



# 128K x 16-Bit 3.3-V Asynchronous Magnetoresistive RAM

## MR1A16A



### Introduction

The MR1A16A is a 2,097,152-bit magnetoresistive random access memory (MRAM) device organized as 131,072 words of 16 bits. The MR1A16A is equipped with chip enable ( $\bar{E}$ ), write enable ( $\bar{W}$ ), and output enable ( $\bar{G}$ ) pins, allowing for significant system design flexibility without bus contention. Because the MR1A16A has separate byte-enable controls ( $\bar{LB}$  and  $\bar{UB}$ ), individual bytes can be written and read.

MRAM is a nonvolatile memory technology that protects data in the event of power loss and does not require periodic refreshing. The MR1A16A is the ideal memory solution for applications that must permanently store and retrieve critical data quickly.

The MR1A16A is available in a 400-mil, 44-lead plastic small-outline TSOP type-II package with an industry-standard center power and ground SRAM pinout.

The MR1A16A is available in Commercial (0°C to 70°C), Industrial (-40°C to 85°C) and Extended (-40°C to 105°C) ambient temperature ranges.

### Features

- Single 3.3-V power supply
- Commercial temperature range (0°C to 70°C), Industrial temperature range (-40°C to 85°C) and Extended temperature range (-40°C to 105°C)
- Symmetrical high-speed read and write with fast access time (35 ns)
- Flexible data bus control — 8 bit or 16 bit access
- Equal address and chip-enable access times
- Automatic data protection with low-voltage inhibit circuitry to prevent writes on power loss
- All inputs and outputs are transistor-transistor logic (TTL) compatible
- Fully static operation
- Full nonvolatile operation with 20 years minimum data retention

