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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	20MHz
Connectivity	I ² C, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	23
Program Memory Size	32KB (16K x 16)
Program Memory Type	FLASH
EEPROM Size	1K x 8
RAM Size	2K 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/atmega328p-aur

- Peripheral Features
 - Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode
 - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
 - Real Time Counter with Separate Oscillator
 - Six PWM Channels
 - 8-channel 10-bit ADC in TQFP and QFN/MLF package
 - Temperature Measurement
 - 6-channel 10-bit ADC in PDIP Package
 - Temperature Measurement
 - Two Master/Slave SPI Serial Interface
 - One Programmable Serial USART
 - One Byte-oriented 2-wire Serial Interface (Philips I²C compatible)
 - Programmable Watchdog Timer with Separate On-chip Oscillator
 - One On-chip Analog Comparator
 - Interrupt and Wake-up on Pin Change
- Special Microcontroller Features
 - Power-on Reset and Programmable Brown-out Detection
 - Internal Calibrated Oscillator
 - External and Internal Interrupt Sources
 - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby
- I/O and Packages
 - 23 Programmable I/O Lines
 - 28-pin PDIP, 32-lead TQFP, 28-pad QFN/MLF and 32-pad QFN/MLF
- Operating Voltage:
 - 1.8 - 5.5V
- Temperature Range:
 - -40°C to 105°C
- Speed Grade:
 - 0 - 4MHz @ 1.8 - 5.5V
 - 0 - 10MHz @ 2.7 - 5.5V
 - 0 - 20MHz @ 4.5 - 5.5V
- Power Consumption at 1MHz, 1.8V, 25°C
 - Active Mode: 0.2mA
 - Power-down Mode: 0.1µA
 - Power-save Mode: 0.75µA (Including 32kHz RTC)

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2. Configuration Summary

Features	ATmega328/P
Pin Count	28/32
Flash (Bytes)	32K
SRAM (Bytes)	2K
EEPROM (Bytes)	1K
Interrupt Vector Size (instruction word/vector)	1/1/2
General Purpose I/O Lines	23
SPI	2
TWI (I ² C)	1
USART	1
ADC	10-bit 15kSPS
ADC Channels	8
8-bit Timer/Counters	2
16-bit Timer/Counters	1

and support a real Read-While-Write Self-Programming mechanism. There is a separate Boot Loader Section, and the SPM instruction can only execute from there. In , there is no Read-While-Write support and no separate Boot Loader Section. The SPM instruction can execute from the entire Flash.

3. Ordering Information

3.1. ATmega328

Speed [MHz] ⁽³⁾	Power Supply [V]	Ordering Code ⁽²⁾	Package ⁽¹⁾	Operational Range
20	1.8 - 5.5	ATmega328-AU ATmega328-AUR ⁽⁵⁾ ATmega328-MMH ⁽⁴⁾ ATmega328-MMHR ⁽⁴⁾⁽⁵⁾ ATmega328-MU ATmega328-MUR ⁽⁵⁾ ATmega328-PU	32A 32A 28M1 28M1 32M1-A 32M1-A 28P3	Industrial (-40°C to 85°C)

Note:

1. This device can also be supplied in wafer form. Please contact your local Atmel sales office for detailed ordering information and minimum quantities.
2. Pb-free packaging, complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.
3. Please refer to *Speed Grades* for Speed vs. V_{CC}
4. Tape & Reel.
5. NiPdAu Lead Finish.

