#### **Features**

- Single Voltage Operation
  - 5V Read
  - 5V Reprogramming
- Fast Read Access Time 50 ns
- Internal Program Control and Timer
- 8K Bytes Boot Block With Lockout
- Fast Erase Cycle Time 10 seconds
- Byte-by-Byte Programming 10 μs/Byte
- Hardware Data Protection
- DATA Polling For End Of Program Detection
- Low Power Dissipation
  - 30 mA Active Current
  - 100 µA CMOS Standby Current
- Typical 10,000 Write Cycles

### **Description**

The AT49F512 is a 5-volt-only in-system programmable and erasable Flash Memory. Its 512K of memory is organized as 65,536 words by 8 bits. Manufactured with Atmel's advanced nonvolatile CMOS technology, the devices offer access times to 50 ns with a power dissipation of just 165 mW over the commercial temperature range. When the device is deselected, the CMOS standby current is less than 100  $\mu$ A.

To allow for simple in-system reprogrammability, the AT49F512 does not require high input voltages for programming. Five-volt-only commands determine the read and programming operation of the device. Reading data out of the device is similar to reading from an EPROM. Reprogramming the AT49F512 is performed by erasing the entire 512K of memory and then programming on a byte by byte basis. The typical byte programming time is a fast 10 µs. The end of a program cycle can be optionally (continued)

### **Pin Configurations**

Pin Name	Function
A0 - A15	Addresses
CE	Chip Enable
ŌĒ	Output Enable
WE	Write Enable
I/O0 - I/O7	Data Inputs/Outputs
NC	No Connect

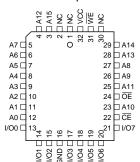
VSOP Top View (8 x 14 mm) or TSOP Top View (8 x 20 mm)

#### Type 1 A11 1 2 30 | CE 29 | I/O7 A8 □ A13 □ A14 □ | I/O6 | I/O5 28 | 1/04 | 1/03 GND | I/O2 NC 10 A15 11 | 1/01 | 1/00 22 A12 🖂 12 20 A0 19 A1 18 A2 A7 🖂 13 A6 🖂 14 A5 15 17 A3



_		-		
		$\overline{}$		l
NC [	1		32	□ vcc
NC [	2		31	□ WE
A15 [	3		30	□ NC
A12 [	4		29	□ A14
A7 [	5		28	□ A13
A6 [	6		27	□ A8
A5 [	7		26	□ A9
A4 [	8		25	□ A11
A3 [	9		24	□ Œ
A2 [	10		23	□ A10
A1 [	11		22	□ CE
A0 [	12		21	□ I/O7
I/O0 [	13		20	□ I/O6
I/O1 [	14		19	□ I/O5
I/O2 [	15		18	□ I/O4
GND [	16		17	□ I/O3

#### **PLCC Top View**





512K (64K x 8) 5-volt Only Flash Memory

AT49F512



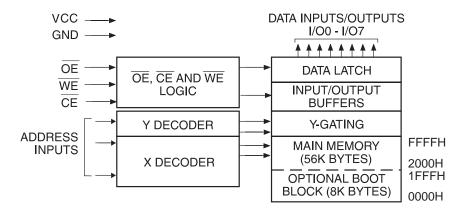




detected by the  $\overline{\text{DATA}}$  polling feature. Once the end of a byte program cycle has been detected, a new access for a read or program can begin. The typical number of program and erase cycles is in excess of 10,000 cycles.

The optional 8K bytes boot block section includes a reprogramming write lock out feature to provide data integrity. The boot sector is designed to contain user secure code, and when the feature is enabled, the boot sector is permanently protected from being reprogrammed.

#### **Block Diagram**



### **Device Operation**

**READ:** The AT49F512 is accessed like an EPROM. When  $\overline{\text{CE}}$  and  $\overline{\text{OE}}$  are low and  $\overline{\text{WE}}$  is high, the data stored at the memory location determined by the address pins is asserted on the outputs. The outputs are put in the high impedance state whenever  $\overline{\text{CE}}$  or  $\overline{\text{OE}}$  is high. This dual-line control gives designers flexibility in preventing bus contention.

**ERASURE:** Before a byte can be reprogrammed, the 64K bytes memory array (or 56K bytes if the boot block featured is used) must be erased. The erased state of the memory bits is a logical "1". The entire device can be erased at one time by using a 6-byte software code. The chip erase code consists of 6-byte load commands to specific address locations with a specific data pattern (please refer to the Chip Erase Cycle Waveforms).

