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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	I²C, 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-TQFP
Supplier Device Package	32-TQFP (7x7)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/attiny88-au

1.1 Pin Descriptions

1.1.1 VCC

Digital supply voltage.

1.1.2 AVCC

AV_{CC} is the supply voltage pin for the A/D converter and a selection of I/O pins. This pin should be externally connected to V_{CC} even if the ADC is not used. If the ADC is used, it is recommended this pin is connected to V_{CC} through a low-pass filter, as described in "Analog Noise Canceling Techniques" on page 172.

The following pins receive their supply voltage from AV_{CC}: PC7, PC[5:0] and (in 32-lead packages) PA[1:0]. All other I/O pins take their supply voltage from V_{CC}.

1.1.3 GND

Ground.

1.1.4 Port A (PA3:0)

Port A is a 4-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PA[3:0] output buffers have symmetrical drive characteristics with both 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.

This port is available in 32-lead TQFP, 32-pad QFN and 32-ball UFBGA packages, only.

1.1.5 Port B (PB7:0)

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 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.

Depending on the clock selection fuse settings, PB6 can be used as input to the internal clock operating circuit.

The various special features of Port B are elaborated in "Alternate Functions of Port B" on page 69.

1.1.6 Port C (PC7, PC5:0)

Port C is a 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC7 and PC[5:0] output buffers have symmetrical drive characteristics with both 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.

1.1.7 PC6/$\overline{\text{RESET}}$

If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C.

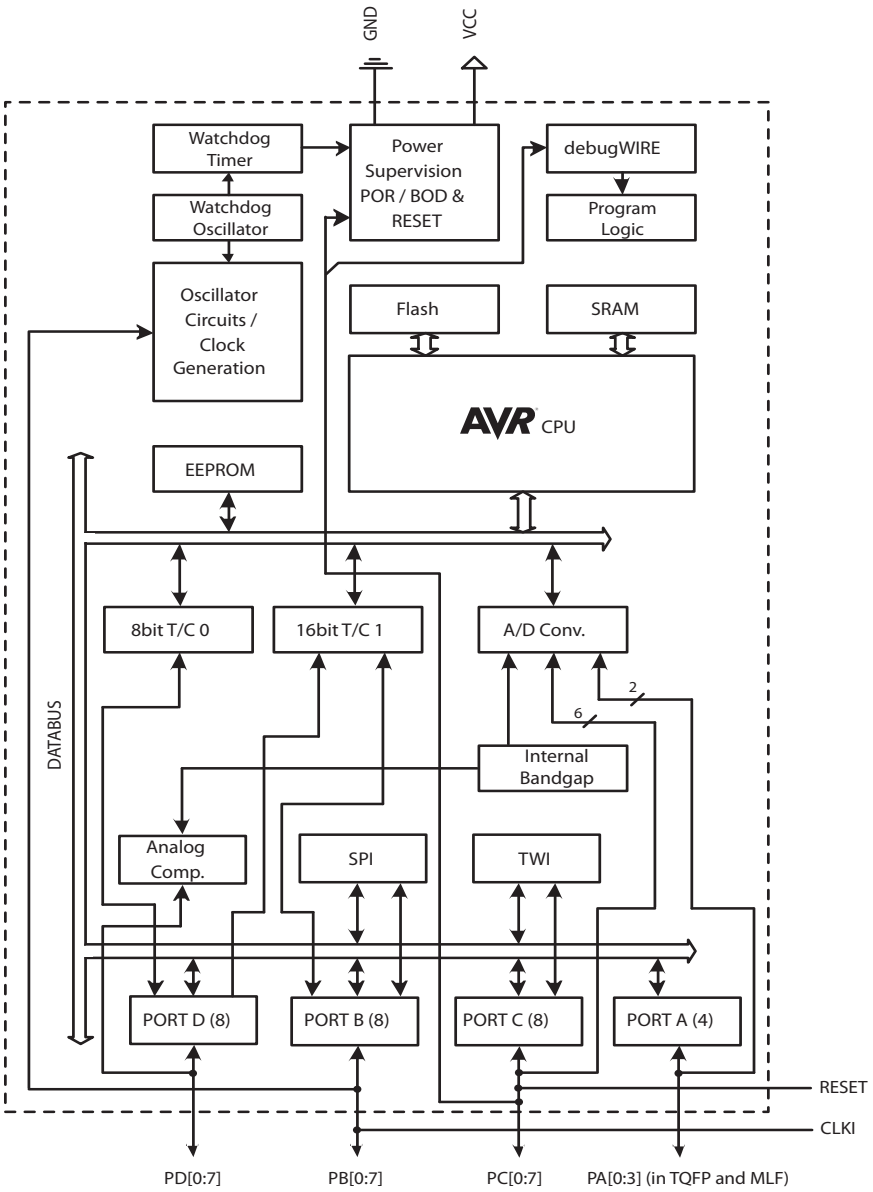
If the RSTDISBL Fuse is unprogrammed, PC6 is used as a reset input. A low level on this pin for longer than the minimum pulse width will generate a reset, even if the clock is not running. The

