

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	12MHz
Connectivity	I ² C, SPI
Peripherals	Brown-out Detect/Reset, POR, WDT
Number of I/O	28
Program Memory Size	8KB (4K x 16)
Program Memory Type	FLASH
EEPROM Size	64 x 8
RAM Size	512 x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 5.5V
Data Converters	A/D 8x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	32-VFQFN Exposed Pad
Supplier Device Package	32-VQFN (5x5)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/attiny88-mu

1. Pin Configurations

Figure 1-1. Pinout of ATtiny48/88

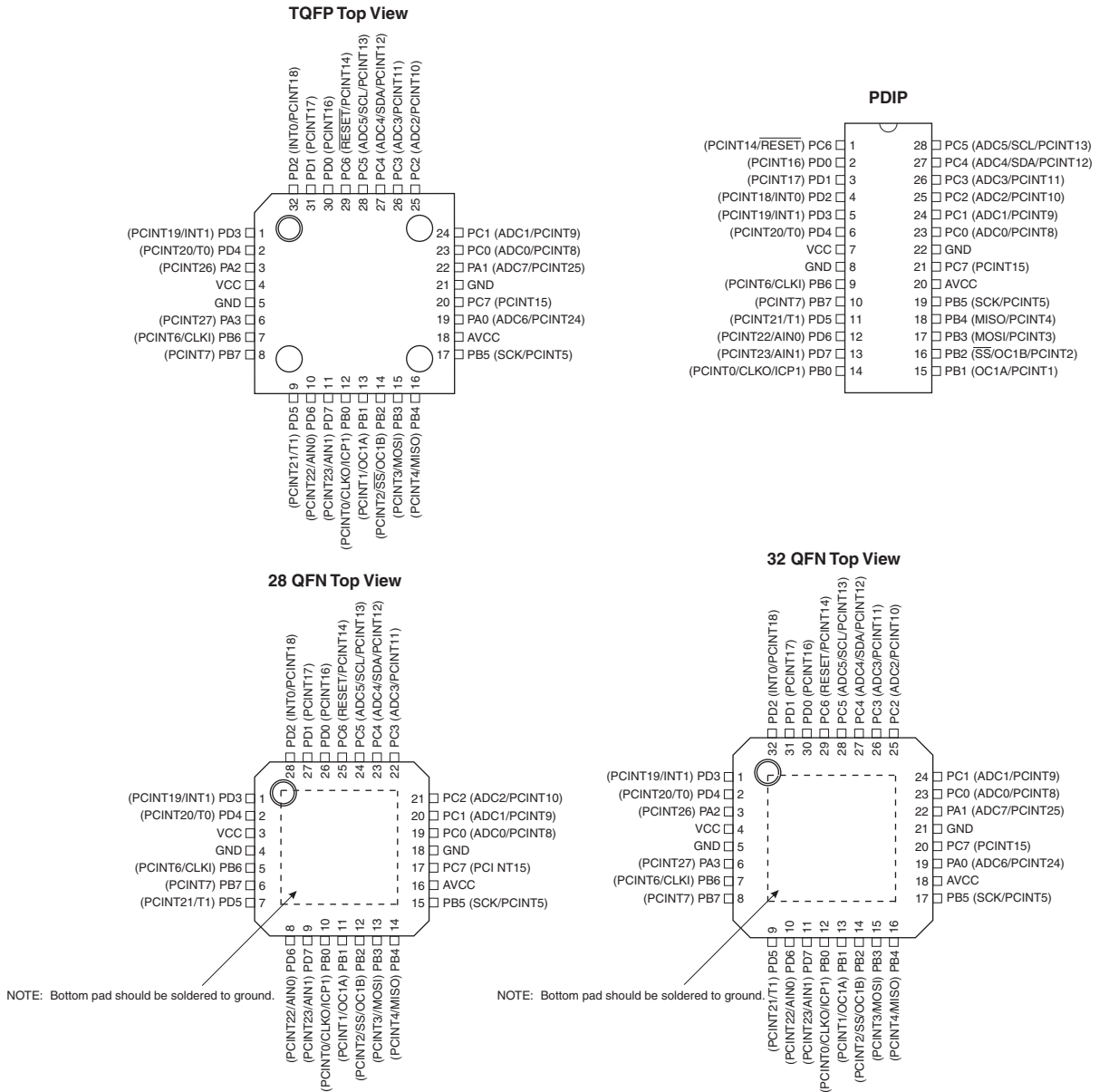


Table 1-1. 32 UFBGA Top View. See [page 288](#).

	1	2	3	4	5	6
A	PD2	PD1	PC6	PC4	PC2	PC1
B	PD3	PD4	PD0	PC5	PC3	PC0
C	GND	PA2			PA1	GND
D	VCC	PA3			PC7	PA0
E	PB6	PD6	PB0	PB2	AVCC	PB5
F	PB7	PD5	PD7	PB1	PB3	PB4

minimum pulse length is given in [Table 22-3 on page 209](#). Shorter pulses are not guaranteed to generate a reset.

The various special features of Port C are elaborated in [“Alternate Functions of Port C” on page 72](#).

1.1.8 Port D (PD7:0)

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PD[7:4] output buffers have symmetrical drive characteristics with both sink and source capabilities, while the PD[3:0] output buffers have high sink capabilities. 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.

