

Features

- Utilizes the AVR[®] RISC Architecture
- AVR – High-performance and Low-power RISC Architecture
 - 121 Powerful Instructions – Most Single Clock Cycle Execution
 - 32 x 8 General-purpose Working Registers + Peripheral Control Registers
 - Up to 6 MIPS Throughput at 6 MHz
- Data and Nonvolatile Program Memory
 - 128K Bytes of In-System Programmable Flash
 - Endurance: 1,000 Write/Erase Cycles
 - 4K Bytes Internal SRAM
 - 4K Bytes of In-System Programmable EEPROM
 - Endurance: 100,000 Write/Erase Cycles
 - Programming Lock for Flash Program and EEPROM Data Security
 - SPI Interface for In-System Programming
- Peripheral Features
 - On-chip Analog Comparator
 - Programmable Watchdog Timer with On-chip Oscillator
 - Programmable Serial UART
 - Master/Slave SPI Serial Interface
 - Real-time Counter (RTC) with Separate Oscillator
 - Two 8-bit Timer/Counters with Separate Prescaler and PWM
 - Expanded 16-bit Timer/Counter System with Separate Prescaler, Compare, Capture Modes and Dual 8-, 9-, or 10-bit PWM
 - Programmable Watchdog Timer with On-chip Oscillator
 - 8-channel, 10-bit ADC
- Special Microcontroller Features
 - Low-power Idle, Power-save and Power-down Modes
 - Software Selectable Clock Frequency
 - External and Internal Interrupt Sources
- Specifications
 - Low-power, High-speed CMOS Process Technology
 - Fully Static Operation
- Power Consumption at 4 MHz, 3V, 25°C
 - Active: 5.5 mA
 - Idle Mode: 1.6 mA
 - Power-down Mode: < 1 µA
- I/O and Packages
 - 32 Programmable I/O Lines, 8 Output Lines, 8 Input Lines
 - 64-lead TQFP
- Operating Voltages
 - 2.7 - 3.6V for ATmega103L
 - 4.0 - 5.5V for ATmega103
- Speed Grades
 - 0 - 4 MHz for ATmega103L
 - 0 - 6 MHz for ATmega103



8-bit AVR[®] Microcontroller with 128K Bytes In-System Programmable Flash

ATmega103(L)

Summary

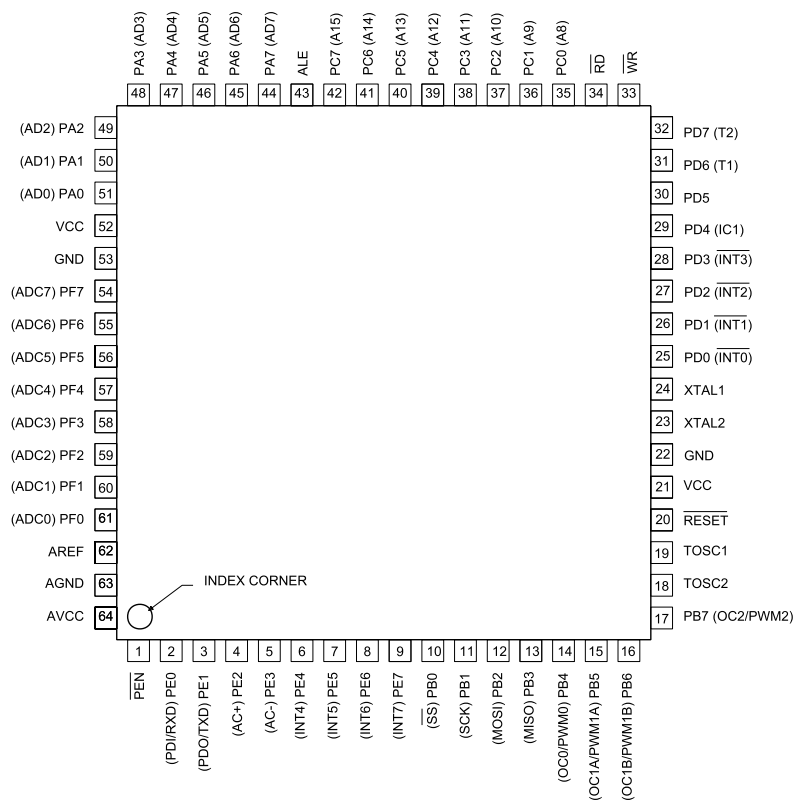
Rev. 0945GS–09/01



Note: This is a summary document. A complete document is available on our web site at www.atmel.com.

