

Features

- High-performance, Low-power AVR[®] 8-bit Microcontroller
- Advanced RISC Architecture
 - 130 Powerful Instructions – Most Single-clock Cycle Execution
 - 32 x 8 General Purpose Working Registers
 - Fully Static Operation
 - Up to 16 MIPS Throughput at 16 MHz
 - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory segments
 - 8K Bytes of In-System Self-programmable Flash program memory
 - 512 Bytes EEPROM
 - 1K Byte Internal SRAM
 - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM ^{(1)/(3)}
 - Data retention: 20 years at 85°C/100 years at 25°C ^{(2)/(3)}
 - 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, one Compare Mode
 - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
 - Real Time Counter with Separate Oscillator
 - Three PWM Channels
 - 8-channel ADC in TQFP and QFN/MLF package
 - Eight Channels 10-bit Accuracy
 - 6-channel ADC in PDIP package
 - Six Channels 10-bit Accuracy
 - Byte-oriented Two-wire Serial Interface
 - Programmable Serial USART
 - Master/Slave SPI Serial Interface
 - Programmable Watchdog Timer with Separate On-chip Oscillator
 - On-chip Analog Comparator
- Special Microcontroller Features
 - Power-on Reset and Programmable Brown-out Detection
 - Internal Calibrated RC Oscillator
 - External and Internal Interrupt Sources
 - Five Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, and Standby
- I/O and Packages
 - 23 Programmable I/O Lines
 - 28-lead PDIP, 32-lead TQFP, and 32-pad QFN/MLF
- Operating Voltages
 - 2.7 - 5.5V (ATmega8L)
 - 4.5 - 5.5V (ATmega8)
- Speed Grades
 - 0 - 8 MHz (ATmega8L)
 - 0 - 16 MHz (ATmega8)
- Power Consumption at 4 Mhz, 3V, 25°C
 - Active: 3.6 mA
 - Idle Mode: 1.0 mA
 - Power-down Mode: 0.5 µA

Notes: 1. At 85°C. Guaranteed after last write cycle.
2. Failure rate less than 1 ppm.
3. Characterized through accelerated tests.