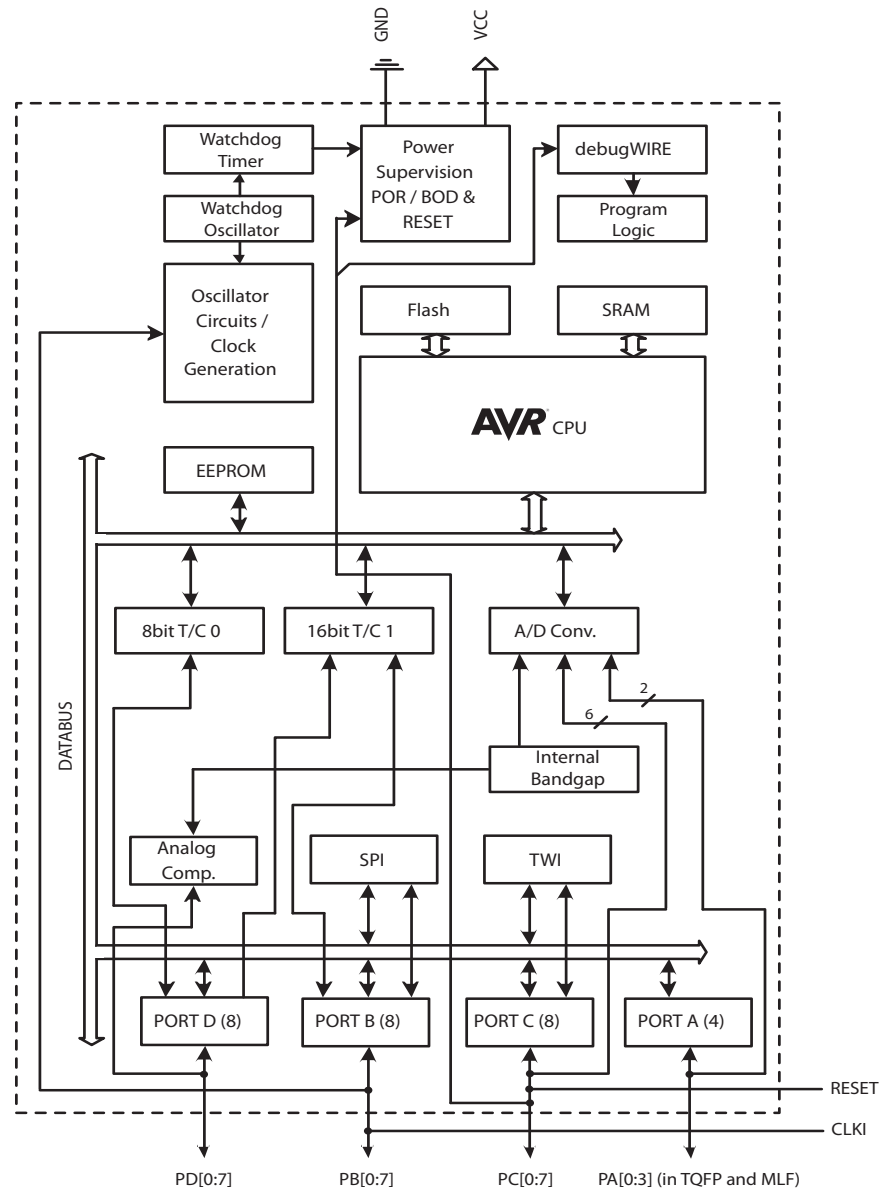
The various special features of Port D are elaborated in [“Alternate Functions of Port D” on page 75](#).

2. Overview

The ATtiny48/88 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 ATtiny48/88 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 ATtiny48/88 provides the following features:

- 4/8K bytes of In-System Programmable Flash
- 64/64 bytes EEPROM
- 256/512 bytes SRAM
- 24 general purpose I/O lines
 - 28 in 32-lead TQFP, 32-pad QFN, and 32-ball UFBGA packages
- 32 general purpose working registers
- Two flexible Timer/Counters with compare modes
- Internal and external interrupts
- A byte-oriented, 2-wire serial interface
- An SPI serial port
- A 6-channel, 10-bit ADC
 - 8 in 32-lead TQFP, 32-pad QFN, and 32-ball UFBGA packages
- A programmable Watchdog Timer with internal oscillator
- Three software selectable power saving modes.

The device includes the following modes for saving power:

- Idle mode: stops the CPU while allowing the timer/counter, ADC, analog comparator, SPI, TWI, 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
- Power-down mode: registers keep their contents and all chip functions are disabled until the next interrupt or hardware reset

The device is manufactured using Atmel's high density non-volatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed In-System through an SPI serial interface, by a conventional non-volatile memory programmer, or by an on-chip boot program running on the AVR core. The boot program can use any interface to download the application program in the Flash memory. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATtiny48/88 is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications.

The ATtiny48/88 AVR is supported by a full suite of program and system development tools including: C compilers, macro assemblers, program debugger/simulators and evaluation kits.

2.2 Comparison Between ATtiny48 and ATtiny88

The ATtiny48 and ATtiny88 differ only in memory sizes, as summarised in [Table 2-1](#), below.

Table 2-1. Memory Size Summary

Device	Flash	EEPROM	RAM
ATtiny48	4K Bytes	64 Bytes	256 Bytes
ATtiny88	8K Bytes	64 Bytes	512 Bytes

3. General Information

3.1 Resources

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

3.2 About Code Examples

This documentation contains simple code examples that briefly show how to use various parts of the device. These code examples assume that the part specific header file is included before compilation. Be aware that not all C compiler vendors include bit definitions in the header files and interrupt handling in C is compiler dependent. Please confirm with the C compiler documentation for more details.

For I/O Registers located in extended I/O map, “IN”, “OUT”, “SBIS”, “SBIC”, “CBI”, and “SBI” instructions must be replaced with instructions that allow access to extended I/O. Typically “LDS” and “STS” combined with “SBR”, “SBRC”, “SBR”, and “CBR”.

3.3 Capacitive Touch Sensing

Atmel QTouch Library provides a simple to use solution for touch sensitive interfaces on Atmel AVR microcontrollers. The QTouch Library includes support for QTouch® and QMatrix® acquisition methods.

Touch sensing is easily added to any application by linking the QTouch Library and using the Application Programming Interface (API) of the library to define the touch channels and sensors. The application then calls the API to retrieve channel information and determine the state of the touch sensor.

The QTouch Library is free and can be downloaded from the Atmel website. For more information and details of implementation, refer to the QTouch Library User Guide – also available from the Atmel website.

3.4 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.

3.5 Disclaimer

Typical values contained in this datasheet are based on simulations and characterization of other AVR microcontrollers manufactured on the same process technology.



