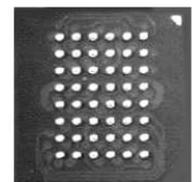


### Features

- Fast 35 ns Read/Write Cycle
- SRAM Compatible Timing and Pin-out Uses Existing SRAM Controllers Without Redesign
- Unlimited Read & Write Endurance
- Data Always Non-volatile for >20-years at Temperature
- One Memory Replaces Flash, SRAM, EEPROM and BBRAM in System for Simpler, More Efficient Design
- Replace battery-backed SRAM solutions with MRAM to eliminate battery assembly, reliability, and liability issues
- 3.3 Volt Power Supply
- Automatic Data Protection on Power Loss
- Commercial, Industrial, Extended Temperatures
- RoHS-Compliant SRAM-compatible TSOPII Package
- RoHS-Compliant SRAM-compatible BGA Package Shrinks Board Area By Three Times



44-TSOP



48-BGA



### Introduction

The MR0A16A is a 1,048,576-bit magnetoresistive random access memory (MRAM) device organized as 65,536 words of 16 bits. The MR0A16A offers SRAM compatible 35 ns read/write timing with unlimited endurance. Data is always non-volatile for greater than 20-years. Data is automatically protected on power loss by low-voltage inhibit circuitry to prevent writes with voltage out of specification. The MR0A16A is the ideal memory solution for applications that must permanently store and retrieve critical data and programs quickly.

The MR0A16A is available in small footprint 400-mil, 44-lead plastic small-outline TSOP type-II package or 8 mm x 8 mm, 48-pin ball grid array (BGA) package with 0.75 mm ball centers. These packages are compatible with similar low-power SRAM products and other non-volatile RAM products.

The MR0A16A provides highly reliable data storage over a wide range of temperatures. The product is offered with commercial temperature (0 to +70°C), industrial temperature (-40 to +85°C), and extended temperature (-40 to +105°C) range options.

# Device Pin Assignment

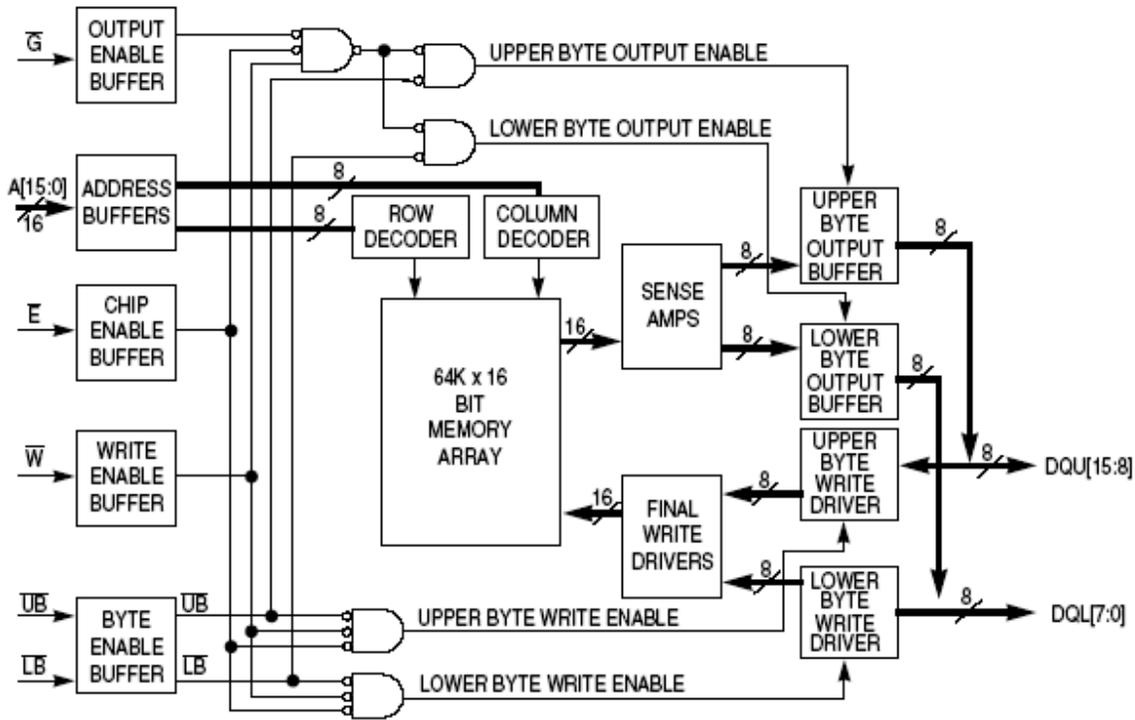
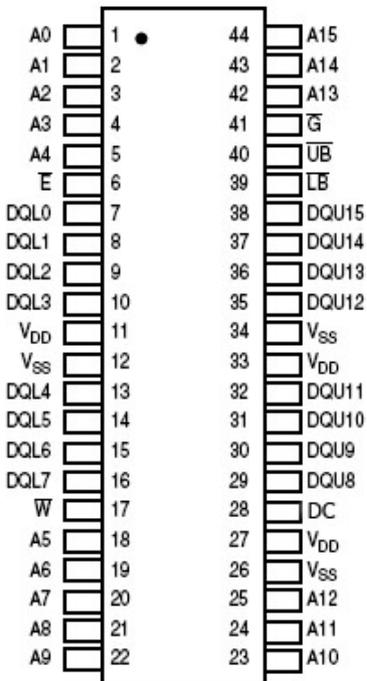


