

## Features

- 168 Pin JEDEC Standard, Unbuffered 8 Byte Dual In-line Memory Module
- 8Mx64, 8Mx72 Dual Bank Extended Data Out Page Mode DIMMs
- Performance:

|                  |                          | -60   | -70   |
|------------------|--------------------------|-------|-------|
| t <sub>RAC</sub> | RAS Access Time          | 60ns  | 70ns  |
| t <sub>CAC</sub> | CAS Access Time          | 15ns  | 20ns  |
| t <sub>AA</sub>  | Access Time From Address | 30ns  | 35ns  |
| t <sub>RC</sub>  | Cycle Time               | 104ns | 124ns |
| t <sub>HPC</sub> | EDO Mode Cycle Time      | 25ns  | 30ns  |

- All inputs and outputs are LVTTTL (3.3V) compatible
- Single 3.3V  $\pm$  0.3V Power Supply
- Au contacts
- Optimized for byte-write non-parity, or ECC applications

- System Performance Benefits:
  - Non buffered for increased performance
  - Reduced noise (35 V<sub>SS</sub>/V<sub>CC</sub> pins)
  - Byte write, byte read accesses
  - Serial PDs
- Extended Data Out (EDO) Mode, Read-Modify-Write Cycles
- Refresh Modes:  $\overline{\text{RAS}}$ -Only, CBR and Hidden Refresh
- 2048 refresh cycles distributed across 32ms (11/11 addressing)
- 4096 refresh cycles distributed across 64ms (12/10 addressing)
- 11/11 or 12/10 addressing (Row/Column)
- Card size: 5.25" x 1.0" x 0.354"
- DRAMS in SOJ Package

## Description

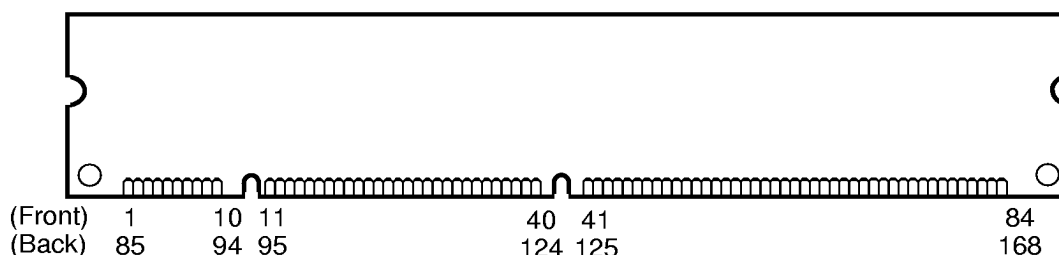
IBM11N8645B IBM11N8645C are industry standard 168-pin 8-byte Dual In-line Memory Modules (DIMMs) which are organized as 8Mx64 and 8Mx72 high speed memory arrays designed with EDO DRAMs for non-parity or ECC applications and are configured as two 4Mx64 and two 4Mx72 banks. The DIMMs use 16 (x64) or 18 (x72) 4Mx4 EDO DRAMs in SOJ packages. The use of EDO DRAMs allows for a reduction in Page Mode Cycle time from 40ns (Fast Page) to 25ns for 60ns DRAM modules.

The DIMMs use serial presence detects implemented via a serial EEPROM using the two pin I<sup>2</sup>C protocol. This communication protocol uses Clock (SCL) and Data I/O (SDA) lines to synchronously

clock data between the master (system logic) and the slave EEPROM device (DIMM). The EEPROM device address pins (SA0-2) are brought out to the DIMM tabs to allow 8 unique DIMM/EEPROM addresses. The first 128 bytes are utilized by the DIMM manufacturer and the second 128 bytes of serial PD data are available to the customer.

All IBM 168-pin DIMMs provide a high performance, flexible 8-byte interface in a 5.25" long space-saving footprint. Related products include the buffered DIMMs (x64, x72 parity and x72 ECC Optimized) for applications which can benefit from the on-card buffers.

## Card Outline





## Pin Description

|             |                             |                 |                                       |
|-------------|-----------------------------|-----------------|---------------------------------------|
| RAS0, RAS2  | Row Address Strobe          | V <sub>CC</sub> | Power (3.3V)                          |
| CAS0 - CAS7 | Column Address Strobe       | V <sub>SS</sub> | Ground                                |
| WE0, WE2    | Read/write Input            | NC              | No Connect                            |
| OE0, OE2    | Output Enable               | DU              | Don't Use                             |
| A0 - A11    | Address Inputs              | SCL             | Serial Presence Detect Clock Input    |
| DQx         | Data Input/Output           | SDA             | Serial Presence Detect Data Input     |
| CBx         | Check Bit Data Input/Output | SA0-2           | Serial Presence Detect Address Inputs |

## Pinout

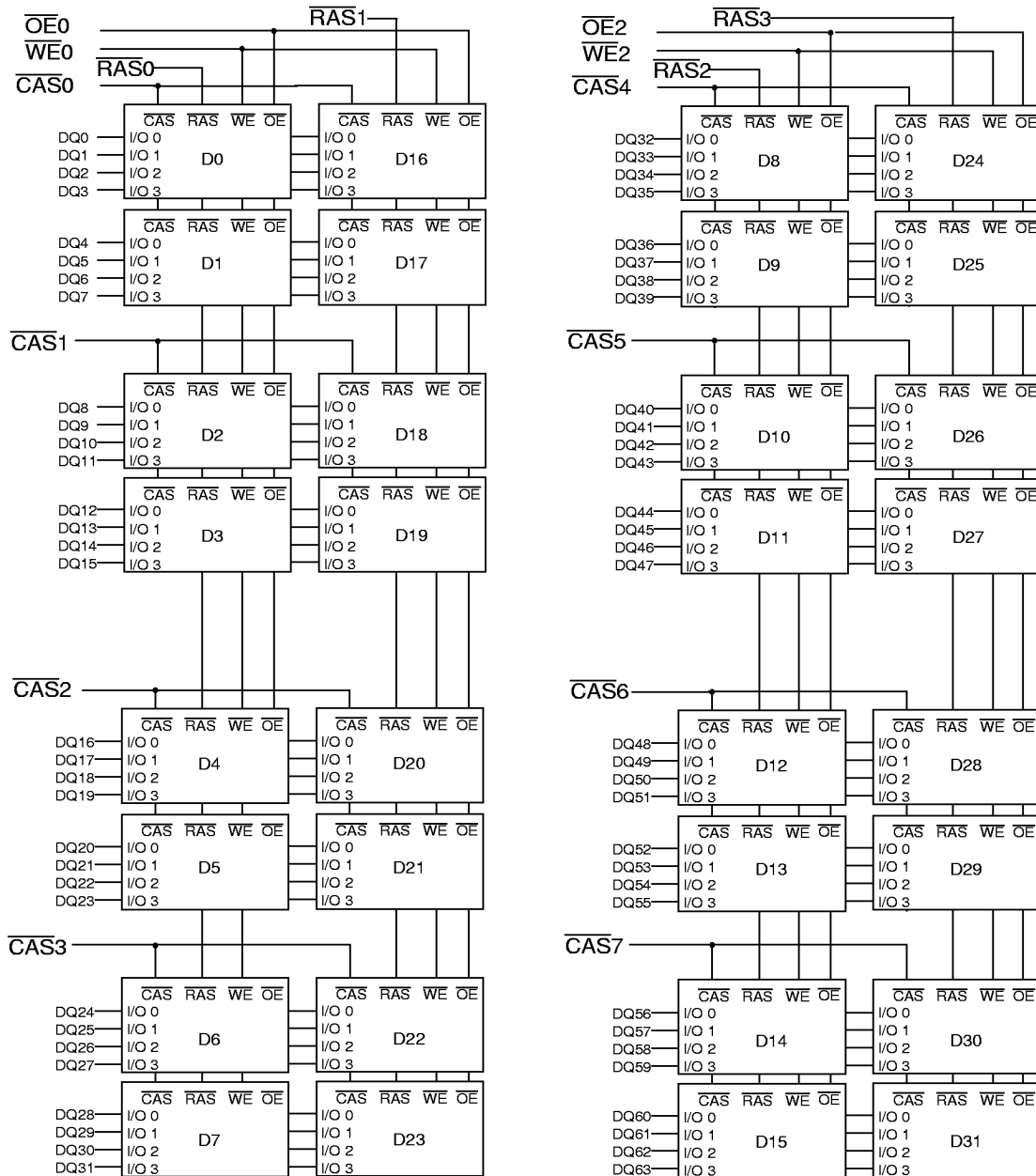
| Pin# | Front Side      | Pin# | Back Side       | Pin# | Front Side      | Pin# | Back Side       | Pin# | Front Side      | Pin# | Back Side       | Pin# | Front Side      | Pin# | Back Side       |
|------|-----------------|------|-----------------|------|-----------------|------|-----------------|------|-----------------|------|-----------------|------|-----------------|------|-----------------|
| 1    | V <sub>SS</sub> | 85   | V <sub>SS</sub> | 22   | CB1             | 106  | CB5             | 43   | V <sub>SS</sub> | 127  | V <sub>SS</sub> | 64   | V <sub>SS</sub> | 148  | V <sub>SS</sub> |
| 2    | DQ0             | 86   | DQ32            | 23   | V <sub>SS</sub> | 107  | V <sub>SS</sub> | 44   | OE2             | 128  | DU              | 65   | DQ21            | 149  | DQ53            |
| 3    | DQ1             | 87   | DQ33            | 24   | NC              | 108  | NC              | 45   | RAS2            | 129  | NC              | 66   | DQ22            | 150  | DQ54            |
| 4    | DQ2             | 88   | DQ34            | 25   | NC              | 109  | NC              | 46   | CAS2            | 130  | CAS6            | 67   | DQ23            | 151  | DQ55            |
| 5    | DQ3             | 89   | DQ35            | 26   | V <sub>CC</sub> | 110  | V <sub>CC</sub> | 47   | CAS3            | 131  | CAS7            | 68   | V <sub>SS</sub> | 152  | V <sub>SS</sub> |
| 6    | V <sub>CC</sub> | 90   | V <sub>CC</sub> | 27   | WE0             | 111  | DU              | 48   | WE2             | 132  | DU              | 69   | DQ24            | 153  | DQ56            |
| 7    | DQ4             | 91   | DQ36            | 28   | CAS0            | 112  | CAS4            | 49   | V <sub>CC</sub> | 133  | V <sub>CC</sub> | 70   | DQ25            | 154  | DQ57            |
| 8    | DQ5             | 92   | DQ37            | 29   | CAS1            | 113  | CAS5            | 50   | NC              | 134  | NC              | 71   | DQ26            | 155  | DQ58            |
| 9    | DQ6             | 93   | DQ38            | 30   | RAS0            | 114  | NC              | 51   | NC              | 135  | NC              | 72   | DQ27            | 156  | DQ59            |
| 10   | DQ7             | 94   | DQ39            | 31   | OE0             | 115  | DU              | 52   | CB2             | 136  | CB6             | 73   | V <sub>CC</sub> | 157  | V <sub>CC</sub> |
| 11   | DQ8             | 95   | DQ40            | 32   | V <sub>SS</sub> | 116  | V <sub>SS</sub> | 53   | CB3             | 137  | CB7             | 74   | DQ28            | 158  | DQ60            |
| 12   | V <sub>SS</sub> | 96   | V <sub>SS</sub> | 33   | A0              | 117  | A1              | 54   | V <sub>SS</sub> | 138  | V <sub>SS</sub> | 75   | DQ29            | 159  | DQ61            |
| 13   | DQ9             | 97   | DQ41            | 34   | A2              | 118  | A3              | 55   | DQ16            | 139  | DQ48            | 76   | DQ30            | 160  | DQ62            |
| 14   | DQ10            | 98   | DQ42            | 35   | A4              | 119  | A5              | 56   | DQ17            | 140  | DQ49            | 77   | DQ31            | 161  | DQ63            |
| 15   | DQ11            | 99   | DQ43            | 36   | A6              | 120  | A7              | 57   | DQ18            | 141  | DQ50            | 78   | V <sub>SS</sub> | 162  | V <sub>SS</sub> |
| 16   | DQ12            | 100  | DQ44            | 37   | A8              | 121  | A9              | 58   | DQ19            | 142  | DQ51            | 79   | NC              | 163  | NC              |
| 17   | DQ13            | 101  | DQ45            | 38   | A10             | 122  | A11             | 59   | V <sub>CC</sub> | 143  | V <sub>CC</sub> | 80   | NC              | 164  | NC              |
| 18   | V <sub>CC</sub> | 102  | V <sub>CC</sub> | 39   | NC              | 123  | NC              | 60   | DQ20            | 144  | DQ52            | 81   | NC              | 165  | SA0             |
| 19   | DQ14            | 103  | DQ46            | 40   | V <sub>CC</sub> | 124  | V <sub>CC</sub> | 61   | NC              | 145  | NC              | 82   | SDA             | 166  | SA1             |
| 20   | DQ15            | 104  | DQ47            | 41   | V <sub>CC</sub> | 125  | DU              | 62   | DU              | 146  | DU              | 83   | SCL             | 167  | SA2             |
| 21   | CB0             | 105  | CB4             | 42   | DU              | 126  | DU              | 63   | NC              | 147  | NC              | 84   | V <sub>CC</sub> | 168  | V <sub>CC</sub> |