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 “SBRS”, “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)	WDTCSR	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	–	–	–	–	–	–	–	–	
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0x2D (0x4D)	SPSR	SPIF	WCOL	–	–	–	–	–	SPI2X	127
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0x23 (0x43)	GTCCR	TSM	–	–	–	–	–	–	PSRSYNC	118
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0x21 (0x41)	EEARL	EEPROM Address Register Low Byte								25
0x20 (0x40)	EEDR	EEPROM Data Register								25
0x1F (0x3F)	EECR	–	–	EEPM1	EEPM0	EERIE	EEMPE	EEPE	EERE	25
0x1E (0x3E)	GPIOR0	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

5. Instruction Set Summary

Mnemonics	Operands	Description	Operation	Flags	#Clocks
ARITHMETIC AND LOGIC INSTRUCTIONS					
ADD	Rd, Rr	Add two Registers	Rd ← Rd + Rr	Z,C,N,V,H	1
ADC	Rd, Rr	Add with Carry two Registers	Rd ← 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 ← Rd - Rr - C	Z,C,N,V,H	1
SBCI	Rd, K	Subtract with Carry Constant from Reg.	Rd ← 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 ← Rd • Rr	Z,N,V	1
ANDI	Rd, K	Logical AND Register and Constant	Rd ← Rd • K	Z,N,V	1
OR	Rd, Rr	Logical OR Registers	Rd ← Rd v Rr	Z,N,V	1
ORI	Rd, K	Logical OR Register and Constant	Rd ← Rd v K	Z,N,V	1
EOR	Rd, Rr	Exclusive OR Registers	Rd ← Rd ⊕ Rr	Z,N,V	1
COM	Rd	One's Complement	Rd ← 0xFF – Rd	Z,C,N,V	1
NEG	Rd	Two's Complement	Rd ← 0x00 – Rd	Z,C,N,V,H	1
SBR	Rd,K	Set Bit(s) in Register	Rd ← Rd v K	Z,N,V	1
CBR	Rd,K	Clear Bit(s) in Register	Rd ← Rd • (0xFF - 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 ← Rd • Rd	Z,N,V	1
CLR	Rd	Clear Register	Rd ← Rd ⊕ Rd	Z,N,V	1
SER	Rd	Set Register	Rd ← 0xFF	None	1
BRANCH INSTRUCTIONS					
RJMP	k	Relative Jump	PC ← PC + k + 1	None	2
IJMP		Indirect Jump to (Z)	PC ← Z	None	2
RCALL	k	Relative Subroutine Call	PC ← PC + k + 1	None	3
ICALL		Indirect Call to (Z)	PC ← Z	None	3
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 ← PC + 2 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 ← 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←PC+k + 1	None	1/2
BREQ	k	Branch if Equal	if (Z = 1) then PC ← PC + k + 1	None	1/2
BRNE	k	Branch if Not Equal	if (Z = 0) then PC ← PC + k + 1	None	1/2
BRCS	k	Branch if Carry Set	if (C = 1) then PC ← 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 ← PC + k + 1	None	1/2
BRLO	k	Branch if Lower	if (C = 1) then PC ← 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 ⊕ V= 0) then PC ← PC + k + 1	None	1/2
BRLT	k	Branch if Less Than Zero, Signed	if (N ⊕ V= 1) then PC ← PC + k + 1	None	1/2
BRHS	k	Branch if Half Carry Flag Set	if (H = 1) then PC ← PC + k + 1	None	1/2
BRHC	k	Branch if Half Carry Flag Cleared	if (H = 0) then PC ← PC + k + 1	None	1/2
BRTS	k	Branch if T Flag Set	if (T = 1) then PC ← PC + k + 1	None	1/2
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
BIT AND BIT-TEST INSTRUCTIONS					
SBI	P,b	Set Bit in I/O Register	I/O(P,b) ← 1	None	2
CBI	P,b	Clear Bit in I/O Register	I/O(P,b) ← 0	None	2
LSL	Rd	Logical Shift Left	Rd(n+1) ← Rd(n), Rd(0) ← 0	Z,C,N,V	1
LSR	Rd	Logical Shift Right	Rd(n) ← Rd(n+1), Rd(7) ← 0	Z,C,N,V	1
ROL	Rd	Rotate Left Through Carry	Rd(0)←C,Rd(n+1)← Rd(n),C←Rd(7)	Z,C,N,V	1
ROR	Rd	Rotate Right Through Carry	Rd(7)←C,Rd(n)← Rd(n+1),C←Rd(0)	Z,C,N,V	1