Pin Configuration

TQFP



Description

The ATmega103(L) is a low-power, CMOS, 8-bit microcontroller based on the AVR RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega103(L) achieves throughputs approaching 1 MIPS per MHz, allowing the system designer to optimize power consumption versus processing speed.

The AVR core is based on an enhanced RISC architecture that 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.

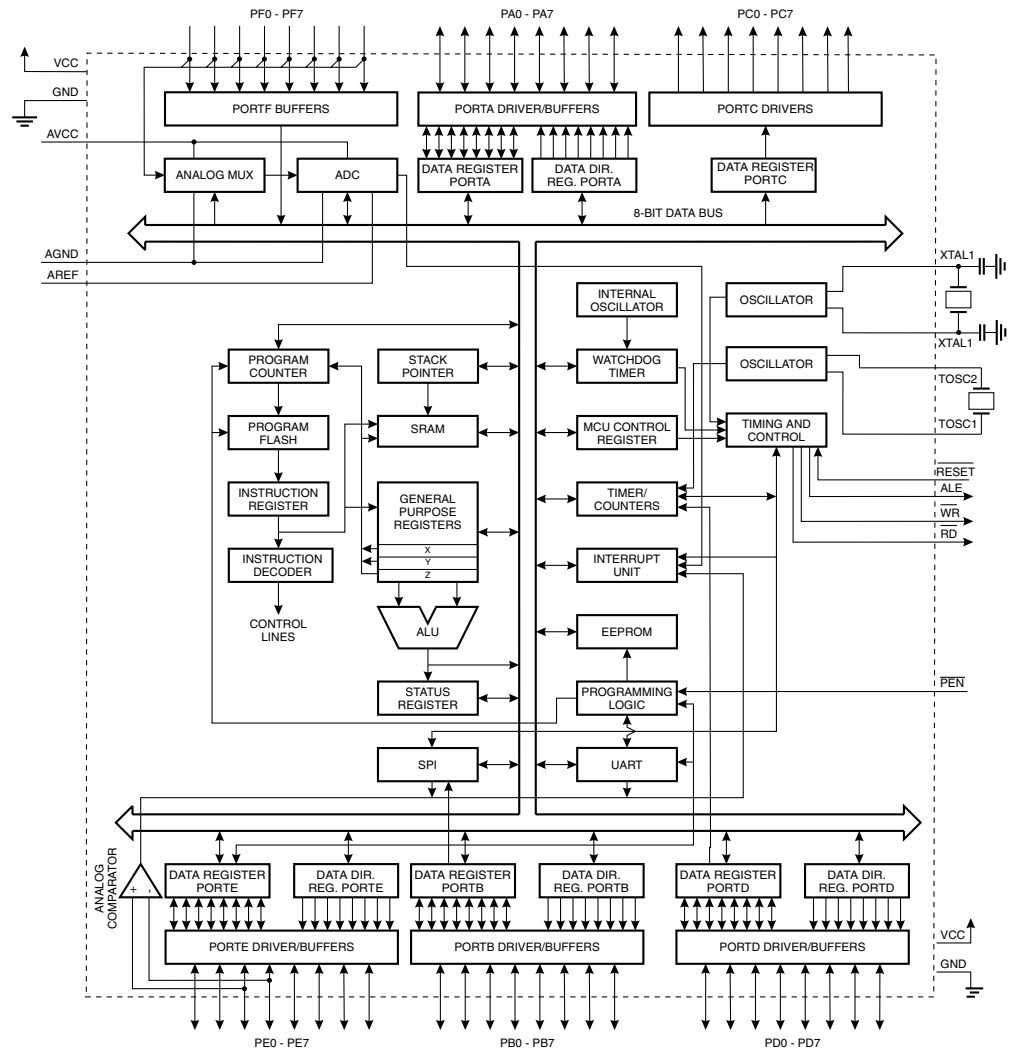
The ATmega103(L) provides the following features: 128K bytes of In-System Programmable Flash, 4K bytes EEPROM, 4K bytes SRAM, 32 general-purpose I/O lines, 8 input lines, 8 output lines, 32 general-purpose working registers, real-time counter (RTC), 4 flexible timer/counters with compare modes and PWM, UART, programmable watchdog timer with internal oscillator, an SPI serial port and 3 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 timer oscillator continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping.