**8-bit AVR[®]
with 8K Bytes
In-System
Programmable
Flash**

**ATmega8
ATmega8L**

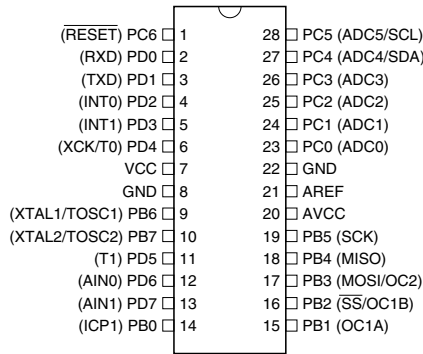
Summary

2486RS-AVR-07/07

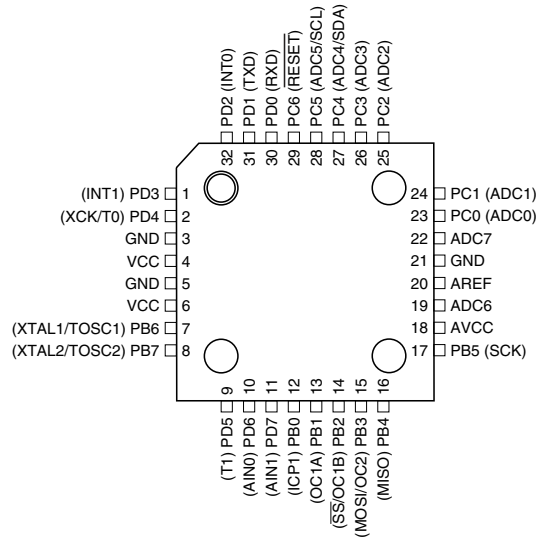


Pin Configurations

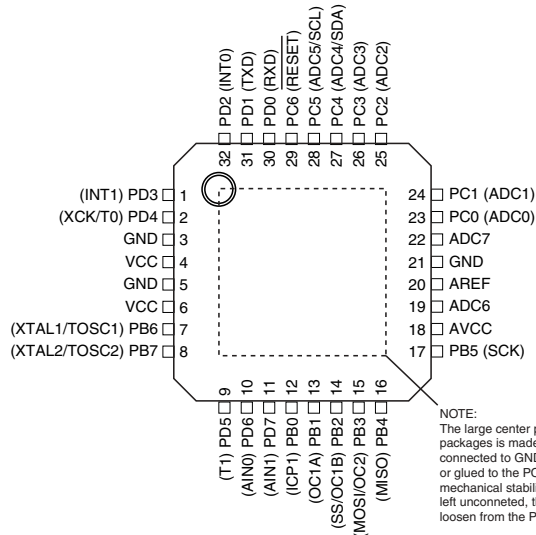
PDIP



TQFP Top View



MLF Top View



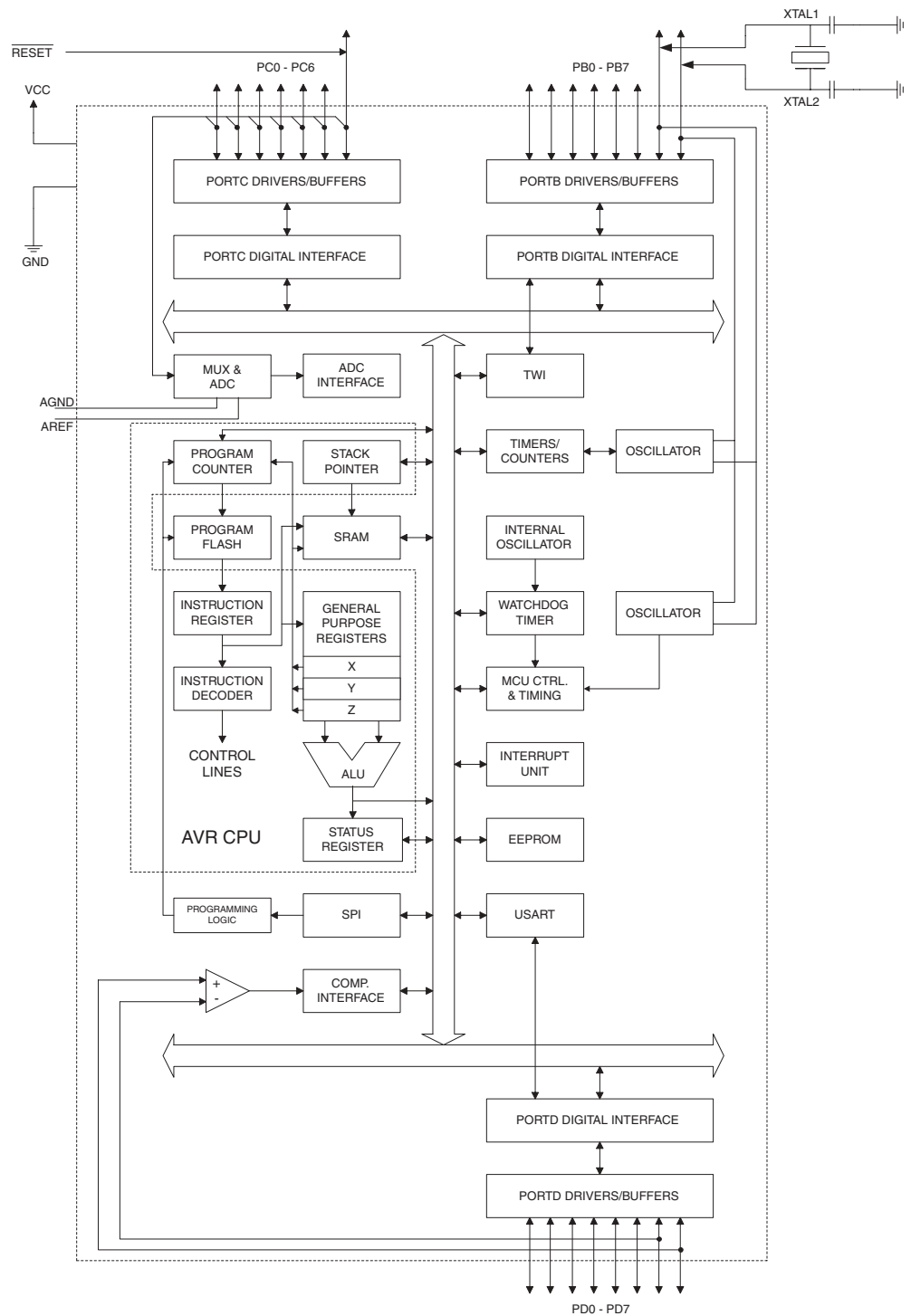
NOTE:
The large center pad underneath the MLF packages is made of metal and internally connected to GND. It should be soldered or glued to the PCB to ensure good mechanical stability. If the center pad is left unconnected, the package might loosen from the PCB.

Overview

The ATmega8 is a low-power CMOS 8-bit microcontroller based on the AVR RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega8 achieves throughputs approaching 1 MIPS per MHz, allowing the system designer to optimize power consumption versus processing speed.

Block Diagram

Figure 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 ATmega8 provides the following features: 8K bytes of In-System Programmable Flash with Read-While-Write capabilities, 512 bytes of EEPROM, 1K byte of SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte oriented Two-wire Serial Interface, a 6-channel ADC (eight channels in TQFP and QFN/MLF packages) with 10-bit accuracy, a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and five 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.

The device is manufactured using Atmel's high density non-volatile memory technology. The Flash Program memory can be reprogrammed In-System through an SPI serial interface, by a conventional non-volatile 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 ATmega8 is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications.

The ATmega8 AVR 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.

Disclaimer

Typical values contained in this datasheet are based on simulations and characterization of other AVR microcontrollers manufactured on the same process technology. Min and Max values will be available after the device is characterized.

Pin Descriptions

VCC Digital supply voltage.

GND Ground.

**Port B (PB7..PB0)
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 “Alternate Functions of Port B” on page 58 and “System Clock and Clock Options” on page 25.

Port C (PC5..PC0) Port C is an 7-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.

PC6/RESET If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C.

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 15 on page 38. Shorter pulses are not guaranteed to generate a Reset.

The various special features of Port C are elaborated on page 61.

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 ATmega8 as listed on page 63.

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 Table 15 on page 38. Shorter pulses are not guaranteed to generate a reset.



AV_{CC}

AV_{CC} is the supply voltage pin for the A/D Converter, Port C (3..0), and ADC (7..6). 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. Note that Port C (5..4) use digital supply voltage, V_{CC}.

AREF

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

ADC7..6 (TQFP and QFN/MLF Package Only)

In the TQFP and QFN/MLF package, ADC7..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.

