

The most important thing we build is trust

## FEATURES

- ❑ Single 3.3-V power supply read/write
- ❑ Fast 45ns read/write access time
- ❑ Functionally compatible with traditional asynchronous SRAMs
- ❑ Equal address and chip-enable access times
- ❑ HiRel temperature range (-40°C to 105°C)
- ❑ Automatic data protection with low-voltage inhibit circuitry to prevent writes on power loss
- ❑ CMOS and TTL compatible
- ❑ Data retention: 20 years (-40°C to 105°C)
- ❑ Read/write endurance: unlimited for 20 years (-40°C to 105°C)
- ❑ Operational environment:
  - Total dose: 1Mrad(Si)
  - SEL Immune: 112 MeV-cm<sup>2</sup>/mg @ 125°C
  - SEU Immune: Memory Cell 112 MeV-cm<sup>2</sup>/mg @ 25°C
- ❑ Two 40-pin package options available
- ❑ Standard Microelectronics Drawing 5962-12227
  - QML Q, Q+
  - QML V

## INTRODUCTION

The Cobham (formerly) Aeroflex 16Megabit Non-Volatile magnetoresistive random access memory (MRAM) is a high-performance memory compatible with traditional asynchronous SRAM operations, organized as a 2,097,152 words by 8bits.

The MRAM is equipped with chip enable (/E), write enable (/W), and output enable (/G) pins, allowing for significant system design flexibility without bus contention. Data is non-volatile for > 20 year retention at temperature and data is automatically protected against power loss by a low voltage write inhibit.

The 16Mb MRAM is designed specifically for operation in HiRel environments. As shown in Table 3, the magneto-resistive bit cells are immune to Single Event Effects (SEE). To guard against transient effects, an Error Correction Code (ECC) is included within the device. ECC check bits are generated and stored within the MRAM array during writes. If a single bit error is found during a read cycle, it is automatically corrected in the data presented to the user.

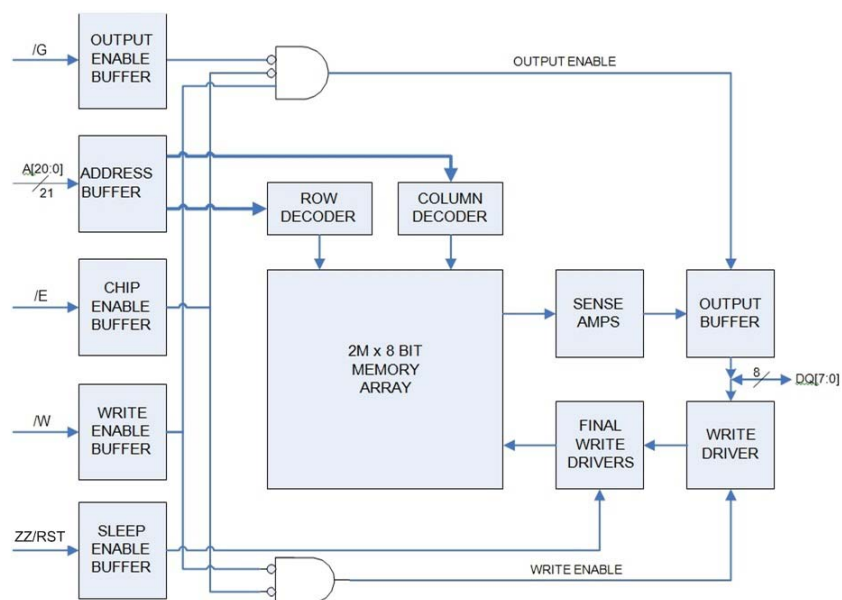


Figure 1. UT8MR2M8 MRAM Block Diagram

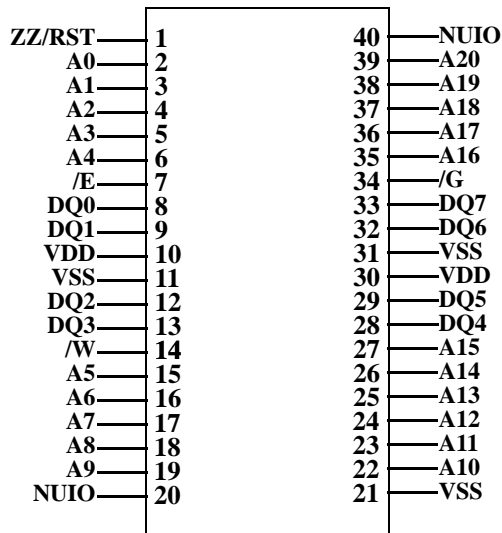


Figure 2. Package (X) 40-lead CFP-50 Mil Pitch

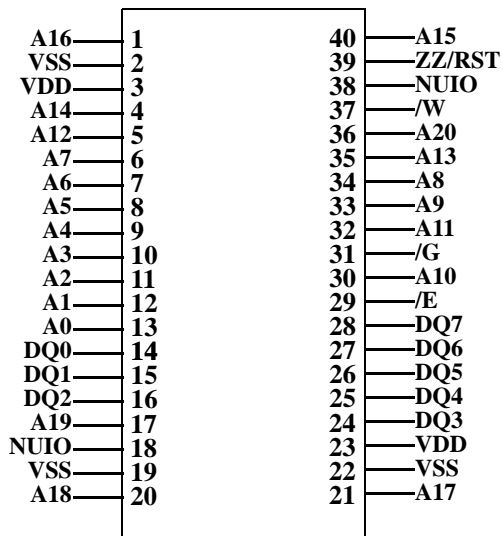


Figure 3. Package (Y) 40-lead CFP-25 Mil Pitch

## PIN NAMES

Table 1. 2M x 8 Pin Functions

Signal Name	Function
A[20:0]	Address Input
/E	Chip Enable
/W	Write Enable
/G	Output Enable
DQ[7:0]	Data I/O
VDD	Power Supply
VSS	Ground
ZZ/RST	Deep Power Down/ Reset (Internal pull down)
NUIO	Not used input/output Recommend tie low

## DEVICE OPERATION

The UT8MR2M8 has four control inputs called Chip Enable (/E), Write Enable (/W), Output Enable (/G) and Sleep/Reset Mode (ZZ/RST); 21 address inputs, A[20:0]; and eight bidirectional data lines, DQ[7:0]. /E controls device selection, active, and standby modes. Asserting /E enables the device, causes  $I_{DD}$  to rise to its active value, and decodes the 21 address inputs to select one of 2,097,152 words in the memory. /W controls read and write operations. During a read cycle, /G must be asserted to enable the outputs. ZZ/RST controls the sleep/reset mode operation and provides device reset capability. Enabling sleep/reset mode causes all other inputs to be don't cares. The following descriptions assume that sleep/reset mode is disabled when ZZ/RST is logic low.

