

Features

- High-performance, low-power 8-bit Atmel® AVR® Microcontroller
- Advanced RISC architecture
 - 131 powerful Instructions – most single-clock cycle execution
 - 32 × 8 general purpose working registers
 - Fully static operation
 - Up to 20MIPS throughput at 20MHz
 - On-chip 2-cycle multiplier
- High endurance non-volatile memory segments
 - 16/32/64/128KBytes of In-System Self-programmable Flash program memory
 - 512/1K/2K/4KBytes EEPROM
 - 1/2/4/16KBytes Internal SRAM
 - Write/Erase Cycles: 10,000 Flash/ 100,000 EEPROM
 - Data retention: 20 years at 85°C/ 100 years at 25°C⁽¹⁾
 - 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
- Atmel QTouch® library support
 - Capacitive touch buttons, sliders and wheels
 - QTouch and QMatrix acquisition
 - Up to 64 sense channels
- JTAG (IEEE std. 1149.1 Compliant) Interface
 - Boundary-scan Capabilities According to the JTAG Standard
 - Extensive On-chip Debug Support
 - Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface
- Peripheral Features
 - Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
 - One/two 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
 - Differential mode with selectable gain at 1x, 10x or 200x
 - Byte-oriented Two-wire Serial Interface
 - Two Programmable Serial USART
 - Master/Slave SPI Serial Interface
 - 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 RC 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
 - 32 Programmable I/O Lines
 - 40-pin PDIP, 44-lead TQFP, 44-pad VQFN/QFN/MLF
 - 44-pad DRQFN
 - 49-ball VFBGA
- Operating Voltages
 - 1.8 - 5.5V
- Speed Grades
 - 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: 0.4mA
 - Power-down Mode: 0.1µA
 - Power-save Mode: 0.6µA (Including 32kHz RTC)

Note: 1. See "Data retention" on page 9 for details.



8-bit Atmel Microcontroller with 16/32/64/128K Bytes In-System Programmable Flash

ATmega164A
ATmega164PA
ATmega324A
ATmega324PA
ATmega644A
ATmega644PA
ATmega1284
ATmega1284P

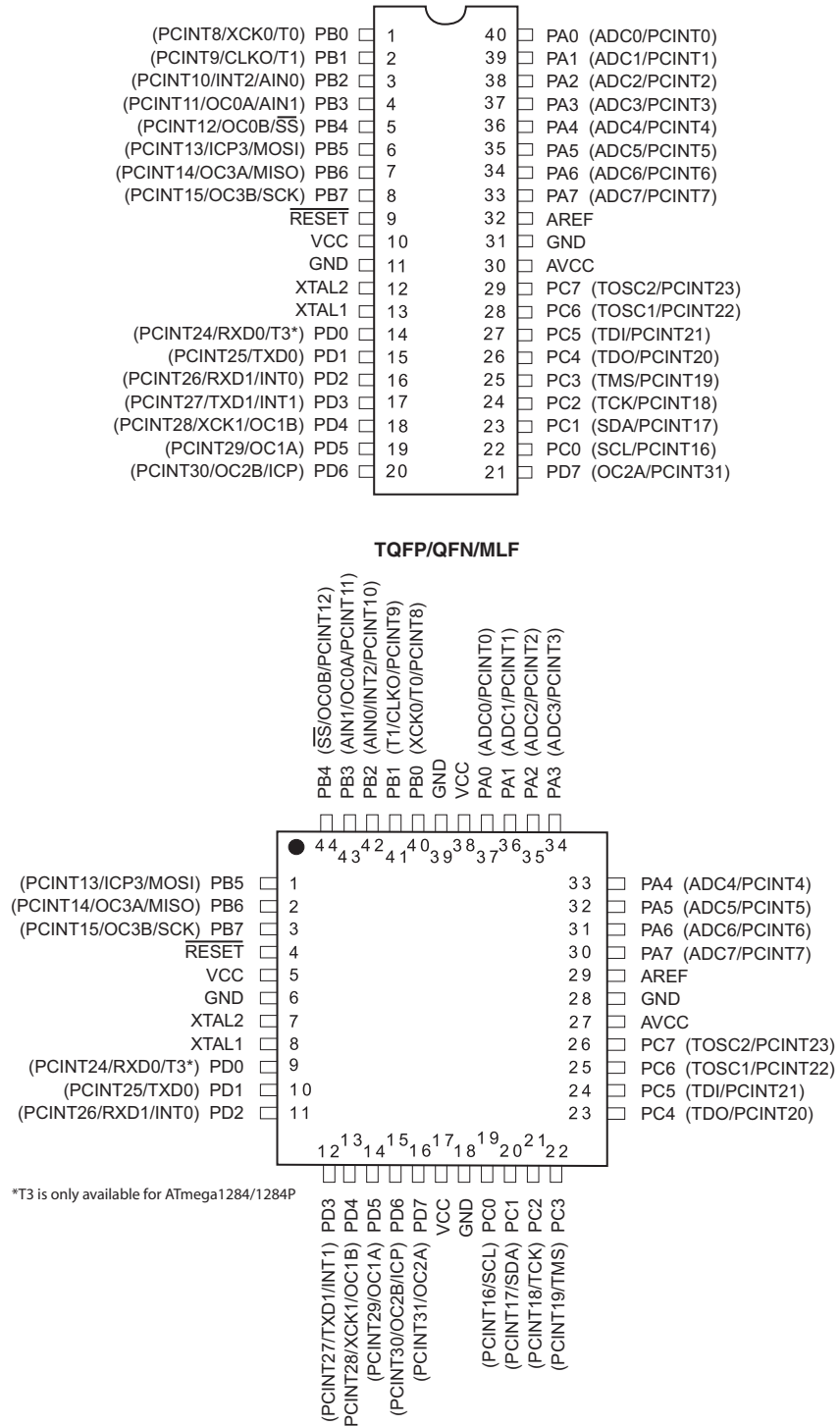
Summary

8272ES-AVR-04/2013

1. Pin configurations

1.1 Pinout - PDIP/TQFP/VQFN/QFN/MLF for ATmega164A/164PA/324A/324PA/644A/644PA/1284/1284P

Figure 1-1. Pinout.



Note: The large center pad underneath the VQFN/QFN/MLF package should be soldered to ground on the board to ensure good mechanical stability.

1.2 Pinout - DRQFN for Atmel ATmega164A/164PA/324A/324PA

Figure 1-2. DRQFN - pinout.

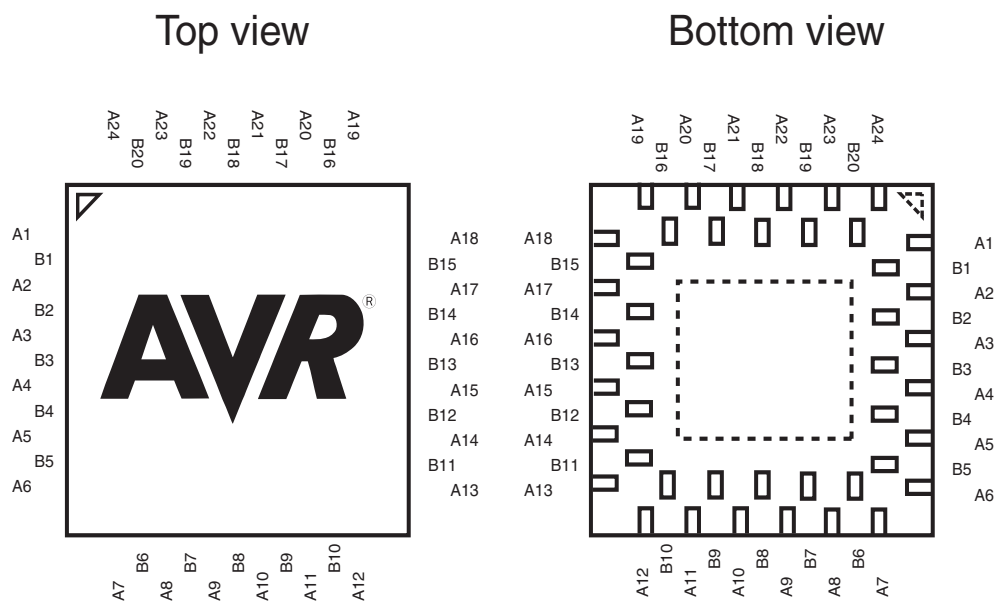


Table 1-1. DRQFN - pinout.

A1	PB5	A7	PD3	A13	PC4	A19	PA3
B1	PB6	B6	PD4	B11	PC5	B16	PA2
A2	PB7	A8	PD5	A14	PC6	A20	PA1
B2	RESET	B7	PD6	B12	PC7	B17	PA0
A3	VCC	A9	PD7	A15	AVCC	A21	VCC
B3	GND	B8	VCC	B13	GND	B18	GND
A4	XTAL2	A10	GND	A16	AREF	A22	PB0
B4	XTAL1	B9	PC0	B14	PA7	B19	PB1
A5	PD0	A11	PC1	A17	PA6	A23	PB2
B5	PD1	B10	PC2	B15	PA5	B20	PB3
A6	PD2	A12	PC3	A18	PA4	A24	PB4

1.3 Pinout - VFBGA for Atmel ATmega164A/164PA/324A/324PA

Figure 1-3. VFBGA - pinout.

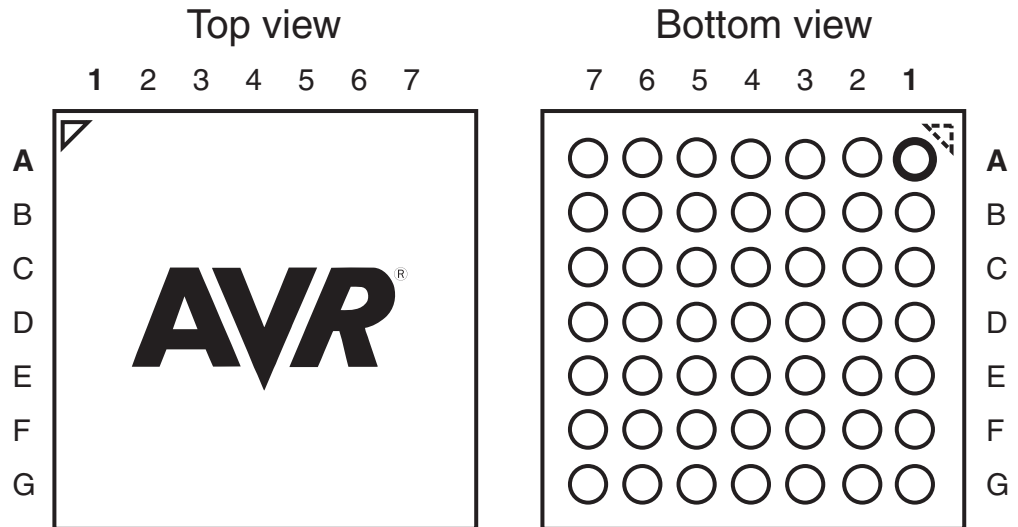


Table 1-2. BGA - pinout.