**Note:** All pin assignments are consistent for all 8 Byte unbuffered versions.

## Ordering Information

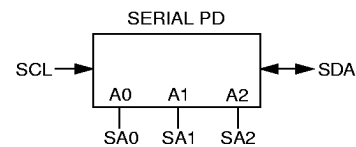
| Part Number      | Organization | Speed | Addr. | Leads | Dimension          | Power | Notes |
|------------------|--------------|-------|-------|-------|--------------------|-------|-------|
| IBM11N8645BB-60J | 8Mx64        | 60ns  | 11/11 | Au    | 5.25"x1.5"x 0.354" | 3.3V  |       |
| IBM11N8645BB-70J |              | 70ns  |       |       |                    |       |       |
| IBM11N8645CB-60J |              | 60ns  | 12/10 |       |                    |       |       |
| IBM11N8645CB-70J |              | 70ns  |       |       |                    |       |       |
| IBM11N8735BB-60J | 8Mx72        | 60ns  | 11/11 |       |                    |       |       |
| IBM11N8735BB-70J |              | 70ns  |       |       |                    |       |       |
| IBM11N8735CB-60J |              | 60ns  | 12/10 |       |                    |       |       |
| IBM11N8735CB-70J |              | 70ns  |       |       |                    |       |       |

## x64 DIMM Block Diagram (2 Bank, x4 DRAMs)

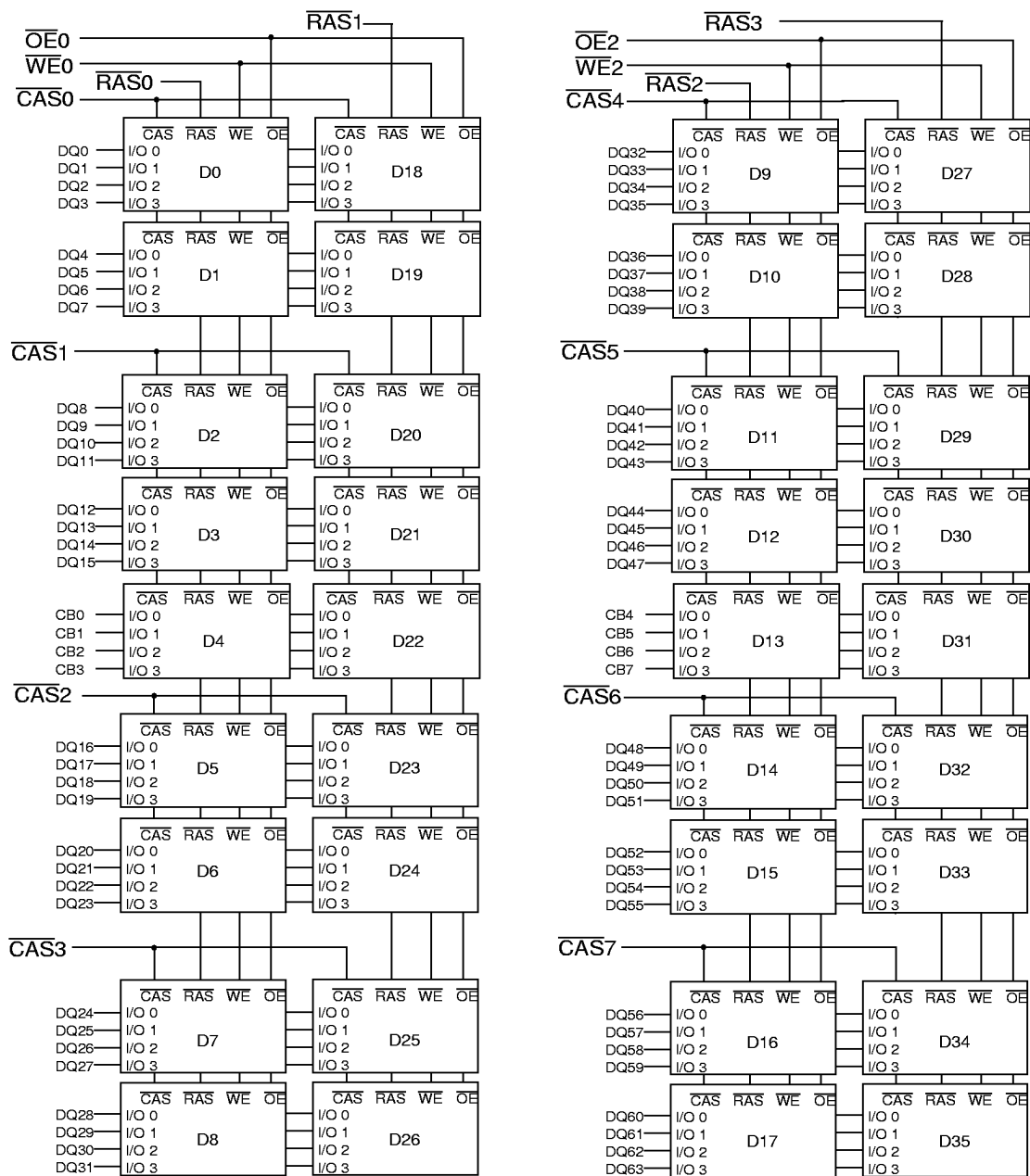


A0-AN → A0- AN: DRAMS D0 - D31

$V_{CC}$  → D0 - D31  
 $V_{SS}$  → D0 - D31

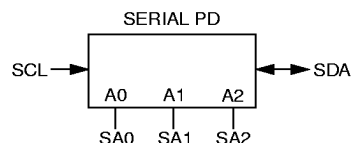


## x72 ECC DIMM Block Diagram (2 Bank, x4 DRAMs)



A0-AN → A0- AN: DRAMS D0 - D35

V<sub>CC</sub> → D0 - D35  
 V<sub>SS</sub> → D0 - D35





## Truth Table

| Function                                                         |       | $\overline{\text{RAS}}$ | $\overline{\text{CAS}}$ | $\overline{\text{WE}}$ | $\overline{\text{OE}}$ | Row Address | Column Address | DQx               |
|------------------------------------------------------------------|-------|-------------------------|-------------------------|------------------------|------------------------|-------------|----------------|-------------------|
| Standby                                                          |       | H                       | H→X                     | X                      | X                      | X           | X              | High Impedance    |
| Read                                                             |       | L                       | L                       | H                      | L                      | Row         | Col            | Valid Data Out    |
| Early-Write                                                      |       | L                       | L                       | L                      | X                      | Row         | Col            | Valid Data In     |
| Late-Write                                                       |       | L                       | L                       | H→L                    | H                      | Row         | Col            | Valid Data In     |
| RMW                                                              |       | L                       | L                       | H→L                    | L→H                    | Row         | Col            | Valid Data In/Out |
| EDO Page Mode - Read 1st Cycle                                   |       | L                       | H→L                     | H                      | L                      | Row         | Col            | Valid Data Out    |
| Subsequent Cycles                                                |       | L                       | H→L                     | H                      | L                      | N/A         | Col            | Valid Data Out    |
| EDO Page Mode - Write 1st Cycle                                  |       | L                       | H→L                     | L                      | X                      | Row         | Col            | Valid Data In     |
| Subsequent Cycles                                                |       | L                       | H→L                     | L                      | X                      | N/A         | Col            | Valid Data In     |
| EDO Page Mode - RMW 1st Cycle                                    |       | L                       | H→L                     | H→L                    | L→H                    | Row         | Col            | Valid Data In/Out |
| Subsequent Cycles                                                |       | L                       | H→L                     | H→L                    | L→H                    | N/A         | Col            | Valid Data In/Out |
| $\overline{\text{RAS}}$ -Only Refresh                            |       | L                       | H                       | X                      | X                      | Row         | N/A            | High Impedance    |
| $\overline{\text{CAS}}$ -Before- $\overline{\text{RAS}}$ Refresh |       | H→L                     | L                       | H                      | X                      | X           | X              | High Impedance    |
| Hidden Refresh                                                   | Read  | L→H→L                   | L                       | H                      | L                      | Row         | Col            | Data Out          |
|                                                                  | Write | L→H→L                   | L                       | H                      | X                      | Row         | Col            | Data In           |

## Serial Presence Detect

| Byte #    | Description                                         | SPD Entry Value      | Serial PD Data Entry (Hexadecimal) |
|-----------|-----------------------------------------------------|----------------------|------------------------------------|
| 0         | Number of Serial PD Bytes Written during Production | 128                  | 80                                 |
| 1         | Total Number of Bytes in Serial PD device           | 256                  | 08                                 |
| 2         | Fundamental Memory Type                             | EDO                  | 02                                 |
| 3         | Number of Row Addresses on Assembly                 | 12                   | 0C                                 |
|           |                                                     | 11                   | 0B                                 |
| 4         | Number of Column Addresses on Assembly              | 10                   | 0A                                 |
|           |                                                     | 11                   | 0B                                 |
| 5         | Number of DIMM Banks                                | 2                    | 02                                 |
| 6 - 7     | Data Width of Assembly                              | 8M x 64              | x64                                |
|           |                                                     | 8M x 72              | x72                                |
| 8         | Assembly Voltage Interface Levels                   | LVTTL                | 01                                 |
| 9         | $\overline{\text{RAS}}$ Access                      | 60ns                 | 3C                                 |
|           |                                                     | 70ns                 | 46                                 |
| 10        | $\overline{\text{CAS}}$ Access                      | 15ns                 | 0F                                 |
|           |                                                     | 20ns                 | 14                                 |
| 11        | Assembly Error Detection/Correction Scheme          | 8M x 64              | Non-Parity                         |
|           |                                                     | 8M x 72              | ECC                                |
| 12        | Assembly Refresh Rate/Type                          | Normal 15.6us        | 00                                 |
| 13        | Primary DRAM Width                                  | x4                   | 04                                 |
| 14        | Secondary DRAM Width                                | 8M x 64              | N/A                                |
|           |                                                     | 8M x 72              | x4                                 |
| 15 - 62   | Reserved                                            | Undefined            | 00                                 |
| 63        | Checksum for bytes 0 - 62                           | Checksum Data        | cc                                 |
| 64 - 71   | Manufacturers' JEDEC ID Code                        | IBM                  | A400000000000000                   |
| 72        | Assembly Manufacturing Location                     | Toronto, Canada      | 91                                 |
|           |                                                     | Vimercate, Italy     | 53                                 |
| 73 - 90   | Assembly Part Number<br>(70ns examples not shown)   | 8M x 64              | ASCII '11N8645BB'R'-60J'           |
|           |                                                     | 8M x 64              | ASCII '11N8645CB'R'-60J'           |
|           |                                                     | 8M x 72              | ASCII '11N8735BB'R'-60J'           |
|           |                                                     | 8M x 72              | ASCII '11N8735CB'R'-60J'           |
| 91 - 92   | Assembly Revision Code                              | "R" plus ASCII blank | rr20                               |
| 93 - 94   | Assembly Manufacturing Date                         | Week/Year Code       | wwyy                               |
| 95 - 98   | Assembly Serial Number                              | Serial Number        | ssssssss                           |
| 99 - 127  | Reserved                                            | Undefined            | 00                                 |
| 128 - 255 | Unused Storage Locations                            | Undefined            | 00                                 |

cc = Checksum Data byte, 00-FF (Hex)  
 "R" = Alphanumeric revision code, A-Z, 0-9  
 rr = ASCII coded revision code byte "R"  
 ww = Binary coded decimal week code, 00-53 (Decimal) → 00-35 (Hex)  
 yy = Binary coded decimal year code, 00-99 (Decimal) → 00-63 (Hex)  
 ss = Serial number data byte, 00-FF (Hex)



