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

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

Details

Product Status	Active
Core Processor	AVR
Core Size	8-Bit
Speed	16MHz
Connectivity	SPI, UART/USART, USI
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	54
Program Memory Size	16KB (8K x 16)
Program Memory Type	FLASH
EEPROM Size	512 x 8
RAM Size	1K x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 5.5V
Data Converters	A/D 8x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	64-TQFP
Supplier Device Package	64-TQFP (14x14)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/atmega165pa-au

- Programmable serial USART
- Master/Slave SPI Serial Interface
- Universal Serial Interface with Start Condition detector
- Programmable Watchdog Timer with separate on-chip oscillator
- On-chip Analog Comparator
- Interrupt and Wake-up on pin change
- Special microcontroller features
 - Power-on reset and programmable Brown-out detection
 - Internal calibrated oscillator
 - External and internal interrupt sources
 - Five sleep modes: Idle, ADC Noise Reduction, Power-save, Power-down and Standby
- I/O and packages
 - 54/69 programmable I/O lines
 - 64/100-lead TQFP, 64-pad QFN/MLF and 64-pad DRQFN
- Speed grade:
 - ATmega 165A/165PA/645A/645P: 0 - 16MHz @ 1.8 - 5.5V
 - ATmega325A/325PA/3250A/3250PA/6450A/6450P: 0 - 20MHz @ 1.8 - 5.5V
- Temperature range:
 - -40°C to 85°C industrial
- Ultra-low power consumption (picoPower® devices)
 - Active mode:
 - 1MHz, 1.8V: 215µA
 - 32kHz, 1.8V: 8µA (including oscillator)
 - Power-down mode: 0.1µA at 1.8V
 - Power-save mode: 0.6µA at 1.8V (Including 32kHz RTC)

Note: 1. 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.

2.3.11 Port J (PJ6:PJ0)

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

Port J also serves the functions of various special features of the Atmel ATmega3250A/3250PA/6450A/6450P as listed on [page 83](#).

2.3.12 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 28-13 on page 304](#). Shorter pulses are not guaranteed to generate a reset.

2.3.13 XTAL1

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

2.3.14 XTAL2

Output from the inverting Oscillator amplifier.

2.3.15 AVCC

AVCC is the supply voltage pin for Port F and the A/D 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.

2.3.16 AREF

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

3. Resources

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

4. 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.

5. 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.

These 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".

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 Atmel 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

Note: Registers with bold type only available in ATmega3250A/3250PA/6450A/6450P.

(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)	PORTJ	-	PORTJ6	PORTJ5	PORTJ4	PORTJ3	PORTJ2	PORTJ1	PORTJ0	88
(0xDC)	DDRJ	-	DDJ6	DDJ5	DDJ4	DDJ3	DDJ2	DDJ1	DDJ0	88
(0xDB)	PINJ	-	PINJ6	PINJ5	PINJ4	PINJ3	PINJ2	PINJ1	PINJ0	88
(0xDA)	PORTH	PORTH7	PORTH6	PORTH5	PORTH4	PORTH3	PORTH2	PORTH1	PORTH0	87
(0xD9)	DDRH	DDH7	DDH6	DDH5	DDH4	DDH3	DDH2	DDH1	DDH0	87
(0xD8)	PINH	PINH7	PINH6	PINH5	PINH4	PINH3	PINH2	PINH1	PINH0	88
(0xD7)	Reserved	-	-	-	-	-	-	-	-	
(0xD6)	Reserved	-	-	-	-	-	-	-	-	
(0xD5)	Reserved	-	-	-	-	-	-	-	-	
(0xD4)	Reserved	-	-	-	-	-	-	-	-	
(0xD3)	Reserved	-	-	-	-	-	-	-	-	
(0xD2)	Reserved	-	-	-	-	-	-	-	-	
(0xD1)	Reserved	-	-	-	-	-	-	-	-	
(0xD0)	Reserved	-	-	-	-	-	-	-	-	
(0xCF)	Reserved	-	-	-	-	-	-	-	-	
(0xCE)	Reserved	-	-	-	-	-	-	-	-	
(0xCD)	Reserved	-	-	-	-	-	-	-	-	
(0xCC)	Reserved	-	-	-	-	-	-	-	-	
(0xCB)	Reserved	-	-	-	-	-	-	-	-	
(0xCA)	Reserved	-	-	-	-	-	-	-	-	
(0xC9)	Reserved	-	-	-	-	-	-	-	-	
(0xC8)	Reserved	-	-	-	-	-	-	-	-	
(0xC7)	Reserved	-	-	-	-	-	-	-	-	
(0xC6)	UDR0	USART0 Data Register								178
(0xC5)	UBRR0H	USART0 Baud Rate Register High								182