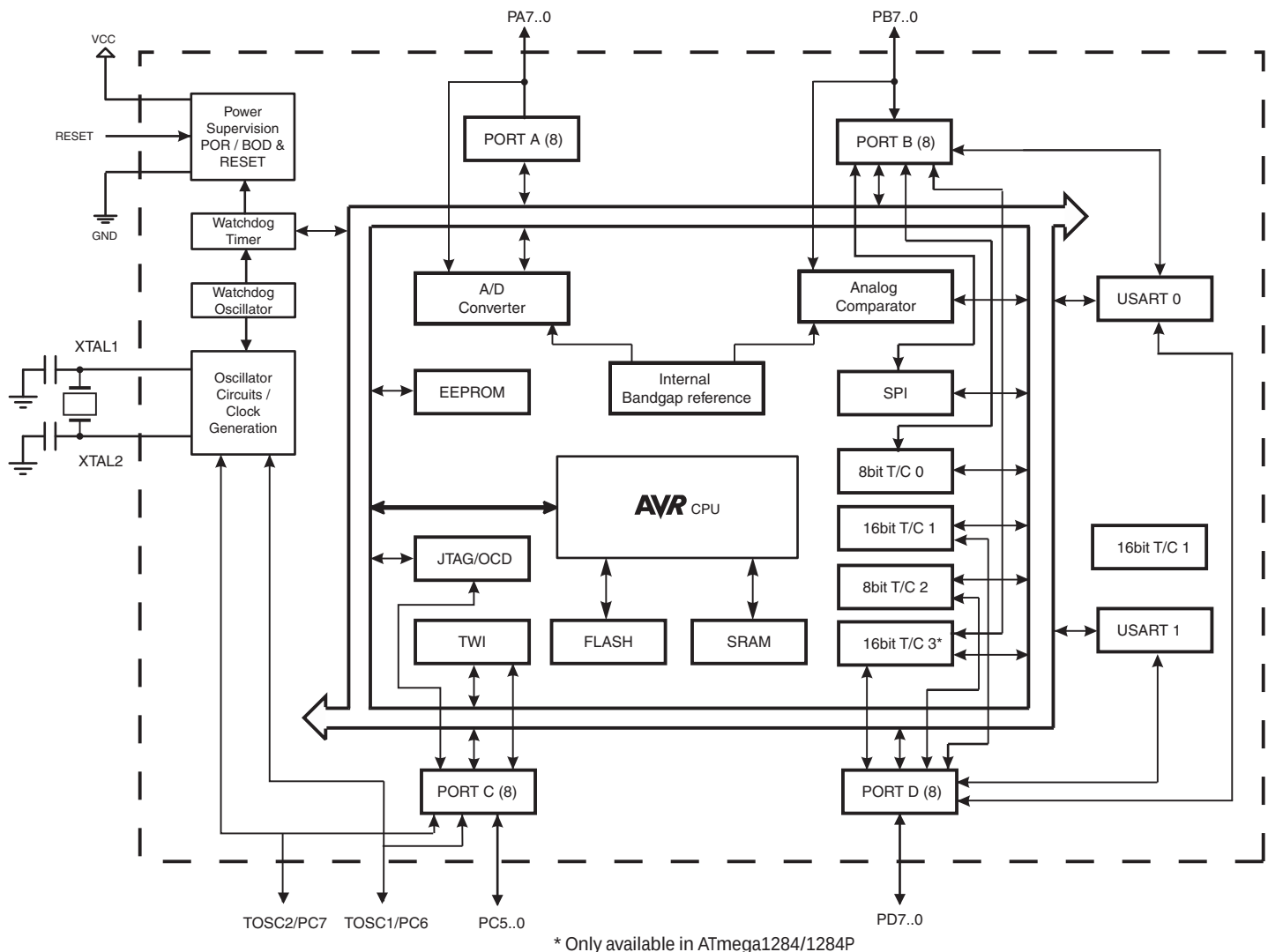
	1	2	3	4	5	6	7
A	GND	PB4	PB2	GND	VCC	PA2	GND
B	PB6	PB5	PB3	PB0	PA0	PA3	PA5
C	VCC	RESET	PB7	PB1	PA1	PA6	AREF
D	GND	XTAL2	PD0	GND	PA4	PA7	GND
E	XTAL1	PD1	PD5	PD7	PC5	PC7	AVCC
F	PD2	PD3	PD6	PC0	PC2	PC4	PC6
G	GND	PD4	VCC	GND	PC1	PC3	GND

2. Overview

The Atmel ATmega164A/164PA/324A/324PA/644A/644PA/1284/1284P is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega164A/164PA/324A/324PA/644A/644PA/1284/1284P achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

2.1 Block diagram

Figure 2-1. Block diagram.



The AVR core 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 up to ten times faster than conventional CISC microcontrollers.

The Atmel ATmega164A/164PA/324A/324PA/644A/644PA/1284/1284P provide the following features:

16/32/64/128Kbytes of In-System Programmable Flash with Read-While-Write capabilities, 512/1K/2K/4Kbytes EEPROM, 1/2/4/16Kbytes SRAM, 32 general purpose I/O lines, 32 general purpose working registers, Real Time Counter (RTC), three (four for ATmega1284/1284P) flexible Timer/Counters with compare modes and PWM, 2 USARTs, a byte oriented two-wire Serial Interface, a 8-channel, 10-bit ADC with optional differential input stage with programmable gain, programmable Watchdog Timer with Internal Oscillator, an SPI serial port, IEEE std. 1149.1 compliant JTAG test interface, also used for accessing the On-chip Debug system and programming and six software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or Hardware Reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except Asynchronous Timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the Crystal/Resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low power consumption. In Extended Standby mode, both the main Oscillator and the Asynchronous Timer continue to run.

Atmel offers the QTouch® library for embedding capacitive touch buttons, sliders and wheels functionality into AVR microcontrollers. The patented charge-transfer signal acquisition offers robust sensing and includes fully debounced reporting of touch keys and includes Adjacent Key Suppression® (AKS™) technology for unambiguous detection of key events. The easy-to-use QTouch Suite toolchain allows you to explore, develop and debug your own touch applications.

The device is manufactured using Atmel's high-density nonvolatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed in-system through an SPI serial interface, by a conventional nonvolatile memory programmer, or by an On-chip Boot program running on the AVR core. The boot program can use any interface to download the application program in the application Flash memory. 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-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega164A/164PA/324A/324PA/644A/644PA/1284/1284P is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications.

The ATmega164A/164PA/324A/324PA/644A/644PA/1284/1284P is supported with a full suite of program and system development tools including: C compilers, macro assemblers, program debugger/simulators, in-circuit emulators, and evaluation kits.

2.2 Comparison between ATmega164A, ATmega164PA, ATmega324A, ATmega324PA, ATmega644A, ATmega644PA, ATmega1284 and ATmega1284P

Table 2-1. Differences between ATmega164A, ATmega164PA, ATmega324A, ATmega324PA, ATmega644A, ATmega644PA, ATmega1284 and ATmega1284P.

Device	Flash	EEPROM	RAM	Units
ATmega164A	16K	512	1K	bytes
ATmega164PA	16K	512	1K	
ATmega324A	32K	1K	2K	
ATmega324PA	32K	1K	2K	
ATmega644A	64K	2K	4K	
ATmega644PA	64K	2K	4K	
ATmega1284	128K	4K	16K	
ATmega1284P	128K	4K	16K	

2.3 Pin Descriptions¹

2.3.1 VCC

Digital supply voltage.

2.3.2 GND

Ground.

2.3.3 Port A (PA7:PA0)

Port A serves as analog inputs to the Analog-to-digital Converter.

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

Port A also serves the functions of various special features of the Atmel ATmega164A/164PA/324A/324PA/644A/644PA/1284/1284P as listed on [page 80](#).

2.3.4 Port B (PB7:PB0)

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.

Port B also serves the functions of various special features of the ATmega164A/164PA/324A/324PA/644A/644PA/1284/1284P as listed on [page 82](#).

2.3.5 Port C (PC7:PC0)

Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C 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.

Port C also serves the functions of the JTAG interface, along with special features of the Atmel ATmega164A/164PA/324A/324PA/644A/644PA/1284/1284P as listed on [page 85](#).

2.3.6 Port D (PD7:PD0)

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.

Port D also serves the functions of various special features of the ATmega164A/164PA/324A/324PA/644A/644PA/1284/1284P as listed on [page 88](#).

2.3.7 $\overline{\text{RESET}}$

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 [" on page 337](#). Shorter pulses are not guaranteed to generate a reset.

2.3.8 XTAL1

Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

2.3.9 XTAL2

Output from the inverting Oscillator amplifier.

2.3.10 AVCC

AVCC is the supply voltage pin for Port A and the Analog-to-digital Converter. It should be externally connected to V_{CC} , even if the ADC is not used. If the ADC is used, it should be connected to V_{CC} through a low-pass filter.

2.3.11 AREF

This is the analog reference pin for the Analog-to-digital Converter.

3. Resources

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

4. About code examples

This documentation contains simple code examples that briefly show how to use various parts of the device. Be aware that not all C compiler vendors include bit definitions in the header files and interrupt handling in C is compiler dependent. Please confirm with the C compiler documentation for more details.

The code examples assume that the part specific header file is included before compilation. 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".

5. 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 or 100 years at 25°C.

6. Capacitive touch sensing

The Atmel QTouch Library provides a simple to use solution to realize touch sensitive interfaces on most Atmel AVR microcontrollers. The QTouch Library includes support for the QTouch and QMatrix acquisition methods.

Touch sensing can be added to any application by linking the appropriate Atmel QTouch Library for the AVR Microcontroller. This is done by using a simple set of APIs to define the touch channels and sensors, and then calling the touch sensing API's to retrieve the channel information and determine the touch sensor states.

The QTouch Library is FREE and downloadable from the Atmel website at the following location: www.atmel.com/qtouchlibrary. For implementation details and other information, refer to the [Atmel QTouch Library User Guide](#) - also available for download from the Atmel website.