## Absolute Maximum Ratings

| Symbol                                                                                                                                                                                                                                                                                                                                                                                                         | Parameter                        |     | Rating (3.3V)                            |                  | Units | Notes |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|-----|------------------------------------------|------------------|-------|-------|
| V <sub>CC</sub>                                                                                                                                                                                                                                                                                                                                                                                                | Power Supply Voltage             |     | -0.5 to +4.6                             |                  | V     | 1     |
| V <sub>IN</sub>                                                                                                                                                                                                                                                                                                                                                                                                | Input Voltage                    |     | -0.5 to min (V <sub>CC</sub> + 0.5, 4.6) |                  | V     | 1     |
| V <sub>IN/OUT</sub> (SPD)                                                                                                                                                                                                                                                                                                                                                                                      | Input Voltage (Serial PD Device) |     | -0.3 to +6.5                             |                  | V     | 1     |
| V <sub>OUT</sub>                                                                                                                                                                                                                                                                                                                                                                                               | Output Voltage                   |     | -0.5 to min (V <sub>CC</sub> + 0.5, 4.6) |                  | V     | 1     |
| T <sub>OPR</sub>                                                                                                                                                                                                                                                                                                                                                                                               | Operating Temperature            |     | 0 to +70                                 |                  | °C    | 1     |
| T <sub>STG</sub>                                                                                                                                                                                                                                                                                                                                                                                               | Storage Temperature              |     | -55 to +125                              |                  | °C    | 1     |
| P <sub>D</sub>                                                                                                                                                                                                                                                                                                                                                                                                 | Power Dissipation                |     | 11/11 Addressing                         | 12/10 Addressing | W     | 1, 2  |
|                                                                                                                                                                                                                                                                                                                                                                                                                |                                  | x64 | 9.8                                      | 8.6              |       |       |
|                                                                                                                                                                                                                                                                                                                                                                                                                |                                  | x72 | 11                                       | 9.7              |       |       |
| I <sub>OUT</sub>                                                                                                                                                                                                                                                                                                                                                                                               | Short Circuit Output Current     |     | 50                                       |                  | mA    | 1     |
| <div>1. Stresses greater than those listed 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 is not implied. Exposure to absolute maximum rating condition for extended periods may affect reliability.</div> <div>2. Maximum power occurs when all banks are active (refresh cycle).</div> |                                  |     |                                          |                  |       |       |

## Recommended DC Operating Conditions ( $T_A = 0$ to $70^\circ\text{C}$ )

| Symbol                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Parameter          | 3.3V |     |                | Units | Notes |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|------|-----|----------------|-------|-------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                    | Min  | Typ | Max            |       |       |
| $V_{CC}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Supply Voltage     | 3.0  | 3.3 | 3.6            | V     | 1     |
| $V_{IH}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Input High Voltage | 2.0  | —   | $V_{CC} + 0.5$ | V     | 1, 2  |
| $V_{IL}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Input Low Voltage  | -0.5 | —   | 0.8            | V     | 1, 2  |
| <p>1. All voltages referenced to <math>V_{SS}</math>.</p> <p>2. <math>V_{IH}</math> may overshoot to <math>V_{CC} + 1.2\text{V}</math> for pulse widths of <math>\leq 4.0\text{ns}</math> (or <math>V_{CC} + 1.0\text{V}</math> for <math>\leq 8.0\text{ns}</math>). Additionally, <math>V_{IL}</math> may undershoot to <math>-2.0\text{V}</math> for pulse widths <math>\leq 4.0\text{ns}</math> (or <math>-1.0\text{V}</math> for <math>\leq 8.0\text{ns}</math>). Pulse widths measured at 50% points with amplitude measured peak to DC reference.</p> |                    |      |     |                |       |       |

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

| Symbol    | Parameter                                               | Max |     | Units |
|-----------|---------------------------------------------------------|-----|-----|-------|
|           |                                                         | x64 | x72 |       |
| $C_{I1}$  | Input Capacitance (A0-A11)                              | 160 | 200 | pF    |
| $C_{I2}$  | Input Capacitance ( $\overline{RAS}$ )                  | 70  | 75  | pF    |
| $C_{I3}$  | Input Capacitance ( $\overline{WE}$ , $\overline{OE}$ ) | 90  | 100 | pF    |
| $C_{I4}$  | Input Capacitance ( $\overline{CAS}$ )                  | 40  | 50  | pF    |
| $C_{I5}$  | Input Capacitance ( $\overline{SCL}$ , SA0-3)           | 8   | 8   | pF    |
| $C_{IO1}$ | Input/Output Capacitance (DQx, CBx)                     | 22  | 22  | pF    |
| $C_{IO2}$ | Input/Output Capacitance (SDA)                          | 10  | 10  | pF    |

## DC Electrical Characteristics (T<sub>A</sub> = 0 to +70°C, V<sub>CC</sub> = 3.3V ± 0.3V)

| Symbol            | Parameter                                                                                                                                                                                         |                                                 | 11/11 Addressing |                 |      |                 | 12/10 Addressing |                 |      |                 | Units | Notes   |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|------------------|-----------------|------|-----------------|------------------|-----------------|------|-----------------|-------|---------|
|                   |                                                                                                                                                                                                   |                                                 | x64              |                 | x72  |                 | x64              |                 | x72  |                 |       |         |
|                   |                                                                                                                                                                                                   |                                                 | Min.             | Max.            | Min. | Max.            | Min.             | Max.            | Min. | Max.            |       |         |
| I <sub>CC1</sub>  | Operating Current                                                                                                                                                                                 | -60                                             | —                | 1392            | —    | 1566            | —                | 1232            | —    | 1386            | mA    | 1, 2, 3 |
|                   | Average Power Supply Operating Current<br>( $\overline{\text{RAS}}$ , $\overline{\text{CAS}}$ , Address Cycling: $t_{\text{RC}} = t_{\text{RC min.}}$ )                                           | -70                                             | —                | 1232            | —    | 1386            | —                | 1072            | —    | 1206            |       |         |
| I <sub>CC2</sub>  | Standby Current (TTL)<br>Power Supply Standby Current<br>( $\overline{\text{RAS}} = \overline{\text{CAS}} = V_{\text{IH}}$ )                                                                      |                                                 | —                | 64              | —    | 72              | —                | 64              | —    | 72              | mA    |         |
| I <sub>CC3</sub>  | $\overline{\text{RAS}}$ Only Refresh Current                                                                                                                                                      | -60                                             | —                | 1392            | —    | 1566            | —                | 1232            | —    | 1386            | mA    | 1, 3    |
|                   | Average Power Supply Current, $\overline{\text{RAS}}$ Only Mode<br>( $\overline{\text{RAS}}$ Cycling, $\overline{\text{CAS}} = V_{\text{IH}}$ ; $t_{\text{RC}} = t_{\text{RC min}}$ )             | -70                                             | —                | 1232            | —    | 1386            | —                | 1072            | —    | 1206            |       |         |
| I <sub>CC4</sub>  | EDO Page Mode Current                                                                                                                                                                             | -60                                             | —                | 1072            | —    | 1206            | —                | 1072            | —    | 1206            | mA    | 1, 2, 3 |
|                   | Average Power Supply Current, EDO Page Mode<br>( $\overline{\text{RAS}} = V_{\text{IL}}$ , $\overline{\text{CAS}}$ , Address Cycling: $t_{\text{HPC}} = t_{\text{HPC min}}$ )                     | -70                                             | —                | 912             | —    | 1026            | —                | 912             | —    | 1026            |       |         |
| I <sub>CC5</sub>  | Standby Current (CMOS)<br>Power Supply Standby Current<br>( $\overline{\text{RAS}} = \overline{\text{CAS}} = V_{\text{CC}} - 0.2\text{V}$ )                                                       |                                                 | —                | 32              | —    | 36              | —                | 32              | —    | 36              | mA    |         |
| I <sub>CC6</sub>  | $\overline{\text{CAS}}$ Before $\overline{\text{RAS}}$ Refresh Current                                                                                                                            | -60                                             | —                | 1392            | —    | 1566            | —                | 1232            | —    | 1386            | mA    | 1, 3, 4 |
|                   | Average Power Supply Current, $\overline{\text{CAS}}$ Before $\overline{\text{RAS}}$ Mode<br>( $\overline{\text{RAS}}$ , $\overline{\text{CAS}}$ , Cycling: $t_{\text{RC}} = t_{\text{RC min}}$ ) | -70                                             | —                | 1232            | —    | 1386            | —                | 1072            | —    | 1206            |       |         |
| 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                                  | $\overline{\text{RAS}}$                         | -80              | +80             | -90  | +90             | -80              | +80             | -90  | +90             | μA    |         |
|                   |                                                                                                                                                                                                   | $\overline{\text{WE}}$ , $\overline{\text{OE}}$ | -160             | +160            | -180 | +180            | -160             | +160            | -180 | +180            |       |         |
|                   |                                                                                                                                                                                                   | $\overline{\text{CAS}}$                         | -40              | +40             | -60  | +60             | -40              | +40             | -60  | +60             |       |         |
|                   |                                                                                                                                                                                                   | Address                                         | -320             | +320            | -360 | +360            | -320             | +320            | -360 | +360            |       |         |
| I <sub>O(L)</sub> | Output Leakage Current<br>( $\text{D}_{\text{OUT}}$ is disabled, $0.0 \leq V_{\text{OUT}} \leq V_{\text{CC}}$ )                                                                                   |                                                 | -20              | +20             | -20  | +20             | -20              | +20             | -20  | +20             | μA    |         |
| V <sub>OH</sub>   | Output Level (TTL)<br>Output “H” Level Voltage<br>( $I_{\text{OUT}} = -2.5\text{mA}$ )                                                                                                            |                                                 | 2.4              | V <sub>CC</sub> | 2.4  | V <sub>CC</sub> | 2.4              | V <sub>CC</sub> | 2.4  | V <sub>CC</sub> | V     |         |
| V <sub>OL</sub>   | Output Level (TTL)<br>Output “L” Level Voltage<br>( $I_{\text{OUT}} = +2.1\text{mA}$ )                                                                                                            |                                                 | 0.0              | 0.4             | 0.0  | 0.4             | 0.0              | 0.4             | 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.
2. I<sub>CC1</sub> and I<sub>CC4</sub> depend on output loading. Specified values are obtained with the output open.
3. Address can be changed once or less while  $\overline{\text{RAS}}$  = V<sub>IL</sub>. In the case of I<sub>CC4</sub>, it can be changed once or less when  $\overline{\text{CAS}}$  = V<sub>IH</sub>.
4. Refresh current is specified for 1 bank active and 1 bank standby.



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

- $V_{IH}$  (min) and  $V_{IL}$  (max) are reference levels for measuring timing of input signals. Transition times are measured between  $V_{IH}$  and  $V_{IL}$ .
- 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 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..
- AC measurements assume  $t_T = 2\text{ns}$ .

