

## Features

- High-performance, Low-power AVR<sup>®</sup> 8-bit Microcontroller
- Advanced RISC Architecture
  - 130 Powerful Instructions – Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers + Peripheral Control Registers
  - Fully Static Operation
  - Up to 16 MIPS Throughput at 16 MHz
  - On-chip 2-cycle Multiplier
- Non-volatile Program and Data Memories
  - 64K Bytes of In-System Reprogrammable Flash
    - Endurance: 10,000 Write/Erase Cycles
  - Optional Boot Code Section with Independent Lock Bits
    - In-System Programming by On-chip Boot Program
    - True Read-While-Write Operation
  - 2K Bytes EEPROM
    - Endurance: 100,000 Write/Erase Cycles
  - 4K Bytes Internal SRAM
  - Up to 64K Bytes Optional External Memory Space
  - Programming Lock for Software Security
  - SPI Interface for In-System Programming
- JTAG (IEEE std. 1149.1 Compliant) Interface
  - Boundary-scan Capabilities According to the JTAG Standard
  - Extensive On-chip Debug Support
  - Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
  - Two Expanded 16-bit Timer/Counters with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Two 8-bit PWM Channels
  - 6 PWM Channels with Programmable Resolution from 1 to 16 Bits
  - 8-channel, 10-bit ADC
    - 8 Single-ended Channels
    - 7 Differential Channels
    - 2 Differential Channels with Programmable Gain (1x, 10x, 200x)
  - Byte-oriented Two-wire Serial Interface
  - Dual Programmable Serial USARTs
  - Master/Slave SPI Serial Interface
  - Programmable Watchdog Timer with 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
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby
  - Software Selectable Clock Frequency
  - ATmega103 Compatibility Mode Selected by a Fuse
  - Global Pull-up Disable
- I/O and Packages
  - 53 Programmable I/O Lines
  - 64-lead TQFP and 64-pad QFN/MLF
- Operating Voltages
  - 2.7 - 5.5V for ATmega64L
  - 4.5 - 5.5V for ATmega64
- Speed Grades
  - 0 - 8 MHz for ATmega64L
  - 0 - 16 MHz for ATmega64



**8-bit AVR<sup>®</sup>  
Microcontroller  
with 64K Bytes  
In-System  
Programmable  
Flash**

**ATmega64  
ATmega64L**

**Summary**

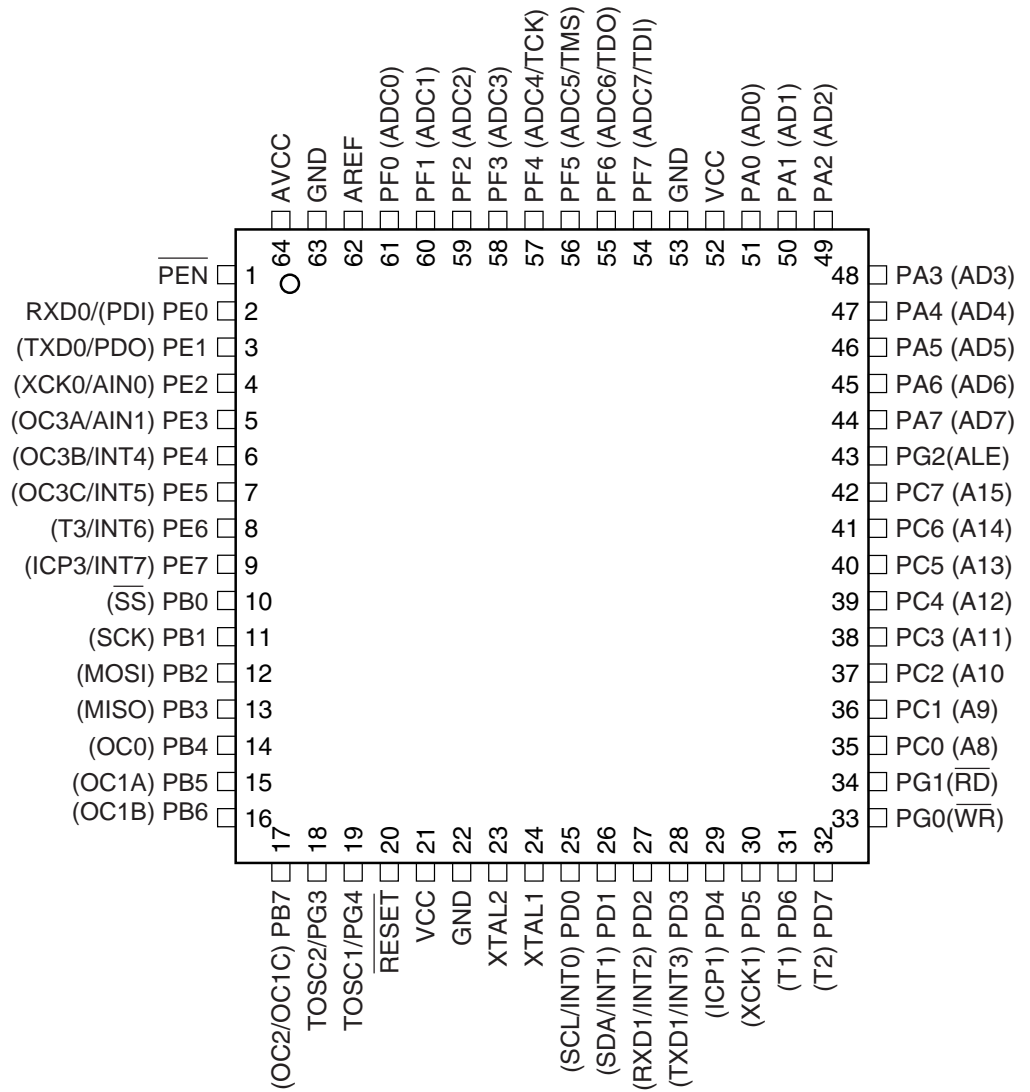


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## Pin Configuration

Figure 1. Pinout ATmega64

### TQFP/MLF



Note: The bottom pad under the QFN/MLF package should be soldered to ground.