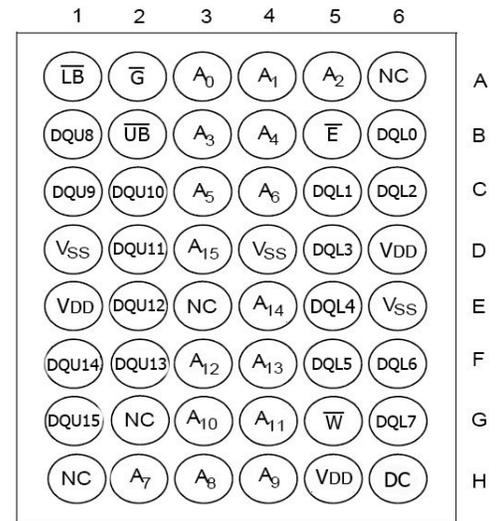
Figure 1. Block Diagram



44-Pin TSOP Type II

Table 1 - Pin Functions

Signal Name	Function
A	Address Input
/E	Chip Enable
/W	Write Enable
/G	Output Enable
DQ	Data I/O
VDD	Power Supply
VSS	Ground
DC	Do Not Connect
NC	No Connection



48-Pin BGA

**Table 2. Operating Modes**

$\overline{E}^1$	$\overline{G}^1$	$\overline{W}^1$	$\overline{LB}^1$	$\overline{UB}^1$	Mode	$V_{DD}$ Current	DQL[7:0] <sup>2</sup>	DQU[15:8] <sup>2</sup>
H	X	X	X	X	Not selected	$I_{SB1}, I_{SB2}$	Hi-Z	Hi-Z
L	H	H	X	X	Output disabled	$I_{DDR}$	Hi-Z	Hi-Z
L	X	X	H	H	Output disabled	$I_{DDR}$	Hi-Z	Hi-Z
L	L	H	L	H	Lower byte read	$I_{DDR}$	$D_{Out}$	Hi-Z
L	L	H	H	L	Upper byte read	$I_{DDR}$	Hi-Z	$D_{Out}$
L	L	H	L	L	Word read	$I_{DDR}$	$D_{Out}$	$D_{Out}$
L	X	L	L	H	Lower byte write	$I_{DDW}$	$D_{In}$	Hi-Z
L	X	L	H	L	Upper byte write	$I_{DDW}$	Hi-Z	$D_{In}$
L	X	L	L	L	Word write	$I_{DDW}$	$D_{In}$	$D_{In}$

NOTES:

- <sup>1</sup> H = high, L = low, X = don't care
- <sup>2</sup> Hi-Z = high impedance

## Electrical Specifications

### Absolute Maximum Ratings

This device contains circuitry to protect the inputs against damage caused by high static voltages or electric fields; however, it is advised that normal precautions be taken to avoid application of any voltage greater than maximum rated voltages to these high-impedance (Hi-Z) circuits.

The device also contains protection against external magnetic fields. Precautions should be taken to avoid application of any magnetic field more intense than the maximum field intensity specified in the maximum ratings.

**Table 3 - Absolute Maximum Ratings<sup>1</sup>**

Parameter	Symbol	Value	Unit
Supply voltage <sup>2</sup>	$V_{DD}$	-0.5 to 4.0	V
Voltage on any pin <sup>2</sup>	$V_{In}$	-0.5 to $V_{DD} + 0.5$	V
Output current per pin	$I_{Out}$	$\pm 20$	mA
Package power dissipation <sup>3</sup>	$P_D$	0.600	W
Temperature under bias MR0A16A (Commercial) MR0A16AC (Industrial) MR0A16AV (Extended)	$T_{Bias}$	-10 to 85 -45 to 95 -45 to 110	°C
Storage temperature	$T_{stg}$	-55 to 150	°C
Lead temperature during solder (3 minute max)	$T_{Lead}$	260	°C
Maximum magnetic field during write MR0A16A (All Temperature Grades)	$H_{max\_write}$	2000	A/m
Maximum magnetic field during read or standby	$H_{max\_read}$	8000	A/m

NOTES:

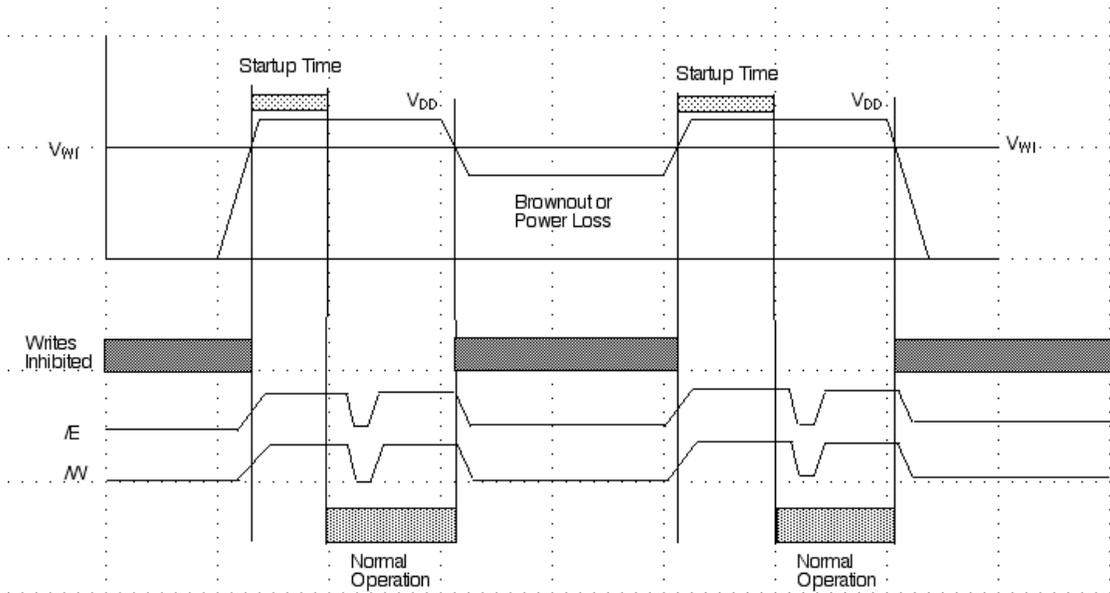
- <sup>1</sup> Permanent device damage may occur if absolute maximum ratings are exceeded. Functional operation should be restricted to recommended operating conditions. Exposure to excessive voltages or magnetic fields could affect device reliability.
- <sup>2</sup> All voltages are referenced to  $V_{SS}$ .
- <sup>3</sup> Power dissipation capability depends on package characteristics and use environment.

