## **Features**

- High-performance, Low-power AVR® 8-bit Microcontroller
- Advanced RISC Architecture
  - 131 Powerful Instructions Most Single-clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 16 MIPS Throughput at 16 MHz
  - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory segments
  - 32K Bytes of In-System Self-programmable Flash program memory
  - 1024 Bytes EEPROM
  - 2K Byte Internal SRAM
  - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
  - Data retention: 20 years at 85°C/100 years at 25°C<sup>(1)</sup>
  - Optional Boot Code Section with Independent Lock Bits
    - In-System Programming by On-chip Boot Program
    - True Read-While-Write Operation
  - Programming Lock for Software Security
- 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
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Four PWM Channels
  - 8-channel, 10-bit ADC
    - 8 Single-ended Channels
    - 7 Differential Channels in TQFP Package Only
    - 2 Differential Channels with Programmable Gain at 1x, 10x, or 200x
  - Byte-oriented Two-wire Serial Interface
  - Programmable Serial USART
  - Master/Slave SPI Serial Interface
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated RC Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby
- I/O and Packages
  - 32 Programmable I/O Lines
  - 40-pin PDIP, 44-lead TQFP, and 44-pad QFN/MLF
- Operating Voltages
  - 2.7 5.5V for ATmega32A
- Speed Grades
  - 0 16 MHz for ATmega32A
- Power Consumption at 1 MHz, 3V, 25°C for ATmega32A
  - Active: 0.6 mA
  - Idle Mode: 0.2 mA
  - Power-down Mode: < 1 μA



8-bit AVR®
Microcontroller
with 32K Bytes
In-System
Programmable
Flash

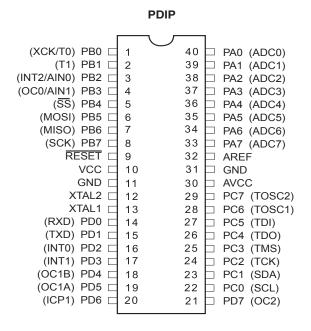
ATmega32A

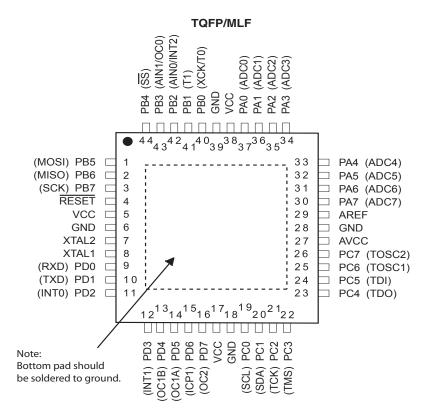
Summary



## 1. Pin Configurations

Figure 1-1. Pinout ATmega32A





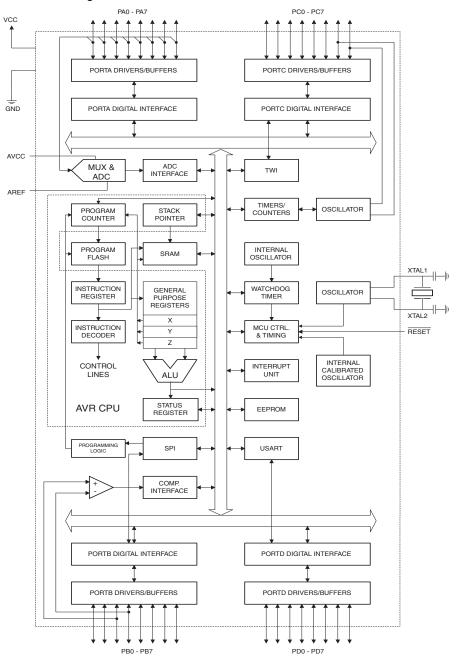


## 2. Overview

The ATmega32A 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 ATmega32A 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 ATmega32A provides the following features: 32K bytes of In-System Programmable Flash Program memory with Read-While-Write capabilities, 1024 bytes EEPROM, 2K byte SRAM, 32 general purpose I/O lines, 32 general purpose working registers, a JTAG interface for Boundaryscan, On-chip Debugging support and programming, three flexible Timer/Counters with compare modes, Internal and External Interrupts, a serial programmable USART, a byte oriented Two-wire Serial Interface, an 8-channel, 10-bit ADC with optional differential input stage with programmable gain (TQFP package only), a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and six software selectable power saving modes. The Idle mode stops the CPU while allowing the USART, Two-wire interface, A/D Converter, 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 External 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 Onchip 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 ATmega32A is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications.