Mnemonics	Operands	Description	Operation	Flags	#Clocks
ASR	Rd	Arithmetic Shift Right	Rd(n) ← Rd(n+1), n=0..6	Z,C,N,V	1
SWAP	Rd	Swap Nibbles	Rd(3..0)←Rd(7..4),Rd(7..4)←Rd(3..0)	None	1
BSET	s	Flag Set	SREG(s) ← 1	SREG(s)	1
BCLR	s	Flag Clear	SREG(s) ← 0	SREG(s)	1
BST	Rr, b	Bit Store from Register to T	T ← Rr(b)	T	1
BLD	Rd, b	Bit load from T to Register	Rd(b) ← T	None	1
SEC		Set Carry	C ← 1	C	1
CLC		Clear Carry	C ← 0	C	1
SEN		Set Negative Flag	N ← 1	N	1
CLN		Clear Negative Flag	N ← 0	N	1
SEZ		Set Zero Flag	Z ← 1	Z	1
CLZ		Clear Zero Flag	Z ← 0	Z	1
SEI		Global Interrupt Enable	I ← 1	I	1
CLI		Global Interrupt Disable	I ← 0	I	1
SES		Set Signed Test Flag	S ← 1	S	1
CLS		Clear Signed Test Flag	S ← 0	S	1
SEV		Set Twos Complement Overflow.	V ← 1	V	1
CLV		Clear Twos Complement Overflow	V ← 0	V	1
SET		Set T in SREG	T ← 1	T	1
CLT		Clear T in SREG	T ← 0	T	1
SEH		Set Half Carry Flag in SREG	H ← 1	H	1
CLH		Clear Half Carry Flag in SREG	H ← 0	H	1
DATA TRANSFER INSTRUCTIONS					
MOV	Rd, Rr	Move Between Registers	Rd ← Rr	None	1
MOVW	Rd, Rr	Copy Register Word	Rd+1:Rd ← Rr+1:Rr	None	1
LDI	Rd, K	Load Immediate	Rd ← K	None	1
LD	Rd, X	Load Indirect	Rd ← (X)	None	2
LD	Rd, X+	Load Indirect and Post-Inc.	Rd ← (X), X ← X + 1	None	2
LD	Rd, - X	Load Indirect and Pre-Dec.	X ← X - 1, Rd ← (X)	None	2
LD	Rd, Y	Load Indirect	Rd ← (Y)	None	2
LD	Rd, Y+	Load Indirect and Post-Inc.	Rd ← (Y), Y ← Y + 1	None	2
LD	Rd, - Y	Load Indirect and Pre-Dec.	Y ← Y - 1, Rd ← (Y)	None	2
LDD	Rd,Y+q	Load Indirect with Displacement	Rd ← (Y + q)	None	2
LD	Rd, Z	Load Indirect	Rd ← (Z)	None	2
LD	Rd, Z+	Load Indirect and Post-Inc.	Rd ← (Z), Z ← Z+1	None	2
LD	Rd, -Z	Load Indirect and Pre-Dec.	Z ← Z - 1, Rd ← (Z)	None	2
LDD	Rd, Z+q	Load Indirect with Displacement	Rd ← (Z + q)	None	2
LDS	Rd, k	Load Direct from SRAM	Rd ← (k)	None	2
ST	X, Rr	Store Indirect	(X) ← Rr	None	2
ST	X+, Rr	Store Indirect and Post-Inc.	(X) ← Rr, X ← X + 1	None	2
ST	- X, Rr	Store Indirect and Pre-Dec.	X ← X - 1, (X) ← Rr	None	2
ST	Y, Rr	Store Indirect	(Y) ← Rr	None	2
ST	Y+, Rr	Store Indirect and Post-Inc.	(Y) ← Rr, Y ← Y + 1	None	2
ST	- Y, Rr	Store Indirect and Pre-Dec.	Y ← Y - 1, (Y) ← Rr	None	2
STD	Y+q,Rr	Store Indirect with Displacement	(Y + q) ← Rr	None	2
ST	Z, Rr	Store Indirect	(Z) ← Rr	None	2
ST	Z+, Rr	Store Indirect and Post-Inc.	(Z) ← Rr, Z ← Z + 1	None	2
ST	-Z, Rr	Store Indirect and Pre-Dec.	Z ← Z - 1, (Z) ← Rr	None	2
STD	Z+q,Rr	Store Indirect with Displacement	(Z + q) ← Rr	None	2
STS	k, Rr	Store Direct to SRAM	(k) ← Rr	None	2
LPM		Load Program Memory	R0 ← (Z)	None	3
LPM	Rd, Z	Load Program Memory	Rd ← (Z)	None	3
LPM	Rd, Z+	Load Program Memory and Post-Inc	Rd ← (Z), Z ← Z+1	None	3
SPM		Store Program Memory	(Z) ← R1:R0	None	-
IN	Rd, P	In Port	Rd ← P	None	1
OUT	P, Rr	Out Port	P ← Rr	None	1
PUSH	Rr	Push Register on Stack	STACK ← Rr	None	2
POP	Rd	Pop Register from Stack	Rd ← STACK	None	2
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