**Table 4. Operating Conditions**

Parameter	Symbol	Min	Typ	Max	Unit
Power supply voltage	$V_{DD}$	3.0 <sup>1</sup>	3.3	3.6	V
Write inhibit voltage	$V_{WI}$	2.5	2.7	3.0 <sup>1</sup>	V
Input high voltage	$V_{IH}$	2.2	—	$V_{DD} + 0.3$ <sup>2</sup>	V
Input low voltage	$V_{IL}$	-0.5 <sup>3</sup>	—	0.8	V
Operating temperature					
MR0A16A (Commercial)	$T_A$	0		70	°C
MR0A16AC (Industrial)		-40		85	
MR0A16AV (Extended)		-40		105	

**NOTES:**

- 1 There is a 2 ms startup time once  $V_{DD}$  exceeds  $V_{DDmin}$ . See Power up and Powerdown Sequencing section below
- 2  $V_{IH} (max) = V_{DD} + 0.3 V_{dc}$ ;  $V_{IH} (max) = V_{DD} + 2.0 V_{ac}$  (pulse width  $\leq 10$  ns) for  $I \leq 20.0$  mA.
- 3  $V_{IL} (min) = -0.5 V_{dc}$ ;  $V_{IL} (min) = -2.0 V_{ac}$  (pulse width  $\leq 10$  ns) for  $I \leq 20.0$  mA.



**Power Up and Power Down Sequencing**

MRAM is protected from write operations whenever  $V_{DD}$  is less than  $V_{WI}$ . As soon as  $V_{DD}$  exceeds  $V_{DDmin}$ , there is a startup time of 2 ms before read or write operations can start. This time allows memory power supplies to stabilize. The  $/E$  and  $/W$  control signals should track  $V_{DD}$  on power up to  $V_{DD}-0.2v$  or  $V_{IH}$  (whichever is lower) and remain high for the startup time. In most systems, this means that these signals should be pulled up with a resistor so that signal remains high if the driving signal is Hi-Z during power up. Any logic that drives  $/E$  and  $/W$  should hold the signals high with a power-on reset signal for longer than the startup time. During power loss or brownout where  $V_{DD}$  goes below  $V_{WI}$ , writes are protected and a startup time must be observed when power returns above  $V_{DDmin}$ .

**Table 5 - DC Characteristics**

Parameter	Symbol	Min	Typ	Max	Unit
Input leakage current	$I_{lkg(I)}$	—	—	$\pm 1$	$\mu A$
Output leakage current	$I_{lkg(O)}$	—	—	$\pm 1$	$\mu A$
Output low voltage ( $I_{OL} = +4 \text{ mA}$ ) ( $I_{OL} = +100 \mu A$ )	$V_{OL}$	—	—	0.4 $V_{SS} + 0.2$	V
Output high voltage ( $I_{OH} = -4 \text{ mA}$ ) ( $I_{OH} = -100 \mu A$ )	$V_{OH}$	2.4 $V_{DD} - 0.2$	—	—	V

**Table 6 - Power Supply Characteristics**

Parameter	Symbol	Typ	Max	Unit
ac active supply current — read modes <sup>1</sup> ( $I_{Out} = 0 \text{ mA}$ , $V_{DD} = \text{max}$ )	$I_{DDR}$	55	80	mA
ac active supply current — write modes <sup>1</sup> ( $V_{DD} = \text{max}$ ) MR0A16A (Commercial) MR0A16AC (Industrial) MR0A16AV (Extended)	$I_{DDW}$	105 105 105	155 165 165	mA
ac standby current ( $V_{DD} = \text{max}$ , $\bar{E} = V_{IH}$ ) (no other restrictions on other inputs)	$I_{SB1}$	18	28	mA
CMOS standby current ( $\bar{E} \geq V_{DD} - 0.2 \text{ V}$ and $V_{In} \leq V_{SS} + 0.2 \text{ V}$ or $\geq V_{DD} - 0.2 \text{ V}$ ) ( $V_{DD} = \text{max}$ , $f = 0 \text{ MHz}$ )	$I_{SB2}$	9	12	mA

## NOTES:

<sup>1</sup> All active current measurements are measured with one address transition per cycle and at minimum cycle time.

## Timing Specifications

**Table 7. Capacitance<sup>1</sup>**

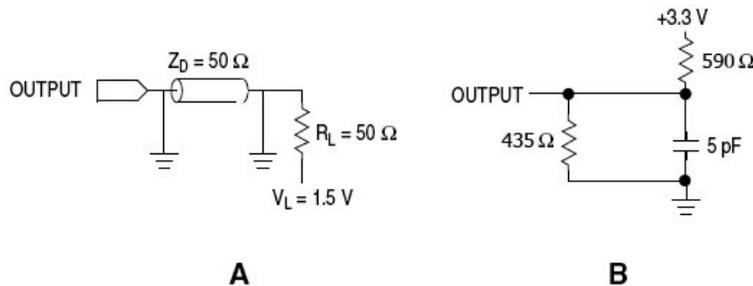
Parameter	Symbol	Typ	Max	Unit
Address input capacitance	$C_{In}$	—	6	pF
Control input capacitance	$C_{In}$	—	6	pF
Input/output capacitance	$C_{I/O}$	—	8	pF

**NOTES:**

<sup>1</sup>  $f = 1.0 \text{ MHz}$ ,  $dV = 3.0 \text{ V}$ ,  $T_A = 25^\circ\text{C}$ , periodically sampled rather than 100% tested.

