



Welcome to [E-XFL.COM](https://www.e-xfl.com)

### What is "[Embedded - Microcontrollers](#)"?

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

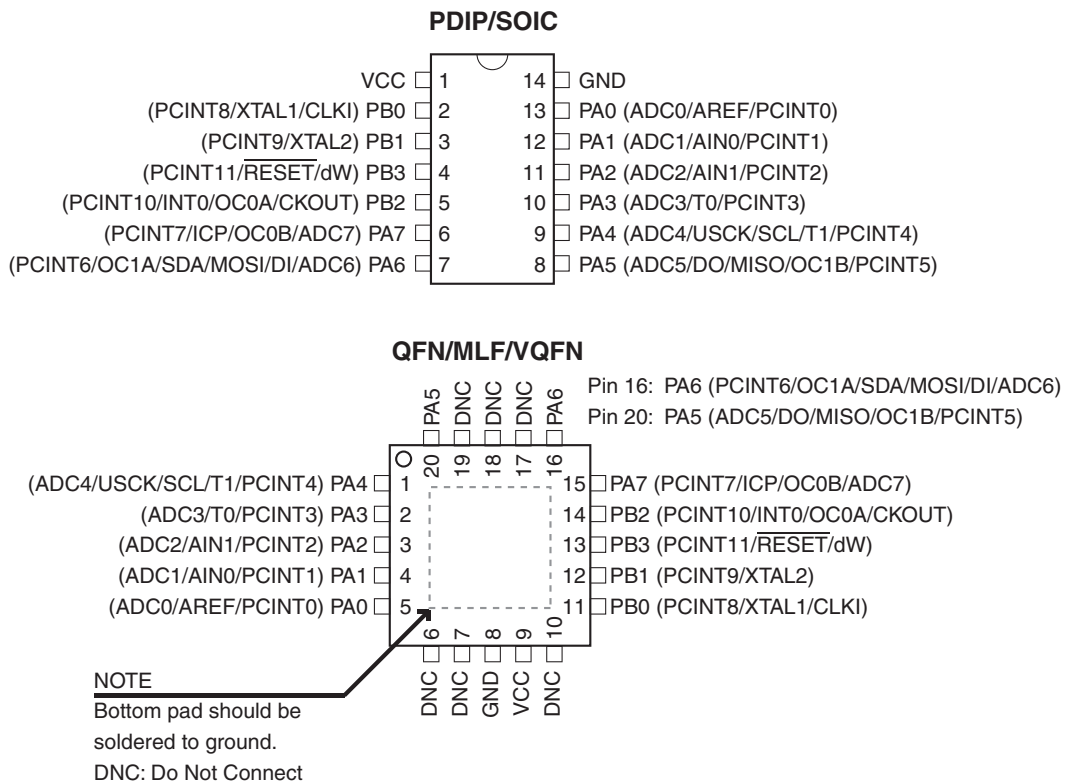
### Applications of "[Embedded - Microcontrollers](#)"

#### Details

Product Status	Active
Core Processor	AVR
Core Size	8-Bit
Speed	20MHz
Connectivity	USI
Peripherals	Brown-out Detect/Reset, POR, PWM, Temp Sensor, WDT
Number of I/O	12
Program Memory Size	2KB (1K x 16)
Program Memory Type	FLASH
EEPROM Size	128 x 8
RAM Size	128 x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 5.5V
Data Converters	A/D 8x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Surface Mount
Package / Case	20-WFQFN Exposed Pad
Supplier Device Package	20-QFN-EP (4x4)
Purchase URL	<a href="https://www.e-xfl.com/product-detail/microchip-technology/attiny24a-mf">https://www.e-xfl.com/product-detail/microchip-technology/attiny24a-mf</a>

## 1. Pin Configurations

**Figure 1-1.** Pinout of ATtiny24A/44A/84A



**Table 1-1.** UFBGA - Pinout ATtiny24A/44A/84A (top view)

	1	2	3	4
<b>A</b>		PA5	PA6	PB2
<b>B</b>	PA4	PA7	PB1	PB3
<b>C</b>	PA3	PA2	PA1	PB0
<b>D</b>	PA0	GND	GND	VCC

## **1.1 Pin Descriptions**

### **1.1.1 VCC**

Supply voltage.

### **1.1.2 GND**

Ground.

### **1.1.3 Port B (PB3:PB0)**

Port B is a 4-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 except PB3 which has the  $\overline{\text{RESET}}$  capability. To use pin PB3 as an I/O pin, instead of RESET pin, program ('0') RSTDISBL fuse. 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 ATtiny24A/44A/84A as listed in [Section 10.2 "Alternate Port Functions" on page 58](#).

### **1.1.4 $\overline{\text{RESET}}$**

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 and provided the reset pin has not been disabled. The minimum pulse length is given in [Table 20-4 on page 176](#). Shorter pulses are not guaranteed to generate a reset.

The reset pin can also be used as a (weak) I/O pin.

### **1.1.5 Port A (PA7:PA0)**

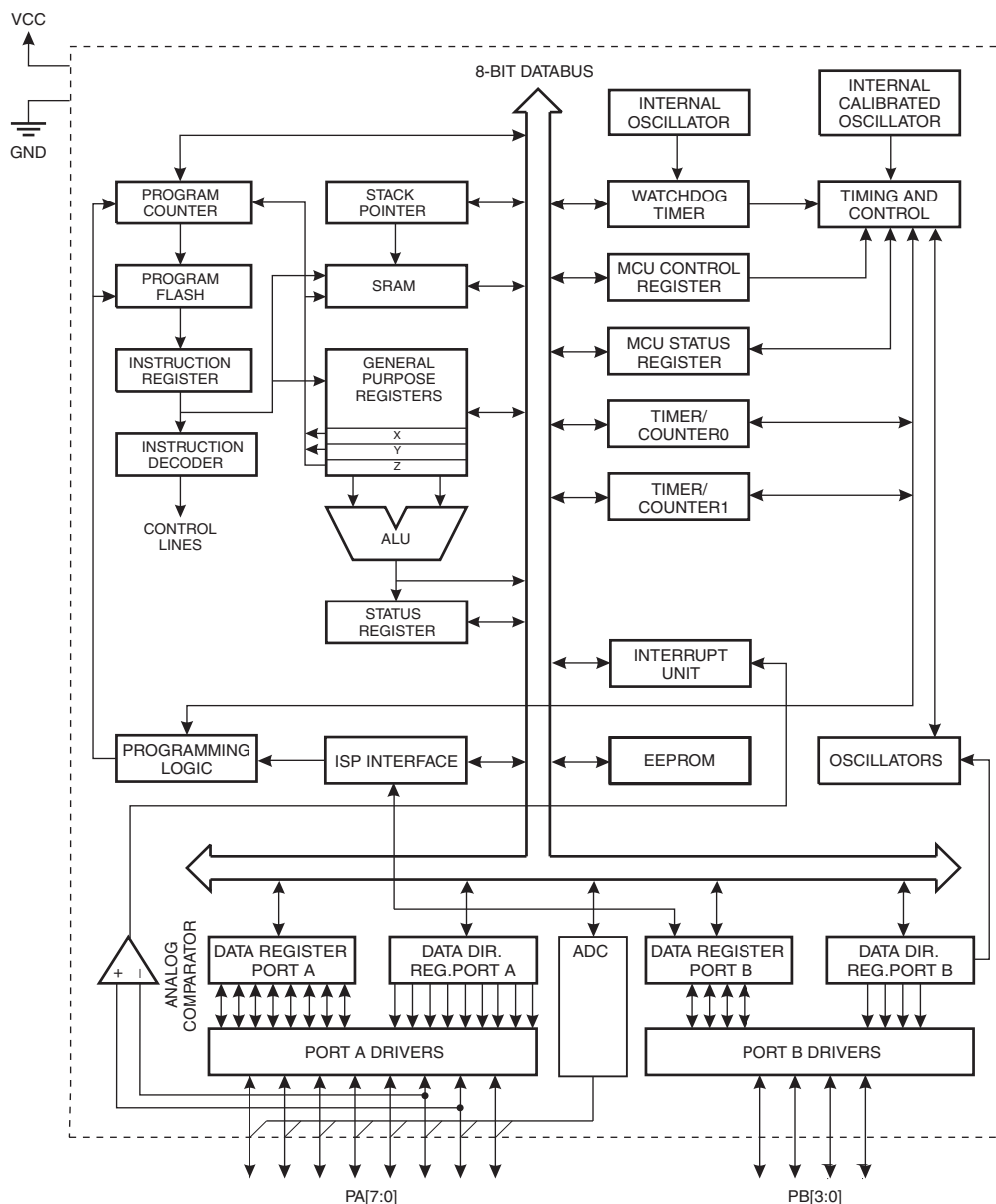
Port A is a 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port A pins that are externally pulled low will source current if the pull-up resistors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

