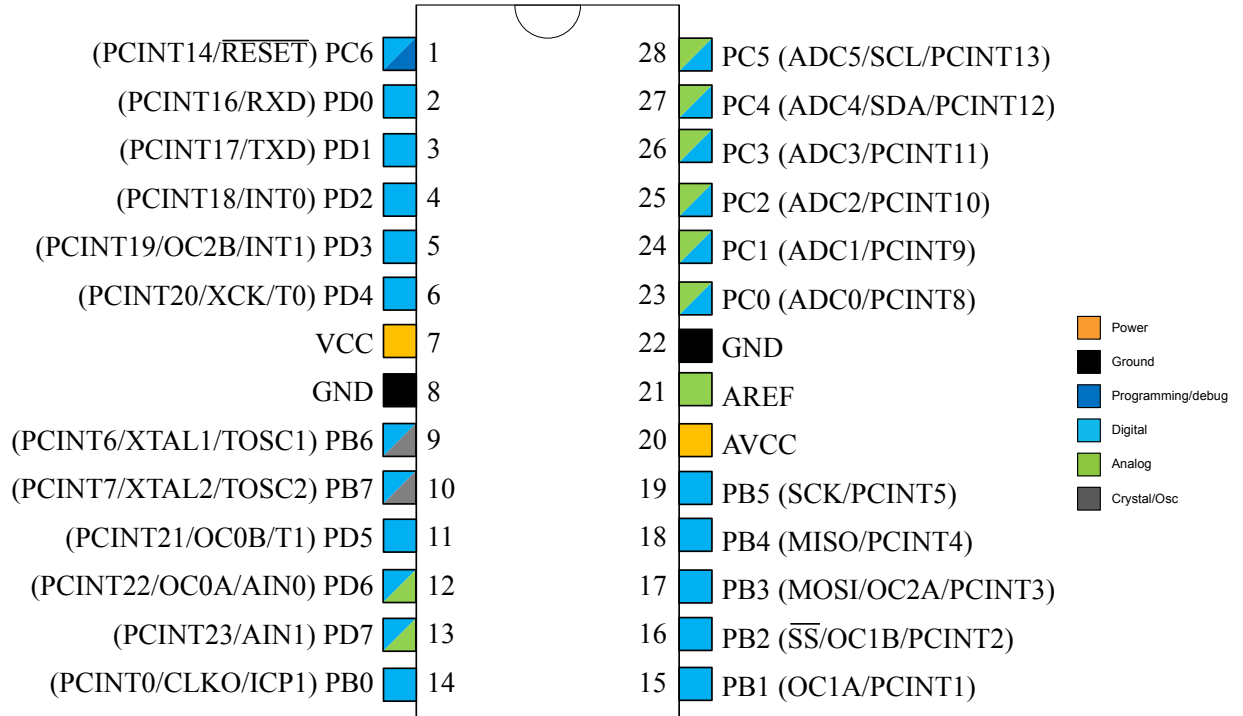
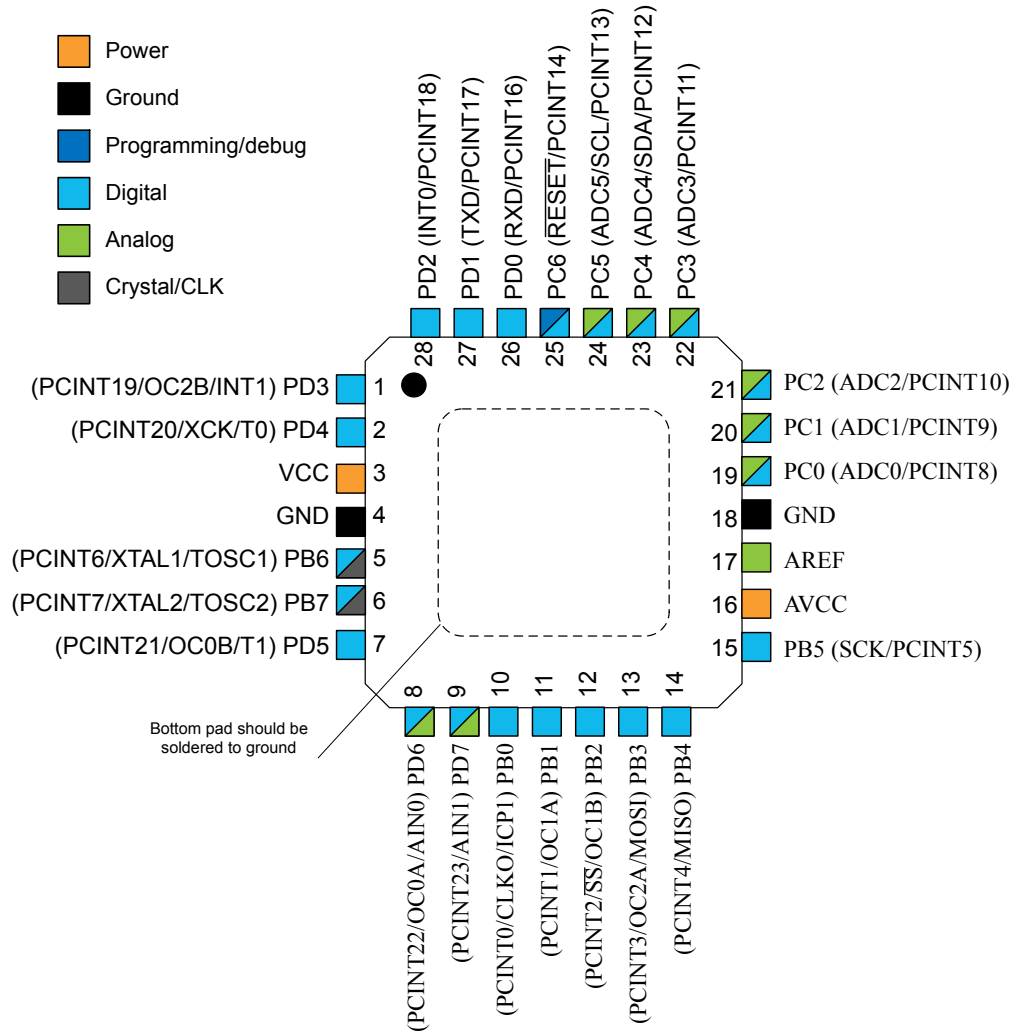