7. Register summary

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
(0xFF)	Reserved	-	-	-	-	-	-	-	-	
(0xFE)	Reserved	-	-	-	-	-	-	-	-	
(0xFD)	Reserved	-	-	-	-	-	-	-	-	
(0xFC)	Reserved	-	-	-	-	-	-	-	-	
(0xFB)	Reserved	-	-	-	-	-	-	-	-	
(0xFA)	Reserved	-	-	-	-	-	-	-	-	
(0xF9)	Reserved	-	-	-	-	-	-	-	-	
(0xF8)	Reserved	-	-	-	-	-	-	-	-	
(0xF7)	Reserved	-	-	-	-	-	-	-	-	
(0xF6)	Reserved	-	-	-	-	-	-	-	-	
(0xF5)	Reserved	-	-	-	-	-	-	-	-	
(0xF4)	Reserved	-	-	-	-	-	-	-	-	
(0xF3)	Reserved	-	-	-	-	-	-	-	-	
(0xF2)	Reserved	-	-	-	-	-	-	-	-	
(0xF1)	Reserved	-	-	-	-	-	-	-	-	
(0xF0)	Reserved	-	-	-	-	-	-	-	-	
(0xEF)	Reserved	-	-	-	-	-	-	-	-	
(0xEE)	Reserved	-	-	-	-	-	-	-	-	
(0xED)	Reserved	-	-	-	-	-	-	-	-	
(0xEC)	Reserved	-	-	-	-	-	-	-	-	
(0xEB)	Reserved	-	-	-	-	-	-	-	-	
(0xEA)	Reserved	-	-	-	-	-	-	-	-	
(0xE9)	Reserved	-	-	-	-	-	-	-	-	
(0xE8)	Reserved	-	-	-	-	-	-	-	-	
(0xE7)	Reserved	-	-	-	-	-	-	-	-	
(0xE6)	Reserved	-	-	-	-	-	-	-	-	
(0xE5)	Reserved	-	-	-	-	-	-	-	-	
(0xE4)	Reserved	-	-	-	-	-	-	-	-	
(0xE3)	Reserved	-	-	-	-	-	-	-	-	
(0xE2)	Reserved	-	-	-	-	-	-	-	-	
(0xE1)	Reserved	-	-	-	-	-	-	-	-	
(0xE0)	Reserved	-	-	-	-	-	-	-	-	
(0xDF)	Reserved	-	-	-	-	-	-	-	-	
(0xDE)	Reserved	-	-	-	-	-	-	-	-	
(0xDD)	Reserved	-	-	-	-	-	-	-	-	
(0xDC)	Reserved	-	-	-	-	-	-	-	-	
(0xDB)	Reserved	-	-	-	-	-	-	-	-	
(0xDA)	Reserved	-	-	-	-	-	-	-	-	
(0xD9)	Reserved	-	-	-	-	-	-	-	-	
(0xD8)	Reserved	-	-	-	-	-	-	-	-	
(0xD7)	Reserved	-	-	-	-	-	-	-	-	
(0xD6)	Reserved	-	-	-	-	-	-	-	-	
(0xD5)	Reserved	-	-	-	-	-	-	-	-	
(0xD4)	Reserved	-	-	-	-	-	-	-	-	
(0xD3)	Reserved	-	-	-	-	-	-	-	-	
(0xD2)	Reserved	-	-	-	-	-	-	-	-	
(0xD1)	Reserved	-	-	-	-	-	-	-	-	
(0xD0)	Reserved	-	-	-	-	-	-	-	-	
(0xCF)	Reserved	-	-	-	-	-	-	-	-	
(0xCE)	UDR1	USART1 I/O Data Register								193
(0xCD)	UBRR1H	-	-	-	-	USART1 Baud Rate Register High Byte				197/210
(0xCC)	UBRR1L	USART1 Baud Rate Register Low Byte								197/210
(0xCB)	Reserved	-	-	-	-	-	-	-	-	
(0xCA)	UCSR1C	UMSEL11	UMSEL10	UPM11	UPM10	USBS1	UCSZ11/UDORD0 ⁽⁵⁾	UCSZ10/UCPHA0 ⁽⁵⁾	UCPOL1	195/209
(0xC9)	UCSR1B	RXCIE1	TXCIE1	UDRIE1	RXEN1	TXEN1	UCSZ12	RXB81	TXB81	194/208
(0xC8)	UCSR1A	RXC1	TXC1	UDRE1	FE1	DOR1	UPE1	U2X1	MPCM1	193/208
(0xC7)	Reserved	-	-	-	-	-	-	-	-	
(0xC6)	UDR0	USART0 I/O Data Register								193
(0xC5)	UBRR0H	-	-	-	-	USART0 Baud Rate Register High Byte				197/210
(0xC4)	UBRR0L	USART0 Baud Rate Register Low Byte								197/210
(0xC3)	Reserved	-	-	-	-	-	-	-	-	
(0xC2)	UCSR0C	UMSEL01	UMSEL00	UPM01	UPM00	USBS0	UCSZ01/UDORD0 ⁽⁵⁾	UCSZ00/UCPHA0 ⁽⁵⁾	UCPOL0	195/209
(0xC1)	UCSR0B	RXCIE0	TXCIE0	UDRIE0	RXEN0	TXEN0	UCSZ02	RXB80	TXB80	194/208

ATmega164A/PA/324A/PA/644A/PA/1284/P

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
(0xC0)	UCSR0A	RXC0	TXC0	UDRE0	FE0	DOR0	UPE0	U2X0	MPCM0	193/208
(0xBF)	Reserved	-	-	-	-	-	-	-	-	
(0xBE)	Reserved	-	-	-	-	-	-	-	-	
(0xBD)	TWAMR	TWAM6	TWAM5	TWAM4	TWAM3	TWAM2	TWAM1	TWAM0	-	239
(0xBC)	TWCR	TWINT	TWEA	TWSTA	TWSTO	TWWC	TWEN	-	TWIE	236
(0xBB)	TWDR	two-wire Serial Interface Data Register								238
(0xBA)	TWAR	TWA6	TWA5	TWA4	TWA3	TWA2	TWA1	TWA0	TWGCE	239
(0xB9)	TWSR	TWS7	TWS6	TWS5	TWS4	TWS3	-	TWPS1	TWPS0	238
(0xB8)	TWBR	two-wire Serial Interface Bit Rate Register								236
(0xB7)	Reserved	-	-	-	-	-	-	-	-	
(0xB6)	ASSR	-	EXCLK	AS2	TCN2UB	OCR2AUB	OCR2BUB	TCR2AUB	TCR2BUB	162
(0xB5)	Reserved	-	-	-	-	-	-	-	-	
(0xB4)	OCR2B	Timer/Counter2 Output Compare Register B								161
(0xB3)	OCR2A	Timer/Counter2 Output Compare Register A								161
(0xB2)	TCNT2	Timer/Counter2 (8 Bit)								161
(0xB1)	TCCR2B	FOC2A	FOC2B	-	-	WGM22	CS22	CS21	CS20	160
(0xB0)	TCCR2A	COM2A1	COM2A0	COM2B1	COM2B0	-	-	WGM21	WGM20	157
(0xAF)	Reserved	-	-	-	-	-	-	-	-	
(0xAE)	Reserved	-	-	-	-	-	-	-	-	
(0xAD)	Reserved	-	-	-	-	-	-	-	-	
(0xAC)	Reserved	-	-	-	-	-	-	-	-	
(0xAB)	Reserved	-	-	-	-	-	-	-	-	
(0xAA)	Reserved	-	-	-	-	-	-	-	-	
(0xA9)	Reserved	-	-	-	-	-	-	-	-	
(0xA8)	Reserved	-	-	-	-	-	-	-	-	
(0xA7)	Reserved	-	-	-	-	-	-	-	-	
(0xA6)	Reserved	-	-	-	-	-	-	-	-	
(0xA5)	Reserved	-	-	-	-	-	-	-	-	
(0xA4)	Reserved	-	-	-	-	-	-	-	-	
(0xA3)	Reserved	-	-	-	-	-	-	-	-	
(0xA2)	Reserved	-	-	-	-	-	-	-	-	
(0xA1)	Reserved	-	-	-	-	-	-	-	-	
(0xA0)	Reserved	-	-	-	-	-	-	-	-	
(0x9F)	Reserved	-	-	-	-	-	-	-	-	
(0x9E)	Reserved	-	-	-	-	-	-	-	-	
(0x9D)	Reserved	-	-	-	-	-	-	-	-	
(0x9C)	Reserved	-	-	-	-	-	-	-	-	
(0x9B)	OCR3BH	Timer/Counter3 - Output Compare Register B High Byte ⁽⁷⁾								138
(0x9A)	OCR3BL	Timer/Counter3 - Output Compare Register B Low Byte ⁽⁷⁾								138
(0x99)	OCR3AH	Timer/Counter3 - Output Compare Register A High Byte ⁽⁷⁾								137
(0x98)	OCR3AL	Timer/Counter3 - Output Compare Register A Low Byte ⁽⁷⁾								137
(0x97)	ICR3H	Timer/Counter3 - Input Capture Register High Byte ⁽⁷⁾								138
(0x96)	ICR3L	Timer/Counter3 - Input Capture Register Low Byte ⁽⁷⁾								138
(0x95)	TCNT3H	Timer/Counter3 - Counter Register High Byte ⁽⁷⁾								137
(0x94)	TCNT3L	Timer/Counter3 - Counter Register Low Byte ⁽⁷⁾								137
(0x93)	Reserved	-	-	-	-	-	-	-	-	
(0x92)	TCCR3C	FOC3A	FOC3B	-	-	-	-	-	-	136
(0x91)	TCCR3B	ICNC3	ICES3	-	WGM33	WGM32	CS32	CS31	CS30	135
(0x90)	TCCR3A	COM3A1	COM3A0	COM3B1	COM3B0	-	-	WGM31	WGM30	133
(0x8F)	Reserved	-	-	-	-	-	-	-	-	
(0x8E)	Reserved	-	-	-	-	-	-	-	-	
(0x8D)	Reserved	-	-	-	-	-	-	-	-	
(0x8C)	Reserved	-	-	-	-	-	-	-	-	
(0x8B)	OCR1BH	Timer/Counter1 - Output Compare Register B High Byte								138
(0x8A)	OCR1BL	Timer/Counter1 - Output Compare Register B Low Byte								138
(0x89)	OCR1AH	Timer/Counter1 - Output Compare Register A High Byte								137
(0x88)	OCR1AL	Timer/Counter1 - Output Compare Register A Low Byte								137
(0x87)	ICR1H	Timer/Counter1 - Input Capture Register High Byte								138
(0x86)	ICR1L	Timer/Counter1 - Input Capture Register Low Byte								138
(0x85)	TCNT1H	Timer/Counter1 - Counter Register High Byte								137
(0x84)	TCNT1L	Timer/Counter1 - Counter Register Low Byte								137
(0x83)	Reserved	-	-	-	-	-	-	-	-	
(0x82)	TCCR1C	FOC1A	FOC1B	-	-	-	-	-	-	136
(0x81)	TCCR1B	ICNC1	ICES1	-	WGM13	WGM12	CS12	CS11	CS10	135
(0x80)	TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	-	-	WGM11	WGM10	133
(0x7F)	DIDR1	-	-	-	-	-	-	AIN1D	AIN0D	243