## Disclaimer

Typical values contained in this data sheet 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.

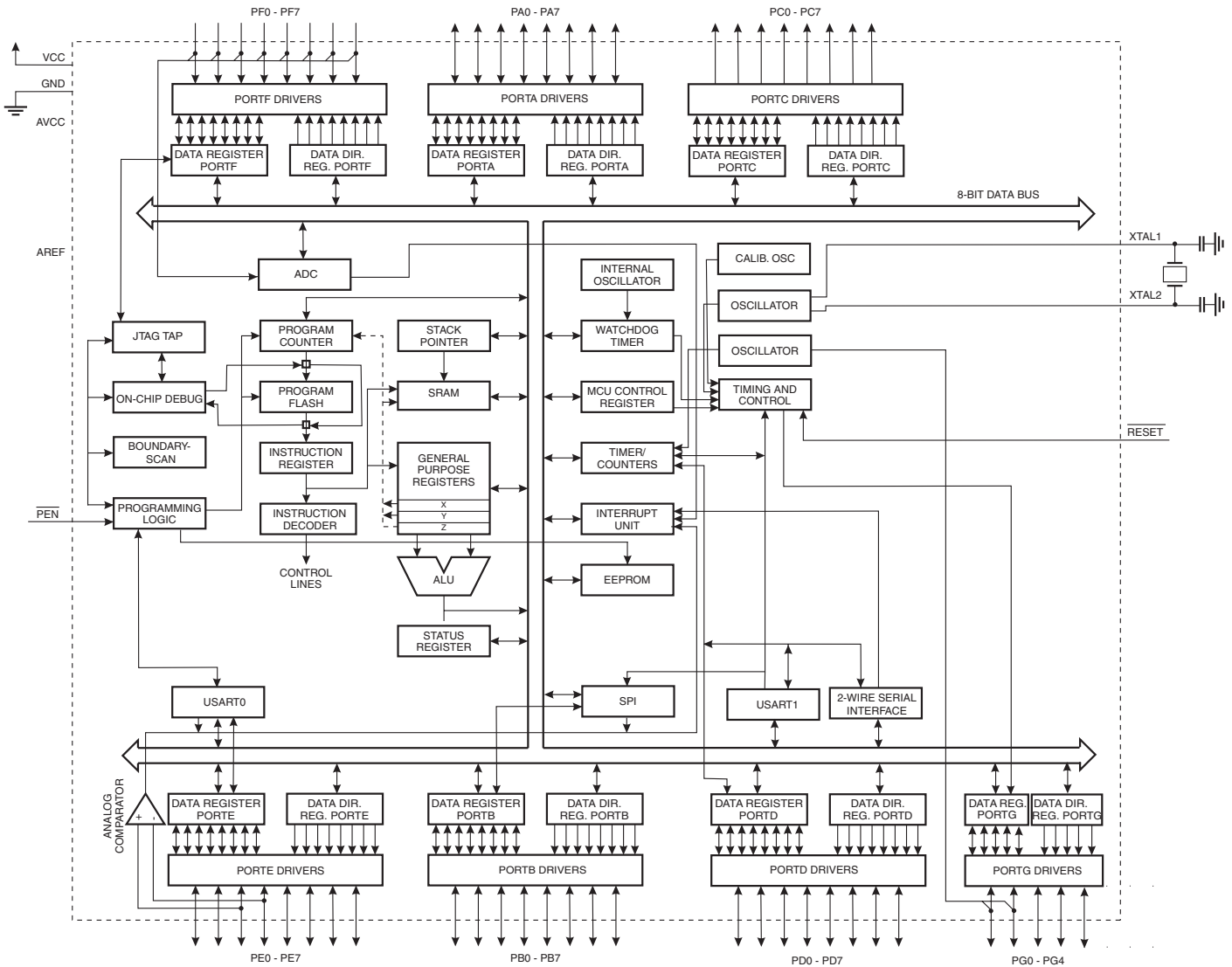
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## Overview

The ATmega64 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 ATmega64 achieves throughputs approaching 1 MIPS per MHz, allowing the system designer to optimize power consumption versus processing speed.

## Block Diagram

Figure 2. 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.



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The ATmega64 provides the following features: 64K bytes of In-System Programmable Flash with Read-While-Write capabilities, 2K bytes EEPROM, 4K bytes SRAM, 53 general purpose I/O lines, 32 general purpose working registers, Real Time Counter (RTC), four flexible Timer/Counters with compare modes and PWM, two USARTs, a byte oriented Two-wire Serial Interface, an 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 non-volatile memory technology. The On-chip ISP Flash allows the program memory to 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 ATmega64 is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications.

The ATmega64 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.

### **ATmega103 and ATmega64 Compatibility**

The ATmega64 is a highly complex microcontroller where the number of I/O locations supersedes the 64 I/O location reserved in the AVR instruction set. To ensure backward compatibility with the ATmega103, all I/O locations present in ATmega103 have the same location in ATmega64. Most additional I/O locations are added in an Extended I/O space starting from 0x60 to 0xFF (i.e., in the ATmega103 internal RAM space). These location can be reached by using LD/LDS/LDD and ST/STS/STD instructions only, not by using IN and OUT instructions. The relocation of the internal RAM space may still be a problem for ATmega103 users. Also, the increased number of Interrupt Vectors might be a problem if the code uses absolute addresses. To solve these problems, an ATmega103 compatibility mode can be selected by programming the fuse M103C. In this mode, none of the functions in the Extended I/O space are in use, so the internal RAM is located as in ATmega103. Also, the extended Interrupt Vectors are removed.

