



## Features

- 1,048,576 word by 16 bit organization
- Single 3.3V ± 0.3V or 5.0V ± 0.5V power supply
- Standard Power (SP) and Low Power (LP)
- 1024 Refresh Cycles
  - 16 ms Refresh Rate (SP version)
  - 128 ms Refresh Rate (LP version)
- High Performance:
 

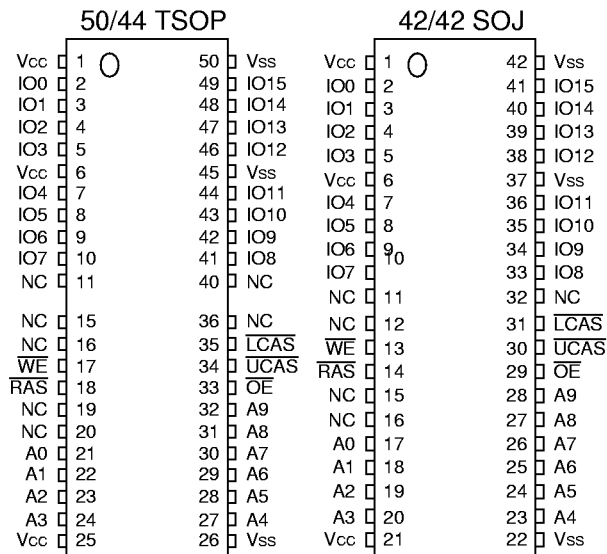
|                  |                            | -50  | -60   | -70   |
|------------------|----------------------------|------|-------|-------|
| t <sub>RAC</sub> | RAS Access Time            | 50ns | 60ns  | 70ns  |
| t <sub>CAC</sub> | CAS Access Time            | 13ns | 15ns  | 20ns  |
| t <sub>AA</sub>  | Column Address Access Time | 25ns | 30ns  | 35ns  |
| t <sub>RC</sub>  | Cycle Time                 | 95ns | 110ns | 130ns |
| t <sub>PC</sub>  | Fast Page Mode Cycle Time  | 35ns | 40ns  | 45ns  |
- Low Power Dissipation
  - Active (max) - 185 mA / 160 mA / 140 mA
  - Standby: TTL Inputs (max) - 2.0 mA
  - Standby: CMOS Inputs (max)
    - 1.0 mA (SP version)
    - 0.2 mA (LP version)
  - Self Refresh (LP version only)
    - 200µA (3.3 Volt)
    - 300µA (5.0 Volt)
- 2  $\overline{\text{CAS}}$
- Read-Modify-Write
- $\overline{\text{RAS}}$  Only and  $\overline{\text{CAS}}$  before  $\overline{\text{RAS}}$
- Hidden Refresh
- Package:
  - TSOP-II 50/44 (400milx825mil)
  - SOJ 42/42 (400mil)

## Description

The IBM0118160 is a dynamic RAM organized 1,048,576 words by 16 bits, which has a very low “sleep mode” power consumption option. These devices are fabricated in IBM’s advanced 0.5µm CMOS silicon gate process technology. The circuit and process have been carefully designed to pro-

vide high performance, low power dissipation, and high reliability. The devices operate with a single 3.3V ± 0.3V or 5.0V ± 0.5V power supply. The 20 addresses required to access any bit of data are multiplexed (10 are strobed with  $\overline{\text{RAS}}$ , 10 are strobed with  $\overline{\text{CAS}}$ ).

## Pin Assignments (Top View)



## Pin Description

|   |                           |
|---|---------------------------|
| $\overline{\text{RAS}}$                           | Row Address Strobe        |
| $\overline{\text{LCAS}} / \overline{\text{UCAS}}$ | L/U Column Address Strobe |
| $\overline{\text{WE}}$                            | Read/Write Input          |
| A0 - A9   | Address Inputs            |
| $\overline{\text{OE}}$                            | Output Enable             |
| I/O0 - I/O15                                      | Data Input/Output         |
| V <sub>CC</sub>                                   | Power (+3.3V or +5.0V)    |
| V <sub>SS</sub>                                   | Ground                    |

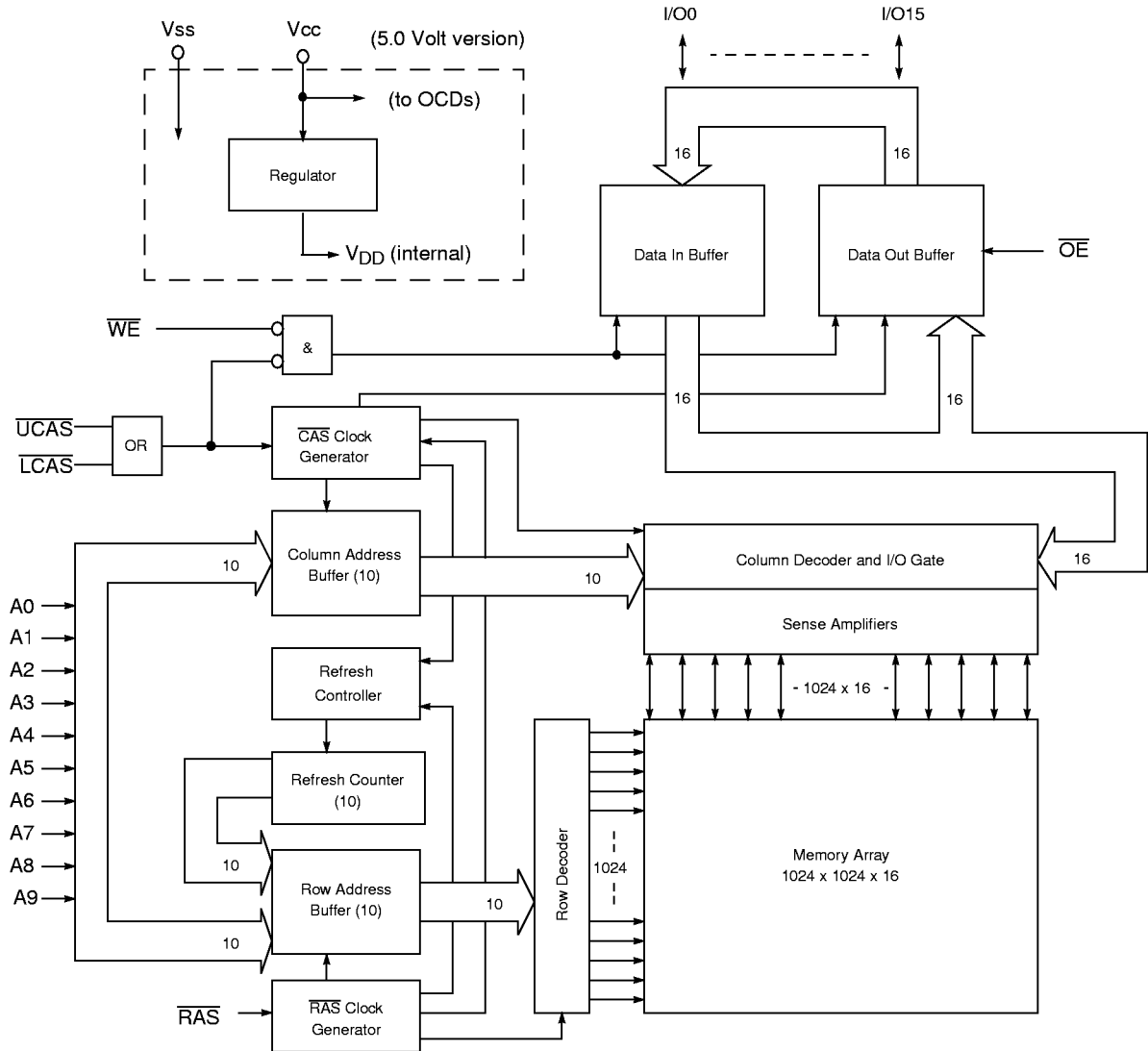


## Ordering Information

| Part Number       | SP / LP | Self Refresh | Power Supply | Speed | Package              | Notes |
|-------------------|---------|--------------|--------------|-------|----------------------|-------|
| IBM0118160T3 -50  | SP      | No           | 5.0V         | 50ns  | 400mil TSOP-II 50/44 | 1     |
| IBM0118160T3 -60  | SP      | No           | 5.0V         | 60ns  | 400mil TSOP-II 50/44 | 1     |
| IBM0118160T3 -70  | SP      | No           | 5.0V         | 70ns  | 400mil TSOP-II 50/44 | 1     |
| IBM0118160BT3 -50 | SP      | No           | 3.3V         | 50ns  | 400mil TSOP-II 50/44 | 1     |
| IBM0118160BT3 -60 | SP      | No           | 3.3V         | 60ns  | 400mil TSOP-II 50/44 | 1     |
| IBM0118160BT3 -70 | SP      | No           | 3.3V         | 70ns  | 400mil TSOP-II 50/44 | 1     |
| IBM0118160J3 -50  | SP      | No           | 5.0V         | 50ns  | 400mil SOJ 42/42     | 1     |
| IBM0118160J3 -60  | SP      | No           | 5.0V         | 60ns  | 400mil SOJ 42/42     | 1     |
| IBM0118160J3 -70  | SP      | No           | 5.0V         | 70ns  | 400mil SOJ 42/42     | 1     |
| IBM0118160BJ3 -50 | SP      | No           | 3.3V         | 50ns  | 400mil SOJ 42/42     | 1     |
| IBM0118160BJ3 -60 | SP      | No           | 3.3V         | 60ns  | 400mil SOJ 42/42     | 1     |
| IBM0118160BJ3 -70 | SP      | No           | 3.3V         | 70ns  | 400mil SOJ 42/42     | 1     |
| IBM0118160MT3 -50 | LP      | Yes          | 5.0V         | 50ns  | 400mil TSOP-II 50/44 | 1     |
| IBM0118160MT3 -60 | LP      | Yes          | 5.0V         | 60ns  | 400mil TSOP-II 50/44 | 1     |
| IBM0118160MT3 -70 | LP      | Yes          | 5.0V         | 70ns  | 400mil TSOP-II 50/44 | 1     |
| IBM0118160PT3 -50 | LP      | Yes          | 3.3V         | 50ns  | 400mil TSOP-II 50/44 | 1     |
| IBM0118160PT3 -60 | LP      | Yes          | 3.3V         | 60ns  | 400mil TSOP-II 50/44 | 1     |
| IBM0118160PT3 -70 | LP      | Yes          | 3.3V         | 70ns  | 400mil TSOP-II 50/44 | 1     |
| IBM0118160MJ3 -50 | LP      | Yes          | 5.0V         | 50ns  | 400mil SOJ 42/42     | 1     |
| IBM0118160MJ3 -60 | LP      | Yes          | 5.0V         | 60ns  | 400mil SOJ 42/42     | 1     |
| IBM0118160MJ3 -70 | LP      | Yes          | 5.0V         | 70ns  | 400mil SOJ 42/42     | 1     |
| IBM0118160PJ3 -50 | LP      | Yes          | 3.3V         | 50ns  | 400mil SOJ 42/42     | 1     |
| IBM0118160PJ3 -60 | LP      | Yes          | 3.3V         | 60ns  | 400mil SOJ 42/42     | 1     |
| IBM0118160PJ3 -70 | LP      | Yes          | 3.3V         | 70ns  | 400mil SOJ 42/42     | 1     |