After the chip erase has been initiated, the device will internally time the erase operation so that no external clocks are required. The maximum time needed to erase the whole chip is  $t_{\rm EC}$ . If the boot block lockout feature has been enabled, the data in the boot sector will not be erased.

BYTE PROGRAMMING: Once the memory array is erased, the device is programmed (to a logical "0") on a byte-by-byte basis. Please note that a data "0" cannot be programmed back to a "1"; only erase operations can convert "0"s to "1"s. Programming is accomplished via the internal device command register and is a 4 bus cycle operation (please refer to the Command Definitions table). The device will automatically generate the required internal program pulses.

The program cycle has addresses latched on the falling edge of  $\overline{\text{WE}}$  or  $\overline{\text{CE}}$ , whichever occurs last, and the data

latched on the rising edge of  $\overline{\text{WE}}$  or  $\overline{\text{CE}}$ , whichever occurs first. Programming is completed after the specified  $t_{BP}$  cycle time. The  $\overline{\text{DATA}}$  polling feature may also be used to indicate the end of a program cycle.

BOOT BLOCK PROGRAMMING LOCKOUT: The device has one designated block that has a programming lockout feature. This feature prevents programming of data in the designated block once the feature has been enabled. The size of the block is 8K bytes. This block, referred to as the boot block, can contain secure code that is used to bring up the system. Enabling the lockout feature will allow the boot code to stay in the device while data in the rest of the device is updated. This feature does not have to be activated; the boot block's usage as a write protected region is optional to the user. The address range of the boot block is 0000H to 1FFFH.

Once the feature is enabled, the data in the boot block can no longer be erased or programmed. Data in the main memory block can still be changed through the regular programming method. To activate the lockout feature, a series of six program commands to specific addresses with specific data must be performed. Please refer to the Command Definitions table.

BOOT BLOCK LOCKOUT DETECTION: A software method is available to determine if programming of the boot block section is locked out. When the device is in the software product identification mode (see Software Product Identification Entry and Exit sections) a read from address location 00002H will show if programming the boot block is locked out. If the data on I/O0 is low, the boot block can be programmed; if the data on I/O0 is high, the program lock-

out feature has been activated and the block cannot be programmed. The software product identification code should be used to return to standard operation.

**PRODUCT IDENTIFICATION:** The product identification mode identifies the device and manufacturer as Atmel. It may be accessed by hardware or software operation. The hardware operation mode can be used by an external programmer to identify the correct programming algorithm for the Atmel product.

For details, see Operating Modes (for hardware operation) or Software Product Identification. The manufacturer and device code is the same for both modes.

**DATA POLLING:** The AT49F512 features DATA polling to indicate the end of a program cycle. During a program cycle an attempted read of the last byte loaded will result in the complement of the loaded data on I/O7. Once the program cycle has been completed, true data is valid on all

outputs and the next cycle may begin. DATA polling may begin at any time during the program cycle.

**TOGGLE BIT:** In addition to DATA polling the AT49F512 provides another method for determining the end of a program or erase cycle. During a program or erase operation, successive attempts to read data from the device will result in I/O6 toggling between one and zero. Once the program cycle has completed, I/O6 will stop toggling and valid data will be read. Examining the toggle bit may begin at any time during a program cycle.

**HARDWARE DATA PROTECTION:** Hardware features protect against inadvertent programs to the AT49F512 in the following ways: (a)  $V_{CC}$  sense: if  $V_{CC}$  is below 3.8V (typical), the program function is inhibited. (b) Program inhibit: holding any one of  $\overline{OE}$  low,  $\overline{CE}$  high or  $\overline{WE}$  high inhibits program cycles. (c) Noise filter: Pulses of less than 15 ns (typical) on the  $\overline{WE}$  or  $\overline{CE}$  inputs will not initiate a program cycle.

