## Features

- 3.0V to 3.6V Read/Write
- Burst Read Performance
  - ≤100 MHz (RAS Latency = 2, CAS Latency = 6), 10 ns Cycle Time t<sub>SAC</sub> = 7 ns
  - ≤75 MHz (RAS Latency = 2, CAS Latency = 5), 13 ns Cycle Time t<sub>SAC</sub> = 8 ns
  - <50 MHz (RAS Latency = 1, CAS Latency = 4), 20 ns Cycle Time t<sub>SAC</sub> = 9 ns
- MRS Cycle with Address Key Programs
  - RAS Latency (1 and 2)
  - CAS Latency (2 ~ 8)
  - Burst Length: 4, 8
  - Burst Type: Sequential and Interleaved
- Word Selectable Organization
  - 16 (Word Mode)/x 32 (Double Word Mode)
- Sector Erase Architecture
  - Eight 256K Word or 128K Double Word (4-Mbit) Sectors
- Independent Asynchronous Boot Block
  - 8K x 16 Bits with Hardware Lockout
- Fast Program Time
  - 3-volt, 100 µs per Word/Double Word Typical
  - 12-volt, 30 µs per Word/Double Word Typical
- Fast Sector Erase Time
  - 2.5 Seconds at 3 Volts
  - 1.6 Seconds at 12 Volts
- Low-power Operation
- I<sub>CC</sub> Read = 75 mA Typical
- Input and Output Pin Continuity Test Mode Optimizes Off-board Programming
  Package:
- 86-pin TSOP Type II with Off-center Parting Line (OCPL) for Improved Reliability
- LVTTL-compatible Inputs and Outputs

# Description

The AT49LD3200 or AT49LD3200B SFlash<sup>™</sup> is a synchronous, high-bandwidth Flash memory fabricated with Atmel's high-performance CMOS process technology and is organized either as 2,097,152 x 16 bits (word mode) or as 1,048,576 x 32 bits (double word mode), depending on the polarity of the WORD pin (see Pin Function Description Table). Synchronous design allows precise cycle control. I/O transactions are possible on every clock cycle. All operations are synchronized to the rising edge of the system clock. The range of operating frequencies, programmable burst length and programmable latencies allow the same device to be useful for a variety of high-bandwidth, high-performance memory system applications.

The AT49LD3200B will automatically activate the Asynchronous Boot Block after power-up, whereas with the AT49LD3200, the Asynchronous Boot Block can be activated through Mode Register Set.

The synchronous DRAM interface allows designers to maximize system performance while eliminating the need to shadow slow asynchronous Flash memory into high-speed RAM.

The 32-megabit SFlash device is designed to sit on the synchronous memory bus and operate alongside SDRAM.



32-megabit (1M x 32 or 2M x 16) High-speed Synchronous Flash Memory

AT49LD3200 AT49LD3200B SFlash<sup>™</sup>







To maximize system manufacturing throughput the AT49LD3200(B) features highspeed 12-volt program and erase options. Additionally, stand-alone programming cycle time of individual devices or modules is optimized with Atmel's unique input and output pin continuity test mode.

## **Pin Configuration**



<sup>2</sup> AT49LD3200(B)

# **Pin Function Description**

Pin	Name	Input Function
CLK	System Clock	Active on the rising edge to sample all inputs.
CS	Chip Select	Disables or enables device operation by masking or enabling all inputs except CLK and CKE.
СКЕ	Clock Enable	Masks system clock to freeze operation from the next clock cycle. CKE should be enabled at least one cycle prior to new command. Disables input buffers for power- down in standby mode.
A0 - A12	Address	Row/column addresses are multiplexed on the same pins. Row address: $RA_0 \sim RA_{12}$ , Column address: $CA_0 \sim CA_6$ (x32), $CA_0 \sim CA_7$ (x16)
RAS	Row Address Strobe	Latches row addresses on the rising edge of the CLK with $\overline{\text{RAS}}$ low. Enables row access.
CAS	Column Address Strobe	Latches column addresses on the rising edge of the CLK with $\overline{\text{CAS}}$ low. Enables column access.
MR	Mode Register Set	Enables mode register set with $\overline{\text{MR}}$ low. (Simultaneously $\overline{\text{CS}}$ , $\overline{\text{RAS}}$ and $\overline{\text{CAS}}$ are low).
DQ0 - DQ31	Data Input/Output	Data input for program/erase. Data output for read.
VCC/VSS	Power Supply/Ground	Power and ground for the input buffers and the core logic.
VCCQ/VSSQ	Data Output Power/Ground	Power and ground for the output buffers.
WORD	x32/x16 Mode Selection	Double word mode/word mode, depending on polarity of $\overline{\text{WORD}}$ pin ( $\overline{\text{WORD}}$ = high, double word mode; $\overline{\text{WORD}}$ = low, word mode). Should be set to the desired state during power-up and prior to any device operation.
DQM	Data-out Masking	Masks output operation when a complete burst is not required.
NC	No Connection	Not connected
WE	Write Enable	Enables the chip to be written.
VPP	Program/Erase Pin Supply	Program/Erase power supply.





# **Absolute Maximum Ratings\***

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 +4.6V
All Output Voltages with Respect to Ground0.6V to $\rm V_{\rm CC}$ + 0.6V
Voltage on V <sub>PP</sub> with Respect to Ground0.6V to +13.5V
Power Dissipation 1 W

\*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.