Port A has alternate functions as analog inputs for the ADC, analog comparator, timer/counter, SPI and pin change interrupt as described in ["Alternate Port Functions" on page 58](#).

## 2. Overview

ATtiny24A/44A/84A are low-power CMOS 8-bit microcontrollers based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATtiny24A/44A/84A achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

**Figure 2-1.** Block Diagram



The AVR core combines a rich instruction set with 32 general purpose working registers. All 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 ATtiny24A/44A/84A provides the following features: 2K/4K/8K byte of In-System Programmable Flash, 128/256/512 bytes EEPROM, 128/256/512 bytes SRAM, 12 general purpose I/O lines, 32 general purpose working registers, an 8-bit Timer/Counter with two PWM channels, a 16-bit timer/counter with two PWM channels, Internal and External Interrupts, a 8-channel 10-bit ADC, programmable gain stage (1x, 20x) for 12 differential ADC channel pairs, a programmable Watchdog Timer with internal oscillator, internal calibrated oscillator, and four software selectable power saving modes. Idle mode stops the CPU while allowing the SRAM, Timer/Counter, ADC, Analog Comparator, and Interrupt system to continue functioning. ADC Noise Reduction mode minimizes switching noise during ADC conversions by stopping the CPU and all I/O modules except the ADC. In Power-down mode registers keep their contents and all chip functions are disabled until the next interrupt or hardware reset. In Standby mode, the crystal/resonator oscillator is running while the rest of the device is sleeping, allowing very fast start-up combined with low power consumption.

The device is manufactured using Atmel's high density non-volatile memory technology. The on-chip ISP Flash allows the Program memory to be re-programmed in-system through an SPI serial interface, by a conventional non-volatile memory programmer or by an on-chip boot code running on the AVR core.

The ATtiny24A/44A/84A AVR is supported with a full suite of program and system development tools including: C Compilers, Macro Assemblers, Program Debugger/Simulators and Evaluation kits.

