

WIDE DRAM

2 MEG x 8 DRAM

5.0V, FAST-PAGE-MODE (MT4C2M8A1/2)
3.0/3.3V, FAST-PAGE-MODE (MT4LC2M8A1/2)

FEATURES

- Industry-standard x8 pinouts, timing, functions and packages
- Address entry: 12 row-addresses, 9 column-addresses (64ms)
- High-performance CMOS silicon-gate process
- Single +5V only or 3.0/3.3V only $\pm 10\%$ power supply
- Low power, 5mW standby; 400mW active, typical (5V)
- All device pins are TTL-compatible
- 4,096-cycle refresh (2,048-cycle refresh available as MT4(L)C2M8B1/2)
- Refresh modes: $\overline{\text{RAS}}$ -ONLY, $\overline{\text{CAS}}$ -BEFORE- $\overline{\text{RAS}}$ (CBR) and HIDDEN
- Optional FAST-PAGE-MODE access cycle
- NONPERSISTENT MASKED WRITE access cycle (MT4(L)C2M8A2 only)

OPTIONS

- Timing
 - 60ns access -6
 - 70ns access -7
 - 80ns access -8
- Power Supply
 - 5V $\pm 10\%$ only 4C
 - 3.0/3.3V $\pm 10\%$ only 4LC
- MASKED WRITE
 - Not available A1
 - Available A2
- Packages
 - Plastic 28-pin SOJ (400 mil) DJ
 - Plastic 28-pin TSOP (400 mil) TG
 - Plastic 32-pin SOJ (400 mil) DL
 - Plastic 32-pin TSOP (400 mil) TL
- Part Number Example: MT4LC2M8A1DJ-6

MARKING

PART DESCRIPTION

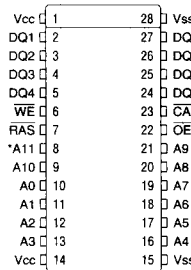
| | |
|------------|---------------------------|
| MT4C2M8A1 | 5V, NONMASKED WRITE |
| MT4C2M8A2 | 5V, MASKED WRITE |
| MT4LC2M8A1 | 3.0/3.3V, NONMASKED WRITE |
| MT4LC2M8A2 | 3.0/3.3V, MASKED WRITE |

GENERAL DESCRIPTION

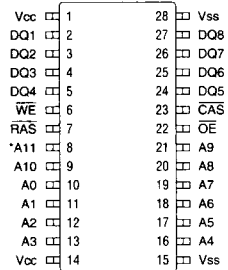
The MT4C2M8A1/2 and MT4LC2M8A1/2 are randomly accessed solid-state memories containing 16,777,216 bits organized in a x8 configuration. The MT4C2M8A1/2 and the MT4LC2M8A1/2 are the same DRAM versions except that the MT4LC2M8A1/2 are low voltage versions of the

PIN ASSIGNMENT (Top View)

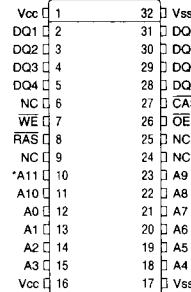
28-Pin SOJ (DC-4)



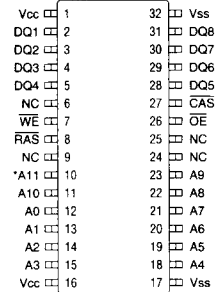
28-Pin TSOP (DD-3)



32-Pin SOJ (DC-5)



32-Pin TSOP (DD-4)



*NC on 11 row-address version

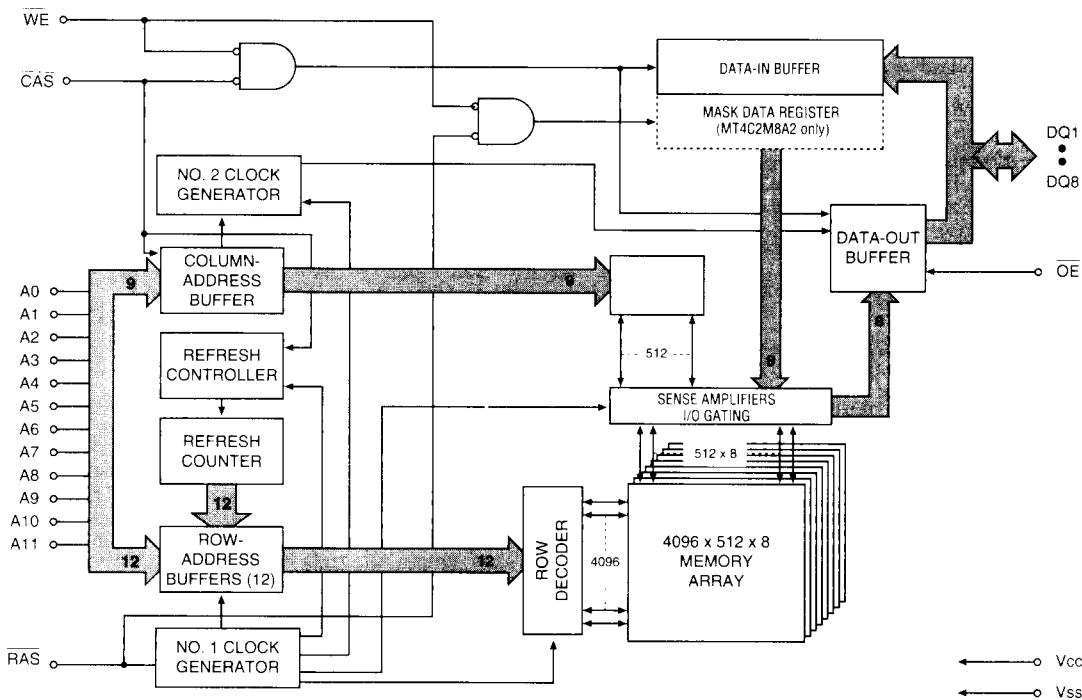
WIDE DRAM

MT4C2M8A1/2. The MT4LC2M8A1/2 are designed to operate in either a 3.0V $\pm 10\%$ or a 3.3V $\pm 10\%$ memory system. All further references made to the MT4C2M8A1/2 also apply to the MT4LC2M8A1/2, unless specifically stated otherwise. Each byte is uniquely addressed through the 21 address bits during READ or WRITE cycles. The address is entered first by $\overline{\text{RAS}}$ latching 12 bits (A0-11) and then $\overline{\text{CAS}}$ latching 9 bits (A0-A9).

