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## 8-bit AVR Microcontroller with 32K Bytes In-System Programmable Flash

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### DATASHEET

### Features

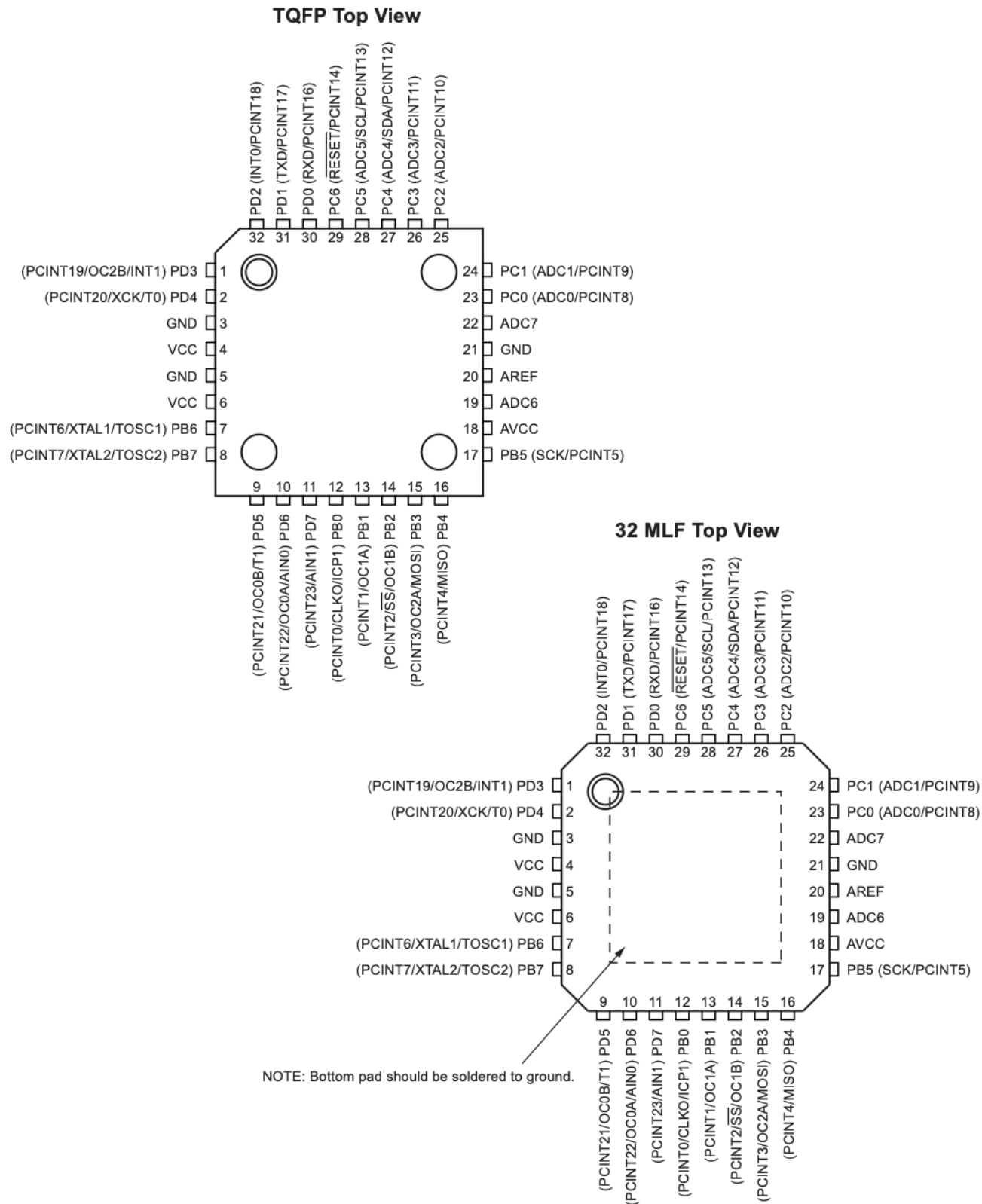
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- High performance, low power AVR® 8-bit microcontroller
- Advanced RISC architecture
  - 131 powerful instructions – most single clock cycle execution
  - 32 × 8 general purpose working registers
  - Fully static operation
  - Up to 16MIPS throughput at 16MHz
  - On-chip 2-cycle multiplier
- High endurance non-volatile memory segments
  - 32K bytes of in-system self-programmable flash program memory
  - 1Kbytes EEPROM
  - 2Kbytes internal SRAM
  - Write/erase cycles: 10,000 flash/100,000 EEPROM
  - Optional boot code section with independent lock bits
    - In-system programming by on-chip boot program
    - True read-while-write operation
  - Programming lock for software security
- 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
  - Programmable serial USART
  - Master/slave SPI serial interface
  - Byte-oriented 2-wire serial interface (Phillips I<sup>2</sup>C compatible)
  - Programmable watchdog timer with separate on-chip oscillator
  - 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
  - 32-lead TQFP, and 32-pad QFN/MLF
- Operating voltage:
  - 2.7V to 5.5V for ATmega328P
- Temperature range:
  - Automotive temperature range:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$
- Speed grade:
  - 0 to 8MHz at 2.7 to 5.5V (automotive temperature range:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ )
  - 0 to 16MHz at 4.5 to 5.5V (automotive temperature range:  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ )
- Low power consumption
  - Active mode: 1.5mA at 3V - 4MHz
  - Power-down mode: 1 $\mu\text{A}$  at 3V

# 1. Pin Configurations

Figure 1-1. Pinout



## 1.1 Pin Descriptions

### 1.1.1 VCC

Digital supply voltage.

### 1.1.2 GND

Ground.

### 1.1.3 Port B (PB7:0) XTAL1/XTAL2/TOSC1/TOSC2

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Depending on the clock selection fuse settings, PB6 can be used as input to the inverting oscillator amplifier and input to the internal clock operating circuit.

Depending on the clock selection fuse settings, PB7 can be used as output from the inverting oscillator amplifier.

If the internal calibrated RC oscillator is used as chip clock source, PB7..6 is used as TOSC2..1 input for the asynchronous Timer/Counter2 if the AS2 bit in ASSR is set.

The various special features of port B are elaborated in [Section 13.3.1 "Alternate Functions of Port B" on page 65](#) and [Section 8. "System Clock and Clock Options" on page 24](#).

### 1.1.4 Port C (PC5:0)

Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC5..0 output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

### 1.1.5 PC6/RESET

If the RSTDISBL fuse is programmed, PC6 is used as an input pin. If the RSTDISBL fuse is unprogrammed, PC6 is used as a reset input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. The minimum pulse length is given in [Table 28-4 on page 261](#). Shorter pulses are not guaranteed to generate a reset.

The various special features of port C are elaborated in [Section 13.3.2 "Alternate Functions of Port C" on page 68](#).

### 1.1.6 Port D (PD7:0)

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, port D pins that are externally pulled low will source current if the pull-up resistors are activated. The port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

The various special features of port D are elaborated in [Section 13.3.3 "Alternate Functions of Port D" on page 70](#).

### 1.1.7 AV<sub>CC</sub>

AV<sub>CC</sub> is the supply voltage pin for the A/D converter, PC3:0, and ADC7:6. It should be externally connected to V<sub>CC</sub>, even if the ADC is not used. If the ADC is used, it should be connected to V<sub>CC</sub> through a low-pass filter. Note that PC6..4 use digital supply voltage, V<sub>CC</sub>.

### 1.1.8 AREF

AREF is the analog reference pin for the A/D converter.