Table 2. Device Operation Truth Table

ZZ/ Reset	/E	/G	/W	Mode	VDD Current	DQ[7:0]
H	X	X	X	Deep Sleep/ Reset Mode	$Q_{IZZ}$	HI-Z
L	H	X	X	Not Selected	$Q_{IDD}$	HI-Z
L	L	H	H	Output Disabled	$I_{DDR}$	HI-Z
L	L	L	H	Byte Read	$I_{DDR}$	$D_{OUT}$
L	L	X	L	Byte Write	$I_{DDW}$	$D_{IN}$

## READ CYCLE

A combination of /W greater than  $V_{IH}$  (min) and /E less than  $V_{IL}$  (max) defines a read cycle. Read access time is measured from the latter of chip enable, output enable, or valid address to valid data output.

MRAM Read Cycle 1, the Address Access in Figure 5a, is initiated by a change in address inputs while the chip is enabled with /G asserted and /W deasserted. Valid data appears on data outputs DQ[7:0] after the specified  $t_{AVQV}$  is satisfied. Outputs remain active throughout the entire cycle. As long as chip enable and output enable are active, the address inputs may change at a rate equal to the minimum read cycle time ( $t_{AVAV}$ ).

MRAM Read Cycle 2, the Chip Enable-controlled Access in Figure 5b, is initiated by /E going active while /G remains asserted, /W remains deasserted, and the addresses remain stable for the entire cycle. After the specified  $t_{ELQV}$  is satisfied, the eight-bit word addressed by A[20:0] is accessed and appears at the data outputs DQ[7:0].

## WRITE CYCLE

A combination of /W and /E less than  $V_{IL}$ (max) defines a write cycle. The state of /G is a “don’t care” for a write cycle. The outputs are placed in the high-impedance state when either /G is greater than  $V_{IH}$ (min), or when /W is less than  $V_{IL}$ (max).

Write Cycle 1, the Write Enable-controlled Access in Figure 6a, is defined by a write terminated by /W going high, with /E still active. The write pulse width is defined by  $t_{WLWH}$  when the write is initiated by /W, and by  $t_{WLEH}$  when the write is initiated by /E. Unless the outputs have been previously placed in the high-impedance state by /G, the user must wait  $t_{WLQZ}$  before applying data to the eight bidirectional pins DQ[7:0] to avoid bus contention.

Write Cycle 2, the Chip Enable-controlled Access in Figure 6b, is defined by a write terminated by /E going inactive. The write pulse width is defined by  $t_{ELWH}$  when the write is initiated by /W, and by  $t_{ELEH}$  when the write is initiated by /E going active. For the /E initiated write, unless the outputs have been previously placed in the high-impedance state by /G, the user must wait  $t_{WLQZ}$  before applying data to the eight bidirectional pins DQ[7:0] to avoid bus contention.

## OPERATIONAL ENVIRONMENT

The UT8MR2M8 MRAM incorporates special design and layout features which allows operation in harsh environments.

**Table 3. Operational Environment Design Specifications**

PARAMETER	LIMIT	UNITS
TID	1	Mrad(Si)
SEL Immunity <sup>1</sup>	≤ 112	MeV-cm <sup>2</sup> /mg
SEU Memory Cell Immunity <sup>2</sup>	≤ 112	MeV-cm <sup>2</sup> /mg

**Notes:**

1. SEL test performance at  $V_{DD} = 3.6V$  and temperature= 125°C.
2. SEU test performance at  $V_{DD} = 3.0V$  and unpowered at room temperature.

## POWER UP AND POWER DOWN SEQUENCING

The MRAM is protected from write operations whenever  $V_{DD}$  is less than  $V_{WI}$ . As soon as  $V_{DD}$  exceeds  $V_{DD}(\min)$ , 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  $V_{DD} - 0.2 V$  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 the 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  $V_{DD}(\min)$ .

The MRAM supports sleep/reset mode operation using the ZZ/RST control pin. To enter sleep/reset mode, ZZ/RST must be pulled high. The device will enter sleep/reset mode within 40ns. In order to exit sleep/reset mode, /E and /W must be high before ZZ/RST is pulled low. As soon as ZZ/RST is driven low, the user must allow 100us before performing any other operation in order for the device to properly initialize. Aeroflex recommends designing a system level method to toggle the ZZ/RST pin in order to reset the MRAM device.