The MT4C2M8A2 has NONPERSISTENT MASKED WRITE, allowing it to perform WRITE-PER-BIT accesses.

FUNCTIONAL BLOCK DIAGRAM
4096 ROWS

WIDE DRAM



PIN DESCRIPTIONS

| 28-PIN DEVICE PIN NUMBERS | 32-PIN DEVICE PIN NUMBERS | SYMBOL | TYPE | DESCRIPTION |
|------------------------------|------------------------------|-------------------------|--------|---|
| 7 | 8 | $\overline{\text{RAS}}$ | Input | Row-Address Strobe: $\overline{\text{RAS}}$ is used to clock-in the 12 row-address bits and strobe the $\overline{\text{WE}}$ and DQs in the MASKED WRITE mode (MT4C2M8A2 only). |
| 23 | 27 | $\overline{\text{CAS}}$ | Input | Column-Address Strobe: $\overline{\text{CAS}}$ is used to clock-in the 9 column-address bits, enable the DRAM output buffers and strobe the data inputs on WRITE cycles. |
| 6 | 7 | $\overline{\text{WE}}$ | Input | Write Enable: $\overline{\text{WE}}$ is used to select a READ ($\overline{\text{WE}}$ = HIGH) or WRITE ($\overline{\text{WE}}$ = LOW) cycle. $\overline{\text{WE}}$ also serves as a mask enable ($\overline{\text{WE}}$ = LOW) at the falling edge of $\overline{\text{RAS}}$ in a MASKED WRITE cycle (MT4C2M8A2). |
| 22 | 26 | $\overline{\text{OE}}$ | Input | Output Enable: $\overline{\text{OE}}$ enables the output buffers when taken LOW during a READ access cycle. $\overline{\text{RAS}}$ and $\overline{\text{CAS}}$ must be LOW and $\overline{\text{WE}}$ must be HIGH before $\overline{\text{OE}}$ will control the output buffers. Otherwise, the output buffers are in a High-Z state. |
| 10-13, 16-21, 9, 8 | 12-15, 18-23, 11, 10 | A0-A11 | Input | Address Inputs: These inputs are multiplexed and clocked by $\overline{\text{RAS}}$ and $\overline{\text{CAS}}$ to select one byte out of the 2 Meg available words. |
| 2-5, 24-27 | 2-5, 28-31 | DQ1-DQ8 | Input | Data I/O: Includes inputs, outputs or High-Z and/or output masked data input (for MASKED WRITE cycle only). |
| | 6, 9, 24, 25 | NC | - | No Connect: These pins should be either left unconnected or tied to ground. |
| 1, 14 | 1, 16 | Vcc | Supply | Power Supply: +5V \pm 10% (C), 2.7V to 3.6V (LC) |
| 15, 28 | 17, 32 | Vss | Supply | Ground |



FUNCTIONAL DESCRIPTION

Each bit is uniquely addressed through the 21 address bits during READ or WRITE cycles. First, \overline{RAS} is used to latch 12 bits (A0-A11) then, \overline{CAS} latches 9 bits (A0-A8).

The \overline{CAS} control also determines whether the cycle will be a refresh cycle (\overline{RAS} -ONLY) or an active cycle (READ, WRITE or READ-WRITE) once \overline{RAS} goes LOW.

READ or WRITE cycles are selected by \overline{WE} . A logic HIGH on \overline{WE} dictates READ mode while a logic LOW on \overline{WE} dictates WRITE mode. During a WRITE cycle, data-in (D) is latched by the falling edge of \overline{WE} or \overline{CAS} , whichever occurs last. Taking \overline{WE} LOW will initiate a WRITE cycle, selecting DQ1 through DQ8. If \overline{WE} goes LOW prior to \overline{CAS} going LOW, the output pin(s) remain open (High-Z) until the next \overline{CAS} cycle. If \overline{WE} goes LOW after \overline{CAS} goes LOW and data reaches the output pins, data-out (Q) is activated and retains the selected cell data as long as \overline{CAS} and \overline{OE} remain LOW (regardless of \overline{WE} or \overline{RAS}). This late \overline{WE} pulse results in a READ-WRITE cycle.

The eight data inputs and eight data outputs are routed through eight pins using common I/O and pin direction is controlled by \overline{OE} and \overline{WE} .

FAST-PAGE-MODE operations allow faster data operations (READ, WRITE or READ-MODIFY-WRITE) within a row-address-defined (A0-12) page boundary. The FAST-PAGE-MODE cycle is always initiated with a row-address strobed-in by \overline{RAS} followed by a column-address strobed-in by \overline{CAS} . \overline{CAS} may be toggled-in by holding \overline{RAS} LOW and strobing-in different column-addresses, thus executing faster memory cycles. Returning \overline{RAS} HIGH terminates the FAST-PAGE-MODE operation.

Returning \overline{RAS} and \overline{CAS} HIGH terminates a memory cycle and decreases chip current to a reduced standby level. The chip is also preconditioned for the next cycle during the

\overline{RAS} HIGH time. Memory cell data is retained in its correct state by maintaining power and executing any \overline{RAS} cycle (READ, WRITE) or \overline{RAS} REFRESH cycle (\overline{RAS} -ONLY, CBR, or HIDDEN) so that all 4,096 combinations of \overline{RAS} addresses (A0-11) are executed at least every 64ms, regardless of sequence. The CBR REFRESH cycle will also invoke the refresh counter and controller for row-address control.