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 a serial interface or by a conventional nonvolatile memory programmer. By combining an 8-bit RISC CPU with a large array of ISP Flash on a monolithic chip, the Atmel ATmega103(L) is a powerful microcontroller that provides a highly flexible and cost-effective solution to many embedded control applications.

The ATmega103(L) 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.

Block Diagram

Figure 1. The ATmega103(L) Block Diagram



Pin Descriptions

VCC	Supply voltage.
GND	Ground.
Port A (PA7..PA0)	<p>Port A is an 8-bit bi-directional I/O port. Port pins can provide internal pull-up resistors (selected for each bit). The Port A output buffers can sink 20 mA and can drive LED displays directly. When pins PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated.</p> <p>Port A serves as Multiplexed Address/Data bus when using external SRAM.</p> <p>The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.</p>
Port B (PB7..PB0)	<p>Port B is an 8-bit bi-directional I/O port with internal pull-up resistors. The Port B output buffers can sink 20 mA. As inputs, Port B pins that are externally pulled low, will source current if the pull-up resistors are activated.</p> <p>Port B also serves the functions of various special features.</p> <p>The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.</p>
Port C (PC7..PC0)	<p>Port C is an 8-bit output port. The Port C output buffers can sink 20 mA.</p> <p>Port C also serves as Address output when using external SRAM.</p> <p>Since Port C is an output only port, the Port C pins are <i>not</i> tri-stated when a reset condition becomes active.</p>
Port D (PD7..PD0)	<p>Port D is an 8-bit bi-directional I/O port with internal pull-up resistors. The Port D output buffers can sink 20 mA. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated.</p> <p>Port D also serves the functions of various special features.</p> <p>The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.</p>
Port E (PE7..PE0)	<p>Port E is an 8-bit bi-directional I/O port with internal pull-up resistors. The Port E output buffers can sink 20 mA. As inputs, Port E pins that are externally pulled low will source current if the pull-up resistors are activated.</p> <p>Port E also serves the functions of various special features.</p> <p>The Port E pins are tri-stated when a reset condition becomes active, even if the clock is not running.</p>
Port F (PF7..PF0)	Port F is an 8-bit input port. Port F also serves as the analog inputs for the ADC.
$\overline{\text{RESET}}$	Reset input. An external reset is generated by a low level on the $\overline{\text{RESET}}$ pin. Reset pulses longer than 50 ns will generate a reset, even if the clock is not running. Shorter pulses are not guaranteed to generate a reset.
XTAL1	Input to the inverting oscillator amplifier and input to the internal clock operating circuit.
XTAL2	Output from the inverting oscillator amplifier.



TOSC1	Input to the inverting Timer/Counter oscillator amplifier.
TOSC2	Output from the inverting Timer/Counter oscillator amplifier.
$\overline{\text{WR}}$	External SRAM write strobe
$\overline{\text{RD}}$	External SRAM read strobe
ALE	ALE is the Address Latch Enable used when the External Memory is enabled. The ALE strobe is used to latch the low-order address (8 bits) into an address latch during the first access cycle, and the AD0-7 pins are used for data during the second access cycle.
AVCC	Supply voltage for Port F, including ADC. The pin must be connected to VCC when not used for the ADC. See "ADC Noise Canceling Techniques" on page 74 for details when using the ADC.
AREF	AREF is the analog reference input for the ADC converter. For ADC operations, a voltage in the range AGND to AVCC must be applied to this pin.
AGND	If the board has a separate analog ground plane, this pin should be connected to this ground plane. Otherwise, connect to GND.
$\overline{\text{PEN}}$	PEN is a programming enable pin for the serial programming mode. By holding this pin low during a power-on reset, the device will enter the serial programming mode. $\overline{\text{PEN}}$ has no function during normal operation.