1. SP = Standard Power version (IBM0118160 and IBM0118160B); LP = Low Power version (IBM0118160M and IBM00118160P)

## Block Diagram





## Truth Table

| Function   |           | $\overline{\text{RAS}}$ | $\overline{\text{LCAS}}$ | $\overline{\text{UCAS}}$ | $\overline{\text{WE}}$ | $\overline{\text{OE}}$ | Row Address | Column Address | I/O0 - I/O15                               |
|--|-----------|-------------------------|--------------------------|--------------------------|------------------------|------------------------|-------------|----------------|--|
| Standby  |           | H                       | H→X                      | H→X                      | X                      | X                      | X           | X              | High Impedance                             |
| Read: Word   |           | L                       | L                        | L                        | H                      | L                      | Row         | Col            | Data Out                                   |
| Read: Lower Byte   |           | L                       | L                        | H                        | H                      | L                      | Row         | Col            | Lower Byte: Data Out<br>Upper Byte: High-Z |
| Read: Upper Byte   |           | L                       | H                        | L                        | H                      | L                      | Row         | Col            | Lower Byte: High-Z<br>Upper Byte: Data Out |
| Write: Word<br>Early-Write                                       |           | L                       | L                        | L                        | L                      | X                      | Row         | Col            | Data In                                    |
| Write: Lower Byte<br>Early-Write                                 |           | L                       | L                        | H                        | L                      | X                      | Row         | Col            | Lower Byte: Data In<br>Upper Byte: High-Z  |
| Write: Upper Byte<br>Early-Write                                 |           | L                       | H                        | L                        | L                      | X                      | Row         | Col            | Lower Byte: High-Z<br>Upper Byte: Data In  |
| Read-Modify-Write  |           | L                       | L                        | L                        | H→L                    | L→H                    | Row         | Col            | Data Out, Data In                          |
| Fast Page Mode<br>Read   | 1st Cycle | L                       | H→L                      | H→L                      | H                      | L                      | Row         | Col            | Data Out                                   |
|  | 2nd Cycle | L                       | H→L                      | H→L                      | H                      | L                      | N/A         | Col            | Data Out                                   |
| Fast Page Mode<br>Write  | 1st Cycle | L                       | H→L                      | H→L                      | L                      | X                      | Row         | Col            | Data In                                    |
|  | 2nd Cycle | L                       | H→L                      | H→L                      | L                      | X                      | N/A         | Col            | Data In                                    |
| Fast Page Mode<br>Read-Modify-Write                              | 1st Cycle | L                       | H→L                      | H→L                      | H→L                    | L→H                    | Row         | Col            | Data Out, Data In                          |
|  | 2nd Cycle | L                       | H→L                      | H→L                      | H→L                    | L→H                    | N/A         | Col            | Data Out, Data In                          |
| $\overline{\text{RAS}}$ -Only Refresh                            |           | L                       | H                        | H                        | X                      | X                      | Row         | N/A            | High Impedance                             |
| $\overline{\text{CAS}}$ -Before- $\overline{\text{RAS}}$ Refresh |           | H→L                     | L                        | L                        | H                      | X                      | X           | N/A            | High Impedance                             |
| Hidden Refresh   | Read      | L→H→L                   | L                        | L                        | H                      | L                      | Row         | Col            | Data Out                                   |
|  | Write     | L→H→L                   | L                        | L                        | H                      | X                      | Row         | Col            | Data In                                    |
| Self Refresh (LP version only)                                   |           | H→L                     | L                        | L                        | H                      | X                      | X           | X              | High Impedance                             |



## Absolute Maximum Ratings

| Symbol           | Parameter                    | Rating                                  |   | Units | Notes |
|------------------|------------------------------|---|---|-------|-------|
|                  |                              | 3.3 Volt Device                         | 5.0 Volt Device                         |       |       |
| V <sub>CC</sub>  | Power Supply Voltage         | -0.5 to +4.6                            | -1.0 to +7.0                            | V     | 1     |
| V <sub>IN</sub>  | Input Voltage                | -0.5 to min (V <sub>CC</sub> +0.5, 4.6) | -0.5 to min (V <sub>CC</sub> +0.5, 7.0) | V     | 1     |
| V <sub>OUT</sub> | Output Voltage               | -0.5 to min (V <sub>CC</sub> +0.5, 4.6) | -0.5 to min (V <sub>CC</sub> +0.5, 7.0) | V     | 1     |
| T <sub>OPR</sub> | Operating Temperature        | 0 to +70                                | 0 to +70                                | °C    | 1     |
| T <sub>STG</sub> | Storage Temperature          | -55 to +150                             | -55 to +150                             | °C    | 1     |
| P <sub>D</sub>   | Power Dissipation            | 1.0                                     | 1.0                                     | W     | 1     |
| I <sub>OUT</sub> | Short Circuit Output Current | 50                                      | 50                                      | mA    | 1     |

1. 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.

## Recommended DC Operating Conditions (T<sub>A</sub> = 0 to 70°C)

| Symbol          | Parameter          | 3.3 Volt Device |      |                       | 5.0 Volt Device |      |                       | Units | Notes |
|-----------------|--------------------|-----------------|------|-----------------------|-----------------|------|-----------------------|-------|-------|
|                 |                    | Min.            | Typ. | Max.                  | Min.            | Typ. | Max.                  |       |       |
| V <sub>CC</sub> | Supply Voltage     | 3.0             | 3.3  | 3.6                   | 4.5             | 5.0  | 5.5                   | V     | 1     |
| V <sub>IH</sub> | Input High Voltage | 2.0             | —    | V <sub>CC</sub> + 0.5 | 2.4             | —    | V <sub>CC</sub> + 0.5 | V     | 1, 2  |
| V <sub>IL</sub> | Input Low Voltage  | -0.5            | —    | 0.8                   | -0.5            | —    | 0.8                   | V     | 1, 2  |

1. All voltages referenced to V<sub>SS</sub>.  
 2. V<sub>IH</sub> may overshoot to V<sub>CC</sub> + 1.2V for pulse widths of ≤ 4.0ns with 3.3 Volt, or V<sub>CC</sub> + 2.0V for pulse widths of ≤ 4.0ns (or V<sub>CC</sub> + 1.0V for ≤ 8.0ns) with 5.0 Volt. Additionally, V<sub>IL</sub> may undershoot to -2.0V for pulse widths ≤ 4.0ns with 3.3 Volt, or to -2.0V for pulse widths ≤ 4.0ns (or -1.0V for ≤ 8.0ns) with 5.0 Volt. Pulse widths measured at 50% points with amplitude measured peak to DC reference.

## Capacitance (T<sub>A</sub> = 25°C, V<sub>CC</sub> = 3.3V ± 0.3V or V<sub>CC</sub> = 5.0V ± 0.5V)

| Symbol          | Parameter   | Min. | Max. | Units | Notes |
|-----------------|---|------|------|-------|-------|
| C <sub>I1</sub> | Input Capacitance (A0 - A9)   | —    | 5    | pF    | 1     |
| C <sub>I2</sub> | Input Capacitance ( $\overline{\text{RAS}}$ , $\overline{\text{LCAS}}$ , $\overline{\text{UCAS}}$ , $\overline{\text{WE}}$ , $\overline{\text{OE}}$ ) | —    | 7    | pF    | 1     |
| C <sub>O</sub>  | Output Capacitance (I/O0 - I/O15)   | —    | 7    | pF    | 1     |

1. Input capacitance measurements made with rise time shift method with  $\overline{\text{CAS}} = V_{IH}$  to disable output.



**DC Electrical Characteristics** ( $T_A = 0$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 3.3\text{V} \pm 0.3\text{V}$  or  $V_{CC} = 5.0\text{V} \pm 0.5\text{V}$ )

| Symbol   | Parameter   | Min.       | Max.            | Units         | Notes         |         |
|--|---|------------|-----------------|---------------|---------------|---------|
| I <sub>CC1</sub>   | Operating Current<br>Average Power Supply Operating Current<br>( $\overline{\text{RAS}}$ , $\overline{\text{CAS}}$ , Address Cycling: $t_{\text{RC}} = t_{\text{RC min.}}$ )  | -50        | —               | 185           | mA            | 1, 2, 3 |
|  |   | -60        | —               | 165           |               |         |
|  |   | -70        | —               | 140           |               |         |
| I <sub>CC2</sub>   | Standby Current (TTL)<br>Power Supply Standby Current<br>( $\overline{\text{RAS}} = \overline{\text{CAS}} = V_{\text{IH}}$ )  | —          | 1               | mA            |               |         |
| I <sub>CC3</sub>   | $\overline{\text{RAS}}$ Only Refresh Current<br>Average Power Supply Current, $\overline{\text{RAS}}$ Only Mode<br>(RAS Cycling, $\overline{\text{CAS}} = V_{\text{IH}}$ ; $t_{\text{RC}} = t_{\text{RC min.}}$ )   | -50        | —               | 185           | mA            | 1, 3    |
|  |   | -60        | —               | 165           |               |         |
|  |   | -70        | —               | 140           |               |         |
| I <sub>CC4</sub>   | Fast Page Mode Current<br>Average Power Supply Current<br>( $\overline{\text{RAS}} = V_{\text{IL}}$ , $\overline{\text{CAS}}$ , Address Cycling: $t_{\text{PC}} = t_{\text{PC min.}}$ )   | -50        | —               | 100           | mA            | 1, 2, 3 |
|  |   | -60        | —               | 90            |               |         |
|  |   | -70        | —               | 80            |               |         |
| I <sub>CC5</sub>   | Standby Current (CMOS)<br>Power Supply Standby Current<br>( $\overline{\text{RAS}} = \overline{\text{CAS}} = V_{\text{CC}} - 0.2\text{V}$ )   | SP version | —               | 1             | mA            |         |
|  |   | LP version | —               | 0.2           |               |         |
| I <sub>CC6</sub>   | $\overline{\text{CAS}}$ Before $\overline{\text{RAS}}$ Refresh Current<br>Average Power Supply Current, $\overline{\text{CAS}}$ Before $\overline{\text{RAS}}$ Mode<br>(RAS, $\overline{\text{CAS}}$ , Cycling: $t_{\text{RC}} = t_{\text{RC min.}}$ )  | -50        | —               | 185           | mA            | 1, 3    |
|  |   | -60        | —               | 165           |               |         |
|  |   | -70        | —               | 140           |               |         |
| I <sub>CC7</sub>   | Self Refresh Current, LP version only<br>Average Power Supply Current during Self Refresh<br>CBR cycle with $\overline{\text{RAS}} \geq t_{\text{RASS (min)}}$ ; $\overline{\text{CAS}}$ held low;<br>$\overline{\text{WE}} = V_{\text{CC}} - 0.2\text{V}$ ; Addresses and $D_{\text{IN}} = V_{\text{CC}} - 0.2\text{V}$ or $0.2\text{V}$ . | 3.3V       | —               | 200           | $\mu\text{A}$ |         |
|  |   | 5.0V       | —               | 300           |               |         |
| I <sub>I(L)</sub>  | Input Leakage Current<br>Input Leakage Current, any input<br>( $0.0 \leq V_{\text{IN}} \leq (V_{\text{CC}} + 0.3\text{V})$ ), All Other Pins Not Under Test = 0V  | -5         | +5              | $\mu\text{A}$ |               |         |
| I <sub>O(L)</sub>  | Output Leakage Current<br>( $D_{\text{OUT}}$ is disabled, $0.0 \leq V_{\text{OUT}} \leq V_{\text{CC}}$ )  | -5         | +5              | $\mu\text{A}$ |               |         |
| V <sub>OH</sub>  | Output Level (TTL)<br>Output "H" Level Voltage<br>( $I_{\text{OUT}} = -2.0\text{mA}$ for 3.3V, or $I_{\text{OUT}} = -5\text{mA}$ for 5.0V)  | 2.4        | V <sub>CC</sub> | V             |               |         |
| V <sub>OL</sub>  | Output Level (TTL)<br>Output "L" Level Voltage<br>( $I_{\text{OUT}} = +2.0\text{mA}$ for 3.3V, or $I_{\text{OUT}} = +4.2\text{mA}$ for 5.0V)  | 0.0        | 0.4             | V             |               |         |
| 1. I <sub>CC1</sub> , I <sub>CC3</sub> , I <sub>CC4</sub> and I <sub>CC6</sub> depend on cycle rate.<br>2. I <sub>CC1</sub> and I <sub>CC4</sub> depend on output loading. Specified values are obtained with the output open.<br>3. Address can be changed once or less while $\overline{\text{RAS}} = V_{\text{IL}}$ . In the case of I <sub>CC4</sub> , it can be changed once or less when $\overline{\text{CAS}} = V_{\text{IH}}$ . |   |            |                 |               |               |         |



## AC Characteristics ( $T_A = 0$ to $+70^\circ\text{C}$ , $V_{CC} = 3.3\text{V} \pm 0.3\text{V}$ or $V_{CC} = 5.0\text{V} \pm 0.5\text{V}$ )

1. An initial pause of 200 $\mu\text{s}$  is required after power-up followed by 8  $\overline{\text{RAS}}$  only refresh cycles before proper device operation is achieved. In case of using the internal refresh counter, a minimum of 8  $\overline{\text{CAS}}$  before  $\overline{\text{RAS}}$  refresh cycles instead of 8  $\overline{\text{RAS}}$  only refresh cycles is required.
2. AC measurements assume  $t_T = 5\text{ns}$ .
3.  $V_{IH}(\text{min.})$  and  $V_{IL}(\text{max.})$  are reference levels for measuring timing of input signals. Also, transition times are measured between  $V_{IH}$  and  $V_{IL}$ .
4. When both  $\overline{\text{LCAS}}$  and  $\overline{\text{UCAS}}$  go low at the same time, all 16 bits of data are read/written into the device.  $\overline{\text{LCAS}}$  and  $\overline{\text{UCAS}}$  cannot be staggered within the same read/write cycle.