## Device Pin Assignment

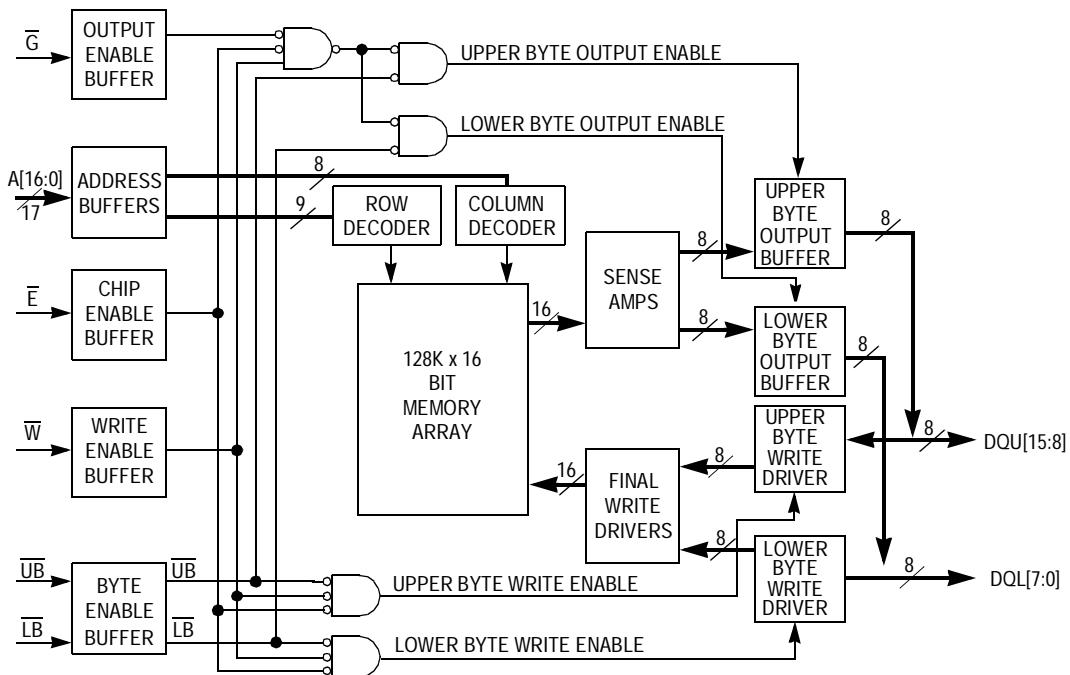


Figure 1. Block Diagram

## Device Pin Assignment

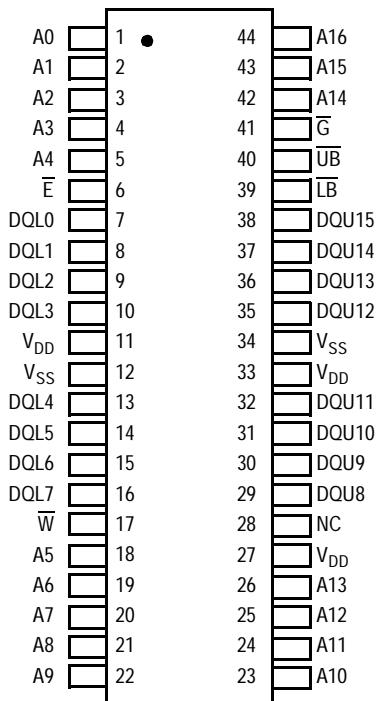


Table 1. Pin Functions

Signal Name	Function
A	Address input
$\bar{E}$	Chip enable
$\bar{W}$	Write enable
$\bar{G}$	Output enable
UB	Upper byte select
LB	Lower byte select
DQL	Data I/O, lower byte
DQU	Data I/O, upper byte
V <sub>DD</sub>	Power supply
V <sub>SS</sub>	Ground
NC	Do not connect this pin

Figure 2. MR1A16A in 44-Pin TSOP Type II Package

**Table 2. Operating Modes**

<b><math>\overline{E}^1</math></b>	<b><math>\overline{G}^1</math></b>	<b><math>\overline{W}^1</math></b>	<b><math>\overline{LB}^1</math></b>	<b><math>\overline{UB}^1</math></b>	<b>Mode</b>	<b><math>V_{DD}</math> Current</b>	<b>DQL[7:0]<sup>2</sup></b>	<b>DQU[15:8]<sup>2</sup></b>
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.

## Electrical Specifications

**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 MR1A16AYS35 (Commercial) MR1A16ACYS35 (Industrial) MR1A16AVYS35 (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 MR1A16AYS35 (Commercial) MR1A16ACYS35 (Industrial) MR1A16AVYS35 (Extended)	$H_{max\_write}$	15 25 25	Oe
Maximum magnetic field during read or standby	$H_{max\_read}$	100	Oe

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 MR1A16AYS35 (Commercial) MR1A16ACYS35 (Industrial) MR1A16AVYS35 (Extended)	$T_A$	0 -40 -40		70 85 105	°C

NOTES:

<sup>1</sup> After power up or if  $V_{DD}$  falls below  $V_{WI}$ , a waiting period of 2 ms must be observed, and  $\overline{E}$  and  $\overline{W}$  must remain high for 2 ms. Memory is designed to prevent writing for all input pin conditions if  $V_{DD}$  falls below minimum  $V_{WI}$ .

<sup>2</sup>  $V_{IH}$  (max) =  $V_{DD} + 0.3$  Vdc;  $V_{IH}$  (max) =  $V_{DD} + 2.0$  Vac (pulse width  $\leq 10$  ns) for  $I \leq 20.0$  mA.

<sup>3</sup>  $V_{IL}$  (min) = -0.5 Vdc;  $V_{IL}$  (min) = -2.0 Vac (pulse width  $\leq 10$  ns) for  $I \leq 20.0$  mA.

## Direct Current (dc)

Table 5. dc Characteristics

Parameter	Symbol	Min	Typ	Max	Unit
Input leakage current	$I_{Ikg(I)}$	—	—	$\pm 1$	$\mu A$
Output leakage current	$I_{Ikg(O)}$	—	—	$\pm 1$	$\mu A$
Output low voltage ( $I_{OL} = +4$ mA) ( $I_{OL} = +100$ $\mu A$ )	$V_{OL}$	—	—	0.4 $V_{SS} + 0.2$	V
Output high voltage ( $I_{OH} = -4$ mA) ( $I_{OH} = -100$ mA)	$V_{OH}$	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> ( $I_{Out} = 0$ mA, $V_{DD} = \text{max}$ )	$I_{DDR}$	55	80	mA
ac active supply current — write modes <sup>1</sup> ( $V_{DD} = \text{max}$ ) MR1A16AYS35 (Commercial) MR1A16ACYS35 (Industrial) MR1A16AVYS35 (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 ( $\bar{E} \geq V_{DD} - 0.2$ V and $V_{In} \leq V_{SS} + 0.2$ V or $\geq V_{DD} - 0.2$ V) ( $V_{DD} = \text{max}$ , $f = 0$ MHz)	$I_{SB2}$	9	12	mA