Register Summary

Address	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	Page
\$3F (\$5F)	SREG	I	T	H	S	V	N	Z	C	page 19
\$3E (\$5E)	SPH	SP15	SP14	SP13	SP12	SP11	SP10	SP9	SP8	page 20
\$3D (\$5D)	SPL	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0	page 20
\$3C (\$5C)	XDIV	XDIVEN	XDIV6	XDIV5	XDIV4	XDIV3	XDIV2	XDIV1	XDIV0	page 22
\$3B (\$5B)	RAMPZ	—	—	—	—	—	—	—	RAMPZ0	page 20
\$3A (\$5A)	EICR	ISC71	ISC70	ISC61	ISC60	ISC51	ISC50	ISC41	ISC40	page 29
\$39 (\$59)	EIMSK	INT7	INT6	INT5	INT4	INT3	INT2	INT1	INT0	page 28
\$38 (\$58)	EIFR	INTF7	INTF6	INTF5	INTF4	—	—	—	—	page 29
\$37 (\$57)	TIMSK	OCIE2	TOIE2	TICIE1	OCIE1A	OCIE1B	TOIE1	OCIE0	TOIE0	page 30
\$36 (\$56)	TIFR	OCF2	TOV2	ICF1	OCF1A	OCF1B	TOV1	OCF0	TOV0	page 31
\$35 (\$55)	MCUCR	SRE	SRW	SE	SM1	SM0	—	—	—	page 21
\$34 (\$54)	MCUSR	—	—	—	—	—	—	EXTRF	PORF	page 27
\$33 (\$53)	TCCR0	—	PWM0	COM01	COM00	CTC0	CS02	CS01	CS00	page 37
\$32 (\$52)	TCNT0	Timer/Counter0 (8-bit)								page 38
\$31 (\$51)	OCR0	Timer/Counter0 Output Compare Register								page 39
\$30 (\$50)	ASSR	—	—	—	—	AS0	TCN0UB	OCR0UB	TCR0UB	page 40
\$2F (\$4F)	TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	—	—	PWM11	PWM10	page 45
\$2E (\$4E)	TCCR1B	ICNC1	ICES1	—	—	CTC1	CS12	CS11	CS10	page 46
\$2D (\$4D)	TCNT1H	Timer/Counter1 – Counter Register High Byte								page 47
\$2C (\$4C)	TCNT1L	Timer/Counter1 – Counter Register Low Byte								page 47
\$2B (\$4B)	OCR1AH	Timer/Counter1 – Output Compare Register A High Byte								page 47
\$2A (\$4A)	OCR1AL	Timer/Counter1 – Output Compare Register A Low Byte								page 47
\$29 (\$49)	OCR1BH	Timer/Counter1 – Output Compare Register B High Byte								page 48
\$28 (\$48)	OCR1BL	Timer/Counter1 – Output Compare Register B Low Byte								page 48
\$27 (\$47)	ICR1H	Timer/Counter1 – Input Capture Register High Byte								page 48
\$26 (\$46)	ICR1L	Timer/Counter1 – Input Capture Register Low Byte								page 48
\$25 (\$45)	TCCR2	—	PWM2	COM21	COM20	CTC2	CS22	CS21	CS20	page 37
\$24 (\$44)	TCNT2	Timer/Counter2 (8-bit)								page 38
\$23 (\$43)	OCR2	Timer/Counter2 Output Compare Register								page 39