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

| Symbol                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Parameter                                                         | -60 |     | -70 |     | Unit | Notes |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|-----|-----|-----|-----|------|-------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                   | Min | Max | Min | Max |      |       |
| $t_{RC}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Random Read or Write Cycle Time                                   | 104 | —   | 124 | —   | ns   |       |
| $t_{RP}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | $\overline{\text{RAS}}$ Precharge Time                            | 40  | —   | 50  | —   | ns   |       |
| $t_{CP}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | $\overline{\text{CAS}}$ Precharge Time                            | 10  | —   | 10  | —   | ns   |       |
| $t_{RAS}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | $\overline{\text{RAS}}$ Pulse Width                               | 60  | 10K | 70  | 10K | ns   |       |
| $t_{CAS}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | $\overline{\text{CAS}}$ Pulse Width                               | 10  | 10K | 12  | 10K | ns   |       |
| $t_{ASR}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Row Address Setup Time                                            | 0   | —   | 0   | —   | ns   |       |
| $t_{RAH}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Row Address Hold Time                                             | 10  | —   | 10  | —   | ns   |       |
| $t_{ASC}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Column Address Setup Time                                         | 0   | —   | 0   | —   | ns   |       |
| $t_{CAH}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Column Address Hold Time                                          | 10  | —   | 10  | —   | ns   |       |
| $t_{RCD}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | $\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ Delay Time     | 14  | 45  | 14  | 50  | ns   | 1     |
| $t_{RAD}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | $\overline{\text{RAS}}$ to Column Address Delay Time              | 12  | 30  | 12  | 35  | ns   | 2     |
| $t_{RSH}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | $\overline{\text{RAS}}$ Hold Time                                 | 10  | —   | 12  | —   | ns   |       |
| $t_{CSH}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | $\overline{\text{CAS}}$ Hold Time                                 | 50  | —   | 55  | —   | ns   |       |
| $t_{CRP}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | $\overline{\text{CAS}}$ to $\overline{\text{RAS}}$ Precharge Time | 5   | —   | 5   | —   | ns   |       |
| $t_{ODD}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | $\overline{\text{OE}}$ to $D_{IN}$ Delay Time                     | 15  | —   | 15  | —   | ns   | 3     |
| $t_{DZO}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | $\overline{\text{OE}}$ Delay Time from $D_{IN}$                   | 0   | —   | 0   | —   | ns   | 4     |
| $t_{DZC}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | $\overline{\text{CAS}}$ Delay Time from $D_{IN}$                  | 0   | —   | 0   | —   | ns   | 4     |
| $t_T$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Transition Time (Rise and Fall)                                   | 2   | 30  | 2   | 30  | ns   |       |
| <ol style="list-style-type: none"><li>Operation within the <math>t_{RCD}(\text{max})</math> limit ensures that <math>t_{RAC}(\text{max})</math> can be met. The <math>t_{RCD}(\text{max})</math> is specified as a reference point only: If <math>t_{RCD}</math> is greater than the specified <math>t_{RCD}(\text{max})</math> limit, then access time is controlled by <math>t_{CAC}</math>.</li><li>Operation within the <math>t_{RAD}(\text{max})</math> limit ensures that <math>t_{RAC}(\text{max})</math> can be met. The <math>t_{RAD}(\text{max})</math> is specified as a reference point only: If <math>t_{RAD}</math> is greater than the specified <math>t_{RAD}(\text{max})</math> limit, then access time is controlled by <math>t_{AA}</math>.</li><li>Either <math>t_{CDD}</math> or <math>t_{ODD}</math> must be satisfied.</li><li>Either <math>t_{DZC}</math> or <math>t_{DZO}</math> must be satisfied.</li></ol> |                                                                   |     |     |     |     |      |       |

## Write Cycle

| Symbol                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Parameter                                   | -60 |     | -70 |     | Unit | Notes |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|-----|-----|-----|-----|------|-------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                             | Min | Max | Min | Max |      |       |
| $t_{WCS}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Write Command Set Up Time                   | 0   | —   | 0   | —   | ns   | 1     |
| $t_{WCH}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Write Command Hold Time                     | 10  | —   | 12  | —   | ns   |       |
| $t_{WP}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Write Command Pulse Width                   | 10  | —   | 12  | —   | ns   |       |
| $t_{RWL}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Write Command to $\overline{RAS}$ Lead Time | 10  | —   | 12  | —   | ns   |       |
| $t_{CWL}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Write Command to $\overline{CAS}$ Lead Time | 10  | —   | 12  | —   | ns   |       |
| $t_{DS}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | $D_{IN}$ Setup Time                         | 0   | —   | 0   | —   | ns   | 2     |
| $t_{DH}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | $D_{IN}$ Hold Time                          | 10  | —   | 12  | —   | ns   | 2     |
| <p>1. <math>t_{WCS}</math>, <math>t_{RWD}</math>, <math>t_{CWD}</math>, and <math>t_{AWD}</math> are not restrictive parameters. They are included in the data sheet as electrical characteristics only. If <math>t_{WCS} \geq t_{WCS}(\text{min.})</math>, the entire cycle is an early write cycle and the data pin will remain open circuit (high impedance) through the entire cycle; If <math>t_{RWD} \geq t_{RWD}(\text{min.})</math>, <math>t_{CWD} \geq t_{CWD}(\text{min.})</math> and <math>t_{AWD} \geq t_{AWD}(\text{min.})</math>, the cycle is a Read-Modify-Write cycle and the data will contain read from the selected cell; If neither of the above sets of conditions are met, the condition of the data (at access time) is indeterminate.</p> <p>2. Data-in set-up and hold is measured from the latter of the two timings, <math>\overline{CAS}</math> or <math>\overline{WE}</math>.</p> |                                             |     |     |     |     |      |       |



## Read Cycle

| Symbol                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Parameter                                                             | -60 |     | -70 |     | Unit | Notes |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|-----|-----|-----|-----|------|-------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                       | Min | Max | Min | Max |      |       |
| $t_{RAC}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Access Time from $\overline{RAS}$                                     | —   | 60  | —   | 70  | ns   | 1, 2  |
| $t_{CAC}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Access Time from $\overline{CAS}$                                     | —   | 15  | —   | 20  | ns   | 1, 2  |
| $t_{AA}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Access Time from Address                                              | —   | 30  | —   | 35  | ns   | 1, 2  |
| $t_{OEA}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Access Time from $\overline{OE}$                                      | —   | 15  | —   | 20  | ns   | 1, 2  |
| $t_{RCS}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Read Command Setup Time                                               | 0   | —   | 0   | —   | ns   |       |
| $t_{RCH}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Read Command Hold Time to $\overline{CAS}$                            | 0   | —   | 0   | —   | ns   | 3     |
| $t_{RRH}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Read Command Hold Time to $\overline{RAS}$                            | 0   | —   | 0   | —   | ns   | 3     |
| $t_{RAL}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Column Address to $\overline{RAS}$ Lead Time                          | 30  | —   | 35  | —   | ns   |       |
| $t_{CLZ}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | $\overline{CAS}$ to Output in Low-Z                                   | 0   | —   | 0   | —   | ns   |       |
| $t_{OES}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | $\overline{OE}$ setup time prior to $\overline{CAS}$                  | 5   | —   | 5   | —   | ns   |       |
| $t_{ORD}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | $\overline{OE}$ setup time prior to $\overline{RAS}$ (Hidden Refresh) | 0   | —   | 0   | —   | ns   |       |
| $t_{CDD}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | $\overline{CAS}$ to $D_{IN}$ Delay Time                               | 15  | —   | 15  | —   | ns   | 5     |
| $t_{OEZ}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Output Buffer Turn-off Delay from $\overline{OE}$                     | —   | 15  | —   | 15  | ns   | 4     |
| $t_{OFF}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Output Buffer Turn-off Delay                                          | —   | 15  | —   | 15  | ns   | 4, 6  |
| <ol style="list-style-type: none"><li>1. Measured with the specified current load and 100pF.</li><li>2. Access time is determined by the latter of <math>t_{RAC}</math>, <math>t_{CAC}</math>, <math>t_{CPA}</math>, <math>t_{AA}</math>, <math>t_{OEA}</math>.</li><li>3. Either <math>t_{RCH}</math> or <math>t_{RRH}</math> must be satisfied.</li><li>4. <math>t_{OFF}</math> (max) and <math>t_{OEZ}</math> (max) define the time at which the output achieves the open circuit condition and is not referenced to output voltage levels.</li><li>5. Either <math>t_{CDD}</math> or <math>t_{ODD}</math> must be satisfied.</li><li>6. <math>t_{OFF}</math> is referenced from the rising edge of <math>\overline{RAS}</math> or <math>\overline{CAS}</math>, whichever is last.</li></ol> |                                                                       |     |     |     |     |      |       |

## Read-Modify-Write Cycle

| Symbol    | Parameter                                      | -60 |     | -70 |     | Unit | Notes |
|-----------|------------------------------------------------|-----|-----|-----|-----|------|-------|
|           |                                                | Min | Max | Min | Max |      |       |
| $t_{RWC}$ | Read-Modify-Write Cycle Time                   | 135 | —   | 162 | —   | ns   |       |
| $t_{RWD}$ | $\overline{RAS}$ to $\overline{WE}$ Delay Time | 79  | —   | 94  | —   | ns   | 1     |
| $t_{CWD}$ | $\overline{CAS}$ to $\overline{WE}$ Delay Time | 34  | —   | 44  | —   | ns   | 1     |
| $t_{AWD}$ | Column Address to $\overline{WE}$ Delay Time   | 49  | —   | 59  | —   | ns   | 1     |
| $t_{OEH}$ | $\overline{OE}$ Command Hold Time              | 10  | —   | 12  | —   | ns   |       |

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

## EDO Mode Cycle

| Symbol      | Parameter                                                              | -60  |      | -70  |      | Units | Notes |
|-------------|------------------------------------------------------------------------|------|------|------|------|-------|-------|
|             |                                                                        | Min. | Max. | Min. | Max. |       |       |
| $t_{HCAS}$  | $\overline{CAS}$ Pulse Width (EDO Page Mode)                           | 10   | 10K  | 12   | 10K  | ns    |       |
| $t_{HPC}$   | EDO Page Mode Cycle Time (Read/Write)                                  | 25   | —    | 30   | —    | ns    |       |
| $t_{HPRWC}$ | EDO Page Mode Read Modify Write Cycle Time                             | 60   | —    | 72   | —    | ns    |       |
| $t_{DOH}$   | Data-out Hold Time from $\overline{CAS}$                               | 5    | —    | 5    | —    | ns    |       |
| $t_{WHZ}$   | Output buffer Turn-Off Delay from $\overline{WE}$                      | 0    | 10   | 0    | 15   | ns    |       |
| $t_{WPZ}$   | $\overline{WE}$ Pulse Width to Output Disable at $\overline{CAS}$ High | 10   | —    | 10   | —    | ns    |       |
| $t_{CPRH}$  | $\overline{RAS}$ Hold Time from $\overline{CAS}$ Precharge             | 35   | —    | 40   | —    | ns    |       |
| $t_{CPA}$   | Access Time from $\overline{CAS}$ Precharge                            | —    | 35   | —    | 40   | ns    | 1     |
| $t_{RASP}$  | EDO Page Mode $\overline{RAS}$ Pulse Width                             | 60   | 125K | 70   | 125K | ns    |       |
| $t_{OEP}$   | $\overline{OE}$ High Pulse Width                                       | 10   | —    | 10   | —    | ns    |       |
| $t_{OEHC}$  | $\overline{OE}$ High Hold Time from $\overline{CAS}$ High              | 10   | —    | 10   | —    | ns    |       |

1. Measured with the specified current load and 100pF at  $V_{OL} = 0.8V$  and  $V_{OH} = 2.0V$ .



## Refresh Cycle

| Symbol    | Parameter                                                                   | -60 |     | -70 |     | Unit | Notes |
|-----------|-----------------------------------------------------------------------------|-----|-----|-----|-----|------|-------|
|           |                                                                             | Min | Max | Min | Max |      |       |
| $t_{CHR}$ | CAS Hold Time<br>( $\overline{CAS}$ before $\overline{RAS}$ Refresh Cycle)  | 10  | —   | 10  | —   | ns   |       |
| $t_{CSR}$ | CAS Setup Time<br>( $\overline{CAS}$ before $\overline{RAS}$ Refresh Cycle) | 5   | —   | 5   | —   | ns   |       |
| $t_{WRP}$ | WE Setup Time<br>( $\overline{CAS}$ before $\overline{RAS}$ Refresh Cycle)  | 10  | —   | 10  | —   | ns   |       |
| $t_{WRH}$ | WE Hold Time<br>( $\overline{CAS}$ before $\overline{RAS}$ Refresh Cycle)   | 10  | —   | 10  | —   | ns   |       |
| $t_{RPC}$ | RAS Precharge to $\overline{CAS}$ Hold Time                                 | 5   | —   | 5   | —   | ns   |       |
| $t_{REF}$ | Refresh Period                                                              | —   | 32  | —   | 32  | ms   | 1     |
|           |                                                                             | —   | 64  | —   | 64  | ms   | 2     |