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]

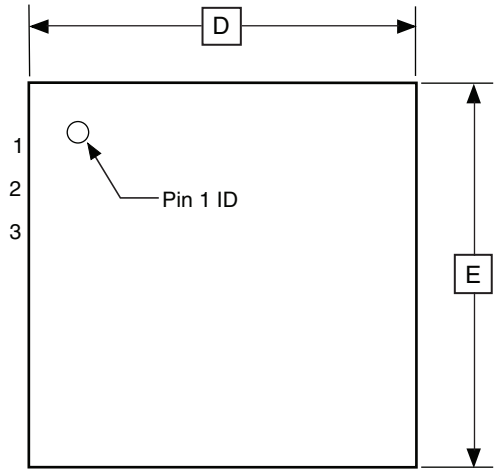
Notes: 1. Code indicators:
- H: NiPdAu lead finish
- U: matte tin
- R: tape & reel

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.

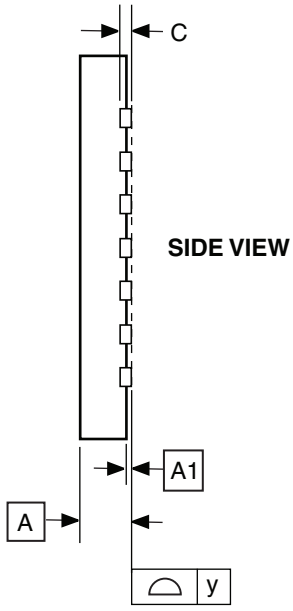
Package Type	
28M1	28-pad, 4 x 4 x 1.0 body, Lead Pitch 0.45 mm, Quad Flat No-Lead (QFN)
28P3	28-lead, 0.300” Wide, Plastic Dual Inline Package (PDIP)
32A	32-lead, Thin (1.0 mm) Plastic Quad Flat Package (TQFP)
32CC1	32-ball (6 x 6 Array), 0.50 mm Pitch, 4 x 4 x 0.6 mm, Ultra Thin, Fine-Pitch Ball Grid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