(0xC4)	UBRR0L	USART0 Baud Rate Register Low								182
(0xC3)	Reserved	-	-	-	-	-	-	-	-	
(0xC2)	UCSR0C	-	UMSEL0	UPM01	UPM00	USBS0	UCSZ01	UCSZ00	UCPOL0	180
(0xC1)	UCSR0B	RXCIE0	TXCIE0	UDRIE0	RXEN0	TXEN0	UCSZ02	RXB80	TXB80	179
(0xC0)	UCSR0A	RXC0	TXC0	UDRE0	FE0	DOR0	UPE0	U2X0	MPCM0	178
(0xBF)	Reserved	-	-	-	-	-	-	-	-	
(0xBE)	Reserved	-	-	-	-	-	-	-	-	
(0xBD)	Reserved	-	-	-	-	-	-	-	-	
(0xBC)	Reserved	-	-	-	-	-	-	-	-	
(0xBB)	Reserved	-	-	-	-	-	-	-	-	
(0xBA)	USIDR	USI Data Register								190
(0xB9)	USISR	USISIF	USIOIF	USIPF	USIDC	USICNT3	USICNT2	USICNT1	USICNT0	190
(0xB8)	USICR	USISIE	USIOIE	USIWM1	USIWM0	USICS1	USICS0	USICLK	USITC	191
(0xB7)	Reserved	-	-	-	-	-	-	-	-	
(0xB6)	ASSR	-	-	-	EXCLK	AS2	TCN2UB	OCR2UB	TCR2UB	146
(0xB5)	Reserved	-	-	-	-	-	-	-	-	
(0xB4)	Reserved	-	-	-	-	-	-	-	-	
(0xB3)	OCR2A	Timer/Counter 2 Output Compare Register A								145
(0xB2)	TCNT2	Timer/Counter2								144
(0xB1)	Reserved	-	-	-	-	-	-	-	-	
(0xB0)	TCCR2A	FOC2A	WGM20	COM2A1	COM2A0	WGM21	CS22	CS21	CS20	143
(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)	Reserved	-	-	-	-	-	-	-	-	
(0x9A)	Reserved	-	-	-	-	-	-	-	-	
(0x99)	Reserved	-	-	-	-	-	-	-	-	
(0x98)	Reserved	-	-	-	-	-	-	-	-	
(0x97)	Reserved	-	-	-	-	-	-	-	-	
(0x96)	Reserved	-	-	-	-	-	-	-	-	
(0x95)	Reserved	-	-	-	-	-	-	-	-	
(0x94)	Reserved	-	-	-	-	-	-	-	-	
(0x93)	Reserved	-	-	-	-	-	-	-	-	
(0x92)	Reserved	-	-	-	-	-	-	-	-	
(0x91)	Reserved	-	-	-	-	-	-	-	-	
(0x90)	Reserved	-	-	-	-	-	-	-	-	
(0x8F)	Reserved	-	-	-	-	-	-	-	-	
(0x8E)	Reserved	-	-	-	-	-	-	-	-	
(0x8D)	Reserved	-	-	-	-	-	-	-	-	
(0x8C)	Reserved	-	-	-	-	-	-	-	-	
(0x8B)	OCR1BH	Timer/Counter1 Output Compare Register B High								126
(0x8A)	OCR1BL	Timer/Counter1 Output Compare Register B Low								126
(0x89)	OCR1AH	Timer/Counter1 Output Compare Register A High								126
(0x88)	OCR1AL	Timer/Counter1 Output Compare Register A Low								126
(0x87)	ICR1H	Timer/Counter1 Input Capture Register High								126
(0x86)	ICR1L	Timer/Counter1 Input Capture Register Low								126
(0x85)	TCNT1H	Timer/Counter1 High								126
(0x84)	TCNT1L	Timer/Counter1 Low								126

