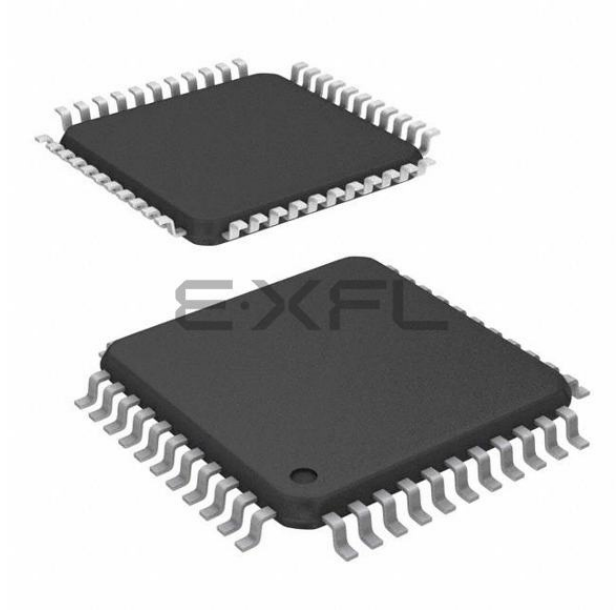

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What is "Embedded - Microcontrollers"?

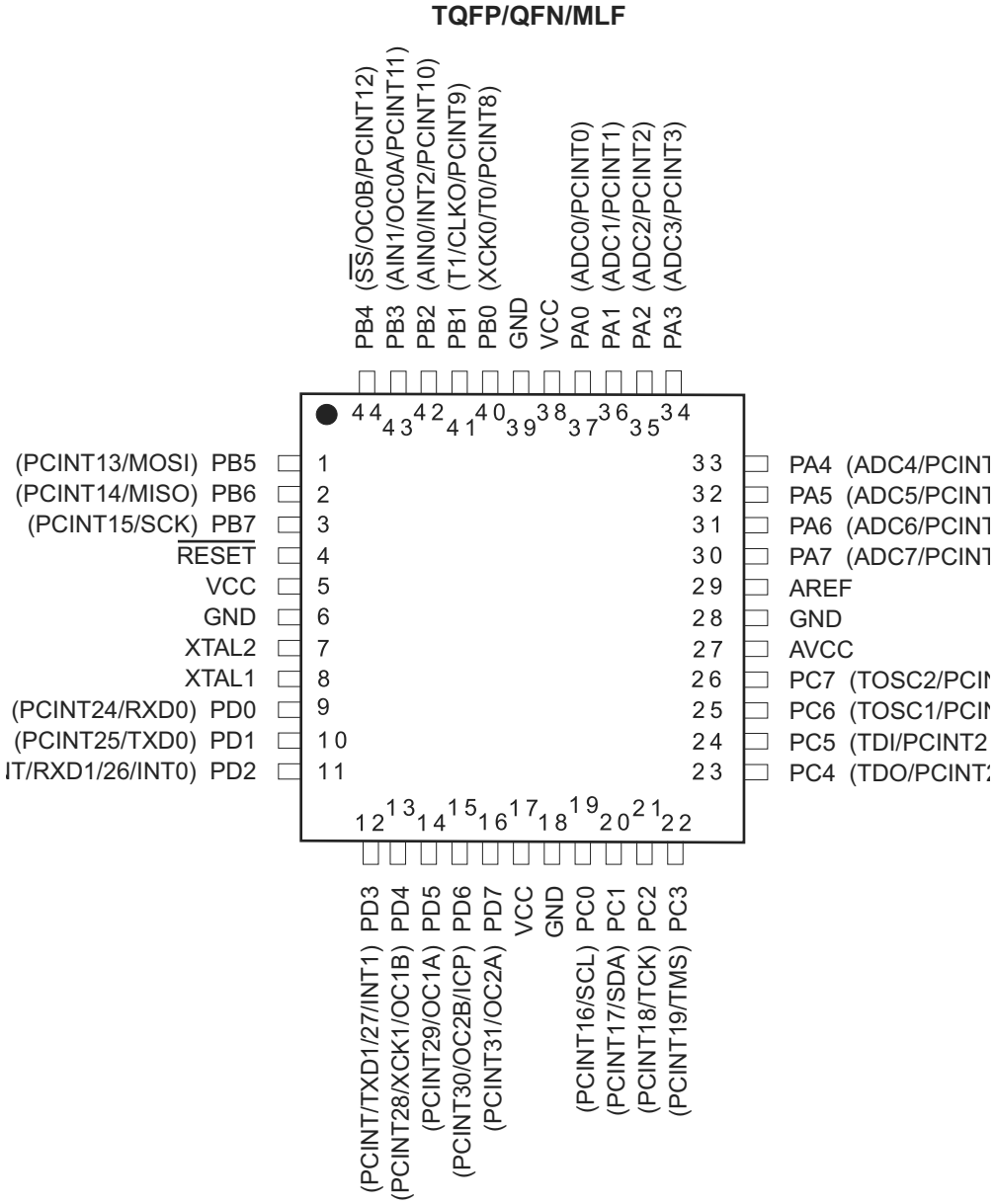
"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded"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