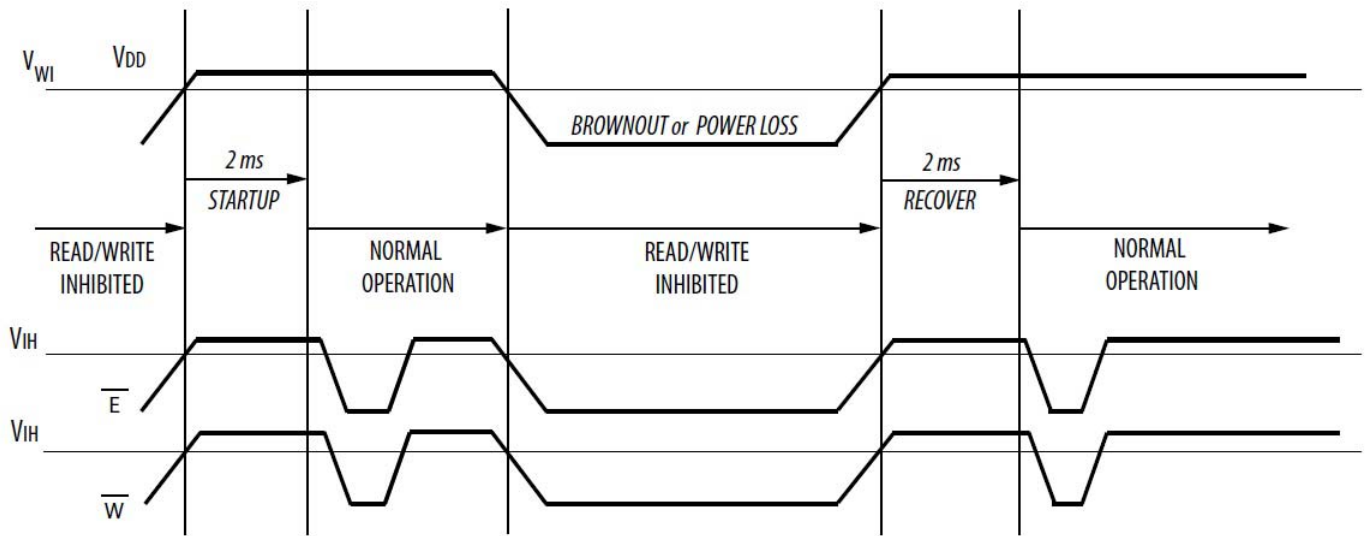


Figure 4. UT8MR2M8 Power Up and Power Down Sequencing Diagram

## ABSOLUTE MAXIMUM RATINGS<sup>1</sup>

(Referenced to  $V_{SS}$ )

The device contains protection against magnetic fields. Precautions should be taken to avoid device exposure of any magnetic field intensity greater than specified.

SYMBOL	PARAMETER	VALUE	UNIT
$V_{DD}$	Supply Voltage <sup>2</sup>	-0.5 to 4.3	V
$V_{IN}$	Voltage on any pin <sup>2</sup>	-0.5 to $V_{DD}+0.5$	V
$I_{IO}$	DC I/O current per pin @ $T_J = 125^\circ$ for 20yrs	$\pm 20$	mA
$P_D$	Package power dissipation permitted <sup>3</sup>	4	W
$T_J$	Maximum junction temperature	+150	$^\circ\text{C}$
$\theta_{JC}$	Thermal resistance junction to case	5	$^\circ\text{C}/\text{W}$
$T_{STG}$	Storage temperature	-65 to +125	$^\circ\text{C}$
$ESD_{HBM}$	ESD (Class 2)	2000	V
$H_{\max\_write}$	Maximum magnetic field during write	8000	A/m
$H_{\max\_read}$	Maximum magnetic field during read or standby	8000	A/m

### Notes:

1. 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.
2. All voltages are referenced to  $V_{SS}$ .
3. Power dissipation capability depends on package characteristics and use environment.

## RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	LIMITS
$T_C$	Operating case temperature	-40 to +105 $^\circ\text{C}$
$V_{DD}$	Operating supply voltage	3.0V to 3.6V
$V_{WI}$	Write inhibit voltage	2.5V to 3.0V <sup>1</sup>
$V_{IH}$	Input high voltage	2.0V to $V_{DD}+0.3\text{V}$
$V_{IL}$	Input low voltage	$V_{SS}-0.3\text{V}$ to 0.8V

### Notes:

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

## DC ELECTRICAL CHARACTERISTICS (Pre and Post-Radiation)\*

$V_{DD} = 3.0V$  to  $3.6V$ ; Unless otherwise noted,  $T_c$  is per the temperature ordered

SYMBOL	PARAMETER	CONDITION	MIN	MAX	UNIT
$V_{IH}$	High-level input voltage		2.0		V
$V_{IL}$	Low-level input voltage			0.8	V
$V_{OL1}$	Low-level output voltage	$I_{OL} = 4mA, V_{DD} = V_{DD} (min)$		0.4	V
$V_{OL2}$	Low-level output voltage	$I_{OL} = +100\mu A, V_{DD} = V_{DD} (min)$		$V_{SS} + 0.2$	V
$V_{OH1}$	High-level output voltage	$I_{OH} = -4mA, V_{DD} = V_{DD} (min)$	2.4		V
$V_{OH2}$	High-level output voltage	$I_{OH} = -100\mu A, V_{DD} = V_{DD} (min)$	$V_{DD} - 0.2$		V
$C_{IN}^1$	Input capacitance (Applies to A[20:0])	$f = 1MHz @ 0V$		12	pF
$C_{IO}^1$	Bidirectional I/O capacitance	$f = 1MHz @ 0V$		14	pF
$C_{IO2}^1$	Package X Bidirectional I/O capacitance (applies to DQ[7:0])	$f = 1MHz @ 0V$		10	pF
$I_{IN}$	Input leakage current	$V_{IN} = V_{DD}$ and $V_{SS}$	-1	+1	$\mu A$
$I_{INZZ}$	Input leakage current ZZ/RST	$V_{IN} = V_{DD}$ and $V_{SS}$		$\pm 100$	$\mu A$
$I_{OZ}$	Three-state output leakage current	$V_O = V_{DD}$ and $V_{SS}$ , $V_{DD} = V_{DD} (max)$ $/G = V_{DD} (max)$	-1	+1	$\mu A$
$I_{OS}^{2,3}$	Short-circuit output current	$V_{DD} = V_{DD} (max), V_O = V_{DD}$ $V_{DD} = V_{DD} (max), V_O = V_{SS}$	-100	+100	mA
$I_{DDR}$	Active read supply current	Read mode $f = MAX$ ( $I_{OUT} = 0mA; V_{DD} = max$ )		110	mA
$I_{DDW}$	Active write supply current	Write mode $f = 10 MHz$ ( $V_{DD} = max$ )		110	mA
$Q_{IDD}$	Quiescent supply current	CMOS leakage current ( $/E$ and $/W = V_{DD}$ ; all other inputs equal $V_{SS}$ or $V_{DD}$ ; $V_{DD} = max$ )	-40°C and +25°C	11	mA
			+105°C	20	mA
$Q_{IZZ}^4$	Deep power down and reset supply current	CMOS leakage current ( $/E, /W, ZZ = V_{DD}$ ; all other inputs equal $V_{SS}$ or $V_{DD}$ ; $V_{DD} = max$ )		1	mA