0x22 (0x42)	EEARH	–	–	–	–	–	–	–	–	25
0x21 (0x41)	EEARL	EEPROM Address Register Low								25
0x20 (0x40)	EEDR	EEPROM Data Register								26
0x1F (0x3F)	EECR	–	–	–	–	EERIE	EEMWE	EEWE	EERE	26
0x1E (0x3E)	GPOR0	General Purpose I/O Register								27
0x1D (0x3D)	EIMSK	PCIE	PCIE2	PCIE1	PCIE0	–	–	–	INT0	61
0x1C (0x3C)	EIFR	PCIF3	PCIF2	PCIF1	PCIF0	–	–	–	INTF0	62
0x1B (0x3B)	Reserved	–	–	–	–	–	–	–	–	
0x1A (0x3A)	Reserved	–	–	–	–	–	–	–	–	
0x19 (0x39)	Reserved	–	–	–	–	–	–	–	–	
0x18 (0x38)	Reserved	–	–	–	–	–	–	–	–	
0x17 (0x37)	TIFR2	–	–	–	–	–	–	OCF2A	TOV2	145
0x16 (0x36)	TIFR1	–	–	ICF1	–	–	OCF1B	OCF1A	TOV1	127
0x15 (0x35)	TIFR0	–	–	–	–	–	–	OCF0A	TOV0	130
0x14 (0x34)	PORTG	–	–	–	PORTG4	PORTG3	PORTG2	PORTG1	PORTG0	87
0x13 (0x33)	DDRG	–	–	–	DDG4	DDG3	DDG2	DDG1	DDG0	87
0x12 (0x32)	PING	–	–	PING5	PING4	PING3	PING2	PING1	PING0	87
0x11 (0x31)	PORTF	PORTF7	PORTF6	PORTF5	PORTF4	PORTF3	PORTF2	PORTF1	PORTF0	87
0x10 (0x30)	DDRF	DDF7	DDF6	DDF5	DDF4	DDF3	DDF2	DDF1	DDF0	87
0x0F (0x2F)	PINF	PINF7	PINF6	PINF5	PINF4	PINF3	PINF2	PINF1	PINF0	87
0x0E (0x2E)	PORTE	PORTE7	PORTE6	PORTE5	PORTE4	PORTE3	PORTE2	PORTE1	PORTE0	86
0x0D (0x2D)	DDRE	DDE7	DDE6	DDE5	DDE4	DDE3	DDE2	DDE1	DDE0	86
0x0C (0x2C)	PINE	PINE7	PINE6	PINE5	PINE4	PINE3	PINE2	PINE1	PINE0	87
0x0B (0x2B)	PORTD	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0	86
0x0A (0x2A)	DDRD	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0	86
0x09 (0x29)	PIND	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0	86
0x08 (0x28)	PORTC	PORTC7	PORTC6	PORTC5	PORTC4	PORTC3	PORTC2	PORTC1	PORTC0	86
0x07 (0x27)	DDRC	DDC7	DDC6	DDC5	DDC4	DDC3	DDC2	DDC1	DDC0	86
0x06 (0x26)	PINC	PINC7	PINC6	PINC5	PINC4	PINC3	PINC2	PINC1	PINC0	86
0x05 (0x25)	PORTB	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0	85
0x04 (0x24)	DDRB	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0	85
0x03 (0x23)	PINB	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0	85
0x02 (0x22)	PORTA	PORTA7	PORTA6	PORTA5	PORTA4	PORTA3	PORTA2	PORTA1	PORTA0	85
0x01 (0x21)	DDRA	DDA7	DDA6	DDA5	DDA4	DDA3	DDA2	DDA1	DDA0	85
0x00 (0x20)	PINA	PINA7	PINA6	PINA5	PINA4	PINA3	PINA2	PINA1	PINA0	85