NOTES:

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

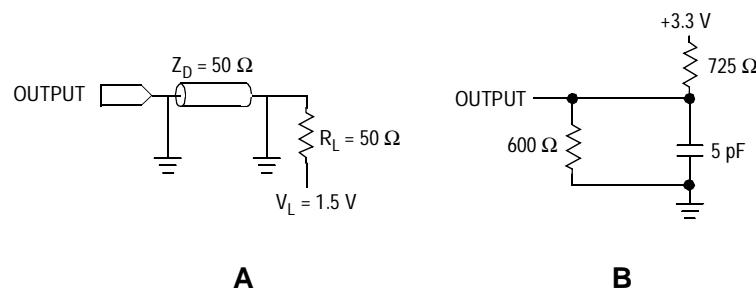
NOTES:

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

## Electrical Specifications

**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**

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## Timing Specifications

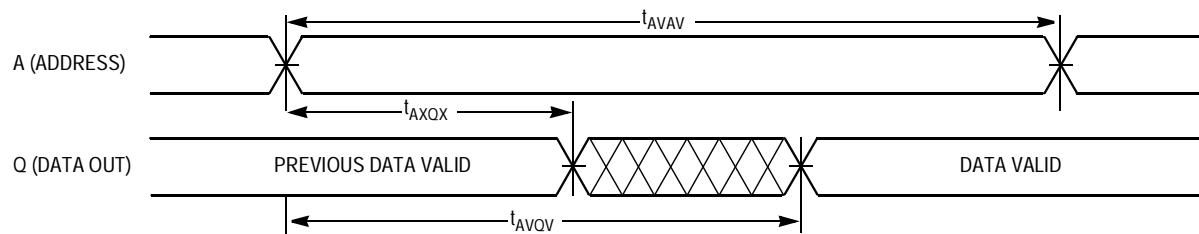
### Read Mode

**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  $\overline{W}$  is high for read cycle.
- 2 Due to product sensitivities to noise, power supplies must be properly grounded and decoupled, and bus contention conditions must be minimized or eliminated during read and write cycles.
- 3 Addresses valid before or at the same time  $\overline{E}$  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 ( $\overline{E} \leq V_{IL}$ ,  $\overline{G} \leq V_{IL}$ ).