## **Functional Block Diagram**



# **DC and AC Operating Range**

		AT49LD3200(B)-10	AT49LD3200(B)-13	AT49LD3200(B)-20
Operating Temperature	Commercial	0°C - 70°C	0°C - 70°C	0°C - 70°C
(Case)	Industrial	-40°C - 85°C	-40°C - 85°C	-40°C - 85°C
V <sub>CC</sub> , V <sub>CCQ</sub> Power Supply		3.0V to 3.6V	3.0V to 3.6V	3.0V to 3.6V

# **DC Characteristics**

Symbol	Parameter	Condition	Min	Max	Units
I <sub>SB1</sub>	V <sub>CC</sub> Standby Current CMOS	$CKE = 0, t_{CC} = Min$		20	mA
I <sub>SB2</sub>	V <sub>CC</sub> Standby Current TTL	$CKE \le V_{IL}$ (Max), $t_{CC}$ = Min		20	mA
I <sub>SB3</sub>	V <sub>CC</sub> Active Standby Current	$\overline{\text{CS}} \ge V_{\text{IH}}$ (Min), $t_{\text{CC}}$ = Min		50	mA
I <sub>cc</sub>	V <sub>CC</sub> Active Current	t <sub>CC</sub> = Min, All Outputs Open		150	mA
IIL	Input Leakage Current	$\begin{array}{l} 0V \leq V_{\text{IN}} \leq V_{\text{DD}} + 0.3V \\ \text{Pins not under test} = 0V \end{array}$	-10	10	μΑ
I <sub>OL</sub>	Output Leakage Current (IO <sub>OUT</sub> Disabled)	$(0V \le V_{OUT} \le V_{DD} Max)$ All Outputs in High-Z	-10	10	μA
V <sub>IH</sub>	Input High Voltage, All Inputs	Note <sup>(1)</sup>	2.0	V <sub>DD</sub> + 0.3	V
V <sub>IL</sub>	Input Low Voltage, All Inputs	Note <sup>(2)</sup>	-0.3	0.8	V
V <sub>OH</sub>	Output High Voltage Level (Logic 1)	I <sub>OH</sub> = -2 mA	2.4		V
V <sub>OL</sub>	Output Low Voltage Level (Logic 0)	$I_{OL} = 2 \text{ mA}$		0.4	V

Notes: 1.  $V_{IH}$  (max) = 4.6V for pulse width <10 ns acceptable, pulse width measured at 50% of pulse amplitude.

2.  $V_{IL}$  (min) = -1.5V for pulse width <10 ns acceptable, pulse width measured at 50% of pulse amplitude.

# **AC Operating Test Conditions**

 $T_A = 0$  to 70°C,  $V_{CC} = 3.3V \pm 0.3V$ , unless otherwise noted.

Parameter <sup>(1)</sup>	Value
Timing Reference Levels of Input/Output Signals	1.4V
Input Signal Levels	$V_{IH}/V_{IL} = 2.4V/0.4V$
Transition Time (Rise & Fall) of Input Signals	$t_r/t_f = 1 \text{ ns}/1 \text{ ns}$
Output Load	LVTTL

Note: 1. If CLK transition time is longer than 1 ns, timing parameters should be compensated. Add [(t<sub>r</sub> + t<sub>f</sub>)/2-1] ns for transition time longer than 1 ns. Transition time is measured between V<sub>IL</sub> (max) and V<sub>IH</sub> (min).





Figure 1. DC Output Load Circuit







# Pin Capacitance<sup>(1)</sup>

f = 1 MHz, T = 25°C

Symbol	Тур	Мах	Units	Conditions
C <sub>IN</sub>	4	6	pF	$V_{IN} = 0V$
C <sub>OUT</sub> <sup>(2)</sup>	8	12	pF	$V_{OUT} = 0V$

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

2.  $V_{PP}$  behaves as an output pin.

# **AC Read Characteristics**

AC operating conditions unless otherwise noted.

		<u>&lt;</u> 100	MHz	<u>&lt;</u> 75	MHz	<u>&lt;</u> 50	MHz	
Symbol	Parameter	Min	Max	Min	Max	Min	Max	Units
t <sub>CC</sub>	CLK Cycle Time	10		13		20		ns
t <sub>SAC</sub>	CLK to Valid Output Delay		7		8		9	ns
t <sub>OH</sub>	Data Output Hold Time	3		4		4		ns
t <sub>CH</sub>	CLK High Pulse Width	3		4		6.5		ns
t <sub>CL</sub>	CLK Low Pulse Width	3		4		6.5		ns
t <sub>RC</sub>	Row-active to Row-active <sup>(1)</sup>	11		10		9		clks
t <sub>SS</sub>	Input Setup Time	2		4		4		ns
t <sub>SH</sub>	Input Hold Time	1		2		2		ns
t <sub>SLZ</sub>	CLK to Output in Low-Z	0		0		0		ns
t <sub>SHZ</sub>	CLK to Output in High-Z		7		10		15	ns
t <sub>T</sub>	Transition Time	0.1	10	0.1	10	0.1	10	ns
t <sub>VCVC</sub>	Valid CAS Enable to Valid CAS Enable <sup>(2)</sup>	9		8		7		clks

Notes: 1. These  $t_{RC}$  values are for BL = 8. For BL = 4,  $t_{RC}$  = 7 CLKs for up to 100 MHz,  $t_{RC}$  = 6 CLKs for up to 75 MHz,  $t_{RC}$  = 5 CLKs for up to 50 MHz. RAS latency increase means a simultaneous  $t_{RC}$  increase in the same number of cycles. (If RAS latency is 3 CLKs,  $t_{RC}$  is 12 CLKs for BL = 8.) Refer to page 27 for gapless operation.

2. These  $t_{VCVC}$  values are for BL = 8. For BL = 4,  $t_{VCVC}$  = 5 CLKs for up to 100 MHz,  $t_{VCVC}$  = 4 CLKs for up to 75 MHz,  $t_{VCVC}$  = 3 CLKs for up to 50 MHz. Refer to page 27 for gapless operation.