### Notes:

\* For devices procured with a total ionizing dose tolerance guarantee, the post-irradiation performance is guaranteed at 25°C per MIL-STD-883 Method 1019, Condition A up to the maximum TID level procured.

1. Measured only for initial qualification and after process or design changes that could affect input/output capacitance.
2. Guaranteed by design.
3. Not more than one output may be shorted at a time for maximum duration of one second.
4. Allow 100 $\mu s$  to exit sleep/reset mode before performing any other operation and observe start up time and start up conditions for  $/W$  and  $/E$ .

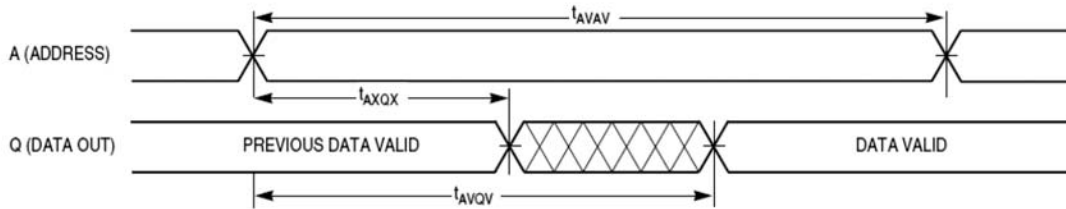
**AC CHARACTERISTICS READ CYCLE<sup>1</sup> (Pre and Post-Radiation)\***V<sub>DD</sub> = 3.0V to 3.6V; Unless otherwise noted, T<sub>c</sub> is per the temperature ordered

SYMBOL	PARAMETER	MIN	MAX	UNIT
t <sub>AVAV</sub>	Read cycle time	45		ns
t <sub>AVQV</sub>	Address access time		45	ns
t <sub>ELQV</sub> <sup>2</sup>	Enable access time		45	ns
t <sub>GLQV</sub>	Output enable access time		22	ns
t <sub>AXQX</sub>	Output hold from address change	3		ns
t <sub>ELQX</sub> <sup>3</sup>	Enable low to output active	3		ns
t <sub>GLQX</sub> <sup>3</sup>	Output enable low to output active	0		ns
t <sub>EHQZ</sub> <sup>3</sup>	Enable high to output Hi-Z	0	15	ns
t <sub>GHQZ</sub> <sup>3</sup>	Output enable high to output Hi-Z	0	10	ns

**Notes:**

\* For devices procured with a total ionizing dose tolerance guarantee, the post-irradiation performance is guaranteed at 25°C per MIL-STD-883 Method 1019, Condition A up to the maximum TID level procured.

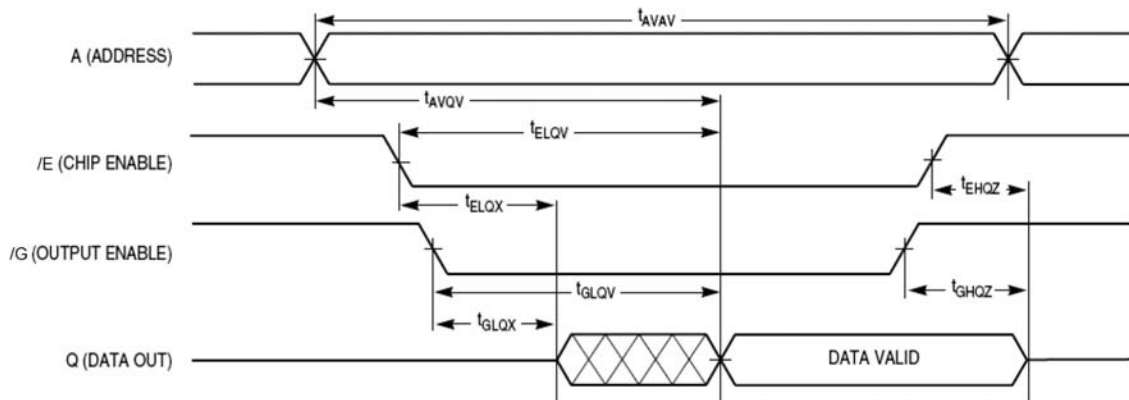
1. /W is high for read cycle. Power supplies must be properly grounded and decoupled, and bus contention conditions must be minimized or eliminated during read or write cycles.
2. Address valid before or at the same time /E goes low.
3. Transition is measured at +/-400mV from the steady-state voltage.