MASKED WRITE ACCESS CYCLE (MT4C2M8A2 ONLY)

Every WRITE access cycle can be a MASKED WRITE, depending on the state of \overline{WE} at \overline{RAS} time. A MASKED WRITE is selected when \overline{WE} is LOW at \overline{RAS} time and mask data is supplied on the DQ pins.

The mask data present on the DQ1-DQ8 inputs at \overline{RAS} time will be written to an internal mask data register and will then act as an individual write enable for each of the corresponding DQ inputs. If a LOW (logic "0") is written to a mask data register bit, the input port for that bit is disabled during the subsequent WRITE operation and no new data will be written to that DRAM cell location. A HIGH (logic "1") on a mask data register bit enables the input port and allows normal WRITE operations to proceed. At \overline{CAS} time, the bits present on the DQ1-DQ8 inputs will be written to the DRAM (if the mask data bit was HIGH) or ignored (if the mask data bit was LOW).

In NONPERSISTENT MASKED WRITES, new mask data must be supplied each time a MASKED WRITE cycle is initiated.

Figure 1 illustrates the MT4C2M8A2 MASKED WRITE operation (Note: \overline{RAS} or \overline{CAS} time refers to the time at which \overline{RAS} or \overline{CAS} transition from HIGH to LOW).

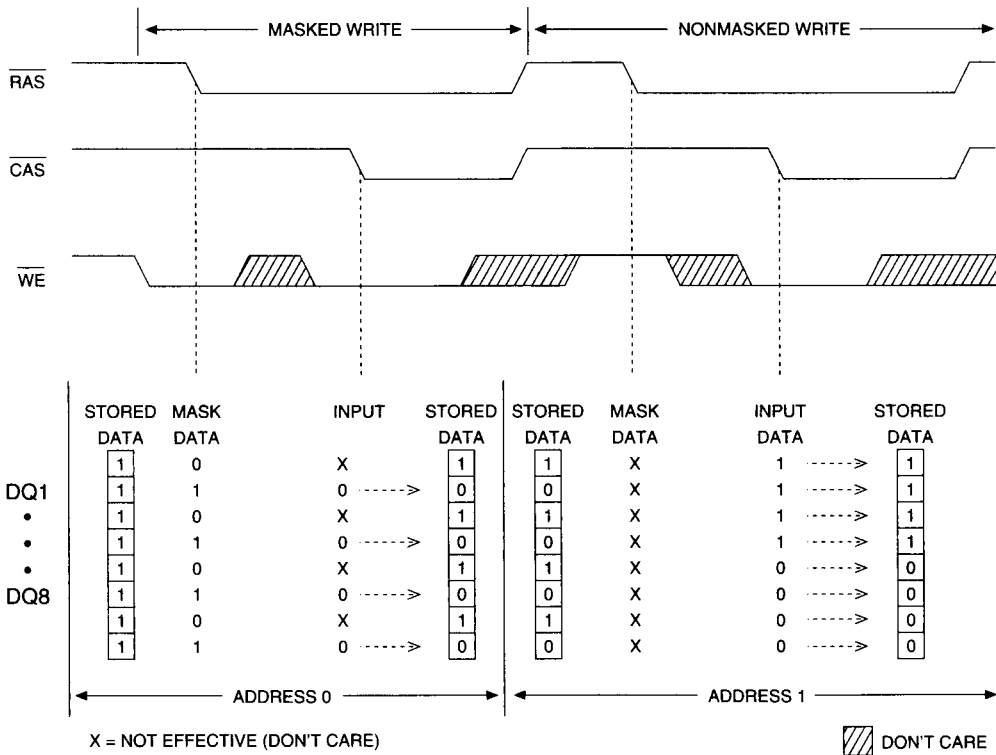


Figure 1
MT4C2M8A2 MASKED WRITE EXAMPLE



TRUTH TABLE

WIDE DRAM

| FUNCTION | | RAS | CAS | WE | OE | ADDRESSES | | DQs | NOTES |
|---------------------------|-----------|-------|-----|-----|-----|-----------|-----|-------------------|-------|
| | | | | | | 'R | 'C | | |
| Standby | | H | H→X | X | X | X | X | High-Z | |
| READ | | L | L | H | L | ROW | COL | Data-Out | |
| EARLY-WRITE | | L | L | L | X | ROW | COL | Data-In | 1 |
| READ-WRITE | | L | L | H→L | L→H | ROW | COL | Data-Out, Data-In | 1 |
| FAST-PAGE-MODE READ | 1st Cycle | L | H→L | H | L | ROW | COL | Data-Out | |
| | 2nd Cycle | L | H→L | H | L | n/a | COL | Data-Out | |
| FAST-PAGE-MODE WRITE | 1st Cycle | L | H→L | L | X | ROW | COL | Data-In | 1 |
| | 2nd Cycle | L | H→L | L | X | n/a | COL | Data-In | 1 |
| FAST-PAGE-MODE READ-WRITE | 1st Cycle | L | H→L | H→L | L→H | ROW | COL | Data-Out, Data-In | 1 |
| | 2nd Cycle | L | H→L | H→L | L→H | n/a | COL | Data-Out, Data-In | 1 |
| HIDDEN REFRESH | READ | L→H→L | L | H | L | ROW | COL | Data-Out | |
| | WRITE | L→H→L | L | L | X | ROW | COL | Data-In | 1, 2 |
| RAS-ONLY REFRESH | | L | H | X | X | ROW | n/a | High-Z | |
| CBR REFRESH | | H→L | L | H | X | X | X | High-Z | |

NOTE: 1. Data-in will be dependent on the mask provided (MT4C2M8A2 only). Refer to Figure 1.
2. EARLY WRITE only.