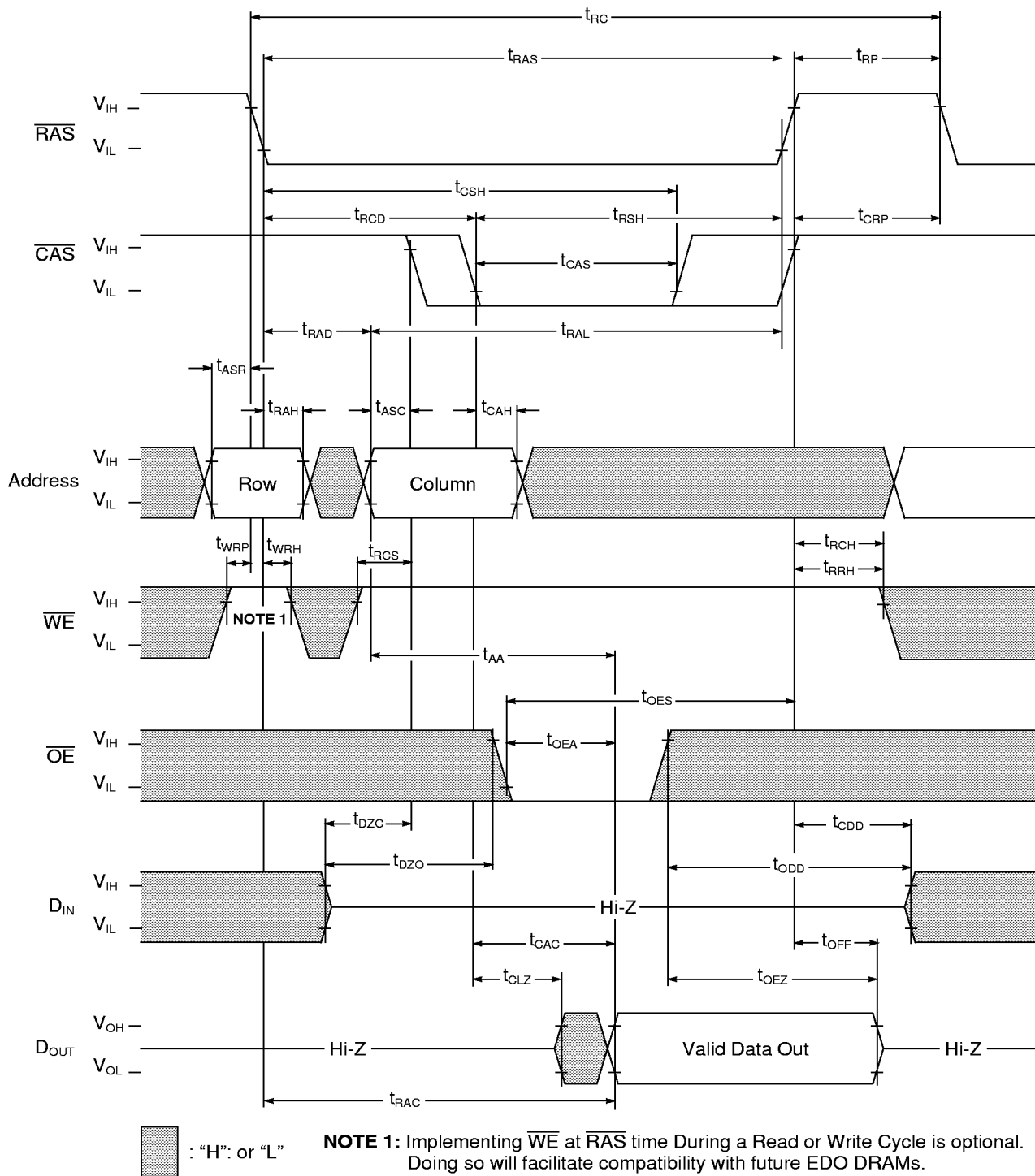
1. 2048 refreshes are required every 32ms (11/11 addressing).  
2. 4096 refreshes are required every 64ms (12/10 addressing).

## Presence Detect Read and Write Cycle

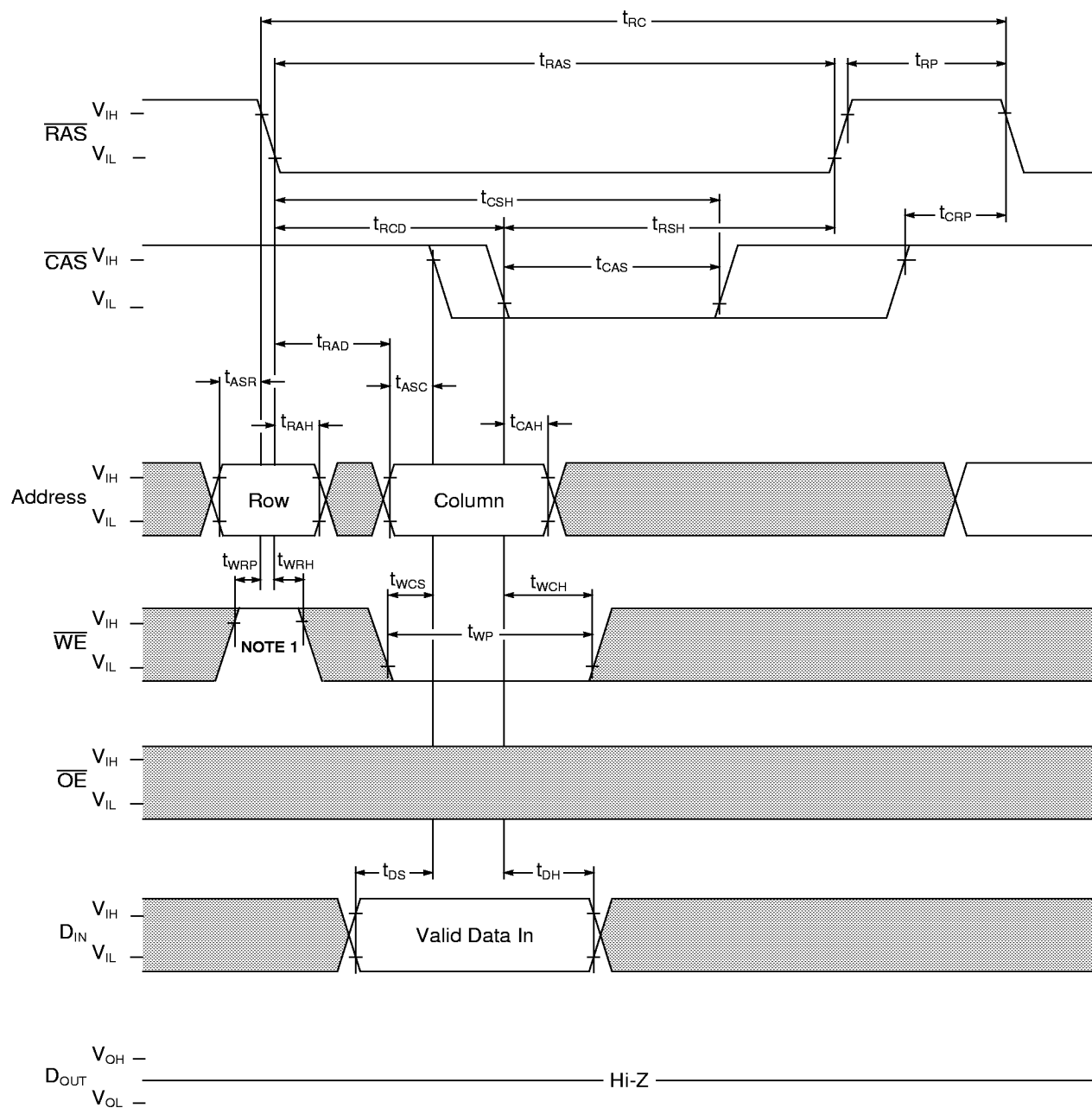
| Symbol       | Parameter                                                     | Min | Max | Unit    | Notes |
|--------------|---------------------------------------------------------------|-----|-----|---------|-------|
| $f_{SCL}$    | SCL Clock Frequency                                           |     | 100 | kHz     |       |
| $T_I$        | Noise Suppression Time Constant at SCL, SDA Inputs            |     | 100 | ns      |       |
| $t_{AA}$     | SCL Low to SDA Data Out Valid                                 | 0.3 | 3.5 | $\mu s$ |       |
| $t_{BUF}$    | Time the Bus Must Be Free before a New Transmission Can Start | 4.7 |     | $\mu s$ |       |
| $t_{HD:STA}$ | Start Condition Hold Time                                     | 4.0 |     | $\mu s$ |       |
| $t_{LOW}$    | Clock Low Period                                              | 4.7 |     | $\mu s$ |       |
| $t_{HIGH}$   | Clock High Period                                             | 4.0 |     | $\mu s$ |       |
| $t_{SU:STA}$ | Start Condition Setup Time(for a Repeated Start Condition)    | 4.7 |     | $\mu s$ |       |
| $t_{HD:DAT}$ | Data in Hold Time                                             | 0   |     | $\mu s$ |       |
| $t_{SU:DAT}$ | Data in Setup Time                                            | 250 |     | ns      |       |
| $t_r$        | SDA and SCL Rise Time                                         |     | 1   | $\mu s$ |       |
| $t_f$        | SDA and SCL Fall Time                                         |     | 300 | ns      |       |
| $t_{SU:STO}$ | Stop Condition Setup Time                                     | 4.7 |     | $\mu s$ |       |
| $t_{DH}$     | Data Out Hold Time                                            | 300 |     | ns      |       |
| $t_{WR}$     | Write Cycle Time                                              |     | 15  | ms      | 1     |

1. The write cycle time( $t_{WR}$ ) is the time from a valid stop condition of a write sequence to the end of the internal erase/program cycle. During the write cycle, the bus interface circuits are disabled, SDA is allowed to remain high per the bus-level pull-up resistor, and the device does not respond to its slave address.

## Read Cycle



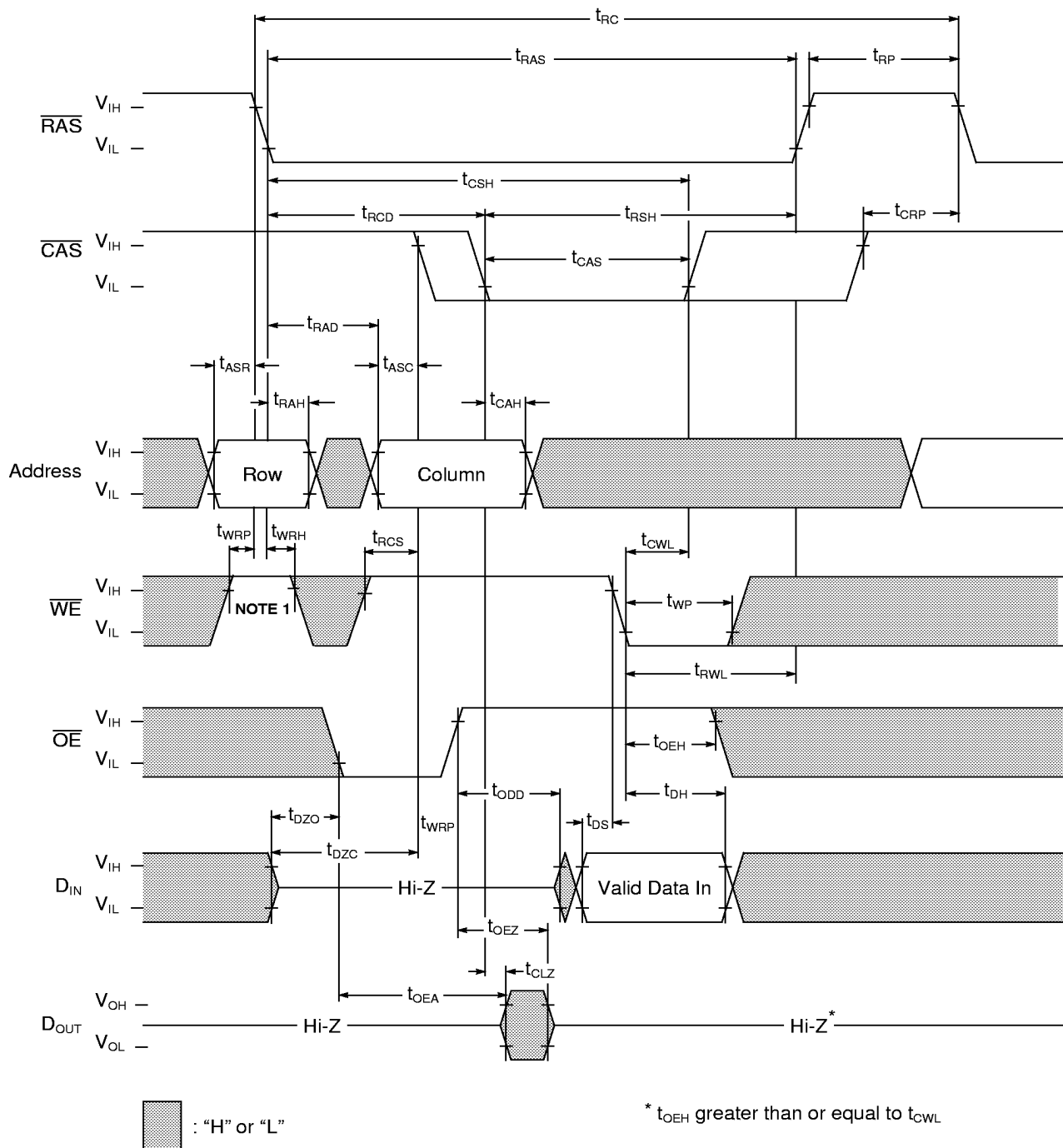
## Write Cycle (Early Write)