Figure 4. Read Cycle 1

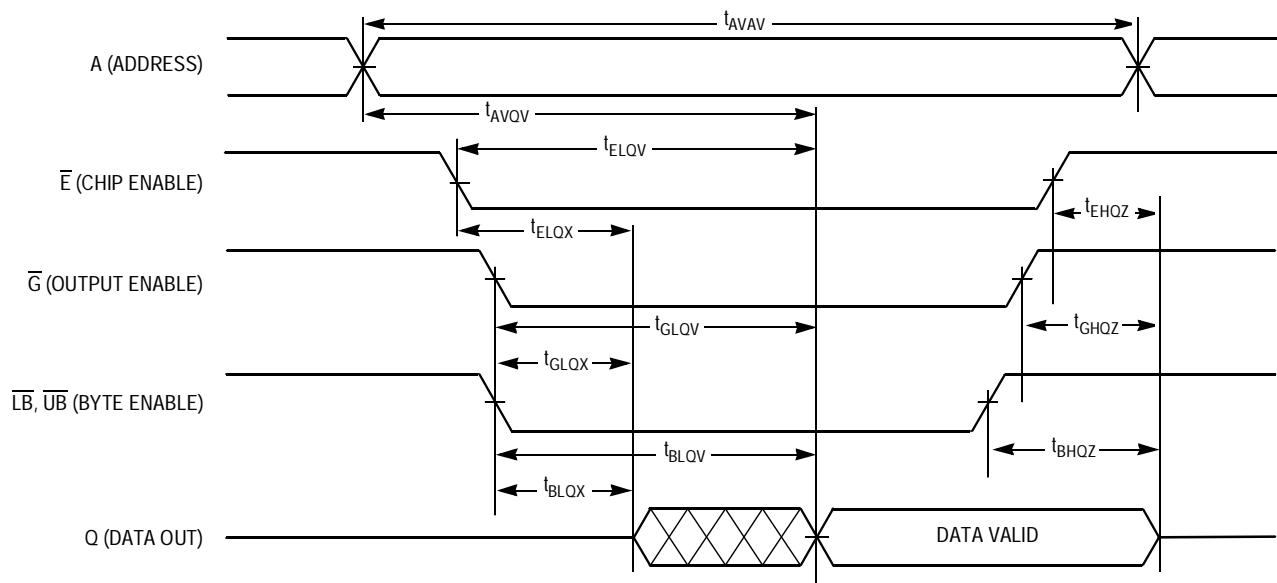


Figure 5. Read Cycle 2

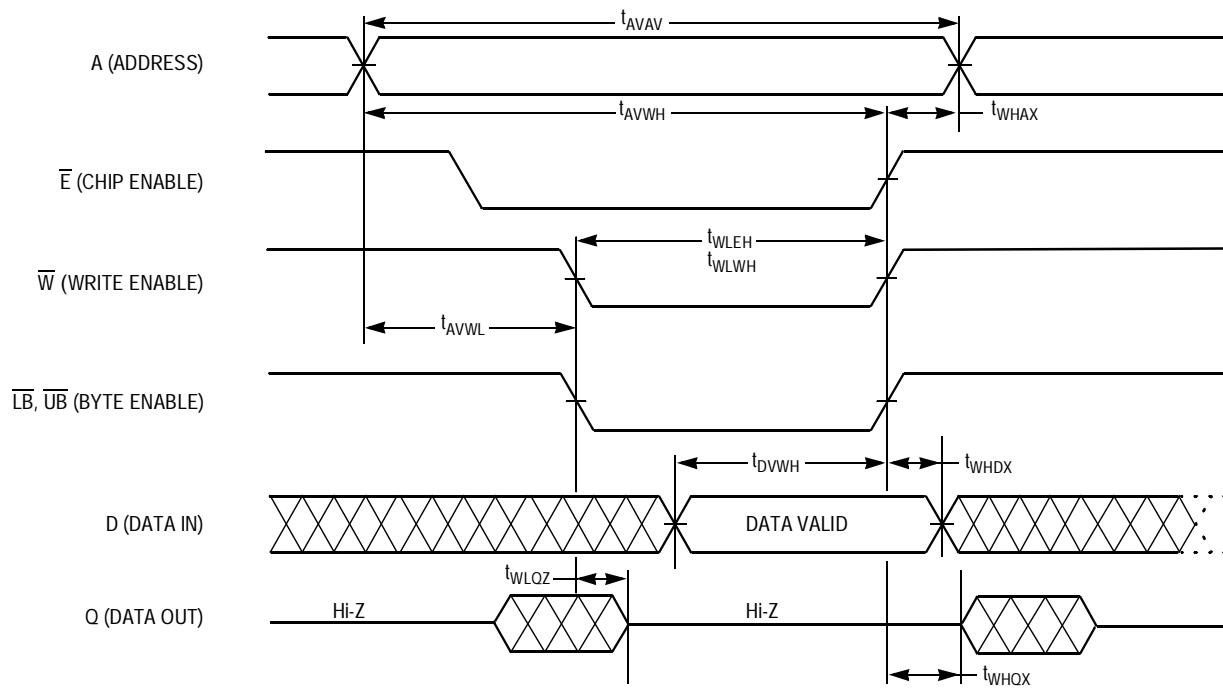
## Write Mode

**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:

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

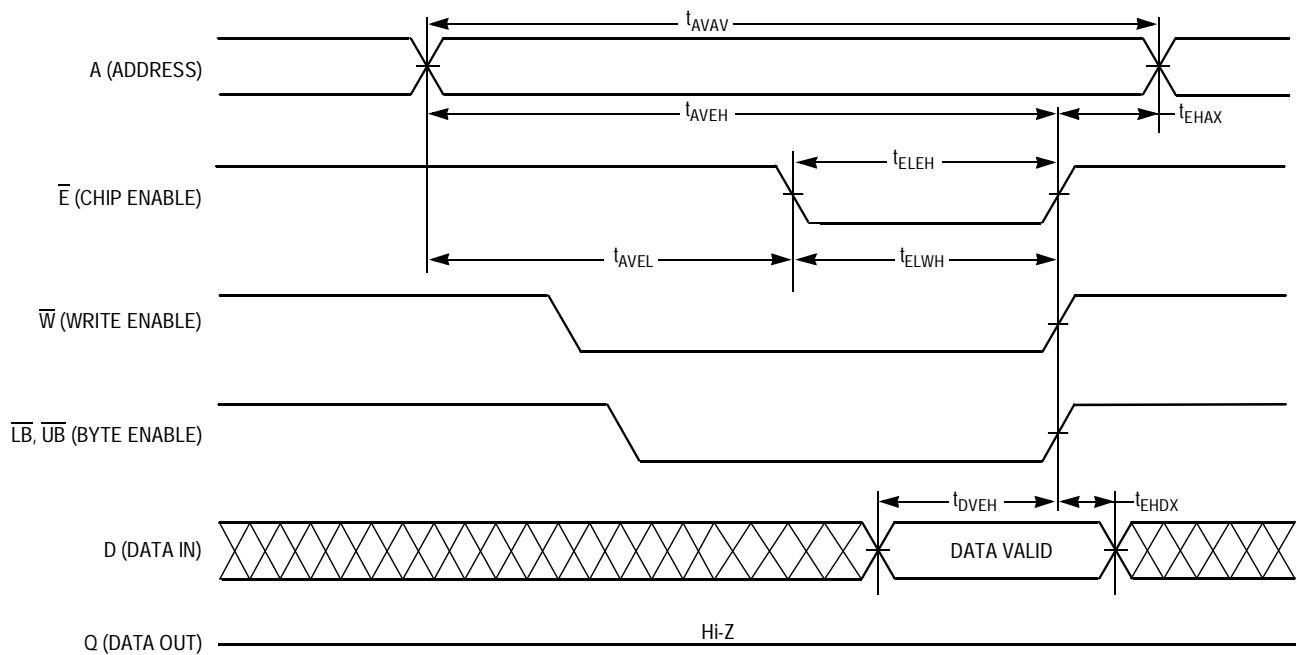
Figure 6. Write Cycle 1 ( $\bar{W}$  Controlled)

**Table 11. Write Cycle Timing 2 ( $\bar{E}$  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 ( $\bar{G}$ high)	$t_{AVEH}$	18	—	ns
Address valid to end of write ( $\bar{G}$ low)	$t_{AVEH}$	20	—	ns
Enable to end of write ( $\bar{G}$ high)	$t_{ELEH}$ $t_{ELWH}$	15	—	ns
Enable to end of write ( $\bar{G}$ 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:

- 1 A write occurs during the overlap of  $\bar{E}$  low and  $\bar{W}$  low.
- 2 Due to product sensitivities to noise, power supplies must be properly grounded and decoupled and bus contention conditions must be minimized or eliminated during read and write cycles.
- 3 If  $\bar{G}$  goes low at the same time or after  $\bar{W}$  goes low, the output will remain in a high-impedance state.
- 4 After  $\bar{W}$ ,  $\bar{E}$ , or  $\bar{UB}/\bar{LB}$  has been brought high, the signal must remain in steady-state high for a minimum of 2 ns.
- 5 The minimum time between  $\bar{E}$  being asserted low in one cycle to  $\bar{E}$  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 If  $\bar{E}$  goes low at the same time or after  $\bar{W}$  goes low, the output will remain in a high-impedance state.
- 8 If  $\bar{E}$  goes high at the same time or before  $\bar{W}$  goes high, the output will remain in a high-impedance state.