The ATmega64 is 100% pin compatible with ATmega103, and can replace the ATmega103 on current printed circuit boards. The application notes "Replacing ATmega103 by ATmega128" and "Migration between ATmega64 and ATmega128" describes what the user should be aware of replacing the ATmega103 by an ATmega128 or ATmega64.

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### ATmega103 Compatibility Mode

By programming the M103C Fuse, the ATmega64 will be compatible with the ATmega103 regards to RAM, I/O pins and Interrupt Vectors as described above. However, some new features in ATmega64 are not available in this compatibility mode, these features are listed below:

- One USART instead of two, asynchronous mode only. Only the eight least significant bits of the Baud Rate Register is available.
- One 16 bits Timer/Counter with two compare registers instead of two 16 bits Timer/Counters with three compare registers.
- Two-wire serial interface is not supported.
- Port G serves alternate functions only (not a general I/O port).
- Port F serves as digital input only in addition to analog input to the ADC.
- Boot Loader capabilities is not supported.
- It is not possible to adjust the frequency of the internal calibrated RC Oscillator.
- The External Memory Interface can not release any Address pins for general I/O, neither configure different wait states to different External Memory Address sections.
- Only EXTRF and PORF exist in the MCUCSR Register.
- No timed sequence is required for Watchdog Timeout change.
- Only low-level external interrupts can be used on four of the eight External Interrupt sources.
- Port C is output only.
- USART has no FIFO buffer, so Data OverRun comes earlier.
- The user must have set unused I/O bits to 0 in ATmega103 programs.

### Pin Descriptions

<b>VCC</b>	Digital supply voltage.
<b>GND</b>	Ground.
<b>Port A (PA7..PA0)</b>	<p>Port A is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port A pins that are externally pulled low will source current if the pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.</p> <p>Port A also serves the functions of various special features of the ATmega64 as listed on page 74.</p>
<b>Port B (PB7..PB0)</b>	<p>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.</p> <p>Port B also serves the functions of various special features of the ATmega64 as listed on page 75.</p>



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### Port C (PC7..PC0)

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

Port C also serves the functions of special features of the ATmega64 as listed on page 78. In ATmega103 compatibility mode, Port C is output only, and the port C pins are **not** tri-stated when a reset condition becomes active.

### 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 ATmega64 as listed on page 79.

### Port E (PE7..PE0)

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

Port E also serves the functions of various special features of the ATmega64 as listed on page 82.

### Port F (PF7..PF0)

Port F serves as the analog inputs to the A/D Converter.

Port F also serves as an 8-bit bi-directional I/O port, if the A/D Converter is not used. Port pins can provide internal pull-up resistors (selected for each bit). The Port F output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port F pins that are externally pulled low will source current if the pull-up resistors are activated. The Port F pins are tri-stated when a reset condition becomes active, even if the clock is not running. If the JTAG interface is enabled, the pull-up resistors on pins PF7(TDI), PF5(TMS) and PF4(TCK) will be activated even if a reset occurs.

The TDO pin is tri-stated unless TAP states that shift out data are entered.

Port F also serves the functions of the JTAG interface.

In ATmega103 compatibility mode, Port F is an input port only.

### Port G (PG4..PG0)

Port G is a 5-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port G output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port G pins that are externally pulled low will source current if the pull-up resistors are activated. The Port G pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port G also serves the functions of various special features.

In ATmega103 compatibility mode, these pins only serves as strobes signals to the external memory as well as input to the 32 kHz Oscillator, and the pins are initialized to PG0 = 1, PG1 = 1, and PG2 = 0 asynchronously when a reset condition becomes active, even if the clock is not running. PG3 and PG4 are Oscillator pins.

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<b>RESET</b>	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 19 on page 53. Shorter pulses are not guaranteed to generate a reset.
<b>XTAL1</b>	Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.
<b>XTAL2</b>	Output from the inverting Oscillator amplifier.
<b>AVCC</b>	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.
<b>AREF</b>	AREF is the analog reference pin for the A/D Converter.
<b>PEN</b>	This is a programming enable pin for the SPI Serial Programming mode. By holding this pin low during a Power-on Reset, the device will enter the SPI Serial Programming mode. $\overline{PEN}$ has no function during normal operation.