: "H" or "L"

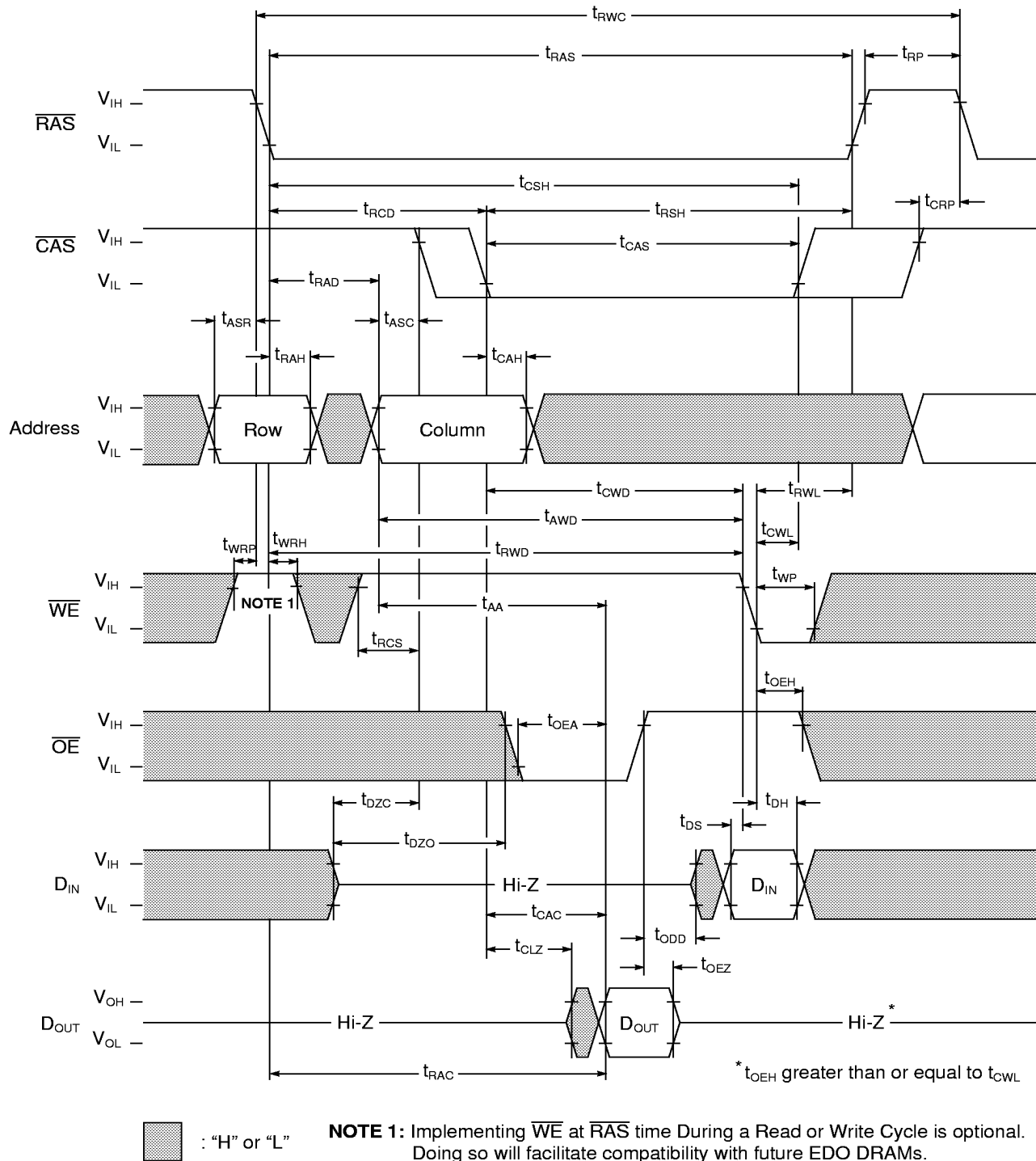
**NOTE 1:** Implementing  $\overline{WE}$  at  $\overline{RAS}$  time During a Read or Write Cycle is optional. Doing so will facilitate compatibility with future EDO DRAMs.

## Write Cycle (Late Write)



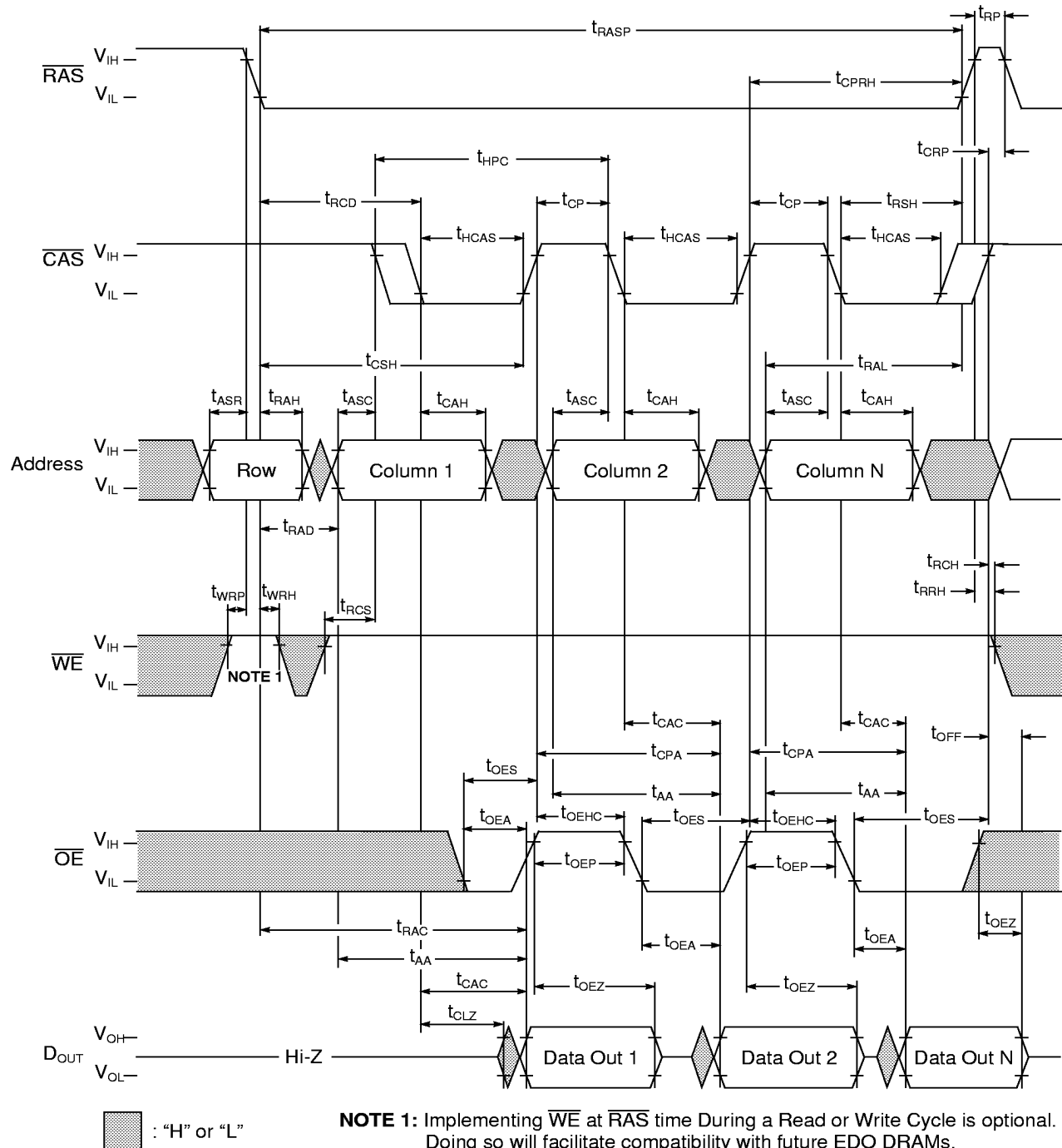
**NOTE 1:** Implementing  $\overline{\text{WE}}$  at  $\overline{\text{RAS}}$  time During a Read or Write Cycle is optional. Doing so will facilitate compatibility with future EDO DRAMs.

## Read-Modify-Write-Cycle





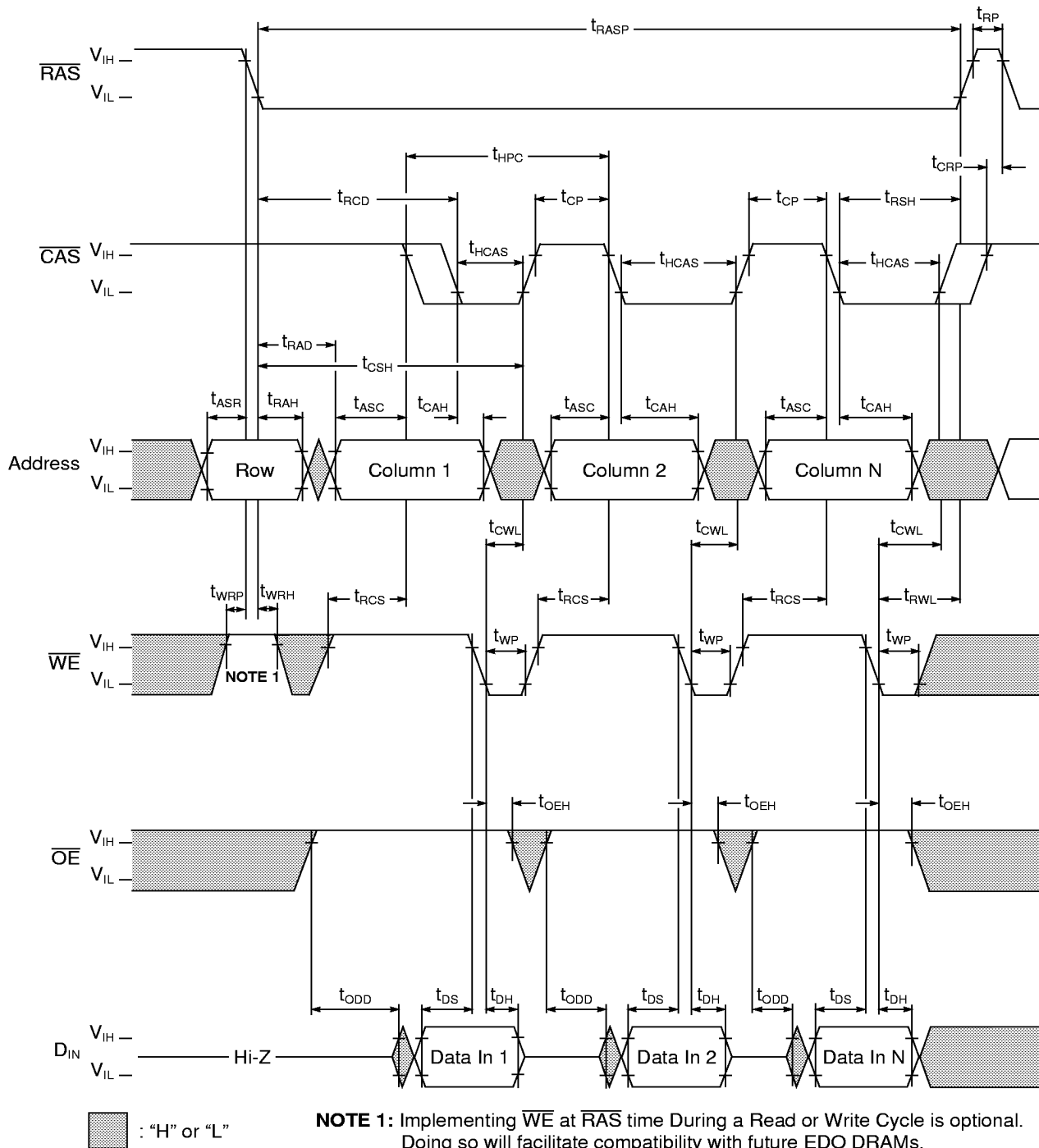
## EDO Page Mode Read Cycle ( $\overline{OE}$ Control)