**Table 8. ac Measurement Conditions**

Parameter	Value
Logic input timing measurement reference level	1.5 V
Logic output timing measurement reference level	1.5 V
Logic input pulse levels	0 or 3.0 V
Input rise/fall time	2 ns
Output load for low and high impedance parameters	See Figure 3A
Output load for all other timing parameters	See Figure 3B



**Figure 3. Output Load for ac Test**

# Timing Specifications

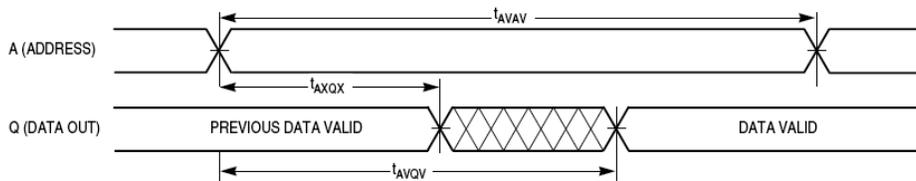
## Read Mode

Table 9. Read Cycle Timing<sup>1,2</sup>

Parameter	Symbol	Min	Max	Unit
Read cycle time	$t_{AVAV}$	35	—	ns
Address access time	$t_{AVQV}$	—	35	ns
Enable access time <sup>3</sup>	$t_{ELQV}$	—	35	ns
Output enable access time	$t_{GLQV}$	—	15	ns
Byte enable access time	$t_{BLQV}$	—	15	ns
Output hold from address change	$t_{AXQX}$	3	—	ns
Enable low to output active <sup>4,5</sup>	$t_{ELQX}$	3	—	ns
Output enable low to output active <sup>4,5</sup>	$t_{GLQX}$	0	—	ns
Byte enable low to output active <sup>4,5</sup>	$t_{BLQX}$	0	—	ns
Enable high to output Hi-Z <sup>4,5</sup>	$t_{EHQZ}$	0	15	ns
Output enable high to output Hi-Z <sup>4,5</sup>	$t_{GHQZ}$	0	10	ns
Byte high to output Hi-Z <sup>4,5</sup>	$t_{BHQZ}$	0	10	ns

NOTES:

- 1  $\bar{W}$  is high for read cycle.
- 2 Power supplies must be properly grounded and decoupled, and bus contention conditions must be minimized or eliminated during read or write cycles.
- 3 Addresses valid before or at the same time  $\bar{E}$  goes low.
- 4 This parameter is sampled and not 100% tested.
- 5 Transition is measured  $\pm 200$  mV from steady-state voltage.



NOTES:

Device is continuously selected ( $\bar{E} \leq V_{IL}$ ,  $\bar{G} \leq V_{IL}$ ).

Figure 4. Read Cycle 1

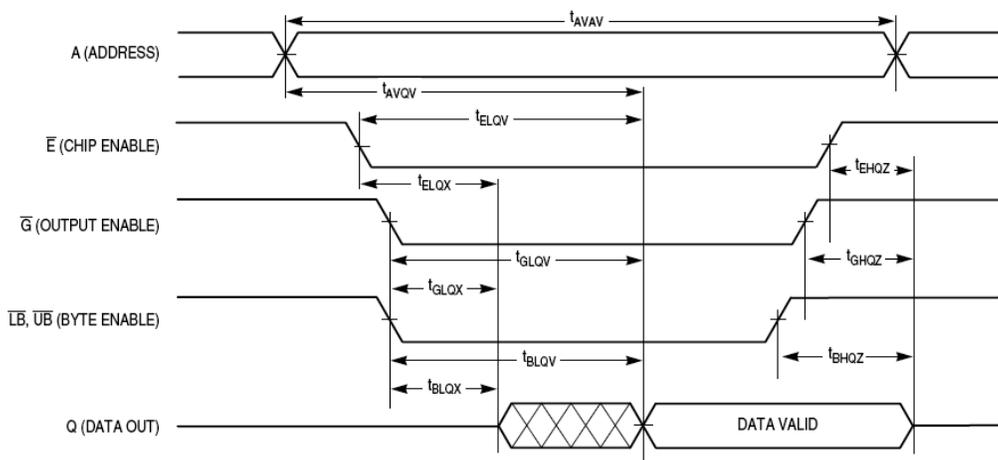


Figure 5. Read Cycle 2

# Timing Specifications

## Write Mode

Table 10. Write Cycle Timing 1 ( $\overline{W}$  Controlled)<sup>1, 2, 3, 4, 5</sup>

Parameter	Symbol	Min	Max	Unit
Write cycle time <sup>6</sup>	$t_{AVAV}$	35	—	ns
Address set-up time	$t_{AVWL}$	0	—	ns
Address valid to end of write ( $\overline{G}$ high)	$t_{AVWH}$	18	—	ns
Address valid to end of write ( $\overline{G}$ low)	$t_{AVWH}$	20	—	ns
Write pulse width ( $\overline{G}$ high)	$t_{WLWH}$ $t_{WLEH}$	15	—	ns
Write pulse width ( $\overline{G}$ low)	$t_{WLWH}$ $t_{WLEH}$	15	—	ns
Data valid to end of write	$t_{DVWH}$	10	—	ns
Data hold time	$t_{WHDX}$	0	—	ns
Write low to data Hi-Z <sup>7, 8, 9</sup>	$t_{WLQZ}$	0	12	ns
Write high to output active <sup>7, 8, 9</sup>	$t_{WHQX}$	3	—	ns
Write recovery time	$t_{WHAX}$	12	—	ns

NOTES:

- 1 A write occurs during the overlap of  $\overline{E}$  low and  $\overline{W}$  low.
- 2 Power supplies must be properly grounded and decoupled, and bus contention conditions must be minimized or eliminated during read and write cycles.
- 3 If  $\overline{G}$  goes low at the same time or after  $\overline{W}$  goes low, the output will remain in a high-impedance state.
- 4 After  $\overline{W}$ ,  $\overline{E}$ , or  $\overline{UB/LB}$  has been brought high, the signal must remain in steady-state high for a minimum of 2 ns.
- 5 The minimum time between  $\overline{E}$  being asserted low in one cycle to  $\overline{E}$  being asserted low in a subsequent cycle is the same as the minimum cycle time allowed for the device.
- 6 All write cycle timings are referenced from the last valid address to the first transition address.
- 7 This parameter is sampled and not 100% tested.
- 8 Transition is measured  $\pm 200$  mV from steady-state voltage.
- 9 At any given voltage or temperature,  $t_{WLQZ}$  max <  $t_{WHQX}$  min.

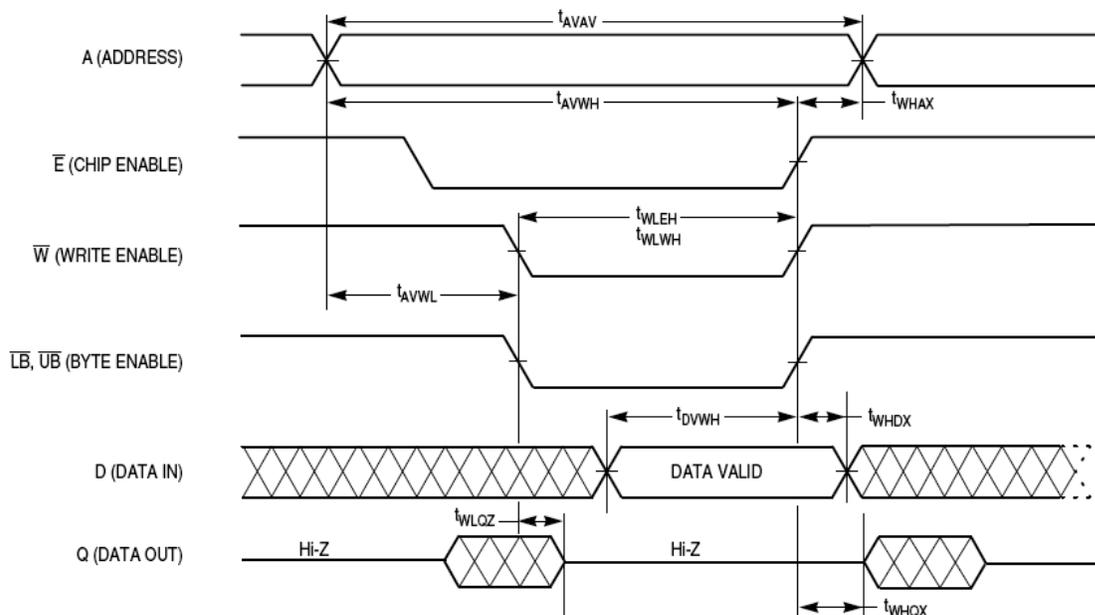


Figure 6. Write Cycle 1 ( $\overline{W}$  Controlled)

## Timing Specifications

Table 11. Write Cycle Timing 2 ( $\overline{E}$  Controlled)<sup>1, 2, 3, 4, 5</sup>

Parameter	Symbol	Min	Max	Unit
Write cycle time <sup>6</sup>	$t_{AVAV}$	35	—	ns
Address set-up time	$t_{AVEL}$	0	—	ns
Address valid to end of write ( $\overline{G}$ high)	$t_{AVEH}$	18	—	ns
Address valid to end of write ( $\overline{G}$ low)	$t_{AVEH}$	20	—	ns
Enable to end of write ( $\overline{G}$ high)	$t_{ELEH}$ $t_{ELWH}$	15	—	ns
Enable to end of write ( $\overline{G}$ low) <sup>7, 8</sup>	$t_{ELEH}$ $t_{ELWH}$	15	—	ns
Data valid to end of write	$t_{DVEH}$	10	—	ns
Data hold time	$t_{EHDX}$	0	—	ns
Write recovery time	$t_{EHAX}$	12	—	ns

NOTES:

- A write occurs during the overlap of  $\overline{E}$  low and  $\overline{W}$  low.
- Power supplies must be properly grounded and decoupled, and bus contention must be minimized or eliminated during read and write cycles.
- If  $\overline{G}$  goes low at the same time or after  $\overline{W}$  goes low, the output will remain in a high-impedance state.
- After  $\overline{W}$ ,  $\overline{E}$ , or  $\overline{UB}/\overline{LB}$  has been brought high, the signal must remain in steady-state high for a minimum of 2 ns.
- The minimum time between  $\overline{E}$  being asserted low in one cycle to  $\overline{E}$  being asserted low in a subsequent cycle is the same as the minimum cycle time allowed for the device.
- All write cycle timings are referenced from the last valid address to the first transition address.
- If  $\overline{E}$  goes low at the same time or after  $\overline{W}$  goes low, the output will remain in a high-impedance state.
- If  $\overline{E}$  goes high at the same time or before  $\overline{W}$  goes high, the output will remain in a high-impedance state.