**NOTES:**

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

**Figure 5a. MRAM Read Cycle 1**



**Figure 5b. MRAM Read Cycle 2**



**AC CHARACTERISTICS /W CONTROLLED WRITE CYCLE (Pre and Post-Radiation)\***

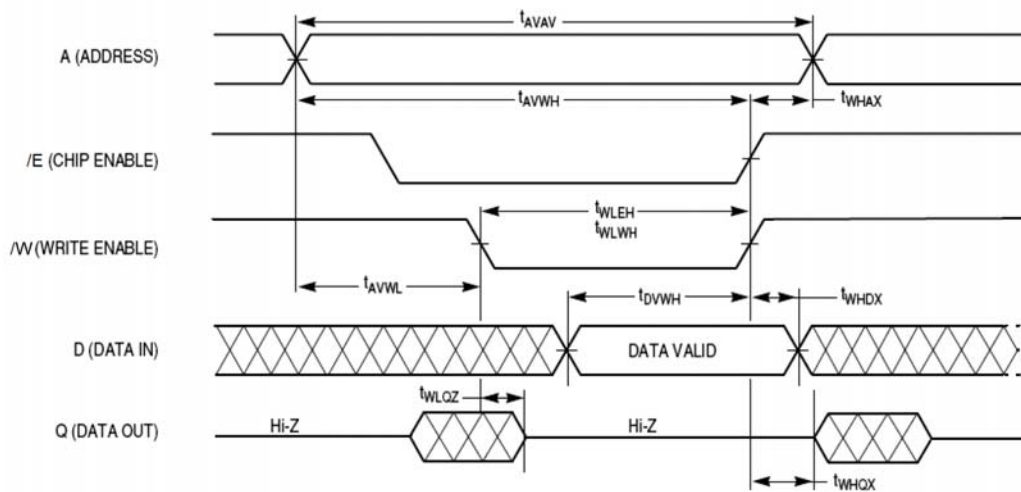
V<sub>DD</sub>= 3.0V to 3.6V; Unless otherwise noted, T<sub>c</sub> is per the temperature ordered.

SYMBOL	PARAMETER	MIN	MAX	UNIT
t <sub>AVAV</sub> <sup>2</sup>	Write cycle time	45		ns
t <sub>AVWL</sub>	Address set-up time	0		ns
t <sub>AVWH</sub>	Address valid to end of write (/G high)	28		ns
t <sub>AVWH</sub>	Address valid to end of write (/G low)	28		
t <sub>WLWH</sub> t <sub>WLEH</sub>	Write pulse width (/G high or low)	28		ns
t <sub>DVWH</sub>	Data valid to end of write	10		ns
t <sub>WHDX</sub>	Data hold time	0		ns
t <sub>WLQZ</sub> <sup>3</sup>	Write low to data Hi-Z	0	15	ns
t <sub>WHQX</sub> <sup>3</sup>	Write high to output active	3		ns
t <sub>WHAX</sub>	Write recovery time	16		ns

**Notes:**

\* For devices procured with a total ionizing dose tolerance guarantee, the post-irradiation performance is guaranteed at 25°C per MIL-STD-883 Method 1019, Condition A up to the maximum TID level procured.

1. All write occurs during the overlap of /E low and /W low. Power supplies must be properly grounded and decoupled, and bus contention conditions must be minimized or eliminated during read or write cycles. If /G goes low at the same time or after /W goes low, the output will remain in a high impedance state.
2. All write cycle timings are referenced from the last valid address to the first transition address.
3. Transition is measured +/-400mV from the steady-state voltage.



**Figure 6a. MRAM Write Cycle 1 (/W Controlled Access)**

**AC CHARACTERISTICS /E CONTROLLED WRITE CYCLE<sup>1</sup> (Pre and Post-Radiation)\***

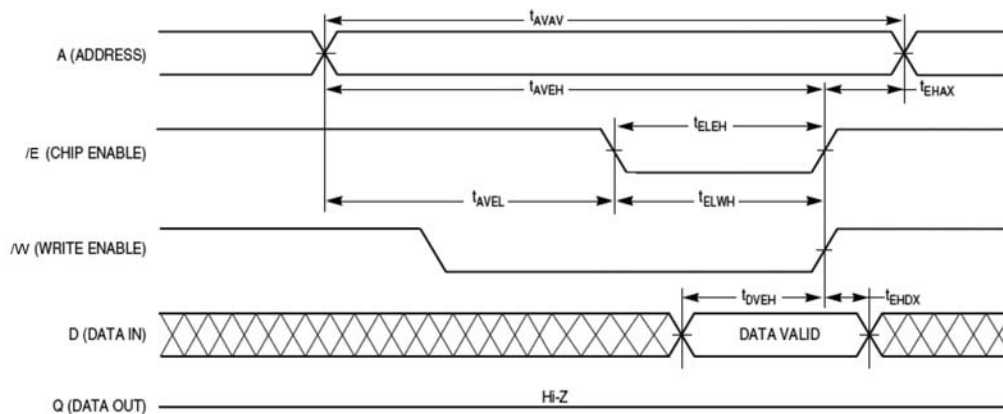
V<sub>DD</sub>= 3.0V to 3.6V; Unless otherwise noted, T<sub>c</sub> is per the temperature ordered.

SYMBOL	PARAMETER	MIN	MAX	UNIT
t <sub>AVAV</sub> <sup>2</sup>	Write cycle time	45		ns
t <sub>AVEL</sub>	Address set-up time	0		ns
t <sub>AVEH</sub>	Address valid to end of write (/G high)	28		ns
t <sub>AVEH</sub>	Address valid to end of write (/G low)	28		
t <sub>ELEH</sub> t <sub>ELWH</sub>	Enable to end of write (/G high)	28		ns
t <sub>ELEH</sub> <sup>3</sup> t <sub>ELWH</sub> <sup>3</sup>	Enable to end of write (/G low)	28		ns
t <sub>DVEH</sub>	Data valid to end of write	10		ns
t <sub>EHDX</sub>	Data hold time	0		ns
t <sub>EHAX</sub>	Write recovery time	16		ns

**Notes:**

\* For devices procured with a total ionizing dose tolerance guarantee, the post-irradiation performance is guaranteed at 25°C per MIL-STD-883 Method 1019, Condition A up to the maximum TID level procured.

1. All write occurs during the overlap of /E low and /W low. Power supplies must be properly grounded and decoupled, and bus contention conditions must be minimized or eliminated during read or write cycles. If /G goes low at the same time or after /W goes low, the output will remain in a high impedance state.
2. All write cycle timings are referenced from the last valid address to the first transition address.
3. If /E goes low at the same time or after /W goes low, the output will remain in a high-impedance state. If /E goes high at the same time or before /W goes high, the output will remain in a high-impedance state.