## Read, Write, Read-Modify-Write and Refresh Cycles (Common Parameters)

| Symbol    | Parameter   | -50  |      | -60  |      | -70  |      | Units | Notes |
|-----------|---|------|------|------|------|------|------|-------|-------|
|           |   | Min. | Max. | Min. | Max. | Min. | Max. |       |       |
| $t_{RC}$  | Random Read or Write Cycle Time                                   | 95   | —    | 110  | —    | 130  | —    | ns    |       |
| $t_{RP}$  | $\overline{\text{RAS}}$ Precharge Time                            | 30   | —    | 40   | —    | 50   | —    | ns    |       |
| $t_{CP}$  | $\overline{\text{CAS}}$ Precharge Time                            | 10   | —    | 10   | —    | 10   | —    | ns    |       |
| $t_{RAS}$ | $\overline{\text{RAS}}$ Pulse Width                               | 50   | 10K  | 60   | 10K  | 70   | 10K  | ns    |       |
| $t_{CAS}$ | $\overline{\text{CAS}}$ Pulse Width                               | 13   | 10K  | 15   | 10K  | 20   | 10K  | ns    |       |
| $t_{ASR}$ | Row Address Setup Time  | 0    | —    | 0    | —    | 0    | —    | ns    |       |
| $t_{RAH}$ | Row Address Hold Time   | 10   | —    | 10   | —    | 10   | —    | ns    |       |
| $t_{ASC}$ | Column Address Setup Time   | 0    | —    | 0    | —    | 0    | —    | ns    |       |
| $t_{CAH}$ | Column Address Hold Time  | 10   | —    | 10   | —    | 10   | —    | ns    |       |
| $t_{RCD}$ | $\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ Delay Time     | 20   | 37   | 20   | 45   | 20   | 50   | ns    | 1     |
| $t_{RAD}$ | $\overline{\text{RAS}}$ to Column Address Delay Time              | 15   | 25   | 15   | 30   | 15   | 35   | ns    | 2     |
| $t_{RSH}$ | $\overline{\text{RAS}}$ Hold Time                                 | 13   | —    | 15   | —    | 20   | —    | ns    |       |
| $t_{CSH}$ | $\overline{\text{CAS}}$ Hold Time                                 | 50   | —    | 60   | —    | 70   | —    | ns    |       |
| $t_{CRP}$ | $\overline{\text{CAS}}$ to $\overline{\text{RAS}}$ Precharge Time | 5    | —    | 5    | —    | 5    | —    | ns    |       |
| $t_{OED}$ | $\overline{\text{OE}}$ to $D_{IN}$ Delay Time                     | 13   | —    | 15   | —    | 15   | —    | ns    | 3     |
| $t_{DZO}$ | $\overline{\text{OE}}$ Delay Time from $D_{IN}$                   | 0    | —    | 0    | —    | 0    | —    | ns    | 4     |
| $t_{DZC}$ | $\overline{\text{CAS}}$ Delay Time from $D_{IN}$                  | 0    | —    | 0    | —    | 0    | —    | ns    | 4     |
| $t_T$     | Transition Time (Rise and Fall)                                   | 3    | 50   | 3    | 50   | 3    | 50   | ns    | 5     |

1. Operation within the  $t_{RCD}(\text{max.})$  limit ensures that  $t_{RAC}(\text{max.})$  can be met.  $t_{RCD}(\text{max.})$  is specified as a reference point only. If  $t_{RCD}$  is greater than the specified  $t_{RCD}(\text{max.})$  limit, then access time is controlled by  $t_{CAC}$ .
2. Operation within the  $t_{RAD}(\text{max.})$  limit ensures that  $t_{RAC}(\text{max.})$  can be met.  $t_{RAD}(\text{max.})$  is specified as a reference point only. If  $t_{RAD}$  is greater than the specified  $t_{RAD}(\text{max.})$  limit, then access time is controlled by  $t_{AA}$ .
3. Either  $t_{CDD}$  or  $t_{OED}$  must be satisfied.
4. Either  $t_{DZC}$  or  $t_{DZO}$  must be satisfied.
5. AC measurements assume  $t_T = 5\text{ns}$ .



## Write Cycle

| Symbol    | Parameter                                   | -50  |      | -60  |      | -70  |      | Units | Notes |
|-----------|---|------|------|------|------|------|------|-------|-------|
|           |   | Min. | Max. | Min. | Max. | Min. | Max. |       |       |
| $t_{WCS}$ | Write Command Set Up Time                   | 0    | —    | 0    | —    | 0    | —    | ns    | 1     |
| $t_{WCH}$ | Write Command Hold Time                     | 10   | —    | 15   | —    | 15   | —    | ns    |       |
| $t_{WP}$  | Write Command Pulse Width                   | 10   | —    | 15   | —    | 15   | —    | ns    |       |
| $t_{RWL}$ | Write Command to $\overline{RAS}$ Lead Time | 13   | —    | 15   | —    | 20   | —    | ns    |       |
| $t_{CWL}$ | Write Command to $\overline{CAS}$ Lead Time | 13   | —    | 15   | —    | 20   | —    | ns    |       |
| $t_{DS}$  | $D_{IN}$ Setup Time                         | 0    | —    | 0    | —    | 0    | —    | ns    | 2     |
| $t_{DH}$  | $D_{IN}$ Hold Time                          | 10   | —    | 12   | —    | 15   | —    | ns    | 2     |

1.  $t_{WCS}$ ,  $t_{RWD}$ ,  $t_{CWD}$ ,  $t_{AWD}$  and  $t_{CPW}$  are not restrictive operating parameters. They are included in the data sheet as electrical characteristics only. If  $t_{WCS} \geq t_{WCS}(\text{min})$ , the cycle is an early write cycle and the data pin will remain open circuit (high impedance) through the entire cycle. If  $t_{RWD} \geq t_{RWD}(\text{min})$ ,  $t_{CWD} \geq t_{CWD}(\text{min})$ ,  $t_{AWD} \geq t_{AWD}(\text{min})$ , and  $t_{CPW} \geq t_{CPW}(\text{min})$  (Fast Page Mode), the cycle is a Read-Modify-Write cycle and the data out will contain data read from the selected cell. If neither of the above sets of conditions are satisfied, the condition of the data out (at access time) is indeterminate.
2. These parameters are referenced to  $\overline{LCAS}$  or  $\overline{UCAS}$  leading edge in early write cycles and to  $\overline{WE}$  leading edge in Read-Modify-Write cycles.





## Read Cycle

| Symbol    | Parameter   | -50  |      | -60  |      | -70  |      | Units | Notes   |
|-----------|---|------|------|------|------|------|------|-------|---------|
|           |   | Min. | Max. | Min. | Max. | Min. | Max. |       |         |
| $t_{RAC}$ | Access Time from $\overline{RAS}$                 | —    | 50   | —    | 60   | —    | 70   | ns    | 1, 2, 3 |
| $t_{CAC}$ | Access Time from $\overline{CAS}$                 | —    | 13   | —    | 15   | —    | 20   | ns    | 1, 3    |
| $t_{AA}$  | Access Time from Address                          | —    | 25   | —    | 30   | —    | 35   | ns    | 2, 3    |
| $t_{OEA}$ | Access Time from $\overline{OE}$                  | —    | 13   | —    | 15   | —    | 20   | ns    | 3       |
| $t_{RCS}$ | Read Command Setup Time                           | 0    | —    | 0    | —    | 0    | —    | ns    |         |
| $t_{RCH}$ | Read Command Hold Time to $\overline{CAS}$        | 0    | —    | 0    | —    | 0    | —    | ns    | 4       |
| $t_{RRH}$ | Read Command Hold Time to $\overline{RAS}$        | 0    | —    | 0    | —    | 0    | —    | ns    | 4       |
| $t_{RAL}$ | Column Address to $\overline{RAS}$ Lead Time      | 25   | —    | 30   | —    | 35   | —    | ns    |         |
| $t_{CAL}$ | Column Address to $\overline{CAS}$ Lead Time      | 25   | —    | 30   | —    | 35   | —    | ns    |         |
| $t_{CLZ}$ | $\overline{CAS}$ to Output in Low-Z               | 0    | —    | 0    | —    | 0    | —    | ns    | 3       |
| $t_{OH}$  | Output Data Hold Time                             | 3    | —    | 3    | —    | 3    | —    | ns    |         |
| $t_{OHO}$ | Output Data Hold from $\overline{OE}$             | 3    | —    | 3    | —    | 3    | —    | ns    |         |
| $t_{OFF}$ | Output Buffer Turn-Off Delay                      | —    | 13   | —    | 15   | —    | 15   | ns    | 5       |
| $t_{OEZ}$ | Output Buffer Turn-Off Delay from $\overline{OE}$ | —    | 13   | —    | 15   | —    | 15   | ns    | 5       |
| $t_{CDD}$ | $\overline{CAS}$ to $D_{IN}$ Delay Time           | 13   | —    | 15   | —    | 15   | —    | ns    | 6       |

1. Operation within the  $t_{RCD}(\text{max.})$  limit ensures that  $t_{RAC}(\text{max.})$  can be met.  $t_{RCD}(\text{max.})$  is specified as a reference point only. If  $t_{RCD}$  is greater than the specified  $t_{RCD}(\text{max.})$  limit, then access time is controlled by  $t_{CAC}$ .
2. Operation within the  $t_{RAD}(\text{max.})$  limit ensures that  $t_{RAC}(\text{max.})$  can be met.  $t_{RAD}(\text{max.})$  is specified as a reference point only. If  $t_{RAD}$  is greater than the specified  $t_{RAD}(\text{max.})$  limit, then access time is controlled by  $t_{AA}$ .
3. Measured with the specified current load and 100pF.
4. Either  $t_{RCH}$  or  $t_{RRH}$  must be satisfied for a read cycle.
5.  $t_{OFF}(\text{max})$  and  $t_{OEZ}(\text{max})$  define the time at which the output achieves the open circuit condition and are not referenced to output voltage levels.
6. Either  $t_{CDD}$  or  $t_{OED}$  must be satisfied.



## Read-Modify-Write Cycle

| Symbol    | Parameter                                      | -50  |      | -60  |      | -70  |      | Units | Notes |
|-----------|--|------|------|------|------|------|------|-------|-------|
|           |  | Min. | Max. | Min. | Max. | Min. | Max. |       |       |
| $t_{RWC}$ | Read-Modify-Write Cycle Time                   | 128  | —    | 150  | —    | 180  | —    | ns    |       |
| $t_{RWD}$ | $\overline{RAS}$ to $\overline{WE}$ Delay Time | 68   | —    | 80   | —    | 95   | —    | ns    | 1     |
| $t_{CWD}$ | $\overline{CAS}$ to $\overline{WE}$ Delay Time | 31   | —    | 35   | —    | 45   | —    | ns    | 1     |
| $t_{AWD}$ | Column Address to $\overline{WE}$ Delay Time   | 43   | —    | 50   | —    | 60   | —    | ns    | 1     |
| $t_{OEH}$ | $\overline{OE}$ Command Hold Time              | 13   | —    | 15   | —    | 15   | —    | ns    |       |

1.  $t_{WCS}$ ,  $t_{RWD}$ ,  $t_{CWD}$ ,  $t_{AWD}$  and  $t_{CPW}$  are not restrictive operating parameters. They are included in the data sheet as electrical characteristics only. If  $t_{WCS} \geq t_{WCS}(\text{min})$ , the cycle is an early write cycle and the data pin will remain open circuit (high impedance) through the entire cycle. If  $t_{RWD} \geq t_{RWD}(\text{min})$ ,  $t_{CWD} \geq t_{CWD}(\text{min})$ ,  $t_{AWD} \geq t_{AWD}(\text{min})$ , and  $t_{CPW} \geq t_{CPW}(\text{min})$ (Fast Page Mode), the cycle is a Read-Modify-Write cycle and the data out will contain data read from the selected cell. If neither of the above sets of conditions are satisfied, the condition of the data out (at access time) is indeterminate.