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Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
(0x7E)	DIDR0	ADC7D	ADC6D	ADC5D	ADC4D	ADC3D	ADC2D	ADC1D	ADC0D	263
(0x7D)	Reserved	-	-	-	-	-	-	-	-	
(0x7C)	ADMUX	REFS1	REFS0	ADLAR	MUX4	MUX3	MUX2	MUX1	MUX0	259
(0x7B)	ADCSRB	-	ACME	-	-	-	ADTS2	ADTS1	ADTS0	242
(0x7A)	ADCSRA	ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0	261
(0x79)	ADCH	ADC Data Register High byte								262
(0x78)	ADCL	ADC Data Register Low byte								262
(0x77)	Reserved	-	-	-	-	-	-	-	-	
(0x76)	Reserved	-	-	-	-	-	-	-	-	
(0x75)	Reserved	-	-	-	-	-	-	-	-	
(0x74)	Reserved	-	-	-	-	-	-	-	-	
(0x73)	PCMSK3	PCINT31	PCINT30	PCINT29	PCINT28	PCINT27	PCINT26	PCINT25	PCINT24	70
(0x72)	Reserved	-	-	-	-	-	-	-	-	
(0x71)	TIMSK3	-	-	ICIE3	-	-	OCIE3B	OCIE3A	TOIE3	140
(0x70)	TIMSK2	-	-	-	-	-	OCIE2B	OCIE2A	TOIE2	163
(0x6F)	TIMSK1	-	-	ICIE1	-	-	OCIE1B	OCIE1A	TOIE1	139
(0x6E)	TIMSK0	-	-	-	-	-	OCIE0B	OCIE0A	TOIE0	109
(0x6D)	PCMSK2	PCINT23	PCINT22	PCINT21	PCINT20	PCINT19	PCINT18	PCINT17	PCINT16	70
(0x6C)	PCMSK1	PCINT15	PCINT14	PCINT13	PCINT12	PCINT11	PCINT10	PCINT9	PCINT8	70
(0x6B)	PCMSK0	PCINT7	PCINT6	PCINT5	PCINT4	PCINT3	PCINT2	PCINT1	PCINT0	71
(0x6A)	Reserved	-	-	-	-	-	-	-	-	
(0x69)	EICRA	-	-	ISC21	ISC20	ISC11	ISC10	ISC01	ISC00	67
(0x68)	PCICR	-	-	-	-	PCIE3	PCIE2	PCIE1	PCIE0	69
(0x67)	Reserved	-	-	-	-	-	-	-	-	
(0x66)	OSCCAL	Oscillator Calibration Register								40
(0x65)	Reserved	-	-	-	-	-	-	-	-	
(0x64)	PRR	PRTWI	PRTIM2	PRTIM0	PRUSART1	PRTIM1	PRSPI	PRUSART0	PRADC	48
(0x63)	Reserved	-	-	-	-	-	-	-	-	
(0x62)	Reserved	-	-	-	-	-	-	-	-	
(0x61)	CLKPR	CLKPCE	-	-	-	CLKPS3	CLKPS2	CLKPS1	CLKPS0	40
(0x60)	WDTCR	WDIF	WDIE	WDP3	WDCE	WDE	WDP2	WDP1	WDP0	59
0x3F (0x5F)	SREG	I	T	H	S	V	N	Z	C	11
0x3E (0x5E)	SPH	SP15	SP14	SP13	SP12	SP11	SP10	SP9	SP8	12
0x3D (0x5D)	SPL	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0	12
0x3C (0x5C)	Reserved	-	-	-	-	-	-	-	-	
0x3B (0x5B)	Reserved	-	-	-	-	-	-	-	-	
0x3A (0x5A)	Reserved	-	-	-	-	-	-	-	-	
0x39 (0x59)	Reserved	-	-	-	-	-	-	-	-	
0x38 (0x58)	Reserved	-	-	-	-	-	-	-	-	
0x37 (0x57)	SPMCSR	SPMIE	RWWSB	SIGRD	RWWSRE	BLBSET	PGWRT	PGERS	SPMEN	296
0x36 (0x56)	Reserved	-	-	-	-	-	-	-	-	
0x35 (0x55)	MCUCR	JTD	BODS ⁽⁶⁾	BODSE ⁽⁶⁾	PUD	-	-	IVSEL	IVCE	91/279
0x34 (0x54)	MCUSR	-	-	-	JTRF	WDRF	BORF	EXTRF	PORF	58/279
0x33 (0x53)	SMCR	-	-	-	-	SM2	SM1	SM0	SE	47
0x32 (0x52)	Reserved	-	-	-	-	-	-	-	-	
0x31 (0x51)	OCDR	On-Chip Debug Register								269
0x30 (0x50)	ACSR	ACD	ACBG	ACO	ACI	ACIE	ACIC	ACIS1	ACIS0	261
0x2F (0x4F)	Reserved	-	-	-	-	-	-	-	-	
0x2E (0x4E)	SPDR	SPI 0 Data Register								174
0x2D (0x4D)	SPSR	SPIF0	WCOL0	-	-	-	-	-	SPI2X0	173
0x2C (0x4C)	SPCR	SPIE0	SPE0	DORD0	MSTR0	CPOL0	CPHA0	SPR01	SPR00	172
0x2B (0x4B)	GPOR2	General Purpose I/O Register 2								29
0x2A (0x4A)	GPOR1	General Purpose I/O Register 1								29
0x29 (0x49)	Reserved	-	-	-	-	-	-	-	-	
0x28 (0x48)	OCR0B	Timer/Counter0 Output Compare Register B								108
0x27 (0x47)	OCR0A	Timer/Counter0 Output Compare Register A								108
0x26 (0x46)	TCNT0	Timer/Counter0 (8 Bit)								108
0x25 (0x45)	TCCR0B	FOC0A	FOC0B	-	-	WGM02	CS02	CS01	CS00	107
0x24 (0x44)	TCCR0A	COM0A1	COM0A0	COM0B1	COM0B0	-	-	WGM01	WGM00	108
0x23 (0x43)	GTCCR	TSM	-	-	-	-	-	PSRASY	PSRSYNC	164
0x22 (0x42)	EEARH	-	-	-	-	EEPROM Address Register High Byte				24
0x21 (0x41)	EEARL	EEPROM Address Register Low Byte								24
0x20 (0x40)	EEDR	EEPROM Data Register								24
0x1F (0x3F)	EECR	-	-	EEPM1	EEPM0	EERIE	EEMPE	EEPE	EERE	24
0x1E (0x3E)	GPOR0	General Purpose I/O Register 0								29
0x1D (0x3D)	EIMSK	-	-	-	-	-	INT2	INT1	INT0	68

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
0x1C (0x3C)	EIFR	-	-	-	-	-	INTF2	INTF1	INTF0	68
0x1B (0x3B)	PCIFR	-	-	-	-	PCIF3	PCIF2	PCIF1	PCIF0	69
0x1A (0x3A)	Reserved	-	-	-	-	-	-	-	-	
0x19 (0x39)	Reserved	-	-	-	-	-	-	-	-	
0x18 (0x38)	TIFR3	-	-	ICF3	-	-	OCF3B	OCF3A	TOV3	141
0x17 (0x37)	TIFR2	-	-	-	-	-	OCF2B	OCF2A	TOV2	163
0x16 (0x36)	TIFR1	-	-	ICF1	-	-	OCF1B	OCF1A	TOV1	140
0x15 (0x35)	TIFR0	-	-	-	-	-	OCF0B	OCF0A	TOV0	109
0x14 (0x34)	Reserved	-	-	-	-	-	-	-	-	
0x13 (0x33)	Reserved	-	-	-	-	-	-	-	-	
0x12 (0x32)	Reserved	-	-	-	-	-	-	-	-	
0x11 (0x31)	Reserved	-	-	-	-	-	-	-	-	
0x10 (0x30)	Reserved	-	-	-	-	-	-	-	-	
0x0F (0x2F)	Reserved	-	-	-	-	-	-	-	-	
0x0E (0x2E)	Reserved	-	-	-	-	-	-	-	-	
0x0D (0x2D)	Reserved	-	-	-	-	-	-	-	-	
0x0C (0x2C)	Reserved	-	-	-	-	-	-	-	-	
0x0B (0x2B)	PORTD	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0	92
0x0A (0x2A)	DDRD	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0	92
0x09 (0x29)	PIND	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0	92
0x08 (0x28)	PORTC	PORTC7	PORTC6	PORTC5	PORTC4	PORTC3	PORTC2	PORTC1	PORTC0	92
0x07 (0x27)	DDRC	DDC7	DDC6	DDC5	DDC4	DDC3	DDC2	DDC1	DDC0	92
0x06 (0x26)	PINC	PINC7	PINC6	PINC5	PINC4	PINC3	PINC2	PINC1	PINC0	92
0x05 (0x25)	PORTB	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0	91
0x04 (0x24)	DDRB	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0	91
0x03 (0x23)	PINB	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0	91
0x02 (0x22)	PORTA	PORTA7	PORTA6	PORTA5	PORTA4	PORTA3	PORTA2	PORTA1	PORTA0	91
0x01 (0x21)	DDRA	DDA7	DDA6	DDA5	DDA4	DDA3	DDA2	DDA1	DDA0	91
0x00 (0x20)	PINA	PINA7	PINA6	PINA5	PINA4	PINA3	PINA2	PINA1	PINA0	91

- Notes:
- For compatibility with future devices, reserved bits should be written to zero if accessed. Reserved I/O memory addresses should never be written.
 - I/O registers within the address range \$00 - \$1F are directly bit-accessible using the SBI and CBI instructions. In these registers, the value of single bits can be checked by using the SBIS and SBIC instructions.
 - Some of the status flags are cleared by writing a logical one to them. Note that the CBI and SBI instructions will operate on all bits in the I/O register, writing a one back into any flag read as set, thus clearing the flag. The CBI and SBI instructions work with registers 0x00 to 0x1F only.
 - When using the I/O specific commands IN and OUT, the I/O addresses \$00 - \$3F must be used. When addressing I/O registers as data space using LD and ST instructions, \$20 must be added to these addresses.
The ATmega164A/164PA/324A/324PA/644A/644PA/1284/1284P is a complex microcontroller with more peripheral units than can be supported within the 64 location reserved in Opcode for the IN and OUT instructions. For the Extended I/O space from \$60 - \$FF, only the ST/STS/STD and LD/LDS/LDD instructions can be used.
 - USART in SPI Master Mode.
 - Only available in the ATmega164PA/324PA/644PA/1284P.
 - Only available in the ATmega1284/1284P.