**Figure 6b. MRAM Write Cycle 2 (/E Controlled)**

**AC CHARACTERISTICS SLEEP/RESET MODE (Pre and Post-Radiation)\***

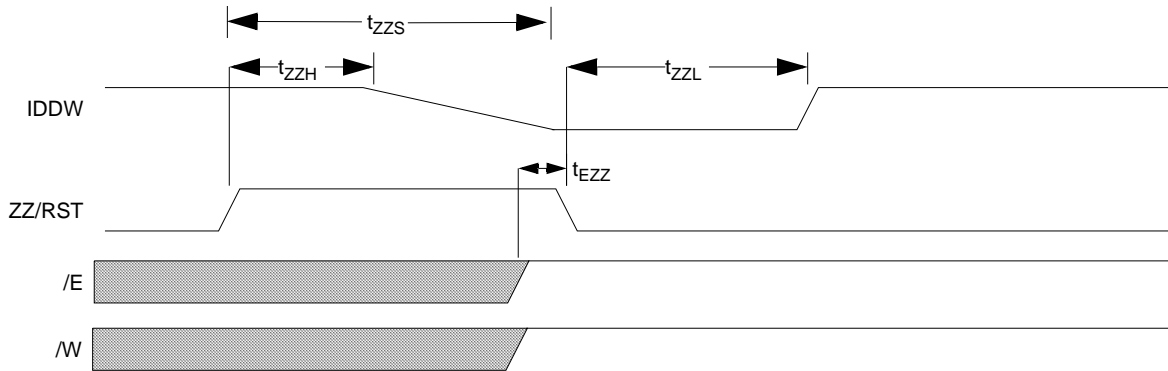
$V_{DD}$  = 3.0V to 3.6V; Unless otherwise noted,  $T_c$  is per the temperature ordered.

SYMBOL	PARAMETER	MIN	MAX	UNIT
$t_{ZZL}^{1,3}$	Sleep/reset mode exit delay		100	$\mu s$
$t_{ZZH}^{2,3}$	Sleep/reset mode access time	45		ns
$t_{EZZ}^3$	Sleep/reset mode exit setup time	0		ns
$t_{ZZS}^3$	Sleep/reset mode settle time		200	$\mu s$

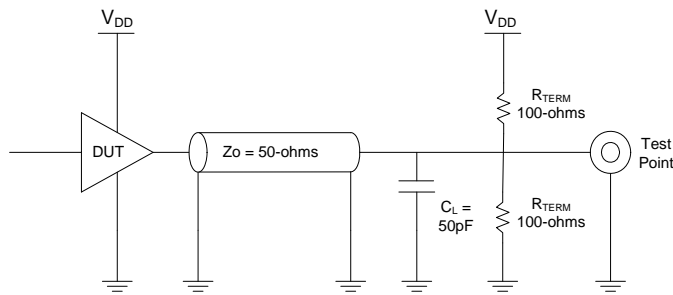
**Notes:**

\* For devices procured with a total ionizing dose tolerance guarantee, the post-irradiation performance is guaranteed at 25°C per MIL-STD-883 Method 1019, Condition A up to the maximum TID level procured.

1. /E and /W must be high when ZZ/RST is pulled low in order to exit sleep/reset mode.
2. ZZ/RST must be high for 40ns in order to enter sleep/reset mode.
3. Guaranteed by design.