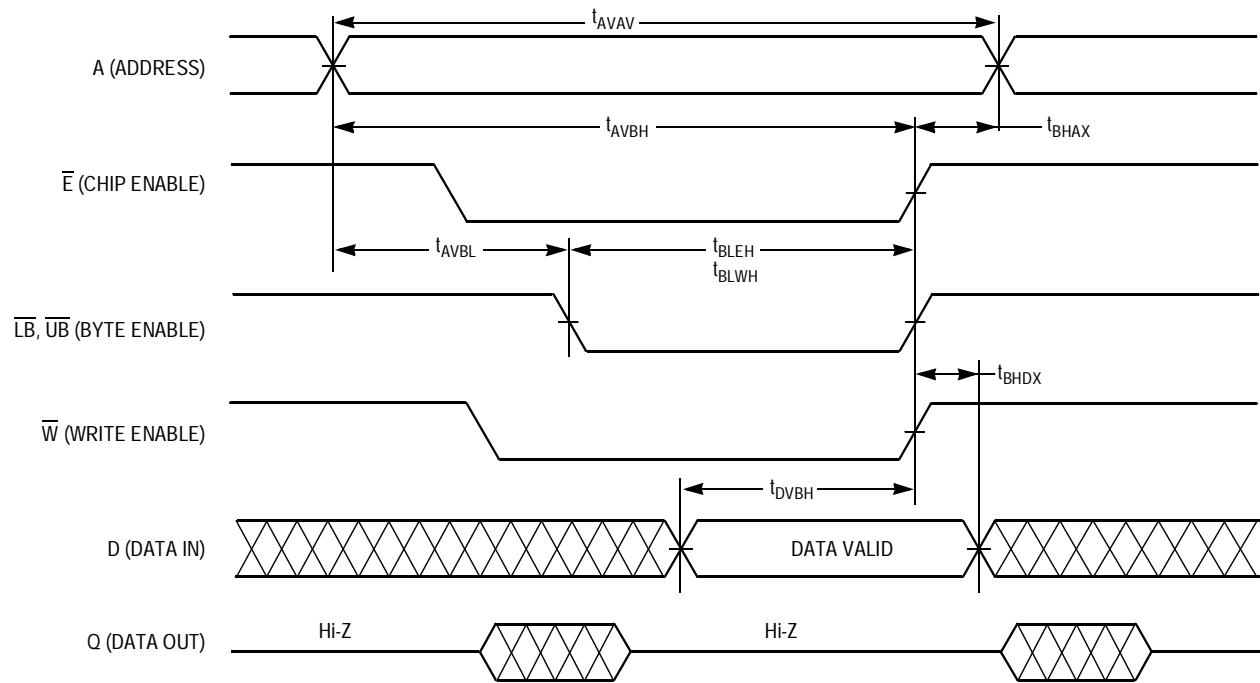
Figure 7. Write Cycle 2 ( $\bar{E}$  Controlled)

**Table 12. Write Cycle Timing 3 (LB/UB Controlled)<sup>1, 2, 3, 4, 5, 6</sup>**

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

## NOTES:

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

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

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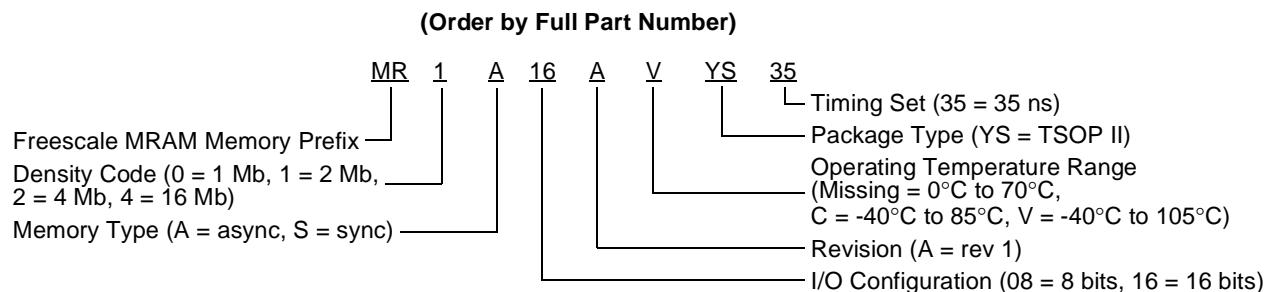
## Ordering Information

This product is available in Commercial, Industrial, and Extended temperature versions.