ABSOLUTE MAXIMUM RATINGS*

Voltage on V_{CC} supply relative to V_{SS} (5V) -1V to +7V
 Voltage on V_{CC} supply relative to V_{SS} (3V) -1V to +4.6V
 Operating Temperature, T_A (ambient) 0°C to +70°C
 Storage Temperature (plastic) -55°C to +150°C
 Power Dissipation 1W
 Short Circuit Output Current 50mA

*Stresses greater than 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 above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

DC OPERATING SPECIFICATIONS FOR 5V VERSION

(Notes: 1, 3, 4, 6, 7, 30) (0°C ≤ T_A ≤ 70°C; V_{CC} = 5V ±10%)

| PARAMETER/CONDITION | SYMBOL | MIN | MAX | UNITS | NOTES |
|---|-----------------|------|--------------------|-------|-------|
| Supply Voltage | V _{CC} | 4.5 | 5.5 | V | 1, 30 |
| Input High (Logic 1) Voltage, all inputs | V _{IH} | 2.4 | V _{CC} +1 | V | 1 |
| Input Low (Logic 0) Voltage, all inputs | V _{IL} | -1.0 | 0.8 | V | 1 |
| INPUT LEAKAGE CURRENT Any input 0V ≤ V _{IN} ≤ V _{CC} (All other pins not under test = 0V) | I _I | -2 | 2 | μA | |
| OUTPUT LEAKAGE CURRENT (Q is disabled; 0V ≤ V _{OUT} ≤ 5.5V) | I _{OZ} | -10 | 10 | μA | |
| OUTPUT LEVELS | | | | | |
| Output High Voltage (I _{OUT} = -2.5mA) | V _{OH} | 2.4 | | V | |
| Output Low Voltage (I _{OUT} = 2.1mA) | V _{OL} | | 0.4 | V | |

DC OPERATING SPECIFICATIONS FOR 3.0/3.3V VERSION

(Notes: 1, 3, 4, 6, 7, 31) (0°C ≤ T_A ≤ 70°C; V_{CC} = 2.7V to 3.6V)

| PARAMETER/CONDITION | SYMBOL | MIN | MAX | UNITS | NOTES |
|---|-----------------|------|--------------------|-------|-------|
| Supply Voltage | V _{CC} | 2.7 | 3.6 | V | 1, 31 |
| Input High (Logic 1) Voltage, all inputs | V _{IH} | 2.0 | V _{CC} +1 | V | 1 |
| Input Low (Logic 0) Voltage, all inputs | V _{IL} | -1.0 | 0.8 | V | 1 |
| INPUT LEAKAGE CURRENT Any input 0V ≤ V _{IN} ≤ V _{CC} (All other pins not under test = 0V) | I _I | -2 | 2 | μA | |
| OUTPUT LEAKAGE CURRENT (Q is disabled; 0V ≤ V _{OUT} ≤ 3.6V) | I _{OZ} | -10 | 10 | μA | |
| OUTPUT LEVELS | | | | | |
| Output High Voltage (I _{OUT} = -2mA) | V _{OH} | 2.4 | | V | |
| Output Low Voltage (I _{OUT} = 2mA) | V _{OL} | | 0.4 | V | |

DC OPERATING SPECIFICATIONS FOR 5V VERSION

 (Notes: 1, 3, 4, 6, 7, 30) ($0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$; $V_{CC} = 5V \pm 10\%$)

| PARAMETER/CONDITION | SYMBOL | MAX | | | UNITS | NOTES |
|--|--------|-----|-----|----|-------|----------|
| | | -6 | -7 | -8 | | |
| STANDBY CURRENT: TTL ($\overline{\text{RAS}} = \overline{\text{CAS}} = V_{IH}$) | Icc1 | 2 | 2 | 2 | mA | |
| STANDBY CURRENT: CMOS ($\overline{\text{RAS}} = \overline{\text{CAS}} = V_{CC} - 0.2V$) | Icc2 | 1 | 1 | 1 | mA | 25 |
| OPERATING CURRENT: Random READ/WRITE Average power supply current ($\overline{\text{RAS}}$, $\overline{\text{CAS}}$, Address Cycling: $t'RC = t'RC$ [MIN]) | Icc3 | 110 | 100 | 90 | mA | 3, 4, 32 |
| OPERATING CURRENT: FAST-PAGE-MODE Average power supply current ($\overline{\text{RAS}} = V_{IL}$, $\overline{\text{CAS}}$, Address Cycling: $t'PC = t'PC$ [MIN]; $t'CP$, $t'ASC = 10\text{ns}$) | Icc4 | 80 | 70 | 60 | mA | 3, 4, 32 |
| REFRESH CURRENT: $\overline{\text{RAS}}$ -ONLY Average power supply current ($\overline{\text{RAS}}$ Cycling, $\overline{\text{CAS}} = V_{IH}$; $t'RC = t'RC$ [MIN]) | Icc5 | 110 | 100 | 90 | mA | 3, 32 |
| REFRESH CURRENT: $\overline{\text{CAS}}$ -BEFORE- $\overline{\text{RAS}}$ Average power supply current ($\overline{\text{RAS}}$, $\overline{\text{CAS}}$, Address Cycling: $t'RC = t'RC$ [MIN]) | Icc6 | 110 | 100 | 90 | mA | 3 |