## 4. Register Summary

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
0x3F (0x5F)	SREG	I	T	H	S	V	N	Z	C	Page 14
0x3E (0x5E)	SPH	–	–	–	–	–	–	SP9	SP8	Page 13
0x3D (0x5D)	SPL	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0	Page 13
0x3C (0x5C)	OCR0B	Timer/Counter0 – Output Compare Register B								Page 83
0x3B (0x5B)	GIMSK	–	INT0	PCIE1	PCIE0	–	–	–	–	Page 50
0x3A (0x5A)	GIFR	–	INTF0	PCIF1	PCIF0	–	–	–	–	Page 51
0x39 (0x59)	TIMSK0	–	–	–	–	–	OCIE0B	OCIE0A	TOIE0	Page 83
0x38 (0x58)	TIFR0	–	–	–	–	–	OCF0B	OCF0A	TOV0	Page 84
0x37 (0x57)	SPMCSR	–	–	RSIG	CTPB	RFLB	PGWRT	PGERS	SPMEN	Page 156
0x36 (0x56)	OCR0A	Timer/Counter0 – Output Compare Register A								Page 83
0x35 (0x55)	MCUCR	BODS	PUD	SE	SM1	SM0	BODSE	ISC01	ISC00	Pages 36, 50, 66
0x34 (0x54)	MCUSR	–	–	–	–	WDRF	BORF	EXTRF	PORF	Page 44
0x33 (0x53)	TCCR0B	FOC0A	FOC0B	–	–	WGM02	CS02	CS01	CS00	Page 82
0x32 (0x52)	TCNT0	Timer/Counter0								Page 83
0x31 (0x51)	OSCCAL	CAL7	CAL6	CAL5	CAL4	CAL3	CAL2	CAL1	CAL0	Page 31
0x30 (0x50)	TCCR0A	COM0A1	COM0A0	COM0B1	COM0B0	–	–	WGM01	WGM00	Page 79
0x2F (0x4F)	TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	–	–	WGM11	WGM10	Page 106
0x2E (0x4E)	TCCR1B	ICNC1	ICES1	–	WGM13	WGM12	CS12	CS11	CS10	Page 108
0x2D (0x4D)	TCNT1H	Timer/Counter1 – Counter Register High Byte								Page 110
0x2C (0x4C)	TCNT1L	Timer/Counter1 – Counter Register Low Byte								Page 110
0x2B (0x4B)	OCR1AH	Timer/Counter1 – Compare Register A High Byte								Page 110
0x2A (0x4A)	OCR1AL	Timer/Counter1 – Compare Register A Low Byte								Page 110
0x29 (0x49)	OCR1BH	Timer/Counter1 – Compare Register B High Byte								Page 110
0x28 (0x48)	OCR1BL	Timer/Counter1 – Compare Register B Low Byte								Page 110
0x27 (0x47)	DWDR	DWDR[7:0]								Page 151
0x26 (0x46)	CLKPR	CLKPCE	–	–	–	CLKPS3	CLKPS2	CLKPS1	CLKPS0	Page 31
0x25 (0x45)	ICR1H	Timer/Counter1 - Input Capture Register High Byte								Page 111
0x24 (0x44)	ICR1L	Timer/Counter1 - Input Capture Register Low Byte								Page 111
0x23 (0x43)	GTCCR	TSM	–	–	–	–	–	–	PSR10	Page 114
0x22 (0x42)	TCCR1C	FOC1A	FOC1B	–	–	–	–	–	–	Page 109
0x21 (0x41)	WDTCR	WDIF	WDIE	WDP3	WDCE	WDE	WDP2	WDP1	WDP0	Page 44
0x20 (0x40)	PCMSK1	–	–	–	–	PCINT11	PCINT10	PCINT9	PCINT8	Page 51
0x1F (0x3F)	EEARH	–	–	–	–	–	–	–	EEAR8	Page 20
0x1E (0x3E)	EEARL	EEAR7	EEAR6	EEAR5	EEAR4	EEAR3	EEAR2	EEAR1	EEAR0	Page 21
0x1D (0x3D)	EEDR	EEPROM Data Register								Page 21
0x1C (0x3C)	EEDR	–	–	EEP1	EEP0	EERIE	EEMPE	EEPE	EERE	Page 23
0x1B (0x3B)	PORTA	PORTA7	PORTA6	PORTA5	PORTA4	PORTA3	PORTA2	PORTA1	PORTA0	Page 66
0x1A (0x3A)	DDRA	DDA7	DDA6	DDA5	DDA4	DDA3	DDA2	DDA1	DDA0	Page 66
0x19 (0x39)	PINA	PINA7	PINA6	PINA5	PINA4	PINA3	PINA2	PINA1	PINA0	Page 67
0x18 (0x38)	PORTB	–	–	–	–	PORTB3	PORTB2	PORTB1	PORTB0	Page 67
0x17 (0x37)	DDRB	–	–	–	–	DDB3	DDB2	DDB1	DDB0	Page 67
0x16 (0x36)	PINB	–	–	–	–	PINB3	PINB2	PINB1	PINB0	Page 67
0x15 (0x35)	GPOR2	General Purpose I/O Register 2								Page 22
0x14 (0x34)	GPOR1	General Purpose I/O Register 1								Page 23
0x13 (0x33)	GPOR0	General Purpose I/O Register 0								Page 23
0x12 (0x32)	PCMSK0	PCINT7	PCINT6	PCINT5	PCINT4	PCINT3	PCINT2	PCINT1	PCINT0	Page 52
0x11 (0x31)	Reserved	–								
0x10 (0x30)	USIBR	USI Buffer Register								Page 127
0x0F (0x2F)	USIDR	USI Data Register								Page 126
0x0E (0x2E)	USISR	USISIF	USIOIF	USIPF	USIDC	USICNT3	USICNT2	USICNT1	USICNT0	Page 125
0x0D (0x2D)	USICR	USISIE	USIOIE	USIWM1	USIWM0	USICS1	USICS0	USICLK	USITC	Page 123
0x0C (0x2C)	TIMSK1	–	–	ICIE1	–	–	OCIE1B	OCIE1A	TOIE1	Page 111
0x0B (0x2B)	TIFR1	–	–	ICF1	–	–	OCF1B	OCF1A	TOV1	Page 112
0x0A (0x2A)	Reserved	–								
0x09 (0x29)	Reserved	–								
0x08 (0x28)	ACSR	ACD	ACBG	ACO	ACI	ACIE	ACIC	ACIS1	ACIS0	Page 129
0x07 (0x27)	ADMUX	REFS1	REFS0	MUX5	MUX4	MUX3	MUX2	MUX1	MUX0	Page 144
0x06 (0x26)	ADCSRA	ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0	Page 146
0x05 (0x25)	ADCH	ADC Data Register High Byte								Page 148
0x04 (0x24)	ADCL	ADC Data Register Low Byte								Page 148
0x03 (0x23)	ADCSRB	BIN	ACME	–	ADLAR	–	ADTS2	ADTS1	ADTS0	Pages 130, 148
0x02 (0x22)	Reserved	–								
0x01 (0x21)	DIDR0	ADC7D	ADC6D	ADC5D	ADC4D	ADC3D	ADC2D	ADC1D	ADC0D	Pages 131, 149
0x00 (0x20)	PRR	–	–	–	–	PRTIM1	PRTIM0	PRUSI	PRADC	Page 37

- Note:
1. For compatibility with future devices, reserved bits should be written to zero if accessed. Reserved I/O memory addresses should never be written.
  2. I/O Registers within the address range 0x00 - 0x1F are directly bit-accessible using the SBI and CBI instructions. In these registers, the value of single bits can be checked by using the SBIS and SBIC instructions.
  3. Some of the Status Flags are cleared by writing a logical one to them. Note that, unlike most other AVR's, the CBI and SBI instructions will only operation the specified bit, and can therefore be used on registers containing such Status Flags. The CBI and SBI instructions work with registers 0x00 to 0x1F only.

## 5. 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	RdI,K	Add Immediate to Word	$Rdh:Rdl \leftarrow Rdh:Rdl + K$	Z,C,N,V,S	2
SUB	Rd, Rr	Subtract two Registers	$Rd \leftarrow Rd - Rr$	Z,C,N,V,H	1
SUBI	Rd, K	Subtract Constant from Register	$Rd \leftarrow Rd - K$	Z,C,N,V,H	1
SBC	Rd, Rr	Subtract with Carry two Registers	$Rd \leftarrow Rd - Rr - C$	Z,C,N,V,H	1
SBCI	Rd, K	Subtract with Carry Constant from Reg.	$Rd \leftarrow Rd - K - C$	Z,C,N,V,H	1
SBIW	RdI,K	Subtract Immediate from Word	$Rdh:Rdl \leftarrow Rdh:Rdl - K$	Z,C,N,V,S	2
AND	Rd, Rr	Logical AND Registers	$Rd \leftarrow Rd \bullet Rr$	Z,N,V	1
ANDI	Rd, K	Logical AND Register and Constant	$Rd \leftarrow Rd \bullet K$	Z,N,V	1
OR	Rd, Rr	Logical OR Registers	$Rd \leftarrow Rd \vee Rr$	Z,N,V	1
ORI	Rd, K	Logical OR Register and Constant	$Rd \leftarrow Rd \vee K$	Z,N,V	1
EOR	Rd, Rr	Exclusive OR Registers	$Rd \leftarrow Rd \oplus Rr$	Z,N,V	1
COM	Rd	One's Complement	$Rd \leftarrow 0xFF - Rd$	Z,C,N,V	1
NEG	Rd	Two's Complement	$Rd \leftarrow 0x00 - Rd$	Z,C,N,V,H	1
SBR	Rd,K	Set Bit(s) in Register	$Rd \leftarrow Rd \vee K$	Z,N,V	1
CBR	Rd,K	Clear Bit(s) in Register	$Rd \leftarrow Rd \bullet (0xFF - K)$	Z,N,V	1
INC	Rd	Increment	$Rd \leftarrow Rd + 1$	Z,N,V	1
DEC	Rd	Decrement	$Rd \leftarrow Rd - 1$	Z,N,V	1
TST	Rd	Test for Zero or Minus	$Rd \leftarrow Rd \bullet Rd$	Z,N,V	1
CLR	Rd	Clear Register	$Rd \leftarrow Rd \oplus Rd$	Z,N,V	1
SER	Rd	Set Register	$Rd \leftarrow 0xFF$	None	1
<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
RCALL	k	Relative Subroutine Call	$PC \leftarrow PC + k + 1$	None	3
ICALL		Indirect Call to (Z)	$PC \leftarrow Z$	None	3
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
<b>BIT AND BIT-TEST INSTRUCTIONS</b>					
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