**Figure 7. MRAM Sleep/Reset Mode Timing Diagram**

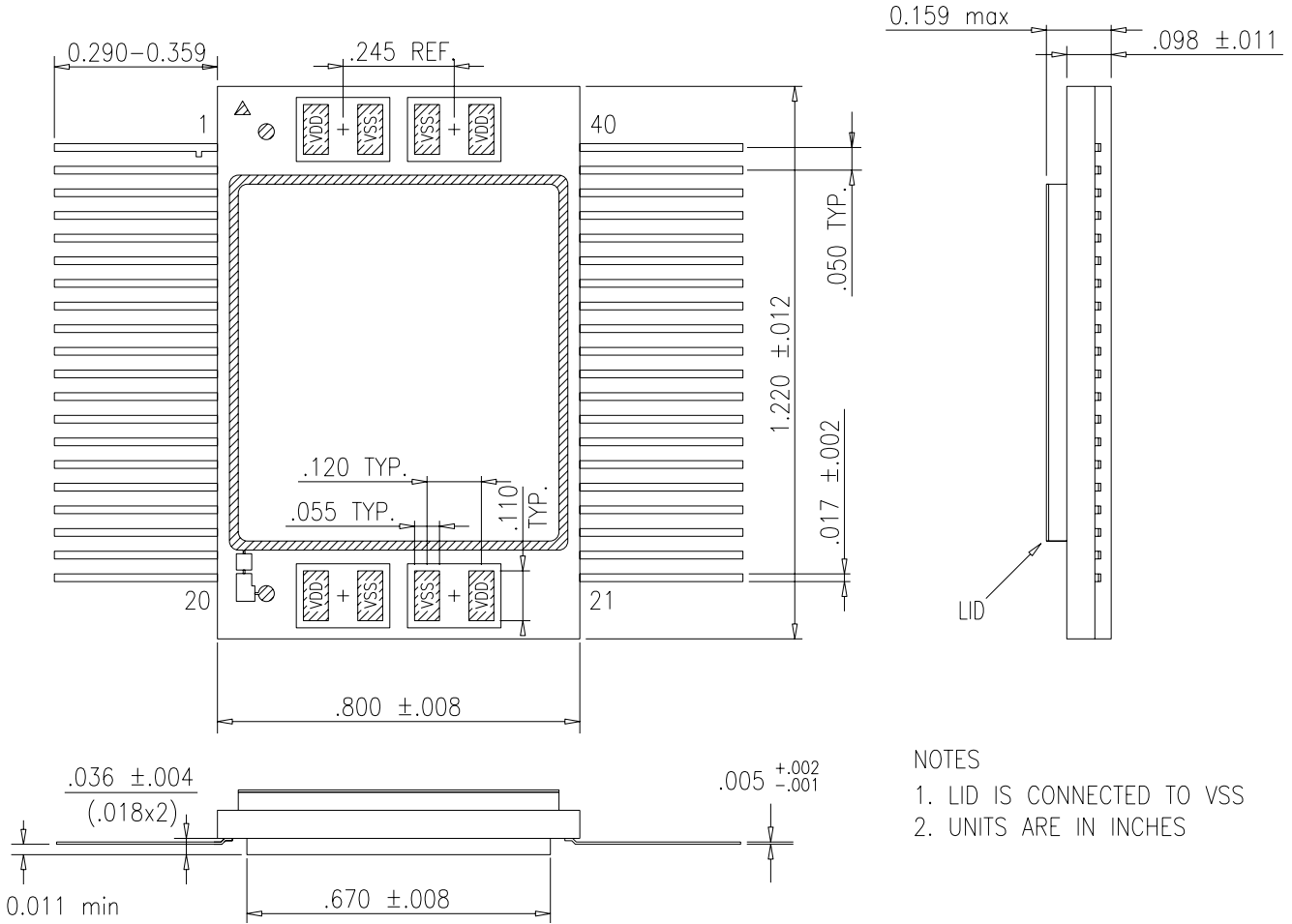


**Notes:**

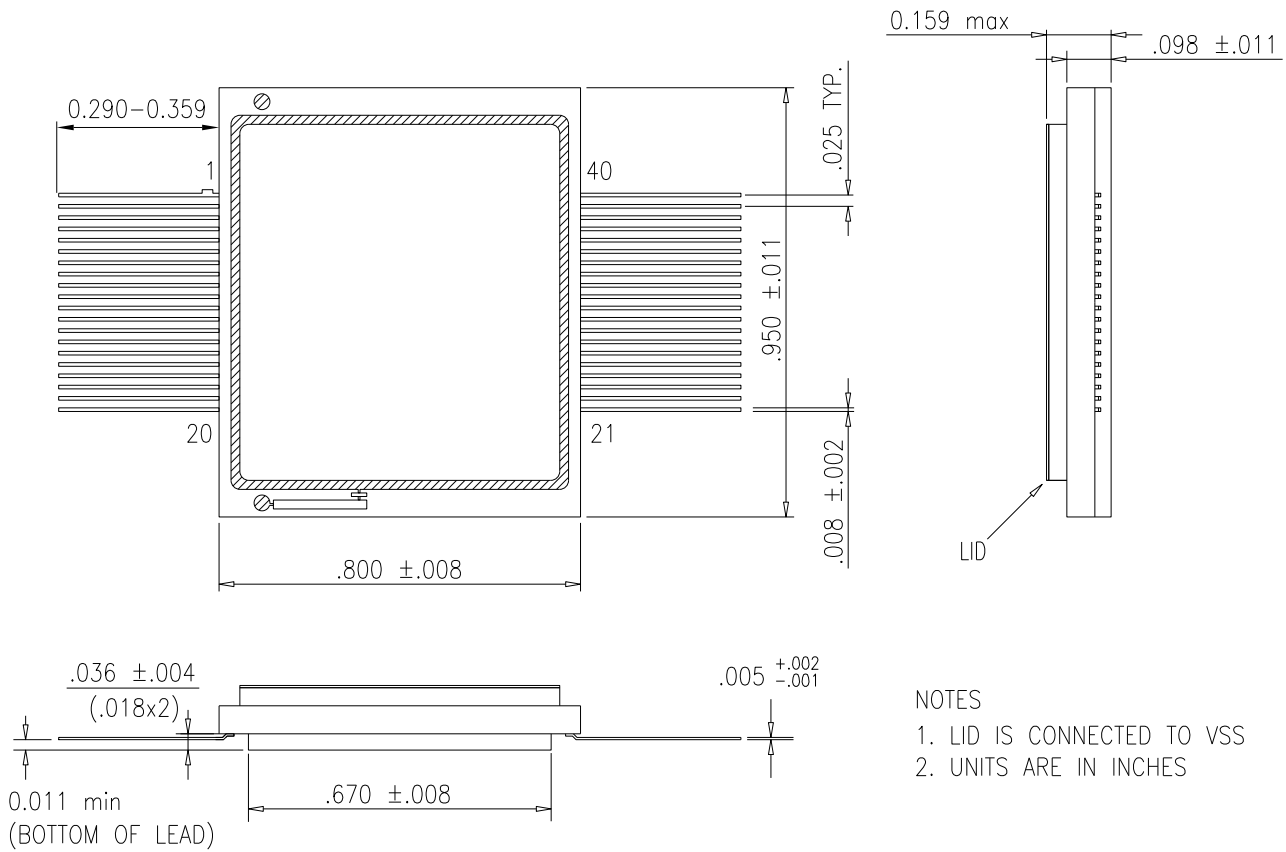
1. Measurement of data output occurs at the low to high or high to low transition mid-point, typically,  $V_{DD}/2$ .