## Resources

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



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## Register Summary

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page	
(0xFF)	Reserved	–	–	–	–	–	–	–	–		
..	Reserved	–	–	–	–	–	–	–	–		
(0x9E)	Reserved	–	–	–	–	–	–	–	–		
(0x9D)	UCSR1C	–	UMSEL1	UPM11	UPM10	USBS1	UCSZ11	UCSZ10	UCPOL1	192	
(0x9C)	UDR1	USART1 I/O Data Register									189
(0x9B)	UCSR1A	RXC1	TXC1	UDRE1	FE1	DOR1	UPE1	U2X1	MPCM1	190	
(0x9A)	UCSR1B	RXCIE1	TXCIE1	UDRIE1	RXEN1	TXEN1	UCSZ12	RXB81	TXB81	191	
(0x99)	UBRR1L	USART1 Baud Rate Register Low									194
(0x98)	UBRR1H	–	–	–	–	USART1 Baud Rate Register High				194	
(0x97)	Reserved	–	–	–	–	–	–	–	–		
(0x96)	Reserved	–	–	–	–	–	–	–	–		
(0x95)	UCSR0C	–	UMSEL0	UPM01	UPM00	USBS0	UCSZ01	UCSZ00	UCPOL0	192	
(0x94)	Reserved	–	–	–	–	–	–	–	–		
(0x93)	Reserved	–	–	–	–	–	–	–	–		
(0x92)	Reserved	–	–	–	–	–	–	–	–		
(0x91)	Reserved	–	–	–	–	–	–	–	–		
(0x90)	UBRR0H	–	–	–	–	USART0 Baud Rate Register High				194	
(0x8F)	Reserved	–	–	–	–	–	–	–	–		
(0x8E)	ADCSRB	–	–	–	–	–	ADTS2	ADTS1	ADTS0	249	
(0x8D)	Reserved	–	–	–	–	–	–	–	–		
(0x8C)	TCCR3C	FOC3A	FOC3B	FOC3C	–	–	–	–	–	139	
(0x8B)	TCCR3A	COM3A1	COM3A0	COM3B1	COM3B0	COM3C1	COM3C0	WGM31	WGM30	134	
(0x8A)	TCCR3B	ICNC3	ICES3	–	WGM33	WGM32	CS32	CS31	CS30	137	
(0x89)	TCNT3H	Timer/Counter3 – Counter Register High Byte									139
(0x88)	TCNT3L	Timer/Counter3 – Counter Register Low Byte									139
(0x87)	OCR3AH	Timer/Counter3 – Output Compare Register A High Byte									140
(0x86)	OCR3AL	Timer/Counter3 – Output Compare Register A Low Byte									140
(0x85)	OCR3BH	Timer/Counter3 – Output Compare Register B High Byte									140
(0x84)	OCR3BL	Timer/Counter3 – Output Compare Register B Low Byte									140
(0x83)	OCR3CH	Timer/Counter3 – Output Compare Register C High Byte									140
(0x82)	OCR3CL	Timer/Counter3 – Output Compare Register C Low Byte									140
(0x81)	ICR3H	Timer/Counter3 – Input Capture Register High Byte									141
(0x80)	ICR3L	Timer/Counter3 – Input Capture Register Low Byte									141
(0x7F)	Reserved	–	–	–	–	–	–	–	–		
(0x7E)	Reserved	–	–	–	–	–	–	–	–		
(0x7D)	ETIMSK	–	–	TICIE3	OCIE3A	OCIE3B	TOIE3	OCIE3C	OCIE1C	142	
(0x7C)	ETIFR	–	–	ICF3	OCF3A	OCF3B	TOV3	OCF3C	OCF1C	143	
(0x7B)	Reserved	–	–	–	–	–	–	–	–		
(0x7A)	TCCR1C	FOC1A	FOC1B	FOC1C	–	–	–	–	–	138	
(0x79)	OCR1CH	Timer/Counter1 – Output Compare Register C High Byte									140
(0x78)	OCR1CL	Timer/Counter1 – Output Compare Register C Low Byte									140
(0x77)	Reserved	–	–	–	–	–	–	–	–		
(0x76)	Reserved	–	–	–	–	–	–	–	–		
(0x75)	Reserved	–	–	–	–	–	–	–	–		
(0x74)	TWCR	TWINT	TWEA	TWSTA	TWSTO	TWWC	TWEN	–	TWIE	207	
(0x73)	TWDR	Two-wire Serial Interface Data Register									209
(0x72)	TWAR	TWA6	TWA5	TWA4	TWA3	TWA2	TWA1	TWA0	TWGCE	209	
(0x71)	TWSR	TWS7	TWS6	TWS5	TWS4	TWS3	–	TWPS1	TWPS0	208	
(0x70)	TWBR	Two-wire Serial Interface Bit Rate Register									207
(0x6F)	OSCCAL	Oscillator Calibration Register									43
(0x6E)	Reserved	–	–	–	–	–	–	–	–		
(0x6D)	XMCRA	–	SRL2	SRL1	SRL0	SRW01	SRW00	SRW11	–	32	
(0x6C)	XMCRB	XMBK	–	–	–	–	XMM2	XMM1	XMM0	34	
(0x6B)	Reserved	–	–	–	–	–	–	–	–		
(0x6A)	EICRA	ISC31	ISC30	ISC21	ISC20	ISC11	ISC10	ISC01	ISC00	91	
(0x69)	Reserved	–	–	–	–	–	–	–	–		
(0x68)	SPMCSR	SPMIE	RWWSB	–	RWWSRE	BLBSET	PGWRT	PGERS	SPMEN	283	
(0x67)	Reserved	–	–	–	–	–	–	–	–		
(0x66)	Reserved	–	–	–	–	–	–	–	–		
(0x65)	PORTG	–	–	–	PORTG4	PORTG3	PORTG2	PORTG1	PORTG0	90	
(0x64)	DDRG	–	–	–	DDG4	DDG3	DDG2	DDG1	DDG0	90	
(0x63)	PING	–	–	–	PING4	PING3	PING2	PING1	PING0	90	
(0x62)	PORTF	PORTF7	PORTF6	PORTF5	PORTF4	PORTF3	PORTF2	PORTF1	PORTF0	89	
(0x61)	DDRF	DDF7	DDF6	DDF5	DDF4	DDF3	DDF2	DDF1	DDF0	90	



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## Register Summary (Continued)