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Obsolete
Core Processor	AVR
Core Size	8-Bit
Speed	16MHz
Connectivity	I²C, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	32
Program Memory Size	32KB (16K x 16)
Program Memory Type	FLASH
EEPROM Size	1K x 8
RAM Size	2K x 8
Voltage - Supply (Vcc/Vdd)	2.7V ~ 5.5V
Data Converters	A/D 8x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Surface Mount
Package / Case	44-TQFP
Supplier Device Package	44-TQFP (10x10)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/atmega324p-15az

1. Pin Configurations

Figure 1-1. Pinout ATmega164P/324P/644P



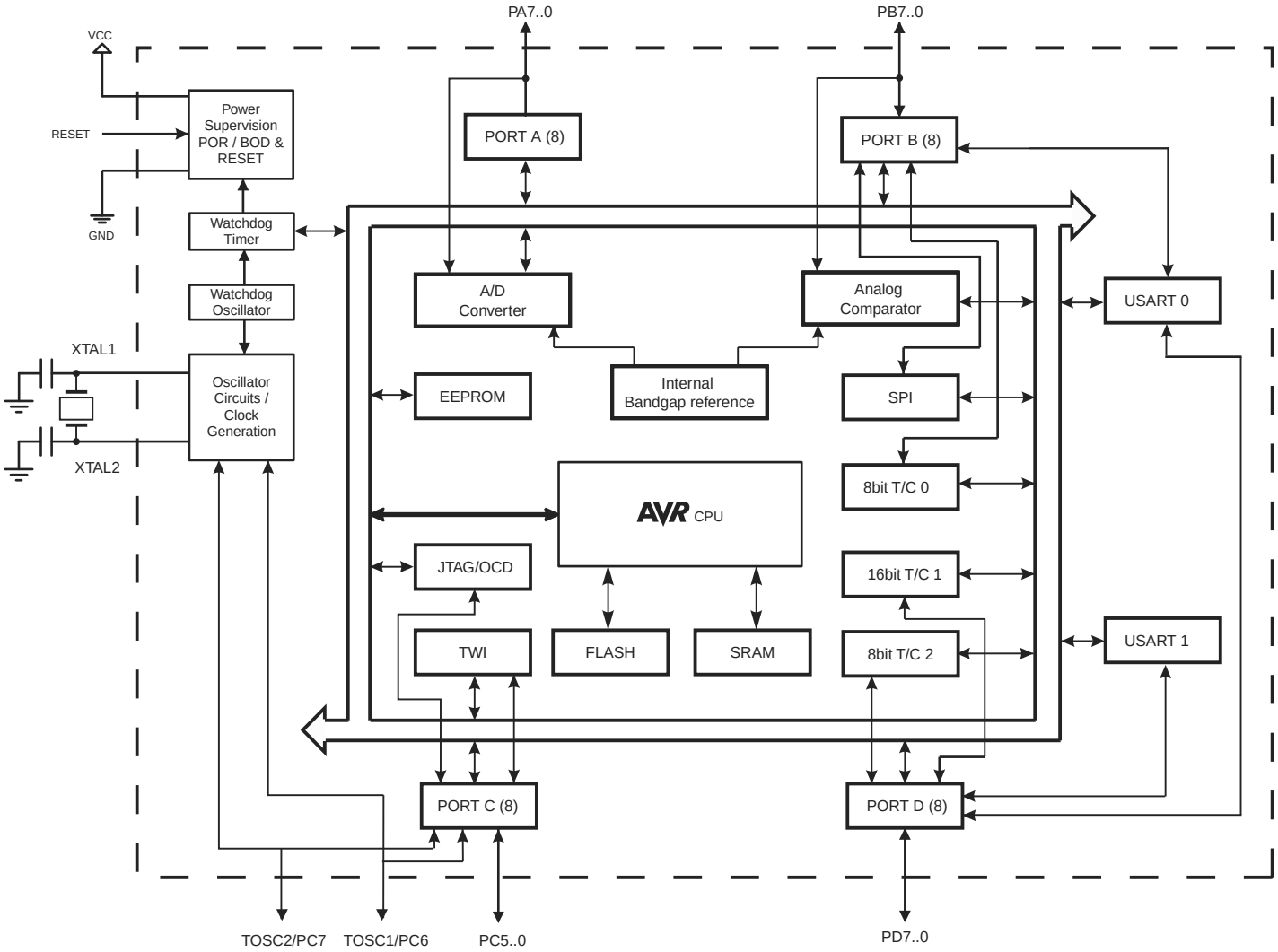
Note: The large center pad underneath the QFN/MLF package should be soldered to ground on the board to ensure good mechanical stability.