## Fast Page Mode Cycle

| Symbol     | Parameter  | -50  |      | -60  |      | -70  |      | Units | Notes |
|------------|--|------|------|------|------|------|------|-------|-------|
|            |  | Min. | Max. | Min. | Max. | Min. | Max. |       |       |
| $t_{PC}$   | Fast Page Mode Cycle Time                                  | 35   | —    | 40   | —    | 45   | —    | ns    |       |
| $t_{RASP}$ | Fast Page Mode $\overline{RAS}$ Pulse Width                | 50   | 200K | 60   | 200K | 70   | 200K | ns    |       |
| $t_{CPA}$  | Access Time from $\overline{CAS}$ Precharge                | —    | 28   | —    | 35   | —    | 40   | ns    | 1     |
| $t_{CPRH}$ | $\overline{RAS}$ Hold Time from $\overline{CAS}$ Precharge | 30   | —    | 35   | —    | 40   | —    | ns    |       |

1. Measured with the specified current load and 100pF.

## Fast Page Mode Read-Modify-Write Cycle

| Symbol     | Parameter  | -50  |      | -60  |      | -70  |      | Units | Notes |
|------------|--|------|------|------|------|------|------|-------|-------|
|            |  | Min. | Max. | Min. | Max. | Min. | Max. |       |       |
| $t_{PRWC}$ | Fast Page Mode Read-Modify-Write Cycle Time                | 71   | —    | 80   | —    | 95   | —    | ns    |       |
| $t_{CPW}$  | $\overline{WE}$ Delay Time from $\overline{CAS}$ Precharge | 48   | —    | 55   | —    | 65   | —    | ns    | 1     |

1.  $t_{WCS}$ ,  $t_{RWD}$ ,  $t_{CWD}$ ,  $t_{AWD}$  and  $t_{CPW}$  are not restrictive operating parameters. They are included in the data sheet as electrical characteristics only. If  $t_{WCS} \geq t_{WCS}(\text{min})$ , the cycle is an early write cycle and the data pin will remain open circuit (high impedance) through the entire cycle. If  $t_{RWD} \geq t_{RWD}(\text{min})$ ,  $t_{CWD} \geq t_{CWD}(\text{min})$ ,  $t_{AWD} \geq t_{AWD}(\text{min})$ , and  $t_{CPW} \geq t_{CPW}(\text{min})$ (Fast Page Mode), the cycle is a Read-Modify-Write cycle and the data out will contain data read from the selected cell. If neither of the above sets of conditions are satisfied, the condition of the data out (at access time) is indeterminate.



## Refresh Cycle

| Symbol    | Parameter   | -50  |      | -60  |      | -70  |      | Units | Notes |
|-----------|---|------|------|------|------|------|------|-------|-------|
|           |   | Min. | Max. | Min. | Max. | Min. | Max. |       |       |
| $t_{CSR}$ | $\overline{CAS}$ Setup Time<br>(CAS before RAS Refresh Cycle) | 5    | —    | 5    | —    | 5    | —    | ns    |       |
| $t_{CHR}$ | $\overline{CAS}$ Hold Time<br>(CAS before RAS Refresh Cycle)  | 10   | —    | 10   | —    | 10   | —    | ns    |       |
| $t_{WRP}$ | $\overline{WE}$ Setup Time<br>(CAS before RAS Refresh Cycle)  | 10   | —    | 10   | —    | 10   | —    | ns    |       |
| $t_{WRH}$ | $\overline{WE}$ Hold Time<br>(CAS before RAS Cycle)           | 10   | —    | 10   | —    | 10   | —    | ns    |       |
| $t_{RPC}$ | $\overline{RAS}$ Precharge to $\overline{CAS}$ Hold Time      | 5    | —    | 5    | —    | 5    | —    | ns    |       |

## Self Refresh Cycle - Low Power version only

| Symbol     | Parameter  | -50  |      | -60  |      | -70  |      | Units   | Notes |
|------------|--|------|------|------|------|------|------|---------|-------|
|            |  | Min. | Max. | Min. | Max. | Min. | Max. |         |       |
| $t_{RASS}$ | RAS Pulse Width<br>During Self Refresh Cycle                             | 100  | —    | 100  | —    | 100  | —    | $\mu$ s | 1     |
| $t_{RPS}$  | RAS Precharge Time<br>During Self Refresh Cycle                          | 89   | —    | 104  | —    | 124  | —    | ns      | 1     |
| $t_{CHS}$  | $\overline{CAS}$ Hold Time From RAS Rising<br>During Self Refresh Cycle  | -50  | —    | -50  | —    | -50  | —    | ns      | 1, 2  |
| $t_{CHD}$  | $\overline{CAS}$ Hold Time From RAS Falling<br>During Self Refresh Cycle | 350  | —    | 350  | —    | 350  | —    | $\mu$ s | 1, 2  |

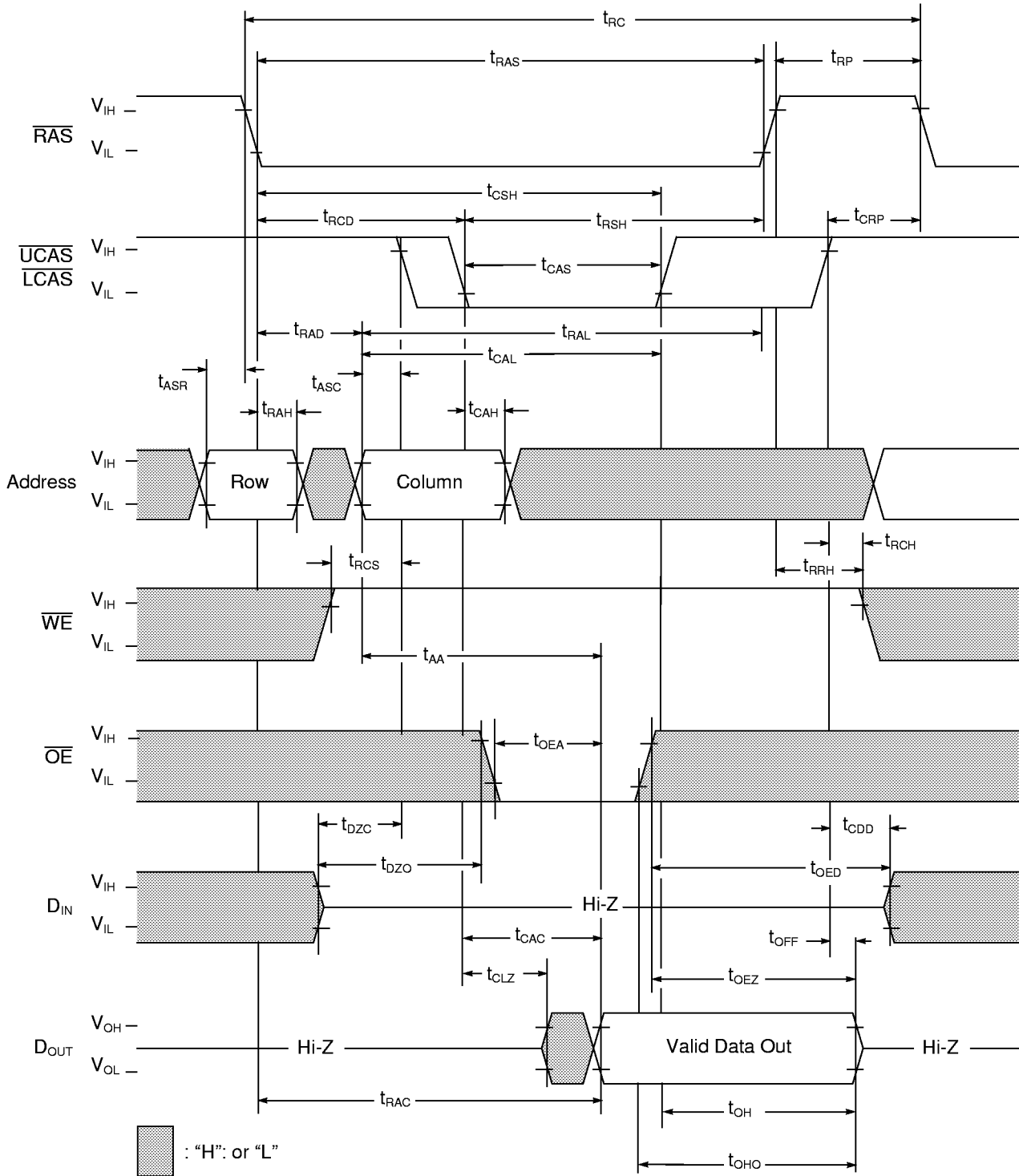
- When using Self Refresh mode, the following refresh operations must be performed to ensure proper DRAM operation:  
 If row addresses are being refreshed in an EVENLY DISTRIBUTED manner over the refresh interval using CBR refresh cycles, then only one CBR cycle must be performed immediately after exit from Self Refresh.  
 If row addresses are being refreshed in any other manner (ROR- Distributed/Burst; or CBR-Burst) over the refresh interval, then a full set of row refreshes must be performed immediately before entry to and immediately after exit from Self Refresh.
- If  $t_{RASS} > t_{CHD}$  (min) then  $t_{CHD}$  applies. If  $t_{RASS} \leq t_{CHD}$  (min) then  $t_{CHS}$  applies.

## Refresh

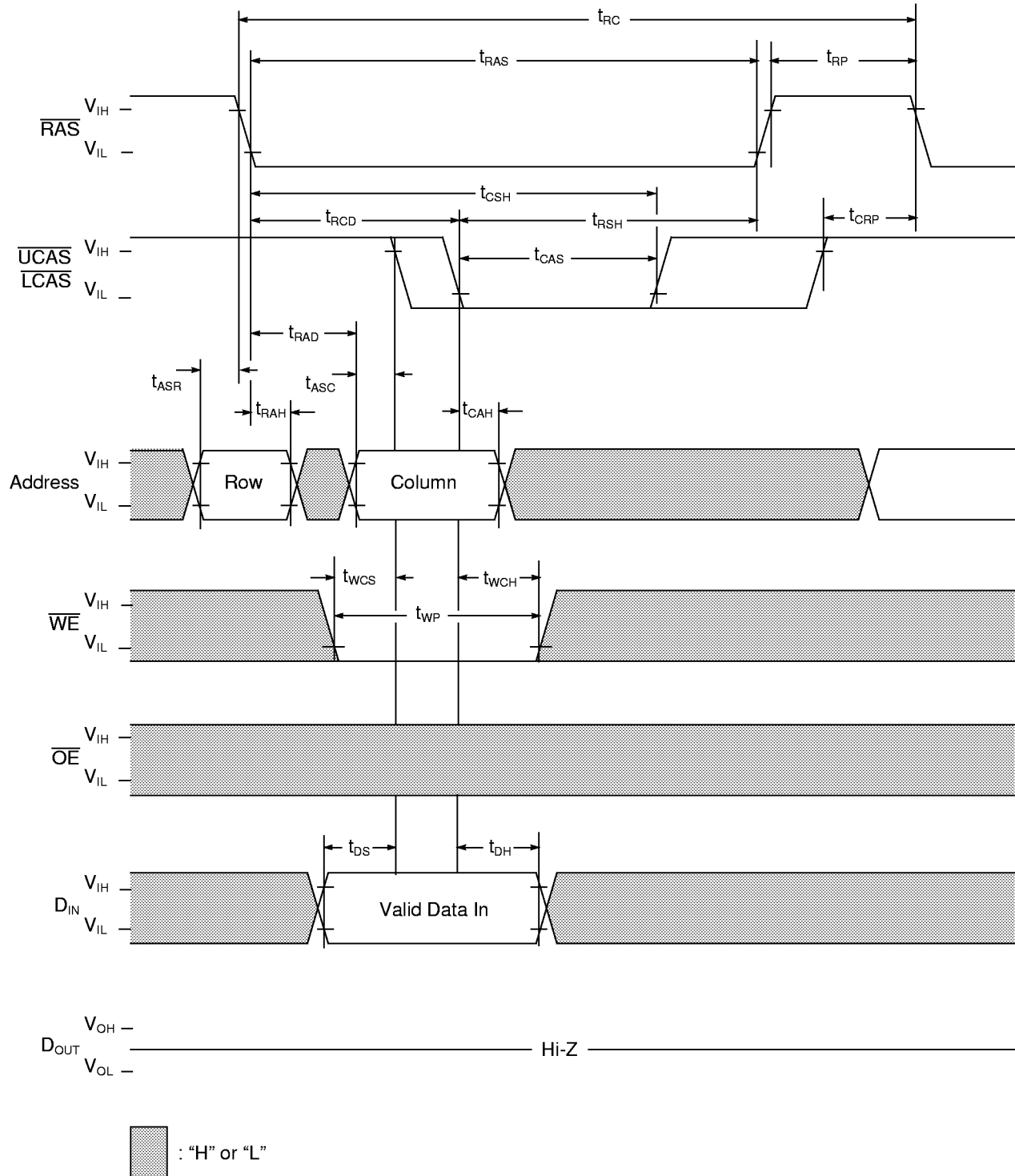
| SYMBOL    | Parameter      | -50        |      | -60  |      | -70  |      | Units | Notes |   |
|-----------|----------------|------------|------|------|------|------|------|-------|-------|---|
|           |                | Min.       | Max. | Min. | Max. | Min. | Max. |       |       |   |
| $t_{REF}$ | Refresh Period | SP version | —    | 16   | —    | 16   | —    | 16    | ms    | 1 |
|           |                | LP version | —    | 128  | —    | 128  | —    | 128   |       |   |

- 1024 cycles.