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
(0x60)	Reserved	–	–	–	–	–	–	–	–	
0x3F (0x5F)	SREG	I	T	H	S	V	N	Z	C	12
0x3E (0x5E)	SPH	SP15	SP14	SP13	SP12	SP11	SP10	SP9	SP8	14
0x3D (0x5D)	SPL	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0	14
0x3C (0x5C)	XDIV	XDIVEN	XDIV6	XDIV5	XDIV4	XDIV3	XDIV2	XDIV1	XDIV0	39
0x3B (0x5B)	Reserved	–	–	–	–	–	–	–	–	
0x3A (0x5A)	EICRB	ISC71	ISC70	ISC61	ISC60	ISC51	ISC50	ISC41	ISC40	92
0x39 (0x59)	EIMSK	INT7	INT6	INT5	INT4	INT3	INT2	INT1	INT0	93
0x38 (0x58)	EIFR	INTF7	INTF6	INTF5	INTF4	INTF3	INTF	INTF1	INTF0	93
0x37 (0x57)	TIMSK	OCIE2	TOIE2	TICIE1	OCIE1A	OCIE1B	TOIE1	OCIE0	TOIE0	110, 141, 161
0x36 (0x56)	TIFR	OCF2	TOV2	ICF1	OCF1A	OCF1B	TOV1	OCF0	TOV0	110, 143, 161
0x35 (0x55)	MCUCR	SRE	SRW10	SE	SM1	SM0	SM2	IVSEL	IVCE	32, 47, 65
0x34 (0x54)	MCUCSR	JTD	–	–	JTRF	WDRF	BORF	EXTRF	PORF	56, 258
0x33 (0x53)	TCCR0	FOC0	WGM00	COM01	COM00	WGM01	CS02	CS01	CS00	105
0x32 (0x52)	TCNT0	Timer/Counter0 (8 Bit)								107
0x31 (0x51)	OCR0	Timer/Counter0 Output Compare Register								107
0x30 (0x50)	ASSR	–	–	–	–	AS0	TCN0UB	OCR0UB	TCR0UB	108
0x2F (0x4F)	TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	COM1C1	COM1C0	WGM11	WGM10	134
0x2E (0x4E)	TCCR1B	ICNC1	ICES1	–	WGM13	WGM12	CS12	CS11	CS10	137
0x2D (0x4D)	TCNT1H	Timer/Counter1 – Counter Register High Byte								139
0x2C (0x4C)	TCNT1L	Timer/Counter1 – Counter Register Low Byte								139
0x2B (0x4B)	OCR1AH	Timer/Counter1 – Output Compare Register A High Byte								140
0x2A (0x4A)	OCR1AL	Timer/Counter1 – Output Compare Register A Low Byte								140
0x29 (0x49)	OCR1BH	Timer/Counter1 – Output Compare Register B High Byte								140
0x28 (0x48)	OCR1BL	Timer/Counter1 – Output Compare Register B Low Byte								140
0x27 (0x47)	ICR1H	Timer/Counter1 – Input Capture Register High Byte								141
0x26 (0x46)	ICR1L	Timer/Counter1 – Input Capture Register Low Byte								141
0x25 (0x45)	TCCR2	FOC2	WGM20	COM21	COM20	WGM21	CS22	CS21	CS20	158
0x24 (0x44)	TCNT2	Timer/Counter2 (8 Bit)								160
0x23 (0x43)	OCR2	Timer/Counter2 Output Compare Register								161
0x22 (0x42)	OCDR	IDRD/ OCDR7	OCDR6	OCDR5	OCDR4	OCDR3	OCDR2	OCDR1	OCDR0	255
0x21 (0x41)	WDTCSR	–	–	–	WDCE	WDE	WDP2	WDP1	WDP0	58
0x20 (0x40)	SFIOR	TSM	–	–	–	ACME	PUD	PSR0	PSR321	73, 112, 146, 229
0x1F (0x3F)	EEARH	–	–	–	–	–	EEPROM Address Register High Byte			22
0x1E (0x3E)	EEARL	EEPROM Address Register Low Byte								22
0x1D (0x3D)	EEDR	EEPROM Data Register								22
0x1C (0x3C)	EECR	–	–	–	–	EERIE	EEMWE	EEWE	EERE	22
0x1B (0x3B)	PORTA	PORTA7	PORTA6	PORTA5	PORTA4	PORTA3	PORTA2	PORTA1	PORTA0	88
0x1A (0x3A)	DDRA	DDA7	DDA6	DDA5	DDA4	DDA3	DDA2	DDA1	DDA0	88
0x19 (0x39)	PINA	PINA7	PINA6	PINA5	PINA4	PINA3	PINA2	PINA1	PINA0	88
0x18 (0x38)	PORTB	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0	88
0x17 (0x37)	DDRB	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0	88
0x16 (0x36)	PINB	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0	88
0x15 (0x35)	PORTC	PORTC7	PORTC6	PORTC5	PORTC4	PORTC3	PORTC2	PORTC1	PORTC0	88
0x14 (0x34)	DDRC	DDC7	DDC6	DDC5	DDC4	DDC3	DDC2	DDC1	DDC0	88
0x13 (0x33)	PINC	PINC7	PINC6	PINC5	PINC4	PINC3	PINC2	PINC1	PINC0	89
0x12 (0x32)	PORTD	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0	89
0x11 (0x31)	DDRD	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0	89
0x10 (0x30)	PIND	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0	89
0x0F (0x2F)	SPDR	SPI Data Register								170
0x0E (0x2E)	SPSR	SPIF	WCOL	–	–	–	–	–	SPI2X	170
0x0D (0x2D)	SPCR	SPIE	SPE	DORD	MSTR	CPOL	CPHA	SPR1	SPR0	168
0x0C (0x2C)	UDR0	USART0 I/O Data Register								189
0x0B (0x2B)	UCSR0A	RXC0	TXC0	UDRE0	FE0	DOR0	UPE0	U2X0	MPCM0	190
0x0A (0x2A)	UCSR0B	RXCIE0	TXCIE0	UDRIE0	RXEN0	TXEN0	UCSZ02	RXB80	TXB80	191
0x09 (0x29)	UBRR0L	USART0 Baud Rate Register Low								194
0x08 (0x28)	ACSR	ACD	ACBG	ACO	ACI	ACIE	ACIC	ACIS1	ACIS0	230
0x07 (0x27)	ADMUX	REFS1	REFS0	ADLAR	MUX4	MUX3	MUX2	MUX1	MUX0	245
0x06 (0x26)	ADCSRA	ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0	247
0x05 (0x25)	ADCH	ADC Data Register High Byte								248
0x04 (0x24)	ADCL	ADC Data Register Low byte								248
0x03 (0x23)	PORTE	PORTE7	PORTE6	PORTE5	PORTE4	PORTE3	PORTE2	PORTE1	PORTE0	89
0x02 (0x22)	DDRE	DDE7	DDE6	DDE5	DDE4	DDE3	DDE2	DDE1	DDE0	89
0x01 (0x21)	PINE	PINE7	PINE6	PINE5	PINE4	PINE3	PINE2	PINE1	PINE0	89





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## Register Summary (Continued)

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
0x00 (0x20)	PINF	PINF7	PINF6	PINF5	PINF4	PINF3	PINF2	PINF1	PINF0	90

- 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. 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.