2. Overview

The ATmega164P/324P/644P 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 ATmega164P/324P/644P 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 ATmega164P/324P/644P provides the following features: 16/32/64K bytes of In-System Programmable Flash with Read-While-Write capabilities, 512B/1K/2K bytes EEPROM, 1/2/4K bytes SRAM, 32 general purpose I/O lines, 32 general purpose working registers, Real Time Counter (RTC), three flexible Timer/Counters with compare modes and PWM, 2 USARTs, a byte oriented 2-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.

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 ATmega164P/324P/644P is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications.

The ATmega164P/324P/644P 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.

2.2 Comparison Between ATmega164P, ATmega324P and ATmega644P

Table 2-1. Differences between ATmega164P and ATmega644P

Device	Flash	EEPROM	RAM
ATmega164P	16 Kbyte	512 Bytes	1 Kbyte
ATmega324P	32 Kbyte	1 Kbyte	2 Kbyte
ATmega644P	64 Kbyte	2 Kbyte	4 Kbyte

Automotive Quality Grade

The ATmega164P/324P/644P have been developed and manufactured according to the most stringent requirements of the international standard ISO-TS-16949. This data sheet contains limit values extracted from the results of extensive characterization (Temperature and Voltage). The quality and reliability of the ATmega164P/324P/644P have been verified during regular product qualification as per AEC-Q100 grade 1.

As indicated in the ordering information paragraph, the products are available in three different temperature grades, but with equivalent quality and reliability objectives. Different temperature identifiers have been defined as listed in Table 1.

Table 1. Temperature Grade Identification for Automotive Products

Temperature	Temperature Identifier	Comments
-40 ; +85	T	Similar to Industrial Temperature Grade but with Automotive Quality
-40 ; +105	T1	Reduced Automotive Temperature Range
-40 ; +125	Z	Full AutomotiveTemperature Range

3. 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								188
(0xCD)	UBRR1H	-	-	-	-	USART1 Baud Rate Register High Byte				192/205
(0xCC)	UBRR1L	USART1 Baud Rate Register Low Byte								192/205
(0xCB)	Reserved	-	-	-	-	-	-	-	-	
(0xCA)	UCSR1C	UMSEL11	UMSEL10	UPM11	UPM10	USBS1	UCSZ11	UCSZ10	UCPOL1	190/204
(0xC9)	UCSR1B	RXCIE1	TXCIE1	UDRIE1	RXEN1	TXEN1	UCSZ12	RXB81	TXB81	189/203
(0xC8)	UCSR1A	RXC1	TXC1	UDRE1	FE1	DOR1	UPE1	U2X1	MPCM1	188/203
(0xC7)	Reserved	-	-	-	-	-	-	-	-	
(0xC6)	UDR0	USART0 I/O Data Register								188
(0xC5)	UBRR0H	-	-	-	-	USART0 Baud Rate Register High Byte				192/205
(0xC4)	UBRR0L	USART0 Baud Rate Register Low Byte								192/205
(0xC3)	Reserved	-	-	-	-	-	-	-	-	
(0xC2)	UCSR0C	UMSEL01	UMSEL00	UPM01	UPM00	USBS0	UCSZ01	UCSZ00	UCPOL0	190/204
(0xC1)	UCSR0B	RXCIE0	TXCIE0	UDRIE0	RXEN0	TXEN0	UCSZ02	RXB80	TXB80	189/203
(0xC0)	UCSR0A	RXC0	TXC0	UDRE0	FE0	DOR0	UPE0	U2X0	MPCM0	188/203