8. Instruction set summary

Mnemonics	Operands	Description	Operation	Flags	#Clocks
ARITHMETIC AND LOGIC INSTRUCTIONS					
ADD	Rd, Rr	Add two Registers	$Rd \leftarrow Rd + Rr$	Z,C,N,V,H	1
ADC	Rd, Rr	Add with Carry two Registers	$Rd \leftarrow Rd + Rr + C$	Z,C,N,V,H	1
ADIW	Rdl, K	Add Immediate to Word	$Rdh:Rdl \leftarrow Rdh:Rdl + K$	Z,C,N,V,S	2
SUB	Rd, Rr	Subtract two Registers	$Rd \leftarrow Rd - Rr$	Z,C,N,V,H	1
SUBI	Rd, K	Subtract Constant from Register	$Rd \leftarrow Rd - K$	Z,C,N,V,H	1
SBC	Rd, Rr	Subtract with Carry two Registers	$Rd \leftarrow Rd - Rr - C$	Z,C,N,V,H	1
SBCI	Rd, K	Subtract with Carry Constant from Reg.	$Rd \leftarrow Rd - K - C$	Z,C,N,V,H	1
SBIW	Rdl, K	Subtract Immediate from Word	$Rdh:Rdl \leftarrow Rdh:Rdl - K$	Z,C,N,V,S	2
AND	Rd, Rr	Logical AND Registers	$Rd \leftarrow Rd \cdot Rr$	Z,N,V	1
ANDI	Rd, K	Logical AND Register and Constant	$Rd \leftarrow Rd \cdot K$	Z,N,V	1
OR	Rd, Rr	Logical OR Registers	$Rd \leftarrow Rd \vee Rr$	Z,N,V	1
ORI	Rd, K	Logical OR Register and Constant	$Rd \leftarrow Rd \vee K$	Z,N,V	1
EOR	Rd, Rr	Exclusive OR Registers	$Rd \leftarrow Rd \oplus Rr$	Z,N,V	1
COM	Rd	One's Complement	$Rd \leftarrow 0xFF - Rd$	Z,C,N,V	1
NEG	Rd	Two's Complement	$Rd \leftarrow 0x00 - Rd$	Z,C,N,V,H	1
SBR	Rd, K	Set Bit(s) in Register	$Rd \leftarrow Rd \vee K$	Z,N,V	1
CBR	Rd, K	Clear Bit(s) in Register	$Rd \leftarrow Rd \cdot (0xFF - K)$	Z,N,V	1
INC	Rd	Increment	$Rd \leftarrow Rd + 1$	Z,N,V	1
DEC	Rd	Decrement	$Rd \leftarrow Rd - 1$	Z,N,V	1
TST	Rd	Test for Zero or Minus	$Rd \leftarrow Rd \cdot Rd$	Z,N,V	1
CLR	Rd	Clear Register	$Rd \leftarrow Rd \oplus Rd$	Z,N,V	1
SER	Rd	Set Register	$Rd \leftarrow 0xFF$	None	1
MUL	Rd, Rr	Multiply Unsigned	$R1:R0 \leftarrow Rd \times Rr$	Z,C	2
MULS	Rd, Rr	Multiply Signed	$R1:R0 \leftarrow Rd \times Rr$	Z,C	2
MULSU	Rd, Rr	Multiply Signed with Unsigned	$R1:R0 \leftarrow Rd \times Rr$	Z,C	2
FMUL	Rd, Rr	Fractional Multiply Unsigned	$R1:R0 \leftarrow (Rd \times Rr) \ll 1$	Z,C	2
FMULS	Rd, Rr	Fractional Multiply Signed	$R1:R0 \leftarrow (Rd \times Rr) \ll 1$	Z,C	2
FMULSU	Rd, Rr	Fractional Multiply Signed with Unsigned	$R1:R0 \leftarrow (Rd \times Rr) \ll 1$	Z,C	2
BRANCH INSTRUCTIONS					
RJMP	k	Relative Jump	$PC \leftarrow PC + k + 1$	None	2
IJMP		Indirect Jump to (Z)	$PC \leftarrow Z$	None	2
JMP	k	Direct Jump	$PC \leftarrow k$	None	3
RCALL	k	Relative Subroutine Call	$PC \leftarrow PC + k + 1$	None	4
ICALL		Indirect Call to (Z)	$PC \leftarrow Z$	None	4
CALL	k	Direct Subroutine Call	$PC \leftarrow k$	None	5
RET		Subroutine Return	$PC \leftarrow STACK$	None	5
RETI		Interrupt Return	$PC \leftarrow STACK$	I	5
CPSE	Rd, Rr	Compare, Skip if Equal	if $(Rd = Rr)$ $PC \leftarrow PC + 2$ or 3	None	1/2/3
CP	Rd, Rr	Compare	$Rd - Rr$	Z, N, V, C, H	1
CPC	Rd, Rr	Compare with Carry	$Rd - Rr - C$	Z, N, V, C, H	1
CPI	Rd, K	Compare Register with Immediate	$Rd - K$	Z, N, V, C, H	1
SBRC	Rr, b	Skip if Bit in Register Cleared	if $(Rr(b)=0)$ $PC \leftarrow PC + 2$ or 3	None	1/2/3
SBRSC	Rr, b	Skip if Bit in Register is Set	if $(Rr(b)=1)$ $PC \leftarrow PC + 2$ or 3	None	1/2/3
SBIC	P, b	Skip if Bit in I/O Register Cleared	if $(P(b)=0)$ $PC \leftarrow PC + 2$ or 3	None	1/2/3
SBIS	P, b	Skip if Bit in I/O Register is Set	if $(P(b)=1)$ $PC \leftarrow PC + 2$ or 3	None	1/2/3
BRBS	s, k	Branch if Status Flag Set	if $(SREG(s) = 1)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRBC	s, k	Branch if Status Flag Cleared	if $(SREG(s) = 0)$ then $PC \leftarrow PC + k + 1$	None	1/2
BREQ	k	Branch if Equal	if $(Z = 1)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRNE	k	Branch if Not Equal	if $(Z = 0)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRCS	k	Branch if Carry Set	if $(C = 1)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRCC	k	Branch if Carry Cleared	if $(C = 0)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRSH	k	Branch if Same or Higher	if $(C = 0)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRLO	k	Branch if Lower	if $(C = 1)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRMI	k	Branch if Minus	if $(N = 1)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRPL	k	Branch if Plus	if $(N = 0)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRGE	k	Branch if Greater or Equal, Signed	if $(N \oplus V = 0)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRLT	k	Branch if Less Than Zero, Signed	if $(N \oplus V = 1)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRHS	k	Branch if Half Carry Flag Set	if $(H = 1)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRHC	k	Branch if Half Carry Flag Cleared	if $(H = 0)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRTS	k	Branch if T Flag Set	if $(T = 1)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRTC	k	Branch if T Flag Cleared	if $(T = 0)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRVS	k	Branch if Overflow Flag is Set	if $(V = 1)$ then $PC \leftarrow PC + k + 1$	None	1/2

Mnemonics	Operands	Description	Operation	Flags	#Clocks
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
BIT AND BIT-TEST INSTRUCTIONS					
SBI	P,b	Set Bit in I/O Register	I/O(P,b) ← 1	None	2
CBI	P,b	Clear Bit in I/O Register	I/O(P,b) ← 0	None	2
LSL	Rd	Logical Shift Left	Rd(n+1) ← Rd(n), Rd(0) ← 0	Z,C,N,V	1
LSR	Rd	Logical Shift Right	Rd(n) ← Rd(n+1), Rd(7) ← 0	Z,C,N,V	1
ROL	Rd	Rotate Left Through Carry	Rd(0) ← C, Rd(n+1) ← Rd(n), C ← Rd(7)	Z,C,N,V	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), Rd(7..4) ← Rd(3..0)	None	1
BSET	s	Flag Set	SREG(s) ← 1	SREG(s)	1
BCLR	s	Flag Clear	SREG(s) ← 0	SREG(s)	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 Twos Complement Overflow	V ← 1	V	1
CLV		Clear Twos 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
DATA TRANSFER INSTRUCTIONS					
MOV	Rd, Rr	Move Between Registers	Rd ← Rr	None	1
MOVW	Rd, Rr	Copy Register Word	Rd+1:Rd ← Rr+1:Rr	None	1
LDI	Rd, K	Load Immediate	Rd ← K	None	1
LD	Rd, X	Load Indirect	Rd ← (X)	None	2
LD	Rd, X+	Load Indirect and Post-Inc.	Rd ← (X), X ← X + 1	None	2
LD	Rd, -X	Load Indirect and Pre-Dec.	X ← X - 1, Rd ← (X)	None	2
LD	Rd, Y	Load Indirect	Rd ← (Y)	None	2
LD	Rd, Y+	Load Indirect and Post-Inc.	Rd ← (Y), Y ← Y + 1	None	2
LD	Rd, -Y	Load Indirect and Pre-Dec.	Y ← Y - 1, Rd ← (Y)	None	2
LDD	Rd, Y+q	Load Indirect with Displacement	Rd ← (Y + q)	None	2
LD	Rd, Z	Load Indirect	Rd ← (Z)	None	2
LD	Rd, Z+	Load Indirect and Post-Inc.	Rd ← (Z), Z ← Z + 1	None	2
LD	Rd, -Z	Load Indirect and Pre-Dec.	Z ← Z - 1, Rd ← (Z)	None	2
LDD	Rd, Z+q	Load Indirect with Displacement	Rd ← (Z + q)	None	2
LDS	Rd, k	Load Direct from SRAM	Rd ← (k)	None	2
ST	X, Rr	Store Indirect	(X) ← Rr	None	2
ST	X+, Rr	Store Indirect and Post-Inc.	(X) ← Rr, X ← X + 1	None	2
ST	-X, Rr	Store Indirect and Pre-Dec.	X ← X - 1, (X) ← Rr	None	2
ST	Y, Rr	Store Indirect	(Y) ← Rr	None	2
ST	Y+, Rr	Store Indirect and Post-Inc.	(Y) ← Rr, Y ← Y + 1	None	2
ST	-Y, Rr	Store Indirect and Pre-Dec.	Y ← Y - 1, (Y) ← Rr	None	2
STD	Y+q, Rr	Store Indirect with Displacement	(Y + q) ← Rr	None	2
ST	Z, Rr	Store Indirect	(Z) ← Rr	None	2
ST	Z+, Rr	Store Indirect and Post-Inc.	(Z) ← Rr, Z ← Z + 1	None	2
ST	-Z, Rr	Store Indirect and Pre-Dec.	Z ← Z - 1, (Z) ← Rr	None	2
STD	Z+q, Rr	Store Indirect with Displacement	(Z + q) ← Rr	None	2
STS	k, Rr	Store Direct to SRAM	(k) ← Rr	None	2
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-Inc	Rd ← (Z), Z ← Z + 1	None	3
SPM		Store Program Memory	(Z) ← R1:R0	None	-
IN	Rd, P	In Port	Rd ← P	None	1
OUT	P, Rr	Out Port	P ← Rr	None	1

Mnemonics	Operands	Description	Operation	Flags	#Clocks
PUSH	Rr	Push Register on Stack	STACK ← Rr	None	2
POP	Rd	Pop Register from Stack	Rd ← STACK	None	2
MCU CONTROL INSTRUCTIONS					
NOP		No Operation		None	1
SLEEP		Sleep	(see specific descr. for Sleep function)	None	1
WDR		Watchdog Reset	(see specific descr. for WDR/timer)	None	1
BREAK		Break	For On-chip Debug Only	None	N/A

9. Ordering information

9.1 Atmel ATmega164A

Speed [MHz] ⁽³⁾	Power supply	Ordering code ⁽²⁾	Package ⁽¹⁾	Operational range
20	1.8 - 5.5V	ATmega164A-AU ATmega164A-AUR ⁽⁵⁾ ATmega164A-PU ATmega164A-MU ATmega164A-MUR ⁽⁵⁾ ATmega164A-MCH ⁽⁴⁾ ATmega164A-MCHR ⁽⁴⁾⁽⁵⁾ ATmega164A-CU ATmega164A-CUR ⁽⁵⁾	44A 44A 40P6 44M1 44M1 44MC 44MC 49C2 49C2	Industrial (-40°C to 85°C)

- Notes:
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. For Speed vs. V_{CC} see ["Speed grades" on page 336](#).
 4. NiPdAu Lead Finish.
 5. Tape & Reel.