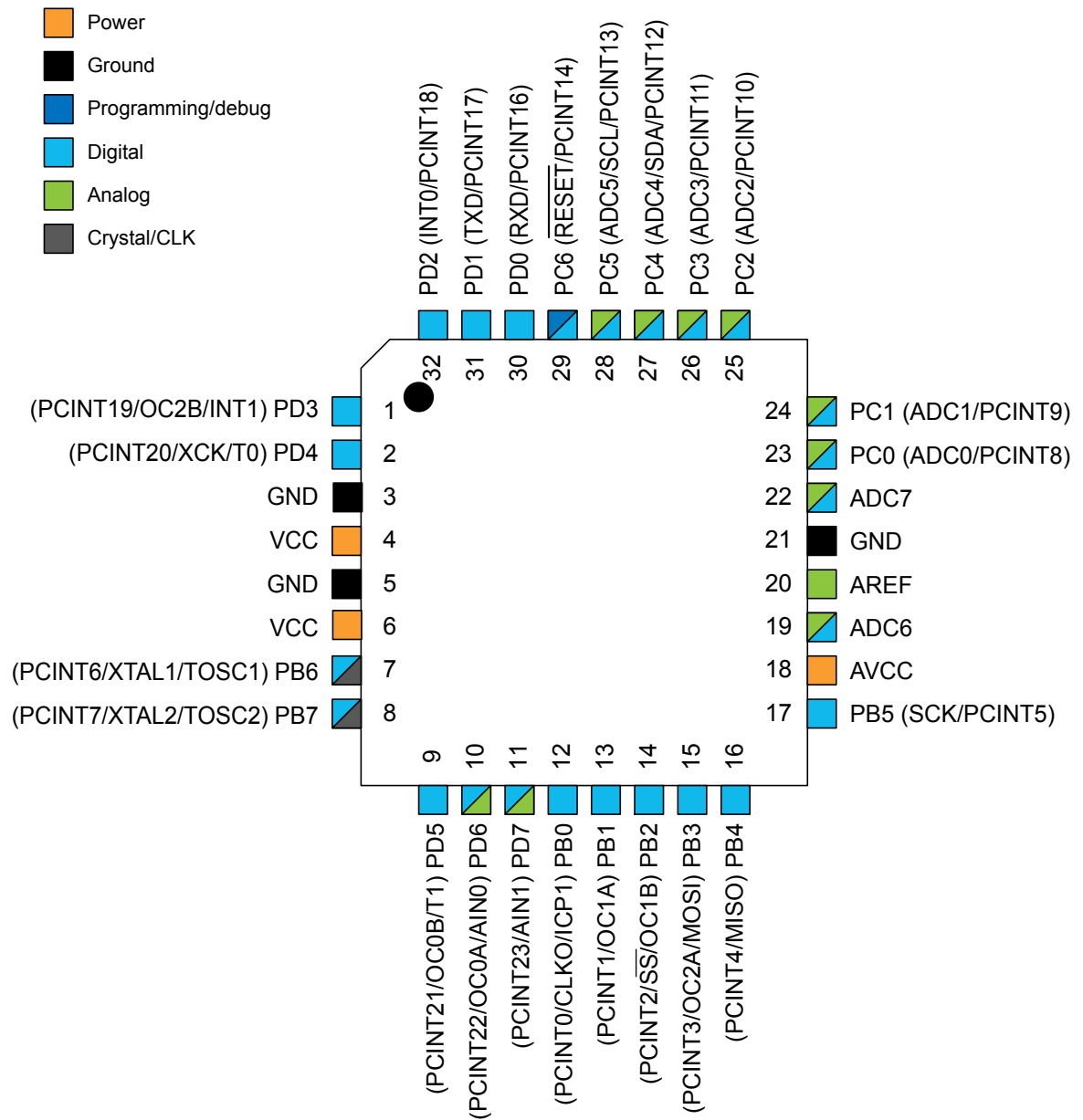