- Note:
1. For compatibility with future devices, reserved bits should be written to zero if accessed. Reserved I/O memory addresses should never be written.
 2. I/O Registers within the address range 0x00 - 0x1F 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.
 3. Some of the Status Flags are cleared by writing a logical one to them. Note that, unlike most other AVRs, the CBI and SBI instructions will only operate on the specified bit, and can therefore be used on registers containing such Status Flags. The CBI and SBI instructions work with registers 0x00 to 0x1F only.
 4. When using the I/O specific commands IN and OUT, the I/O addresses 0x00 - 0x3F must be used. When addressing I/O Registers as data space using LD and ST instructions, 0x20 must be added to these addresses. The ATmega165A/165PA/325A/325PA/3250A/3250PA/645A/645P/6450A/6450P 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 0x60 - 0xFF in SRAM, only the ST/STS/STD and LD/LDS/LDD instructions can be used.

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	RdI,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	RdI,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	$R1:R0 \leftarrow (Rd \times Rr) \ll 1$	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	3
ICALL		Indirect Call to (Z)	$PC \leftarrow Z$	None	3
CALL	k	Direct Subroutine Call	$PC \leftarrow k$	None	4
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

Mnemonics	Operands	Description	Operation	Flags	#Clocks
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 ATmega165A

Speed (MHz) ⁽³⁾	Power Supply	Ordering Code ⁽²⁾	Package ⁽¹⁾	Operation Range
16	1.8 - 5.5V	ATmega165A-AU ATmega165A-AUR ⁽⁴⁾ ATmega165A-MU ATmega165A-MUR ⁽⁴⁾ ATmega165A-MCH ATmega165A-MCHR ⁽⁴⁾	64A 64A 64M1 64M1 64MC 64MC	Industrial (-40°C to 85°C)
		ATmega165A-AN ATmega165A-ANR ⁽⁴⁾ ATmega165A-MN ATmega165A-MNR ⁽⁴⁾	64A 64A 64M1 64M1	Extended (-40°C to 105°C) ⁽⁵⁾

- 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 [Figure 28-1 on page 302](#).
 4. Tape & Reel
 5. See characterization specifications at 105°C.

Package Type	
64A	64-Lead, Thin (1.0mm) Plastic Gull Wing Quad Flat Package (TQFP)
64M1	64-pad, 9 x 9 x 1.0mm body, lead pitch 0.50mm, Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)
64MC	64-lead (2-row Staggered), 7 x 7 x 1.0 mm body, 4.0 x 4.0mm Exposed Pad, Quad Flat No-Lead Package (QFN)

9.2 ATmega165PA

Speed (MHz) ⁽³⁾	Power Supply	Ordering Code ⁽²⁾	Package ⁽¹⁾	Operation Range
16	1.8 - 5.5V	ATmega165PA-AU ATmega165PA-AUR ⁽⁴⁾ ATmega165PA-MU ATmega165PA-MUR ⁽⁴⁾ ATmega165PA-MCH ATmega165PA-MCHR ⁽⁴⁾	64A 64A 64M1 64M1 64MC 64MC	Industrial (-40°C to 85°C)
		ATmega165PA-AN ATmega165PA-ANR ⁽⁴⁾ ATmega165PA-MN ATmega165PA-MNR ⁽⁴⁾	64A 64A 64M1 64M1	Extended (-40°C to 105°C) ⁽⁵⁾

- 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 [Figure 28-1 on page 302](#).
 4. Tape & Reel.
 5. See characterization specifications at 105°C.