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
(0xBF)	Reserved	-	-	-	-	-	-	-	-	
(0xBE)	Reserved	-	-	-	-	-	-	-	-	
(0xBD)	TWAMR	TWAM6	TWAM5	TWAM4	TWAM3	TWAM2	TWAM1	TWAM0	-	234
(0xBC)	TWCR	TWINT	TWEA	TWSTA	TWSTO	TWWC	TWEN	-	TWIE	231
(0xBB)	TWDR	2-wire Serial Interface Data Register								233
(0xBA)	TWAR	TWA6	TWA5	TWA4	TWA3	TWA2	TWA1	TWA0	TWGCE	234
(0xB9)	TWSR	TWS7	TWS6	TWS5	TWS4	TWS3	-	TWPS1	TWPS0	233
(0xB8)	TWBR	2-wire Serial Interface Bit Rate Register								231
(0xB7)	Reserved	-	-	-	-	-	-	-	-	
(0xB6)	ASSR	-	EXCLK	AS2	TCN2UB	OCR2AUB	OCR2BUB	TCR2AUB	TCR2BUB	157
(0xB5)	Reserved	-	-	-	-	-	-	-	-	
(0xB4)	OCR2B	Timer/Counter2 Output Compare Register B								157
(0xB3)	OCR2A	Timer/Counter2 Output Compare Register A								157
(0xB2)	TCNT2	Timer/Counter2 (8 Bit)								156
(0xB1)	TCCR2B	FOC2A	FOC2B	-	-	WGM22	CS22	CS21	CS20	155
(0xB0)	TCCR2A	COM2A1	COM2A0	COM2B1	COM2B0	-	-	WGM21	WGM20	152
(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 Byte								136
(0x8A)	OCR1BL	Timer/Counter1 - Output Compare Register B Low Byte								136
(0x89)	OCR1AH	Timer/Counter1 - Output Compare Register A High Byte								136
(0x88)	OCR1AL	Timer/Counter1 - Output Compare Register A Low Byte								136
(0x87)	ICR1H	Timer/Counter1 - Input Capture Register High Byte								137
(0x86)	ICR1L	Timer/Counter1 - Input Capture Register Low Byte								137
(0x85)	TCNT1H	Timer/Counter1 - Counter Register High Byte								136
(0x84)	TCNT1L	Timer/Counter1 - Counter Register Low Byte								136
(0x83)	Reserved	-	-	-	-	-	-	-	-	
(0x82)	TCCR1C	FOC1A	FOC1B	-	-	-	-	-	-	135
(0x81)	TCCR1B	ICNC1	ICES1	-	WGM13	WGM12	CS12	CS11	CS10	134
(0x80)	TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	-	-	WGM11	WGM10	132
(0x7F)	DIDR1	-	-	-	-	-	-	AIN1D	AIN0D	238
(0x7E)	DIDR0	ADC7D	ADC6D	ADC5D	ADC4D	ADC3D	ADC2D	ADC1D	ADC0D	258