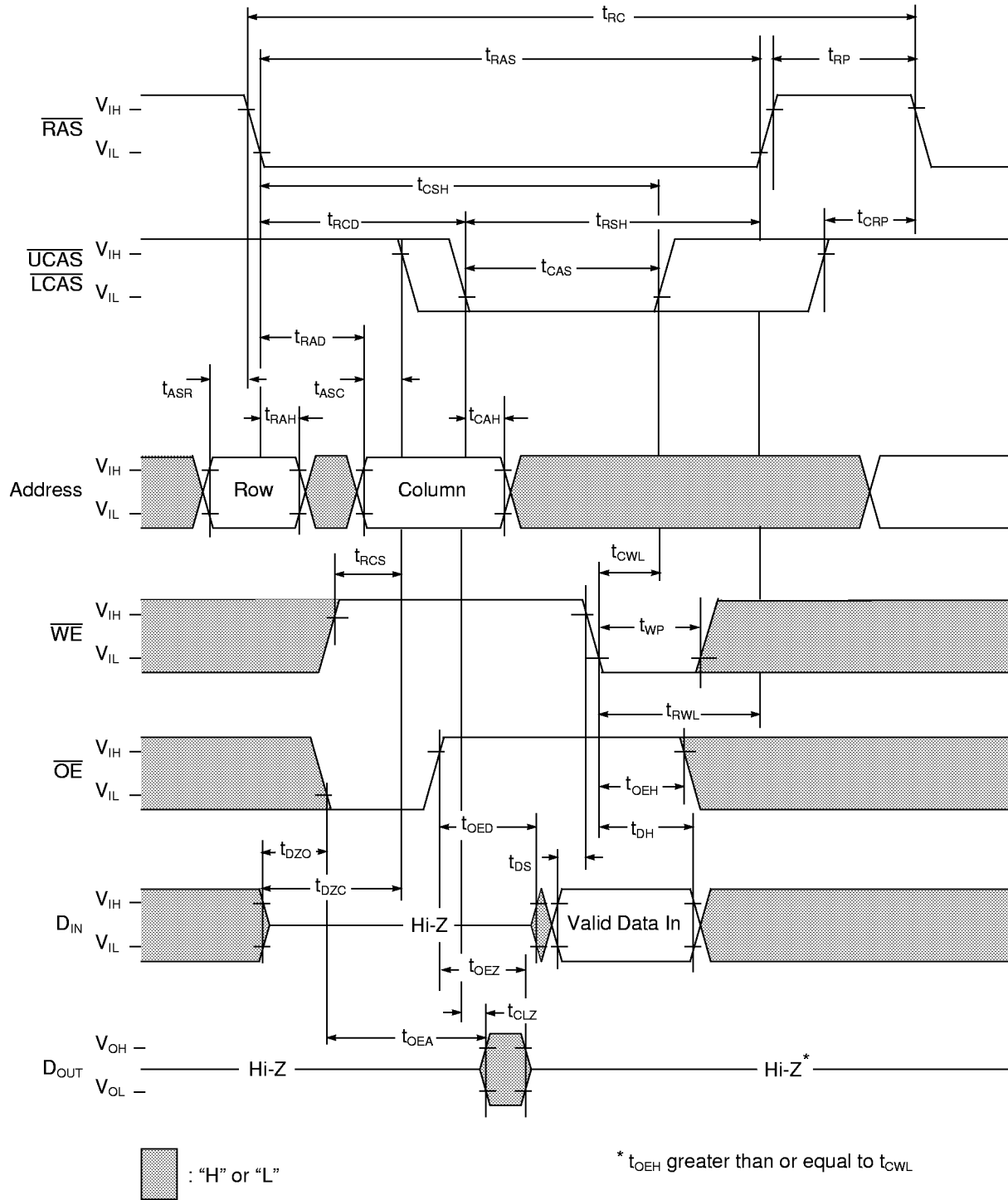
## Read Cycle



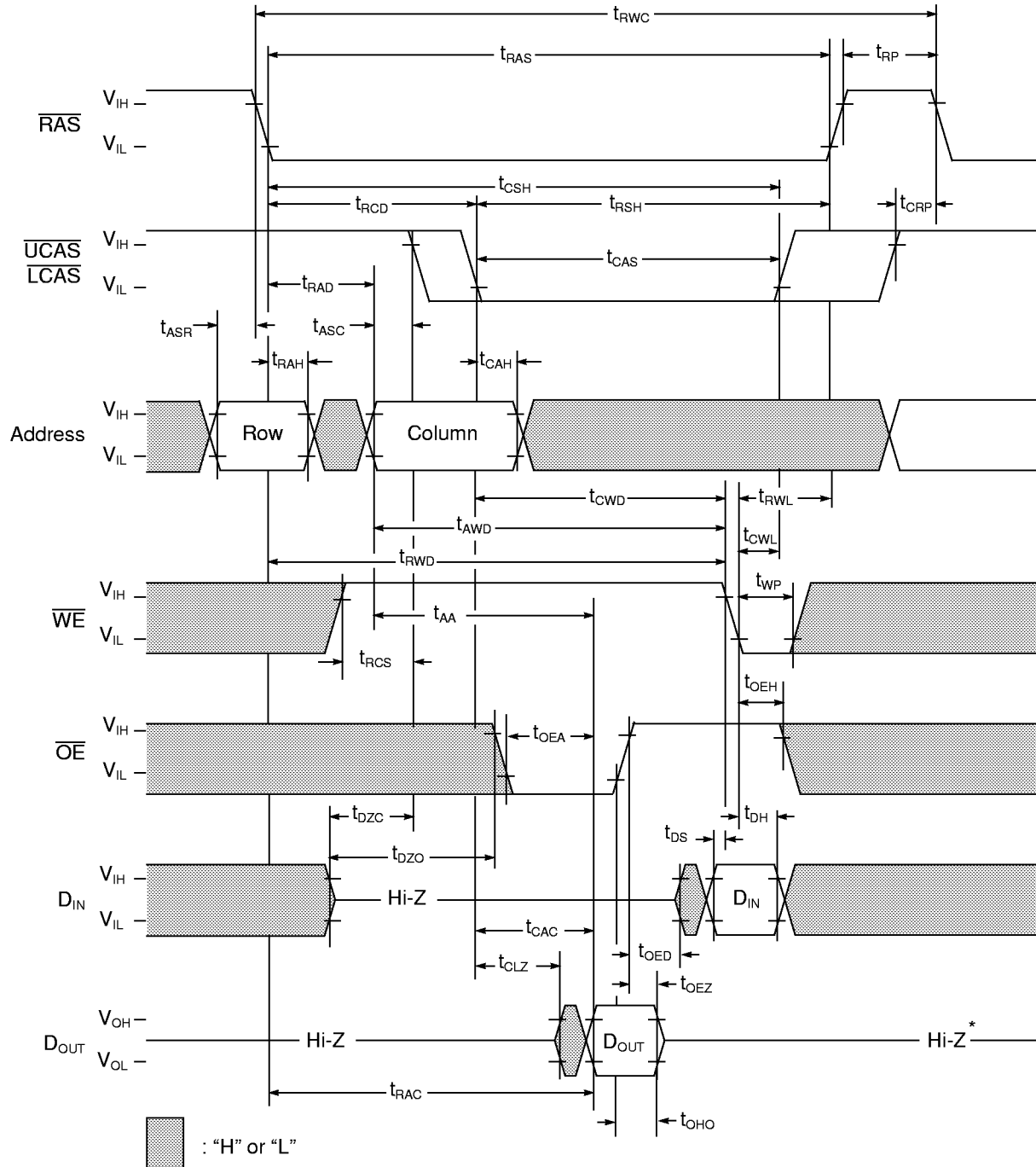
### Write Cycle (Early Write)