## **Function Truth Table**

(V = Valid, X = Don't Care, H = Logic High, L = Logic Low)

Abbreviations (RA: Row Address, CA: Column Address, NOP: No Operation Command, DWM: Double Word Mode, WM: Word Mode)

Command			CKEn-1	CKEn	CS	RAS	CAS	<b>MR</b> <sup>(9)</sup>	DQM	Add.	WORD	VPP	WE
Register <sup>(1)</sup>	Mode Regi	ster Set	Н	Х	L	L	L	L	Х	Code	Х	Х	Х
Row Active	Row Acces & Latch	S	н	Х	L	L	Н	Н	х	RA	х	х	Х
Read	Column Ac & Latch	cess	н	Х	L	н	L	Н	х	CA	х	х	Н
			Н	Х	L	Н	Н	L	Х	Х	Х	Х	Х
Burst Stop	(Precharge on Synch. DRAM)		н	Х	L	L	Н	L	х	х	х	х	х
Power-down	Two	Entry	Н	L	Х	Х	Х	Х	Х	Х	Х	Х	Х
and Clock Suspend <sup>(2)</sup>	Standby Mode	Exit	L	Н	х	х	Х	Х	Х	Х	Х	х	Х
DQM <sup>(3)</sup>		Н	Х	х	Х	Х	Х	V	Х	Х	Х	Х	
No Oneration Co	(4)		Н	Х	н	Х	Х	Х	Х	Х	Х	Х	Х
No Operation Co	ommand		Н	Х	L	Н	Н	Н	Х	Х	Х	Х	Х
Organization Co	ntrol <sup>(5)</sup>		н	х	L	н	L	н	х	СА	Н	x	н
Program/Erase <sup>(6</sup>	i)		н	Х	L	Н	L	Х	Х	CA	X	Х	L
Fast Program/Er	ase <sup>(6)</sup>		Н	Х	L	н	L	Х	Х	CA	х	12V	L
Program/Erase I	nhibit		Н	Х	н	х	Х	Х	Х	Х	х	Х	Х
Product	Mode Regi	ster Set	Н	Х	L	L	L	L	Х	$A_7 = H$	х	Х	Х
Identification <sup>(7)</sup>	Read		Н	Х	L	Н	L	Н	Х	L	Х	Х	Н
		Entry	н	Х	L	Н	L	Х	Х	CA	Х	Х	L
Continuity lest N	loae	Exit	Х	Х	Х	Х	Х	Х	Х	Code <sup>(8)</sup>	Х	Х	Х

Notes: 1. A<sub>0</sub> ~ A<sub>6</sub>: Program keys (@MRS). After power-up, mode register set can be set before issuing other input command. After the Mode Register Set command is completed, no new commands can be issued for 3 CLK Cycles, and  $\overline{CS}$  or  $\overline{MR}$  state must be defined "H" within 3 CLK cycles. Refer to the Mode Register Control Table.

2. In the case CKE is low, two standby modes are possible. Those are standby mode in power-down, and active standby mode in clock suspend (non-power-down).

Power-down: CKE = "L" (after no command is issued for 60  $\mu$ s)

Clock Suspend: CKE = "L" (at the range of Row Active, Read and Data Out)

3. DQM sampled at rising edge of a CLK makes a high-Z state the data-out state, delayed by 2 CLK cycles.

4. Precharge command on Synch. DRAM can be used for Burst Stop operation during burst read operation only.

5. Mode selection is controlled by the polarity of WORD pin, "H" state is DWM, "L" state is WM. WORD should be set to the desired state during power-up and prior to any device operation.

- 6. Data is provided through  $DQ_0 \sim DQ_{31}$ . Refer to AC programming and erasing waveforms.
- 7.  $DQ_0 \sim DQ_{31}$  will output Manufacturer Code/Device Code.
- 8.  $A_0 = A_2 = A_{11} = "\underline{H}", A_1 = \underline{A}_{10} = A_{12} = "L"$

9. The user can tie MR and WE together to simplify the interface of the AT49LD3200(B) onto the standard SDRAM bus.

## **Asynchronous Boot Block Function Truth Table**

Command	<b>CLK</b> <sup>(2)</sup>	<b>CKE</b> <sup>(2)</sup>	CS	RAS	CAS	MR	DQM	Add.	WORD	VPP	WE
Read	Х	Х	L	Х	Х	Х	L	Add	Х	х	Х
Output Disable	Х	Х	L	Х	Х	Х	н	Х	Х	Х	х
Program/Erase <sup>(1)</sup>	_ <b>_</b>	Н	L	Н	L	Х	Х	Add	Х	Х	L
Fast Program/Erase <sup>(1)</sup>		Н	L	Н	L	Х	Х	Add	Х	12V	L
Program/Erase Inhibit		Н	Н	Х	Х	Х	Х	Х	Х	Х	Х

Notes: 1. Program/Erase is performed through the synchronous bus cycle operation after the boot block is activated through either power-up or Mode Register Set.

2. It is recommended to hold CKE Low if CLK is running during asynchronous boot block mode except for synchronous command cycle and MRS operations.

# Mode Register Control Table<sup>(1)</sup>

## **Register Programmed with MRS**

Address	A7	A6	A5	A5 A4		A2	A1	A0
Function	Product ID	RAS Latency	C/	AS Laten	су	Burst Type	Burst I	Length

Prod	uct ID	RAS	Latency		CA	AS Late	ency		Burst Type	Burst Length			
A7	"Read"	A6	Туре	A5	A4	A3	Length	A2	Туре	A1	A0	Length	
0	Array	0	1	0	0	0	Reserved	0	Sequential	0	0	Reserved	
1	ID	1	2	0	0	1	2	1	Interleave	0	1	4	
				0	1	0	3			1	0	8	
				0	1	1	4			1	1	Boot Block	
				1	0	0	5						
				1	0	1	6						
				1	1	0	7						
				1	1	1	8						

Note: 1. After power-up, when the user wants to change Mode Register Set, the user must exit from power-down mode and start Mode Register Set before entering normal operation mode. Reserved modes are not to be used; device function in these modes is not guaranteed.