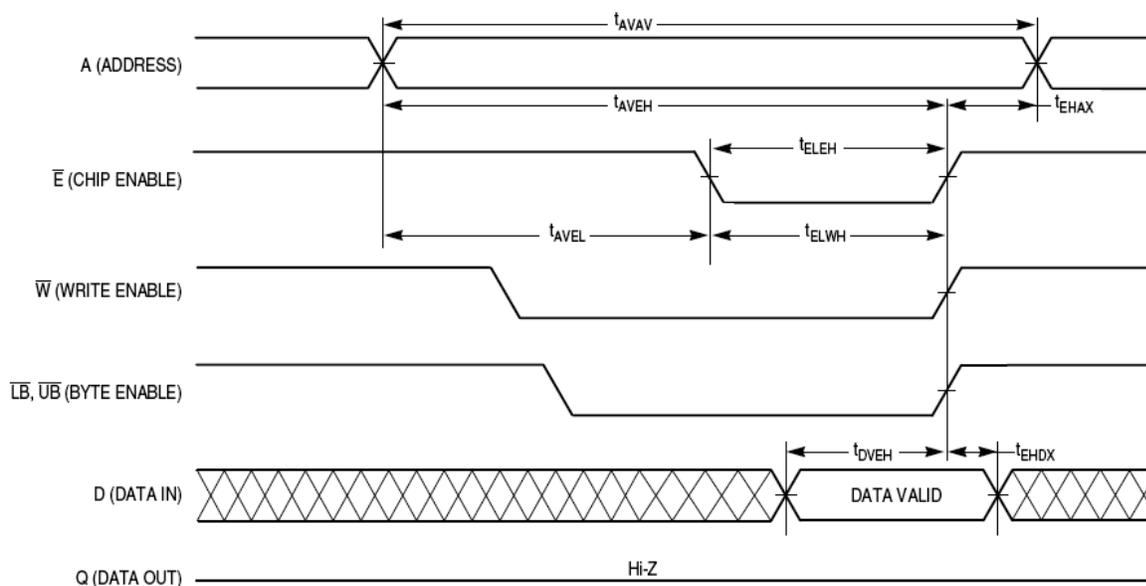


Figure 7. Write Cycle 2 ( $\overline{E}$  Controlled)

## Timing Specifications

Table 12. Write Cycle Timing 3 ( $\overline{\text{LB}}/\overline{\text{UB}}$  Controlled)<sup>1, 2, 3, 4, 5, 6</sup>

Parameter	Symbol	Min	Max	Unit
Write cycle time <sup>7</sup>	$t_{\text{AVAV}}$	35	—	ns
Address set-up time	$t_{\text{AVBL}}$	0	—	ns
Address valid to end of write ( $\overline{\text{G}}$ high)	$t_{\text{AVBH}}$	18	—	ns
Address valid to end of write ( $\overline{\text{G}}$ low)	$t_{\text{AVBH}}$	20	—	ns
Byte pulse width ( $\overline{\text{G}}$ high)	$t_{\text{BLEH}}$ $t_{\text{BLWH}}$	15	—	ns
Byte pulse width ( $\overline{\text{G}}$ low)	$t_{\text{BLEH}}$ $t_{\text{BLWH}}$	15	—	ns
Data valid to end of write	$t_{\text{DVBH}}$	10	—	ns
Data hold time	$t_{\text{BHDX}}$	0	—	ns
Write recovery time	$t_{\text{BHAX}}$	12	—	ns

NOTES:

- 1 A write occurs during the overlap of  $\overline{\text{E}}$  low and  $\overline{\text{W}}$  low.
- 2 Power supplies must be properly grounded and decoupled, and bus contention conditions must be minimized or eliminated during read and write cycles.
- 3 If  $\overline{\text{G}}$  goes low at the same time or after  $\overline{\text{W}}$  goes low, the output will remain in a high-impedance state.
- 4 After  $\overline{\text{W}}$ ,  $\overline{\text{E}}$ , or  $\overline{\text{UB}}/\overline{\text{LB}}$  has been brought high, the signal must remain in steady-state high for a minimum of 2 ns.
- 5 If both byte control signals are asserted, the two signals must have no more than 2 ns skew between them.
- 6 The minimum time between  $\overline{\text{E}}$  being asserted low in one cycle to  $\overline{\text{E}}$  being asserted low in a subsequent cycle is the same as the minimum cycle time allowed for the device.
- 7 All write cycle timings are referenced from the last valid address to the first transition address.

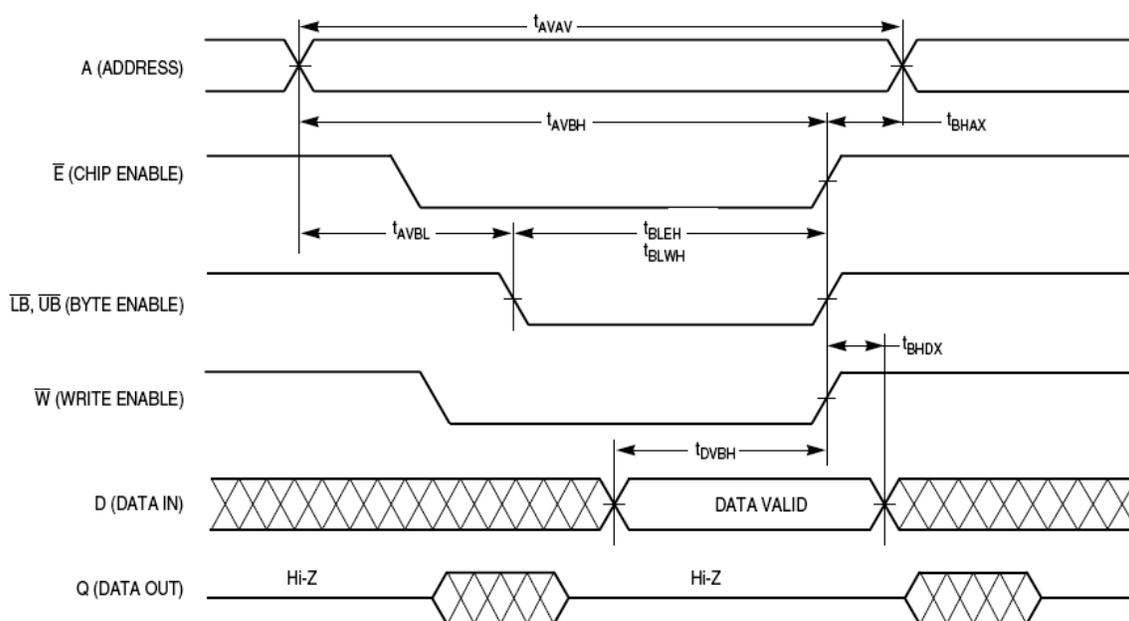
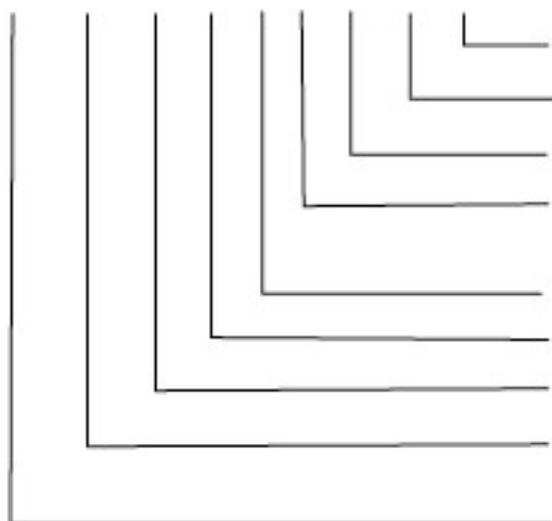