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## Instruction Set Summary

Mnemonics	Operands	Description	Operation	Flags	#Clocks
<b>ARITHMETIC AND LOGIC INSTRUCTIONS</b>					
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
<b>BRANCH INSTRUCTIONS</b>					
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
BRVC	k	Branch if Overflow Flag is Cleared	if $(V = 0)$ then $PC \leftarrow PC + k + 1$	None	1/2



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## 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
<b>DATA TRANSFER INSTRUCTIONS</b>					
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
<b>BIT AND BIT-TEST INSTRUCTIONS</b>					
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

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## Instruction Set Summary (Continued)

CLH		Clear Half Carry Flag in SREG	H ← 0	H	1
<b>MCU CONTROL INSTRUCTIONS</b>					
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



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## Ordering Information

Speed (MHz)	Power Supply	Ordering Code	Package <sup>(1)</sup>	Operation Range	
8	2.7 - 5.5	ATmega64L-8AC	64A	Commercial (0°C to 70°C)	
		ATmega64L-8MC	64M1		
		ATmega64L-8AI	64A	Industrial (-40°C to 85°C)	
		ATmega64L-8MI	64M1		
16	4.5 - 5.5	ATmega64L-8AU <sup>(2)</sup>	64A	Commercial (0°C to 70°C)	
		ATmega64L-8MU <sup>(2)</sup>	64M1		
		ATmega64-16AC	64A		Industrial (-40°C to 85°C)
		ATmega64-16MC	64M1		
16	4.5 - 5.5	ATmega64-16AI	64A	Industrial (-40°C to 85°C)	
		ATmega64-16MI	64M1		
		ATmega64-16AU <sup>(2)</sup>	64A		
		ATmega64-16MU <sup>(2)</sup>	64M1		

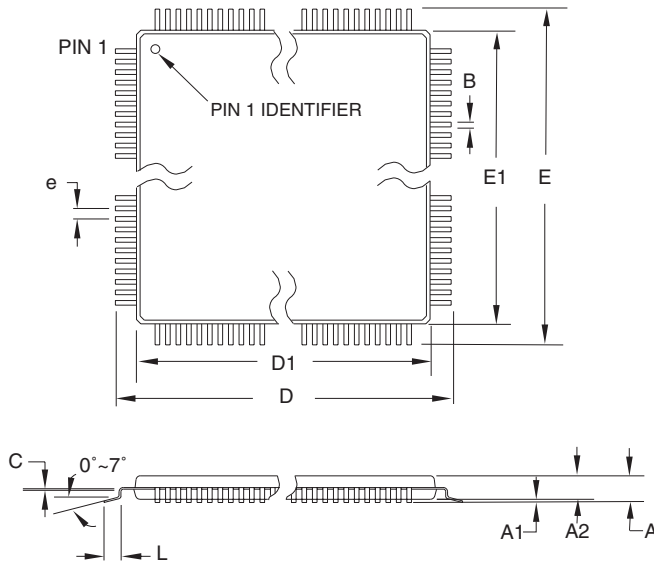
- Note:
1. This device can also be supplied in wafer form. Please contact your local Atmel sales office for detailed ordering information and minimum quantities.
  2. Pb-free packaging alternative, complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.

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

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## Packaging Information

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 0.25 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**

**64A**, 64-lead, 14 x 14 mm Body Size, 1.0 mm Body Thickness,  
0.8 mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP)