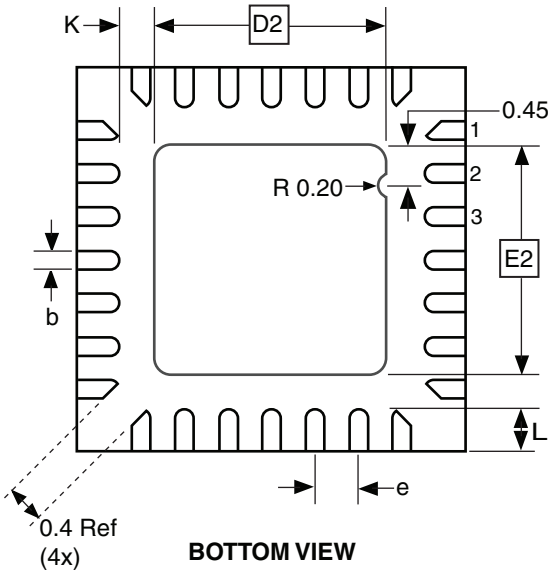
7. Packaging Information

7.1 28M1



TOP VIEW





BOTTOM VIEW

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

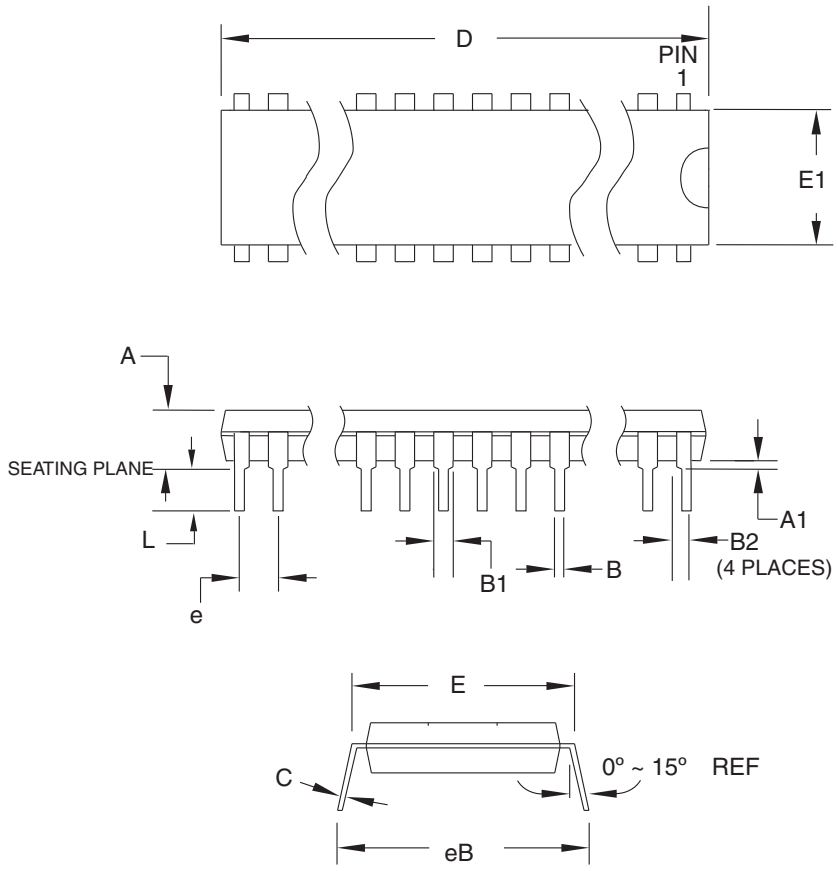
COMMON DIMENSIONS
(Unit of Measure = mm)

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

	TITLE	GPC	DRAWING NO.	REV.
Package Drawing Contact: packagedrawings@atmel.com	**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)	ZBV	28M1	B

7.2 28P3



COMMON DIMENSIONS
(Unit of Measure = mm)