\$21 (\$47)	WDTCSR	—	—	—	WDTOE	WDE	WDP2	WDP1	WDP0	page 51
\$1F (\$3F)	EEARH	—	—	—	—	EEAR11	EEAR10	EEAR9	EEAR8	page 53
\$1E (\$3E)	EEARL	EEPROM Address Register L								page 53
\$1D (\$3D)	EEDR	EEPROM Data Register								page 53
\$1C (\$3C)	EEDR	—	—	—	—	EEERIE	EEMWE	EEWE	EEERIE	page 53
\$1B (\$3B)	PORTA	PORTA7	PORTA6	PORTA5	PORTA4	PORTA3	PORTA2	PORTA1	PORTA0	page 79
\$1A (\$3A)	DDRA	DDA7	DDA6	DDA5	DDA4	DDA3	DDA2	DDA1	DDA0	page 79
\$19 (\$39)	PINA	PINA7	PINA6	PINA5	PINA4	PINA3	PINA2	PINA1	PINA0	page 79
\$18 (\$38)	PORTB	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0	page 81
\$17 (\$37)	DDRB	ddb7	ddb6	ddb5	ddb4	ddb3	ddb2	ddb1	ddb0	page 81
\$16 (\$36)	PINB	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0	page 81
\$15 (\$35)	PORTC	PORTC7	PORTC6	PORTC5	PORTC4	PORTC3	PORTC2	PORTC1	PORTC0	page 87
\$12 (\$32)	PORTD	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0	page 88
\$11 (\$31)	DDRD	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0	page 88
\$10 (\$30)	PIND	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0	page 88
\$0F (\$2F)	SPDR	SPI Data Register								page 60
\$0E (\$2E)	SPSR	SPIF	WCOL	—	—	—	—	—	—	page 59
\$0D (\$2D)	SPCR	SPIE	SPE	DORD	MSTR	CPOL	CPHA	SPR1	SPR0	page 58
\$0C (\$2C)	UDR	UART I/O Data Register								page 64
\$0B (\$2B)	USR	RXC	TXC	UDRE	FE	OR	—	—	—	page 64
\$0A (\$2A)	UCR	RXCIE	TXCIE	UDRIE	RXEN	TXEN	CHR9	RXB8	TXB8	page 65
\$09 (\$29)	UBRR	UART Baud Rate Register								page 67
\$08 (\$28)	ACSR	ACD	—	ACO	ACI	ACIE	ACIC	ACIS1	ACIS0	page 68
\$07 (\$27)	ADMUX	—	—	—	—	—	MUX2	MUX1	MUX0	page 73
\$06 (\$26)	ADCSR	ADEN	ADSC	—	ADIF	ADIE	ADPS2	ADPS1	ADPS0	page 73
\$05 (\$25)	ADCH	—	—	—	—	—	—	ADC9	ADC8	page 74
\$04 (\$24)	ADCL	ADC7	ADC6	ADC5	ADC4	ADC3	ADC2	ADC1	ADC0	page 74
\$03 (\$23)	PORTE	PORTE7	PORTE6	PORTE5	PORTE4	PORTE3	PORTE2	PORTE1	PORTE0	page 92
\$02 (\$22)	DDRE	DDE7	DDE6	DDE5	DDE4	DDE3	DDE2	DDE1	DDE0	page 92
\$01 (\$21)	PINE	PINE7	PINE6	PINE5	PINE4	PINE3	PINE2	PINE1	PINE0	page 92
\$00 (\$20)	PINF	PINF7	PINF6	PINF5	PINF4	PINF3	PINF2	PINF1	PINF0	page 96