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
(0x7D)	Reserved	-	-	-	-	-	-	-	-	
(0x7C)	ADMUX	REFS1	REFS0	ADLAR	MUX4	MUX3	MUX2	MUX1	MUX0	254
(0x7B)	ADCSRB	-	ACME	-	-	-	ADTS2	ADTS1	ADTS0	237
(0x7A)	ADCSRA	ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0	256
(0x79)	ADCH	ADC Data Register High byte								257
(0x78)	ADCL	ADC Data Register Low byte								257
(0x77)	Reserved	-	-	-	-	-	-	-	-	
(0x76)	Reserved	-	-	-	-	-	-	-	-	
(0x75)	Reserved	-	-	-	-	-	-	-	-	
(0x74)	Reserved	-	-	-	-	-	-	-	-	
(0x73)	PCMSK3	PCINT31	PCINT30	PCINT29	PCINT28	PCINT27	PCINT26	PCINT25	PCINT24	70
(0x72)	Reserved	-	-	-	-	-	-	-	-	
(0x71)	Reserved	-	-	-	-	-	-	-	-	
(0x70)	TIMSK2	-	-	-	-	-	OCIE2B	OCIE2A	TOIE2	158
(0x6F)	TIMSK1	-	-	ICIE1	-	-	OCIE1B	OCIE1A	TOIE1	137
(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)	WDTCSR	WDIF	WDIE	WDP3	WDCE	WDE	WDP2	WDP1	WDP0	60
0x3F (0x5F)	SREG	I	T	H	S	V	N	Z	C	10
0x3E (0x5E)	SPH	SP15	SP14	SP13	SP12	SP11	SP10	SP9	SP8	11
0x3D (0x5D)	SPL	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0	11
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	290
0x36 (0x56)	Reserved	-	-	-	-	-	-	-	-	
0x35 (0x55)	MCUCR	JTD	BODS	BODSE	PUD	-	-	IVSEL	IVCE	91/274
0x34 (0x54)	MCUSR	-	-	-	JTRF	WDRF	BORF	EXTRF	PORF	59/274
0x33 (0x53)	SMCR	-	-	-	-	SM2	SM1	SM0	SE	47
0x32 (0x52)	Reserved	-	-	-	-	-	-	-	-	
0x31 (0x51)	OCDR	On-Chip Debug Register								264
0x30 (0x50)	ACSR	ACD	ACBG	ACO	ACI	ACIE	ACIC	ACIS1	ACIS0	256
0x2F (0x4F)	Reserved	-	-	-	-	-	-	-	-	
0x2E (0x4E)	SPDR	SPI 0 Data Register								169
0x2D (0x4D)	SPSR	SPIF0	WCOL0	-	-	-	-	-	SPI2X0	168
0x2C (0x4C)	SPCR	SPIE0	SPE0	DORD0	MSTR0	CPOL0	CPHA0	SPR01	SPR00	167
0x2B (0x4B)	GPIOR2	General Purpose I/O Register 2								28
0x2A (0x4A)	GPIOR1	General Purpose I/O Register 1								28
0x29 (0x49)	Reserved	-	-	-	-	-	-	-	-	
0x28 (0x48)	OCR0B	Timer/Counter0 Output Compare Register B								109
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	109
0x23 (0x43)	GTCCR	TSM	-	-	-	-	-	PSR2	PSR54310	159
0x22 (0x42)	EEARH	-	-	-	-	EEPROM Address Register High Byte				23
0x21 (0x41)	EEARL	EEPROM Address Register Low Byte								23
0x20 (0x40)	EEDR	EEPROM Data Register								23
0x1F (0x3F)	EECR	-	-	EEPM1	EEPM0	EERIE	EEMWE	EEWE	EERE	23
0x1E (0x3E)	GPIOR0	General Purpose I/O Register 0								28
0x1D (0x3D)	EIMSK	-	-	-	-	-	INT2	INT1	INT0	68
0x1C (0x3C)	EIFR	-	-	-	-	-	INTF2	INTF1	INTF0	68

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
0x1B (0x3B)	PCIFR	-	-	-	-	PCIF3	PCIF2	PCIF1	PCIF0	69
0x1A (0x3A)	Reserved	-	-	-	-	-	-	-	-	
0x19 (0x39)	Reserved	-	-	-	-	-	-	-	-	
0x18 (0x38)	Reserved	-	-	-	-	-	-	-	-	
0x17 (0x37)	TIFR2	-	-	-	-	-	OCF2b	OCF2A	TOV2	159
0x16 (0x36)	TIFR1	-	-	ICF1	-	-	OCF1B	OCF1A	TOV1	138
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:
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 $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.
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.
4. 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 ATmega164P/324P/644P 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.