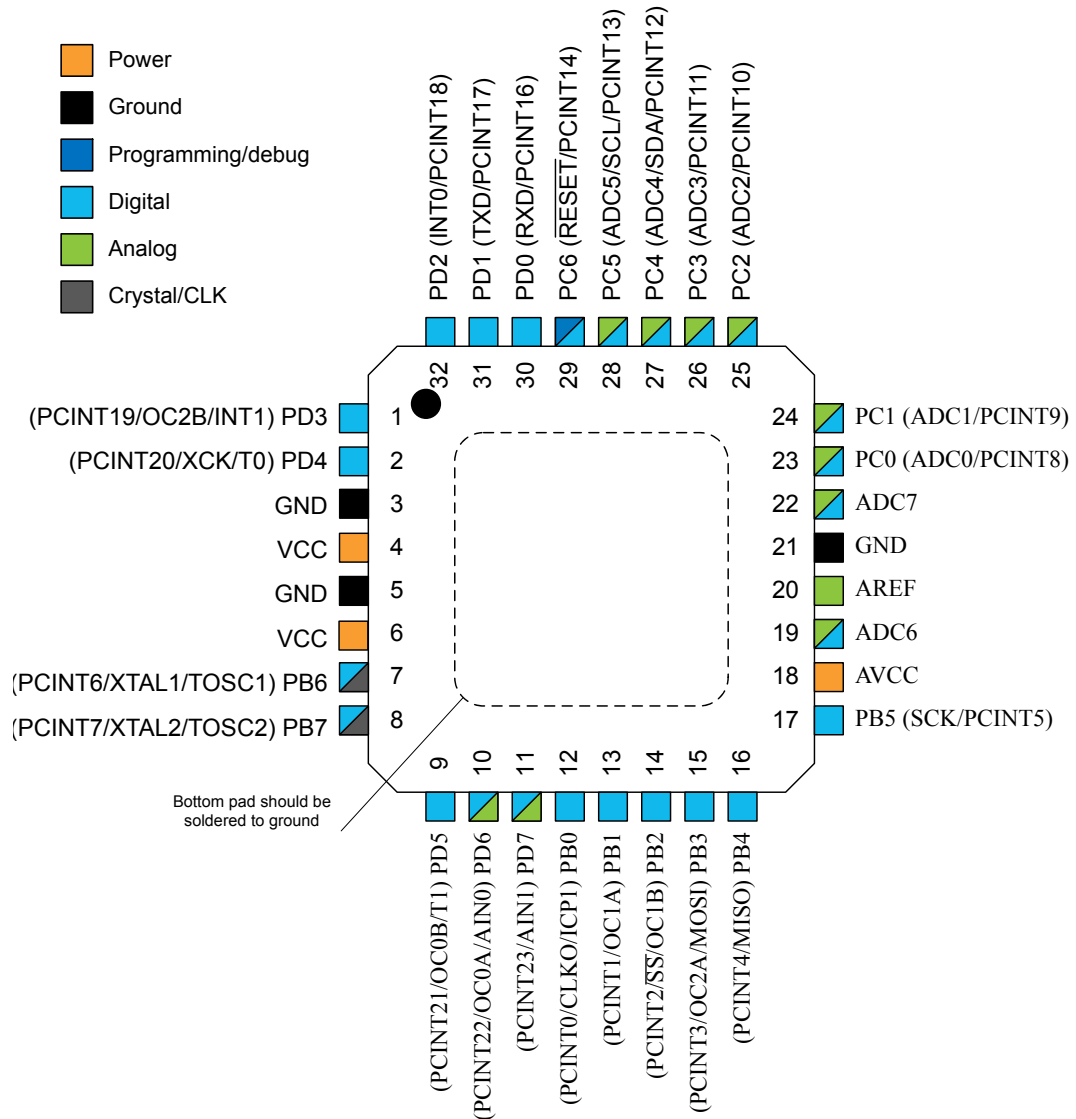
Figure 5-2. 28-pin MLF Top View



**Figure 5-3. 32-pin TQFP Top View**



**Figure 5-4. 32-pin MLF Top View**



**Table 5-1. 32UFBGA**

|   | 1   | 2   | 3   | 4   | 5    | 6    |
|---|-----|-----|-----|-----|------|------|
| A | PD2 | PD1 | PC6 | PC4 | PC2  | PC1  |
| B | PD3 | PD4 | PD0 | PC5 | PC3  | PC0  |
| C | GND | GND | -   | -   | ADC7 | GND  |
| D | VCC | VCC | -   | -   | AREF | ADC6 |
| E | PB6 | PD6 | PB0 | PB2 | AVCC | PB5  |
| F | PB7 | PD5 | PD7 | PB1 | PB3  | PB4  |

#### **5.2.9. ADC[7:6] (TQFP and VFQFN Package Only)**

In the TQFP and VFQFN package, ADC[7:6] serve as analog inputs to the A/D converter. These pins are powered from the analog supply and serve as 10-bit ADC channels.

## 6. I/O Multiplexing

Each pin is by default controlled by the PORT as a general purpose I/O and alternatively it can be assigned to one of the peripheral functions.

The following table describes the peripheral signals multiplexed to the PORT I/O pins.

**Table 6-1. PORT Function Multiplexing**

| (32-pin<br>32UFBGA)<br>Pin# | (32-pin<br>MLF/<br>TQFP)<br>Pin# | (28-pin<br>MLF)<br>Pin# | (28-pin<br>PIPD)<br>Pin# | PAD   | EXTINT | PCINT   | ADC/A<br>C | OSC             | T/C #0 | T/C<br>#1 | USART<br>0 | I2C 0 | SPI 0 |
|-----------------------------|----------------------------------|-------------------------|--------------------------|-------|--------|---------|------------|-----------------|--------|-----------|------------|-------|-------|
| B1                          | 1                                | 1                       | 5                        | PD[3] | INT1   | PCINT19 |            |                 | OC2B   |           |            |       |       |
| B2                          | 2                                | 2                       | 6                        | PD[4] |        | PCINT20 |            |                 | T0     |           | XCK0       |       |       |
| D1                          | 4                                | 3                       | 7                        | VCC   |        |         |            |                 |        |           |            |       |       |
| C1                          | 3                                | 4                       | 8                        | GND   |        |         |            |                 |        |           |            |       |       |
| D2                          | 6                                | -                       | -                        | VCC   |        |         |            |                 |        |           |            |       |       |
| C2                          | 5                                | -                       | -                        | GND   |        |         |            |                 |        |           |            |       |       |
| E1                          | 7                                | 5                       | 9                        | PB[6] |        | PCINT6  |            | XTAL1/<br>TOSC1 |        |           |            |       |       |
| F1                          | 8                                | 6                       | 10                       | PB[7] |        | PCINT7  |            | XTAL2/<br>TOSC2 |        |           |            |       |       |
| F2                          | 9                                | 7                       | 11                       | PD[5] |        | PCINT21 |            |                 | OC0B   | T1        |            |       |       |
| E2                          | 10                               | 8                       | 12                       | PD[6] |        | PCINT22 | AIN0       |                 | OC0A   |           |            |       |       |
| F3                          | 11                               | 9                       | 13                       | PD[7] |        | PCINT23 | AIN1       |                 |        |           |            |       |       |