Resources

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

Register Summary

| Address | Name | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 | Page |
|--|----------|--|--------|--------|--------|-------------|--------|--------|--------|------------------|
| 0x3F (0x5F) | SREG | I | T | H | S | V | N | Z | C | 11 |
| 0x3E (0x5E) | SPH | – | – | – | – | – | SP10 | SP9 | SP8 | 13 |
| 0x3D (0x5D) | SPL | SP7 | SP6 | SP5 | SP4 | SP3 | SP2 | SP1 | SP0 | 13 |
| 0x3C (0x5C) | Reserved | | | | | | | | | |
| 0x3B (0x5B) | GICR | INT1 | INT0 | – | – | – | – | IVSEL | IVCE | 49, 67 |
| 0x3A (0x5A) | GIFR | INTF1 | INTF0 | – | – | – | – | – | – | 68 |
| 0x39 (0x59) | TIMSK | OCIE2 | TOIE2 | TICIE1 | OCIE1A | OCIE1B | TOIE1 | – | TOIE0 | 72, 102, 122 |
| 0x38 (0x58) | TIFR | OCF2 | TOV2 | ICF1 | OCF1A | OCF1B | TOV1 | – | TOV0 | 73, 103, 122 |
| 0x37 (0x57) | SPMCR | SPMIE | RWWSB | – | RWWSRE | BLBSET | PGWRT | PGERS | SPMEN | 213 |
| 0x36 (0x56) | TWCR | TWINT | TWEA | TWSTA | TWSTO | TWWC | TWEN | – | TWIE | 171 |
| 0x35 (0x55) | MCUCR | SE | SM2 | SM1 | SM0 | ISC11 | ISC10 | ISC01 | ISC00 | 33, 66 |
| 0x34 (0x54) | MCUCSR | – | – | – | – | WDRF | BORF | EXTRF | PORF | 41 |
| 0x33 (0x53) | TCCR0 | – | – | – | – | – | CS02 | CS01 | CS00 | 72 |
| 0x32 (0x52) | TCNT0 | Timer/Counter0 (8 Bits) | | | | | | | | 72 |
| 0x31 (0x51) | OSCCAL | Oscillator Calibration Register | | | | | | | | 31 |
| 0x30 (0x50) | SFIOR | – | – | – | – | ACME | PUD | PSR2 | PSR10 | 58, 75, 123, 193 |
| 0x2F (0x4F) | TCCR1A | COM1A1 | COM1A0 | COM1B1 | COM1B0 | FOC1A | FOC1B | WGM11 | WGM10 | 97 |
| 0x2E (0x4E) | TCCR1B | ICNC1 | ICES1 | – | WGM13 | WGM12 | CS12 | CS11 | CS10 | 100 |
| 0x2D (0x4D) | TCNT1H | Timer/Counter1 – Counter Register High byte | | | | | | | | 101 |
| 0x2C (0x4C) | TCNT1L | Timer/Counter1 – Counter Register Low byte | | | | | | | | 101 |
| 0x2B (0x4B) | OCR1AH | Timer/Counter1 – Output Compare Register A High byte | | | | | | | | 101 |
| 0x2A (0x4A) | OCR1AL | Timer/Counter1 – Output Compare Register A Low byte | | | | | | | | 101 |
| 0x29 (0x49) | OCR1BH | Timer/Counter1 – Output Compare Register B High byte | | | | | | | | 101 |
| 0x28 (0x48) | OCR1BL | Timer/Counter1 – Output Compare Register B Low byte | | | | | | | | 101 |
| 0x27 (0x47) | ICR1H | Timer/Counter1 – Input Capture Register High byte | | | | | | | | 102 |
| 0x26 (0x46) | ICR1L | Timer/Counter1 – Input Capture Register Low byte | | | | | | | | 102 |
| 0x25 (0x45) | TCCR2 | FOC2 | WGM20 | COM21 | COM20 | WGM21 | CS22 | CS21 | CS20 | 117 |
| 0x24 (0x44) | TCNT2 | Timer/Counter2 (8 Bits) | | | | | | | | 119 |
| 0x23 (0x43) | OCR2 | Timer/Counter2 Output Compare Register | | | | | | | | 119 |
| 0x22 (0x42) | ASSR | – | – | – | – | AS2 | TCN2UB | OCR2UB | TCR2UB | 119 |
| 0x21 (0x41) | WDTCSR | – | – | – | WDCE | WDE | WDP2 | WDP1 | WDP0 | 43 |
| 0x20 ⁽¹⁾ (0x40 ⁽¹⁾) | UBRRH | URSEL | – | – | – | UBRR1[11:8] | | | | 158 |
| | UCSRC | URSEL | UMSEL | UPM1 | UPM0 | USBS | UCSZ1 | UCSZ0 | UCPOL | 156 |
| 0x1F (0x3F) | EEAR8 | – | – | – | – | – | – | – | EEAR8 | 20 |
| 0x1E (0x3E) | EEARL | EEAR7 | EEAR6 | EEAR5 | EEAR4 | EEAR3 | EEAR2 | EEAR1 | EEAR0 | 20 |
| 0x1D (0x3D) | EEDR | EEPROM Data Register | | | | | | | | 20 |
| 0x1C (0x3C) | EECR | – | – | – | – | EERIE | EEMWE | EERE | EERE | 20 |
| 0x1B (0x3B) | Reserved | | | | | | | | | |
| 0x1A (0x3A) | Reserved | | | | | | | | | |
| 0x19 (0x39) | Reserved | | | | | | | | | |
| 0x18 (0x38) | PORTB | PORTB7 | PORTB6 | PORTB5 | PORTB4 | PORTB3 | PORTB2 | PORTB1 | PORTB0 | 65 |
| 0x17 (0x37) | DDRB | DDB7 | DDB6 | DDB5 | DDB4 | DDB3 | DDB2 | DDB1 | DDB0 | 65 |
| 0x16 (0x36) | PINB | PINB7 | PINB6 | PINB5 | PINB4 | PINB3 | PINB2 | PINB1 | PINB0 | 65 |
| 0x15 (0x35) | PORTC | – | PORTC6 | PORTC5 | PORTC4 | PORTC3 | PORTC2 | PORTC1 | PORTC0 | 65 |
| 0x14 (0x34) | DDRC | – | DDC6 | DDC5 | DDC4 | DDC3 | DDC2 | DDC1 | DDC0 | 65 |
| 0x13 (0x33) | PINC | – | PINC6 | PINC5 | PINC4 | PINC3 | PINC2 | PINC1 | PINC0 | 65 |
| 0x12 (0x32) | PORTD | PORTD7 | PORTD6 | PORTD5 | PORTD4 | PORTD3 | PORTD2 | PORTD1 | PORTD0 | 65 |
| 0x11 (0x31) | DDRD | DDD7 | DDD6 | DDD5 | DDD4 | DDD3 | DDD2 | DDD1 | DDD0 | 65 |
| 0x10 (0x30) | PIND | PIND7 | PIND6 | PIND5 | PIND4 | PIND3 | PIND2 | PIND1 | PIND0 | 65 |
| 0x0F (0x2F) | SPDR | SPI Data Register | | | | | | | | 131 |
| 0x0E (0x2E) | SPSR | SPIF | WCOL | – | – | – | – | – | SPI2X | 131 |
| 0x0D (0x2D) | SPCR | SPIE | SPE | DORD | MSTR | CPOL | CPHA | SPR1 | SPR0 | 129 |
| 0x0C (0x2C) | UDR | USART I/O Data Register | | | | | | | | 153 |
| 0x0B (0x2B) | UCSRA | RXC | TXC | UDRE | FE | DOR | PE | U2X | MPCM | 154 |
| 0x0A (0x2A) | UCSRB | RXCIE | TXCIE | UDRIE | RXEN | TXEN | UCSZ2 | RXB8 | TXB8 | 155 |
| 0x09 (0x29) | UBRRL | USART Baud Rate Register Low byte | | | | | | | | 158 |
| 0x08 (0x28) | ACSR | ACD | ACBG | ACO | ACI | ACIE | ACIC | ACIS1 | ACIS0 | 194 |
| 0x07 (0x27) | ADMUX | REFS1 | REFS0 | ADLAR | – | MUX3 | MUX2 | MUX1 | MUX0 | 205 |
| 0x06 (0x26) | ADCSRA | ADEN | ADSC | ADFR | ADIF | ADIE | ADPS2 | ADPS1 | ADPS0 | 207 |
| 0x05 (0x25) | ADCH | ADC Data Register High byte | | | | | | | | 208 |
| 0x04 (0x24) | ADCL | ADC Data Register Low byte | | | | | | | | 208 |
| 0x03 (0x23) | TWDR | Two-wire Serial Interface Data Register | | | | | | | | 173 |
| 0x02 (0x22) | TWAR | TWA6 | TWA5 | TWA4 | TWA3 | TWA2 | TWA1 | TWA0 | TWGCE | 174 |