### Write Cycle (Delayed Write)

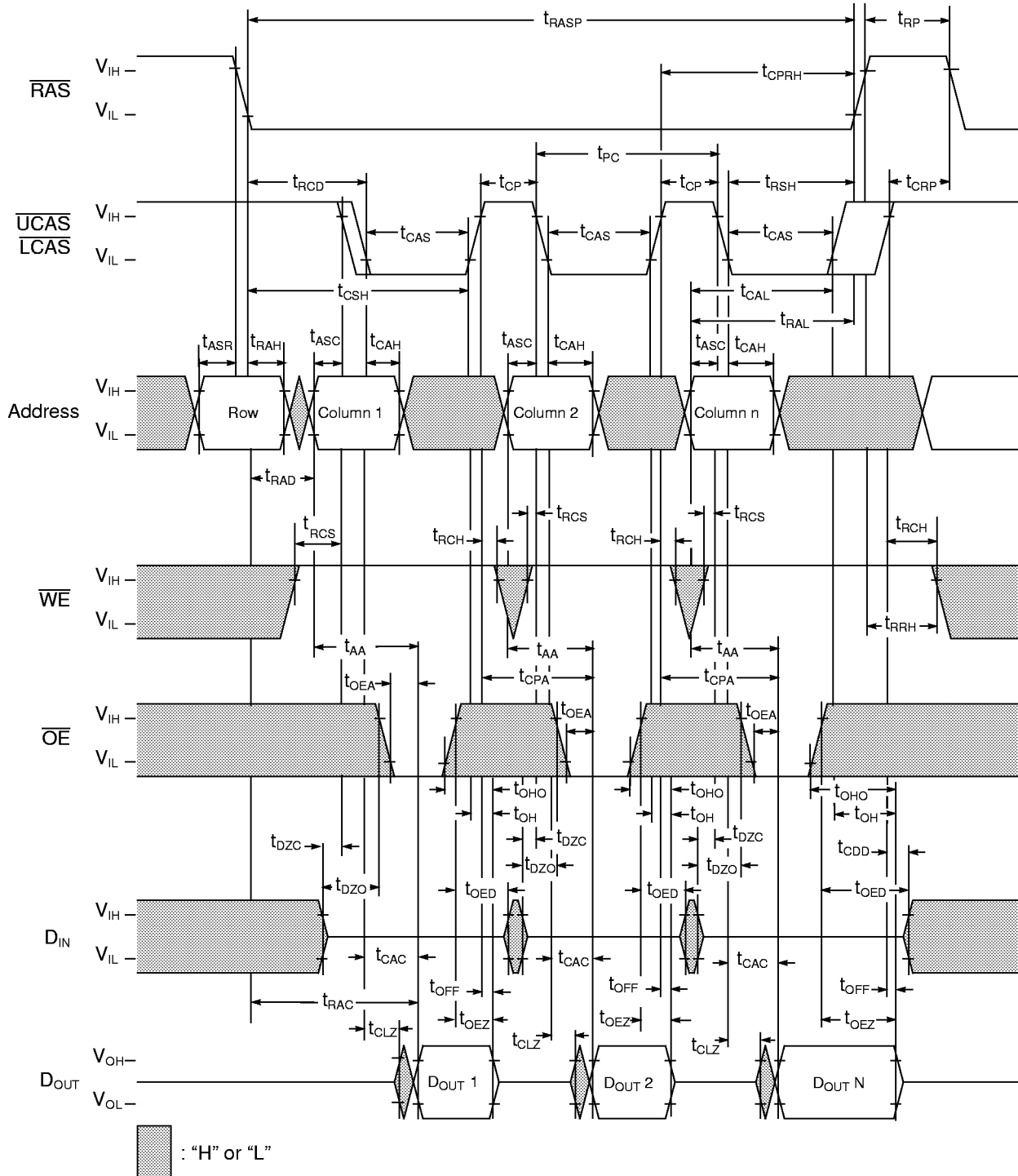


### Read-Modify-Write Cycle



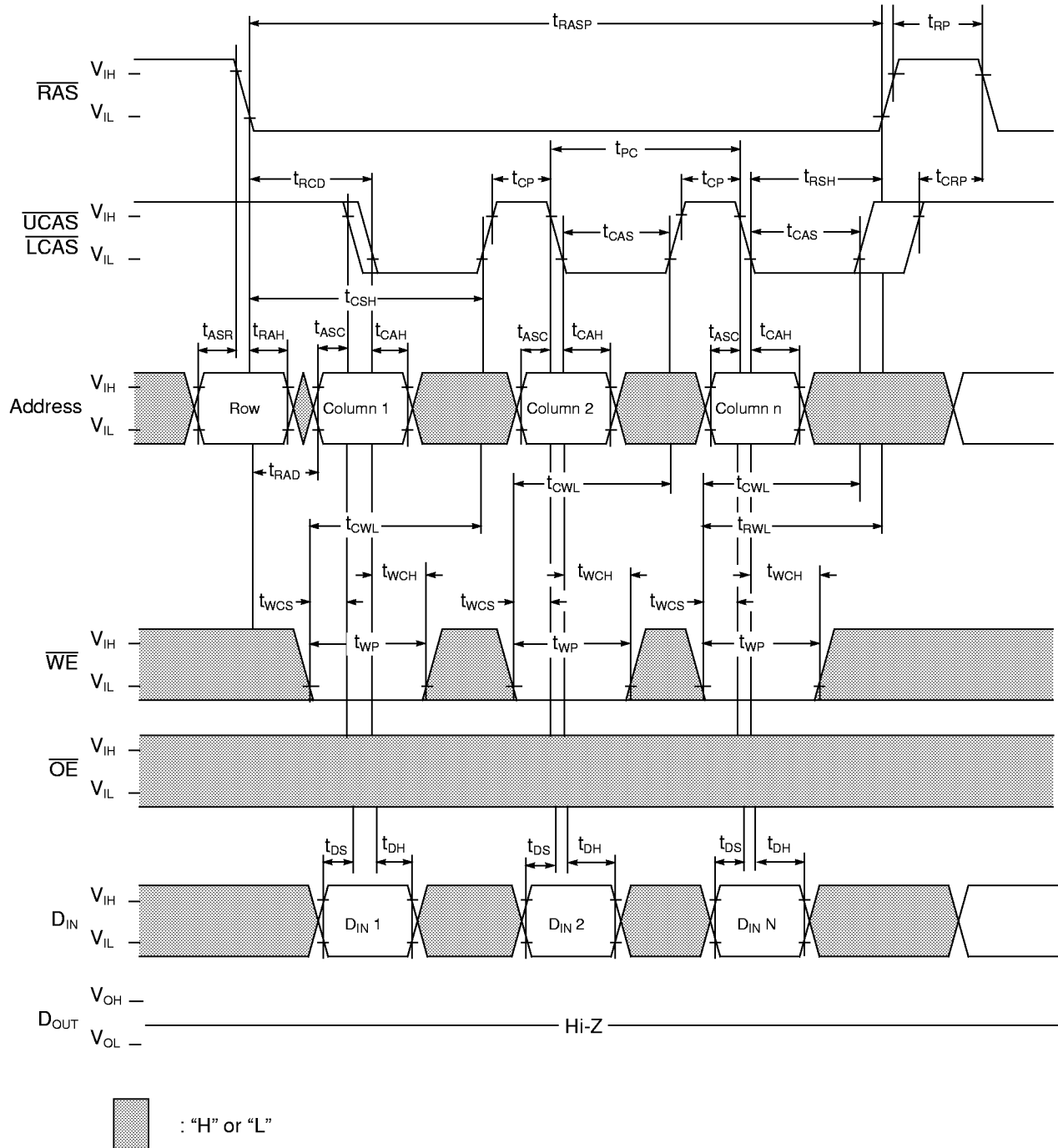
\*  $t_{OEH}$  greater than or equal to  $t_{CWL}$