### **Command Definition (in Hex)**

Command Sequence	Bus Cycles		Bus cle	2nd Cy			Bus cle		Bus cle		Bus cle		Bus cle
		Addr	Data	Addr	Data	Addr	Data	Addr	Data	Addr	Data	Addr	Data
Read	1	Addr	D <sub>OUT</sub>										
Chip Erase	6	5555	AA	2AAA	55	5555	80	5555	AA	2AAA	55	5555	10
Byte Program	4	5555	AA	2AAA	55	5555	A0	Addr	D <sub>IN</sub>				
Boot Block Lockout <sup>(1)</sup>	6	5555	AA	2AAA	55	5555	80	5555	AA	2AAA	55	5555	40
Product ID Entry	3	5555	AA	2AAA	55	5555	90						
Product ID Exit <sup>(2)</sup>	3	5555	AA	2AAA	55	5555	F0						
Product ID Exit <sup>(2)</sup>	1	XXXX	F0										

Notes: 1. The 8K byte boot sector has the address range 0000H to 1FFFH.

2. Either one of the Product ID exit commands can be used.

### **Absolute Maximum Ratings\***

3-
Temperature Under Bias55°C to +125°C
Storage Temperature65°C to +150°C
All Input Voltages (including NC pins) with Respect to Ground0.6V to +6.25V
All Output Voltages with Respect to Ground0.6V to V <sub>CC</sub> + 0.6V
Voltage on $\overline{\text{OE}}$ with Respect to Ground0.6V to +13.5V

\*NOTICE:

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.





# **DC and AC Operating Range**

		AT49F512-50	AT49F512-70	AT49F512-90
Operating	Com.	0°C - 70°C	0°C - 70°C	0°C - 70°C
Temperature (Case)	Ind.	-40°C - 85°C	-40°C - 85°C	-40°C - 85°C
V <sub>CC</sub> Power Supply		5V ± 10%	5V ± 10%	5V ± 10%

# **Operating Modes**

Mode	CE	ŌĒ	WE	Ai	I/O
Read	V <sub>IL</sub>	V <sub>IL</sub>	V <sub>IH</sub>	Ai	D <sub>OUT</sub>
Program <sup>(2)</sup>	V <sub>IL</sub>	V <sub>IH</sub>	V <sub>IL</sub>	Ai	D <sub>IN</sub>
Standby/Write Inhibit	V <sub>IH</sub>	X <sup>(1)</sup>	Х	X	High Z
Program Inhibit	Х	Х	V <sub>IH</sub>		
Program Inhibit	Х	V <sub>IL</sub>	Х		
Output Disable	Х	V <sub>IH</sub>	Х		High Z
Product Identification					
Handrian				A1 - A15 = $V_{IL}$ , A9 = $V_{H}$ , A0 = $V_{IL}$ <sup>(3)</sup>	Manufacturer Code <sup>(4)</sup>
Hardware	V <sub>IL</sub>	V <sub>IL</sub>	V <sub>IH</sub>	A1 - A15 = V <sub>IL</sub> , A9 = V <sub>H</sub> , A0 = V <sub>IH</sub> <sup>(3)</sup>	Device Code <sup>(4)</sup>
Software <sup>(5)</sup>				A0 = V <sub>IL</sub> , A1 - A15 = V <sub>IL</sub>	Manufacturer Code <sup>(4)</sup>
Software				A0 = V <sub>IH</sub> , A1 - A15 = V <sub>IL</sub>	Device Code <sup>(4)</sup>

Notes: 1. X can be  $V_{IL}$  or  $V_{IH}$ .

2. Refer to AC Programming Waveforms.

3.  $V_H = 12.0V \pm 0.5V$ .