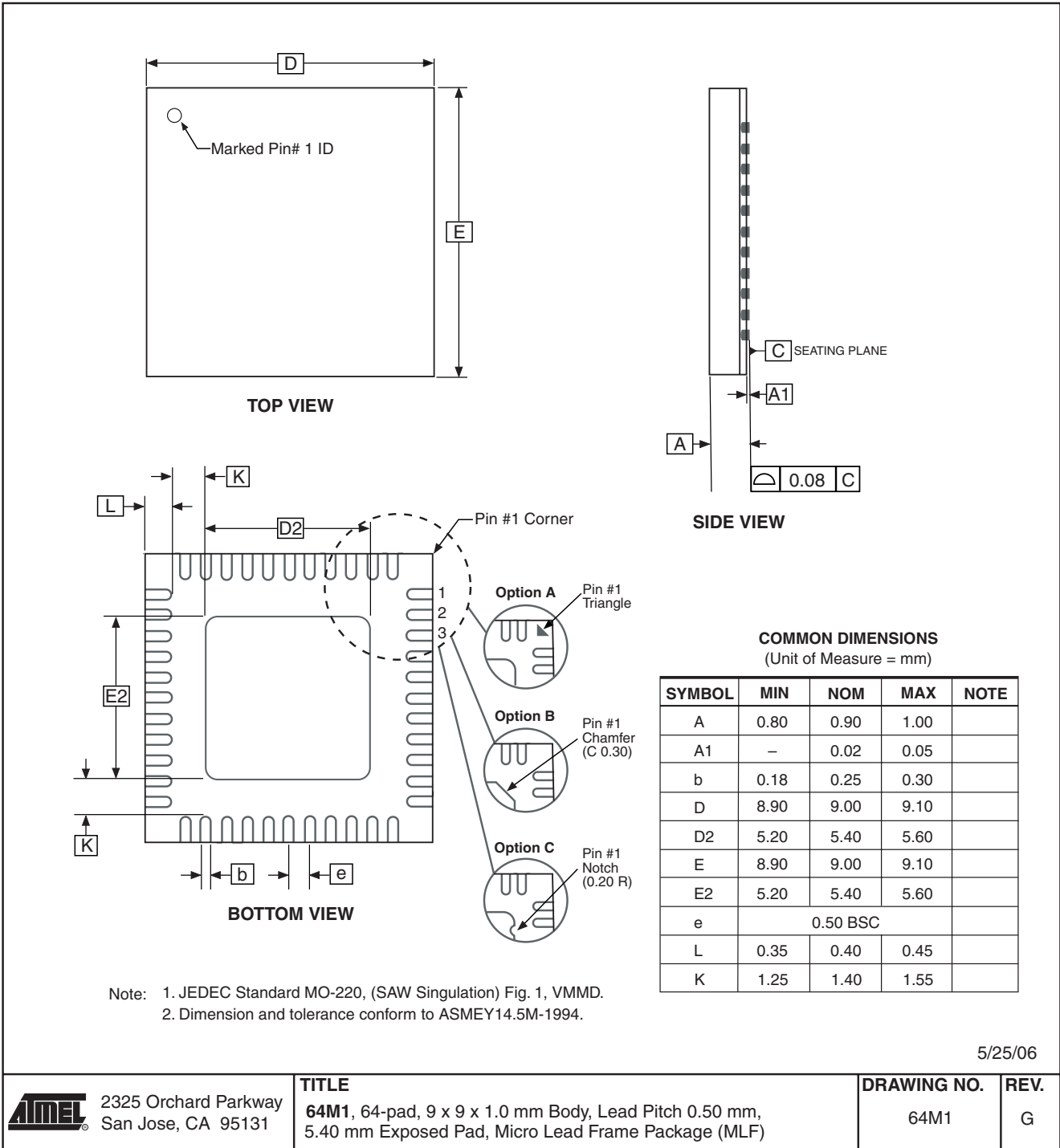
**DRAWING NO.**

64A

**REV.**

B







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## Errata

The revision letter in this section refers to the revision of the ATmega64 device.

### ATmega64, rev. A to C

- First Analog Comparator conversion may be delayed
- Interrupts may be lost when writing the timer registers in the asynchronous timer
- Stabilizing time needed when changing XDIV Register
- Stabilizing time needed when changing OSCCAL Register
- IDCODE masks data from TDI input

#### 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. Stabilizing time needed when changing XDIV Register

After increasing the source clock frequency more than 2% with settings in the XDIV register, the device may execute some of the subsequent instructions incorrectly.

##### Problem Fix / Workaround

The NOP instruction will always be executed correctly also right after a frequency change. Thus, the next 8 instructions after the change should be NOP instructions. To ensure this, follow this procedure:

1. Clear the I bit in the SREG Register.
2. Set the new pre-scaling factor in XDIV register.
3. Execute 8 NOP instructions
4. Set the I bit in SREG

This will ensure that all subsequent instructions will execute correctly.

##### Assembly Code Example:

```

CLI                ; clear global interrupt enable
OUT  XDIV, temp    ; set new prescale value
NOP                ; no operation
NOP                ; no operation
NOP                ; no operation
NOP                ; no operation
NOP                ; no operation
NOP                ; no operation
NOP                ; no operation
NOP                ; no operation
NOP                ; no operation
NOP                ; no operation
SEI                ; clear global interrupt enable
    
```



**4. Stabilizing time needed when changing OSCCAL Register**

After increasing the source clock frequency more than 2% with settings in the OSCCAL register, the device may execute some of the subsequent instructions incorrectly.

**Problem Fix / Workaround**

The behavior follows errata number 1., and the same Fix / Workaround is applicable on this errata.

**5. IDCODE masks data from TDI input**

The JTAG instruction IDCODE is not working correctly. Data to succeeding devices are replaced by all-ones during Update-DR.

**Problem Fix / Workaround**

- If ATmega64 is the only device in the scan chain, the problem is not visible.
- Select the Device ID Register of the ATmega64 by issuing the IDCODE instruction or by entering the Test-Logic-Reset state of the TAP controller to read out the contents of its Device ID Register and possibly data from succeeding devices of the scan chain. Issue the BYPASS instruction to the ATmega64 while reading the Device ID Registers of preceding devices of the boundary scan chain.
- If the Device IDs of all devices in the boundary scan chain must be captured simultaneously, the ATmega64 must be the first device in the chain.

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## 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. 2490K-04/06 to Rev. 2490L-10/06

1. Added note to “Timer/Counter Oscillator” on page 45.
2. Updated “Fast PWM Mode” on page 125.
3. Updated Table 52 on page 104, Table 54 on page 105, Table 59 on page 134, Table 61 on page 136, Table 64 on page 158, and Table 66 on page 158.
4. Updated “Errata” on page 381.

### Changes from Rev. 2490J-03/05 to Rev. 2490K-04/06

1. Updated Figure 2 on page 3.
2. Added “Resources” on page 7.
3. Added Addresses in Register Descriptions.
4. Updated “SPI – Serial Peripheral Interface” on page 164.
5. Updated Register- and bit names in “USART” on page 172.
6. Updated note in “Bit Rate Generator Unit” on page 205.
7. Updated Features in “Analog to Digital Converter” on page 232.

### Changes from Rev. 2490I-10/04 to Rev. 2490J-03/05

1. MLF-package alternative changed to “Quad Flat No-Lead/Micro Lead Frame Package QFN/MLF”.
2. Updated “Electrical Characteristics” on page 328
3. Updated “Ordering Information” on page 14

### Changes from Rev. 2490H-10/04 to Rev. 2490I-11/04

1. Removed “Preliminary” and TBD’s.
2. Updated Table 8 on page 40, Table 11 on page 42, Table 19 on page 53, Table 132 on page 330, Table 134 on page 333.
3. Updated features in “Analog to Digital Converter” on page 232.
4. Updated “Electrical Characteristics” on page 328.