| E3                          | 12                               | 10                      | 14                       | PB[0] |        | PCINT0  |            | CLKO            | ICP1   |           |            |       |       |
| F4                          | 13                               | 11                      | 15                       | PB[1] |        | PCINT1  |            |                 | OC1A   |           |            |       |       |
| E4                          | 14                               | 12                      | 16                       | PB[2] |        | PCINT2  |            |                 | OC1B   |           |            |       | SS0   |
| F5                          | 15                               | 13                      | 17                       | PB[3] |        | PCINT3  |            |                 | OC2A   |           |            |       | MOSI0 |
| F6                          | 16                               | 14                      | 18                       | PB[4] |        | PCINT4  |            |                 |        |           |            |       | MISO0 |
| E6                          | 17                               | 15                      | 19                       | PB[5] |        | PCINT5  |            |                 |        |           |            |       | SCK0  |
| E5                          | 18                               | 16                      | 20                       | AVCC  |        |         |            |                 |        |           |            |       |       |
| D6                          | 19                               | -                       | -                        | ADC6  |        |         | ADC6       |                 |        |           |            |       |       |
| D5                          | 20                               | 17                      | 21                       | AREF  |        |         |            |                 |        |           |            |       |       |
| C6                          | 21                               | 18                      | 22                       | GND   |        |         |            |                 |        |           |            |       |       |
| C5                          | 22                               | -                       | -                        | ADC7  |        |         | ADC7       |                 |        |           |            |       |       |
| B6                          | 23                               | 19                      | 13                       | PC[0] |        | PCINT8  | ADC0       |                 |        |           |            |       |       |
| A6                          | 24                               | 20                      | 24                       | PC[1] |        | PCINT9  | ADC1       |                 |        |           |            |       |       |
| A2                          | 25                               | 21                      | 25                       | PC[2] |        | PCINT10 | ADC2       |                 |        |           |            |       |       |
| B5                          | 26                               | 22                      | 26                       | PC[3] |        | PCINT11 | ADC3       |                 |        |           |            |       |       |
| A4                          | 27                               | 23                      | 27                       | PC[4] |        | PCINT12 | ADC4       |                 |        |           |            | SDA0  |       |
| B4                          | 28                               | 24                      | 28                       | PC[5] |        | PCINT13 | ADC5       |                 |        |           |            | SCL0  |       |