## Fast Page Mode Read Cycle

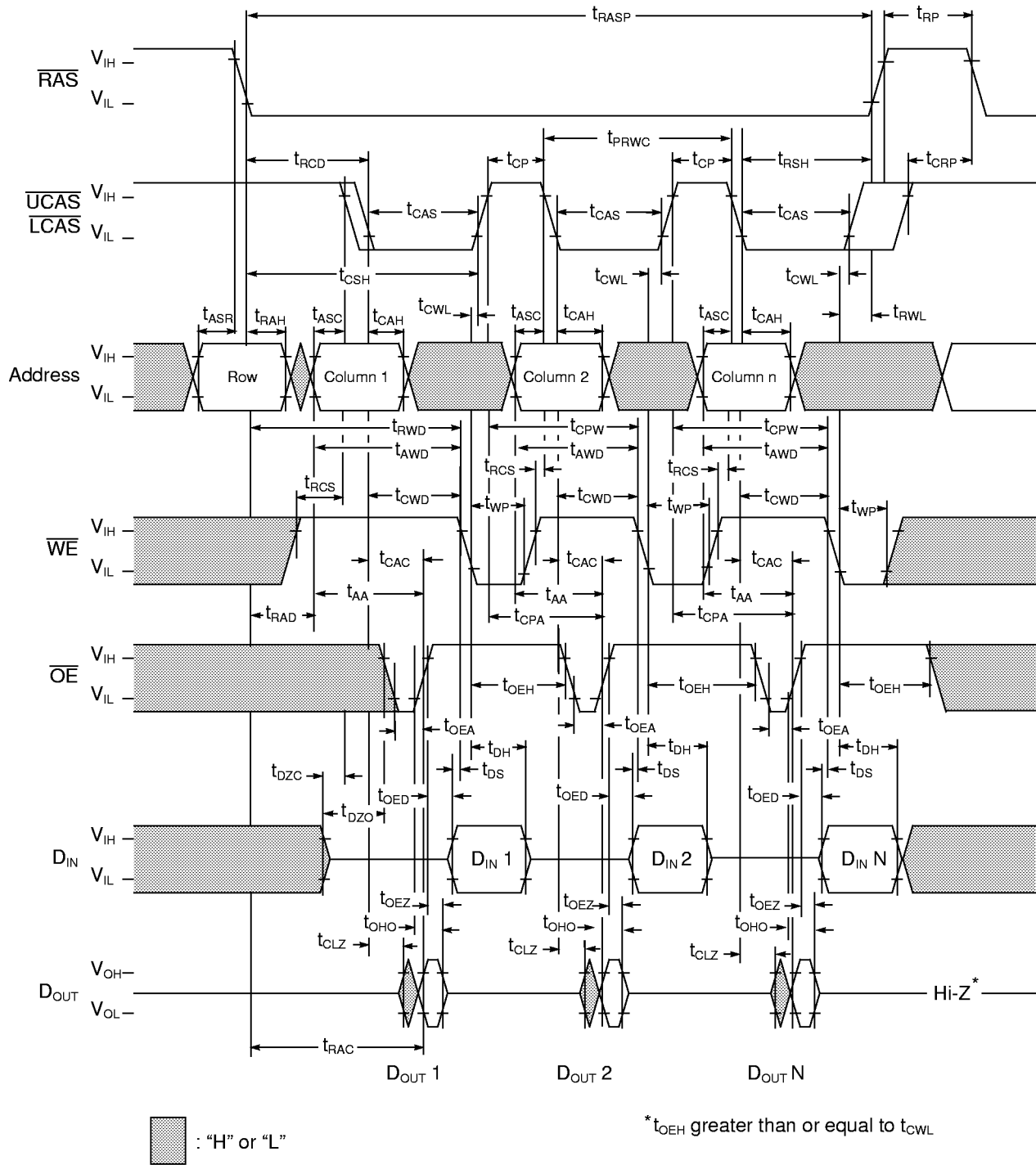




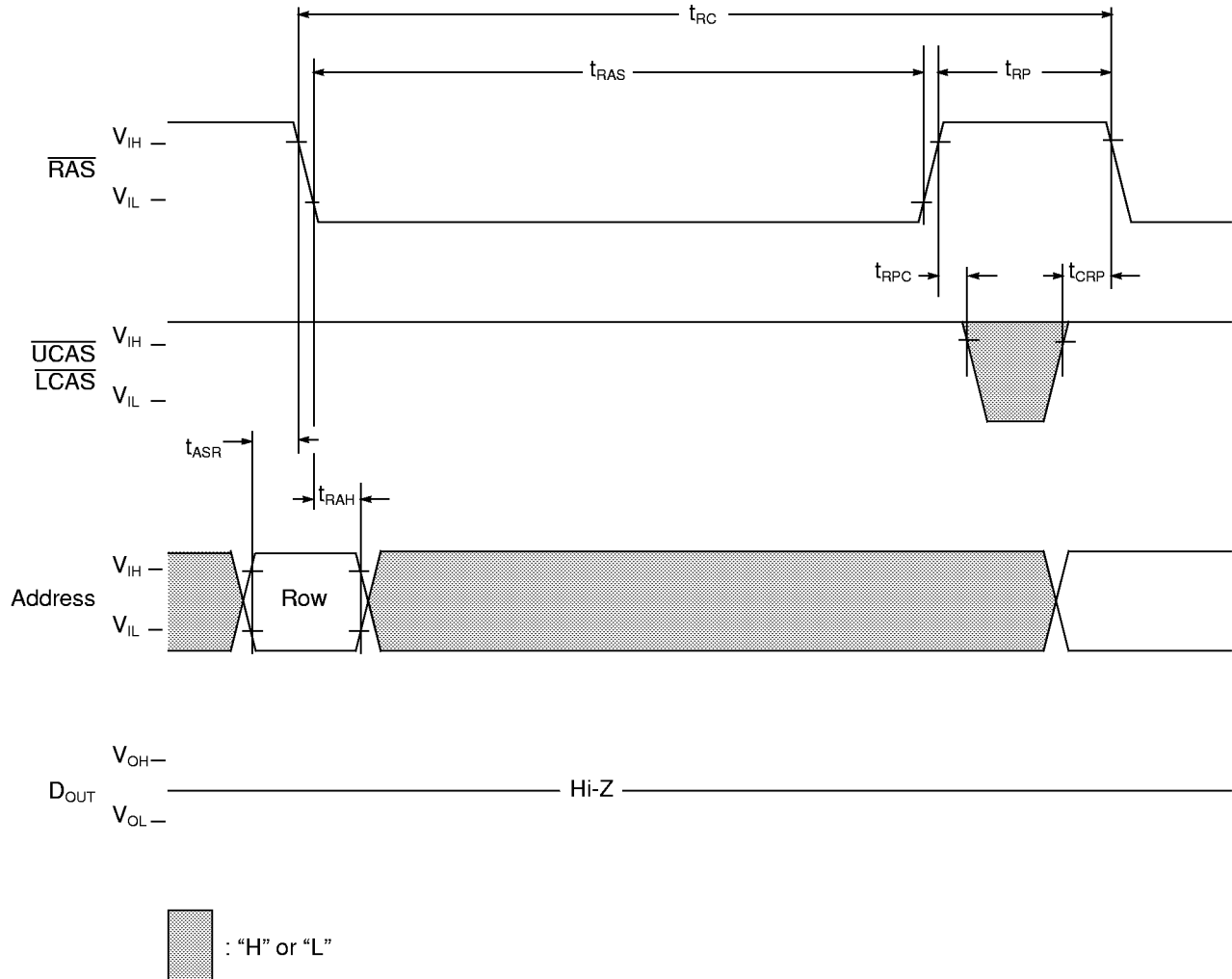
### Fast Page Mode Write Cycle



### Fast Page Mode Read-Modify-Write Cycle

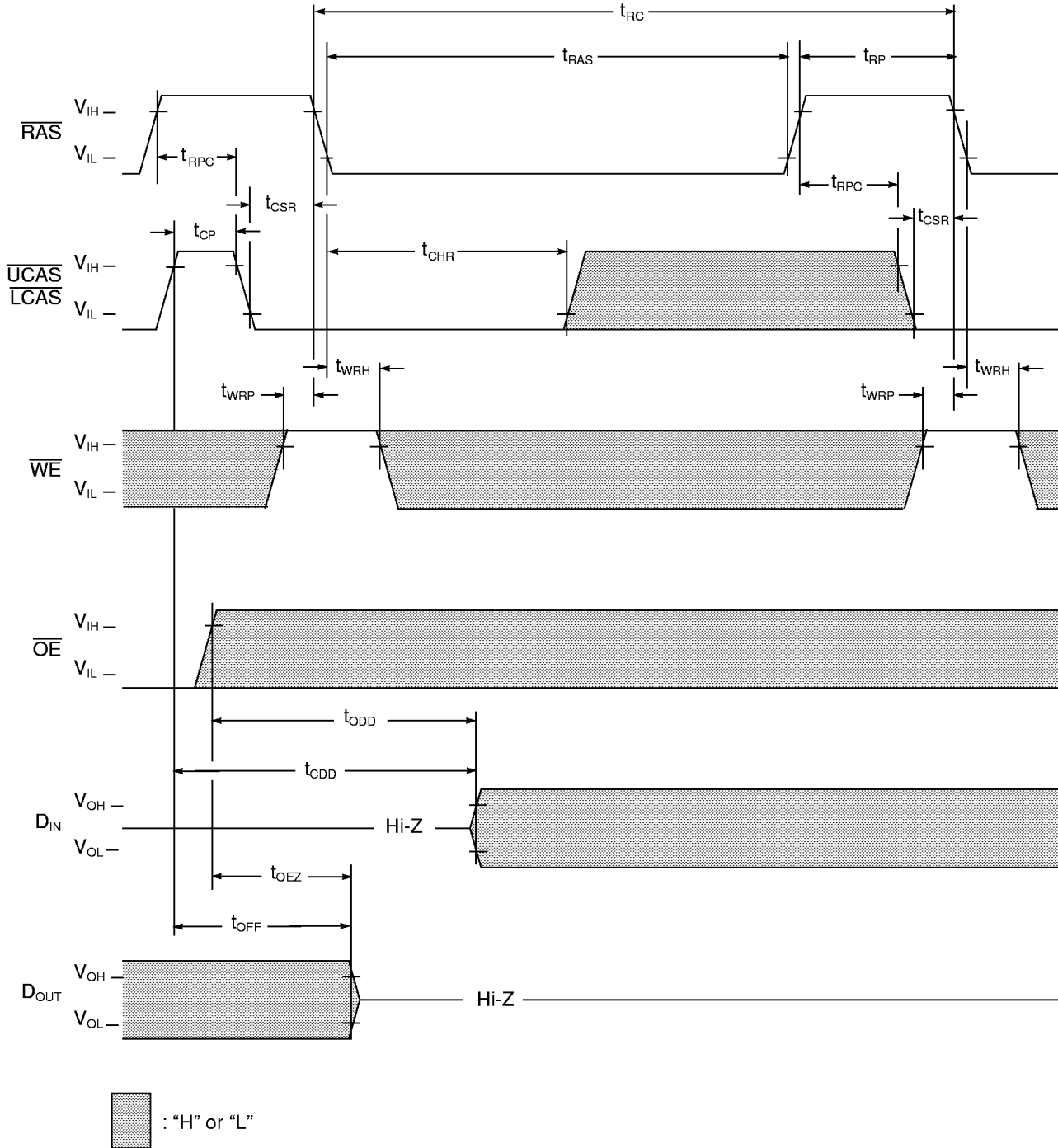


### RAS Only Refresh Cycle



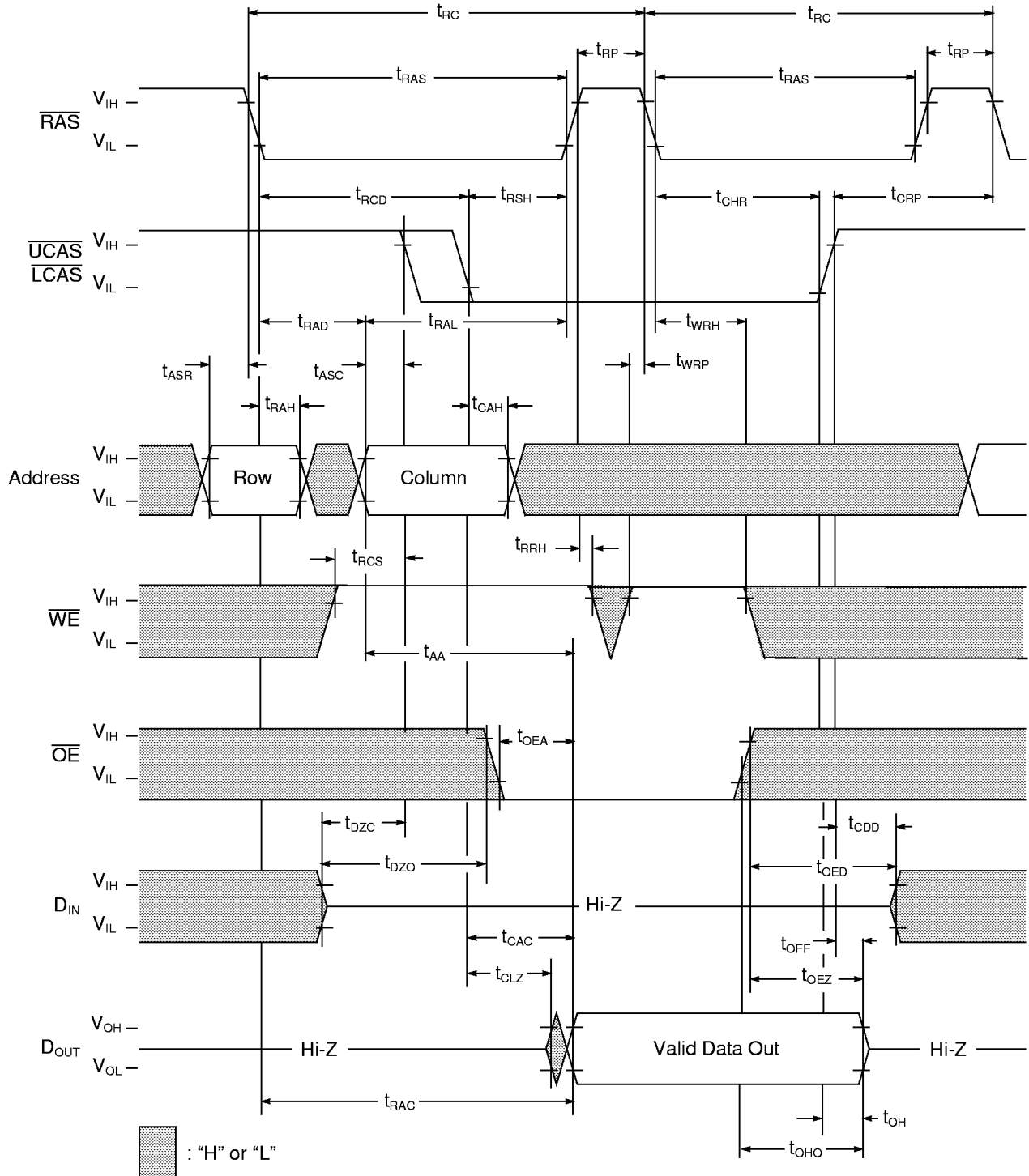
NOTE:  $\overline{WE}$ ,  $\overline{OE}$  and  $D_{IN}$  are "H" or "L"

### CAS Before RAS Refresh Cycle

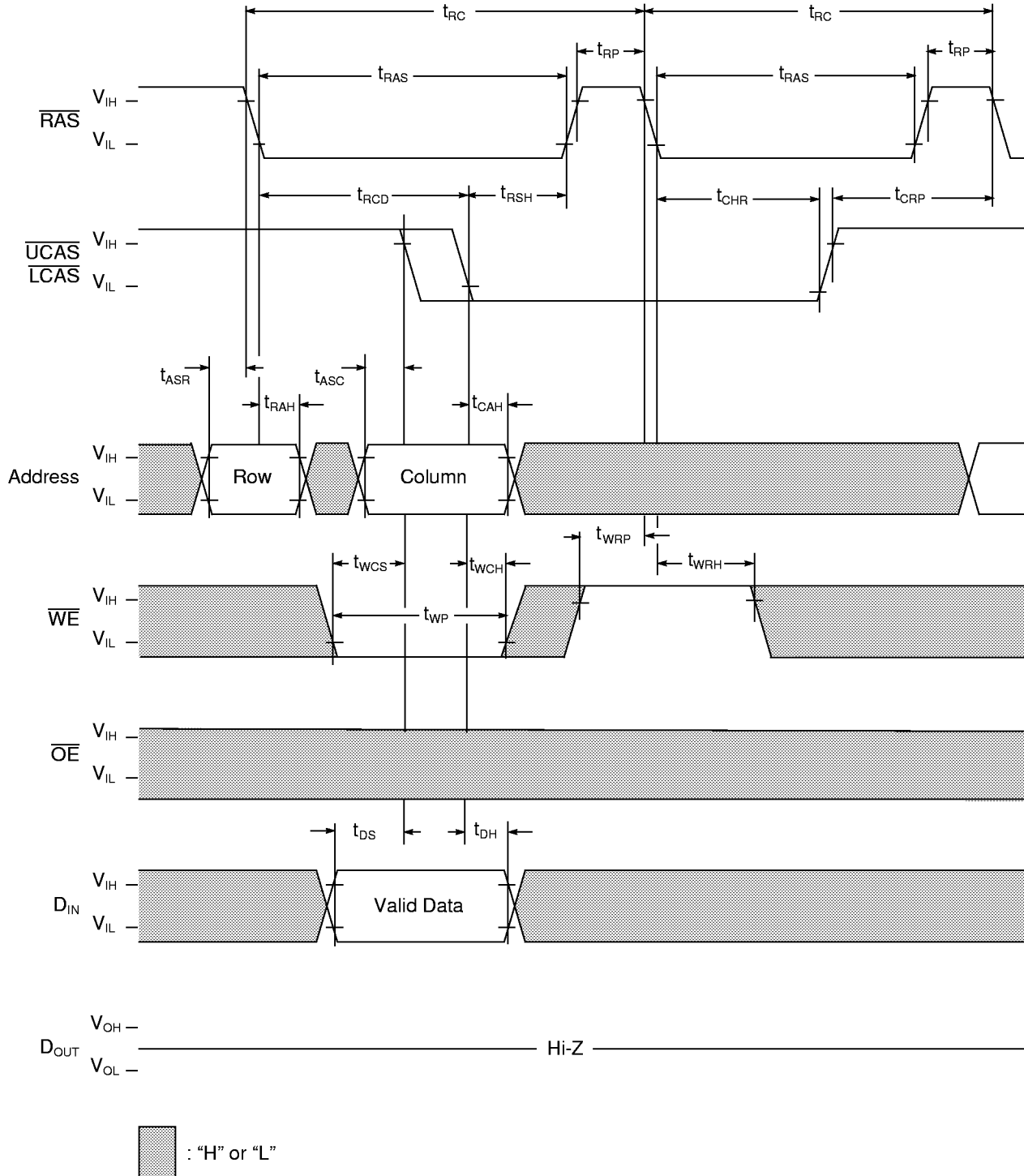


NOTE: Address is "H" or "L"