Note: For compatibility with future devices, reserved bits should be written to zero if accessed. Reserved I/O memory addresses should never be written. Some of the status flags are cleared by writing a logical “1” 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 \$00 to \$1F only.



Instruction Set Summary

Mnemonic	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	$Rd \leftarrow \$FF - Rd$	Z,C,N,V	1
NEG	Rd	Two's Complement	$Rd \leftarrow \$00 - Rd$	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	$Rd \leftarrow Rd \bullet (\$FF - K)$	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	$Rd \leftarrow \$FF$	None	1
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
BRVC	k	Branch if Overflow Flag is Cleared	if $(V = 0)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRIE	k	Branch if Interrupt Enabled	if $(I = 1)$ then $PC \leftarrow PC + k + 1$	None	1/2
BRID	k	Branch if Interrupt Disabled	if $(I = 0)$ then $PC \leftarrow PC + k + 1$	None	1/2
DATA TRANSFER INSTRUCTIONS					
ELPM		Extended Load Program Memory	$R0 \leftarrow (Z + RAMPZ)$	None	3
MOV	Rd, Rr	Move between Registers	$Rd \leftarrow Rr$	None	1
LDI	Rd, K	Load Immediate	$Rd \leftarrow K$	None	1

Instruction Set Summary (Continued)

Mnemonic	Operands	Description	Operation	Flags	# Clocks
LD	Rd, X	Load Indirect	$Rd \leftarrow (X)$	None	2
LD	Rd, X+	Load Indirect and Post-increment	$Rd \leftarrow (X), X \leftarrow X + 1$	None	2
LD	Rd, -X	Load Indirect and Pre-decrement	$X \leftarrow X - 1, Rd \leftarrow (X)$	None	2
LD	Rd, Y	Load Indirect	$Rd \leftarrow (Y)$	None	2
LD	Rd, Y+	Load Indirect and Post-increment	$Rd \leftarrow (Y), Y \leftarrow Y + 1$	None	2
LD	Rd, -Y	Load Indirect and Pre-decrement	$Y \leftarrow Y - 1, Rd \leftarrow (Y)$	None	2
LDD	Rd, Y+q	Load Indirect with Displacement	$Rd \leftarrow (Y + q)$	None	2
LD	Rd, Z	Load Indirect	$Rd \leftarrow (Z)$	None	2
LD	Rd, Z+	Load Indirect and Post-increment	$Rd \leftarrow (Z), Z \leftarrow Z + 1$	None	2
LD	Rd, -Z	Load Indirect and Pre-decrement	$Z \leftarrow Z - 1, Rd \leftarrow (Z)$	None	2
LDD	Rd, Z+q	Load Indirect with Displacement	$Rd \leftarrow (Z + q)$	None	2
LDS	Rd, k	Load Direct from SRAM	$Rd \leftarrow (k)$	None	2
ST	X, Rr	Store Indirect	$(X) \leftarrow Rr$	None	2
ST	X+, Rr	Store Indirect and Post-increment	$(X) \leftarrow Rr, X \leftarrow X + 1$	None	2
ST	-X, Rr	Store Indirect and Pre-decrement	$X \leftarrow X - 1, (X) \leftarrow Rr$	None	2
ST	Y, Rr	Store Indirect	$(Y) \leftarrow Rr$	None	2
ST	Y+, Rr	Store Indirect and Post-increment	$(Y) \leftarrow Rr, Y \leftarrow Y + 1$	None	2
ST	-Y, Rr	Store Indirect and Pre-decrement	$Y \leftarrow Y - 1, (Y) \leftarrow Rr$	None	2