Package Type	
44A	44-lead, Thin (1.0mm) Plastic Gull Wing Quad Flat Package (TQFP)
40P6	40-pin, 0.600" Wide, Plastic Dual Inline Package (PDIP)
44M1	44-pad, 7 × 7 × 1.0mm body, lead pitch 0.50mm, Thermally Enhanced Plastic Very Thin Quad Flat No-Lead (VQFN)
44MC	44-lead (2-row Staggered), 5 × 5 × 1.0mm body, 2.60 × 2.60mm Exposed Pad, Quad Flat No-Lead Package (QFN)
49C2	49-ball, (7 × 7 Array) 0.65mm Pitch, 5 × 5 × 1mm, Very Thin, Fine-Pitch Ball Grid Array Package (VFBGA)

9.2 Atmel ATmega164PA

Speed [MHz] ⁽³⁾	Power supply	Ordering code ⁽²⁾	Package ⁽¹⁾	Operational range
20	1.8 - 5.5V	ATmega164PA-AU	44A	Industrial (-40°C to 85°C)
		ATmega164PA-AUR ⁽⁵⁾	44A	
		ATmega164PA-PU	40P6	
		ATmega164PA-MU	44M1	
		ATmega164PA-MUR ⁽⁵⁾	44M1	
		ATmega164PA-MCH ⁽⁴⁾	44MC	
		ATmega164PA-MCHR ⁽⁴⁾⁽⁵⁾	44MC	
		ATmega164PA-CU	49C2	
		ATmega164PA-CUR ⁽⁵⁾	49C2	

- Notes:
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. For Speed vs. V_{CC} see ["Speed grades" on page 336](#).
 4. NiPdAu Lead Finish.
 5. Tape & Reel.

Package Type	
44A	44-lead, Thin (1.0mm) Plastic Gull Wing Quad Flat Package (TQFP)
40P6	40-pin, 0.600" Wide, Plastic Dual Inline Package (PDIP)
44M1	44-pad, 7 × 7 × 1.0mm body, lead pitch 0.50mm, Thermally Enhanced Plastic Very Thin Quad Flat No-Lead (VQFN)
44MC	44-lead (2-row Staggered), 5 × 5 × 1.0mm body, 2.60 × 2.60mm Exposed Pad, Quad Flat No-Lead Package (QFN)
49C2	49-ball, (7 × 7 Array) 0.65mm Pitch, 5 × 5 × 1mm, Very Thin, Fine-Pitch Ball Grid Array Package (VFBGA)

9.3 Atmel ATmega324A

Speed [MHz] ⁽³⁾	Power supply	Ordering code ⁽²⁾	Package ⁽¹⁾	Operational range
20	1.8 - 5.5V	ATmega324A-AU	44A	Industrial (-40°C to 85°C)
		ATmega324A-AUR ⁽⁵⁾	44A	
		ATmega324A-PU	40P6	
		ATmega324A-MU	44M1	
		ATmega324A-MUR ⁽⁵⁾	44M1	
		ATmega324A-MCH ⁽⁴⁾	44MC	
		ATmega324A-MCHR ⁽⁴⁾⁽⁵⁾	44MC	
		ATmega324A-CU	49C2	
		ATmega324A-CUR ⁽⁵⁾	49C2	

- Notes:
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. For Speed vs. V_{CC} see ["Speed grades" on page 336](#).
 4. NiPdAu Lead Finish.
 5. Tape & Reel.

Package Type	
44A	44-lead, Thin (1.0mm) Plastic Gull Wing Quad Flat Package (TQFP)
40P6	40-pin, 0.600" Wide, Plastic Dual Inline Package (PDIP)
44M1	44-pad, 7 × 7 × 1.0mm body, lead pitch 0.50mm, Thermally Enhanced Plastic Very Thin Quad Flat No-Lead (VQFN)
44MC	44-lead (2-row Staggered), 5 × 5 × 1.0mm body, 2.60 × 2.60mm Exposed Pad, Quad Flat No-Lead Package (QFN)
49C2	49-ball, (7 × 7 Array) 0.65mm Pitch, 5 × 5 × 1mm, Very Thin, Fine-Pitch Ball Grid Array Package (VFBGA)

9.4 Atmel ATmega324PA

Speed [MHz] ⁽³⁾	Power supply	Ordering code ⁽²⁾	Package ⁽¹⁾	Operational range
20	1.8 - 5.5V	ATmega324PA-AU	44A	Industrial (-40°C to 85°C)
		ATmega324PA-AUR ⁽⁵⁾	44A	
		ATmega324PA-PU	40P6	
		ATmega324PA-MU	44M1	
		ATmega324PA-MUR ⁽⁵⁾	44M1	
		ATmega324PA-MCH ⁽⁴⁾	44MC	
		ATmega324PA-MCHR ⁽⁴⁾⁽⁵⁾	44MC	
		ATmega324PA-CU	49C2	
		ATmega324PA-CUR ⁽⁵⁾	49C2	

- Notes:
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. For Speed vs. V_{CC} see ["Speed grades" on page 336](#).
 4. NiPdAu Lead Finish.
 5. Tape & Reel.

Package Type	
44A	44-lead, Thin (1.0mm) Plastic Gull Wing Quad Flat Package (TQFP)
40P6	40-pin, 0.600" Wide, Plastic Dual Inline Package (PDIP)
44M1	44-pad, 7 × 7 × 1.0mm body, lead pitch 0.50mm, Thermally Enhanced Plastic Very Thin Quad Flat No-Lead (VQFN)
44MC	44-lead (2-row Staggered), 5 × 5 × 1.0mm body, 2.60 × 2.60mm Exposed Pad, Quad Flat No-Lead Package (QFN)
49C2	49-ball, (7 × 7 Array) 0.65mm Pitch, 5 × 5 × 1mm, Very Thin, Fine-Pitch Ball Grid Array Package (VFBGA)

9.5 Atmel ATmega644A

Speed [MHz] ⁽³⁾	Power supply	Ordering code ⁽²⁾	Package ⁽¹⁾	Operational range
20	1.8 - 5.5V	ATmega644A-AU ATmega644A-AUR ⁽⁴⁾ ATmega644A-PU ATmega644A-MU ATmega644A-MUR ⁽⁴⁾	44A 44A 40P6 44M1 44M1	Industrial (-40°C to 85°C)

- Notes:
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. For Speed vs. V_{CC} see ["Speed grades" on page 336](#).
 4. Taper & Reel.

Package Type	
44A	44-lead, Thin (1.0mm) Plastic Gull Wing Quad Flat Package (TQFP)
40P6	40-pin, 0.600" Wide, Plastic Dual Inline Package (PDIP)
44M1	44-pad, 7 × 7 × 1.0mm body, lead pitch 0.5 mm, Thermally Enhanced Plastic Very Thin Quad Flat No-Lead (VQFN)

9.6 Atmel ATmega644PA

Speed [MHz] ⁽³⁾	Power supply	Ordering code ⁽²⁾	Package ⁽¹⁾	Operational range
20	1.8 - 5.5V	ATmega644PA-AU	44A	Industrial (-40°C to 85°C)
		ATmega644PA-AUR ⁽⁴⁾	44A	
		ATmega644PA-PU	40P6	
		ATmega644PA-MU	44M1	
		ATmega644PA-MUR ⁽⁴⁾	44M1	

- Notes:
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. For Speed vs. V_{CC} see "[Speed grades](#)" on page 336.
 4. Taper & Reel.

Package Type	
44A	44-lead, Thin (1.0mm) Plastic Gull Wing Quad Flat Package (TQFP)
40P6	40-pin, 0.600" Wide, Plastic Dual Inline Package (PDIP)
44M1	44-pad, 7 × 7 × 1.0mm body, lead pitch 0.50mm, Thermally Enhanced Plastic Very Thin Quad Flat No-Lead (VQFN)

9.7 Atmel ATmega1284

Speed [MHz] ⁽³⁾	Power supply	Ordering code ⁽²⁾	Package ⁽¹⁾	Operational range
20	1.8 - 5.5V	ATmega1284-AU ATmega1284-AUR ⁽⁴⁾ ATmega1284-PU ATmega1284-MU ATmega1284-MUR ⁽⁴⁾	44A 44A 40P6 44M1 44M1	Industrial (-40°C to 85°C)

- Notes:
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. For Speed vs. V_{CC} see "[Speed grades](#)" on page 336.
 4. Tape & Reel.

Package Type	
44A	44-lead, Thin (1.0mm) Plastic Gull Wing Quad Flat Package (TQFP)
40P6	40-pin, 0.600" Wide, Plastic Dual Inline Package (PDIP)
44M1	44-pad, 7 × 7 × 1.0mm body, lead pitch 0.50mm, Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)

9.8 Atmel ATmega1284P

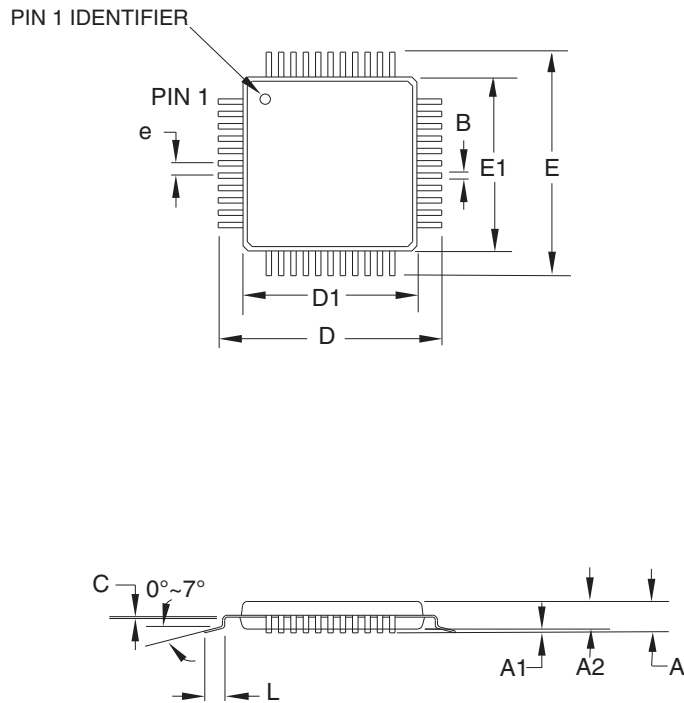
Speed [MHz] ⁽³⁾	Power supply	Ordering code ⁽²⁾	Package ⁽¹⁾	Operational range
20	1.8 - 5.5V	ATmega1284P-AU	44A	Industrial (-40°C to 85°C)
		ATmega1284P-AUR ⁽⁴⁾	44A	
		ATmega1284P-PU	40P6	
		ATmega1284P-MU	44M1	
		ATmega1284P-MUR ⁽⁴⁾	44M1	

- Notes:
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. For Speed vs. V_{CC} see "[Speed grades](#)" on page 336.
 4. Tape & Reel.