Package Type	
28M1	28-pad, 4 x 4 x 1.0 body, Lead Pitch 0.45mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)
28P3	28-lead, 0.300" Wide, Plastic Dual Inline Package (PDIP)
32M1-A	32-pad, 5 x 5 x 1.0 body, Lead Pitch 0.50mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)
32A	32-lead, Thin (1.0mm) Plastic Quad Flat Package (TQFP)

3.2. ATmega328P

Speed [MHz] ⁽³⁾	Power Supply [V]	Ordering Code ⁽²⁾	Package ⁽¹⁾	Operational Range
20	1.8 - 5.5	ATmega328P-AU	32A	Industrial (-40°C to 85°C)
		ATmega328P-AUR ⁽⁵⁾	32A	
		ATmega328P-MMH ⁽⁴⁾	28M1	
		ATmega328P-MMHR ⁽⁴⁾⁽⁵⁾	28M1	
		ATmega328P-MU	32M1-A	
		ATmega328P-MUR ⁽⁵⁾	32M1-A	
		ATmega328P-PU	28P3	
		ATmega328P-AN	32A	Industrial (-40°C to 105°C)
		ATmega328P-ANR ⁽⁵⁾	32A	
		ATmega328P-MN	32M1-A	
		ATmega328P-MNR ⁽⁵⁾	32M1-A	
		ATmega328P-PN	28P3	

Note:

1. This device can also be supplied in wafer form. Please contact your local Atmel sales office for detailed ordering information and minimum quantities.
2. Pb-free packaging, complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.
3. Please refer to *Speed Grades* for Speed vs. V_{CC}
4. Tape & Reel.
5. NiPdAu Lead Finish.

Package Type	
28M1	28-pad, 4 x 4 x 1.0 body, Lead Pitch 0.45mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)
28P3	28-lead, 0.300" Wide, Plastic Dual Inline Package (PDIP)
32M1-A	32-pad, 5 x 5 x 1.0 body, Lead Pitch 0.50mm Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)
32A	32-lead, Thin (1.0mm) Plastic Quad Flat Package (TQFP)