4. Register Summary

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
(0xFF)	Reserved	-	-	-	-	-	-	-	-	
(0xFE)	Reserved	-	-	-	-	-	-	-	-	
(0xFD)	Reserved	-	-	-	-	-	-	-	-	
(0xFC)	Reserved	-	-	-	-	-	-	-	-	
(0xFB)	Reserved	-	-	-	-	-	-	-	-	
(0xFA)	Reserved	-	-	-	-	-	-	-	-	
(0xF9)	Reserved	-	-	-	-	-	-	-	-	
(0xF8)	Reserved	-	-	-	-	-	-	-	-	
(0xF7)	Reserved	-	-	-	-	-	-	-	-	
(0xF6)	Reserved	-	-	-	-	-	-	-	-	
(0xF5)	Reserved	-	-	-	-	-	-	-	-	
(0xF4)	Reserved	-	-	-	-	-	-	-	-	
(0xF3)	Reserved	-	-	-	-	-	-	-	-	
(0xF2)	Reserved	-	-	-	-	-	-	-	-	
(0xF1)	Reserved	-	-	-	-	-	-	-	-	
(0xF0)	Reserved	-	-	-	-	-	-	-	-	
(0xEF)	Reserved	-	-	-	-	-	-	-	-	
(0xEE)	Reserved	-	-	-	-	-	-	-	-	
(0xED)	Reserved	-	-	-	-	-	-	-	-	
(0xEC)	Reserved	-	-	-	-	-	-	-	-	
(0xEB)	Reserved	-	-	-	-	-	-	-	-	
(0xEA)	Reserved	-	-	-	-	-	-	-	-	
(0xE9)	Reserved	-	-	-	-	-	-	-	-	
(0xE8)	Reserved	-	-	-	-	-	-	-	-	
(0xE7)	Reserved	-	-	-	-	-	-	-	-	
(0xE6)	Reserved	-	-	-	-	-	-	-	-	
(0xE5)	Reserved	-	-	-	-	-	-	-	-	
(0xE4)	Reserved	-	-	-	-	-	-	-	-	
(0xE3)	Reserved	-	-	-	-	-	-	-	-	
(0xE2)	Reserved	-	-	-	-	-	-	-	-	
(0xE1)	Reserved	-	-	-	-	-	-	-	-	
(0xE0)	Reserved	-	-	-	-	-	-	-	-	
(0xDF)	Reserved	-	-	-	-	-	-	-	-	
(0xDE)	Reserved	-	-	-	-	-	-	-	-	
(0xDD)	Reserved	-	-	-	-	-	-	-	-	
(0xDC)	Reserved	-	-	-	-	-	-	-	-	
(0xDB)	Reserved	-	-	-	-	-	-	-	-	
(0xDA)	Reserved	-	-	-	-	-	-	-	-	
(0xD9)	Reserved	-	-	-	-	-	-	-	-	
(0xD8)	Reserved	-	-	-	-	-	-	-	-	
(0xD7)	Reserved	-	-	-	-	-	-	-	-	
(0xD6)	Reserved	-	-	-	-	-	-	-	-	
(0xD5)	Reserved	-	-	-	-	-	-	-	-	
(0xD4)	Reserved	-	-	-	-	-	-	-	-	
(0xD3)	Reserved	-	-	-	-	-	-	-	-	
(0xD2)	Reserved	-	-	-	-	-	-	-	-	
(0xD1)	Reserved	-	-	-	-	-	-	-	-	
(0xD0)	Reserved	-	-	-	-	-	-	-	-	
(0xCF)	Reserved	-	-	-	-	-	-	-	-	
(0xCE)	Reserved	-	-	-	-	-	-	-	-	
(0xCD)	Reserved	-	-	-	-	-	-	-	-	
(0xCC)	Reserved	-	-	-	-	-	-	-	-	
(0xCB)	Reserved	-	-	-	-	-	-	-	-	
(0xCA)	Reserved	-	-	-	-	-	-	-	-	
(0xC9)	Reserved	-	-	-	-	-	-	-	-	
(0xC8)	Reserved	-	-	-	-	-	-	-	-	
(0xC7)	Reserved	-	-	-	-	-	-	-	-	
(0xC6)	Reserved	-	-	-	-	-	-	-	-	
(0xC5)	Reserved	-	-	-	-	-	-	-	-	
(0xC4)	Reserved	-	-	-	-	-	-	-	-	
(0xC3)	Reserved	-	-	-	-	-	-	-	-	
(0xC2)	Reserved	-	-	-	-	-	-	-	-	
(0xC1)	Reserved	-	-	-	-	-	-	-	-	
(0xC0)	Reserved	-	-	-	-	-	-	-	-	
(0xBF)	Reserved	-	-	-	-	-	-	-	-	