Package Type	
44A	44-lead, Thin (1.0mm) Plastic Gull Wing Quad Flat Package (TQFP)
40P6	40-pin, 0.600" Wide, Plastic Dual Inline Package (PDIP)
44M1	44-pad, 7 × 7 × 1.0mm body, lead pitch 0.50mm, Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)

10. Packaging information

10.1 44A



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	11.75	12.00	12.25	
D1	9.90	10.00	10.10	Note 2
E	11.75	12.00	12.25	
E1	9.90	10.00	10.10	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 ACB.
2. Dimensions D1 and E1 do not include mold protrusion. Allowable protrusion is 0.25mm per side. Dimensions D1 and E1 are maximum plastic body size dimensions including mold mismatch.
3. Lead coplanarity is 0.10mm maximum.

2010-10-20



2325 Orchard Parkway
San Jose, CA 95131

TITLE

44A, 44-lead, 10 x 10mm body size, 1.0mm body thickness,
0.8 mm lead pitch, thin profile plastic quad flat package (TQFP)

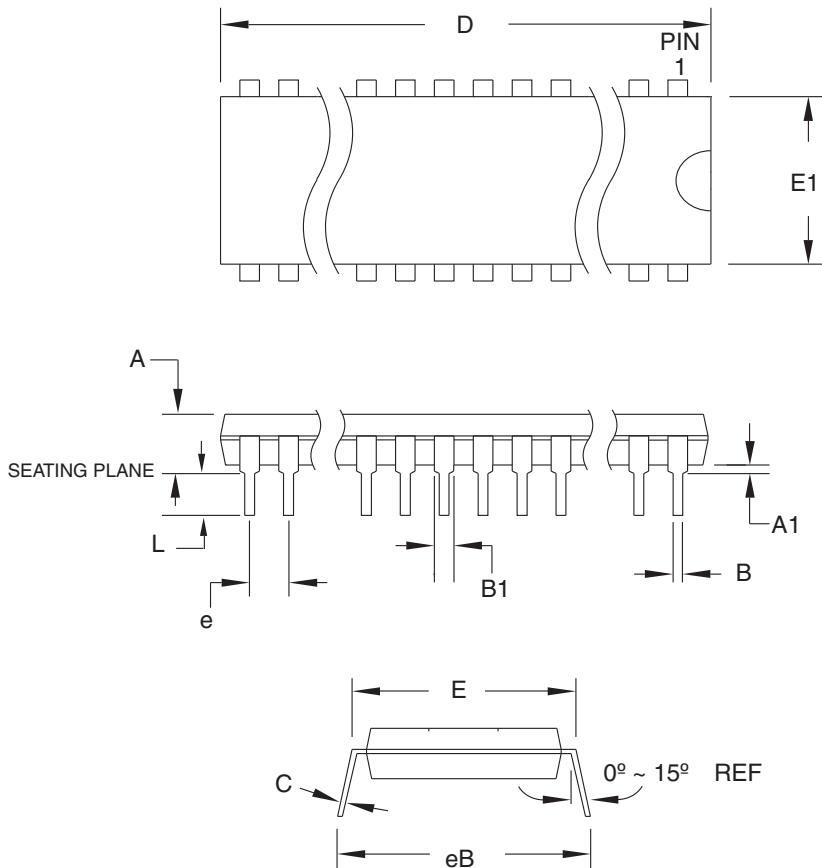
DRAWING NO.

44A

REV.

C

10.2 40P6



COMMON DIMENSIONS
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	—	—	4.826	
A1	0.381	—	—	
D	52.070	—	52.578	Note 2
E	15.240	—	15.875	
E1	13.462	—	13.970	Note 2
B	0.356	—	0.559	
B1	1.041	—	1.651	
L	3.048	—	3.556	
C	0.203	—	0.381	
eB	15.494	—	17.526	
e	2.540 TYP			

Notes:

1. This package conforms to JEDEC reference MS-011, Variation AC.
2. Dimensions D and E1 do not include mold Flash or Protrusion.
Mold Flash or Protrusion shall not exceed 0.25mm (0.010").

09/28/01



2325 Orchard Parkway
San Jose, CA 95131

TITLE

40P6, 40-lead (0.600"/15.24mm Wide) Plastic Dual
Inline Package (PDIP)

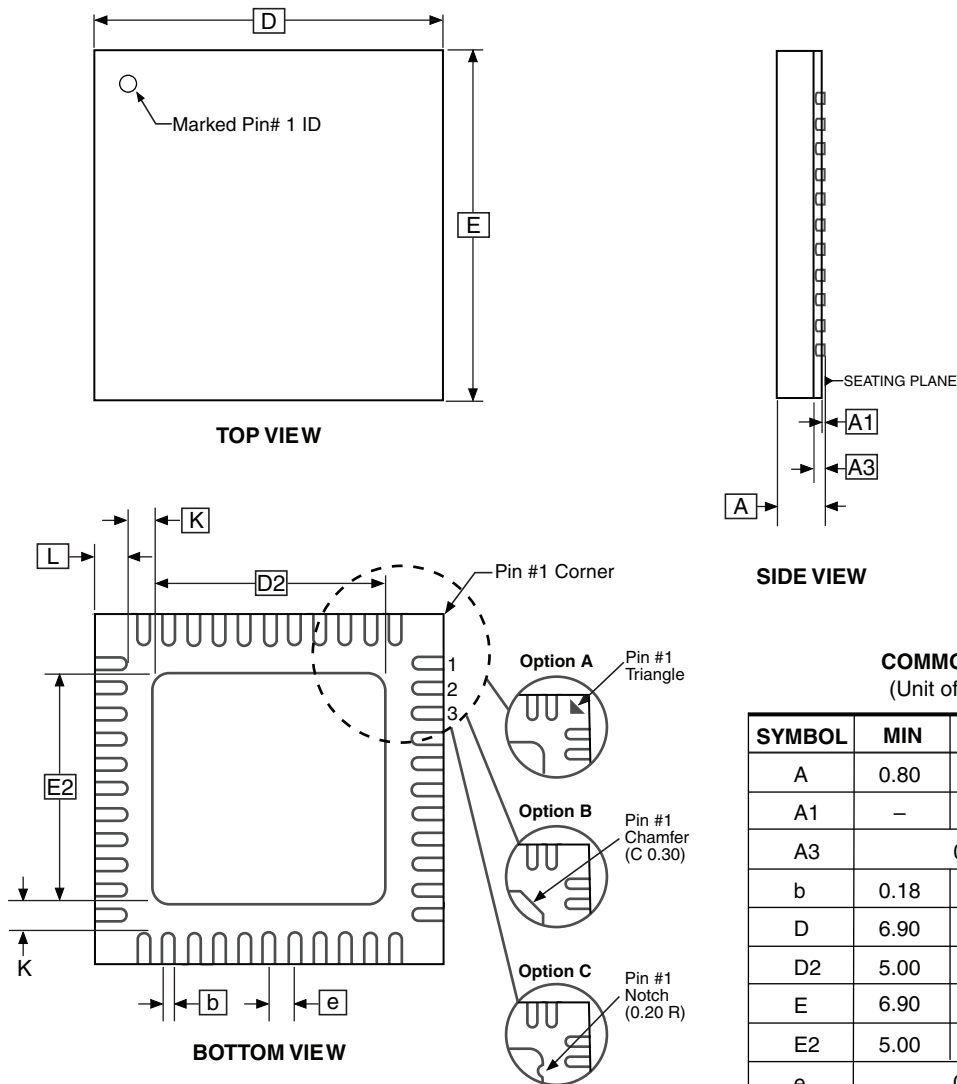
DRAWING NO.

40P6

REV.

B

10.3 44M1



Note: JEDEC Standard MO-220, Fig. 1 (SAW Singulation) VKKD-3.

9/26/08



Package Drawing Contact:
packagedrawings@atmel.com

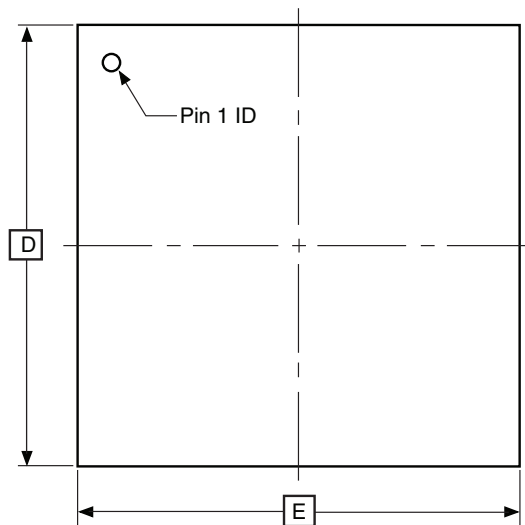
TITLE
44M1, 44-pad, 7 x 7 x 1.0mm body, lead pitch 0.50mm, 5.20mm exposed pad, thermally enhanced plastic very thin quad flat no lead package (VQFN)

GPC
ZWS

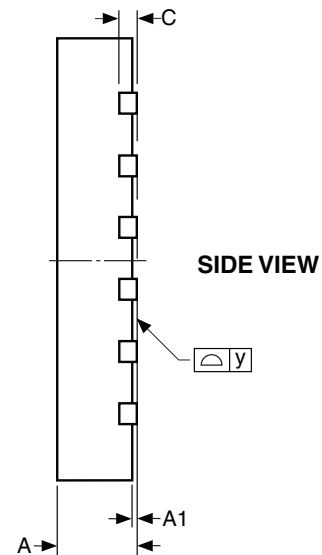
DRAWING NO.
44M1

REV.
H

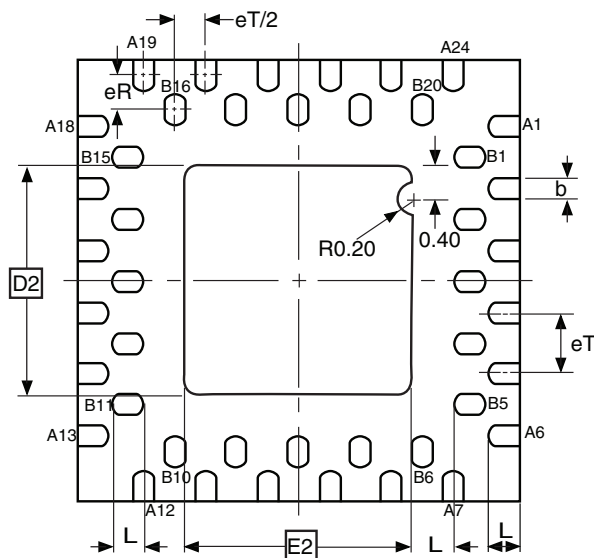
10.4 44MC



TOP VIEW



SIDE VIEW



BOTTOM VIEW

COMMON DIMENSIONS
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	0.80	0.90	1.00	
A1	0.00	0.02	0.05	
b	0.18	0.23	0.30	
C	0.20 REF			
D	4.90	5.00	5.10	
D2	2.55	2.60	2.65	
E	4.90	5.00	5.10	
E2	2.55	2.60	2.65	
eT	—	0.70	—	
eR	—	0.40	—	
K	0.45	—	—	
L	0.30	0.35	0.40	
y	0.00	—	0.075	

Note: 1. The terminal #1 ID is a Laser-marked Feature.