4. Block Diagram

Figure 4-1. Block Diagram

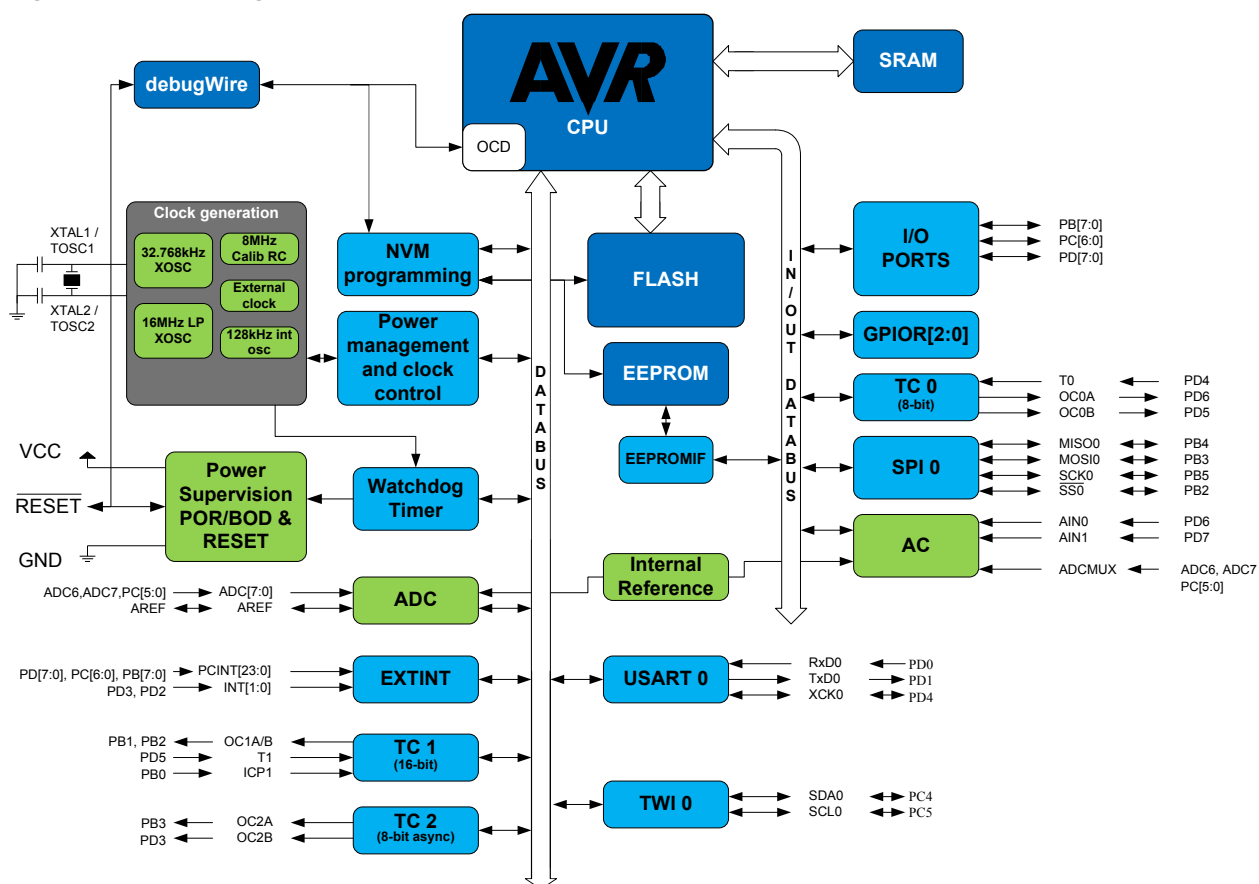


Figure 5-2. 28-pin MLF Top View