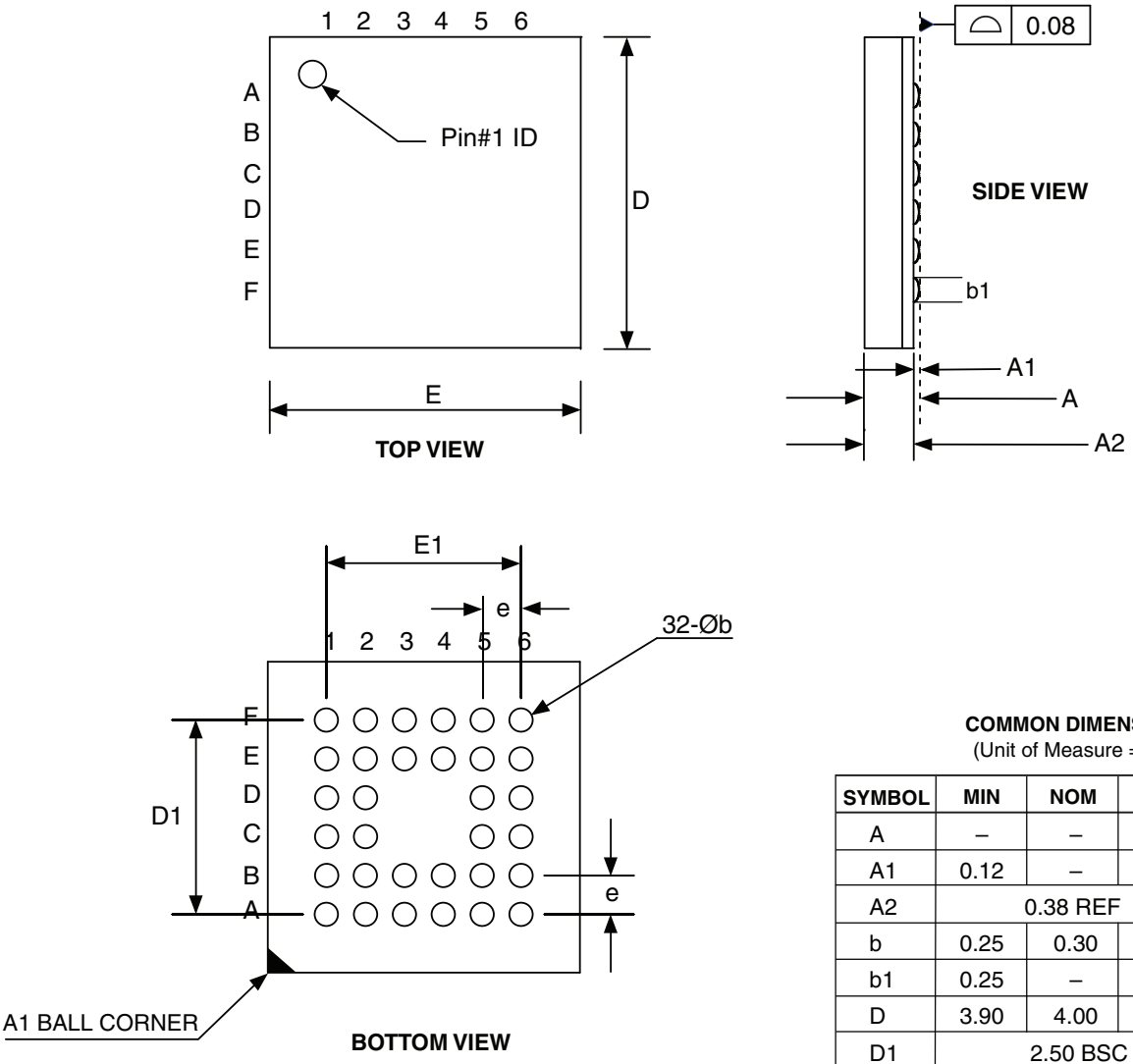
SYMBOL	MIN	NOM	MAX	NOTE
A	–	–	4.5724	
A1	0.508	–	–	
D	34.544	–	34.798	Note 1
E	7.620	–	8.255	
E1	7.112	–	7.493	Note 1
B	0.381	–	0.533	
B1	1.143	–	1.397	
B2	0.762	–	1.143	
L	3.175	–	3.429	
C	0.203	–	0.356	
eB	–	–	10.160	
e	2.540 TYP			

Note: 1. Dimensions D and E1 do not include mold Flash or Protrusion. Mold Flash or Protrusion shall not exceed 0.25 mm (0.010").

09/28/01

	TITLE	DRAWING NO.	REV.
2325 Orchard Parkway San Jose, CA 95131	**28P3**, 28-lead (0.300"/7.62 mm Wide) Plastic Dual Inline Package (PDIP)	28P3	B

7.4 32CC1



COMMON DIMENSIONS
(Unit of Measure = mm)

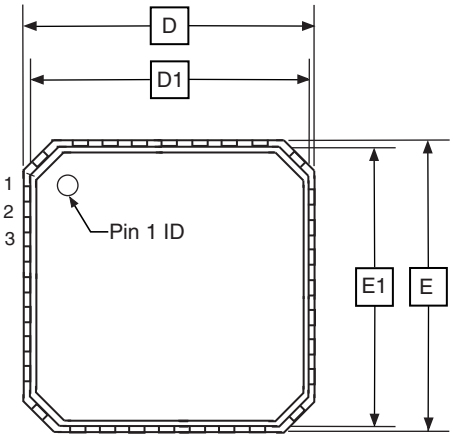
SYMBOL	MIN	NOM	MAX	NOTE
A	–	–	0.60	
A1	0.12	–	–	
A2		0.38 REF		
b	0.25	0.30	0.35	1
b1	0.25	–	–	2
D	3.90	4.00	4.10	
D1		2.50 BSC		
E	3.90	4.00	4.10	
E1		2.50 BSC		
e		0.50 BSC		

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.