STD	Y+q, Rr	Store Indirect with Displacement	$(Y + q) \leftarrow Rr$	None	2
ST	Z, Rr	Store Indirect	$(Z) \leftarrow Rr$	None	2
ST	Z+, Rr	Store Indirect and Post-increment	$(Z) \leftarrow Rr, Z \leftarrow Z + 1$	None	2
ST	-Z, Rr	Store Indirect and Pre-decrement	$Z \leftarrow Z - 1, (Z) \leftarrow Rr$	None	2
STD	Z+q, Rr	Store Indirect with Displacement	$(Z + q) \leftarrow Rr$	None	2
STS	k, Rr	Store Direct to SRAM	$(k) \leftarrow Rr$	None	2
LPM		Load Program Memory	$R0 \leftarrow (Z)$	None	3
IN	Rd, P	In Port	$Rd \leftarrow P$	None	1
OUT	P, Rr	Out Port	$P \leftarrow Rr$	None	1
PUSH	Rr	Push Register on Stack	$STACK \leftarrow Rr$	None	2
POP	Rd	Pop Register from Stack	$Rd \leftarrow STACK$	None	2
BIT AND BIT-TEST INSTRUCTIONS					
SBI	P, b	Set Bit in I/O Register	$I/O(P,b) \leftarrow 1$	None	2
CBI	P, b	Clear Bit in I/O Register	$I/O(P,b) \leftarrow 0$	None	2
LSL	Rd	Logical Shift Left	$Rd(n+1) \leftarrow Rd(n), Rd(0) \leftarrow 0$	Z, C, N, V	1
LSR	Rd	Logical Shift Right	$Rd(n) \leftarrow Rd(n+1), Rd(7) \leftarrow 0$	Z, C, N, V	1
ROL	Rd	Rotate Left through Carry	$Rd(0) \leftarrow C, Rd(n+1) \leftarrow Rd(n), C \leftarrow Rd(7)$	Z, C, N, V	1
ROR	Rd	Rotate Right through Carry	$Rd(7) \leftarrow C, Rd(n) \leftarrow Rd(n+1), C \leftarrow Rd(0)$	Z, C, N, V	1
ASR	Rd	Arithmetic Shift Right	$Rd(n) \leftarrow Rd(n+1), n = 0..6$	Z, C, N, V	1
SWAP	Rd	Swap Nibbles	$Rd(3..0) \leftrightarrow Rd(7..4), Rd(7..4) \leftrightarrow Rd(3..0)$	None	1
BSET	s	Flag Set	$SREG(s) \leftarrow 1$	SREG(s)	1
BCLR	s	Flag Clear	$SREG(s) \leftarrow 0$	SREG(s)	1
BST	Rr, b	Bit Store from Register to T	$T \leftarrow Rr(b)$	T	1
BLD	Rd, b	Bit Load from T to Register	$Rd(b) \leftarrow T$	None	1
SEC		Set Carry	$C \leftarrow 1$	C	1
CLC		Clear Carry	$C \leftarrow 0$	C	1
SEN		Set Negative Flag	$N \leftarrow 1$	N	1
CLN		Clear Negative Flag	$N \leftarrow 0$	N	1
SEZ		Set Zero Flag	$Z \leftarrow 1$	Z	1
CLZ		Clear Zero Flag	$Z \leftarrow 0$	Z	1
SEI		Global Interrupt Enable	$I \leftarrow 1$	I	1
CLI		Global Interrupt Disable	$I \leftarrow 0$	I	1
SES		Set Signed Test Flag	$S \leftarrow 1$	S	1
CLS		Clear Signed Test Flag	$S \leftarrow 0$	S	1
SEV		Set Two's Complement Overflow	$V \leftarrow 1$	V	1
CLV		Clear Two's Complement Overflow	$V \leftarrow 0$	V	1
SET		Set T in SREG	$T \leftarrow 1$	T	1
CLT		Clear T in SREG	$T \leftarrow 0$	T	1
SEH		Set Half-carry Flag in SREG	$H \leftarrow 1$	H	1
CLH		Clear Half-carry Flag in SREG	$H \leftarrow 0$	H	1
NOP		No Operation		None	1
SLEEP		Sleep	(see specific descr. for Sleep function)	None	1
WDR		Watchdog Reset	(see specific descr. for WD timer)	None	1