| (32-pin<br>32UFBGA)<br>Pin# | (32-pin<br>MLF/<br>TQFP)<br>Pin# | (28-pin<br>MLF)<br>Pin# | (28-pin<br>PIPD)<br>Pin# | PAD             | EXTINT | PCINT   | ADC/A<br>C | OSC | T/C #0 | T/C<br>#1 | USART<br>0 | I2C 0 | SPI 0 |
|-----------------------------|----------------------------------|-------------------------|--------------------------|-----------------|--------|---------|------------|-----|--------|-----------|------------|-------|-------|
| A3                          | 29                               | 25                      | 1                        | PC[6]/<br>RESET |        | PCINT14 |            |     |        |           |            |       |       |
| B3                          | 30                               | 26                      | 2                        | PD[0]           |        | PCINT16 |            |     |        |           | RXD0       |       |       |
| A2                          | 31                               | 27                      | 3                        | PD[1]           |        | PCINT17 |            |     |        |           | TXD0       |       |       |
| A1                          | 32                               | 28                      | 4                        | PD[2]           | INT0   | PCINT18 |            |     |        |           |            |       |       |

## 7. Resources

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

## 8. Data Retention

Reliability Qualification results show that the projected data retention failure rate is much less than 1 PPM over 20 years at 85°C.