WIDE DRAM

DC OPERATING SPECIFICATIONS FOR 3.0/3.3V VERSION

 (Notes: 1, 3, 4, 6, 7, 31) ($0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$; $V_{CC} = 2.7V$ to $3.6V$)

| PARAMETER/CONDITION | SYMBOL | MAX | | | UNITS | NOTES |
|--|--------|-----|-----|----|---------------|----------|
| | | -6 | -7 | -8 | | |
| STANDBY CURRENT: TTL ($\overline{\text{RAS}} = \overline{\text{CAS}} = V_{IH}$) | Icc1 | 2 | 2 | 2 | mA | |
| STANDBY CURRENT: CMOS ($\overline{\text{RAS}} = \overline{\text{CAS}} = V_{CC} - 0.2V$) | Icc2 | 1 | 1 | 1 | μA | 25 |
| OPERATING CURRENT: Random READ/WRITE Average power supply current ($\overline{\text{RAS}}$, $\overline{\text{CAS}}$, Address Cycling: $t'RC = t'RC$ [MIN]) | Icc3 | 110 | 100 | 90 | mA | 3, 4, 32 |
| OPERATING CURRENT: FAST-PAGE-MODE Average power supply current ($\overline{\text{RAS}} = V_{IL}$, $\overline{\text{CAS}}$, Address Cycling: $t'PC = t'PC$ [MIN]; $t'CP$, $t'ASC = 10\text{ns}$) | Icc4 | 80 | 70 | 60 | mA | 3, 4, 32 |
| REFRESH CURRENT: $\overline{\text{RAS}}$ -ONLY Average power supply current ($\overline{\text{RAS}}$ Cycling, $\overline{\text{CAS}} = V_{IH}$; $t'RC = t'RC$ [MIN]) | Icc5 | 110 | 100 | 90 | mA | 3, 32 |
| REFRESH CURRENT: CBR Average power supply current ($\overline{\text{RAS}}$, $\overline{\text{CAS}}$, Address Cycling: $t'RC = t'RC$ [MIN]) | Icc6 | 110 | 100 | 90 | mA | 3 |

CAPACITANCE

| PARAMETER | SYMBOL | MAX | UNITS | NOTES |
|--|-----------------|-----|-------|-------|
| Input Capacitance: AO-A11 | C _{I1} | 5 | pF | 2 |
| Input Capacitance: $\overline{\text{RAS}}$, $\overline{\text{CAS}}$, $\overline{\text{WE}}$, $\overline{\text{OE}}$ | C _{I2} | 7 | pF | 2 |
| Input/Output Capacitance: DQ | C _{I0} | 7 | pF | 2 |

ELECTRICAL CHARACTERISTICS AND RECOMMENDED AC OPERATING CONDITIONS

(Notes: 6, 7, 8, 9, 10, 11, 12, 13) ($0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$)

| AC CHARACTERISTICS | | -6 | | -7 | | -8 | | | |
|--|-------------------|-----|---------|-----|---------|-----|---------|-------|------------|
| PARAMETER | SYM | MIN | MAX | MIN | MAX | MIN | MAX | UNITS | NOTES |
| Random READ or WRITE cycle time | ¹ RC | 110 | | 130 | | 150 | | ns | |
| READ-WRITE cycle time | ¹ RWC | 155 | | 180 | | 200 | | ns | |
| FAST-PAGE-MODE READ or WRITE cycle time | ¹ PC | 35 | | 40 | | 45 | | ns | |
| FAST-PAGE-MODE READ-WRITE cycle time | ¹ PRWC | 85 | | 95 | | 100 | | ns | |
| Access time from $\overline{\text{RAS}}$ | ¹ RAC | | 60 | | 70 | | 80 | ns | 14 |
| Access time from $\overline{\text{CAS}}$ | ¹ CAC | | 15 | | 20 | | 20 | ns | 15 |
| Output Enable | ¹ OE | | 15 | | 15 | | 15 | ns | |
| Access time from column-address | ¹ AA | | 30 | | 35 | | 40 | ns | |
| Access time from $\overline{\text{CAS}}$ precharge | ¹ CPA | | 35 | | 40 | | 45 | ns | |
| $\overline{\text{RAS}}$ pulse width | ¹ RAS | 60 | 100,000 | 70 | 100,000 | 80 | 100,000 | ns | |
| $\overline{\text{RAS}}$ pulse width (FAST-PAGE-MODE) | ¹ RASP | 60 | 100,000 | 70 | 100,000 | 80 | 100,000 | ns | |
| $\overline{\text{RAS}}$ hold time | ¹ RSH | 15 | | 20 | | 20 | | ns | |
| $\overline{\text{RAS}}$ precharge time | ¹ RP | 40 | | 50 | | 60 | | ns | |
| $\overline{\text{CAS}}$ pulse width | ¹ CAS | 15 | 100,000 | 20 | 100,000 | 20 | 100,000 | ns | |
| $\overline{\text{CAS}}$ hold time | ¹ CSH | 60 | | 70 | | 80 | | ns | |
| $\overline{\text{CAS}}$ precharge time | ¹ CPN | 10 | | 10 | | 10 | | ns | 16 |
| $\overline{\text{CAS}}$ precharge time (FAST-PAGE-MODE) | ¹ CP | 10 | | 10 | | 10 | | ns | |
| $\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ delay time | ¹ RCD | 15 | 45 | 20 | 50 | 20 | 60 | ns | 17 |
| $\overline{\text{CAS}}$ to $\overline{\text{RAS}}$ precharge time | ¹ CRP | 5 | | 5 | | 5 | | ns | |
| Row-address setup time | ¹ ASR | 0 | | 0 | | 0 | | ns | |
| Row-address hold time | ¹ RAH | 10 | | 10 | | 10 | | ns | |
| $\overline{\text{RAS}}$ to column-address delay time | ¹ RAD | 15 | 30 | 15 | 35 | 15 | 40 | ns | 18 |
| Column-address setup time | ¹ ASC | 0 | | 0 | | 0 | | ns | |
| Column-address hold time | ¹ CAH | 10 | | 15 | | 15 | | ns | |
| Column-address hold time (referenced to $\overline{\text{RAS}}$) | ¹ AR | 50 | | 55 | | 60 | | ns | |
| Column-address to $\overline{\text{RAS}}$ lead time | ¹ RAL | 30 | | 35 | | 40 | | ns | |
| Read command setup time | ¹ RCS | 0 | | 0 | | 0 | | ns | 26 |
| Read command hold time (referenced to $\overline{\text{CAS}}$) | ¹ RCH | 0 | | 0 | | 0 | | ns | 19, 26 |
| Read command hold time (referenced to $\overline{\text{RAS}}$) | ¹ RRH | 0 | | 0 | | 0 | | ns | 19 |
| $\overline{\text{CAS}}$ to output in Low-Z | ¹ CLZ | 3 | | 3 | | 3 | | ns | 33 |
| Output buffer turn-off delay | ¹ OFF | 3 | 15 | 3 | 20 | 3 | 20 | ns | 20, 29, 33 |