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
(0xBE)	TWHSR	–	–	–	–	–	–	–	TWHS	160
(0xBD)	TWAMR	TWAM6	TWAM5	TWAM4	TWAM3	TWAM2	TWAM1	TWAM0	–	160
(0xBC)	TWCR	TWINT	TWEA	TWSTA	TWSTO	TWWC	TWEN	–	TWIE	156
(0xBB)	TWDR	2-wire Serial Interface Data Register								159
(0xBA)	TWAR	TWA6	TWA5	TWA4	TWA3	TWA2	TWA1	TWA0	TWGCE	159
(0xB9)	TWSR	TWS7	TWS6	TWS5	TWS4	TWS3	–	TWPS1	TWPS0	158
(0xB8)	TWBR	2-wire Serial Interface Bit Rate Register								156
(0xB7)	Reserved	–	–	–	–	–	–	–	–	
(0xB6)	Reserved	–	–	–	–	–	–	–	–	
(0xB5)	Reserved	–	–	–	–	–	–	–	–	
(0xB4)	Reserved	–	–	–	–	–	–	–	–	
(0xB3)	Reserved	–	–	–	–	–	–	–	–	
(0xB2)	Reserved	–	–	–	–	–	–	–	–	
(0xB1)	Reserved	–	–	–	–	–	–	–	–	
(0xB0)	Reserved	–	–	–	–	–	–	–	–	
(0xAF)	Reserved	–	–	–	–	–	–	–	–	
(0xAE)	Reserved	–	–	–	–	–	–	–	–	
(0xAD)	Reserved	–	–	–	–	–	–	–	–	
(0xAC)	Reserved	–	–	–	–	–	–	–	–	
(0xAB)	Reserved	–	–	–	–	–	–	–	–	
(0xAA)	Reserved	–	–	–	–	–	–	–	–	
(0xA9)	Reserved	–	–	–	–	–	–	–	–	
(0xA8)	Reserved	–	–	–	–	–	–	–	–	
(0xA7)	Reserved	–	–	–	–	–	–	–	–	
(0xA6)	Reserved	–	–	–	–	–	–	–	–	
(0xA5)	Reserved	–	–	–	–	–	–	–	–	
(0xA4)	Reserved	–	–	–	–	–	–	–	–	
(0xA3)	Reserved	–	–	–	–	–	–	–	–	
(0xA2)	Reserved	–	–	–	–	–	–	–	–	
(0xA1)	Reserved	–	–	–	–	–	–	–	–	
(0xA0)	Reserved	–	–	–	–	–	–	–	–	
(0x9F)	Reserved	–	–	–	–	–	–	–	–	
(0x9E)	Reserved	–	–	–	–	–	–	–	–	
(0x9D)	Reserved	–	–	–	–	–	–	–	–	
(0x9C)	Reserved	–	–	–	–	–	–	–	–	
(0x9B)	Reserved	–	–	–	–	–	–	–	–	
(0x9A)	Reserved	–	–	–	–	–	–	–	–	
(0x99)	Reserved	–	–	–	–	–	–	–	–	
(0x98)	Reserved	–	–	–	–	–	–	–	–	
(0x97)	Reserved	–	–	–	–	–	–	–	–	
(0x96)	Reserved	–	–	–	–	–	–	–	–	
(0x95)	Reserved	–	–	–	–	–	–	–	–	
(0x94)	Reserved	–	–	–	–	–	–	–	–	
(0x93)	Reserved	–	–	–	–	–	–	–	–	
(0x92)	Reserved	–	–	–	–	–	–	–	–	
(0x91)	Reserved	–	–	–	–	–	–	–	–	
(0x90)	Reserved	–	–	–	–	–	–	–	–	
(0x8F)	Reserved	–	–	–	–	–	–	–	–	
(0x8E)	Reserved	–	–	–	–	–	–	–	–	
(0x8D)	Reserved	–	–	–	–	–	–	–	–	
(0x8C)	Reserved	–	–	–	–	–	–	–	–	
(0x8B)	OCR1BH	Timer/Counter1 — Output Compare Register B High Byte								114
(0x8A)	OCR1BL	Timer/Counter1 — Output Compare Register B Low Byte								114
(0x89)	OCR1AH	Timer/Counter1 — Output Compare Register A High Byte								114
(0x88)	OCR1AL	Timer/Counter1 — Output Compare Register A Low Byte								114
(0x87)	ICR1H	Timer/Counter1 — Input Capture Register High Byte								114
(0x86)	ICR1L	Timer/Counter1 — Input Capture Register Low Byte								114
(0x85)	TCNT1H	Timer/Counter1 — Counter Register High Byte								113
(0x84)	TCNT1L	Timer/Counter1 — Counter Register Low Byte								113
(0x83)	Reserved	–	–	–	–	–	–	–	–	
(0x82)	TCCR1C	FOC1A	FOC1B	–	–	–	–	–	–	113
(0x81)	TCCR1B	ICNC1	ICES1	–	WGM13	WGM12	CS12	CS11	CS10	112
(0x80)	TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	–	–	WGM11	WGM10	110
(0x7F)	DIDR1	–	–	–	–	–	–	AIN1D	AIN0D	163
(0x7E)	DIDR0	ADC7D	ADC6D	ADC5D	ADC4D	ADC3D	ADC2D	ADC1D	ADC0D	180
(0x7D)	Reserved	–	–	–	–	–	–	–	–	