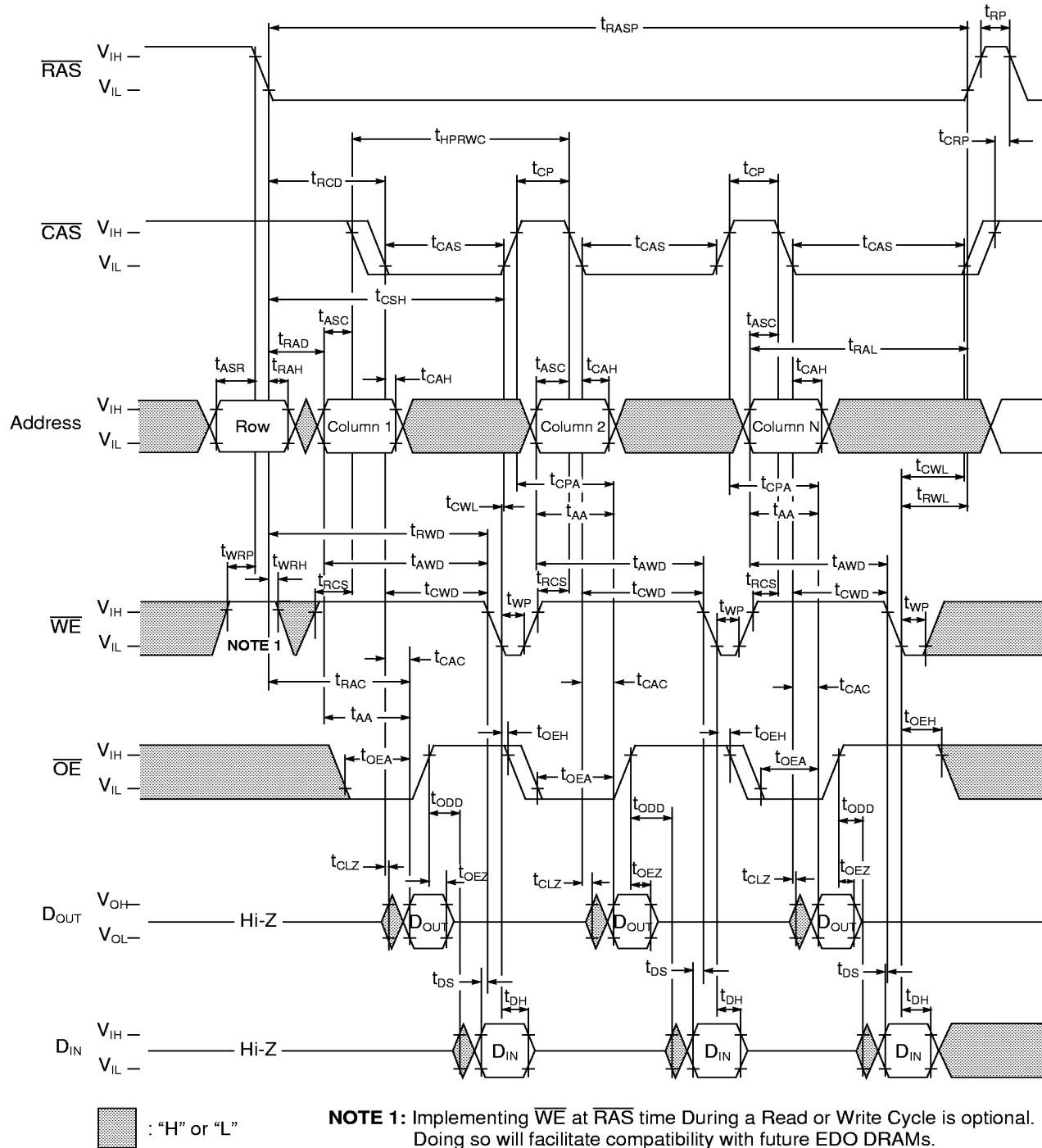
[illegible]