Package Type	
64A	64-Lead, Thin (1.0mm) Plastic Gull Wing Quad Flat Package (TQFP)
64M1	64-pad, 9 x 9 x 1.0mm body, lead pitch 0.50mm, Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)
64MC	64-lead (2-row Staggered), 7 x 7 x 1.0mm body, 4.0 x 4.0 mm Exposed Pad, Quad Flat No-Lead Package (QFN)

9.5 ATmega3250A

Speed (MHz) ⁽³⁾	Power Supply	Ordering Code ⁽²⁾	Package ⁽¹⁾	Operation Range
20	1.8 - 5.5V	ATmega3250A-AU ATmega3250A-AUR ⁽⁴⁾	100A 100A	Industrial (-40°C to 85°C)
		ATmega3250A-AN ATmega3250A-ANR ⁽⁴⁾	100A 100A	Extended (-40°C to 105°C) ⁽⁵⁾

- 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 [Figure 28-1 on page 302](#).
 4. Tape & Reel
 5. See characterization specifications at 105°C.

Package Type	
100A	100-lead, 14 x 14 x 1.0mm, 0.5mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP)

9.8 ATmega645P

Speed (MHz) ⁽³⁾	Power Supply	Ordering Code ⁽²⁾	Package ⁽¹⁾	Operation Range
20	1.8 - 5.5V	ATmega645P-AU ATmega645P-AUR ⁽⁴⁾ ATmega645P-MU ATmega645P-MUR ⁽⁴⁾	64A 64A 64M1 64M1	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 [Figure 28-1 on page 302](#).
 4. Tape & Reel

Package Type	
64A	64-Lead, Thin (1.0mm) Plastic Gull Wing Quad Flat Package (TQFP)
64M1	64-pad, 9 x 9 x 1.0mm body, lead pitch 0.50mm, Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)

9.9 ATmega6450A

Speed (MHz) ⁽³⁾	Power Supply	Ordering Code ⁽²⁾	Package ⁽¹⁾	Operation Range
20	1.8 - 5.5V	ATmega6450A-AU ATmega6450A-AUR ⁽⁴⁾	100A 100A	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 [Figure 28-1 on page 302](#).
 4. Tape & Reel

Package Type	
100A	100-lead, 14 x 14 x 1.0mm, 0.5mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP)

9.10 ATmega6450P

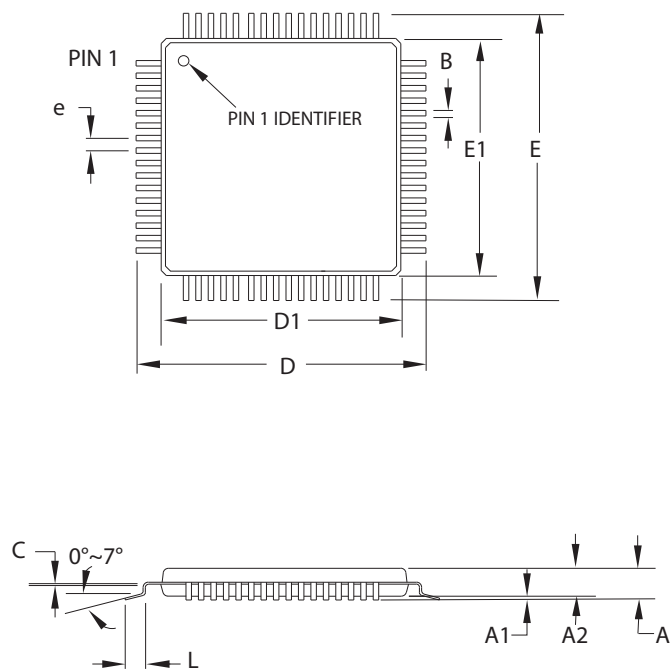
Speed (MHz) ⁽³⁾	Power Supply	Ordering Code ⁽²⁾	Package ⁽¹⁾	Operation Range
20	1.8 - 5.5V	ATmega6450P-AU ATmega6450P-AUR ⁽⁴⁾	100A 100A	Industrial (-40°C to 85°C)

- 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 [Figure 28-1 on page 302](#).
 4. Tape & Reel