4. Manufacturer Code: 1FH, Device Code: 03H

5. See details under Software Product Identification Entry/Exit.

### **DC Characteristics**

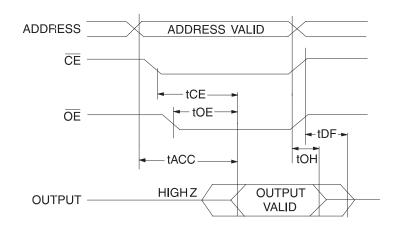
Symbol	Parameter	Condition		Min	Max	Units
I <sub>LI</sub>	Input Load Current	$V_{IN} = 0V \text{ to } V_{CC}$			10	μΑ
I <sub>LO</sub>	Output Leakage Current	$V_{I/O} = 0V \text{ to } V_{CC}$			10	μA
	V Standby Current CMOS	<u>CF</u>	Com.		100	μA
I <sub>SB1</sub> V <sub>CC</sub> Standby Current CMOS	$\overline{\text{CE}} = V_{\text{CC}} - 0.3V \text{ to } V_{\text{CC}}$	Ind.		300	μΑ	
I <sub>SB2</sub>	V <sub>CC</sub> Standby Current TTL	$\overline{\text{CE}}$ = 2.0V to V <sub>CC</sub>	,		3	mA
. (1)	V Astina Command	6	Com.		30	mA
I <sub>CC</sub> <sup>(1)</sup>	$V_{CC}$ Active Current $f = 5 \text{ MHz}$ ; $I_{OUT} = 0 \text{ mA}$	Ind.		40	mA	
V <sub>IL</sub>	Input Low Voltage				0.8	V
V <sub>IH</sub>	Input High Voltage			2.0		V
V <sub>OL</sub>	Output Low Voltage	I <sub>OL</sub> = 2.1 mA			0.45	V
V <sub>OH1</sub>	Output High Voltage	I <sub>OH</sub> = -400 μA		2.4		V
V <sub>OH2</sub>	Output High Voltage CMOS	$I_{OH} = -100 \mu A; V_{CC} = 4.5 V$		4.2		V

Note: 1. In the erase mode,  $I_{CC}$  is 90 mA.

#### **AC Read Characteristics**

		AT49F512-50		AT49F512-70		AT49F512-90			
Symbol	Parameter	Min	Max	Min	Max	Min	Max	Units	
t <sub>ACC</sub>	Address to Output Delay		50		70		90	ns	
t <sub>CE</sub> <sup>(1)</sup>	CE to Output Delay		50		70		90	ns	
t <sub>OE</sub> <sup>(2)</sup>	OE to Output Delay		30		35	0	40	ns	
t <sub>DF</sub> <sup>(3)(4)</sup>	CE or OE to Output Float	0	25	0	25	0	25	ns	
t <sub>OH</sub>	Output Hold from $\overline{OE}$ , $\overline{CE}$ or Address, whichever occurred first	0		0		0		ns	

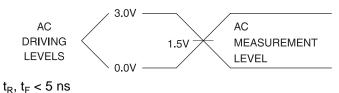
# AC Read Waveforms<sup>(1)(2)(3)(4)</sup>



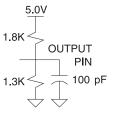
Notes: 1.  $\overline{\text{CE}}$  may be delayed up to  $t_{\text{ACC}}$  -  $t_{\text{CE}}$  after the address transition without impact on  $t_{\text{ACC}}$ .

- OE may be delayed up to t<sub>CE</sub> t<sub>OE</sub>, after the falling edge of CE without impact on t<sub>CE</sub> or by t<sub>ACC</sub> t<sub>OE</sub> after an address change without impact on t<sub>ACC</sub>.
- 3.  $t_{DF}$  is specified from  $\overline{OE}$  or  $\overline{CE}$  whichever occurs first ( $C_L = 5 \text{ pF}$ ).
- 4. This parameter is characterized and is not 100% tested.

# Input Test Waveforms and Measurement Level



### **Output Test Load**



# Pin Capacitance

 $f = 1 \text{ MHz}, T = 25^{\circ}C^{(1)}$ 

Symbol	Тур	Typ Max Units		Conditions
C <sub>IN</sub>	4	6	pF	$V_{IN} = 0V$
C <sub>OUT</sub>	8	12	pF	V <sub>OUT</sub> = 0V

Note: 1. This parameter is characterized and is not 100% tested.