Figure 5-3. 32-pin TQFP Top View

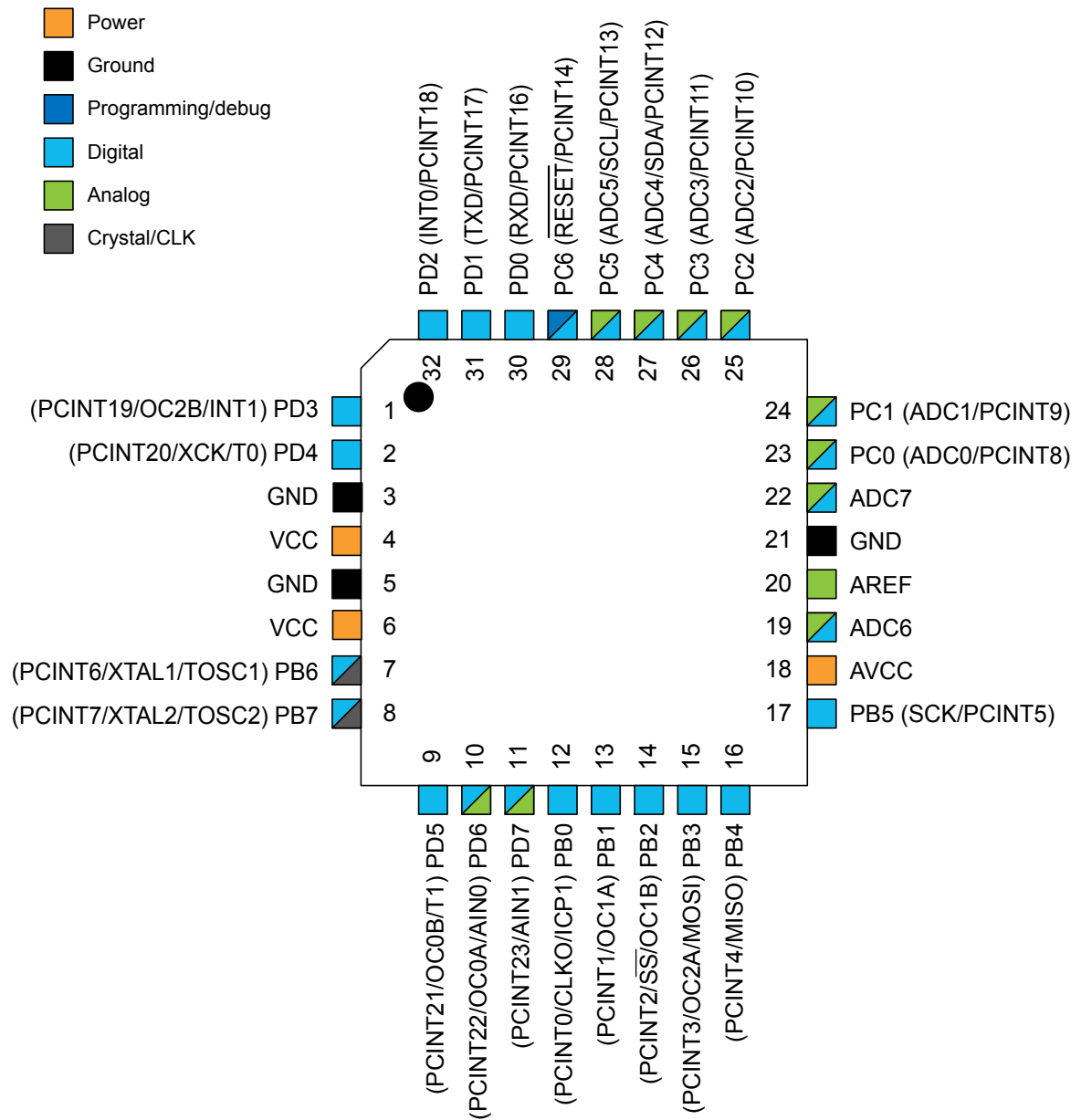
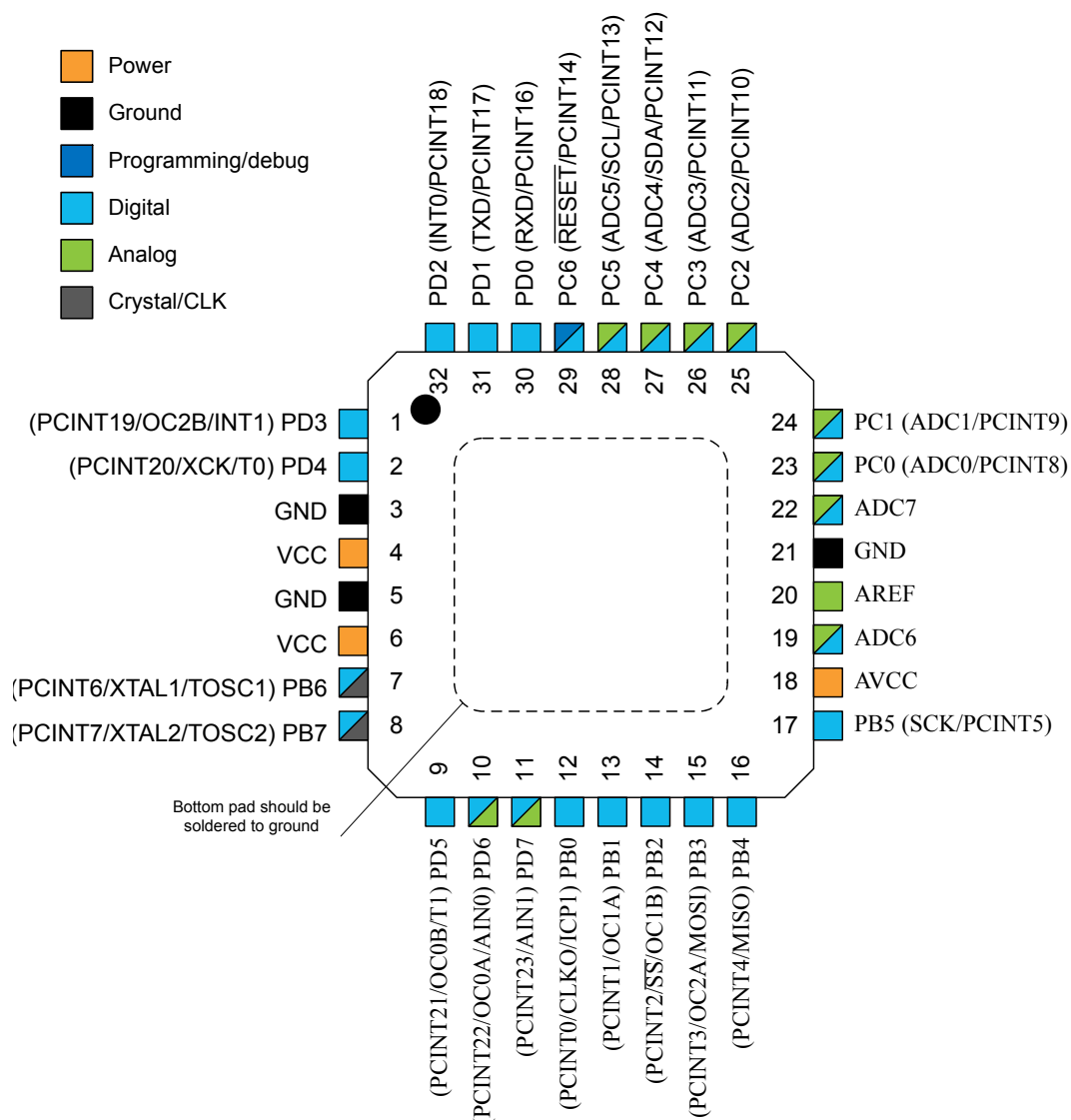