Mnemonics	Operands	Description	Operation	Flags	#Clocks
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	$Rd(3..0) \leftarrow Rd(7..4), Rd(7..4) \leftarrow Rd(3..0)$	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 Twos Complement Overflow	$V \leftarrow 1$	V	1
CLV		Clear Twos 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
<b>DATA TRANSFER INSTRUCTIONS</b>					
MOV	Rd, Rr	Move Between Registers	$Rd \leftarrow Rr$	None	1
MOVW	Rd, Rr	Copy Register Word	$Rd+1:Rd \leftarrow Rr+1:Rr$	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	$Rd \leftarrow (Y)$	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	$Rd \leftarrow (Z)$	None	2
LD	Rd, Z+	Load Indirect and Post-Inc.	$Rd \leftarrow (Z), Z \leftarrow Z + 1$	None	2
LD	Rd, -Z	Load Indirect and Pre-Dec.	$Z \leftarrow Z - 1, Rd \leftarrow (Z)$	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-Inc.	$(X) \leftarrow Rr, X \leftarrow X + 1$	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	$(Y + q) \leftarrow Rr$	None	2
ST	Z, Rr	Store Indirect	$(Z) \leftarrow Rr$	None	2
ST	Z+, Rr	Store Indirect and Post-Inc.	$(Z) \leftarrow Rr, Z \leftarrow Z + 1$	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	$(k) \leftarrow Rr$	None	2
LPM		Load Program Memory	$R0 \leftarrow (Z)$	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	$(z) \leftarrow R1:R0$	None	
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
<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

## 6. Ordering Information

### 6.1 ATtiny24A

Speed (MHz) <sup>(1)</sup>	Supply Voltage (V)	Temperature Range	Package <sup>(2)</sup>	Ordering Code <sup>(3)</sup>
20	1.8 – 5.5V	Industrial (-40°C to +85°C) <sup>(5)</sup>	14S1	ATtiny24A-SSU
				ATtiny24A-SSUR
			14P3	ATtiny24A-PU
			15CC1	ATtiny24A-CCU
				ATtiny24A-CCUR
			20M1	ATtiny24A-MU
				ATtiny24A-MUR
		Industrial (-40°C to +105°C) <sup>(6)</sup>	20M2	ATtiny24A-MMH <sup>(4)</sup>
				ATtiny24A-MMHR <sup>(4)</sup>
			14S1	ATtiny24A-SSN
				ATtiny24A-SSNR
		Industrial (-40°C to +125°C) <sup>(7)</sup>	14S1	ATtiny24A-SSF
				ATtiny24A-SSFR
			20M1	ATtiny24A-MF
				ATtiny24A-MFR
			20M2	ATtiny24A-MM8
				ATtiny24A-MM8R

- Notes:
1. For speed vs. supply voltage, see section [20.3 "Speed" on page 174](#).
  2. All packages are Pb-free, halide-free and fully green and they comply with the European directive for Restriction of Hazardous Substances (RoHS)
  3. Code indicators:
    - H: NiPdAu lead finish
    - F, N, U: matte tin
    - R: tape & reel
  4. Topside marking for ATtiny24A: T24 / Axx / manufacturing data
  5. Also supplied in wafer form. Contact your local Atmel sales office for ordering information and minimum quantities.
  6. For typical and electrical characteristics, see "Appendix A – ATtiny24A/44A Specification at 105°C".
  7. For typical and electrical characteristics, see "Appendix B – ATtiny24A/44A/84A Specification at 125°C".

Package Type	
<b>14S1</b>	14-lead, 0.150" Wide Body, Plastic Gull Wing Small Outline Package (SOIC)
<b>14P3</b>	14-lead, 0.300" Wide, Plastic Dual Inline Package (PDIP)
<b>15CC1</b>	15-ball (4 x 4 Array), 0.65 mm Pitch, 3.0 x 3.0 x 0.6 mm, Ultra Thin, Fine-Pitch Ball Grid Array Package (UFBGA)
<b>20M1</b>	20-pad, 4 x 4 x 0.8 mm Body, Quad Flat No Lead / Micro Lead Frame Package (QFN/MLF)
<b>20M2</b>	20-pad, 3 x 3 x 0.85 mm Body, Very Thin Quad Flat No Lead Package (VQFN)

## 6.2 ATtiny44A

Speed (MHz) <sup>(1)</sup>	Supply Voltage (V)	Temperature Range	Package <sup>(2)</sup>	Ordering Code <sup>(3)</sup>
20	1.8 – 5.5V	Industrial (-40°C to +85°C) <sup>(5)</sup>	14S1	ATtiny44A-SSU
				ATtiny44A-SSUR
			14P3	ATtiny44A-PU
			15CC1	ATtiny44A-CCU
				ATtiny44A-CCUR
			20M1	ATtiny44A-MU
				ATtiny44A-MUR
		Industrial (-40°C to +105°C) <sup>(6)</sup>	20M2	ATtiny44A-MMH <sup>(4)</sup>
				ATtiny44A-MMHR <sup>(4)</sup>
			14S1	ATtiny44A-SSN
				ATtiny44A-SSNR
		Industrial (-40°C to +125°C) <sup>(7)</sup>	14S1	ATtiny44A-SSF
				ATtiny44A-SSFR
			20M1	ATtiny44A-MF
				ATtiny44A-MFR

Notes: 1. For speed vs. supply voltage, see section 20.3 "Speed" on page 174.

2. All packages are Pb-free, halide-free and fully green and they comply with the European directive for Restriction of Hazardous Substances (RoHS).

3. Code indicators:

- H: NiPdAu lead finish
- F, N, U: matte tin
- R: tape & reel

4. Topside marking for ATtiny44A:

- 1st Line: T44
- 2nd Line: Axx
- 3rd Line: manufacturing data

5. These devices can also be supplied in wafer form. Please contact your local Atmel sales office for detailed ordering information and minimum quantities.