4. Instruction Set Summary

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

5. Ordering Information

5.1 ATmega164P

Speed (MHz)[3]	Power Supply	Ordering Code	Package[1]	Operational Range
8-16	2.7 - 5.5V	ATmega164P-15AT[2] ATmega164P-15AT1[2] ATmega164P-15AZ[2]	ML	-40°C to +85°C -40°C to +105°C -40°C to +125°C
8-16	2.7 - 5.5V	ATmega164P-15MT[2] ATmega164P-15MT1[2] ATmega164P-15MZ[2]	PW	-40°C to +85°C -40°C to +105°C -40°C to +125°C

Notes: 1. Green and Rohs packaging
2. Tape & Reel with Dry-pack delivery
3. For Speed vs. V_{CC} see ”Speed Grades” on page 326

Package Type	
ML	44-lead, Thin (1.0 mm) Plastic Gull Wing Quad Flat Package (TQFP)
PW	44-pad, 7 x 7 x 1.0 mm body, lead pitch 0.50 mm, Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)

5.2 ATmega324P

Speed (MHz)[3]	Power Supply	Ordering Code	Package[1]	Operational Range
8-16	2.7 - 5.5V	ATmega324P-15AT[2] ATmega324P-15AT1[2] ATmega324P-15AZ[2]	ML	-40°C to +85°C -40°C to +105°C -40°C to +125°C
8-16	2.7 - 5.5V	ATmega324P-15MT[2] ATmega324P-15MT1[2] ATmega324P-15MZ[2]	PW	-40°C to +85°C -40°C to +105°C -40°C to +125°C

Notes: 1. Green and Rohs packaging
2. Tape & Reel with Dry-pack delivery
3. For Speed vs. V_{CC} see ”Speed Grades” on page 326

Package Type	
ML	44-lead, Thin (1.0 mm) Plastic Gull Wing Quad Flat Package (TQFP)
PW	44-pad, 7 x 7 x 1.0 mm body, lead pitch 0.50 mm, Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)

5.3 ATmega644P

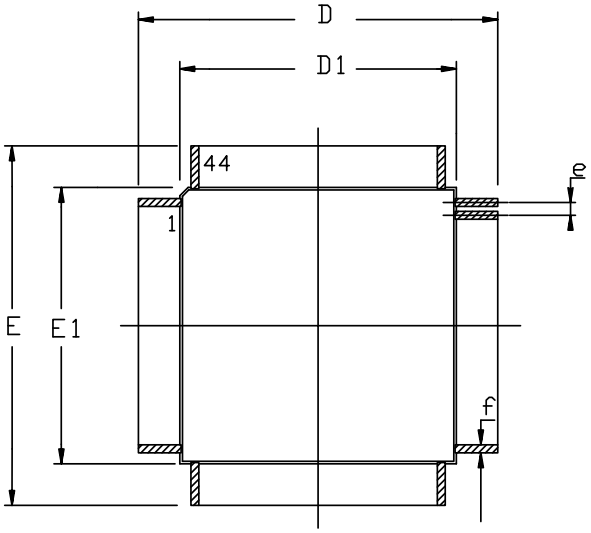
Speed (MHz)[3]	Power Supply	Ordering Code	Package[1]	Operational Range
8-16	2.7 - 5.5V	ATmega644P-15AT [2] ATmega644P-15AT1[2] ATmega644P-15AZ [2]	ML	-40°C to +85°C -40°C to +105°C -40°C to +125°C
8-16	2.7 - 5.5V	ATmega644P-15MT [2] ATmega644P-15MT1[2] ATmega644P-15MZ [2]	PW	-40°C to +85°C -40°C to +105°C -40°C to +125°C

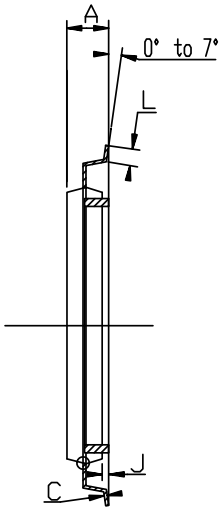
Notes: 1. Green and Rohs packaging
2. Tape & Reel with Dry-pack delivery
3. For Speed vs. V_{CC} see ”Speed Grades” on page 326.