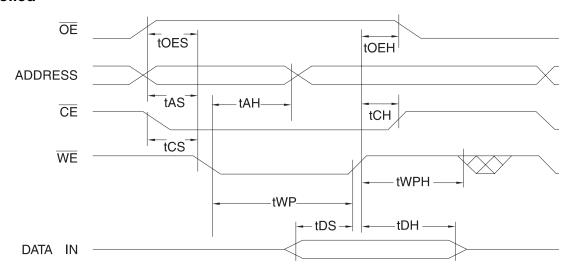


### **AC Word Load Characteristics**

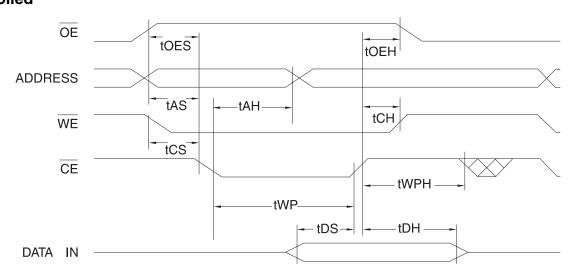
Symbol	Parameter	Min	Max	Units
t <sub>AS</sub> , t <sub>OES</sub>	Address, OE Set-up Time	0		ns
t <sub>AH</sub>	Address Hold Time	50		ns
t <sub>CS</sub>	Chip Select Set-up Time	0		ns
t <sub>CH</sub>	Chip Select Hold Time	0		ns
t <sub>WP</sub>	Write Pulse Width (WE or CE)	90		ns
t <sub>DS</sub>	Data Set-up Time	50		ns
t <sub>DH</sub> , t <sub>OEH</sub>	Data, $\overline{\text{OE}}$ Hold Time	0		ns
t <sub>WPH</sub>	Write Pulse Width High	90		ns

# **AC Byte Load Waveforms**

### **WE** Controlled



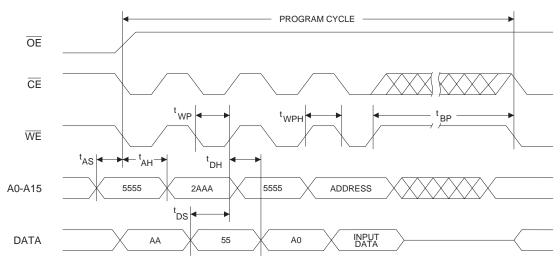
## **CE** Controlled



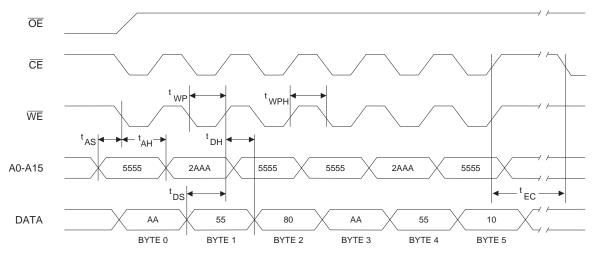
# **Program Cycle Characteristics**

Symbol	Parameter	Min	Тур	Max	Units
t <sub>BP</sub>	Byte Programming Time		10	50	μs
t <sub>AS</sub>	Address Set-up Time	0			ns
t <sub>AH</sub>	Address Hold Time	50			ns
t <sub>DS</sub>	Data Set-up Time	50			ns
t <sub>DH</sub>	Data Hold Time	0			ns
t <sub>WP</sub>	Write Pulse Width	90			ns
t <sub>WPH</sub>	Write Pulse Width High	90			ns
t <sub>EC</sub>	Erase Cycle Time			10	seconds

# **Program Cycle Waveforms**



# **Chip Erase Cycle Waveforms**



Note:  $\overline{OE}$  must be high only when  $\overline{WE}$  and  $\overline{CE}$  are both low.





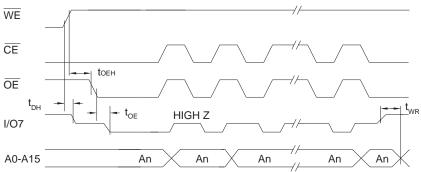
# **Data Polling Characteristics**(1)

Symbol	Parameter	Min	Тур	Max	Units
t <sub>DH</sub>	Data Hold Time	10			ns
t <sub>OEH</sub>	OE Hold Time	10			ns
t <sub>OE</sub>	OE to Output Delay (2)				ns
t <sub>WR</sub>	Write Recovery Time	0			ns

Notes: 1. These parameters are characterized and not 100% tested.

2. See  $t_{OE}$  spec in AC Read Characteristics.

## **Data** Polling Waveforms



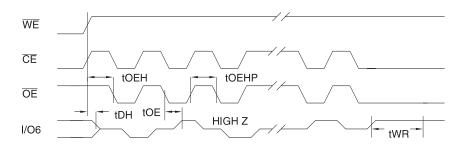
# Toggle Bit Characteristics(1)

Symbol	Parameter	Min	Тур	Max	Units
t <sub>DH</sub>	Data Hold Time	10			ns
t <sub>OEH</sub>	OE Hold Time	10			ns
t <sub>OE</sub>	$\overline{OE}$ to Output Delay <sup>(2)</sup>				ns
t <sub>OEHP</sub>	OE High Pulse	150			ns
t <sub>WR</sub>	Write Recovery Time	0			ns

Notes: 1. These parameters are characterized and not 100% tested.