6. For typical and electrical characteristics, see "Appendix A – ATtiny24A/44A Specification at 105°C".

7. For typical and electrical characteristics, see "Appendix B – ATtiny24A/44A/84A Specification at 125°C".

Package Type	
<b>14S1</b>	14-lead, 0.150" Wide Body, Plastic Gull Wing Small Outline Package (SOIC)
<b>14P3</b>	14-lead, 0.300" Wide, Plastic Dual Inline Package (PDIP)
<b>15CC1</b>	15-ball (4 x 4 Array), 0.65 mm Pitch, 3.0 x 3.0 x 0.6 mm, Ultra Thin, Fine-Pitch Ball Grid Array Package (UFBGA)
<b>20M1</b>	20-pad, 4 x 4 x 0.8 mm Body, Quad Flat No Lead / Micro Lead Frame Package (QFN/MLF)
<b>20M2</b>	20-pad, 3 x 3 x 0.85 mm Body, Very Thin Quad Flat No Lead Package (VQFN)

## 6.3 ATtiny84A

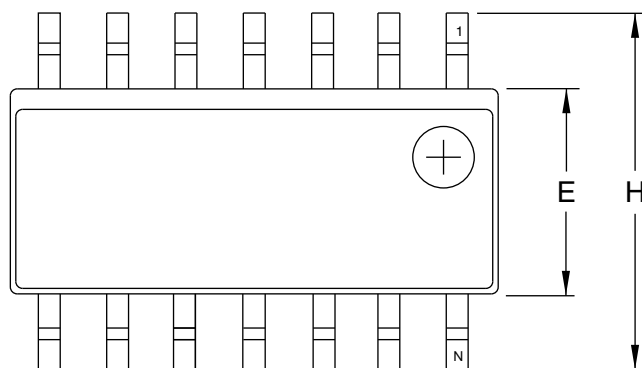
Speed (MHz) <sup>(1)</sup>	Supply Voltage (V)	Temperature Range	Package <sup>(2)</sup>	Ordering Code <sup>(3)</sup>
20	1.8 – 5.5V	Industrial (-40°C to +85°C) <sup>(5)</sup>	14S1	ATtiny84A-SSU
				ATtiny84A-SSUR
			14P3	ATtiny84A-PU
			15CC1	ATtiny84A-CCU
				ATtiny84A-CCUR
			20M1	ATtiny84A-MU
				ATtiny84A-MUR
			20M2	ATtiny84A-MMH <sup>(4)</sup>
				ATtiny84A-MMHR <sup>(4)</sup>
		Industrial (-40°C to +125°C) <sup>(7)</sup>	14S1	ATtiny84A-SSF
				ATtiny84A-SSFR

- Notes:
1. For speed vs. supply voltage, see section 20.3 "Speed" on page 174.
  2. All packages are Pb-free, halide-free and fully green and they comply with the European directive for Restriction of Hazardous Substances (RoHS).
  3. Code indicators:
    - H: NiPdAu lead finish
    - F, N, U: matte tin
    - R: tape & reel
  4. Topside marking for ATtiny84A:
    - 1st Line: T84
    - 2nd Line: Axx
    - 3rd Line: manufacturing data
  5. These devices can also be supplied in wafer form. Please contact your local Atmel sales office for detailed ordering information and minimum quantities.
  6. For typical and electrical characteristics, see "Appendix A – ATtiny24A/44A Specification at 105°C".
  7. For typical and electrical characteristics, see "Appendix B – ATtiny24A/44A/84A Specification at 125°C".

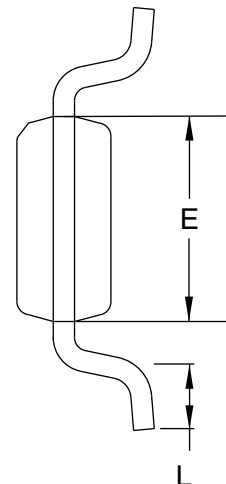
Package Type	
<b>14S1</b>	14-lead, 0.150" Wide Body, Plastic Gull Wing Small Outline Package (SOIC)
<b>14P3</b>	14-lead, 0.300" Wide, Plastic Dual Inline Package (PDIP)
<b>15CC1</b>	15-ball (4 x 4 Array), 0.65 mm Pitch, 3.0 x 3.0 x 0.6 mm, Ultra Thin, Fine-Pitch Ball Grid Array Package (UFBGA)
<b>20M1</b>	20-pad, 4 x 4 x 0.8 mm Body, Quad Flat No Lead / Micro Lead Frame Package (QFN/MLF)
<b>20M2</b>	20-pad, 3 x 3 x 0.85 mm Body, Very Thin Quad Flat No Lead Package (VQFN)

## 7. Packaging Information

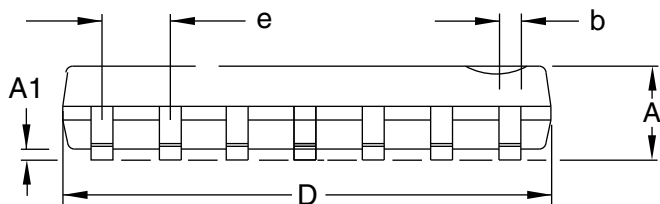
### 7.1 14S1



Top View



End View



Side View

**COMMON DIMENSIONS**  
(Unit of Measure = mm/inches)

SYMBOL	MIN	NOM	MAX	NOTE
A	1.35/0.0532	—	1.75/0.0688	
A1	0.1/0.0040	—	0.25/0.0098	
b	0.33/0.0130	—	0.5/0.02005	
D	8.55/0.3367	—	8.74/0.3444	2
E	3.8/0.1497	—	3.99/0.1574	3
H	5.8/0.2284	—	6.19/0.2440	
L	0.41/0.0160	—	1.27/0.0500	4
e	1.27/0.050 BSC			

- Notes:
1. This drawing is for general information only; refer to JEDEC Drawing MS-012, Variation AB for additional information.
  2. Dimension D does not include mold Flash, protrusions or gate burrs. Mold Flash, protrusion and gate burrs shall not exceed 0.15 mm (0.006") per side.
  3. Dimension E does not include inter-lead Flash or protrusion. Inter-lead flash and protrusions shall not exceed 0.25 mm (0.010") per side.
  4. L is the length of the terminal for soldering to a substrate.
  5. The lead width B, as measured 0.36 mm (0.014") or greater above the seating plane, shall not exceed a maximum value of 0.61 mm (0.024") per side.

2/5/02



2325 Orchard Parkway  
San Jose, CA 95131

**TITLE**

**14S1**, 14-lead, 0.150" Wide Body, Plastic Gull  
Wing Small Outline Package (SOIC)

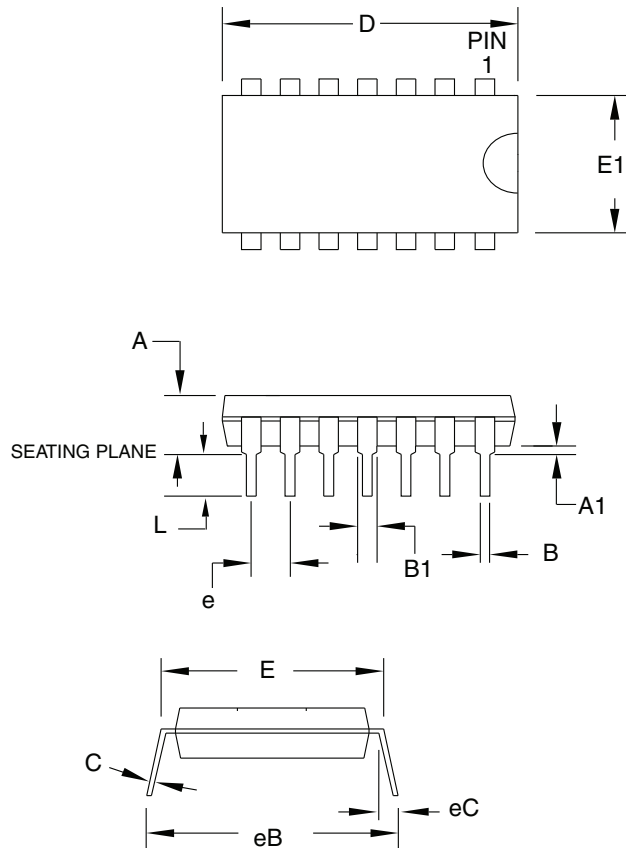
**DRAWING NO.**

14S1

**REV.**

A

## 7.2 14P3



**COMMON DIMENSIONS**  
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	–	–	5.334	
A1	0.381	–	–	
D	18.669	–	19.685	Note 2
E	7.620	–	8.255	
E1	6.096	–	7.112	Note 2
B	0.356	–	0.559	
B1	1.143	–	1.778	
L	2.921	–	3.810	
C	0.203	–	0.356	
eB	–	–	10.922	
eC	0.000	–	1.524	
e	2.540 TYP			