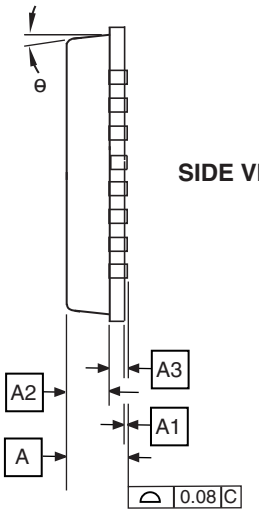
07/06/10

	TITLE	GPC	DRAWING NO.	REV.
Package Drawing Contact: packagedrawings@atmel.com	**32CC1**, 32-ball (6 x 6 Array), 4 x 4 x 0.6 mm package, ball pitch 0.50 mm, Ultra Thin, Fine-Pitch Ball Grid Array (UFBGA)	CAG	32CC1	B

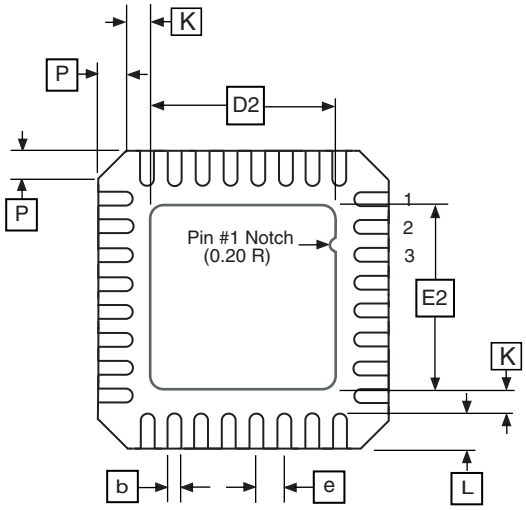
7.5 32M1-A



TOP VIEW



SIDE VIEW



BOTTOM VIEW

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

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^{o}	
K	0.20	–	–	

5/25/06

	TITLE	DRAWING NO.	REV.
2325 Orchard Parkway San Jose, CA 95131	**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)	32M1-A	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.

8.2 ATtiny88

8.2.1 Rev. C

No known errata.

8.2.2 Rev. B

No known errata.

8.2.3 Rev. A

Not sampled.

9. Datasheet Revision History

9.1 Rev. 8008H - 04/11

1. Updated:
   – “Ordering Information” on page 283, added tape & reel code -MMUR

9.2 Rev. 8008G - 04/11

1. Updated:
   – “Block Diagram” on page 5
   – “Memories” on page 17
   – “Clock System” on page 28
   – “Lock Bits, Fuse Bits and Device Signature” on page 188
   – “External Programming” on page 191
   – “Speed” on page 208
   – “Two-Wire Serial Interface Characteristics” on page 212
2. Added:
   – “Capacitive Touch Sensing” on page 7
   – “Register Description” on page 15
   – “Overview” on page 129
   – “Compatibility with SMBus” on page 156
3. Changed document status from “Preliminary” to “Final”.

9.3 Rev. 8008F - 06/10

1. Updated notes 1 and 10 in table in Section 22.2 “DC Characteristics” on page 206.
2. Updated package drawing in Section 27.4 “32CC1” on page 288.
3. Updated bit syntax throughout the datasheet, e.g. from CS02:0 to CS0[2:0].

9.4 Rev. 8008E - 05/10

1. Section 24. “Register Summary” on page 277, added SPH at address 0x3E.
2. Section 27.1 “28M1” on page 285 updated with correct package drawing.

9.5 Rev. 8008D - 03/10

1. Separated Typical Characteristic plots, added Section 23.2 “ATtiny88” on page 248.
2. Updated:
   – Section 1.1 “Pin Descriptions” on page 3, Port D, adjusted texts ‘sink and source’ and ‘high sink’.
   – Table 6-3 on page 28 adjusted, to fix TBD.
   – Section 6.2.3 “Internal 128 kHz Oscillator” on page 31 adjusted, to fix TBD.
   – Section 8.4 “Watchdog Timer” on page 46, updated.
   – Section 22.2 “DC Characteristics” on page 206, updated TBD in notes 5 and 8.
3. Added:

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