### Changes from Rev. 2490G-03/04 to Rev. 2490H-10/04

1. Removed references to Analog Ground, IC1/IC3 changed to ICP1/ICP3, Input Capture Trigger changed to Input Capture Pin.
2. Updated “ATmega103 and ATmega64 Compatibility” on page 4.
3. Updated “External Memory Interface” on page 27
4. Updated “XDIV – XTAL Divide Control Register” to “Clock Sources” on page 38.

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5. Updated code example in “WDTCR – Watchdog Timer Control Register” on page 58.
6. Added section “Unconnected Pins” on page 72.
7. Updated Table 19 on page 53, Table 20 on page 57, Table 95 on page 238, and Table 60 on page 136.
8. Updated Figure 116 on page 241.
9. Updated “Version” on page 257.
10. Updated “DC Characteristics” on page 328.
11. Updated “Typical Characteristics” on page 343.
12. Updated features in “Analog to Digital Converter” on page 232 and Table 136 on page 336.
13. Updated “Ordering Information” on page 14.

**Changes from Rev.  
2490F-12/03 to Rev.  
2490G-03/04**

1. Updated “Errata” on page 17.

**Changes from Rev.  
2490E-09/03 to Rev.  
2490F-12/03**

1. Updated “Calibrated Internal RC Oscillator” on page 43.

**Changes from Rev.  
2490D-02/03 to Rev.  
2490E-09/03**

1. Updated note in “XDIV – XTAL Divide Control Register” on page 39.
2. Updated “JTAG Interface and On-chip Debug System” on page 51.
3. Updated “TAP – Test Access Port” on page 250 regarding JTAGEN.
4. Updated description for the JTD bit on page 260.
5. Added a note regarding JTAGEN fuse to Table 118 on page 294.
6. Updated  $R_{PU}$  values in “DC Characteristics” on page 328.
7. Updated “ADC Characteristics” on page 335.
8. Added a proposal for solving problems regarding the JTAG instruction IDCODE in “Errata” on page 17.

**Changes from Rev.  
2490C-09/02 to Rev.  
2490D-02/03**

1. Added reference to Table 124 on page 298 from both SPI Serial Programming and Self Programming to inform about the Flash page size.
2. Added Chip Erase as a first step under “Programming the Flash” on page 325 and “Programming the EEPROM” on page 326.

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3. Corrected OCn waveforms in Figure 52 on page 127.
4. Various minor Timer1 corrections.
5. Improved the description in “Phase Correct PWM Mode” on page 102 and on page 155.
6. Various minor TWI corrections.
7. Added note under "Filling the Temporary Buffer (Page Loading)" about writing to the EEPROM during an SPM page load.
8. Removed ADHSM completely.
9. Added note about masking out unused bits when reading the Program Counter in “Stack Pointer” on page 14.
10. Added section “EEPROM Write During Power-down Sleep Mode” on page 25.
11. Changed  $V_{HYST}$  value to 120 in Table 19 on page 53.
12. Added information about conversion time for Differential mode with Auto Triggering on page 236.
13. Added  $t_{WD\_FUSE}$  in Table 128 on page 311.
14. Updated “Packaging Information” on page 15.

### Changes from Rev. 2490B-09/02 to Rev. 2490C-09/02

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

### Changes from Rev. 2490A-10/01 to Rev. 2490B-09/02

1. Added 64-pad QFN/MLF Package and updated “Ordering Information” on page 14.
2. Added the section “Using all Locations of External Memory Smaller than 64 KB” on page 35.
3. Added the section “Default Clock Source” on page 39.
4. Renamed SPMCR to SPMCSR in entire document.
5. **Added Some Preliminary Test Limits and Characterization Data**  
Removed some of the TBD's and corrected data in the following tables and pages:  
Table 2 on page 24, Table 7 on page 38, Table 9 on page 41, Table 10 on page 41, Table 12 on page 42, Table 14 on page 43, Table 16 on page 44, Table 19 on page 53, Table 20 on page 57, Table 22 on page 59, “DC Characteristics” on page 328, Table 131 on page 330, Table 134 on page 333, Table 136 on page 336, and Table 137 - Table 144.
6. **Removed Alternative Algorithm for Leaving JTAG Programming Mode.**  
See “Leaving Programming Mode” on page 324.

7. **Improved description on how to do a polarity check of the ADC diff results in “ADC Conversion Result” on page 244.**
8. **Updated Programming Figures:**  
Figure 138 on page 296 and Figure 147 on page 309 are updated to also reflect that AVCC must be connected during Programming mode. Figure 142 on page 305 added to illustrate how to program the fuses.
9. **Added a note regarding usage of the “PROG\_PAGELOAD (0x6)” and “PROG\_PAGEREAD (0x7)” instructions on page 316.**
10. **Updated “TWI – Two-wire Serial Interface” on page 199.**  
More details regarding use of the TWI Power-down operation and using the TWI as master with low TWBRR values are added into the data sheet. Added the note at the end of the “Bit Rate Generator Unit” on page 205. Added the description at the end of “Address Match Unit” on page 206.
11. **Updated Description of OSCCAL Calibration Byte.**  
In the data sheet, 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 “OSCCAL – Oscillator Calibration Register<sup>(1)</sup>” on page 43 and “Calibration Byte” on page 295.
12. **When using external clock there are some limitations regards to change of frequency. This is descried in “External Clock” on page 44 and Table 131 on page 330.**
13. **Added a sub section regarding OCD-system and power consumption in the section “Minimizing Power Consumption” on page 50.**
14. **Corrected typo (WGM-bit setting) for:**
  - “Fast PWM Mode” on page 100 (Timer/Counter0).
  - “Phase Correct PWM Mode” on page 102 (Timer/Counter0).
  - “Fast PWM Mode” on page 153 (Timer/Counter2).
  - “Phase Correct PWM Mode” on page 155 (Timer/Counter2).
15. **Corrected Table 81 on page 193 (USART).**
16. **Corrected Table 102 on page 264 (Boundary-Scan)**



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