Package Type	
ML	44-lead, Thin (1.0 mm) Plastic Gull Wing Quad Flat Package (TQFP)
PW	44-pad, 7 x 7 x 1.0 mm body, lead pitch 0.50 mm, Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)

6. Packaging Information

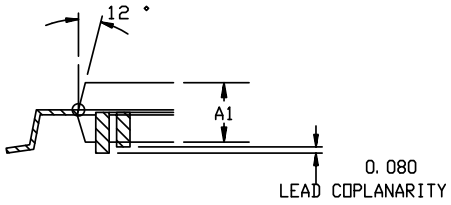
6.1 ML





COMMON DIMENSIONS IN MM

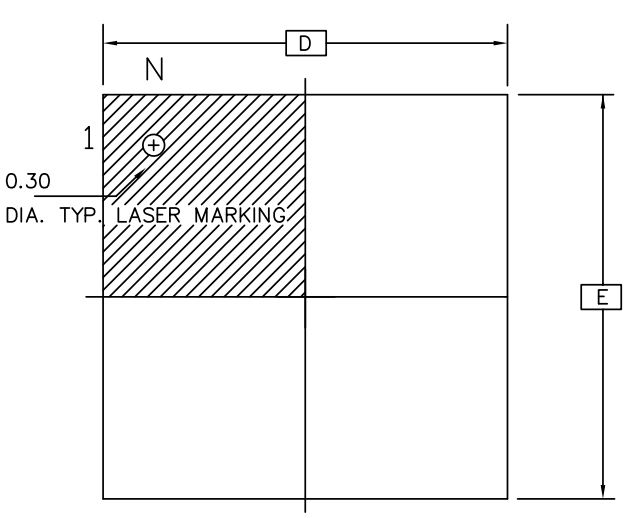
SYMBOL	Min	Max	NOTES
A	----	1.20	
A1	0.95	1.05	
C	0.09	0.20	
D	12.00 BSC		
D1	10.00 BSC		
E	12.00 BSC		
E1	10.00 BSC		
J	0.05	0.15	
L	0.45	0.75	
e	0.80 BSC		
f	0.30	0.45	

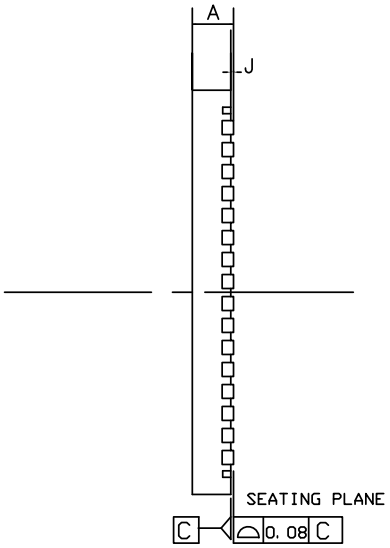


07/27/07

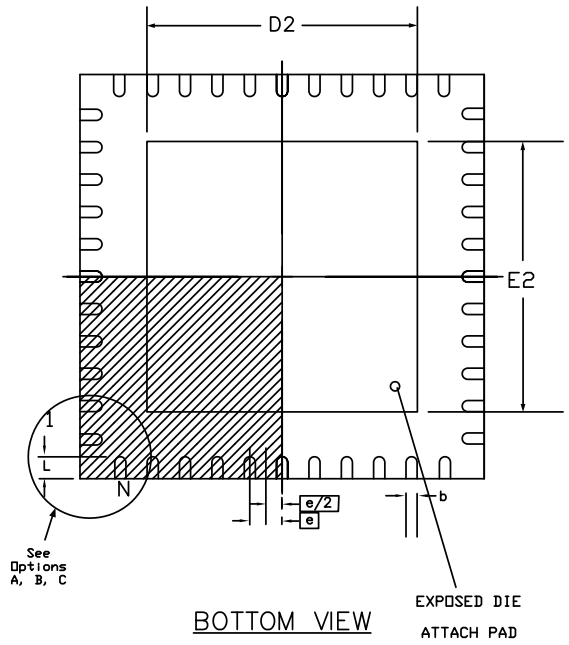
Atmel Nantes S.A. La Chantrerie - BP 70602 44306 Nantes Cedex 3 - France	TITLE ML, 44 - Lead, 10x10 mm Body Size, 1.0 mm Body Thickness 0.8 mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP)	DRAWING No. ML	REV. G