Freescale's semiconductor products can be classified into the following tiers: "Commercial", "Industrial" and "Extended." A product should only be used in applications appropriate to its tier as shown below. For questions, please contact a Freescale sales representative.

- **Commercial** — Typically 5 year applications - personal computers, PDA's, portable telecom products, consumer electronics, etc.
- **Industrial, Extended** — Typically 10 year applications - installed telecom equipment, workstations, servers, etc. These products can also be used in Commercial applications.

## Part Numbering System



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## Package Information

**Table 13. Package Information**

Device	Pin Count	Package Type	Designator	Case No.	Document No.	RoHS Compliant
MR1A16A	44	TSOP Type II	YS	924A-02	98ASS23673W	True

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## Revision History

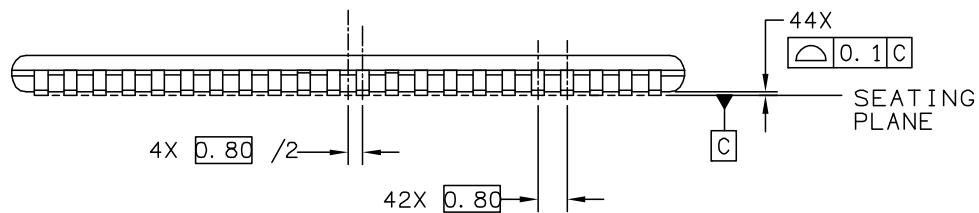
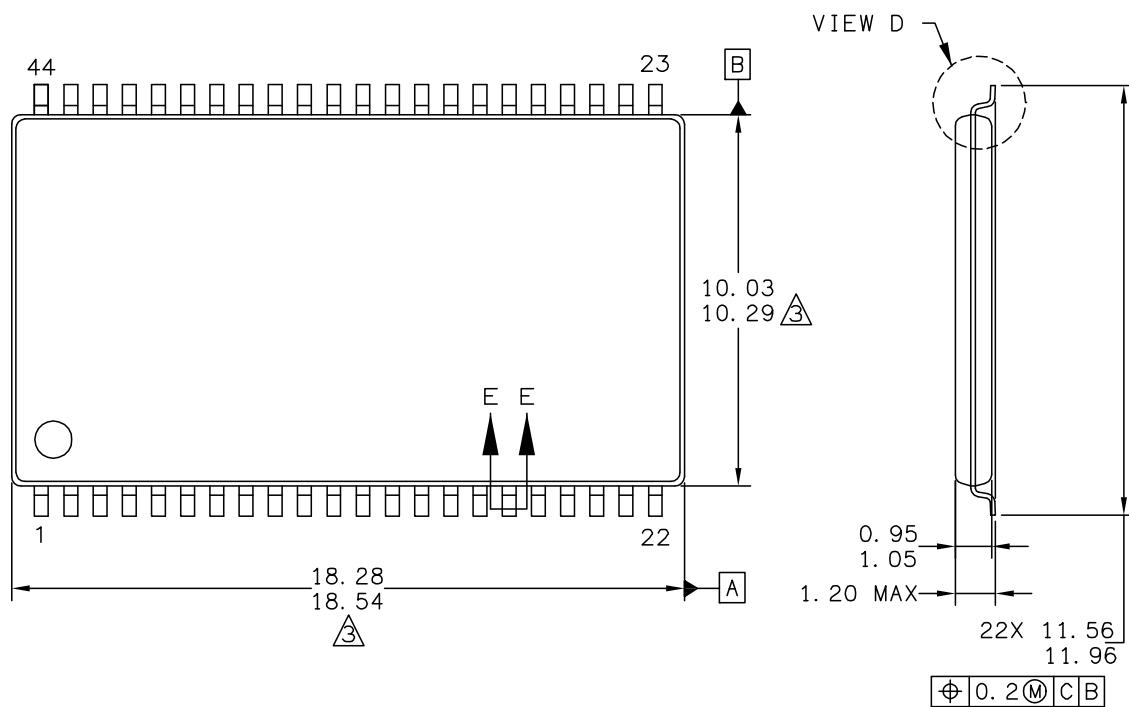
### Revision History

Rev	Date	Description of Change
1	10 Aug 2007	Initial public release version.
2	21 Sep 2007	Table 6: Applied values to TBD's in IDD specifications.
3	12 Nov 2007	Table 2: Changed IDDA to IDDR or IDDW.