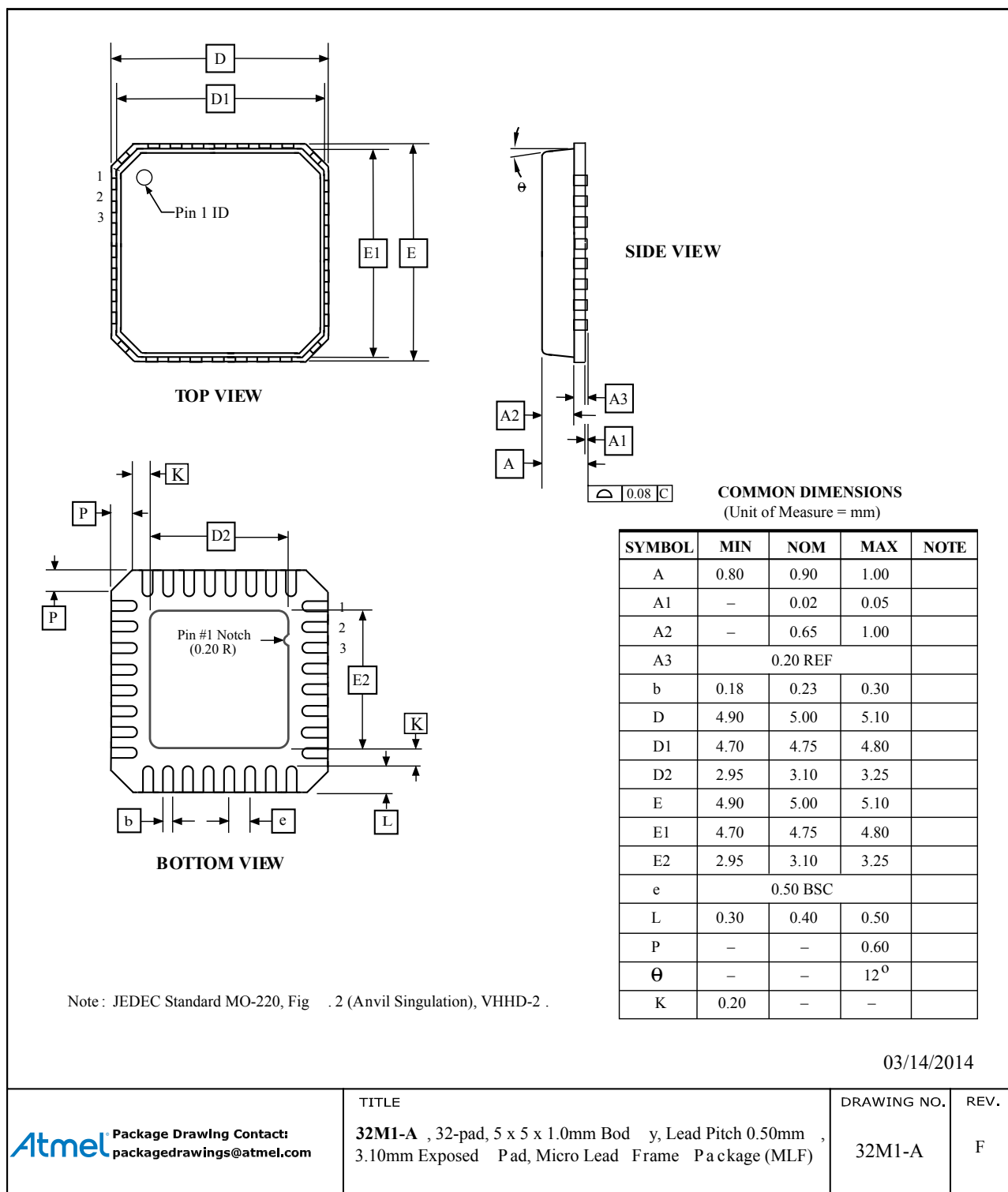


## 9. About Code Examples

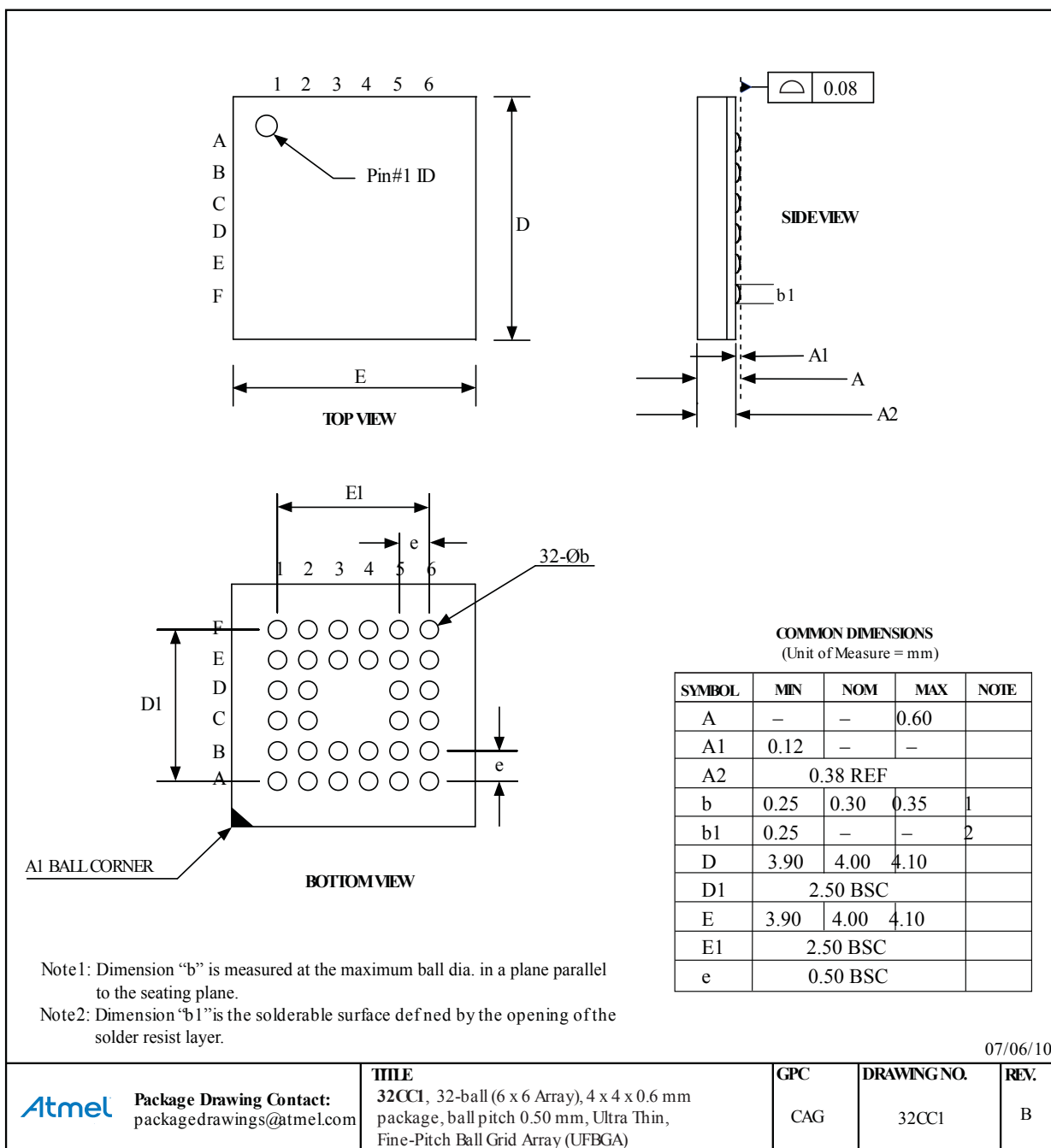
This documentation contains simple code examples that briefly show how to use various parts of the device. These code examples assume that the part specific header file is included before compilation. Be aware that not all C compiler vendors include bit definitions in the header files and interrupt handling in C is compiler dependent. Confirm with the C compiler documentation for more details.

For I/O Registers located in extended I/O map, “IN”, “OUT”, “SBIS”, “SBIC”, “CBI”, and “SBI” instructions must be replaced with instructions that allow access to extended I/O. Typically “LDS” and “STS” combined with “SBR”, “SBRC”, “SBR”, and “CBR”.