WIDE DRAM

ELECTRICAL CHARACTERISTICS AND RECOMMENDED AC OPERATING CONDITIONS

 (Notes: 6, 7, 8, 9, 10, 11, 12, 13) ($0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$)

| AC CHARACTERISTICS | | -6 | | -7 | | -8 | | | |
|--|------------------|-----|-----|-----|-----|-----|-----|-------|--------|
| PARAMETER | SYM | MIN | MAX | MIN | MAX | MIN | MAX | UNITS | NOTES |
| WE command setup time | ^t WCS | 0 | | 0 | | 0 | | ns | 21, 26 |
| Write command hold time | ^t WCH | 10 | | 15 | | 15 | | ns | 26 |
| Write command hold time (referenced to RAS) | ^t WCR | 45 | | 55 | | 60 | | ns | 26 |
| Write command pulse width | ^t WP | 10 | | 15 | | 15 | | ns | 26 |
| Write command to RAS lead time | ^t RWL | 15 | | 20 | | 20 | | ns | 26 |
| Write command to CAS lead time | ^t CWL | 15 | | 20 | | 20 | | ns | 26 |
| Data-in setup time | ^t DS | 0 | | 0 | | 0 | | ns | 22 |
| Data-in hold time | ^t DH | 10 | | 15 | | 15 | | ns | 22 |
| Data-in hold time (referenced to RAS) | ^t DHR | 45 | | 55 | | 60 | | ns | |
| RAS to WE delay time | ^t RWD | 85 | | 95 | | 105 | | ns | 21 |
| Column-address to WE delay time | ^t AWD | 55 | | 60 | | 65 | | ns | 21 |
| CAS to WE delay time | ^t CWD | 40 | | 45 | | 45 | | ns | 21 |
| Transition time (rise or fall) | ^t T | 3 | 50 | 3 | 50 | 3 | 50 | ns | 9, 10 |
| Refresh period (4,096 cycles) | ^t REF | | 64 | | 64 | | 64 | ms | |
| RAS to CAS precharge time | ^t RPC | 0 | | 0 | | 0 | | ns | |
| CAS setup time (CBR REFRESH) | ^t CSR | 5 | | 5 | | 5 | | ns | 5 |
| CAS hold time (CBR REFRESH) | ^t CHR | 15 | | 15 | | 15 | | ns | 5 |
| WE hold time (MASKED WRITE and CBR REFRESH) | ^t WRH | 15 | | 15 | | 15 | | ns | 26 |
| WE setup time (CBR REFRESH) | ^t WRP | 10 | | 10 | | 10 | | ns | 26 |
| WE setup time (MASKED WRITE) | ^t WRS | 10 | | 10 | | 10 | | ns | 26 |
| OE setup prior to RAS during HIDDEN REFRESH cycle | ^t ORD | 0 | | 0 | | 0 | | ns | |
| Output disable | ^t OD | 3 | 15 | 3 | 15 | 3 | 15 | ns | 29, 33 |
| OE hold time from WE during READ-MODIFY-WRITE cycle | ^t OEH | 15 | | 15 | | 15 | | ns | 28 |