# **Addressing Map**

## WORD = "H": x32 Organization<sup>(1)</sup>

Function	A <sub>0</sub>	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>4</sub>	A <sub>5</sub>	A <sub>6</sub>	A <sub>7</sub>	A <sub>8</sub>	A <sub>9</sub>	A <sub>10</sub>	A <sub>11</sub>	A <sub>12</sub>
Row Address	$RA_0$	RA <sub>1</sub>	$RA_2$	$RA_3$	$RA_4$	$RA_5$	$RA_6$	RA <sub>7</sub>	RA <sub>8</sub>	$RA_9$	RA <sub>10</sub>	RA <sub>11</sub>	RA <sub>12</sub>
Column Address	$CA_0$	CA <sub>1</sub>	CA <sub>2</sub>	$CA_3$	$CA_4$	$CA_5$	CA <sub>6</sub> <sup>(1)</sup>	Х	Х	Х	Х	Х	Х

Note: 1. Column Address MSB (at x32 organization) (X = Don't Care)

## WORD = "L": x16 Organization<sup>(1)</sup>

Function	A <sub>0</sub>	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>4</sub>	$A_5$	A <sub>6</sub>	A <sub>7</sub>	A <sub>8</sub>	A <sub>9</sub>	A <sub>10</sub>	A <sub>11</sub>	A <sub>12</sub>
Row Address	RA <sub>0</sub>	RA <sub>1</sub>	$RA_2$	$RA_3$	$RA_4$	$RA_5$	$RA_6$	RA <sub>7</sub>	RA <sub>8</sub>	$RA_9$	RA <sub>10</sub>	RA <sub>11</sub>	RA <sub>12</sub>
Column Address	CA <sub>0</sub>	CA <sub>1</sub>	CA <sub>2</sub>	CA <sub>3</sub>	$CA_4$	CA <sub>5</sub>	CA <sub>6</sub>	CA <sub>7</sub> <sup>(1)</sup>	Х	Х	Х	Х	Х

Note: 1. Column Address MSB (at x16 organization) (X = Don't Care)

## Each Address is Arranged as Follows<sup>(1)(2)</sup>

For X32 operation,

	MSB										LSB	
Address Register	AR <sub>19</sub>	AR <sub>18</sub>	AR <sub>17</sub>	 AR <sub>8</sub>	AR <sub>7</sub>	$AR_6$		AR <sub>3</sub>	AR <sub>2</sub>	AR <sub>1</sub>	AR <sub>0</sub>	
Address	RA <sub>12</sub>	RA <sub>11</sub>	RA <sub>10</sub>	 RA <sub>1</sub>	RA <sub>0</sub>	CA <sub>6</sub>		CA <sub>3</sub>	CA <sub>2</sub>	CA <sub>1</sub>	CA <sub>0</sub>	
										BI	_ = 4	
							*	nitial Addı	ess B	L = 8		

Notes: 1. For X16 operation, when  $CA_0$  is set to Low, data belonging to 0 ~ 15th registers are output to  $DQ_0 \sim DQ_{15}$  pins, and when  $CA_0$  is set to High, data belonging to 16 ~ 31th registers are output to  $DQ_0 \sim DQ_{15}$  pins.

2. Asynchronous Boot Block uses x16 operation and  $A_0 \sim A_{12}$  as address inputs.

# Burst Sequence (Burst Length = 4)

Initial A	ddress											
A1	A0		Sequ	ential		Interleave						
0	0	0	1	2	3	0	1	2	3			
0	1	1	2	3	0	1	0	3	2			
1	0	2	3	0	1	2	3	0	1			
1	1	3	0	1	2	3	2	1	0			

# **Burst Sequence (Burst Length = 8)**

In	itial Addres	SS																
A2	A1	A0		Sequential										Inter	leave			
0	0	0	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
0	0	1	1	2	3	4	5	6	7	0	1	0	3	2	5	4	7	6
0	1	0	2	3	4	5	6	7	0	1	2	3	0	1	6	7	4	5
0	1	1	3	4	5	6	7	0	1	2	3	2	1	0	7	6	5	4
1	0	0	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3
1	0	1	5	6	7	0	1	2	3	4	5	4	7	6	1	0	3	2
1	1	0	6	7	0	1	2	3	4	5	6	7	4	5	2	3	0	1
1	1	1	7	0	1	2	3	4	5	6	7	6	5	4	3	2	1	0

## **Device Operations**

Clock (CLK)

A square wave signal (CLK) must be applied externally at cycle time  $t_{CC}$ . All operations are synchronized to the rising edge of the clock. The clock transitions must be monotonic between  $V_{IL}$  and  $V_{IH}$ . During operation with CKE high, all inputs are assumed to be in valid state (low or high) for the duration of setup and hold time around the positive edge of the clock for proper functionality and  $I_{CC}$  specifications.

- **Clock Enable (CKE)** The clock enable (CKE) gates the clock into the AT49LD3200(B) and is asserted high during all cycles, except for power-down, standby and clock suspend mode. If CKE goes low synchronously with clock (setup and hold time same as other inputs), the internal clock is suspended from the next clock cycle and the state of output and burst address is frozen for as long as the CKE remains low. All other inputs are ignored from the next clock cycle after CKE goes low. The AT49LD3200(B) remains in the power-down mode, ignoring other inputs for as long as CKE remains low. The power-down exit is synchronous as the internal clock is suspended. When CKE goes high at least "1 CLK + t<sub>SS</sub>" before the rising edge of the clock, then the AT49LD3200 becomes active from the same clock edge accepting all the input commands.
- NOP and DeviceWhen RAS, CAS and MR are high, the AT49LD3200(B) performs no operation (NOP).DeselectNOP does not initiate any new operation. Device deselect is also a NOP and is entered<br/>by asserting CS high. CS high disables the command decoder so that RAS, CAS, MR