- Notes: 1. This package conforms to JEDEC reference MS-001, Variation AA.  
2. Dimensions D and E1 do not include mold Flash or Protrusion.  
Mold Flash or Protrusion shall not exceed 0.25 mm (0.010").

2010-10-20



2325 Orchard Parkway  
San Jose, CA 95131

### TITLE

**14P3**, 14-lead (0.300"/7.62 mm Wide) Plastic Dual  
Inline Package (PDIP)

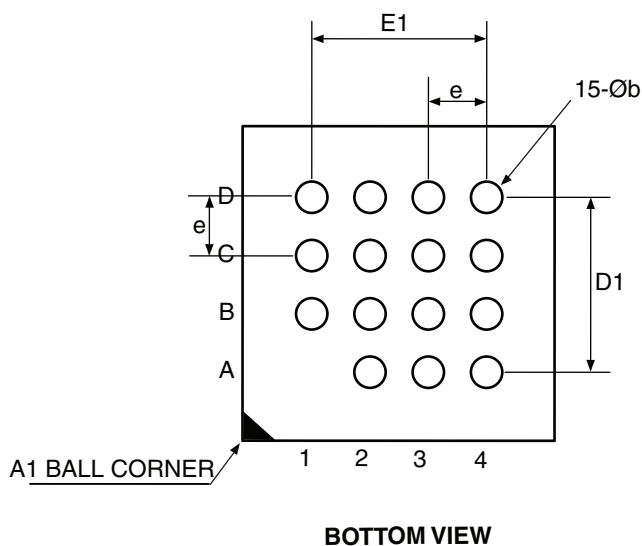
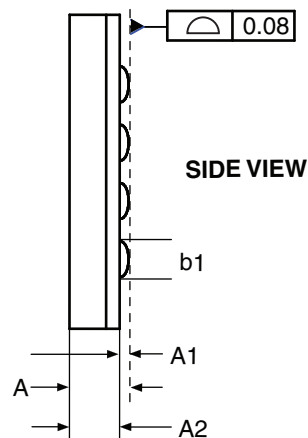
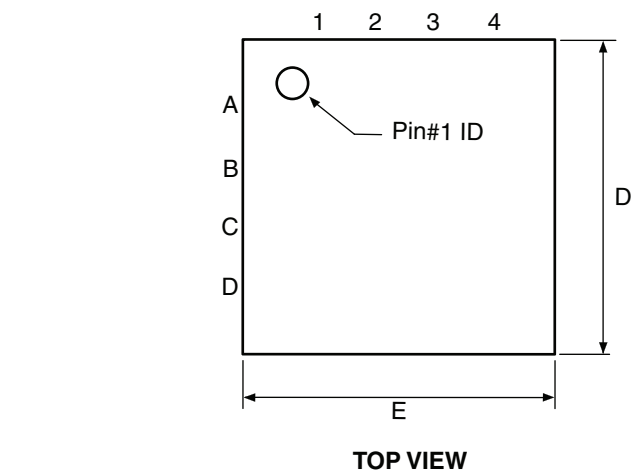
### DRAWING NO.

14P3

### REV.

B

## 7.3 15CC1



**COMMON DIMENSIONS**  
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	—	—	0.60	
A1	0.12	—	—	
A2	0.38 REF			
b	0.25	0.30	0.35	1
b1	0.25	—	—	2
D	2.90	3.00	3.10	
D1	1.95 BSC			
E	2.90	3.00	3.10	
E1	1.95 BSC			
e	0.65 BSC			

Note1: Dimension "b" is measured at the maximum ball dia. in a plane parallel to the seating plane.

Note2: Dimension "b1" is the solderable surface defined by the opening of the solder resist layer.

07/06/10



**Package Drawing Contact:**  
packagedrawings@atmel.com

**TITLE**

**15CC1**, 15-ball (4 x 4 Array), 3.0 x 3.0 x 0.6 mm package, ball pitch 0.65 mm, Ultra thin, Fine-Pitch Ball Grid Array Package (UFBGA)