Figure 8. Write Cycle 3 ( $\overline{\text{LB}}/\overline{\text{UB}}$  Controlled)

## Ordering Information

### Part Numbering System

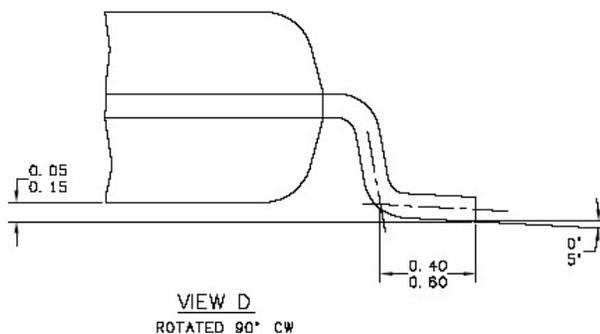
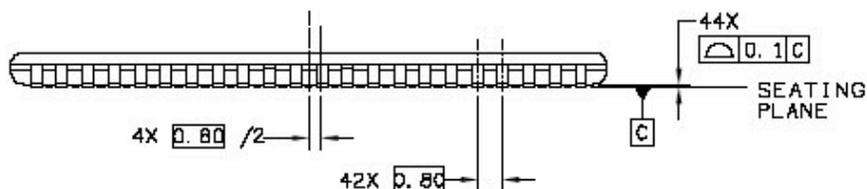
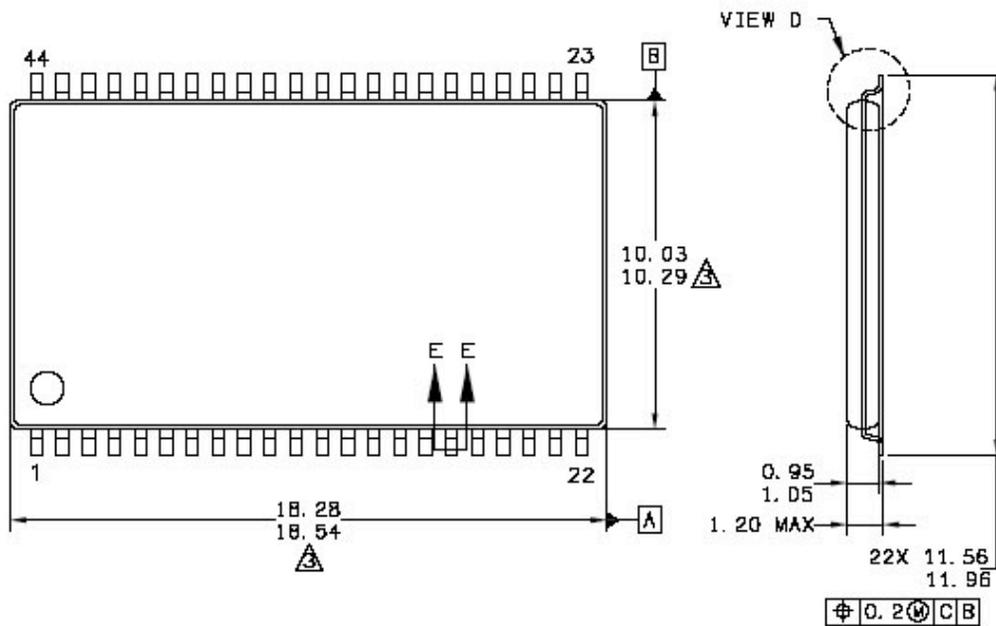
MR 0 A 16 A V YS 35 R