Register Summary (Continued)

| Address | Name | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 | Page |
|-------------|------|---|-------|-------|-------|-------|-------|-------|-------|------|
| 0x01 (0x21) | TWSR | TWS7 | TWS6 | TWS5 | TWS4 | TWS3 | – | TWPS1 | TWPS0 | 173 |
| 0x00 (0x20) | TWBR | Two-wire Serial Interface Bit Rate Register | | | | | | | | 171 |

- Notes:
1. Refer to the USART description for details on how to access UBRRH and UCSRC.
 2. For compatibility with future devices, reserved bits should be written to zero if accessed. Reserved I/O memory addresses should never be written.
 3. 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.

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 | Rd,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 | Rd,K | Subtract Immediate from Word | $Rdh:Rdl \leftarrow Rdh:Rdl - K$ | Z,C,N,V,S | 2 |
| AND | Rd, Rr | Logical AND Registers | $Rd \leftarrow Rd \bullet Rr$ | Z,N,V | 1 |
| ANDI | Rd, K | Logical AND Register and Constant | $Rd \leftarrow Rd \bullet K$ | 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 | $Rd \leftarrow Rd \bullet (0xFF - K)$ | 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 | $Rd \leftarrow Rd \bullet Rd$ | 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 | $R1:R0 \leftarrow (Rd \times Rr) \lll 1$ | Z,C | 2 |
| FMULS | Rd, Rr | Fractional Multiply Signed | $R1:R0 \leftarrow (Rd \times Rr) \lll 1$ | Z,C | 2 |
| FMULSU | Rd, Rr | Fractional Multiply Signed with Unsigned | $R1:R0 \leftarrow (Rd \times Rr) \lll 1$ | 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 |
| RCALL | k | Relative Subroutine Call | $PC \leftarrow PC + k + 1$ | None | 3 |
| ICALL | | Indirect Call to (Z) | $PC \leftarrow Z$ | None | 3 |
| RET | | Subroutine Return | $PC \leftarrow STACK$ | None | 4 |
| RETI | | Interrupt Return | $PC \leftarrow STACK$ | I | 4 |
| 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 |
| SBRS | 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 |
| BRVC | k | Branch if Overflow Flag is Cleared | if $(V = 0)$ then $PC \leftarrow PC + k + 1$ | None | 1 / 2 |
| Mnemonics | Operands | Description | Operation | Flags | #Clocks |

Instruction Set Summary (Continued)

| | | | | | |
|--------------------------------------|-----------------|----------------------------------|--|--------------|----------------|
| 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 | 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 |
| PUSH | Rr | Push Register on Stack | STACK ← Rr | None | 2 |
| POP | Rd | Pop Register from Stack | Rd ← STACK | None | 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 |
| Mnemonics | Operands | Description | Operation | Flags | #Clocks |

Instruction Set Summary (Continued)

| | | | | | |
|--------------------------|--|-------------------------------|--|------|---|
| 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 | | | | | |
| 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 |