9/13/07



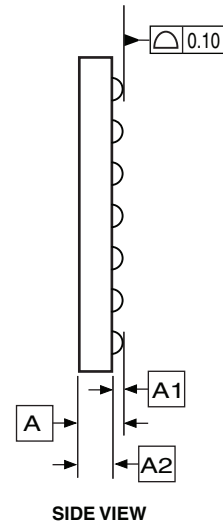
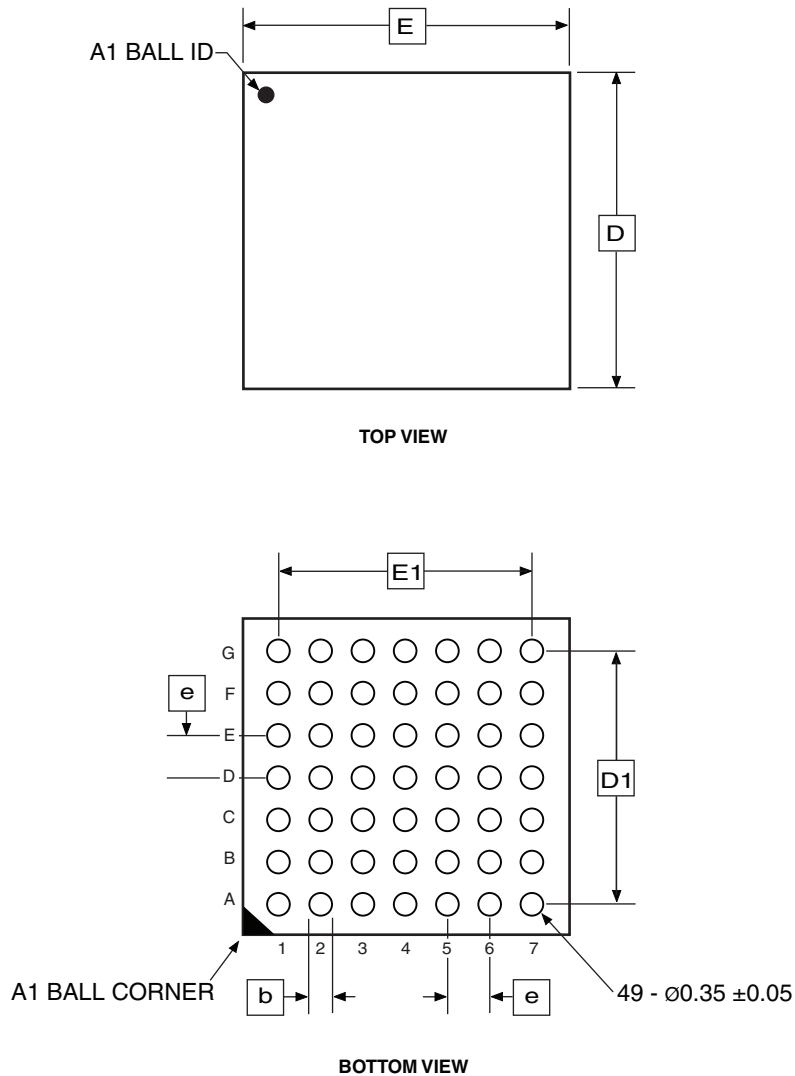
Package Drawing Contact:
packagedrawings@atmel.com

TITLE
44MC, 44QFN (2-Row Staggered), 5 x 5 x 1.00 mm Body,
2.60 x 2.60 mm Exposed Pad, Quad Flat No Lead Package

DRAWING NO.
44MC

REV.
A

10.5 49C2



COMMON DIMENSIONS
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	—	—	1.00	
A1	0.20	—	—	
A2	0.65	—	—	
D	4.90	5.00	5.10	
D1	3.90 BSC			
E	4.90	5.00	5.10	
E1	3.90 BSC			
b	0.30	0.35	0.40	
e	0.65 BSC			

3/14/08



Package Drawing Contact:
packagedrawings@atmel.com

TITLE
49C2, 49-ball (7 x 7 array), 0.65mm pitch,
5.0 x 5.0 x 1.0mm, very thin, fine-pitch
ball grid array package (VFBGA)

GPC

CBD

DRAWING NO.

49C2

REV.

A

11. Errata

11.1 Errata for ATmega164A

11.1.1 Rev. E

No known Errata.

11.2 Errata for ATmega164PA

11.2.1 Rev. E

No known Errata.

11.3 Errata for ATmega324A

11.3.1 Rev. F

No known Errata.

11.4 Errata for ATmega324PA

11.4.1 Rev. F

No known Errata.

11.5 Errata for ATmega644A

11.5.1 Rev. F

No known Errata.

11.6 Errata for ATmega644PA

11.6.1 Rev. F

No known Errata.

11.7 Errata for ATmega1284

11.7.1 Rev. B

No known Errata.

11.8 Errata for ATmega1284P

11.8.1 Rev. B

No known Errata.

12. Datasheet revision history

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

12.1 Rev. 8272E - 04/2013

1. Updated [Figure 1-1 on page 2](#) and [Figure 2-1 on page 5](#): T3 and T/C3 only available in ATmega1284/1284P.
2. Updated descriptive text on page 6 to indicate that ATmega1284/1284P has four T/Cs.
3. Updated the Assembly code example for WDT_off (p.56) following the ej# 705736.
4. Added note in ["16-bit Timer/Counter1 and Timer/Counter3^{\(1\)} with PWM" on page 111](#).
5. Added ["Prescaler Reset" on page 117](#).
6. Corrected three typo for Waveform generation mode (WGM) instead of MGM.
7. Updated [Table 23-6 on page 263](#). ADC Auto Trigger Source Selections, ADTS=0b011, the statement is Timer/Counter0 Compare Match A.
8. Updated [Table 27-18 on page 322](#). Command for 6d Poll for Fuse Write Complete: 0111011_00000000
9. Updated the table notes of the [Table 28-1 on page 330](#).
10. Updated ["Register summary" on page 10](#). Added table note 7: Only available in ATmega1284/1284P.

12.2 Rev. 8272D - 05/12

1. Updated ["Power-down mode" on page 44](#).
2. Updated ["Overview" on page 67](#).
3. Corrected references for Bit 2, Bit 1, and Bit 0 in Section ["UCSRnC – USART MSPIM Control and Status Register n C" on page 209](#).
4. Several small corrections throughout the whole document made according to the template
5. Notes in [Table 27-17 on page 315](#) have been corrected
6. Note (1) in [Table 28-3 on page 332](#) is added

12.3 Rev. 8272C - 06/11

1. Updated ["Atmel ATmega1284P DC characteristics" on page 335](#).

12.4 Rev. 8272B - 05/11

1. Added Atmel QTouch Library Support and QTouch Sensing Capability Features.
2. Replaced the [Figure 1-1 on page 2](#) by an updated “Pinout.” that includes Timer/Counter3.
3. Replaced the [Figure 7-1 on page 10](#) by an updated “Block diagram of the AVR architecture.” that includes Timer/Counter3.
4. Added “RAMPZ – Extended Z-pointer Register for ELPM/SPM⁽¹⁾” on page 15.
5. Added “PRR1 – Power Reduction Register 1” on page 49.
6. Renamed PRR to “PRR0 – Power Reduction Register 0” on page 48.
7. Updated “PCIFR – Pin Change Interrupt Flag Register” on page 69. PCICR replaces EIMSR in the PCIF3, PCIF2, PCIF1 and PCIF0 bit description.
8. Updated “PCMSK3 – Pin Change Mask Register 3” on page 70. PCIE3 replaces PCIE2 in the bit description.
9. Updated “Alternate Functions of Port B” on page 82 to include Timer/Counter3
10. Updated “Alternate Functions of Port D” on page 88 to include Timer/Counter3
11. Added “TCNT3H and TCNT3L –Timer/Counter3” on page 137
12. Added “OCR3AH and OCR3AL – Output Compare Register3 A” on page 138
13. Added “OCR3BH and OCR3BL – Output Compare Register3 B” on page 138
14. Added “TIMSK3 – Timer/Counter3 Interrupt Mask Register” on page 140
15. Updated All “SPI – Serial Peripheral Interface” “Register description” to reflect ATmega1284 and ATmega1284P.
16. Updated “Addressing the Flash During Self-Programming” on page 285 to include RAMPZ register.
17. Updated [Table 27-16 on page 315](#). t_{WD_EEPROM} is 3.6ms instead of 9ms.
18. BODS and BODSE bits denoted as R/W
19. Description of external pin modes below table 16-9 removed.
20. Updated “Register summary” on page 10 to include Timer/Counter3.
21. Updated the datasheet with Atmel new style guide.

12.5 Rev. 8272A - 01/10

1. Initial revision (Based on the ATmega164PA/324PA/644PA/1284P datasheet 8252G-AVR-11/09 and on the ATmega644 datasheet 2593N-AVR-09/09).
2. Changes done:
 - Non-picoPower devices added: ATmega164A/324A/644A/1284
 - Updated [Table 2-1 on page 7](#)
 - Updated [Table 10-1 on page 42](#)
 - Updated “Sleep Modes” on page 42 and “BOD disable⁽¹⁾” on page 43
 - Updated “Register description” on page 67
 - Updated “USART” on page 175 and “USART in SPI mode” on page 202

- Updated "Signature Bytes" on page 301 and "Page Size" on page 301
- Added "DC Characteristics" on page 330 for non-picoPower devices.
- Added "Atmel ATmega164A typical characteristics" on page 346
- Added "Atmel ATmega324A typical characteristics" on page 398
- Added "Atmel ATmega644A typical characteristics" on page 450
- Added "ATmega1284 typical characteristics" on page 502
- Added "Ordering information" on page 17 for non-picoPower devices
- Added "Errata for ATmega164A" on page 30
- Added "Errata for ATmega324A" on page 30
- Added "Errata for ATmega644PA" on page 30
- Added "Errata for ATmega1284" on page 30

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