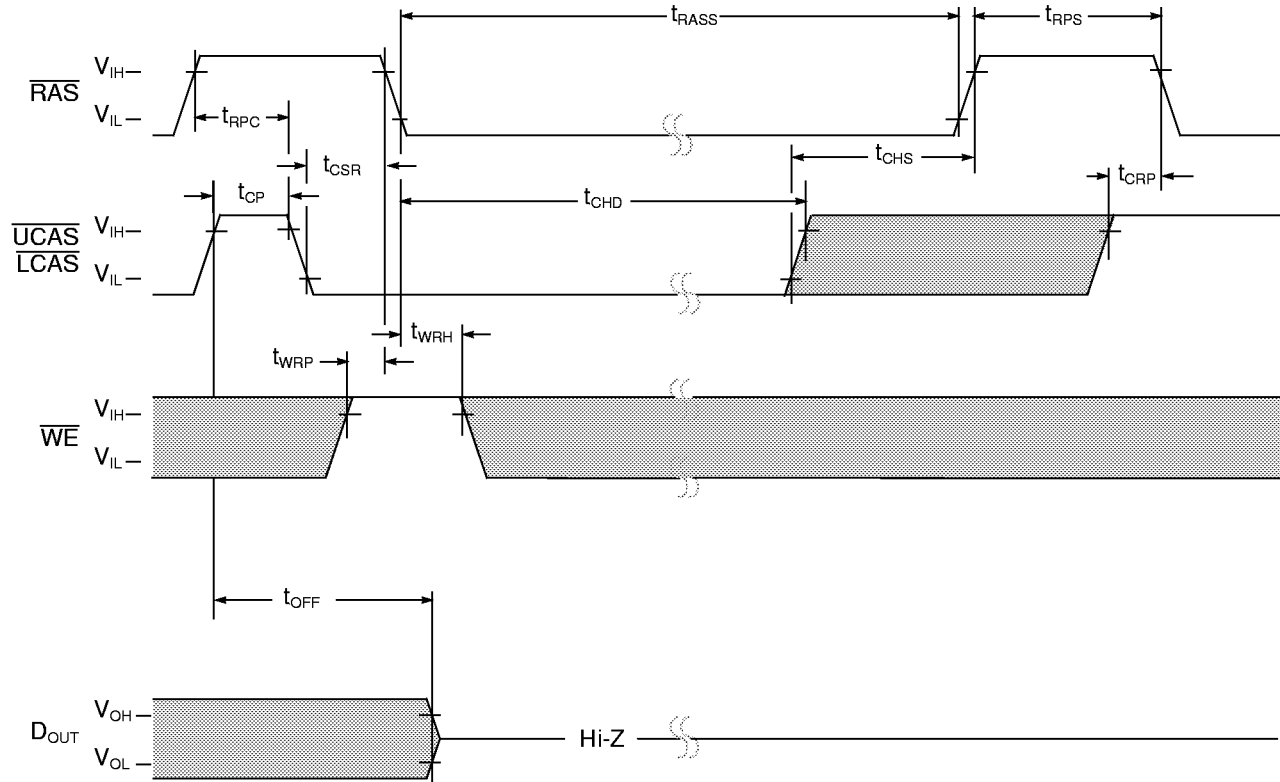
### Hidden Refresh Cycle (Read)



### Hidden Refresh Cycle (Write)



**Self Refresh Cycle (Sleep Mode) - Low Power version only**

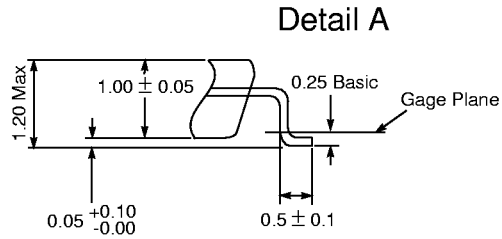
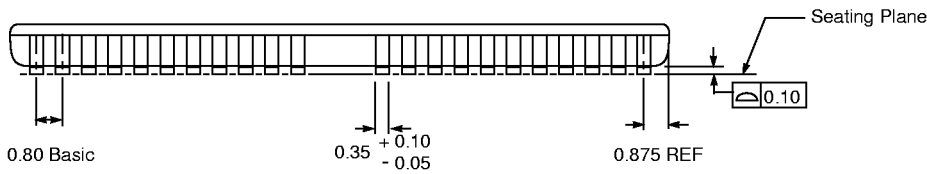
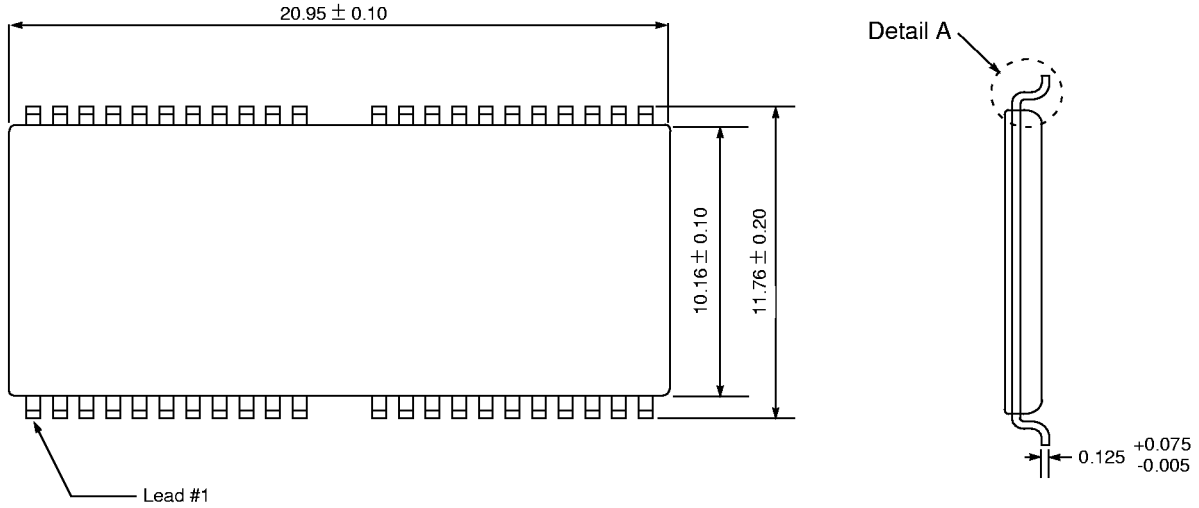


: "H" or "L"

**NOTES:**

1. Address and  $\overline{OE}$  are "H" or "L"
2. Once  $\overline{RAS}$  (min) is provided and  $\overline{RAS}$  remains low, the DRAM will be in Self Refresh, commonly known as "Sleep Mode."
3. If  $t_{RASS} > t_{CHD}$  (min) then  $t_{CHD}$  applies.  
 If  $t_{RASS} \leq t_{CHD}$  (min) then  $t_{CHS}$  applies.

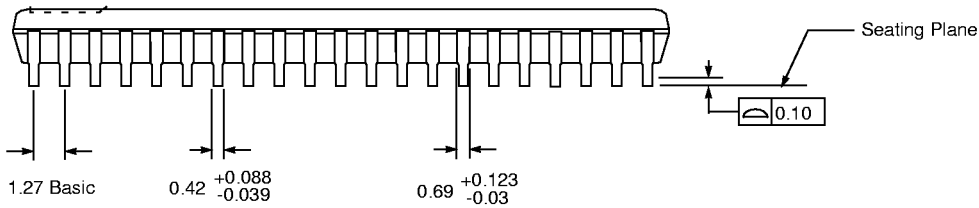
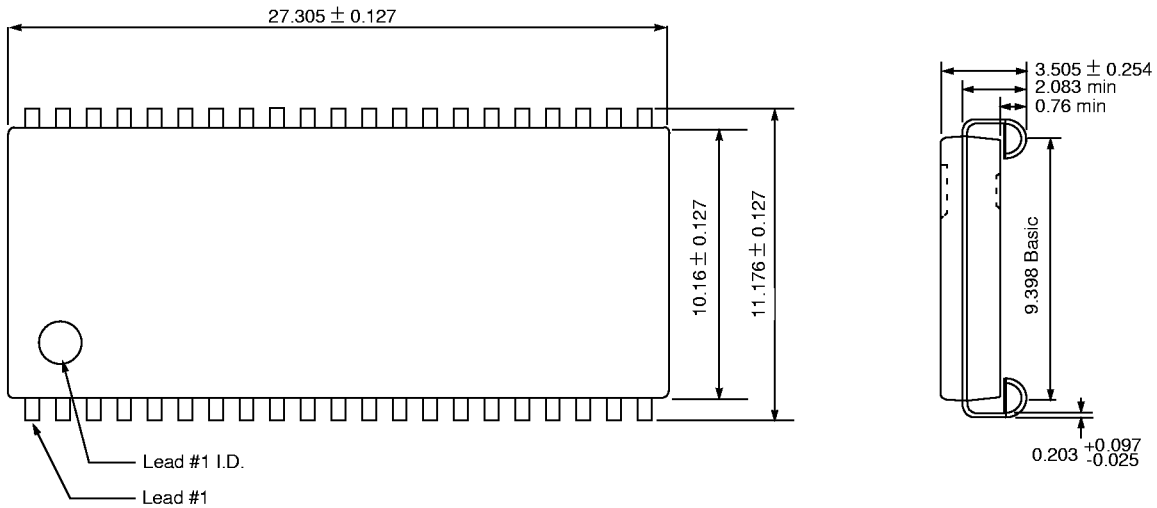
**PACKAGE DIMENSIONS (400mil; 50/44 lead; Thin Small Outline Package)**



**NOTE:** All dimensions are in millimeters; Package diagrams are not drawn to scale.



**PACKAGE DIMENSIONS** (400mil; 42/42 lead; Small Outline J-Lead)



**NOTE:** All dimensions are in millimeters; Package diagrams are not drawn to scale.



## Revision Log

| Revision | Contents Of Modification   |
|----------|--|
| 01/94    | Initial Release  |
| 06/17/94 | Change Fast Page Mode Currents ( $I_{CC4}$ ) from 85, 75, 65, 55mA to 100, 90, 80, 70mA  |
| 09/06/94 | Combine the 3.3 Volt and the 5.0 Volt specifications<br>Change the Refresh Period from 256ms to 128ms<br>Change $I_{CC1}$ , $I_{CC3}$ , $I_{CC6}$ from 215, 195, 170, 150mA to 225, 205, 180, 160mA  |
| 11/15/95 | <ol style="list-style-type: none"> <li>1. Iout changed to +2.0 mA and -2.0 mA in DC Electrical Characteristics table.</li> <li>2. Packaging diagrams modified to clarify lead thickness and standoff height.</li> <li>3. <math>t_{RPC}</math> min changed from 0 to 5ns.</li> <li>4. <math>t_{CHR}</math> min changed from 20 to 10ns.</li> <li>5. Currents in DC Electrical Characteristics table revised.</li> <li>6. Test Modes and Test Circuit Diagram removed.</li> <li>7. Rename <math>t_{ODD}</math> to <math>t_{OED}</math>.</li> <li>8. <math>t_{OED}</math>, <math>t_{CDD}</math>, <math>t_{OEZ}</math>, and <math>t_{OFF}</math> min changed from 20 to 15ns, for the 70ns part.</li> <li>9. <math>t_{RRH}</math> min changed from 5 to 0ns for all speed sorts.</li> <li>10. <math>t_{OEH}</math> min changed from 20 to 15ns for the 70ns part.</li> <li>11. <math>t_{CSR}</math> min changed from 5 to 10ns for all speed sorts.</li> <li>12. <math>t_{CAH}</math> min changed from 15 to 10ns on 60 and 70ns parts.</li> <li>13. <math>t_{OFF}</math> max changed from 20 to 15ns for 70ns parts.</li> </ol> |
| 12/10/95 | <ol style="list-style-type: none"> <li>1. The Low Power and Standard Power Specifications were combined. ES# 43G9387 and ES# 43G9388 were combined into ES# 43G9388.</li> <li>2. Added Die Rev E part numbers.</li> <li>3. <math>t_{DH}</math> was reduced from 15ns to 12ns for the -60 speed sort.</li> <li>4. <math>t_{CHD}</math> was added to the Self Refresh Cycle with a value of 350<math>\mu</math>s for all speed sorts.</li> <li>5. The Self Refresh timing diagram was changed to allow <math>\overline{CAS}</math> to go high <math>t_{CHD}</math> (350<math>\mu</math>s) after <math>\overline{RAS}</math> falls entering a Self Refresh.</li> <li>6. The CBR timing diagram was changed to allow <math>\overline{CAS}</math> to remain low for back-to-back CBR cycles.</li> <li>7. <math>\overline{WE}</math> for the Hidden Refresh Write cycle in the Truth Table was changed from "L" to "H".</li> </ol>   |
| 09/01/96 | <ol style="list-style-type: none"> <li>1. <math>I_{CC2}</math> was changed from 2mA to 1mA.</li> <li>2. <math>I_{I(L)}</math> and <math>I_{O(L)}</math> were altered from +/- 10uA to +/- 5uA.</li> <li>3. <math>t_T</math> was initially at a max of 30ns. It has been modified to 50ns for all speed sorts.</li> <li>4. <math>t_{CPA}</math> was decreased from 30ns to 28ns for the -50 speed sort.</li> <li>5. <math>t_{RASP}</math> max of 125K was raised to 200K for all speed sorts.</li> <li>6. <math>t_{RP}</math> was changed from 35ns to 30ns for the -50 speed sort.</li> </ol>  |