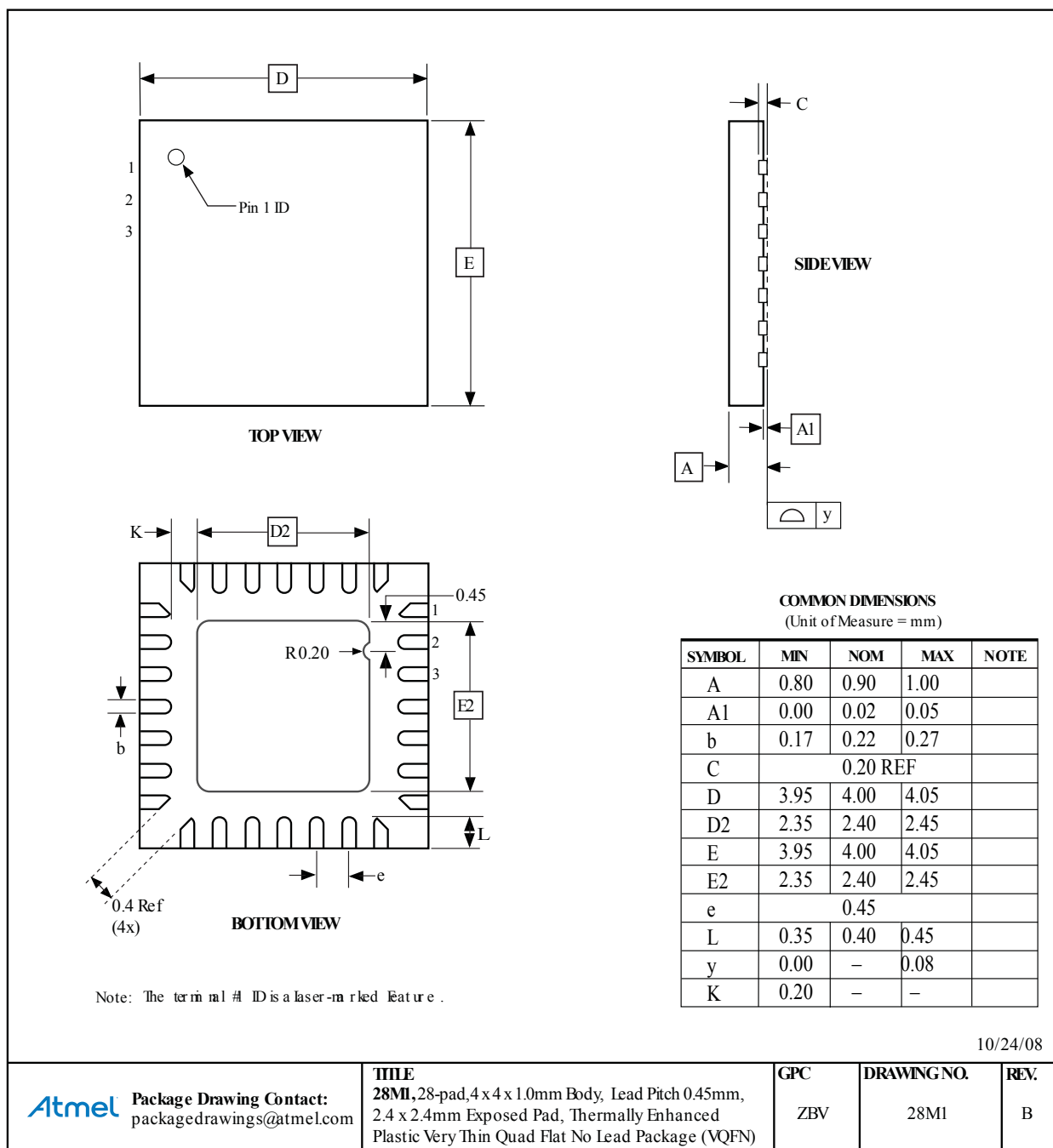
## 11.2. 32-pin 32M1-A



### 11.3. 32-pin 32CC1



## 11.4. 28-pin 28M1



Atmel®, Atmel logo and combinations thereof, Enabling Unlimited Possibilities®, AVR®, and others are registered trademarks or trademarks of Atmel Corporation in U.S. and other countries. Other terms and product names may be trademarks of others.

**DISCLAIMER:** The information in this document is provided in connection with Atmel products. No license, express or implied, by estoppel or otherwise, to any intellectual property right is granted by this document or in connection with the sale of Atmel products. EXCEPT AS SET FORTH IN THE ATMEL TERMS AND CONDITIONS OF SALES LOCATED ON THE ATMEL WEBSITE, ATMEL ASSUMES NO LIABILITY WHATSOEVER AND DISCLAIMS ANY EXPRESS, IMPLIED OR STATUTORY WARRANTY RELATING TO ITS PRODUCTS INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT. IN NO EVENT SHALL ATMEL BE LIABLE FOR ANY DIRECT, INDIRECT, CONSEQUENTIAL, PUNITIVE, SPECIAL OR INCIDENTAL DAMAGES (INCLUDING, WITHOUT LIMITATION, DAMAGES FOR LOSS AND PROFITS, BUSINESS INTERRUPTION, OR LOSS OF INFORMATION) ARISING OUT OF THE USE OR INABILITY TO USE THIS DOCUMENT, EVEN IF ATMEL HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. Atmel makes no representations or warranties with respect to the accuracy or completeness of the contents of this document and reserves the right to make changes to specifications and products descriptions at any time without notice. Atmel does not make any commitment to update the information contained herein. Unless specifically provided otherwise, Atmel products are not suitable for, and shall not be used in, automotive applications. Atmel products are not intended, authorized, or warranted for use as components in applications intended to support or sustain life.

**SAFETY-CRITICAL, MILITARY, AND AUTOMOTIVE APPLICATIONS DISCLAIMER:** Atmel products are not designed for and will not be used in connection with any applications where the failure of such products would reasonably be expected to result in significant personal injury or death ("Safety-Critical Applications") without an Atmel officer's specific written consent. Safety-Critical Applications include, without limitation, life support devices and systems, equipment or systems for the operation of nuclear facilities and weapons systems. Atmel products are not designed nor intended for use in military or aerospace applications or environments unless specifically designated by Atmel as military-grade. Atmel products are not designed nor intended for use in automotive applications unless specifically designated by Atmel as automotive-grade.