	and all the address inputs are ignored. In addition, entering a Mode Register Set com- mand in the middle of a normal operation results in an illegal state in the AT49LD3200(B).
Power-up	<ol> <li>The following power-up sequence is recommended.</li> <li>Apply power and start clock. Hold the MR, CKE and DQM inputs high; all other pins are a NOP condition at the inputs before or along with V<sub>CC</sub> (and V<sub>CCQ</sub>) supply.</li> <li>Set WORD to the desired state (prior to any device operation).</li> <li>To change the default Mode Register Set values, perform a Mode Register Set cycle to program the RAS latency, CAS latency, burst length and burst type.</li> <li>At the end of three clock cycles after the mode register set cycle, the device is ready for operation.</li> </ol>
	When the above sequence is used for power-up, all outputs will be in high impedance state. The high impedance of outputs is not guaranteed in any other power-up sequence.
	For AT49LD3200B, Asynchronous Boot Block will be selected after power-up.
Mode Selection Control	Mode selection is controlled by the polarity of WORD pin. WORD should be set to the desired state during power-up and prior to any device operation. The AT49LD3200(B) can be organized as either double word wide (x32) or word wide (x16). The organization is selected via the WORD pin. When WORD is asserted high (V <sub>IH</sub> ), the double word-wide organization is selected. When WORD is asserted low (V <sub>IL</sub> ), the word-wide organization is selected.
Address Decoding	The address bits required to decode one of the available cell locations out of the total depth are multiplexed onto the address select pins and latched by externally applying two commands. The first command, $\overline{RAS}$ asserted low, latches the row address into the device. A second command, $\overline{CAS}$ asserted low, subsequently latches the column address.
Mode Register Set (MRS)	The mode register stores the data for controlling the various operating modes of AT49LD3200(B). It programs the RAS latency, CAS latency, burst length, burst type, selects product ID Read or activates the Asynchronous Boot Block. For AT49LD3200(B), the default value of the mode register is defined as array read with RAS latency = 2, CAS latency = 5, burst length = 4, sequential burst type. When and if the user wants to change its values, the user must exit from power-down mode and start Mode Register Set before entering normal operation mode. The mode register is reprogrammed by asserting low on $\overline{CS}$ , RAS, CAS and MR (the AT49LD3200(B) should be in active mode with CKE already high prior to writing the mode register). The state of address pins $A_0 \sim A_7$ in the same cycle as $\overline{CS}$ , RAS, CAS and MR going low is the data written in the mode register. Three clock cycles are required to complete the program in the mode register is divided into various fields, depending on functionality. The burst length field uses $A_0 \sim A_1$ , burst type uses $A_2$ , CAS latency (read latency from column address) uses $A_3 \sim A_5$ , RAS latency uses $A_6$ (RAS to CAS delay), array read or product ID read uses A7. Refer to Mode Register Control Table for specific codes for various burst lengths, burst types, CAS latencies, RAS latencies, and read modes.

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Latency	There are latencies between the issuance of a Row Active command and when data is available on the I/O buffers. The RAS to CAS delay is defined as the RAS latency. The CAS to data out delay is the CAS latency. The CAS and RAS latencies are programmable through the mode register. RAS latencies of 1 and 2, and CAS latencies of 2 through 6 are supported. It is understood that some RAS and CAS latency values are reserved for future use, and are not available in this generation of synchronous Flash. The following are the supported minimum values: RAS latency = 2, and CAS latency = 6 for 100 MHz operation, and RAS latency = 2, and CAS latency = 5 for 66 MHz operation, and RAS latency = 4 for 50 MHz operation, and RAS latency = 1, and CAS latency = 3 for 33 MHz operation.
DQM Operation	The DQM is used to mask output operations when a complete burst read is not required. It works similar to $\overline{OE}$ during a read operation. The read latency is two cycles from DQM, which means DQM masking occurs two cycles later in the read cycle. DQM operation is synchronous with the clock. The masking occurs for a complete cycle. (Also refer to the DQM timing diagram.)
Burst Read	The Burst Read command is used to access a burst of data on consecutive clock cycles from an active row state. The Burst Read command is issued by asserting low CS and CAS with MR being high on the rising edge of the clock. The first output appears in CAS latency number of clock cycles after the issuance of the Burst Read command. The burst length, burst sequence and latency from the Burst Read command are determined by the mode register, which is already programmed. Burst read can be initiated on any column address of the active row. The output goes into high-impedance at the end of the burst, unless a new burst read is initiated to keep the data output gapless. The burst read can be terminated by issuing another burst read.
Sector Erase	Before a word/double word can be reprogrammed, it must be erased. The erased state of the memory bits is a logical "1". The AT49LD3200(B) is organized into eight uniform four megabit sectors (SA0 - SA7) that can be individually erased. The Sector Erase command is a synchronous six-bus cycle operation (refer to the Command Definition table and Program Cycle and Erase Cycle waveforms). The erase code consists of 6-byte (DQ8 - DQ31 are Don't Care inputs for the command) load commands to specific address locations with a specific data pattern. The sector address and 30H data input are latched in the sixth cycle. The sector erase starts at the following rising edge of CLK after the sixth cycle. The erase operation is internally controlled; it will automatically time to completion.
	Any commands written to the device during the erase cycle will be ignored. The maximum time needed to erase one sector is $t_{\rm EC}$ .
Word/Double Word Programming	Once a sector is erased, it is programmed (to a logical "0") on a word-by-word/double- word-by-double-word basis. Programming is accomplished via the internal device com- mand register and is synchronous four-bus cycle operation (refer to the Command Definition table and Program Cycle and Erase Cycle waveforms). The programming operation starts at the following rising edge of CLK after the fourth cycle. The device will automatically generate the required internal program pulses. Any commands written to the device during the embedded programming cycle will be
	ignored. 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 completed after the specified $t_{PGM}$ cycle time. The DATA polling feature may also be used to indicate the end of a program cycle.