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
(0x7C)	ADMUX	–	REFS0	ADLAR	–	MUX3	MUX2	MUX1	MUX0	176
(0x7B)	ADCSRB	–	ACME	–	–	–	ADTS2	ADTS1	ADTS0	162, 179
(0x7A)	ADCSRA	ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0	178
(0x79)	ADCH	ADC Data Register High byte								179
(0x78)	ADCL	ADC Data Register Low byte								179
(0x77)	Reserved	–	–	–	–	–	–	–	–	
(0x76)	Reserved	–	–	–	–	–	–	–	–	
(0x75)	Reserved	–	–	–	–	–	–	–	–	
(0x74)	Reserved	–	–	–	–	–	–	–	–	
(0x73)	Reserved	–	–	–	–	–	–	–	–	
(0x72)	Reserved	–	–	–	–	–	–	–	–	
(0x71)	Reserved	–	–	–	–	–	–	–	–	
(0x70)	Reserved	–	–	–	–	–	–	–	–	
(0x6F)	TIMSK1	–	–	ICIE1	–	–	OCIE1B	OCIE1A	TOIE1	114
(0x6E)	TIMSK0	–	–	–	–	–	OCIE0B	OCIE0A	TOIE0	87
(0x6D)	PCMSK2	PCINT23	PCINT22	PCINT21	PCINT20	PCINT19	PCINT18	PCINT17	PCINT16	59
(0x6C)	PCMSK1	PCINT15	PCINT14	PCINT13	PCINT12	PCINT11	PCINT10	PCINT9	PCINT8	59
(0x6B)	PCMSK0	PCINT7	PCINT6	PCINT5	PCINT4	PCINT3	PCINT2	PCINT1	PCINT0	59
(0x6A)	PCMSK3	–	–	–	–	PCINT27	PCINT26	PCINT25	PCINT24	59
(0x69)	EICRA	–	–	–	–	ISC11	ISC10	ISC01	ISC00	55
(0x68)	PCICR	–	–	–	–	PCIE3	PCIE2	PCIE1	PCIE0	57
(0x67)	Reserved	–	–	–	–	–	–	–	–	
(0x66)	OSCCAL	Oscillator Calibration Register								34
(0x65)	Reserved	–	–	–	–	–	–	–	–	
(0x64)	PRR	PRTWI	–	PRTIM0	–	PRTIM1	PRSPI	–	PRADC	40
(0x63)	Reserved	–	–	–	–	–	–	–	–	
(0x62)	Reserved	–	–	–	–	–	–	–	–	
(0x61)	CLKPR	CLKPCE	–	–	–	CLKPS3	CLKPS2	CLKPS1	CLKPS0	34
(0x60)	WDTCR	WDIF	WDIE	WDP3	WDCE	WDE	WDP2	WDP1	WDP0	49
0x3F (0x5F)	SREG	I	T	H	S	V	N	Z	C	9
0x3E (0x5E)	SPH	–	–	–	–	–	–	SP9	SP8	11
0x3D (0x5D)	SPL	SP7	SP6	SP5	SP4	SP3	SP2	SP1	SP0	11
0x3C (0x5C)	Reserved	–	–	–	–	–	–	–	–	
0x3B (0x5B)	Reserved	–	–	–	–	–	–	–	–	
0x3A (0x5A)	Reserved	–	–	–	–	–	–	–	–	
0x39 (0x59)	Reserved	–	–	–	–	–	–	–	–	
0x38 (0x58)	Reserved	–	–	–	–	–	–	–	–	
0x37 (0x57)	SPMCSR	–	RWWBSB	–	CTPB	RFLB	PGWRT	PGERS	SELFPRGEN	186
0x36 (0x56)	Reserved	–	–	–	–	–	–	–	–	
0x35 (0x55)	MCUCR	–	BODS	BODSE	PUD	–	–	–	–	40, 77
0x34 (0x54)	MCUSR	–	–	–	–	WDRF	BORF	EXTRF	PORF	49
0x33 (0x53)	SMCR	–	–	–	–	–	SM1	SM0	SE	39
0x32 (0x52)	Reserved	–	–	–	–	–	–	–	–	
0x31 (0x51)	DWDR	debugWire Data Register								182
0x30 (0x50)	ACSR	ACD	ACBG	ACO	ACI	ACIE	ACIC	ACIS1	ACIS0	162
0x2F (0x4F)	Reserved	–	–	–	–	–	–	–	–	
0x2E (0x4E)	SPDR	SPI Data Register								128
0x2D (0x4D)	SPSR	SPIF	WCOL	–	–	–	–	–	SPI2X	127
0x2C (0x4C)	SPCR	SPIE	SPE	DORD	MSTR	CPOL	CPHA	SPR1	SPR0	126
0x2B (0x4B)	GPOR2	General Purpose I/O Register 2								27
0x2A (0x4A)	GPOR1	General Purpose I/O Register 1								27
0x29 (0x49)	Reserved	–	–	–	–	–	–	–	–	
0x28 (0x48)	OCR0B	Timer/Counter0 Output Compare Register B								87
0x27 (0x47)	OCR0A	Timer/Counter0 Output Compare Register A								86
0x26 (0x46)	TCNT0	Timer/Counter0 (8-bit)								86
0x25 (0x45)	TCCR0A	–	–	–	–	CTC0	CS02	CS01	CS00	85
0x24 (0x44)	Reserved	–	–	–	–	–	–	–	–	
0x23 (0x43)	GTCCR	TSM	–	–	–	–	–	–	PSRSYNC	118
0x22 (0x42)	Reserved	–	–	–	–	–	–	–	–	
0x21 (0x41)	EEARL	EEPROM Address Register Low Byte								25
0x20 (0x40)	EEDR	EEPROM Data Register								25
0x1F (0x3F)	EEDR	–	–	EEP1	EEP0	EERIE	EEMPE	EEPE	EERE	25
0x1E (0x3E)	GPOR0	General Purpose I/O Register 0								27
0x1D (0x3D)	EIMSK	–	–	–	–	–	–	INT1	INT0	56
0x1C (0x3C)	EIFR	–	–	–	–	–	–	INTF1	INTF0	56
0x1B (0x3B)	PCIFR	–	–	–	–	PCIF3	PCIF2	PCIF1	PCIF0	58

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
0x1A (0x3A)	Reserved	–	–	–	–	–	–	–	–	
0x19 (0x39)	Reserved	–	–	–	–	–	–	–	–	
0x18 (0x38)	Reserved	–	–	–	–	–	–	–	–	
0x17 (0x37)	Reserved	–	–	–	–	–	–	–	–	
0x16 (0x36)	TIFR1	–	–	ICF1	–	–	OCF1B	OCF1A	TOV1	115
0x15 (0x35)	TIFR0	–	–	–	–	–	OCF0B	OCF0A	TOV0	87
0x14 (0x34)	Reserved	–	–	–	–	–	–	–	–	
0x13 (0x33)	Reserved	–	–	–	–	–	–	–	–	
0x12 (0x32)	PORTCR	BBMD	BBMC	BBMB	BBMA	PUDD	PUDC	PUDB	PUDA	77
0x11 (0x31)	Reserved	–	–	–	–	–	–	–	–	
0x10 (0x30)	Reserved	–	–	–	–	–	–	–	–	
0x0F (0x2F)	Reserved	–	–	–	–	–	–	–	–	
0x0E (0x2E)	PORTA	–	–	–	–	PORTA3	PORTA2	PORTA1	PORTA0	78
0x0D (0x2D)	DDRA	–	–	–	–	DDA3	DDA2	DDA1	DDA0	78
0x0C (0x2C)	PINA	–	–	–	–	PINA3	PINA2	PINA1	PINA0	78
0x0B (0x2B)	PORTD	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0	79
0x0A (0x2A)	DDRD	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0	79
0x09 (0x29)	PIND	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0	79
0x08 (0x28)	PORTC	PORTC7	PORTC6	PORTC5	PORTC4	PORTC3	PORTC2	PORTC1	PORTC0	78
0x07 (0x27)	DDRC	DDC7	DDC6	DDC5	DDC4	DDC3	DDC2	DDC1	DDC0	78
0x06 (0x26)	PINC	PINC7	PINC6	PINC5	PINC4	PINC3	PINC2	PINC1	PINC0	79
0x05 (0x25)	PORTB	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0	78
0x04 (0x24)	DDRB	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0	78
0x03 (0x23)	PINB	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0	78
0x02 (0x22)	Reserved	–	–	–	–	–	–	–	–	
0x01 (0x21)	Reserved	–	–	–	–	–	–	–	–	
0x00 (0x20)	Reserved	–	–	–	–	–	–	–	–	

- Note:
- For compatibility with future devices, reserved bits should be written to zero if accessed. Reserved I/O memory addresses should never be written.
 - 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.
 - Some of the Status Flags are cleared by writing a logical one to them. Note that, unlike most other AVRs, the CBI and SBI instructions will only operate on 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.
 - When using the I/O specific commands IN and OUT, the I/O addresses 0x00 – 0x3F must be used. When addressing I/O Registers as data space using LD and ST instructions, 0x20 must be added to these addresses. The ATtiny48/88 is a complex microcontroller with more peripheral units than can be supported within the 64 location reserved in Opcode for the IN and OUT instructions. For the Extended I/O space from 0x60 – 0xFF in SRAM, only the ST/STS/STD and LD/LDS/LDD instructions can be used.