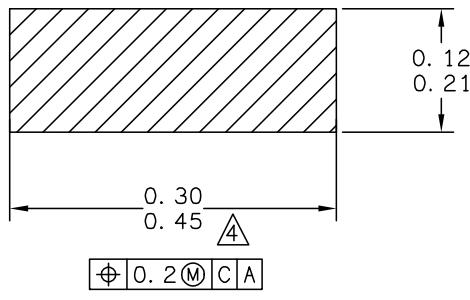
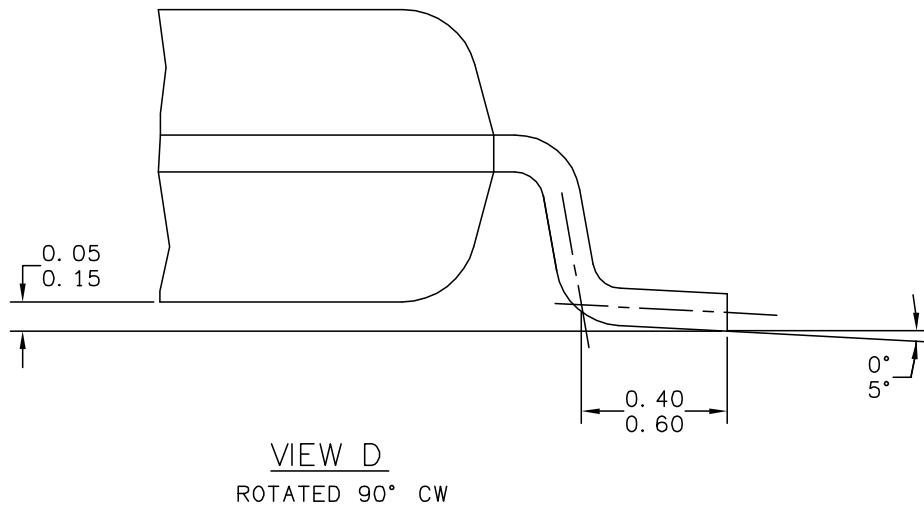
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## Mechanical Drawing

The following pages detail the package available to MR1A16A.



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TITLE:	DOCUMENT NO: 98ASS23673W	REV: C
44 LEAD TSOP, TYPE II, .400 WIDE	CASE NUMBER: 924A-02	17 MAY 2005
	STANDARD: NON-JEDEC	



SECTION E-E  
40 PLACES

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TITLE: 44 LEAD TSOP, TYPE II, .400 WIDE	DOCUMENT NO: 98ASS23673W CASE NUMBER: 924A-02 STANDARD: NON-JEDEC	REV: C 17 MAY 2005

NOTES:

1. DIMENSIONS AND TOLERANCING PER ASME Y14.5M – 1994.
2. DIMENSIONS IN MILLIMETERS.

 3. DIMENSIONS DO NOT INCLUDE MOLD PROTRUSION.  
ALLOWABLE MOLD PROTRUSION IS 0.15 PER SIDE.

 4. DIMENSION DOES NOT INCLUDE DAM BAR PROTRUSIONS.  
DAM BAR PROTRUSION SHALL NOT CAUSE THE LEAD WIDTH  
TO EXCEED 0.58.

© FREESCALE SEMICONDUCTOR, INC. ALL RIGHTS RESERVED.	<b>MECHANICAL OUTLINE</b>		PRINT VERSION NOT TO SCALE
TITLE:  44 LEAD TSOP, TYPE II, .400 WIDE	DOCUMENT NO: 98ASS23673W	REV: C	
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