The ATmega32A 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 Pin Descriptions

2.2.1 VCC

Digital supply voltage.

2.2.2 GND

Ground.

## 2.2.3 Port A (PA7:PA0)

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

Port A 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 A output buffers have sym-



metrical drive characteristics with both high sink and source capability. 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. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.

## 2.2.4 Port B (PB7:PB0)

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.

Port B also serves the functions of various special features of the ATmega32A as listed on page 59.

## 2.2.5 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. If the JTAG interface is enabled, the pull-up resistors on pins PC5(TDI), PC3(TMS) and PC2(TCK) will be activated even if a reset occurs.

The TD0 pin is tri-stated unless TAP states that shift out data are entered.

Port C also serves the functions of the JTAG interface and other special features of the ATmega32A as listed on page 62.

## 2.2.6 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 ATmega32A as listed on page 64.

## 2.2.7 **RESET**

Reset Input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. The minimum pulse length is given in Table 27-1 on page 299. Shorter pulses are not guaranteed to generate a reset.

## 2.2.8 XTAL1

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

### 2.2.9 XTAL2

Output from the inverting Oscillator amplifier.



## 2.2.10 AVCC

AVCC is the supply voltage pin for Port A and the A/D Converter. It should be externally connected to  $V_{CC}$ , even if the ADC is not used. If the ADC is used, it should be connected to  $V_{CC}$  through a low-pass filter.

### 2.2.11 AREF

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

## 3. Resources

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

## 4. Data Retention

Reliability Qualification results show that the projected data retention failure rate is much less than 1 PPM over 20 years at 85°C or 100 years at 25°C.