5. Instruction Set Summary

Mnemonics	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	$Rd \leftarrow 0xFF - Rd$	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
BRANCH INSTRUCTIONS					
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
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

6. Ordering Information

6.1 ATtiny48

Speed (MHz)	Power Supply	Ordering Code ⁽¹⁾	Package ⁽²⁾	Operational Range
12	1.8 – 5.5V	ATtiny48-MMU ATtiny48-MMUR ATtiny48-MMH ATtiny48-MMHR ATtiny48-PU ATtiny48-AU ATtiny48-AUR ATtiny48-CCU ATtiny48-CCUR ATtiny48-MU ATtiny48-MUR	28M1 28M1 28M1 28M1 28P3 32A 32A 32CC1 32CC1 32M1-A 32M1-A	Industrial (-40°C to +85°C) ⁽³⁾

Notes: 1. Code indicators:

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

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

Package Type	
28M1	28-pad, 4 x 4 x 1.0 body, Lead Pitch 0.45 mm, Quad Flat No-Lead (QFN)
28P3	28-lead, 0.300" Wide, Plastic Dual Inline Package (PDIP)
32A	32-lead, Thin (1.0 mm) Plastic Quad Flat Package (TQFP)
32CC1	32-ball (6 x 6 Array), 0.50 mm Pitch, 4 x 4 x 0.6 mm, Ultra Thin, Fine-Pitch Ball Grid Array Package (UFBGA)
32M1-A	32-pad, 5 x 5 x 1.0 body, Lead Pitch 0.50 mm, Quad Flat No-Lead (QFN)

6.2 ATtiny88

Speed (MHz)	Power Supply	Ordering Code ⁽¹⁾	Package ⁽²⁾	Operational Range
12	1.8 – 5.5V	ATtiny88-MMU ATtiny88-MMUR ATtiny88-MMH ATtiny88-MMHR ATtiny88-PU ATtiny88-AU ATtiny88-AUR ATtiny88-CCU ATtiny88-CCUR ATtiny88-MU ATtiny88-MUR	28M1 28M1 28M1 28M1 28P3 32A 32A 32CC1 32CC1 32M1-A 32M1-A	Industrial (-40°C to +85°C) ⁽³⁾

Notes: 1. Code indicators:

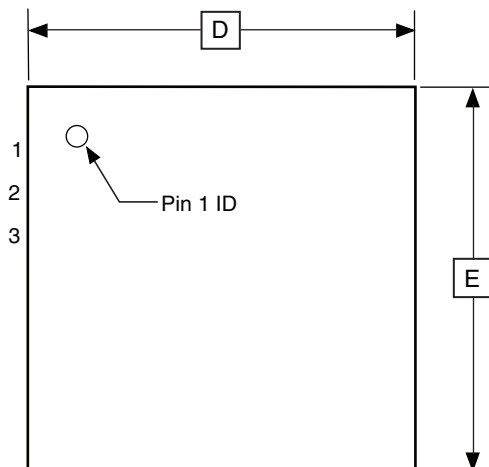
- H: NiPdAu lead finish
- U: matte tin
- R: tape & reel

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

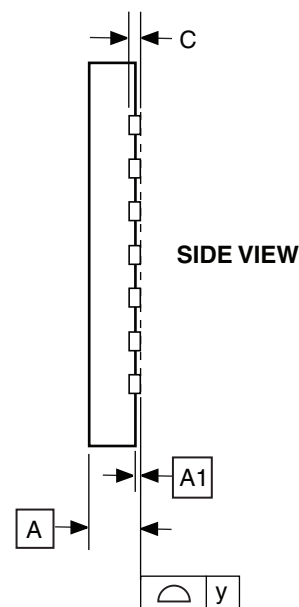
Package Type	
28M1	28-pad, 4 x 4 x 1.0 body, Lead Pitch 0.45 mm, Quad Flat No-Lead (QFN)
28P3	28-lead, 0.300" Wide, Plastic Dual Inline Package (PDIP)
32A	32-lead, Thin (1.0 mm) Plastic Quad Flat Package (TQFP)
32CC1	32-ball (6 x 6 Array), 0.50 mm Pitch, 4 x 4 x 0.6 mm, Ultra Thin, Fine-Pitch Ball Grid Array Package (UFBGA)
32M1-A	32-pad, 5 x 5 x 1.0 body, Lead Pitch 0.50 mm, Quad Flat No-Lead (QFN)

7. Packaging Information

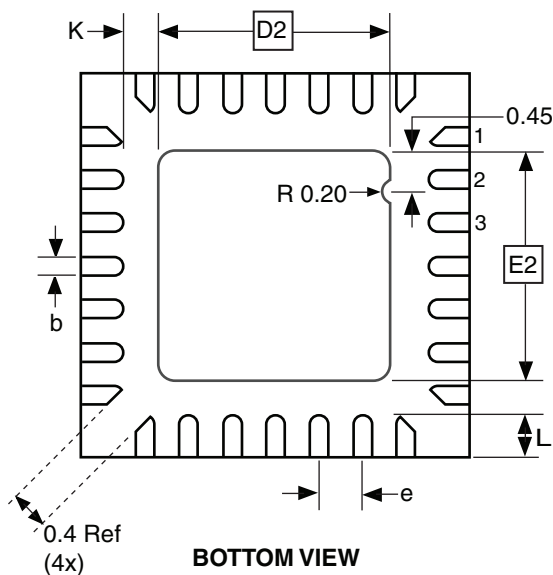
7.1 28M1



TOP VIEW



SIDE VIEW



BOTTOM VIEW

Note: The terminal #1 ID is a Laser-marked Feature.