Figure 5-4. 32-pin MLF Top View



5.2. Pin Descriptions

5.2.1. VCC

Digital supply voltage.

5.2.2. GND

Ground.

5.2.3. Port B (PB[7:0]) XTAL1/XTAL2/TOSC1/TOSC2

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

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

Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier.

If the Internal Calibrated RC Oscillator is used as chip clock source, PB[7:6] is used as TOSC[2:1] input for the Asynchronous Timer/Counter2 if the AS2 bit in ASSR is set.

5.2.4. Port C (PC[5:0])

Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC[5:0] output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

5.2.5. PC6/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 length will generate a Reset, even if the clock is not running. Shorter pulses are not guaranteed to generate a Reset.

The various special features of Port C are elaborated in the *Alternate Functions of Port C* section.

5.2.6. Port D (PD[7:0])

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

5.2.7. AV_{CC}

AV_{CC} is the supply voltage pin for the A/D Converter, PC[3:0], and PE[3:2]. It should be externally connected to V_{CC}, even if the ADC is not used. If the ADC is used, it should be connected to V_{CC} through a low-pass filter. Note that PC[6:4] use digital supply voltage, V_{CC}.

5.2.8. AREF

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

5.2.9. ADC[7:6] (TQFP and VFQFN Package Only)

In the TQFP and VFQFN package, ADC[7:6] serve as analog inputs to the A/D converter. These pins are powered from the analog supply and serve as 10-bit ADC channels.

6. I/O Multiplexing

Each pin is by default controlled by the PORT as a general purpose I/O and alternatively it can be assigned to one of the peripheral functions.

The following table describes the peripheral signals multiplexed to the PORT I/O pins.