Ordering Information

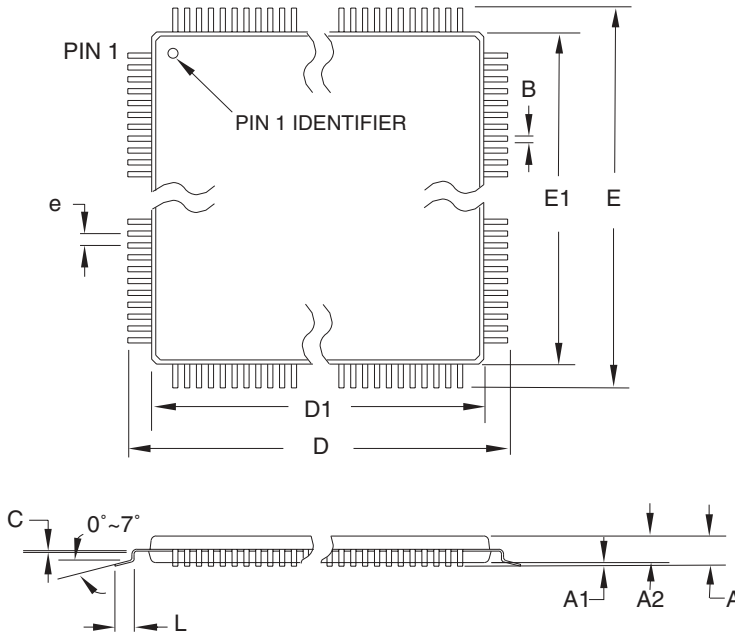
| Speed (MHz) | Power Supply | Ordering Code | Package ⁽¹⁾ | Operation Range |
|-----------------------------|--------------|-----------------------------|------------------------|-------------------------------|
| 8 | 2.7 - 5.5 | ATmega8L-8AC | 32A | Commercial (0°C to 70°C) |
| | | ATmega8L-8PC | 28P3 | |
| | | ATmega8L-8MC | 32M1-A | |
| | | ATmega8L-8AI | 32A | Industrial (-40°C to 85°C) |
| | | ATmega8L-8AU ⁽²⁾ | 32A | |
| | | ATmega8L-8PI | 28P3 | |
| ATmega8L-8PU ⁽²⁾ | 28P3 | | | |
| ATmega8L-8MI | 32M1-A | 32M1-A | | |
| ATmega8L-8MU ⁽²⁾ | 32M1-A | | | |
| 16 | 4.5 - 5.5 | ATmega8-16AC | 32A | Commercial (0°C to 70°C) |
| | | ATmega8-16PC | 28P3 | |
| | | ATmega8-16MC | 32M1-A | |
| | | ATmega8-16AI | 32A | Industrial (-40°C to 85°C) |
| | | ATmega8-16AU ⁽²⁾ | 32A | |
| | | ATmega8-16PI | 28P3 | |
| ATmega8-16PU ⁽²⁾ | 28P3 | | | |
| ATmega8-16MI | 32M1-A | 32M1-A | | |
| ATmega8-16MU ⁽²⁾ | 32M1-A | | | |

- 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 alternative, complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.

| Package Type | |
|---------------|---|
| 32A | 32-lead, Thin (1.0 mm) Plastic Quad Flat Package (TQFP) |
| 28P3 | 28-lead, 0.300" Wide, Plastic Dual Inline Package (PDIP) |
| 32M1-A | 32-pad, 5 x 5 x 1.0 body, Lead Pitch 0.50 mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF) |

Packaging Information

32A



COMMON DIMENSIONS
(Unit of Measure = mm)

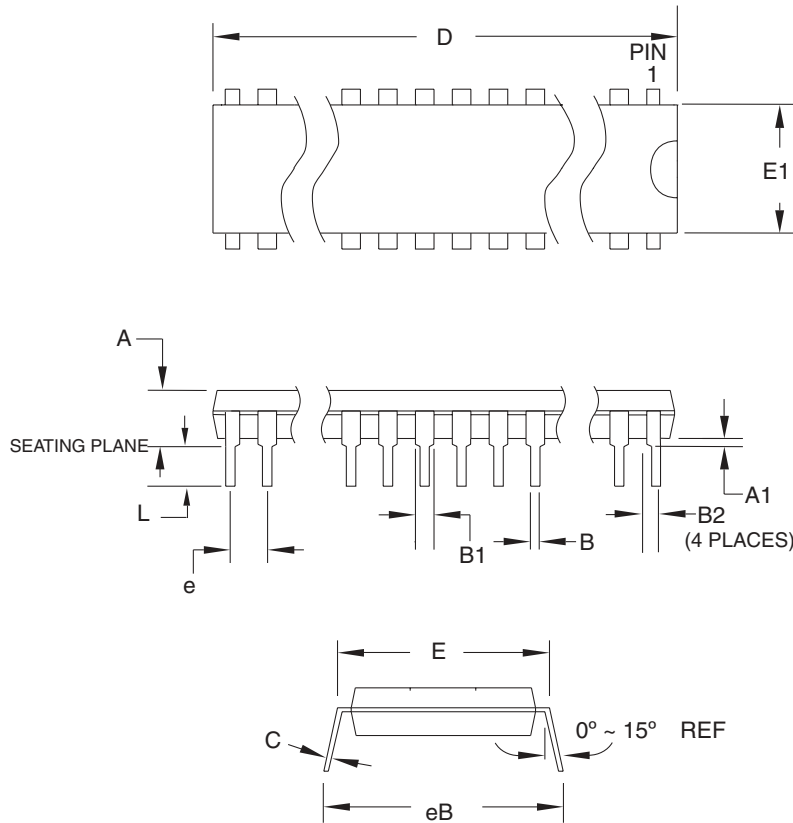
| SYMBOL | MIN | NOM | MAX | NOTE |
|--------|----------|------|------|--------|
| A | - | - | 1.20 | |
| A1 | 0.05 | - | 0.15 | |
| A2 | 0.95 | 1.00 | 1.05 | |
| D | 8.75 | 9.00 | 9.25 | |
| D1 | 6.90 | 7.00 | 7.10 | Note 2 |
| E | 8.75 | 9.00 | 9.25 | |
| E1 | 6.90 | 7.00 | 7.10 | Note 2 |
| B | 0.30 | - | 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 ABA.
 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.

10/5/2001

| | | | |
|--|--|--------------------|-------------|
| 2325 Orchard Parkway San Jose, CA 95131 | TITLE | DRAWING NO. | REV. |
| | 32A , 32-lead, 7 x 7 mm Body Size, 1.0 mm Body Thickness, 0.8 mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP) | 32A | B |

28P3



COMMON DIMENSIONS
(Unit of Measure = mm)

| SYMBOL | MIN | NOM | MAX | NOTE |
|--------|-----------|-----|--------|--------|
| A | - | - | 4.5724 | |
| A1 | 0.508 | - | - | |
| D | 34.544 | - | 34.798 | Note 1 |
| E | 7.620 | - | 8.255 | |
| E1 | 7.112 | - | 7.493 | Note 1 |
| B | 0.381 | - | 0.533 | |
| B1 | 1.143 | - | 1.397 | |
| B2 | 0.762 | - | 1.143 | |
| L | 3.175 | - | 3.429 | |
| C | 0.203 | - | 0.356 | |
| eB | - | - | 10.160 | |
| e | 2.540 TYP | | | |

Note: 1. Dimensions D and E1 do not include mold Flash or Protrusion.
Mold Flash or Protrusion shall not exceed 0.25 mm (0.010").