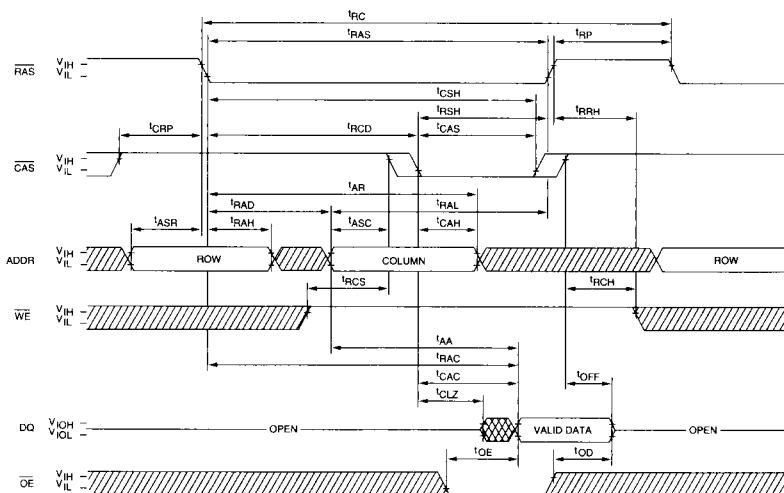
WIDE DRAM

NOTES

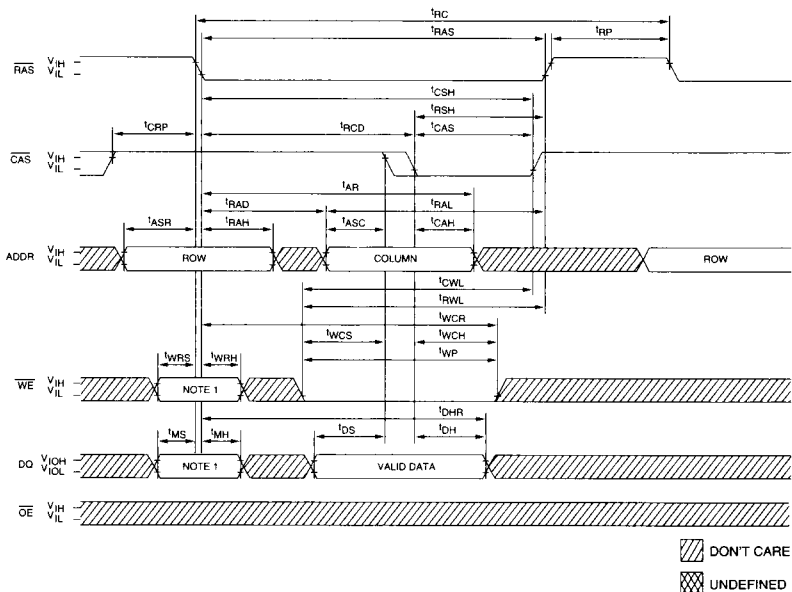
1. All voltages referenced to V_{SS} .
2. This parameter is sampled. $V_{CC} = 5V \pm 10\%$; $f = 1 \text{ MHz}$.
3. I_{CC} is dependent on cycle rates.
4. I_{CC} is dependent on output loading and cycle rates. Specified values are obtained with minimum cycle time and the outputs open.
5. Enables on-chip refresh and address counters.
6. The minimum specifications are used only to indicate cycle time at which proper operation over the full temperature range ($0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$) is assured.
7. An initial pause of $100\mu\text{s}$ is required after power-up followed by eight $\overline{\text{RAS}}$ refresh cycles ($\overline{\text{RAS}}$ -ONLY or CBR) before proper device operation is assured. The eight $\overline{\text{RAS}}$ cycle wake-ups should be repeated any time the ${}^t\text{REF}$ refresh requirement is exceeded.
8. AC characteristics assume ${}^tT = 5\text{ns}$.
9. V_{IH} (MIN) and V_{IL} (MAX) are reference levels for measuring timing of input signals. Transition times are measured between V_{IH} and V_{IL} (or between V_{IL} and V_{IH}).
10. In addition to meeting the transition rate specification, all input signals must transit between V_{IH} and V_{IL} (or between V_{IL} and V_{IH}) in a monotonic manner.
11. If $\overline{\text{CAS}} = V_{IH}$, data output is high impedance.
12. If $\overline{\text{CAS}} = V_{IL}$, data output may contain data from the last valid READ cycle.
13. Measured with a load equivalent to one TTL gate and 50pF .
14. Assumes that ${}^t\text{RCD} < {}^t\text{RCD (MAX)}$. If ${}^t\text{RCD}$ is greater than the maximum recommended value shown in this table, ${}^t\text{RAC}$ will increase by the amount that ${}^t\text{RCD}$ exceeds the value shown.
15. Assumes that ${}^t\text{RCD} \geq {}^t\text{RCD (MAX)}$.
16. If $\overline{\text{CAS}}$ is LOW at the falling edge of $\overline{\text{RAS}}$, Q will be maintained from the previous cycle. To initiate a new cycle and clear the Q buffer, $\overline{\text{CAS}}$ must be pulsed HIGH for ${}^t\text{CPN}$.
17. Operation within the ${}^t\text{RCD (MAX)}$ limit ensures that ${}^t\text{RAC (MAX)}$ can be met. ${}^t\text{RCD (MAX)}$ is specified as a reference point only; if ${}^t\text{RCD}$ is greater than the specified ${}^t\text{RCD (MAX)}$ limit, access time is controlled exclusively by ${}^t\text{CAC}$.
18. Operation within the ${}^t\text{RAD}$ limit ensures that ${}^t\text{RCD (MAX)}$ can be met. ${}^t\text{RAD (MAX)}$ is specified as a reference point only; if ${}^t\text{RAD}$ is greater than the specified ${}^t\text{RAD (MAX)}$ limit, access time is controlled exclusively by ${}^t\text{AA}$.
19. Either ${}^t\text{RCH}$ or ${}^t\text{RRH}$ must be satisfied for a READ cycle.
20. ${}^t\text{OFF (MAX)}$ defines the time at which the output achieves the open circuit condition; it is not a reference to V_{OH} or V_{OL} .
21. ${}^t\text{WCS}$, ${}^t\text{RWD}$, ${}^t\text{AWD}$ and ${}^t\text{CWD}$ are restrictive operating parameters in LATE-WRITE and READ-MODIFY-WRITE cycles only. If ${}^t\text{WCS} \geq {}^t\text{WCS (MIN)}$, the cycle is an EARLY-WRITE cycle and the data output will remain an open circuit throughout the entire cycle. If ${}^t\text{RWD} \geq {}^t\text{RWD (MIN)}$, ${}^t\text{AWD} \geq {}^t\text{AWD (MIN)}$ and ${}^t\text{CWD} \geq {}^t\text{CWD (MIN)}$, the cycle is a READ-WRITE and the data output will contain data read from the selected cell. If neither of the above conditions is met, the state of data-out is indeterminate. $\overline{\text{OE}}$ held HIGH and $\overline{\text{WE}}$ taken LOW after $\overline{\text{CAS}}$ goes LOW results in a LATE-WRITE ($\overline{\text{OE}}$ -controlled) cycle.
22. These parameters are referenced to $\overline{\text{CAS}}$ leading edge in EARLY-WRITE cycles and $\overline{\text{WE}}$ leading edge in LATE-WRITE or READ-MODIFY-WRITE cycles.
23. During a READ cycle, if $\overline{\text{OE}}$ is LOW then taken HIGH before $\overline{\text{CAS}}$ goes HIGH, Q goes open. If $\overline{\text{OE}}$ is tied permanently LOW, LATE-WRITE or READ-MODIFY-WRITE operations are not possible.
24. A HIDDEN REFRESH may also be performed after a WRITE cycle. In this case, $\overline{\text{WE}} = \text{LOW}$ and $\overline{\text{OE}} = \text{HIGH}$.
25. All other inputs at $V_{CC} - 0.2V$.
26. Write command is defined as $\overline{\text{WE}}$ going LOW.
27. MT4C2M8A2 only.
28. LATE-WRITE and READ-MODIFY-WRITE cycles must have both ${}^t\text{OD}$ and ${}^t\text{OE}$ met ($\overline{\text{OE}}$ HIGH during WRITE cycle) in order to ensure that the output buffers will be open during the WRITE cycle. If $\overline{\text{OE}}$ is taken back LOW while $\overline{\text{CAS}}$ remains LOW, the DQs will remain open.
29. The DQs open during READ cycles once ${}^t\text{OD}$ or ${}^t\text{OFF}$ occur. If $\overline{\text{CAS}}$ goes HIGH before $\overline{\text{OE}}$, the DQs will open regardless of the state of $\overline{\text{OE}}$. If $\overline{\text{CAS}}$ stays LOW while $\overline{\text{OE}}$ is brought HIGH, the DQs will open. If $\overline{\text{OE}}$ is brought back LOW ($\overline{\text{CAS}}$ still LOW), the DQs will provide the previously read data.
30. The 5V version is restricted to operate between 4.5 V and 5.5V only.
31. The 3.0/3.3V version is restricted to operate between 2.7V and 3.6V only. The -6 speed version is only valid for $V_{CC} = 3.09V$ to 3.6V whereas the -7 and -8 speed versions are valid for $V_{CC} = 2.7V$ to 3.6V.
32. Column-address changed once while $\overline{\text{RAS}} = V_{IL}$ and $\overline{\text{CAS}} = V_{IH}$.
33. The 3ns minimum is a parameter guaranteed by design.