COMMON DIMENSIONS
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	0.80	0.90	1.00	
A1	0.00	0.02	0.05	
b	0.17	0.22	0.27	
C	0.20 REF			
D	3.95	4.00	4.05	
D2	2.35	2.40	2.45	
E	3.95	4.00	4.05	
E2	2.35	2.40	2.45	
e	0.45			
L	0.35	0.40	0.45	
y	0.00	—	0.08	
K	0.20	—	—	

10/24/08



Package Drawing Contact:
packagedrawings@atmel.com

TITLE

28M1, 28-pad, 4 x 4 x 1.0 mm Body, Lead Pitch 0.45 mm,
2.4 x 2.4 mm Exposed Pad, Thermally Enhanced
Plastic Very Thin Quad Flat No Lead Package (VQFN)

GPC

ZBV

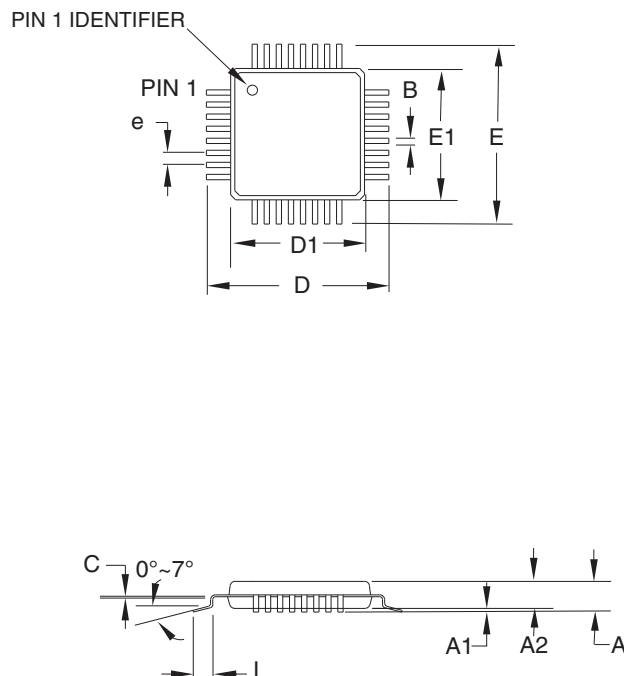
DRAWING NO.

28M1

REV.

B

7.3 32A



COMMON DIMENSIONS
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	—	—	1.20	
A1	0.05	—	0.15	
A2	0.95	1.00	1.05	
D	8.75	9.00	9.25	
D1	6.90	7.00	7.10	Note 2
E	8.75	9.00	9.25	
E1	6.90	7.00	7.10	Note 2
B	0.30	—	0.45	
C	0.09	—	0.20	
L	0.45	—	0.75	
e	0.80 TYP			

Notes:

1. This package conforms to JEDEC reference MS-026, Variation ABA.
2. Dimensions D1 and E1 do not include mold protrusion. Allowable protrusion is 0.25 mm per side. Dimensions D1 and E1 are maximum plastic body size dimensions including mold mismatch.
3. Lead coplanarity is 0.10 mm maximum.

2010-10-20



2325 Orchard Parkway
San Jose, CA 95131

TITLE

32A, 32-lead, 7 x 7 mm Body Size, 1.0 mm Body Thickness,
0.8 mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP)

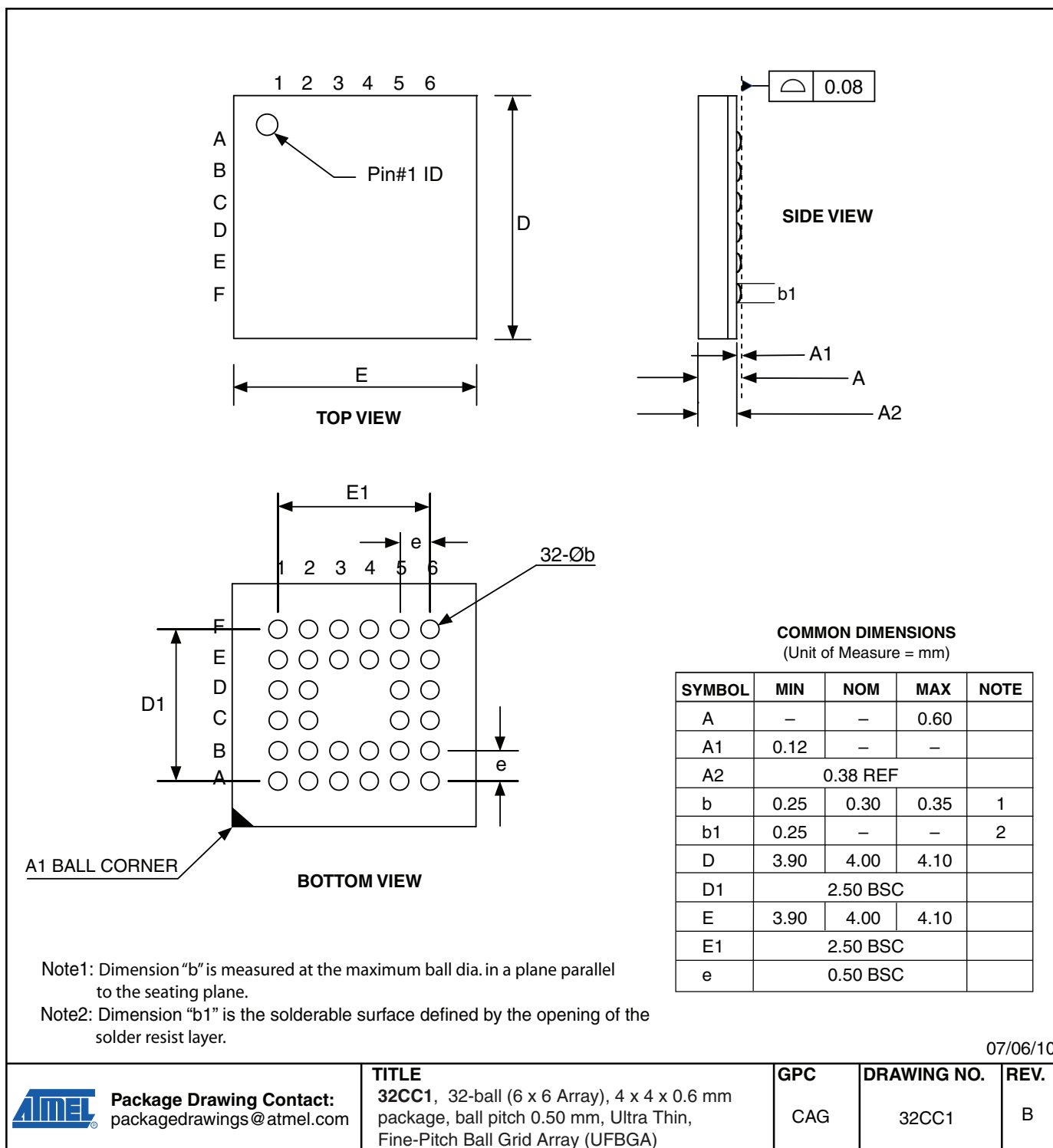
DRAWING NO.