**GPC**

CBC

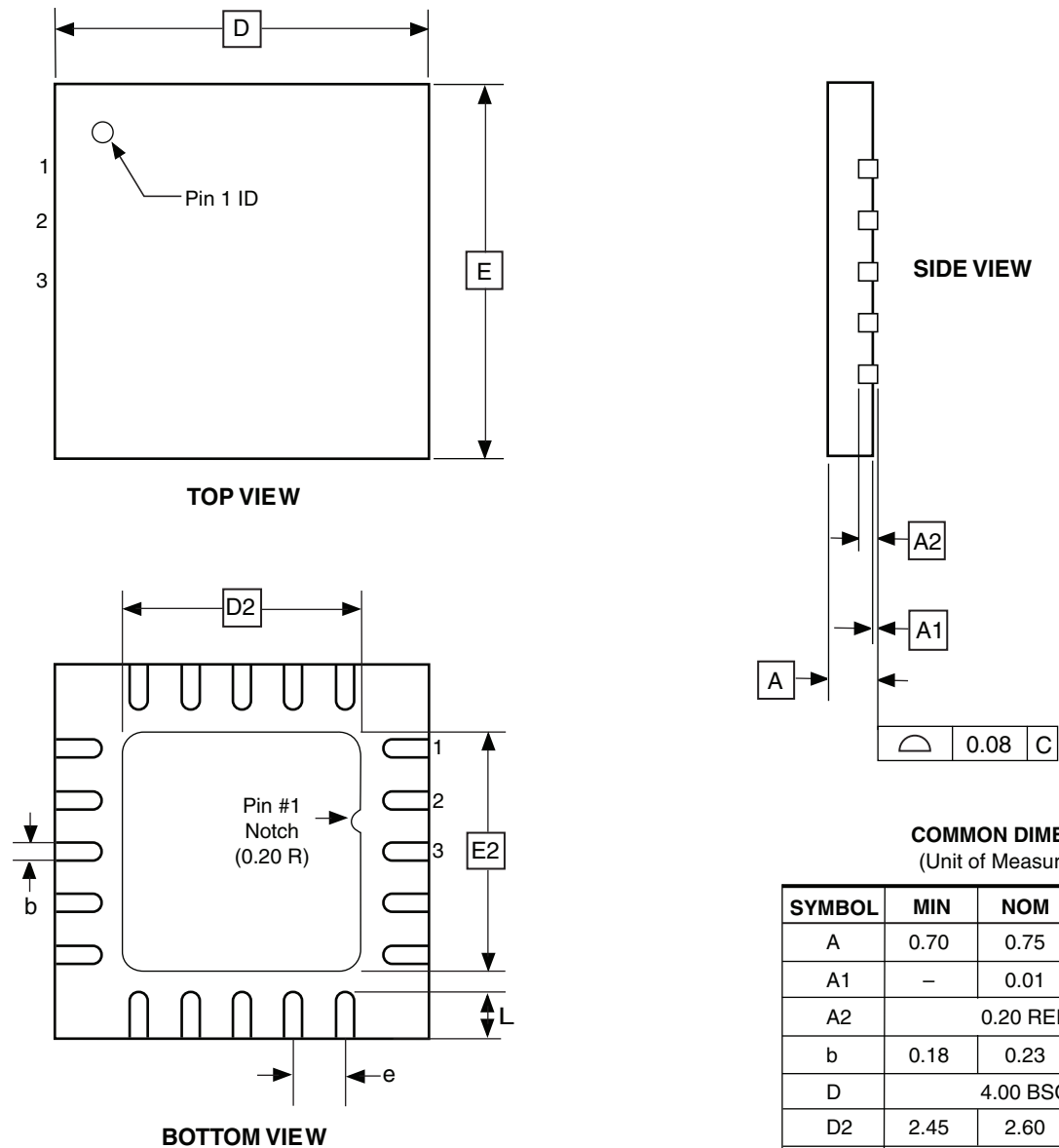
**DRAWING NO.**

15CC1

**REV.**

C

## 7.4 20M1



Note: Reference JEDEC Standard MO-220, Fig.1 (SAW Singulation) WGGD-5.

10/27/04



2325 Orchard Parkway  
San Jose, CA 95131

### TITLE

**20M1**, 20-pad, 4 x 4 x 0.8 mm Body, Lead Pitch 0.50 mm,  
2.6 mm Exposed Pad, Micro Lead Frame Package (MLF)

### DRAWING NO.

20M1

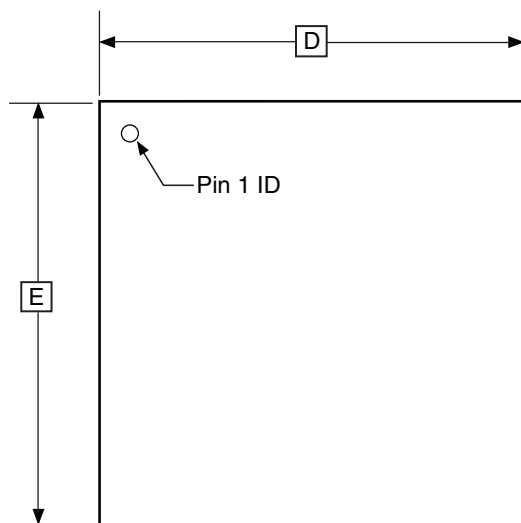
### REV.

B

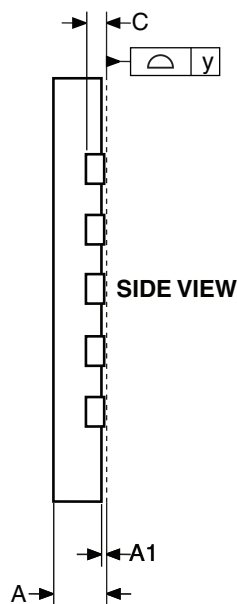




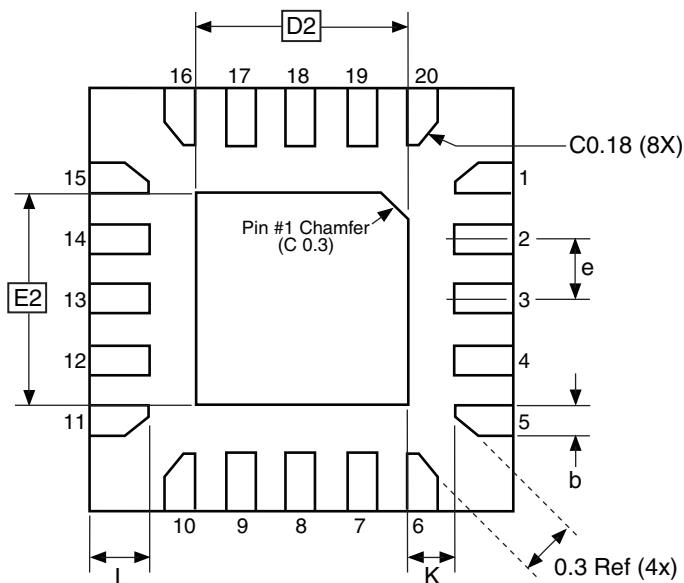
## 7.5 20M2



TOP VIEW



SIDE VIEW



BOTTOM VIEW

COMMON DIMENSIONS  
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	0.75	0.80	0.85	
A1	0.00	0.02	0.05	
b	0.17	0.22	0.27	
C	0.152			
D	2.90	3.00	3.10	
D2	1.40	1.55	1.70	
E	2.90	3.00	3.10	
E2	1.40	1.55	1.70	
e	–	0.45	–	
L	0.35	0.40	0.45	
K	0.20	–	–	
y	0.00	–	0.08	

10/24/08



**Package Drawing Contact:**  
packagedrawings@atmel.com

**TITLE**  
**20M2**, 20-pad, 3 x 3 x 0.85 mm Body, Lead Pitch 0.45 mm,  
1.55 x 1.55 mm Exposed Pad, Thermally Enhanced  
Plastic Very Thin Quad Flat No Lead Package (VQFN)

**GPC**  
ZFC

**DRAWING NO.**  
20M2

**REV.**  
B

## **8. Errata**

The revision letters in this section refer to the revision of the corresponding ATtiny24A/44A/84A device.

### **8.1 ATtiny24A**

#### **8.1.1 Rev. H**

No known errata.

#### **8.1.2 Rev. G**

Not sampled.

#### **8.1.3 Rev. F**

Not sampled.

### **8.2 ATtiny44A**

#### **8.2.1 Rev. G**

No known errata. Yield improvement.

#### **8.2.2 Rev. F**

No known errata.

#### **8.2.3 Rev. E**

Not sampled.

### **8.3 ATtiny84A**

#### **8.3.1 Rev. C**

No known errata.