Package Type	
100A	100-lead, 14 x 14 x 1.0mm, 0.5mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP)

10. Packaging Information

10.1 64A



COMMON DIMENSIONS
(Unit of measure = mm)

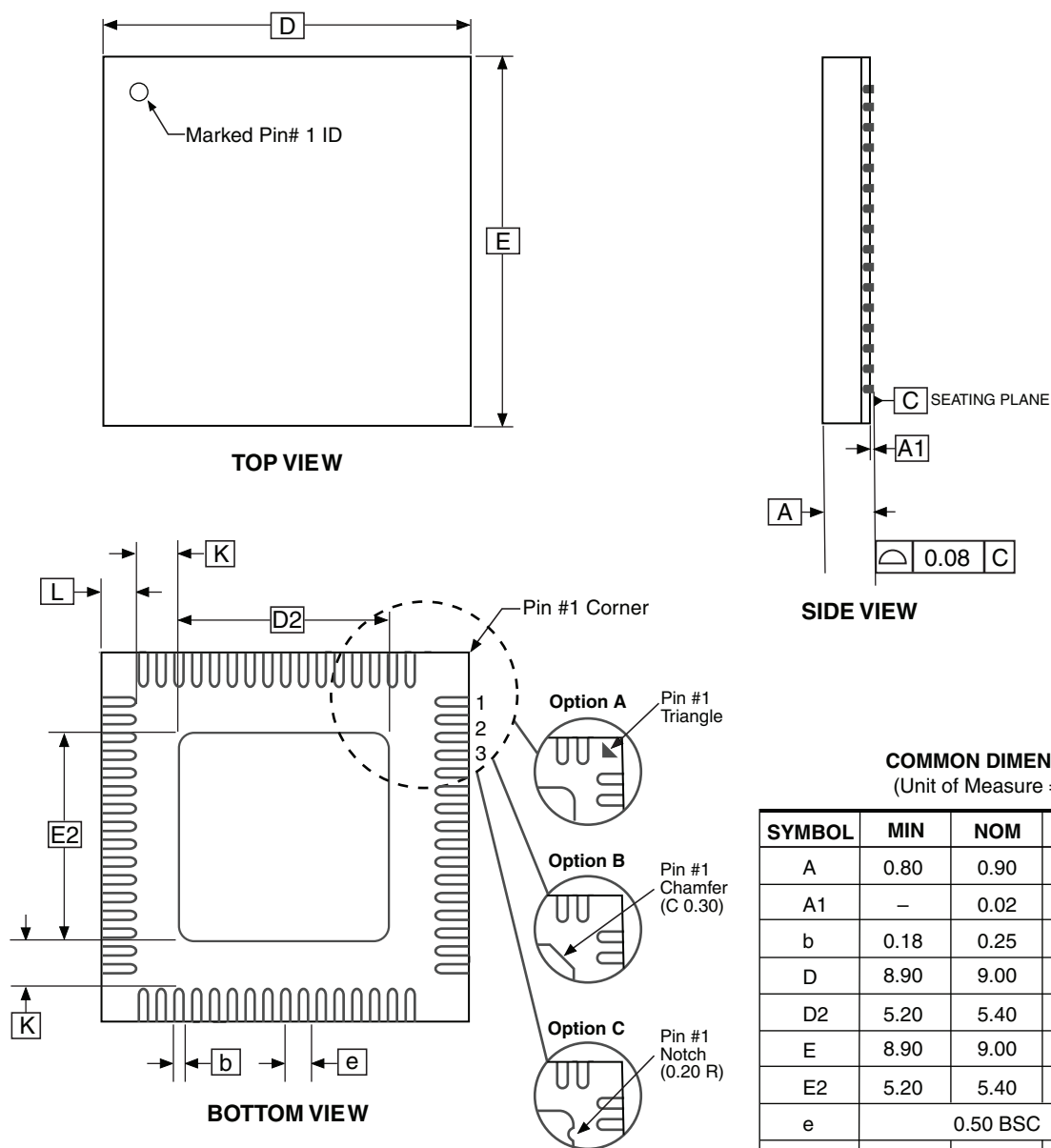
SYMBOL	MIN	NOM	MAX	NOTE
A	–	–	1.20	
A1	0.05	–	0.15	
A2	0.95	1.00	1.05	
D	15.75	16.00	16.25	
D1	13.90	14.00	14.10	Note 2
E	15.75	16.00	16.25	
E1	13.90	14.00	14.10	Note 2
B	0.30–	0.45		
C	0.09	–	0.20	
L	0.45	–	0.75	
e	0.80 TYP			