Ordering Information

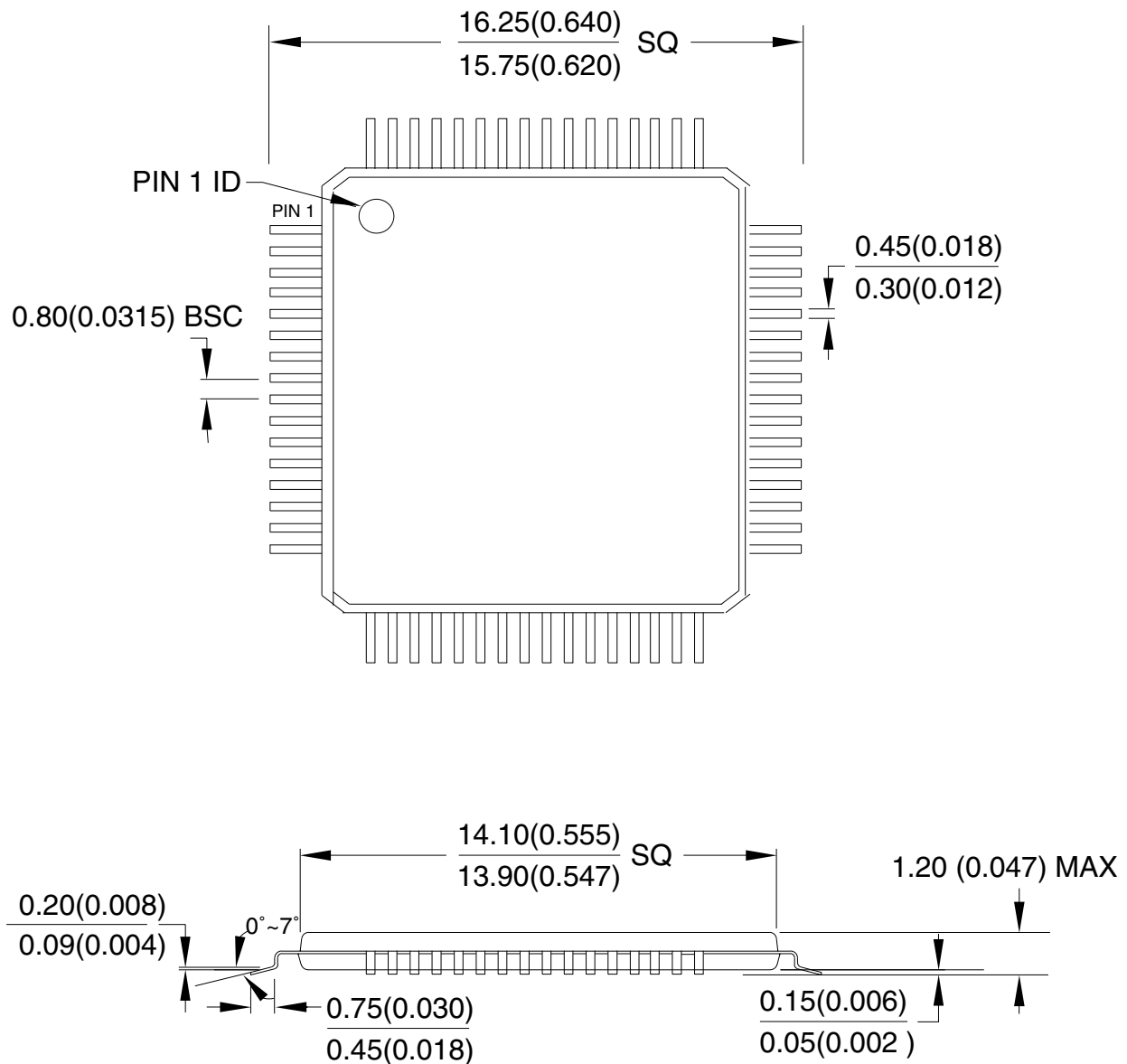
Speed (MHz)	Power Supply	Ordering Code	Package	Operation Range
4	2.7 - 3.6V	ATmega103L-4AC	64A	Commercial (0°C to 70°C)
		ATmega103L-4AI	64A	Industrial (-40°C to 85°C)
6	4.0 - 5.5V	ATmega103-6AC	64A	Commercial (0°C to 70°C)
		ATmega103-6AI	64A	Industrial (-40°C to 85°C)

Package Type	
64A	64-lead, Thin (1.0 mm) Plastic Gull Wing Quad Flat Package (TQFP)

Packaging Information

64A

64-lead, Thin (1.0 mm) Plastic Quad Flat Package
(TQFP), 14x14mm body, 2.0mm footprint, 0.8mm pitch.
Dimensions in Millimeters and (Inches)*
JEDEC STANDARD MS-026 AEB



*Controlling dimension: millimeter

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