## 9. Datasheet Revision History

### 9.1 Rev. 8183F – 06/12

1. Updated:
  - [Table 16-1 on page 138](#)
  - [Figure 16-7 on page 137](#)
  - [“Ordering Information” on page 11](#)

### 9.2 Rev. 8183E – 01/12

1. Updated:
  - Production status for ATtiny24A and ATtiny84A
  - [“Start Condition Detector” on page 122](#)
  - [“Ordering Information” on page 11, 12, and 13](#)

### 9.3 Rev. 8183D – 04/11

1. Added errata for ATtiny44A rev. G in [Section 8. “Errata” on page 19](#)

### 9.4 Rev. 8183C – 03/11

1. Added:
  - ATtiny84A, including typical characteristics plots
  - [Section 3.3 “Capacitive Touch Sensing” on page 6](#)
  - [Table 6-8, “Capacitance of Low-Frequency Crystal Oscillator,” on page 28](#)
  - Analog Comparator Offset plots for ATtiny24A ([Figure 21.2.10 on page 208](#)) and ATtiny44A ([Figure 21.3.11 on page 236](#))
  - Extended temperature part numbers in [Section 6. “Ordering Information” on page 11](#)
2. Updated:
  - Bit syntax throughout the datasheet, e.g. from CS02:0 to CS0[2:0]
  - [Section 6.4 “Clock Output Buffer” on page 30](#), changed CLK0 to CKOUT
  - [Table 16-4, “Single-Ended Input channel Selections,” on page 145](#), added note for Internal 1.1V Reference
  - [Table 19-16, “High-voltage Serial Programming Instruction Set for ATtiny24A/44A/84A,” on page 170](#), adjusted notes
  - [Table 20-1, “DC Characteristics. TA = -40°C to +85°C,” on page 173](#), adjusted notes

### 9.5 Rev. 8183B – 03/10

1. Updated template.
2. Added UFBGA package (15CC1) in: [“Features” on page 1](#), [“Pin Configurations” on page 2](#), [Section 6. “Ordering Information” on page 11](#), and [Section 7.3 “15CC1” on page 16](#).
3. Separated typical characteristic plots, added [Section 21.2 “ATtiny24A” on page 183](#).
4. Updated sections:
  - [Section 14.5.4 “USIBR – USI Buffer Register” on page 127](#), header updated

- [Section 6. “Ordering Information” on page 11](#), added tape & reel and topside marking, updated notes
- 5. Updated Figures:
  - [Figure 4-1 “Block Diagram of the AVR Architecture” on page 7](#)
  - [Figure 8-1 “Reset Logic” on page 38](#)
  - [Figure 14-1 “Universal Serial Interface, Block Diagram” on page 116](#), USIDB -> USIBR
  - [Figure 19-5 “High-voltage Serial Programming Waveforms” on page 169](#)
- 6. Updated Tables:
  - [Table 19-11, “Minimum Wait Delay Before Writing the Next Flash or EEPROM Location,” on page 164](#), updated value for  $t_{WD\_ERASE}$

## **9.6 Rev. 8183A – 12/08**

1. Initial revision. Created from document 8006H.
2. Updated "Ordering Information" on [page 19](#) and [page 19](#). Pb-plated packages are no longer offered and there are no separate ordering codes for commercial operation range, the only available option now is industrial. Also, updated some order codes to reflect changes in leadframe composition and added VQFN package option.
3. Updated data sheet template.
4. Removed all references to 8K device.
5. Updated characteristic plots of section “Typical Characteristics”, starting on [page 182](#).
6. Added characteristic plots:
  - [“Bandgap Voltage vs. Supply Voltage” on page 233](#)
  - [“Bandgap Voltage vs. Temperature” on page 233](#)
7. Updated sections:
  - [“Features” on page 1](#)
  - [“Power Reduction Register” on page 35](#)
  - [“Analog Comparator” on page 128](#)
  - [“Features” on page 132](#)
  - [“Operation” on page 133](#)
  - [“Starting a Conversion” on page 134](#)
  - [“ADC Voltage Reference” on page 139](#)
  - [“Speed” on page 174](#)
8. Updated Figures:
  - [“Program Memory Map” on page 15](#)
  - [“Data Memory Map” on page 16](#)
9. Update Tables:
  - [“Device Signature Bytes” on page 161](#)
  - [“DC Characteristics. TA = -40°C to +85°C” on page 173](#)
  - [“Additional Current Consumption for the different I/O modules \(absolute values\)” on page 182](#)
  - [“Additional Current Consumption \(percentage\) in Active and Idle mode” on page 183](#)



## Headquarters

---

### **Atmel Corporation**

2325 Orchard Parkway  
San Jose, CA 95131  
USA  
Tel: (+1)(408) 441-0311  
Fax: (+1)(408) 487-2600

## International

---

### **Atmel Asia Limited**

Unit 01-5 & 16, 19F  
BEA Tower, Millennium City 5  
418 Kwun Tong Road  
Kwun Tong, Kowloon  
HONG KONG  
Tel: (+852) 2245-6100  
Fax: (+852) 2722-1369

### **Atmel Munich GmbH**

Business Campus  
Parking 4  
D-85748 Garching b. Munich  
GERMANY  
Tel: (+49) 89-31970-0  
Fax: (+49) 89-3194621

### **Atmel Japan**

9F, Tonetsu Shinkawa Bldg.  
1-24-8 Shinkawa  
Chuo-ku, Tokyo 104-0033  
JAPAN  
Tel: (+81)(3) 3523-3551  
Fax: (+81)(3) 3523-7581

## Product Contact

---

### **Web Site**

[www.atmel.com](http://www.atmel.com)

### **Technical Support**

[avr@atmel.com](mailto:avr@atmel.com)

### **Sales Contact**

[www.atmel.com/contacts](http://www.atmel.com/contacts)

### **Literature Requests**

[www.atmel.com/literature](http://www.atmel.com/literature)

---

**Disclaimer:** The information in this document is provided in connection with Atmel products. No license, express or implied, by estoppel or otherwise, to any intellectual property right is granted by this document or in connection with the sale of Atmel products. **EXCEPT AS SET FORTH IN ATMEL'S TERMS AND CONDITIONS OF SALE LOCATED ON ATMEL'S WEB SITE, ATMEL ASSUMES NO LIABILITY WHATSOEVER AND DISCLAIMS ANY EXPRESS, IMPLIED OR STATUTORY WARRANTY RELATING TO ITS PRODUCTS INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT. IN NO EVENT SHALL ATMEL BE LIABLE FOR ANY DIRECT, INDIRECT, CONSEQUENTIAL, PUNITIVE, SPECIAL OR INCIDENTAL DAMAGES (INCLUDING, WITHOUT LIMITATION, DAMAGES FOR LOSS OF PROFITS, BUSINESS INTERRUPTION, OR LOSS OF INFORMATION) ARISING OUT OF THE USE OR INABILITY TO USE THIS DOCUMENT, EVEN IF ATMEL HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.** Atmel makes no representations or warranties with respect to the accuracy or completeness of the contents of this document and reserves the right to make changes to specifications and product descriptions at any time without notice. Atmel does not make any commitment to update the information contained herein. Unless specifically provided otherwise, Atmel products are not suitable for, and shall not be used in, automotive applications. Atmel's products are not intended, authorized, or warranted for use as components in applications intended to support or sustain life.

© 2012 Atmel Corporation. All rights reserved.

Atmel®, logo and combinations thereof, and others are registered trademarks or trademarks of Atmel Corporation or its subsidiaries. Other terms and product names may be trademarks of others.