	(R)

Product Identification	The product identification mode identifies the device and manufacturer as Atmel. This mode can be used by an on-board controller or external programmer to identify the correct programming algorithm for the Atmel product.
DATA Polling	The AT49LD3200(B) features $\overline{DATA}$ polling to indicate the end of a program or sector erase cycle. $\overline{DATA}$ polling may begin at any time during the program or sector erase cycle.
	During a program cycle, an attempted read of the last word/double word loaded will result in the complement of the loaded data in DQ7. Once the program cycle has completed, true valid data can be read on all outputs and the next cycle may begin.
	During a sector erase operation, an attempt to read the device will give a "0" on DQ7. Once the sector erase cycle has completed, logical "1" data can be read on all outputs from the device.
Hardware Data Protection	Hardware features protect against inadvertent programming or erasure to the AT49LD3200(B) in the following way: $V_{CC}$ sense: if $V_{CC}$ is below 2.3V (typical), the program or erase function is inhibited; but if $V_{CC}$ dips below 2.3V during program or erase cycle, the respective function will be interrupted and the data at the location being programmed may be corrupted.
Continuity Test Mode	The AT49LD3200(B) has built-in circuitries to make input and output pin continuity check simple and easy. This mode can be activated via the internal device command register and is a synchronous five-bus cycle operation (refer to the Command Definition Table and Continuity Test Mode Entry Waveforms). After the bus cycle operation, keep DQM high (V <sub>IH</sub> ) and allow 5 µsec for circuit setup time or until data is no longer asserted at DQ0 - DQ7, whichever takes longer. This will keep DQ0 - DQ7 from contention since data is asserted at DQ0 - DQ7 during the mode entry sequence. Then DQM can be asserted low (V <sub>IL</sub> ) to enable DQ0 - DQ7 for test. Once in this asynchronous mode, input pins are virtually tied to output pins internally forming input - output pin pairs. The output pin of the pair will follow the logic state of the input pin of the pair (refer to the Input - Output Pin Pairs table). To exit the mode, A <sub>0</sub> , A <sub>2</sub> and A <sub>II</sub> are asserted high (V <sub>IH</sub> ) and A <sub>1</sub> , A <sub>10</sub> and A <sub>12</sub> are asserted low (V <sub>IL</sub> ), allow 5 µsec for circuit recovery time before returning the device for normal operation.

Input	Output
MR	DQ0, DQ16
RAS	DQ1, DQ17
CAS	DQ2
DQM	DQ18
CS	DQ3
WORD	DQ19
A12	DQ4
A11	DQ20
A10	DQ5
AO	DQ21
A1	DQ6, DQ22
A2	DQ7, DQ23
A3	DQ8, DQ24
A4	DQ9, DQ25
A5	DQ10
A6	DQ26
A7	DQ11
A8	DQ27
A9	DQ12
СКЕ	DQ28
CLK	DQ13, DQ29
WE	DQ14, DQ30
VPP	DQ15, DQ31

### **Input - Output Pin Pairs**

### Asynchronous Boot Block

The AT49LD3200B will automatically activate the Asynchronous Boot Block after power-up and the AT49LD3200 can activate the Asynchronous Boot Block through the Mode Register Set. The size of the boot block is 8K x 16 bits with addresses  $A_0 \sim A_{12}$  and outputs  $DQ_0 \sim DQ_{15}$ . The contents of the boot block are accessed asynchronously, meaning the data at outputs will change according to the address inputs after  $t_{ACC}$ , without any external clocking signals.

Programs and erases are performed using the synchronous bus cycle operation (refer to Command Definitions table and Program Cycle and Erase Cycle waveforms) after the boot block is activated either through power-up or Mode Register Set. Programming of the boot block is set up for x16 mode.

This Asynchronous Boot Block has a lockout feature that prevents programming or erasing of data in this boot block once the feature has been enabled. This feature does not have to be activated; the boot block's usage as a protected region is optional to the user. Once this feature is enabled, the data in the boot block can no longer be erased or programmed when input levels of 3.6V or less are used. To activate the lockout feature,





Boot Block Lockout command, which is a synchronous five-bus cycle operation, must be performed (refer to Command Definitions table and Program Cycle Waveforms).

A software method is available to determine if programming or erasing of the boot block is locked out. Issue Boot Block Lockout Verify command and observe  $DQ_0 \sim DQ_7$ . If the data show 00H/02H, the boot block can be programmed or erased; if the data show 01H/03H, the lockout feature has been enabled and the boot block cannot be programmed or erased. The Boot Block Lockout Verify Exit command should be used to return to standard operation (refer to Command Definition table and Boot Block Lockout Verify Waveforms).

The user can override the boot block lockout by taking the  $\overline{\text{MR}}$  pin to 12 volts after the boot block is activated. When the  $\overline{\text{MR}}$  pin is brought back to TTL levels, the boot block lockout feature is again active.

# Command Definition in Hex<sup>(1)</sup>

Command	ommand Bus		1st Bus Cycle		2nd Bus Cycle		3rd	Bus C	ycle	4th	Bus C	ycle	5th	Bus C	ycle	6th	Bus Cy	ycle	
Sequence	Cycles	RA	CA	Data	RA	CA	Data	RA	CA	Data	RA	CA	Data	RA	CA	Data	RA	CA	Data
Word/ Double Word Program	4	AA	55	AA	55	2A	55	AA	55	A0	RA	CA	D <sub>IN</sub>						
Sector Erase	6	AA	55	AA	55	2A	55	AA	55	80	AA	55	AA	55	2A	55	SA <sup>(2)</sup>	х	30
Continuity Test Mode Entry	5	AA	55	AA	55	2A	55	AA	55	80	AA	55	AA	AA	55	70			
Boot Block Lockout	5	AA	55	AA	55	2A	55	AA	55	80	AA	55	AA	AA	55	40			
Boot Block Lockout Verify	5	AA	55	AA	55	2A	55	AA	55	80	AA	55	AA	AA	55	90			
Boot Block Lockout Verify Exit	5	AA	55	AA	55	2A	55	AA	55	80	AA	55	AA	AA	55	F0			

Notes: 1. The DATA FORMAT in each bus cycle is as follows: DQ31 - DQ8 (Don't Care); DQ7 - DQ0 (Hex).

2. SA = Sector Addresses: Any word/double word address within a sector can be used to designate the sector address. See Sector Address Mapping table below.