09/28/01

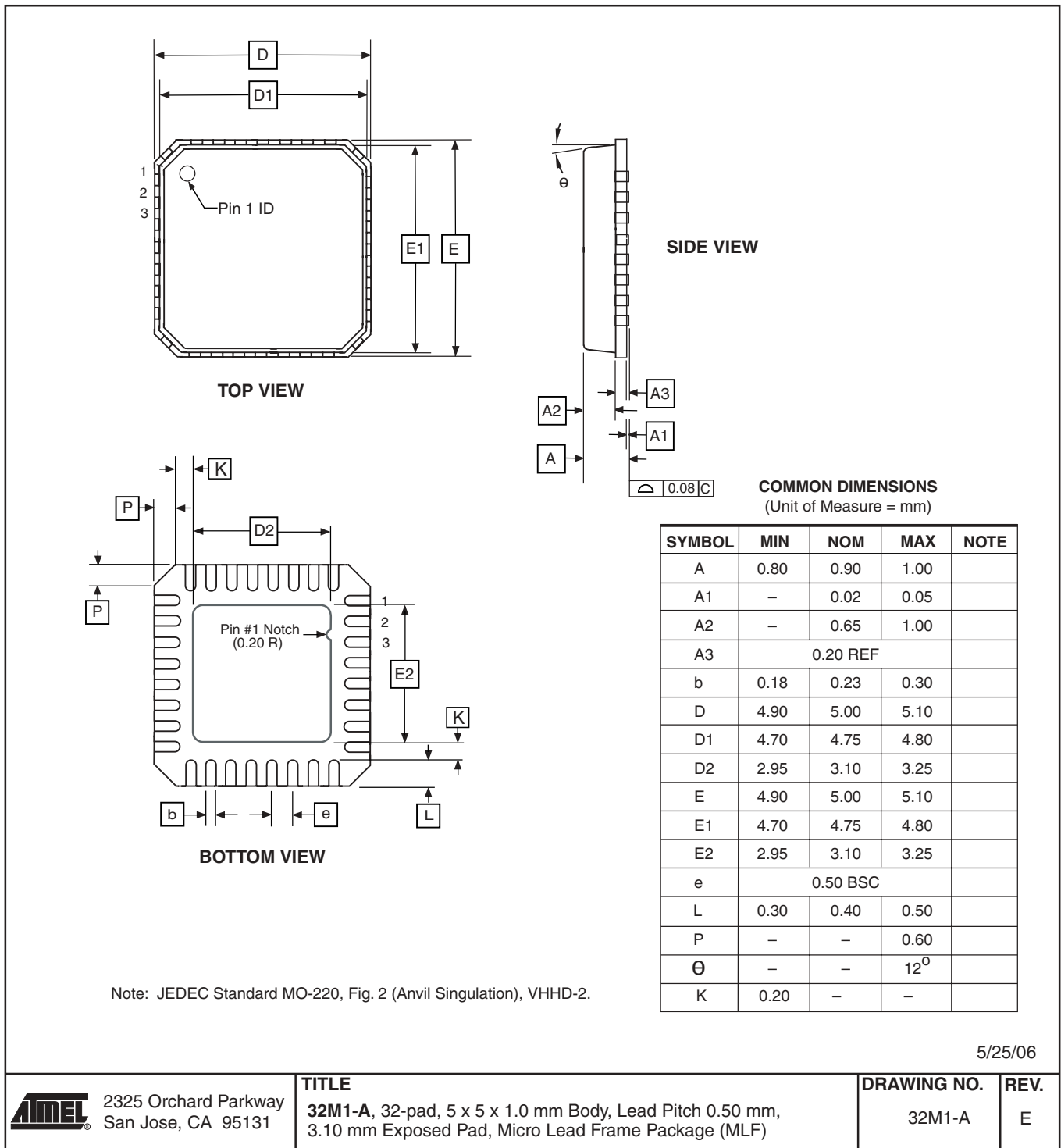
ATMEL 2325 Orchard Parkway
San Jose, CA 95131

TITLE
28P3, 28-lead (0.300"/7.62 mm Wide) Plastic Dual
Inline Package (PDIP)

DRAWING NO.
28P3

REV.
B

32M1-A



Erratas

ATmega8 Rev. D to I

The revision letter in this section refers to the revision of the ATmega8 device.

- **First Analog Comparator conversion may be delayed**
- **Interrupts may be lost when writing the timer registers in the asynchronous timer**
- **Signature may be Erased in Serial Programming Mode**
- **CKOPT Does not Enable Internal Capacitors on XTALn/TOSCn Pins when 32 KHz Oscillator is Used to Clock the Asynchronous Timer/Counter2**

1. **First Analog Comparator conversion may be delayed**

If the device is powered by a slow rising V_{CC} , the first Analog Comparator conversion will take longer than expected on some devices.

Problem Fix/Workaround

When the device has been powered or reset, disable then enable the Analog Comparator before the first conversion.

2. **Interrupts may be lost when writing the timer registers in the asynchronous timer**

If one of the timer registers which is synchronized to the asynchronous timer2 clock is written in the cycle before a overflow interrupt occurs, the interrupt may be lost.

Problem Fix/Workaround

Always check that the Timer2 Timer/Counter register, TCNT2, does not have the value 0xFF before writing the Timer2 Control Register, TCCR2, or Output Compare Register, OCR2

3. **Signature may be Erased in Serial Programming Mode**

If the signature bytes are read before a chip erase command is completed, the signature may be erased causing the device ID and calibration bytes to disappear. This is critical, especially, if the part is running on internal RC oscillator.

Problem Fix/Workaround:

Ensure that the chip erase command has exceeded before applying the next command.