**Figure 8. AC Output Test Load or Equivalent**

**PACKAGES**



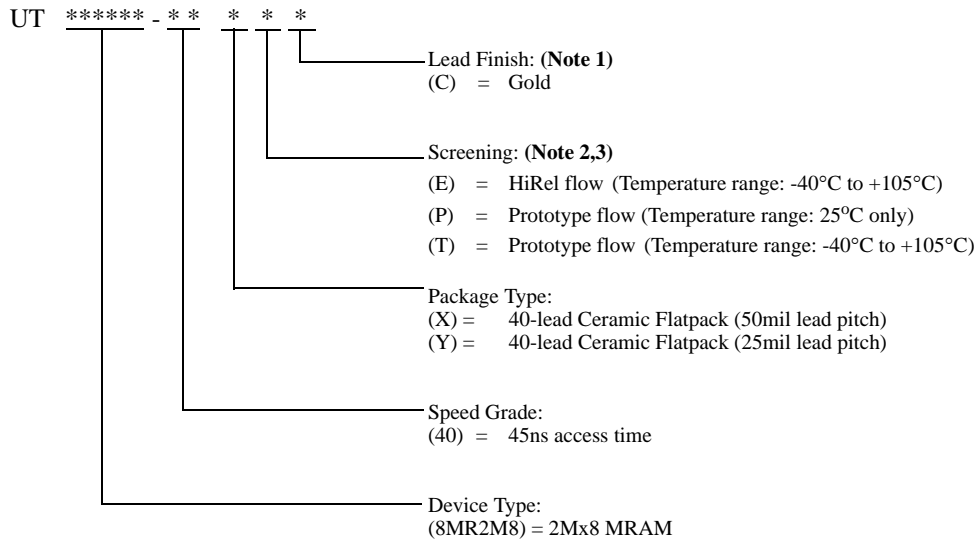
**Figure 9. Package Option X 40-Pin Ceramic Flatpack - 50 Mil Pitch**



**Figure 10. Package Option Y 40-Pin Ceramic Flatpack - 25 Mil Pitch**

## ORDERING INFORMATION

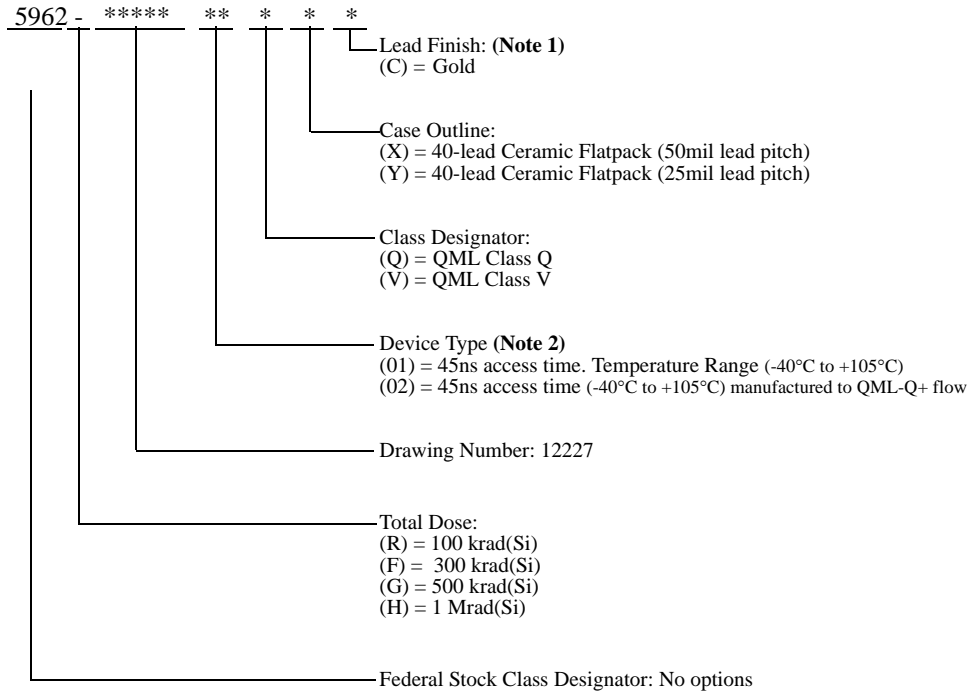
### 2M x 8 MRAM:



#### Notes:

1. Lead finish is "C" (Gold) only.
2. Prototype flow per Aeroflex Colorado Springs Manufacturing Flows Document. Radiation neither tested nor guaranteed.
3. HiRel flow per Aeroflex Colorado Springs Manufacturing Flows Document. Radiation neither tested nor guaranteed.

## 2M x 8 MRAM: SMD



### Notes:

- Lead finish is "C" (Gold) only.
- Aeroflex's Q+ flow, as defined in Section 4.2.2d of SMD, provides QML-Q product through the SMD that is manufactured with Aeroflex's standard QML-V flow.

## NOTES



## ***Cobham Colorado Springs - Datasheet Definition***

**Advanced Datasheet - Product In Development**

**Preliminary Datasheet - Shipping Prototype**

**Datasheet - Shipping QML & Hi-Rel**

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## DATA SHEET REVISION HISTORY

REV	Revision Date	Description of Change	Page(s)
A	3/15/12	Initial Release of Preliminary Datasheet	All
B	8/6/12	Changed Temperature Range, Added ECC verbiage, Added Sleep Mode, Updated AC Timing Specifications, Updated Ordering Information	1, 3,6,9, 10, 13
C	9/18/12	Updated AC Timing Specifications, Updated Sleep Mode AC Specifications	8,9,10
D	12/11/12	Update TID Specification, editorial edits	1,3,All
E	4/5/13	Changed Sleep Mode to Sleep/Reset Mode and added associated verbiage	2,3,6,11
F	8/23/13	Updated Power Up and Power Down Sequencing Diagram, Updated Maximum magnetic field during write specification, changed write access time and associated AC timing specifications,	1,4,5,7,9, 10
G	12/16/13	Final Release of Datasheet, changed read access time and associated AC timing specifications, added temperature range to endurance and retention specification, updated Absolute Maximum Ratings table, updated IDDR and QIZZ specifications, added capacitance specifications, updated Sleep/Reset Mode AC timing specifications, updated package drawings, added revision history	1,5,6,7,11, 12,13,14, 15
H	4/21/14	Updated supply current specifications. Updated package drawings to reflect different lead length. Format edits.	6, 2,13
I	9/30/14	Added frequency conditions for I <sub>DDR</sub> and I <sub>DDW</sub>	6
1.0.0	January 2016	Added new Cobham datasheet template, QML V Achieved, added ZZ/RST description of internal pull-down, updated maximum junction temperature to 150C	All