3. Allow minimum 200 ns after Boot Block Lockout Verify command and before Read.

4. Allow minimum 10 µs after Boot Block Lockout Verify Exit command for the device to return to standard operation.

		د Addres	x16 ss Range	x32 Address Range		
Sector	Size (Word/Double Word)	CA <sub>7-0</sub>	RA <sub>12-0</sub>	CA <sub>6-0</sub>	RA <sub>12-0</sub>	
SA0	256K/128K	х	00XX 03XX	Х	00XX 03XX	
SA1	256K/128K	х	04XX 07XX	Х	04XX 07XX	
SA2	256K/128K	x	08XX 0BXX	х	08XX 0BXX	
SA3	256K/128K	x	0CXX 0FXX	х	0CXX 0FXX	
SA4	256K/128K	х	10XX 13XX	х	10XX 13XX	
SA5	256K/128K	x	14XX 17XX	х	14XX 17XX	
SA6	256K/128K	х	18XX 1BXX	х	18XX 1BXX	
SA7	256K/128K	x	1CXX 1FXX	Х	1CXX 1FXX	

## Sector Address Mapping





# **Basic Feature and Function Descriptions**

## MRS



## **Clock Suspend**





: This command cannot be activated.

## **Clock Suspend Exit and Power-down Exit**



Note: After Mode Register Set command is completed, no new commands can be issued for 3 clock cycles, and MR or CS should be fixed "H" within a minimum of 3 clock cycles.

## **DQM** Operation



Note: DQM makes data out high-Z after 2 CLKs, which should be masked by CKE "L".









Note: When the burst length is 4 at 66 MHz,  $t_{RC}$  is equal to 6 clock cycles.

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### Read Cycle II: Consecutive Column Access @RAS Latency = 2, CAS Latency = 5, Burst Length = 4









#### Read Cycle III: Clock Suspend @RAS Latency = 2, CAS Latency = 5, Burst Length = 4



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Read Interrupted by Precharge Command and Burst Read Stop Cycle @Burst Length = 8

Notes: 1. The Burst Stop command is valid at every page burst length. The data bus goes to high-Z after the CAS latency from the Burst Stop command is issued.

2. The interval between Read command (column address presented) and Burst Stop command is 1 cycle (min).







Power-down and Clock Suspend Cycle: @RAS Latency = 2, CAS Latency = 5, Burst Length = 4

Notes: 1. From next clock after CKE goes low, clock suspend and power-down begins.

2. After power-down exit, NOP should be issued and new command can be issued after 1 clock.

3. Clock suspend is in active standby mode.

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### Mode Register Set: @RAS Latency = 2, CAS Latency = 5, Burst Length = 4

Notes: 1. After the Mode Register Set is completed, no new commands can be issued for 3 CLK cycles.

 After power-up, necessarily Mode Register Set should be completed at least one time and CS or MR must be fixed "H" within 3 clock cycles, and when user wants to change Mode Register Set, user must exit from power-down mode and start Mode Register Set before chip enters normal operation mode.





# **Detailed Functional Truth Table**

Current			Input	Signal			
State	CKE	CS	RAS	CAS	MR	Add.	Next State Operation
	L	Х	Х	Х	Х	Х	Power-down
After Power-up <sup>(1)</sup>	Н	L	L	Н	Н	RA	Row Active; latch RA
i onor up	Н	L	L	L	L	Code	Mode Register Set
	Н	L	L	н	н	RA	If consecutive row access is issued within $t_{RC}$ (min.) without CAS enabling, only the final RA is valid.
Row Active	Н	L	Н	L	Н	CA	Begin READ; latch CA
	Н	L	L	L	L	Code	Illegal <sup>(1)</sup>
	L	Х	Х	Х	Х	Х	Clock Suspend
	Н	L	L	н	н	RA	Row Access in Read State, within the $t_{RC}$ , previous read is ignored and new row is activated. Beyond the $t_{RC}$ , previous read is completed and new read begins.
READ	Н	L	Н	L	н	CA	Consecutive Column Access, within the $t_{VCVC}$ , only the final CA is valid and the previous burst read is ignored. Beyond the $t_{VCVC}$ , the previous read is completed and new read begins.
	Н	L	L	н	L	X	NOP (after Burst Read)/Read Interrupt
	Н	L	Н	Н	L	X	NOP (after Burst Read)/Read Interrupt
	Н	L	L	L	L	Code	Illegal <sup>(1)</sup>
	L	Х	Х	Х	Х	X	Clock Suspend/Power-down
Any State	L	L	L	L	Н	х	Low Power Consumption Mode
Any State	н	L	н	н	н	x	NOP
Any State	Н	L	L	L	Н	Х	llegal
Any State	Н	L	н	L	L	CA	lllegal

Note: 1. After the power-up, when user wants to change MR Set, user must exit from power-down mode and start MR Set before chip enters normal operation mode.

## **Technical Notes**

## Frequency vs. AC Parameter Relationship Table<sup>(1)</sup>

### <u><</u>100 MHz

Burst Length	RAS Latency	CAS Latency	t <sub>RC</sub> (min)	t <sub>vcvc</sub> (min)
4	2	6	7	5 <sup>(2)</sup>
4	2	7	8	6
0	2	6	11	9 <sup>(2)</sup>
8		7	12	10

### <u><</u>75 MHz

Burst Length	RAS Latency	CAS Latency	t <sub>RC</sub> (min)	t <sub>vcvc</sub> (min)
4	0	5	6	4 <sup>(2)</sup>
4	2	6	7	5
0	2	5	10	8 <sup>(2)</sup>
ð		6	11	9

#### <u><</u>50 MHz

Burst Length	RAS Latency	CAS Latency	t <sub>RC</sub> (min)	t <sub>vcvc</sub> (min)
		4	4 <sup>(2)</sup>	3/4 <sup>(2)</sup>
4	1	5	5	4 <sup>(2)</sup>
		6	6	5
		4	8 <sup>(2)</sup>	7/8 <sup>(2)</sup>
8	1	5	9	8 <sup>(2)</sup>
		6	10	9

Notes: 1. Above tables are not specifications values, but rather the actual number of clock cycles. There are no gapless operations for CAS latency 7 and 8.