# 5. Register Summary

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
\$3F (\$5F)	SREG	I	Т	Н	S	V	N	Z	С	8
\$3E (\$5E)	SPH	-	-	-	_	SP11	SP10	SP9	SP8	11
\$3D (\$5D)	SPL	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0	11
\$3C (\$5C)	OCR0	Timer/Counter	0 Output Compar	e Register						86
\$3B (\$5B)	GICR	INT1	INT0	INT2	-	-	-	IVSEL	IVCE	48, 71
\$3A (\$5A)	GIFR	INTF1	INTF0	INTF2	-	-	-	-	-	71
\$39 (\$59)	TIMSK	OCIE2	TOIE2	TICIE1	OCIE1A	OCIE1B	TOIE1	OCIE0	TOIE0	87, 117, 136
\$38 (\$58)	TIFR	OCF2	TOV2	ICF1	OCF1A	OCF1B	TOV1	OCF0	TOV0	87, 117, 136
\$37 (\$57) \$36 (\$56)	SPMCR TWCR	SPMIE TWINT	RWWSB TWEA	TWSTA	RWWSRE TWSTO	BLBSET TWWC	PGWRT TWEN	PGERS	SPMEN TWIE	264 202
\$35 (\$55)	MCUCR	SE	SM2	SM1	SM0	ISC11	ISC10	ISC01	ISC00	36, 69
\$35 (\$55)	MCUCSR	JTD	ISC2	- Sivi i	JTRF	WDRF	BORF	EXTRF	PORF	42, 70, 251
\$33 (\$53)	TCCR0	FOC0	WGM00	COM01	COM00	WGM01	CS02	CS01	CS00	84
\$32 (\$52)	TCNT0	Timer/Counter								86
	OSCCAL		oration Register							32
\$31 <sup>(1)</sup> (\$51) <sup>(1)</sup>	OCDR	On-Chip Debu	g Register							232
\$30 (\$50)	SFIOR	ADTS2	ADTS1	ADTS0	_	ACME	PUD	PSR2	PSR10	66,90,137,206,226
\$2F (\$4F)	TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	FOC1A	FOC1B	WGM11	WGM10	112
\$2E (\$4E)	TCCR1B	ICNC1	ICES1	-	WGM13	WGM12	CS12	CS11	CS10	114
\$2D (\$4D)	TCNT1H		1 – Counter Regi							116
\$2C (\$4C)	TCNT1L		1 – Counter Regi							116
\$2B (\$4B)	OCR1AH			are Register A Hi						116
\$2A (\$4A)	OCR1AL			are Register A Lo						116
\$29 (\$49) \$28 (\$48)	OCR1BH OCR1BL			are Register B Hi are Register B Lo						116 116
\$20 (\$40)	ICR1H			Register High By						116
\$26 (\$46)	ICR1L			Register Low By						116
\$25 (\$45)	TCCR2	FOC2	WGM20	COM21	COM20	WGM21	CS22	CS21	CS20	132
\$24 (\$44)	TCNT2	Timer/Counter		002	0011120	17021	0022	0021	0020	135
\$23 (\$43)	OCR2		2 Output Compar	e Register						135
\$22 (\$42)	ASSR	-	-	-	_	AS2	TCN2UB	OCR2UB	TCR2UB	135
\$21 (\$41)	WDTCR	-	-	-	WDTOE	WDE	WDP2	WDP1	WDP0	43
\$20 <sup>(2)</sup> (\$40) <sup>(2)</sup>	UBRRH	URSEL	-	-	-		UBR	R[11:8]		171
` '	UCSRC	URSEL	UMSEL	UPM1	UPM0	USBS	UCSZ1	UCSZ0	UCPOL	170
\$1F (\$3F)	EEARH	-		-	-	-	-	EEAR9	EEAR8	20
\$1E (\$3E)	EEARL		ress Register Lov	v Byte						20
\$1D (\$3D)	EEDR	EEPROM Data	a Register	_	_	EERIE	EEMWE	EEWE	EERE	21 21
\$1C (\$3C) \$1B (\$3B)	EECR PORTA	PORTA7	PORTA6	PORTA5	PORTA4	PORTA3	PORTA2	PORTA1	PORTA0	66
\$1A (\$3A)	DDRA	DDA7	DDA6	DDA5	DDA4	DDA3	DDA2	DDA1	DDA0	66
\$19 (\$39)	PINA	PINA7	PINA6	PINA5	PINA4	PINA3	PINA2	PINA1	PINA0	66
\$18 (\$38)	PORTB	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0	67
\$17 (\$37)	DDRB	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0	67
\$16 (\$36)	PINB	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0	67
\$15 (\$35)	PORTC	PORTC7	PORTC6	PORTC5	PORTC4	PORTC3	PORTC2	PORTC1	PORTC0	67
\$14 (\$34)	DDRC	DDC7	DDC6	DDC5	DDC4	DDC3	DDC2	DDC1	DDC0	67
\$13 (\$33)	PINC	PINC7	PINC6	PINC5	PINC4	PINC3	PINC2	PINC1	PINC0	67
\$12 (\$32)	PORTD	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0	67
\$11 (\$31)	DDRD	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0	67
\$10 (\$30)	PIND	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0	68
\$0F (\$2F)	SPDR	SPI Data Reg SPIF							SPI2X	145
\$0E (\$2E)	SPSR SPCR	SPIE	WCOL SPE	DORD	MSTR	CPOL	CPHA	SPR1	SPR0	145 143
\$0D (\$2D) \$0C (\$2C)	UDR	USART I/O D		מאטמ	INIOIK	I OFUL	UFNA	J OFNI	J OFRU	167
\$0B (\$2B)	UCSRA	RXC	TXC	UDRE	FE	DOR	PE	U2X	MPCM	168
\$0A (\$2A)	UCSRB	RXCIE	TXCIE	UDRIE	RXEN	TXEN	UCSZ2	RXB8	TXB8	169
\$09 (\$29)	UBRRL		Rate Register Lo		•		•			171
\$08 (\$28)	ACSR	ACD	ACBG	ACO	ACI	ACIE	ACIC	ACIS1	ACIS0	206
\$07 (\$27)	ADMUX	REFS1	REFS0	ADLAR	MUX4	MUX3	MUX2	MUX1	MUX0	222
\$06 (\$26)	ADCSRA	ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0	224
\$05 (\$25)	ADCH	ADC Data Reg	gister High Byte							225
\$04 (\$24)	ADCL	ADC Data Reg	gister Low Byte						_	225
\$03 (\$23)	TWDR		al Interface Data F	, ·	1	1	1	1	1	203
\$02 (\$22)	TWAR	TWA6	TWA5	TWA4	TWA3	TWA2	TWA1	TWA0	TWGCE	204



Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
\$01 (\$21)	TWSR	TWS7	TWS6	TWS5	TWS4	TWS3	-	TWPS1	TWPS0	203
\$00 (\$20)	TWBR	Two-wire Seria	o-wire Serial Interface Bit Rate Register					201		

Notes:

- 1. When the OCDEN Fuse is unprogrammed, the OSCCAL Register is always accessed on this address. Refer to the debugger specific documentation for details on how to use the OCDR Register.
- 2. Refer to the USART description for details on how to access UBRRH and UCSRC.
- 3. For compatibility with future devices, reserved bits should be written to zero if accessed. Reserved I/O memory addresses should never be written.
- 4. 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 \$00 to \$1F only.



# 6. Instruction Set Summary

Mnemonics	Operands	Description	Operation	Flags	#Clocks
ARITHMETIC AND I	OGIC INSTRUCTION	IS		•	•
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	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	$Rd \leftarrow Rd - Rr - C$	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	Rdl,K	Subtract Immediate from Word	Rdh:Rdl ← 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 ← \$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 ← Rd + 1	Z,N,V	1
DEC	Rd	Decrement	Rd ← 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 ← \$FF	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	$R1:R0 \leftarrow (Rd \times Rr) \leq 1$	Z,C	2
FMULS	Rd, Rr	Fractional Multiply Signed	$R1:R0 \leftarrow (Rd \times Rr) \leq 1$	Z,C	2
FMULSU	Rd, Rr	Fractional Multiply Signed with Unsigned	$R1:R0 \leftarrow (Rd \times Rr) \leq 1$	Z,C	2
BRANCH INSTRUC	TIONS				
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	3
ICALL		Indirect Call to (Z)	PC ← Z	None	3
CALL	k	Direct Subroutine Call	PC ← k	None	4
RET		Subroutine Return	PC ← Stack	None	4
RETI		Interrupt Return	PC ← Stack	I	4
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 $(Rr(b)=0) PC \leftarrow PC + 2 \text{ or } 3$	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 $\leftarrow$ 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 ← 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 $\leftarrow$ 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 ← 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 ← 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 $\oplus$ 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
		Branch if Half Carry Flag Set	if (H = 1) then PC $\leftarrow$ PC + k + 1	None	1/2
BRHS	k		,		
BRHS BRHC BRTS	k k	Branch if Half Carry Flag Cleared  Branch if T Flag Set	if (H = 0) then PC $\leftarrow$ PC + k + 1 if (T = 1) then PC $\leftarrow$ PC + k + 1	None None	1/2