Table 6-1. PORT Function Multiplexing

(32-pin MLF/TQFP) Pin#	(28-pin MLF) Pin#	(28-pin PIPD) Pin#	PAD	EXTINT	PCINT	ADC/AC	OSC	T/C #0	T/C #1	USART 0	I2C 0	SPI 0
1	1	5	PD[3]	INT1	PCINT19			OC2B				
2	2	6	PD[4]		PCINT20			T0		XCK0		
4	3	7	VCC									
3	4	8	GND									
6	-	-	VCC									
5	-	-	GND									
7	5	9	PB[6]		PCINT6		XTAL1/ TOSC1					
8	6	10	PB[7]		PCINT7		XTAL2/ TOSC2					
9	7	11	PD[5]		PCINT21			OC0B	T1			
10	8	12	PD[6]		PCINT22	AIN0		OC0A				
11	9	13	PD[7]		PCINT23	AIN1						
12	10	14	PB[0]		PCINT0		CLKO	ICP1				
13	11	15	PB[1]		PCINT1			OC1A				
14	12	16	PB[2]		PCINT2			OC1B				SS0
15	13	17	PB[3]		PCINT3			OC2A				MOSI0
16	14	18	PB[4]		PCINT4							MISO0
17	15	19	PB[5]		PCINT5							SCK0
18	16	20	AVCC									
19	-	-	ADC6			ADC6						
20	17	21	AREF									
21	18	22	GND									
22	-	-	ADC7			ADC7						
23	19	13	PC[0]		PCINT8	ADC0						
24	20	24	PC[1]		PCINT9	ADC1						
25	21	25	PC[2]		PCINT10	ADC2						
26	22	26	PC[3]		PCINT11	ADC3						
27	23	27	PC[4]		PCINT12	ADC4					SDA0	
28	24	28	PC[5]		PCINT13	ADC5					SCL0	
29	25	1	PC[6]/ RESET		PCINT14							

(32-pin MLF/TQFP) Pin#	(28-pin MLF) Pin#	(28-pin PIPD) Pin#	PAD	EXTINT	PCINT	ADC/AC	OSC	T/C #0	T/C #1	USART 0	I2C 0	SPI 0
30	26	2	PD[0]		PCINT16					RXD0		
31	27	3	PD[1]		PCINT17					TXD0		
32	28	4	PD[2]	INT0	PCINT18							

7. Resources

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

9. 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. 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”.

10. Capacitive Touch Sensing

10.1. QTouch Library

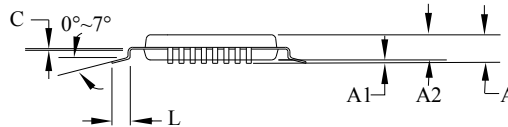
The Atmel® QTouch® Library provides a simple to use solution to realize touch sensitive interfaces on most Atmel AVR® microcontrollers. The QTouch Library includes support for the Atmel QTouch and Atmel QMatrix® acquisition methods.

Touch sensing can be added to any application by linking the appropriate Atmel QTouch Library for the AVR Microcontroller. This is done by using a simple set of APIs to define the touch channels and sensors, and then calling the touch sensing API's to retrieve the channel information and determine the touch sensor states.

The QTouch Library is FREE and downloadable from the Atmel website at the following location: <http://www.atmel.com/technologies/touch/>. For implementation details and other information, refer to the [Atmel QTouch Library User Guide](#) - also available for download from the Atmel website.

11. Packaging Information

11.1. 32-pin 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 0.25mm per side. Dimensions D1 and E1 are maximum plastic body size dimensions including mold mismatch.
3. Lead coplanarity is 0.10mm maximum.

2010-10-20

Atmel

TITLE

32A, 32-lead, 7 x 7mm body size, 1.0mm body thickness,
0.8mm lead pitch, thin profile plastic quad flat package (TQFP)