4. **CKOPT Does not Enable Internal Capacitors on XTALn/TOSCn Pins when 32 KHz Oscillator is Used to Clock the Asynchronous Timer/Counter2**

When the internal RC Oscillator is used as the main clock source, it is possible to run the Timer/Counter2 asynchronously by connecting a 32 KHz Oscillator between XTAL1/TOSC1 and XTAL2/TOSC2. But when the internal RC Oscillator is selected as the main clock source, the CKOPT Fuse does not control the internal capacitors on XTAL1/TOSC1 and XTAL2/TOSC2. As long as there are no capacitors connected to XTAL1/TOSC1 and XTAL2/TOSC2, safe operation of the Oscillator is not guaranteed.

Problem fix/Workaround

Use external capacitors in the range of 20 - 36 pF on XTAL1/TOSC1 and XTAL2/TOSC2. This will be fixed in ATmega8 Rev. G where the CKOPT Fuse will control internal capacitors also when internal RC Oscillator is selected as main clock source. For ATmega8 Rev. G, CKOPT = 0 (programmed) will enable the internal capacitors on XTAL1 and XTAL2. Customers who want compatibility between Rev. G and older revisions, must ensure that CKOPT is unprogrammed (CKOPT = 1).

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.

Changes from Rev. 2486Q- 10/06 to Rev. 2486R- 07/07

1. Added text to Table 81 on page 218.
2. Updated typo in “Peripheral Features” on page 1.
3. Updated Table 16 on page 42.
4. Updated Table 75 on page 206.
5. Removed redundancy and updated typo in Notes section of “DC Characteristics” on page 242.

Changes from Rev. 2486P- 02/06 to Rev. 2486Q- 10/06

1. Updated “Timer/Counter Oscillator” on page 32.
2. Updated “Fast PWM Mode” on page 89.
3. Updated code example in “USART Initialization” on page 138.
4. Updated Table 37 on page 98, Table 39 on page 99, Table 42 on page 117, Table 44 on page 118, and Table 98 on page 240.
5. Updated “Erratas” on page 17.

Changes from Rev. 2486O-10/04 to Rev. 2486P- 02/06

1. Added “Resources” on page 7.
2. Updated “External Clock” on page 32.
3. Updated “Serial Peripheral Interface – SPI” on page 124.
4. Updated Code Example in “USART Initialization” on page 138.
5. Updated Note in “Bit Rate Generator Unit” on page 170.
6. Updated Table 98 on page 240.
7. Updated Note in Table 103 on page 248.
8. Updated “Erratas” on page 17.

Changes from Rev. 2486N-09/04 to Rev. 2486O-10/04

1. Removed to instances of “analog ground”. Replaced by “ground”.
2. Updated Table 7 on page 29, Table 15 on page 38, and Table 100 on page 244.
3. Updated “Calibrated Internal RC Oscillator” on page 30 with the 1 MHz default value.
4. Table 89 on page 225 and Table 90 on page 225 moved to new section “Page Size” on page 225.

5. Updated description for bit 4 in “Store Program Memory Control Register – SPMCR” on page 213.
6. Updated “Ordering Information” on page 13.

Changes from Rev. 2486M-12/03 to Rev. 2486N-09/04

1. Added note to MLF package in “Pin Configurations” on page 2.
2. Updated “Internal Voltage Reference Characteristics” on page 42.
3. Updated “DC Characteristics” on page 242.
4. ADC4 and ADC5 support 10-bit accuracy. Document updated to reflect this. Updated features in “Analog-to-Digital Converter” on page 196. Updated “ADC Characteristics” on page 248.
5. Removed reference to “External RC Oscillator application note” from “External RC Oscillator” on page 29.

Changes from Rev. 2486L-10/03 to Rev. 2486M-12/03

1. Updated “Calibrated Internal RC Oscillator” on page 30.

Changes from Rev. 2486K-08/03 to Rev. 2486L-10/03

1. Removed “Preliminary” and TBDs from the datasheet.
2. Renamed ICP to ICP1 in the datasheet.
3. Removed instructions CALL and JMP from the datasheet.
4. Updated t_{RST} in Table 15 on page 38, V_{BG} in Table 16 on page 42, Table 100 on page 244 and Table 102 on page 246.
5. Replaced text “XTAL1 and XTAL2 should be left unconnected (NC)” after Table 9 in “Calibrated Internal RC Oscillator” on page 30. Added text regarding XTAL1/XTAL2 and CKOPT Fuse in “Timer/Counter Oscillator” on page 32.
6. Updated Watchdog Timer code examples in “Timed Sequences for Changing the Configuration of the Watchdog Timer” on page 45.
7. Removed bit 4, ADHSM, from “Special Function IO Register – SFIOR” on page 58.
8. Added note 2 to Figure 103 on page 215.
9. Updated item 4 in the “Serial Programming Algorithm” on page 238.
10. Added t_{WD_FUSE} to Table 97 on page 239 and updated Read Calibration Byte, Byte 3, in Table 98 on page 240.
11. Updated Absolute Maximum Ratings* and DC Characteristics in “Electrical Characteristics” on page 242.

**Changes from Rev.
2486J-02/03 to Rev.
2486K-08/03**

1. Updated V_{BOT} values in Table 15 on page 38.
2. Updated “ADC Characteristics” on page 248.
3. Updated “ATmega8 Typical Characteristics” on page 249.
4. Updated “Erratas” on page 17.