Mnemonics	Operands	Description	Operation	Flags	#Clocks
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
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
DATA TRANSFER I	NSTRUCTIONS				
MOV	Rd, Rr	Move Between Registers	$Rd \leftarrow Rr$	None	1
MOVW	Rd, Rr	Copy Register Word	Rd+1:Rd ← Rr+1:Rr	None	1
LDI	Rd, K	Load Immediate	$Rd \leftarrow K$	None	1
LD	Rd, X	Load Indirect	$Rd \leftarrow (X)$	None	2
LD	Rd, X+	Load Indirect and Post-Inc.	$Rd \leftarrow (X), X \leftarrow X + 1$	None	2
LD	Rd, - X	Load Indirect and Pre-Dec.	$X \leftarrow X - 1$ , $Rd \leftarrow (X)$	None	2
LD	Rd, Y	Load Indirect	Rd ← (Y)	None	2
LD	Rd, Y+	Load Indirect and Post-Inc.	$Rd \leftarrow (Y), Y \leftarrow Y + 1$	None	2
LD	Rd, - Y	Load Indirect and Pre-Dec.	$Y \leftarrow Y - 1$ , $Rd \leftarrow (Y)$	None	2
LDD	Rd,Y+q	Load Indirect with Displacement	$Rd \leftarrow (Y + q)$	None	2
LD	Rd, Z	Load Indirect	Rd ← (Z)	None	2
LD	Rd, Z+	Load Indirect and Prost-Inc.	$Rd \leftarrow (Z), Z \leftarrow Z+1$	None	2
LDD LDD	Rd, -Z Rd, Z+q	Load Indirect and Pre-Dec.  Load Indirect with Displacement	$Z \leftarrow Z - 1$ , $Rd \leftarrow (Z)$	None	2
LDS	Rd, Z+q Rd, k	Load Indirect with Displacement  Load Direct from SRAM	$Rd \leftarrow (Z + q)$ $Rd \leftarrow (k)$	None None	2
ST	X, Rr	Store Indirect	$(X) \leftarrow Rr$	None	2
ST	X+, Rr	Store Indirect Store Indirect and Post-Inc.	$(X) \leftarrow RI$ $(X) \leftarrow Rr, X \leftarrow X + 1$	None	2
ST	- X, Rr	Store Indirect and Pre-Dec.	$X \leftarrow X - 1, (X) \leftarrow Rr$	None	2
ST	Y, Rr	Store Indirect	$(Y) \leftarrow Rr$	None	2
ST	Y+, Rr	Store Indirect and Post-Inc.	$(Y) \leftarrow Rr, Y \leftarrow Y + 1$	None	2
ST	- Y, Rr	Store Indirect and Pre-Dec.	$Y \leftarrow Y - 1, (Y) \leftarrow Rr$	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.	$Z \leftarrow Z - 1$ , $(Z) \leftarrow Rr$	None	2
STD	Z+q,Rr	Store Indirect with Displacement	$(Z + q) \leftarrow Rr$	None	2
STS	k, Rr	Store Direct to SRAM	(k) ← Rr	None	2
LPM		Load Program Memory	R0 ← (Z)	None	3
LPM	Rd, Z	Load Program Memory	$Rd \leftarrow (Z)$	None	3
LPM	Rd, Z+	Load Program Memory and Post-Inc	$Rd \leftarrow (Z), Z \leftarrow Z+1$	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
	Rd	Pop Register from Stack	Rd ← Stack	None	2
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	$Rd(n+1) \leftarrow Rd(n), Rd(0) \leftarrow 0$	Z,C,N,V	1
LSR	Rd	Logical Shift Right	$Rd(n) \leftarrow Rd(n+1), Rd(7) \leftarrow 0$ $Rd(n) \leftarrow Rd(n+1), Rd(7) \leftarrow 0$	Z,C,N,V	1
ROL	Rd	Rotate Left Through Carry	$Rd(0) \leftarrow Rd(n+1) \leftarrow Rd(n), C \leftarrow Rd(7)$	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)←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	$SREG(s) \leftarrow 0$	SREG(s)	1
BST	Rr, b	Bit Store from Register to T	$T \leftarrow Rr(b)$	Т	1
BLD	Rd, b	Bit load from T to Register	$Rd(b) \leftarrow T$	None	1
SEC		Set Carry	C ← 1	С	1
CLC		Clear Carry	C ← 0	С	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	1←1	1	1
CLI		Global Interrupt Disable	1←0	1	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



Mnemonics	Operands	Description	Operation	Flags	#Clocks
SET		Set T in SREG	T ← 1	Т	1
CLT		Clear T in SREG	T ← 0	T	1
SEH		Set Half Carry Flag in SREG	H ← 1	Н	1
CLH		Clear Half Carry Flag in SREG	H ← 0	Н	1
MCU CONTROL	INSTRUCTIONS				
NOP		No Operation		None	1
SLEEP		Sleep	(see specific descr. for Sleep function)	None	1
WDR		Watchdog Reset	(see specific descr. for WDR/timer)	None	1
BREAK		Break	For On-Chip Debug Only	None	N/A



## 7. Ordering Information

Speed (MHz)	Power Supply	Ordering Code	Package <sup>(1)</sup>	Operational Range
16	2.7 - 5.5V	ATmega32A-AU <sup>(2)</sup> ATmega32A-PU <sup>(2)</sup> ATmega32A-MU <sup>(2)</sup>	44A 40P6 44M1	Industrial (-40°C to 85°C)

Notes: 1. This device can also be supplied in wafer form. Please contact your local Atmel sales office for detailed ordering information and minimum quantities.