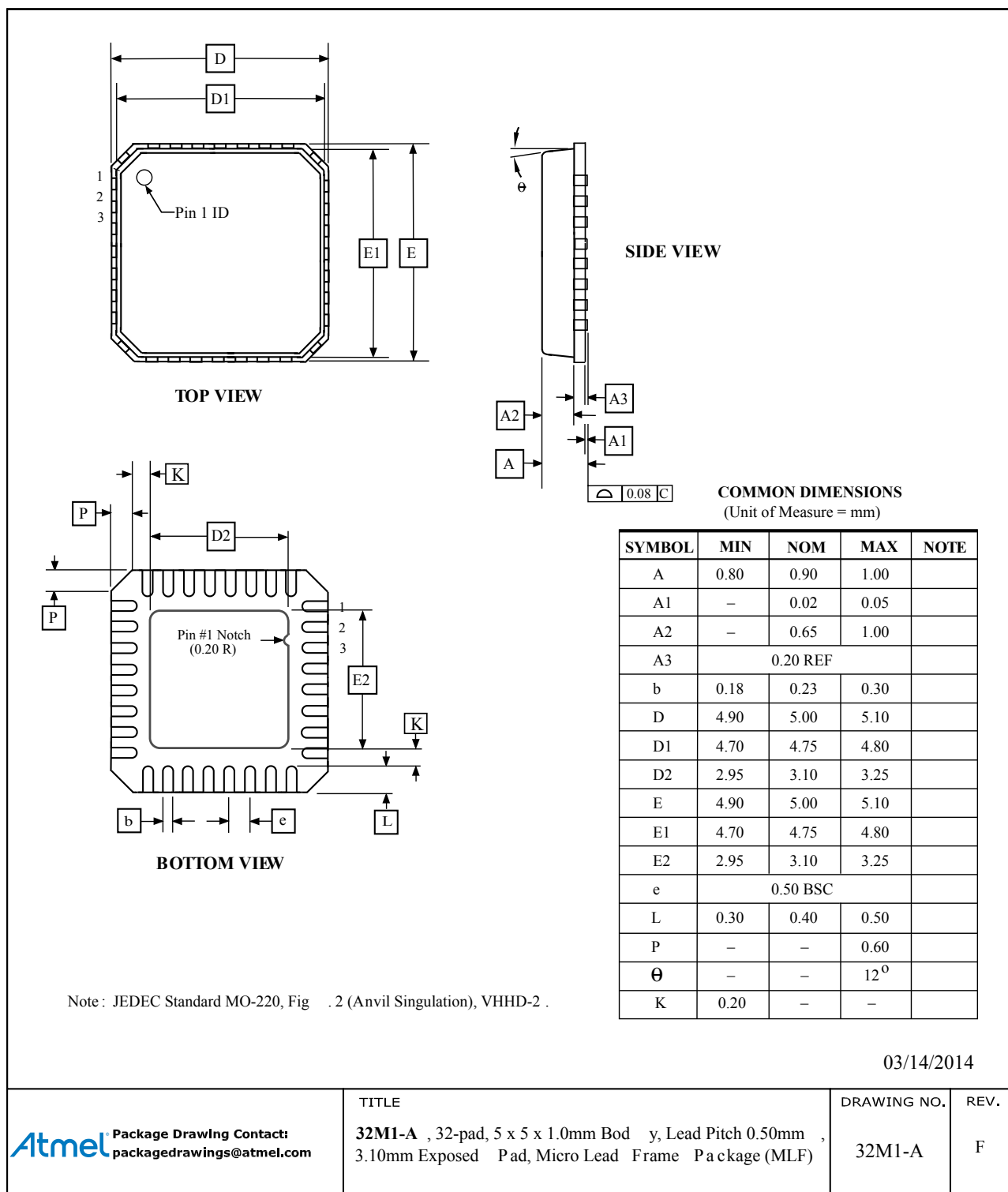
DRAWING NO.