6.2 PW



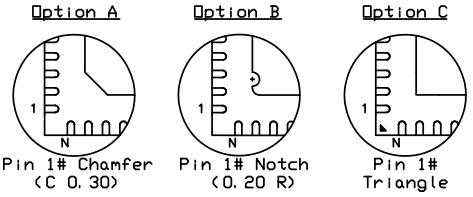


DRAWINGS NOT SCALED



COMMON DIMENSIONS IN MM

SYMBOL	MIN.	NOM.	MAX.	NOTES
A	0.80	----	1.00	
J	0.00	----	0.05	
D/E		7.00 BSC		
D2/E2	2.25	----	5.30	
N		44		
e		0.50 BSC		
L	0.35	0.55	0.75	
b	0.18	0.25	0.30	



Compliant JEDEC Standard MO-220 variation WKKD-1

07/26/07

	TITLE	DRAWING No.	REV.
Atmel Nantes S.A. La Chantrerie - BP 70602 44306 Nantes Cedex 3 - France	PW, 44 - Lead 7.0x7.0 mm Body, 0.50 mm Pitch Quad Flat No Lead Package (QFN)	PW	F

NOTES: QFN STANDARD NOTES

1. DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M. – 1994.

2. DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED
BETWEEN 0.15 AND 0.30 mm FROM TERMINAL TIP. IF THE TERMINAL HAS THE OPTIONAL RADIUS
ON THE OTHER END OF THE TERMINAL, THE DIMENSION b SHOULD NOT BE MEASURED
IN THAT RADIUS AREA.

3. MAX. PACKAGE WARPAGE IS 0.05mm.

4. MAXIMUM ALLOWABLE BURRS IS 0.076 mm IN ALL DIRECTIONS.

5. PIN #1 ID ON TOP WILL BE LASER MARKED.

6. THIS DRAWING CONFORMES TO JEDEC REGISTERED OUTLINE MO–220.

7. A MAXIMUM 0.15mm PULL BACK (L1) MAY BE PRESENT.
L MINUS L1 TO BE EQUAL TO OR GREATER THAN 0.30 mm

8. THE TERMINAL #1 IDENTIFIER ARE OPTIONAL BUT MUST BE LOCATED WITHIN THE ZONE INDICATEI
THE TERMINAL #1 IDENTIFIER BE EITHER A MOLD OR MARKED FEATURE

7. Errata

7.1 ATmega164P Rev. A

No known Errata.

7.2 ATmega324P Rev. A

No known Errata.

7.3 ATmega644P Rev. A

No known Errata.

8. 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.

8.1 Rev. 7674C -05/08

1. VIL reset pin update. Section 26.1 on page 325.
2. Updated EEPROM endurance. See ”Features” on page 1.

8.2 Rev. 7674B -01/08

1. Update to electrical characteristics after product characterization.

8.3 Rev. 7674A - 04/07

1. Initial Automotive revision
2. Insertion of specific § for automative quality references
3. DC and Frequency adapted to Automotive temperature range
4. Part numbering and package selection according to Automotive rules
5. Current Consumption adapted based on Industrial electrical characterization.

9. 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.

9.1 Rev. 7674D -08/08

1. Added ADC differential mode electrical characteristics for ATMega164 Table 26-10 on page 334.
2. Removed Ramp Z register.

9.2 Rev. 7674C -05/08

1. VIL reset pin update. Section 26.1 on page 325.
2. Updated EEPROM endurance. See ”Features” on page 1.

9.3 Rev. 7674B -01/08

1. Update to electrical characteristics after product characterization.

9.4 Rev. 7674A - 04/07

1. Initial Automotive revision
2. Insertion of specific § for automative quality references
3. DC and Frequency adapted to Automotive temperature range
4. Part numbering and package selection according to Automotive rules
5. Current Consumption adapted based on Industrial electrical characterization.

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