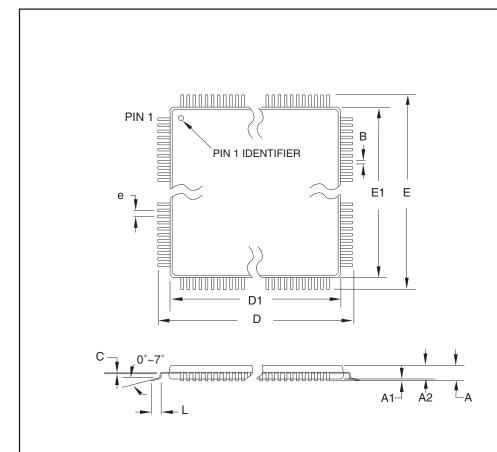
2. Pb-free packaging complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.

	Package Type				
44A	44-lead, 10 x 10 x 1.0 mm, Thin Profile Plastic Quad Flat Package (TQFP)				
40P6	40-pin, 0.600" Wide, Plastic Dual Inline Package (PDIP)				
44M1	44-pad, 7 x 7 x 1.0 mm, Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)				



## 8. Packaging Information

## 8.1 44A



## **COMMON DIMENSIONS**

(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
Α	_	-	1.20	
A1	0.05	İ	0.15	
A2	0.95	1.00	1.05	
D	11.75	12.00	12.25	
D1	9.90	10.00	10.10	Note 2
Е	11.75	12.00	12.25	
E1	9.90	10.00	10.10	Note 2
В	0.30	_	0.45	
С	0.09		0.20	
L	0.45		0.75	
е		0.80 TYP		

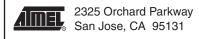
Notes:

- 1. This package conforms to JEDEC reference MS-026, Variation ACB.
- 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.

TITLE

3. Lead coplanarity is 0.10 mm maximum.

10/5/2001

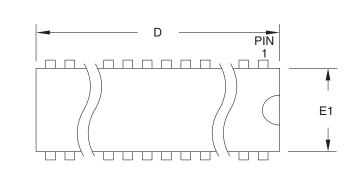


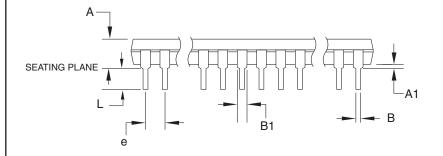
**44A**, 44-lead, 10 x 10 mm Body Size, 1.0 mm Body Thickness, 0.8 mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP)

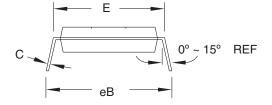
DRAWING NO.	REV.
44A	В



#### 8.2 40P6







Notes:

- 1. This package conforms to JEDEC reference MS-011, Variation AC.
- 2. Dimensions D and E1 do not include mold Flash or Protrusion. Mold Flash or Protrusion shall not exceed 0.25 mm (0.010").

## **COMMON DIMENSIONS**

(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
Α	_	_	4.826	
A1	0.381	_	ı	
D	52.070	_	52.578	Note 2
Е	15.240	_	15.875	
E1	13.462	_	13.970	Note 2
В	0.356	_	0.559	
B1	1.041	_	1.651	
L	3.048	_	3.556	
С	0.203	_	0.381	
еВ	15.494	_	17.526	
е		2.540 TYF	•	