- Notes:
- 1.This package conforms to JEDEC reference MS-026, Variation AEB.
 - 2. Dimensions D1 and E1 do not include mold protrusion. Allowable protrusion is 0.25mm 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 64A, 64-lead, 14 x 14mm Body Size, 1.0mm Body Thickness, 0.8mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP)	DRAWING NO.	REV.
			64A	C

10.2 64M1



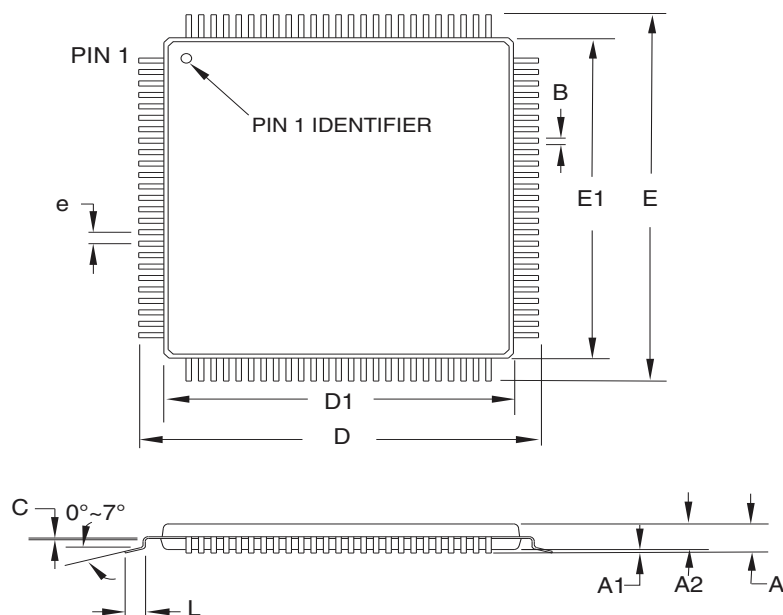
Notes:

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

2010-10-19

Atmel 2325 Orchard Parkway San Jose, CA 95131	TITLE 64M1 , 64-pad, 9 x 9 x 1.0 mm Body, Lead Pitch 0.50 mm, 5.40 mm Exposed Pad, Micro Lead Frame Package (MLF)	DRAWING NO. 64M1	REV. H
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10.4 100A



COMMON DIMENSIONS
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	—	—	1.20	
A1	0.05	—	0.15	
A2	0.95	1.00	1.05	
D	15.75	16.00	16.25	
D1	13.90	14.00	14.10	Note 2
E	15.75	16.00	16.25	
E1	13.90	14.00	14.10	Note 2
B	0.17	—	0.27	
C	0.09	—	0.20	
L	0.45	—	0.75	
e	0.50 TYP			

Notes:

1. This package conforms to JEDEC reference MS-026, Variation AED.
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 0.08mm maximum.

2014-02-05

Atmel	Package Drawing Contact: packagedrawings@atmel.com	TITLE	DRAWING NO.	REV.
		100A, 100-lead, 14 x 14mm Body Size, 1.0mm Body Thickness, 0.5mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP)	100A	E

11. Errata

11.1 ATmega165A/165PA/325A/325PA/3250A/3250PA/645A/645P/6450A/6450P Rev. G

No known errata.

11.2 ATmega165A/165PA/325A/325PA/3250A/3250PA/645A/645P/6450A/6450P Rev. A to F

Not sampled.