2. Minimum clocks for gapless operation.

 t<sub>RC</sub> (max) = t<sub>VCVC</sub> (max) = 50 μs. If t<sub>RC</sub> (max) or t<sub>VCVC</sub> (max) has been reached, a new "ACTIVE" command is necessary for new access.





## **CAS** Interrupt



- Notes: 1. By "Interrupt", it is meant to stop Burst Read by external command before the end of burst. By "CAS Interrupt", to stop Burst Read by CAS access.
  - 2.  $\overline{CAS}$  to  $\overline{CAS}$  delay (=1 CLK).

Data(CL4)

## Read Interrupt Operation by Issuing the Precharge of Burst Stop Command

CASE I ) Issued read Interrupt command during burst read operation period.



CASE II ) Issued read Interrupt command between read command and data out.



Notes: 1. The data bus goes to high-Z after CAS latency from the Burst Stop (or precharge) command.

2. Valid output data will last up to CL-1 clock cycle from PRE command.

## Read Cycle Depending on t<sub>RC</sub>

### @RL = 2, CL = 6, BL = 4; 100 MHz



#### @RL = 2, CL = 5, BL = 4; 75 MHz



#### @RL = 1, CL = 4, BL = 4; 50 MHz







## Read Cycle Depending on $t_{VCVC}$

### @RL = 2, CL = 6, BL = 4; 100 MHz



#### @RL = 2, CL = 5, BL = 4; 75 MHz



#### @RL = 1, CL = 4, BL = 4; 50 MHz



# AC Characteristics for Boot Block Read Operation

Symbol	Parameter	Condition	Min	Max	Units
t <sub>ACC</sub>	Address to Output Delay	CS = DQM = V <sub>IL</sub>		170	ns
t <sub>OE</sub>	DQM to Output Delay	$\overline{\text{CS}} = \text{V}_{\text{IL}}$		60	ns
t <sub>DF</sub>	DQM High to Output Float		40	ns	
t <sub>OH</sub>	Output Hold from Address	0		ns	

# AC Waveforms for Boot Block Read Operation







## **3-volt Program and Erase Cycle Characteristics**

Symbol	Parameter	Тур	Мах	Units
t <sub>PGM</sub>	Word/Double Word Programming Time	50	600	μs
t <sub>EC</sub>	Sector/Boot Block Erase Cycle Time		2.0/300	seconds/ms
t <sub>BBL</sub>	Boot Block Lockout Enable Time		10	ms
I <sub>CC2</sub>	V <sub>CC</sub> Current during Program and Erase Cycle		150	mA

## High-speed 12-volt Program and Erase Cycle Characteristics

Symbol	Parameter	Тур	Мах	Units
t <sub>PGM</sub>	Word/Double Word Programming Time	15	200	μs
t <sub>EC</sub>	Sector/Boot Block Erase Cycle Time		1.2/200	seconds/ms
I <sub>CC3</sub>	V <sub>CC</sub> Current During Program and Erase Cycle		75	mA
I <sub>PP3</sub>	V <sub>PP</sub> Current During Program and Erase Cycle		75	mA

## **Program Cycle Waveforms**



## Sector Erase Cycle Waveforms



Notes: 1. The Precharge command is optional. A Precharge command ( $\overline{CS}$ ,  $\overline{RAS}$ ,  $\overline{MR} = L$ ) during Program and Sector Erase cycles ( $\overline{WE} = L$ ) will be treated as NOP, and the number of clock cycles between the bus cycle and the Precharge command or vice versa should be "Don't Care".

- For boot block programming, RA = CA = A<sub>0</sub> ~ A<sub>12</sub> and be held valid throughout program cycle; DQM should be held "H" during the four-bus cycle command operation.
- 3. For boot block erasing, SA = X; DQM should be held "H" during the six-bus cycle command operation.

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# **Data Polling Waveforms**



Note: During Program cycle, DATA = complement of loaded DQ7. After Program cycle, DATA = same state as loaded DQ7. During Sector Erase cycle, DATA = "0"; after Sector Erase cycle, DATA = "1".

# Data Polling Waveforms for Boot Block



Note: During Program cycle, DATA = complement of loaded DQ7. After Program cycle, DATA = same state as loaded DQ7. During Sector Erase cycle, DATA = "0"; after Sector Erase cycle, DATA = "1".





# **Product ID Cycle Waveforms**



Note: For x16 Mode, Manufacturer Code, MC = 001F(HEX), Device Code, DC = 32C2 (HEX). For x32 Mode, Code, C = 32C2001F (HEX).

## **Continuity Test Mode Entry Waveforms**



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## **Boot Block Lockout Cycle Waveforms**

## **Boot Block Lockout Verify Cycle Waveforms**



Note: DQ = XX00 (Hex) implies Boot Block not activated and Lockout not enabled. DQ = XX01 (Hex) implies Boot Block not activated and Lockout enabled. DQ = XX02 (Hex) implies Boot Block activated and Lockout not enabled.

DQ = XX03 (Hex) implies Boot Block activated and Lockout enabled.





## **Boot Block Lockout Verify Exit Cycle Waveforms**



# AT49LD3200(B)

Max Freq	I <sub>CC</sub> (mA)		I <sub>CC</sub> (mA)				
(MHz)	Active	Standby	Ordering Code	Package	Operation Range		
100	150	0.05	AT49LD3200-10TC	86T	Commercial (0° to 70°C)		
	150	0.05	AT49LD3200-10TI	86T	Industrial (-40° to 85°C)		
75	150	0.05	AT49LD3200-13TC	86T	Commercial (0° to 70°C)		
	150	0.05	AT49LD3200-13TI	86T	Industrial (-40° to 85°C)		
50	150	0.05	AT49LD3200-20TC	86T	Commercial (0° to 70°C)		
	150	0.05	AT49LD3200-20TI	86T	Industrial (-40° to 85°C)		

# **Ordering Information**

Package Type			
86T	86-lead, Thin Small Outline Package (TSOP Type II)		





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