2. See t<sub>OE</sub> spec in AC Read Characteristics.

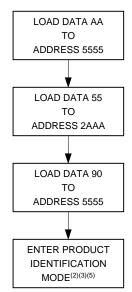
# Toggle Bit Waveforms<sup>(1)(2)(3)</sup>



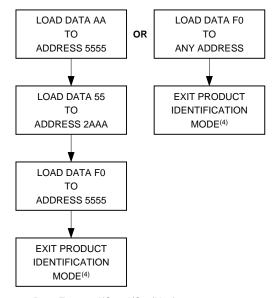
Notes: 1. Toggling either  $\overline{OE}$  or  $\overline{CE}$  or both  $\overline{OE}$  and  $\overline{CE}$  will operate toggle bit. The  $t_{OEHP}$  specification must be met by the toggling input(s)

- 2. Begining and ending state of I/O6 will vary.
- 3. Any address location may be used but the address should not vary.

# **Software Product Identification Entry**<sup>(1)</sup>



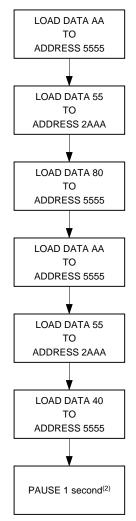
# **Software Product Identification Exit**(1)



Notes:

- Data Format: I/O7 I/O0 (Hex);
   Address Format: A14 A0 (Hex).
- 2. A1 A15 =  $V_{IL}$ . Manufacture Code is read for A0 =  $V_{IL}$ ; Device Code is read for A0 =  $V_{IH}$ .
- The device does not remain in identification mode if powered down.
- 4. The device returns to standard operation mode.
- 5. Manufacturer Code: 1FH Device Code: 03H

# Boot Block Lockout Enable Algorithm<sup>(1)</sup>



Notes:

- 1. Data Format: I/O7 I/O0 (Hex); Address Format: A14 - A0 (Hex).
- 2. Boot block lockout feature enabled.



# **Ordering Information**<sup>(1)</sup>

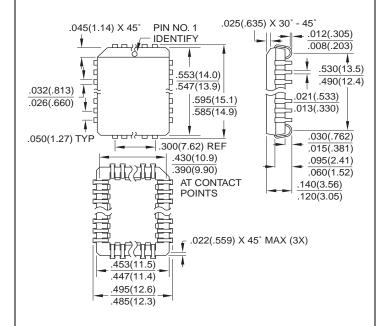
t <sub>ACC</sub>	I <sub>CC</sub> (mA)					
(ns)	Active	Standby	Ordering Code	Package	Operation Range	
50	30	0.1	AT49F512-50JC	32J	Commercial	
			AT49F512-50PC	32P6	(0° to 70°C)	
			AT49F512-50TC	32T		
			AT49F512-50VC	32V		
	40	0.3	AT49F512-50JI	32J	Industrial	
			AT49F512-50PI	32P6	(-40° to 85°C)	
			AT49F512-50TI	32T		
			AT49F512-50VI	32V		
70	30	0.1	AT49F512-70JC	32J	Commercial	
			AT49F512-70PC	32P6	(0° to 70°C)	
			AT49F512-70TC	32T		
			AT49F512-70VC	32V		
	40	0.3	AT49F512-70JI	32J	Industrial	
			AT49F512-70PI	32P6	(-40° to 85°C)	
			AT49F512-70TI	32T		
			AT49F512-70VI	32V		
90	30	0.1	AT49F512-90JC	32J	Commercial	
			AT49F512-90PC	32P6	(0° to 70°C)	
			AT49F512-90TC	32T		
			AT49F512-90VC	32V		
	40	0.3	AT49F512-90JI	32J	Industrial	
			AT49F512-90PI	32P6	(-40° to 85°C)	
			AT49F512-90TI	32T		
			AT49F512-90VI	32V		

Note: 1. The AT49F512 has as optional boot block feature. The part number shown in the Ordering Information table is for devices with the boot block in the lower address range (i.e., 0000H to 1FFFH). Users requiring the boot block to be in the higher address range should contact Atmel.