WIDE DRAM

READ CYCLE

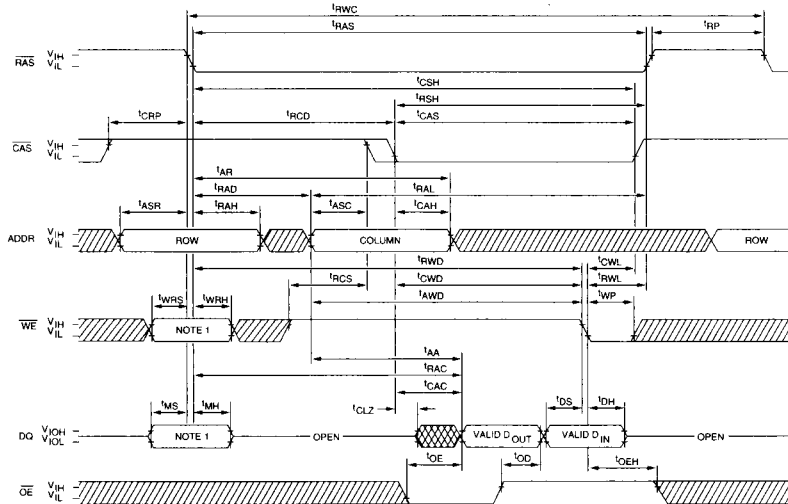


EARLY-WRITE CYCLE



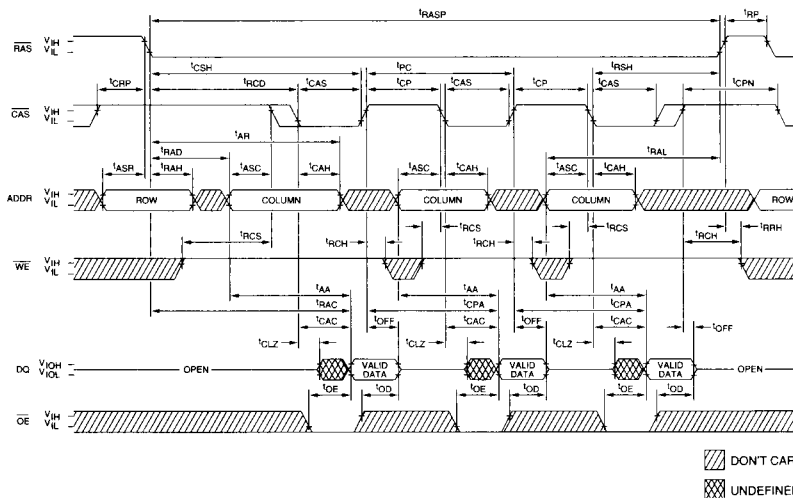
NOTE: 1. Applies to MT4C2M8A2 only; \overline{WE} and DQ inputs on MT4C2M8A1 are “don't care” at \overline{RAS} time. \overline{WE} selects between normal WRITE and MASKED WRITE at \overline{RAS} time. The DQ inputs are “don't care” for a normal WRITE (\overline{WE} HIGH at \overline{RAS} time). The DQ inputs provide the mask data at \overline{RAS} time for a MASKED WRITE, \overline{WE} LOW at \overline{RAS} time.

READ-WRITE CYCLE
(LATE-WRITE and READ-MODIFY-WRITE CYCLES)



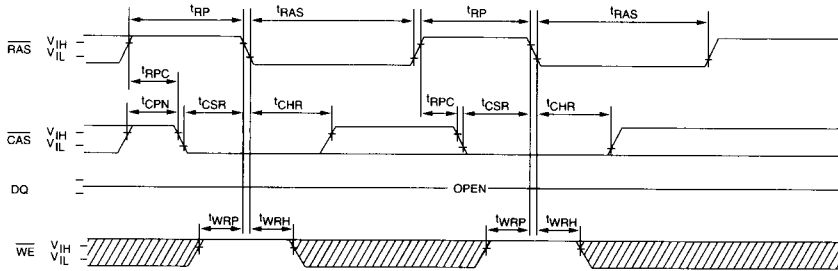
WIDE DRAM

FAST-PAGE-MODE READ CYCLE



NOTE: 1. Applies to MT4C2M8A2 only; \overline{WE} and DQ inputs on MT4C2M8A1 are "don't care" at \overline{RAS} time. \overline{WE} selects between normal WRITE and MASKED WRITE at \overline{RAS} time. The DQ inputs are "don't care" for a normal WRITE (\overline{WE} HIGH at \overline{RAS} time). The DQ inputs provide the mask data at \overline{RAS} time for a MASKED WRITE, \overline{WE} LOW at \overline{RAS} time.

CBR REFRESH CYCLE
 (A0-A11; OE = DON'T CARE)



HIDDEN REFRESH CYCLE²⁴
 (WE = HIGH; OE = LOW)