32A

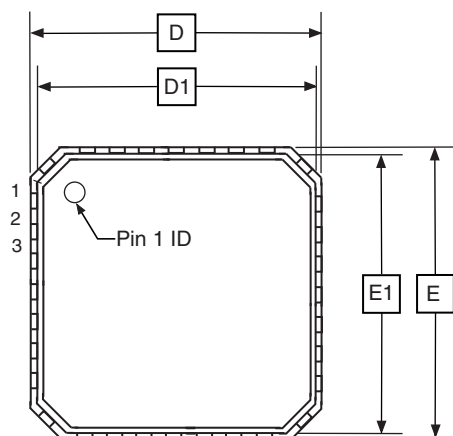
REV.

C

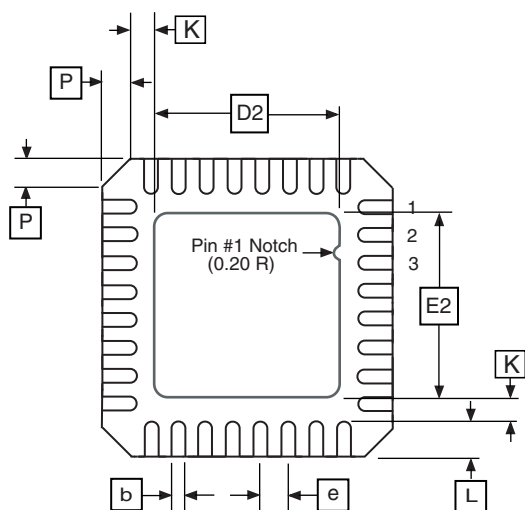
7.4 32CC1



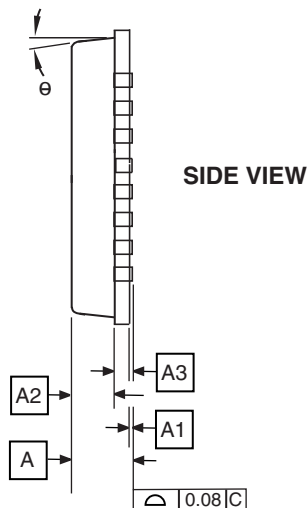
7.5 32M1-A



TOP VIEW



BOTTOM VIEW



SIDE VIEW

COMMON DIMENSIONS
(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	0.80	0.90	1.00	
A1	—	0.02	0.05	
A2	—	0.65	1.00	
A3	0.20 REF			
b	0.18	0.23	0.30	
D	4.90	5.00	5.10	
D1	4.70	4.75	4.80	
D2	2.95	3.10	3.25	
E	4.90	5.00	5.10	
E1	4.70	4.75	4.80	
E2	2.95	3.10	3.25	
e	0.50 BSC			
L	0.30	0.40	0.50	
P	—	—	0.60	
θ	—	—	12°	
K	0.20	—	—	

Note: JEDEC Standard MO-220, Fig. 2 (Anvil Singulation), VHHD-2.

5/25/06



2325 Orchard Parkway
San Jose, CA 95131

TITLE

32M1-A, 32-pad, 5 x 5 x 1.0 mm Body, Lead Pitch 0.50 mm,
3.10 mm Exposed Pad, Micro Lead Frame Package (MLF)

DRAWING NO.

32M1-A

REV.

E

8. Errata

8.1 ATtiny48

8.1.1 Rev. C

No known errata.

8.1.2 Rev. B

Not sampled.

8.1.3 Rev. A

Not sampled.

- UFBGA package (32CC1) in, “Features” on page 1, “Pin Configurations” on page 2, Section 26. “Ordering Information” on page 283, and Section 27. “Packaging Information” on page 285
- Addresses in all Register Desc. tables, with cross-references to Register Summary
- Tape and reel in Section 26. “Ordering Information” on page 283

9.6 Rev. 8008C - 03/09

1. Updated sections:
 - “Features” on page 1
 - “Reset and Interrupt Handling” on page 12
 - “EECR – EEPROM Control Register” on page 25
 - “Features” on page 129
 - “Bit Rate Generator Unit” on page 135
 - “TWBR – TWI Bit Rate Register” on page 156
 - “TWHSR – TWI High Speed Register” on page 160
 - “Analog Comparator” on page 161
 - “Overview” on page 164
 - “Operation” on page 165
 - “Starting a Conversion” on page 166
 - “Programming the Lock Bits” on page 199
 - “Absolute Maximum Ratings*” on page 206
 - “DC Characteristics” on page 206
 - “Speed” on page 208
 - “Register Summary” on page 277
2. Added sections
 - “High-Speed Two-Wire Interface Clock – $\text{clk}_{\text{TWIHS}}$ ” on page 29
 - “Analog Comparator Characteristics” on page 210
3. Updated Figure 6-1 on page 28.
4. Updated order codes on page 283 and page 284 to reflect changes in leadframe composition.

9.7 Rev. 8008B - 06/08

1. Updated introduction of “I/O-Ports” on page 60.
2. Updated “DC Characteristics” on page 206.
3. Added “Typical Characteristics” on page 219.

9.8 Rev. 8008A - 06/08

1. Initial revision.



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 1-5 & 16, 19/F
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

Technical Support

avr@atmel.com

Sales Contact

www.atmel.com/contacts

Literature Requests

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.

© 2011 Atmel Corporation. All rights reserved. Atmel®, logo and combinations thereof, AVR® and others are registered trademarks or trademarks of Atmel Corporation or its subsidiaries. Other terms and product names may be trademarks of others.