Package Type			
32J	32-lead, Plastic, J-leaded Chip Carrier Package (PLCC)		
32P6	32-lead, 0.600" Wide, Plastic Dual Inline Package (PDIP)		
32T	32-lead, Thin Small Outline Package (TSOP) (8 x 20 mm)		
32V	32-lead, Thin Small Outline Package (VSOP) (8 x 14 mm)		

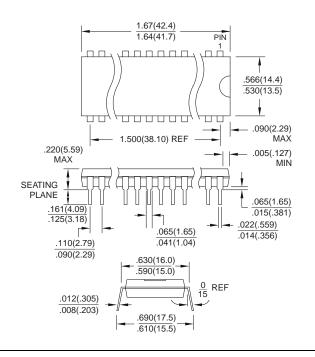
### **Packaging Information**

**32J**, 32-lead, Plastic J-leaded Chip Carrier (PLCC) Dimensions in Inches and (Millimeters)
JEDEC STANDARD MS-016 AE



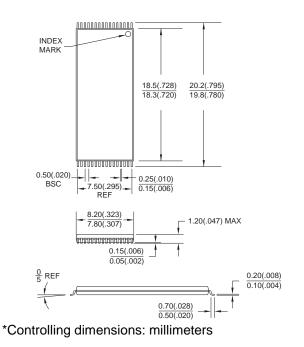
**32P6**, 32-lead, 0.600" Wide, Plastic Dual Inline Package (PDIP)

Dimensions in Inches and (Millimeters)



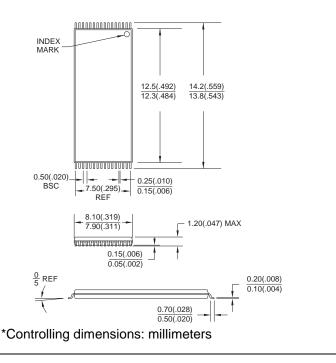
**32T**, 32-lead, Plastic Thin Small Outline Package (TSOP)

Dimensions in Millimeters and (Inches)\*



**32V**, 32-lead, Plastic Thin Small Outline Package (VSOP)

Dimensions in Millimeters and (Inches)\*







#### **Atmel Headquarters**

Corporate Headquarters 2325 Orchard Parkway San Jose, CA 95131 TEL (408) 441-0311 FAX (408) 487-2600

#### Europe

Atmel U.K., Ltd.
Coliseum Business Centre
Riverside Way
Camberley, Surrey GU15 3YL
England
TEL (44) 1276-686-677
FAX (44) 1276-686-697

#### Asia

Atmel Asia, Ltd. Room 1219 Chinachem Golden Plaza 77 Mody Road Tsimhatsui East Kowloon Hong Kong TEL (852) 2721-9778 FAX (852) 2722-1369

#### Japan

Atmel Japan K.K. 9F, Tonetsu Shinkawa Bldg. 1-24-8 Shinkawa Chuo-ku, Tokyo 104-0033 Japan TEL (81) 3-3523-3551 FAX (81) 3-3523-7581

#### **Atmel Operations**

Atmel Colorado Springs 1150 E. Cheyenne Mtn. Blvd. Colorado Springs, CO 80906 TEL (719) 576-3300 FAX (719) 540-1759

#### Atmel Rousset

Zone Industrielle 13106 Rousset Cedex France TEL (33) 4-4253-6000 FAX (33) 4-4253-6001

> Fax-on-Demand North America: 1-(800) 292-8635 International: 1-(408) 441-0732

*e-mail* literature@atmel.com

Web Site http://www.atmel.com

*BBS* 1-(408) 436-4309

#### © Atmel Corporation 1999.

Atmel Corporation makes no warranty for the use of its products, other than those expressly contained in the Company's standard warranty which is detailed in Atmel's Terms and Conditions located on the Company's web site. The Company assumes no responsibility for any errors which may appear in this document, reserves the right to change devices or specifications detailed herein at any time without notice, and does not make any commitment to update the information contained herein. No licenses to patents or other intellectual property of Atmel are granted by the Company in connection with the sale of Atmel products, expressly or by implication. Atmel's products are not authorized for use as critical components in life support devices or systems.

Marks bearing <sup>®</sup> and/or <sup>™</sup> are registered trademarks and trademarks of Atmel Corporation.

Printed on recycled paper.