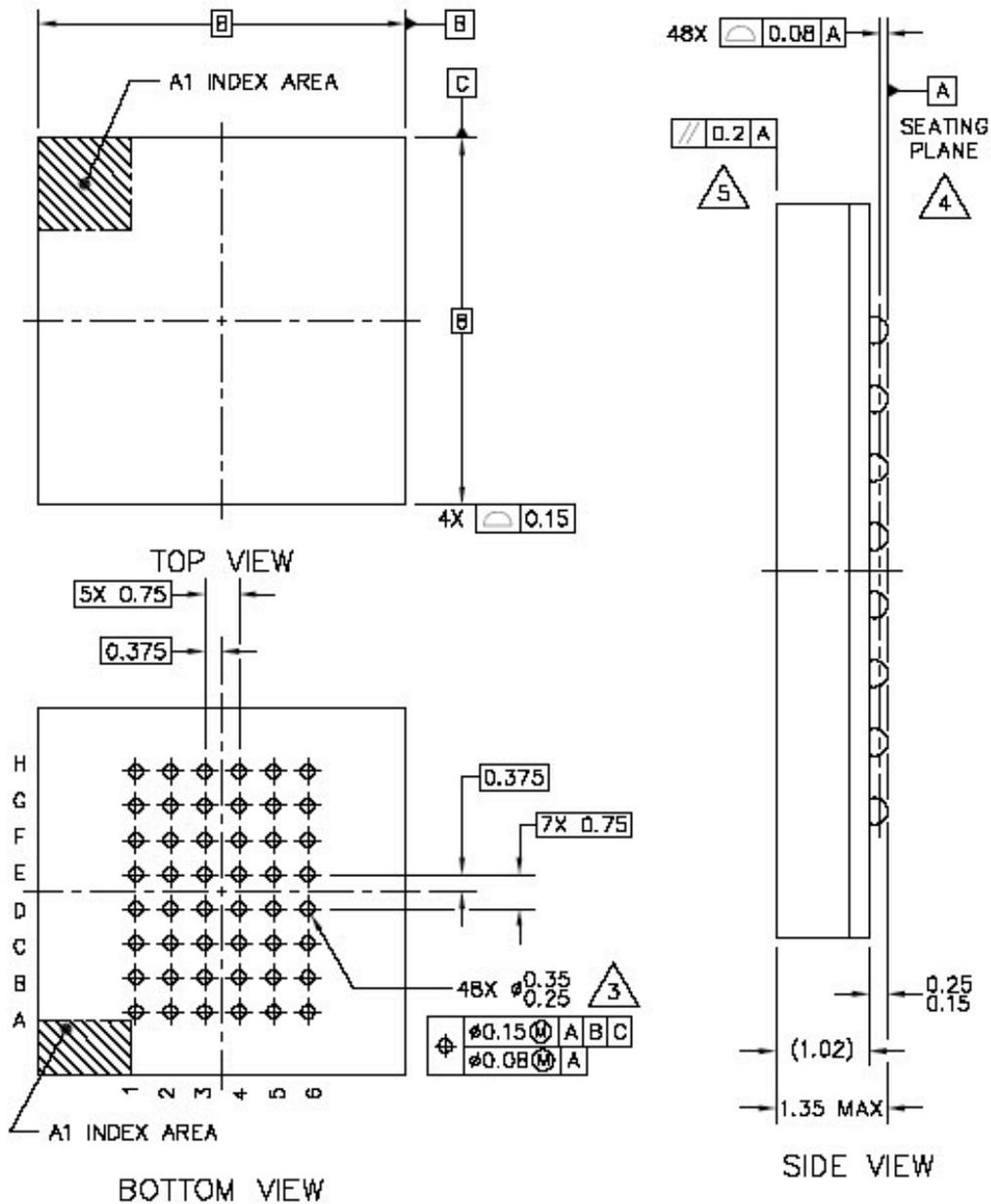
Carrier (Blank=Tray, R=Tape & Reel)  
 Speed (35 ns)  
 Package (YS=TSOPII, MA=BGA)  
 Temperature Range (Blank=0 to 70°C, C=-40 to +85°C, V=-40 to +105°C)  
 Revision (A=180 nm, B=130 nm)  
 Data Width (08=8-bit, 16=16-bit)  
 Type (A=Asynchronous, S=Synchronous)  
 Density (256=256Kb, 0=1Mb, 1=2Mb, 2=4Mb, 4=16Mb)  
 Magnetoresistive RAM (MR)

Part Number	Description	Temperature
MR0A16AYS35	3.3 V 64Kx16 MRAM 44-TSOP	Commercial
MR0A16ACYS35	3.3 V 64Kx16 MRAM 44-TSOP	Industrial
MR0A16AVYS35	3.3 V 64Kx16 MRAM 44-TSOP	Extended
MR0A16AYS35R	3.3 V 64Kx16 MRAM 44-TSOP T&R	Commercial
MR0A16ACYS35R	3.3 V 64Kx16 MRAM 44-TSOP T&R	Industrial
MR0A16AVYS35R	3.3 V 64Kx16 MRAM 44-TSOP T&R	Extended
MR0A16AMA35	3.3 V 64Kx16 MRAM 48-BGA	Commercial
MR0A16ACMA35	3.3 V 64Kx16 MRAM 48-BGA	Industrial
MR0A16AVMA35	3.3 V 64Kx16 MRAM 48-BGA	Extended

# Mechanical Drawing (44-TSOP)



# Mechanical Drawing (48-BGA)



NOTES:

1. ALL DIMENSIONS IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
3. MAXIMUM SOLDER BALL DIAMETER MEASURED PARALLEL TO DATUM A.
4. DATUM A, THE SEATING PLANE, IS DETERMINED BY THE SPHERICAL CROWNS OF THE SOLDER BALLS.
5. PARALLELISM MEASUREMENT SHALL EXCLUDE ANY EFFECT OF MARK ON TOP SURFACE OF PACKAGE.

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## Revision History

Revision	Date	Description of Change
0	Jun 18, 2007	Initial Advanced Information Release
1	Sept 21, 2007	Table 6, Applied Values to TBD's in IDD Specifications
2	Nov 12, 2007	Table 2, Changed IDDA to IDDR or IDDW
3	Sep 12, 2008	Reformat Datasheet for EverSpin, Add BGA Packaging Information, Add Tape & Reel Part Numbers, Add Power Sequencing Info, Correct I <sub>OH</sub> spec of V <sub>OH</sub> to -100 uA, Correct ac Test Conditions

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