32A

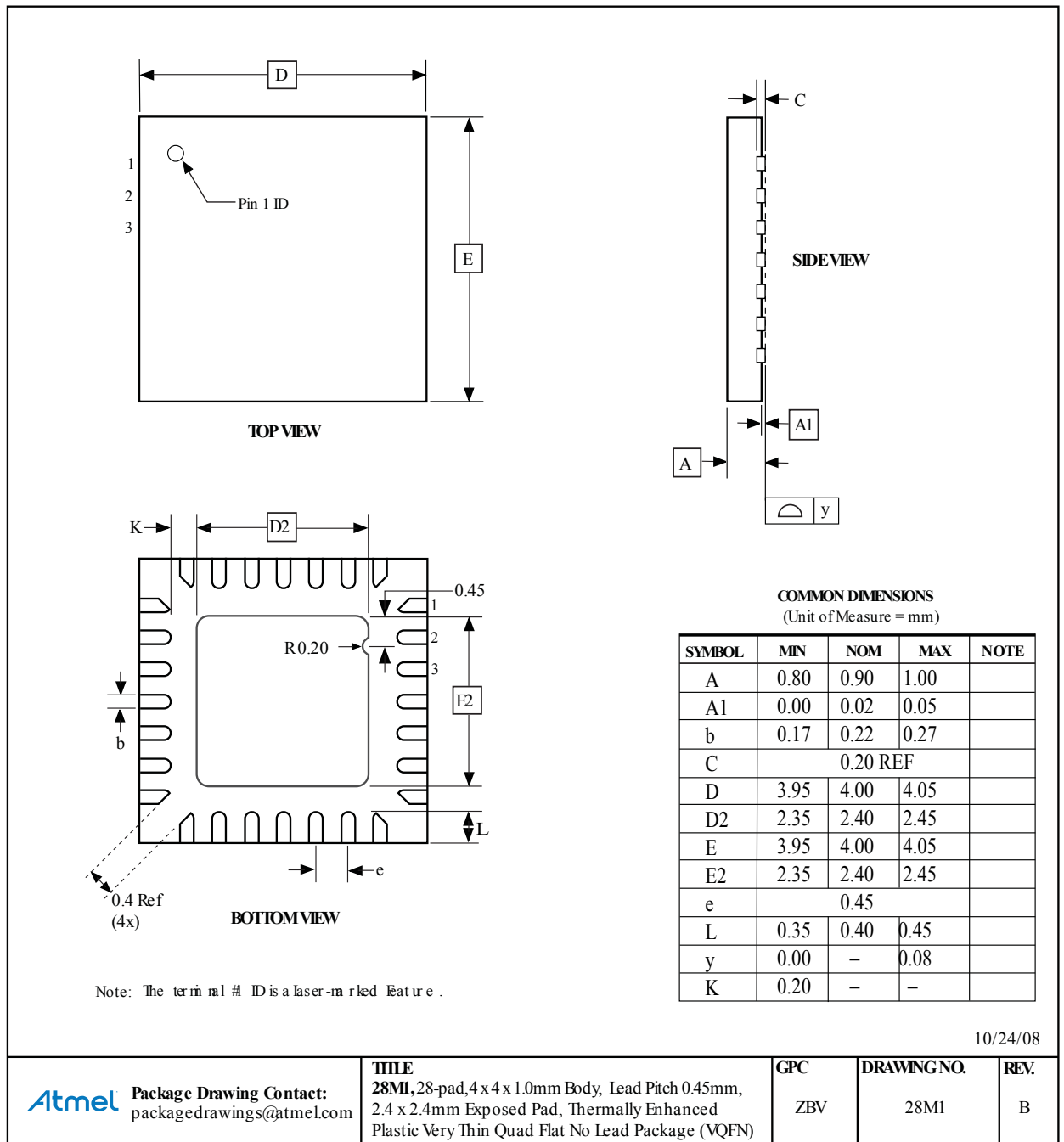
REV.

C

11.2. 32-pin 32M1-A



11.3. 28-pin 28M1



11.4. 28-pin 28P3



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

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			

09/28/01

Atmel 2325 Orchard Parkway
San Jose, CA 95131

TITLE
28P3, 28-lead (0.300"/7.62mm Wide) Plastic Dual
Inline Package (PDIP)

DRAWING NO.
28P3

REV.
B

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