**Changes from Rev.
2486I-12/02 to Rev.
2486J-02/03**

1. Improved the description of “Asynchronous Timer Clock – clk_{ASY} ” on page 26.
2. Removed reference to the “Multipurpose Oscillator” application note and the “32 kHz Crystal Oscillator” application note, which do not exist.
3. Corrected OCn waveforms in Figure 38 on page 90.
4. Various minor Timer 1 corrections.
5. Various minor TWI corrections.
6. Added note under “Filling the Temporary Buffer (Page Loading)” on page 216 about writing to the EEPROM during an SPM Page load.
7. Removed ADHSM completely.
8. Added section “EEPROM Write during Power-down Sleep Mode” on page 23.
9. Removed XTAL1 and XTAL2 description on page 5 because they were already described as part of “Port B (PB7..PB0) XTAL1/XTAL2/TOSC1/TOSC2” on page 5.
10. Improved the table under “SPI Timing Characteristics” on page 246 and removed the table under “SPI Serial Programming Characteristics” on page 241.
11. Corrected PC6 in “Alternate Functions of Port C” on page 61.
12. Corrected PB6 and PB7 in “Alternate Functions of Port B” on page 58.
13. Corrected 230.4 Mbps to 230.4 kbps under “Examples of Baud Rate Setting” on page 159.
14. Added information about PWM symmetry for Timer 2 in “Phase Correct PWM Mode” on page 113.
15. Added thick lines around accessible registers in Figure 76 on page 169.
16. Changed “will be ignored” to “must be written to zero” for unused Z-pointer bits under “Performing a Page Write” on page 216.
17. Added note for RSTDISBL Fuse in Table 87 on page 223.
18. Updated drawings in “Packaging Information” on page 14.

Changes from Rev. 2486H-09/02 to Rev. 2486I-12/02

1. Added errata for Rev D, E, and F on page 17.

Changes from Rev. 2486G-09/02 to Rev. 2486H-09/02

1. Changed the Endurance on the Flash to 10,000 Write/Erase Cycles.

Changes from Rev. 2486F-07/02 to Rev. 2486G-09/02

1. Updated Table 103, “ADC Characteristics,” on page 248.

Changes from Rev. 2486E-06/02 to Rev. 2486F-07/02

1. Changes in “Digital Input Enable and Sleep Modes” on page 55.
2. Addition of OCS2 in “MOSI/OC2 – Port B, Bit 3” on page 59.
3. The following tables have been updated:
Table 51, “CPOL and CPHA Functionality,” on page 132, Table 59, “UCPOL Bit Settings,” on page 158, Table 72, “Analog Comparator Multiplexed Input⁽¹⁾,” on page 195, Table 73, “ADC Conversion Time,” on page 200, Table 75, “Input Channel Selections,” on page 206, and Table 84, “Explanation of Different Variables used in Figure 103 and the Mapping to the Z-pointer,” on page 221.
4. Changes in “Reading the Calibration Byte” on page 234.
5. Corrected Errors in Cross References.

Changes from Rev. 2486D-03/02 to Rev. 2486E-06/02

1. Updated Some Preliminary Test Limits and Characterization Data
The following tables have been updated:
Table 15, “Reset Characteristics,” on page 38, Table 16, “Internal Voltage Reference Characteristics,” on page 42, DC Characteristics on page 242, Table , “ADC Characteristics,” on page 248.
2. Changes in External Clock Frequency
Added the description at the end of “External Clock” on page 32.
Added period changing data in Table 99, “External Clock Drive,” on page 244.
3. Updated TWI Chapter
More details regarding use of the TWI bit rate prescaler and a Table 65, “TWI Bit Rate Prescaler,” on page 173.

Changes from Rev. 2486C-03/02 to Rev. 2486D-03/02

1. Updated Typical Start-up Times.
The following tables has been updated:
Table 5, “Start-up Times for the Crystal Oscillator Clock Selection,” on page 28, Table 6, “Start-up Times for the Low-frequency Crystal Oscillator Clock Selection,” on page 28, Table 8, “Start-up Times for the External RC Oscillator Clock Selection,” on page 29, and Table 12, “Start-up Times for the External Clock Selection,” on page 32.

**Changes from Rev.
2486B-12/01 to Rev.
2486C-03/02**

2. Added “ATmega8 Typical Characteristics” on page 249.

1. Updated TWI Chapter.

More details regarding use of the TWI Power-down operation and using the TWI as Master with low TWBR values are added into the datasheet.

Added the note at the end of the “Bit Rate Generator Unit” on page 170.

Added the description at the end of “Address Match Unit” on page 170.

2. Updated Description of OSCCAL Calibration Byte.

In the datasheet, it was not explained how to take advantage of the calibration bytes for 2, 4, and 8 MHz Oscillator selections. This is now added in the following sections:

Improved description of “Oscillator Calibration Register – OSCCAL” on page 31 and “Calibration Byte” on page 225.

3. Added Some Preliminary Test Limits and Characterization Data.

Removed some of the TBD’s in the following tables and pages:

Table 3 on page 26, Table 15 on page 38, Table 16 on page 42, Table 17 on page 44, “ $T_A = -40^{\circ}\text{C}$ to 85°C , $V_{CC} = 2.7\text{V}$ to 5.5V (unless otherwise noted)” on page 242, Table 99 on page 244, and Table 102 on page 246.

4. Updated Programming Figures.

Figure 104 on page 226 and Figure 112 on page 237 are updated to also reflect that AV_{CC} must be connected during Programming mode.

5. Added a Description on how to Enter Parallel Programming Mode if RESET Pin is Disabled or if External Oscillators are Selected.

Added a note in section “Enter Programming Mode” on page 228.



Headquarters

Atmel Corporation
2325 Orchard Parkway
San Jose, CA 95131
USA
Tel: 1(408) 441-0311
Fax: 1(408) 487-2600

International

Atmel Asia
Room 1219
Chinachem Golden Plaza
77 Mody Road Tsimshatsui
East Kowloon
Hong Kong
Tel: (852) 2721-9778
Fax: (852) 2722-1369

Atmel Europe
Le Krebs
8, Rue Jean-Pierre Timbaud
BP 309
78054 Saint-Quentin-en-
Yvelines Cedex
France
Tel: (33) 1-30-60-70-00
Fax: (33) 1-30-60-71-11

Atmel Japan
9F, Tonetsu Shinkawa Bldg.
1-24-8 Shinkawa
Chuo-ku, Tokyo 104-0033
Japan
Tel: (81) 3-3523-3551
Fax: (81) 3-3523-7581

Product Contact

Web Site
www.atmel.com

Technical Support
avr@atmel.com

Sales Contact
www.atmel.com/contacts

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