09/28/01

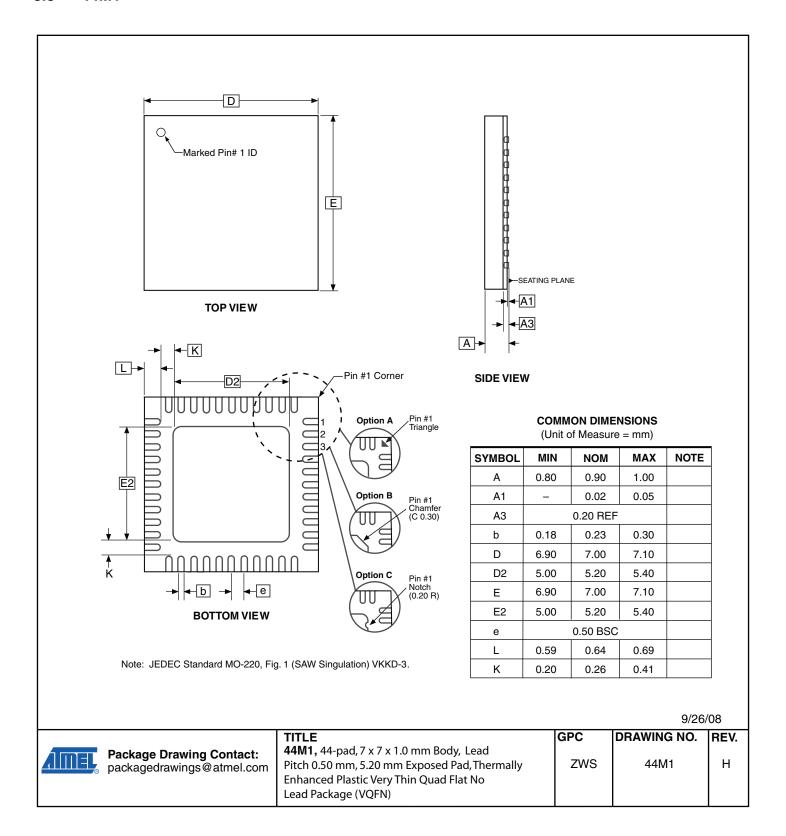
4mei	2325 Orchard Parkw San Jose, CA 9513	ay
AIIIEL	San Jose, CA 9513	1

TITLE  $\bf 40P6,\,40\text{-lead}$  (0.600"/15.24 mm Wide) Plastic Dual Inline Package (PDIP) DRAWING NO. REV. 40P6

В



## 8.3 44M1





## 9. Errata

## 9.1 ATmega32A, rev. G to rev. I

- First Analog Comparator conversion may be delayed
- . Interrupts may be lost when writing the timer registers in the asynchronous timer
- IDCODE masks data from TDI input
- · Reading EEPROM by using ST or STS to set EERE bit triggers unexpected interrupt request.

## 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

The interrupt will be lost if a timer register that is synchronous timer clock is written when the asynchronous Timer/Counter register (TCNTx) is 0x00.

## Problem Fix/Workaround

Always check that the asynchronous Timer/Counter register neither have the value 0xFF nor 0x00 before writing to the asynchronous Timer Control Register (TCCRx), asynchronous Timer Counter Register (TCNTx), or asynchronous Output Compare Register (OCRx).

### 3. 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 ATmega32A is the only device in the scan chain, the problem is not visible.
- Select the Device ID Register of the ATmega32A 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 ATmega32A 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 ATmega32A must be the fist device in the chain.

# 4. Reading EEPROM by using ST or STS to set EERE bit triggers unexpected interrupt request.

Reading EEPROM by using the ST or STS command to set the EERE bit in the EECR register triggers an unexpected EEPROM interrupt request.

## **Problem Fix / Workaround**

Always use OUT or SBI to set EERE in EECR.



## 10. 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.

## 10.1 Rev. 8155B - 07/09

- 1. Updated "Errata" on page 343.
- 2. Updated the last page with Atmel's new addresses.

## 10.2 Rev. 8155A - 06/08

Initial revision (Based on the ATmega32/L datasheet 2503N-AVR-06/08)

Changes done compared ATmega32/L datasheet 2503N-AVR-06/08:

- Updated description in "Stack Pointer" on page 11.
- All Electrical characteristics is moved to "Electrical Characteristics" on page 296.
- Register descriptions are moved to sub sections at the end of each chapter.
- Test limits of Reset Pull-up Resistor (R<sub>RST</sub>) in "DC Characteristics" on page 296.
- New graphs in "Typical Characteristics" on page 306.
- New "Ordering Information" on page 339.





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