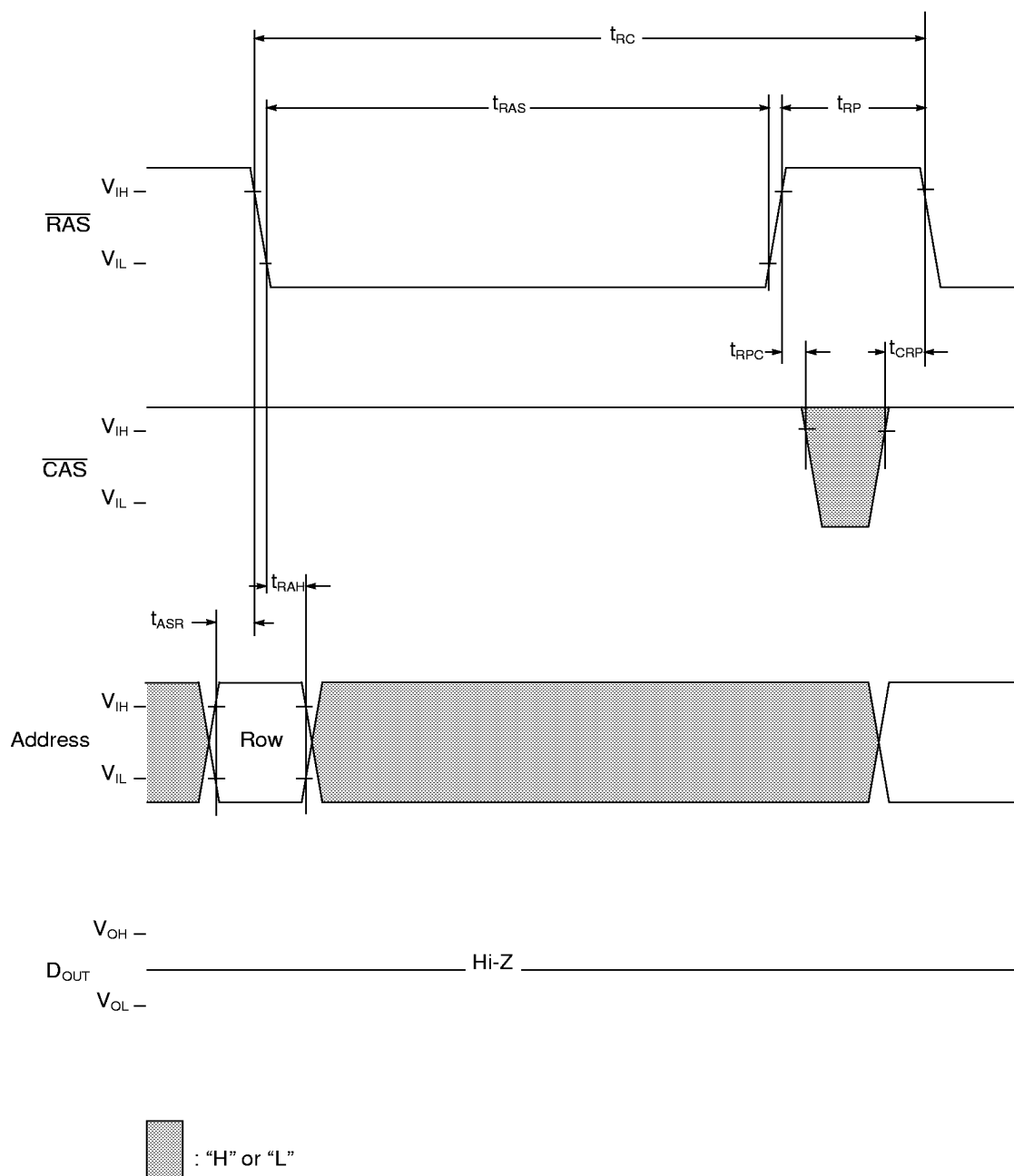
## EDO Page Mode Late Write Cycle



## EDO Page Mode Read Modify Write Cycle

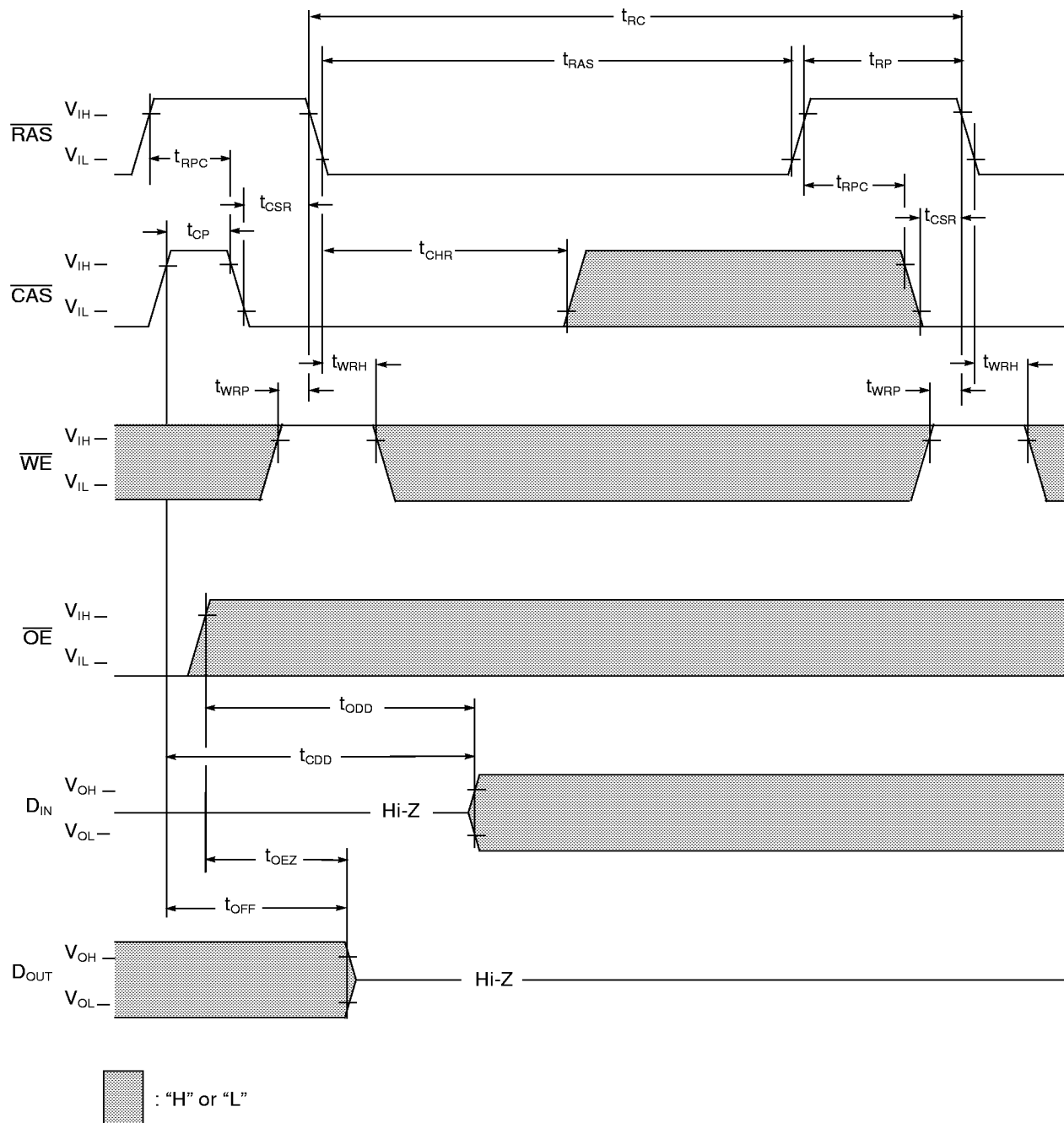


## RAS Only Refresh Cycle



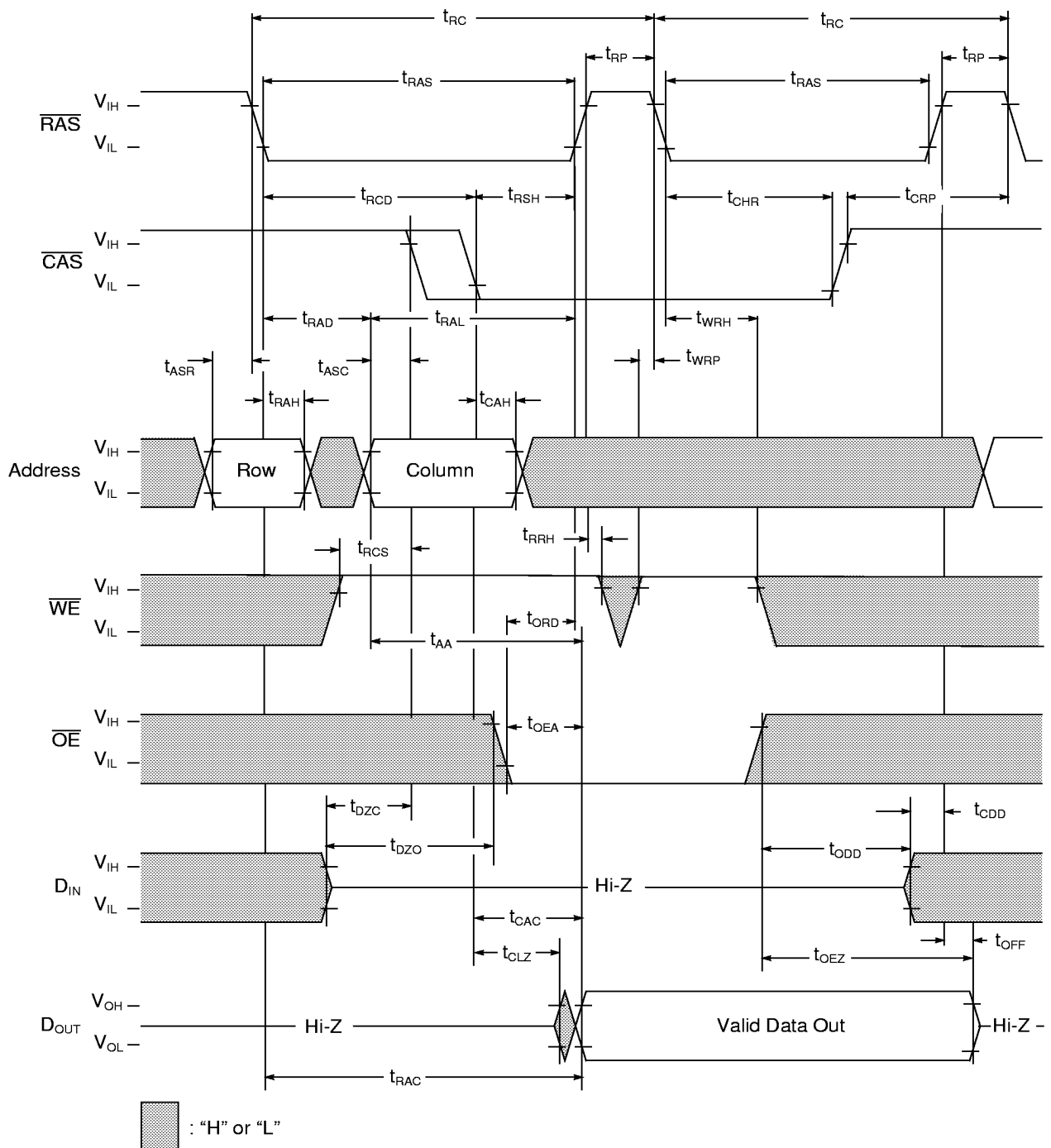
Note:  $\overline{\text{WE}}$ ,  $\overline{\text{OE}}$ ,  $D_{\text{IN}}$  are "H" or "L"

## CAS Before RAS Refresh Cycle

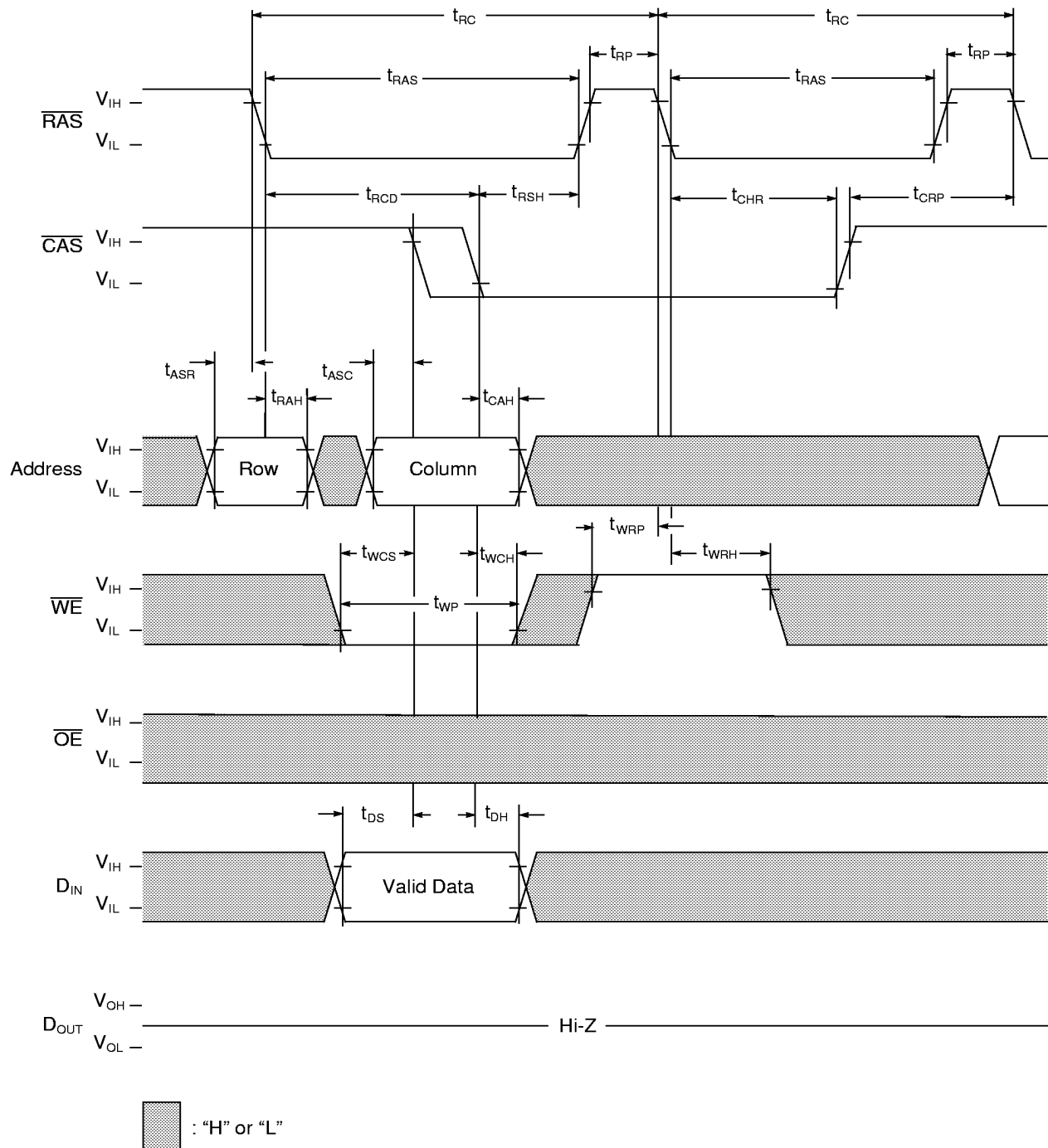


NOTE: Address is "H" or "L"

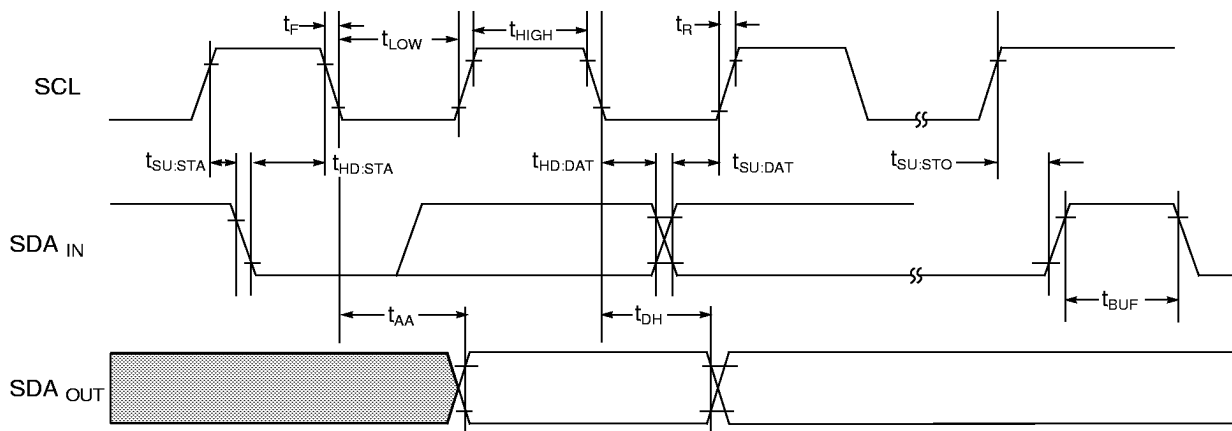
## Hidden Refresh Cycle (Read)



## Hidden Refresh Cycle (Write)



## Presence Detect (EEPROM) Bus Timing



## Presence Detect Operation

**Clock and Data Conventions:** Data states on the SDA line can change only during SCL low. SDA state changes during SCL HIGH are reserved for indicating start and stop conditions (Figure 1 & Figure 2).

**Start Condition:** All commands are preceded by the start condition, which is a HIGH to LOW transition of SDA when SCL is high. The serial PD device continuously monitors the SDA and SCL lines for the start condition and will not respond to any command until this condition has been met.

**Stop Condition:** All communications are terminated by a stop condition, which is a LOW to HIGH transition of SDA when SCL is HIGH. The stop condition is also used to place the serial PD device into standby power mode.

**Acknowledge:** Acknowledge is a software convention used to indicate successful data transfers. The transmitting device, either master or slave, will release the bus after transmitting eight bits. During the ninth clock cycle the receiver will pull the SDA line LOW to acknowledge that it received the eight bits of data (Figure 3).

The PD device will always respond with an acknowledge after recognition of a start condition and its slave address. If both the device and a write operation have been selected, The PD device, will respond with an acknowledge after the receipt of each subsequent eight bit word. In the read mode the PD device will transmit eight bits of data, release the SDA line and monitor the line for an

acknowledge. If an acknowledge is detected and no stop condition is generated by the master, the slave will continue to transmit data. If an acknowledge is not detected, the slave will terminate further data transmissions and await the stop condition to return to standby power mode.

Figure 1. Data Window

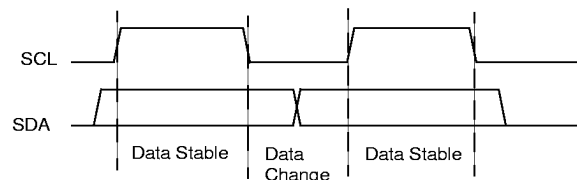


Figure 2. Definition of Start & Stop

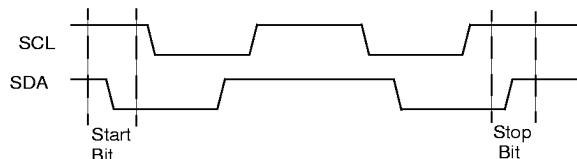
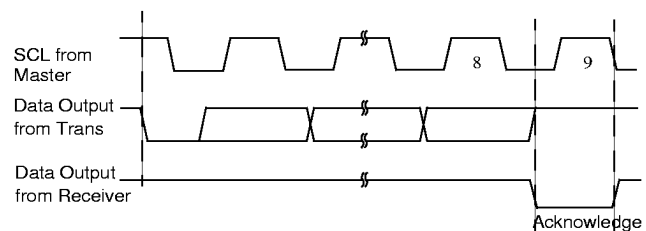
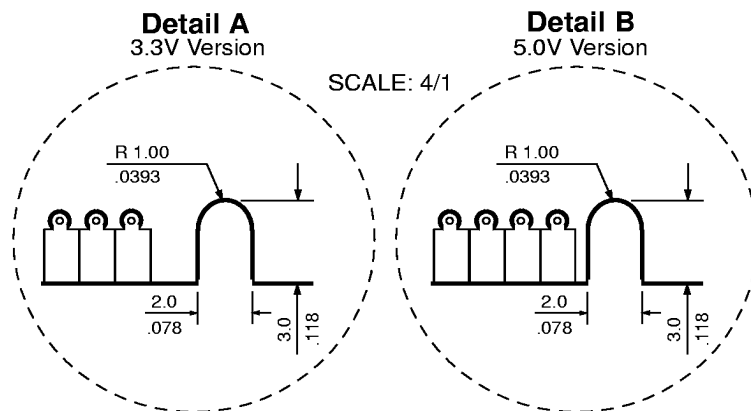
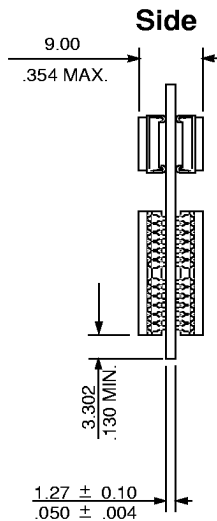
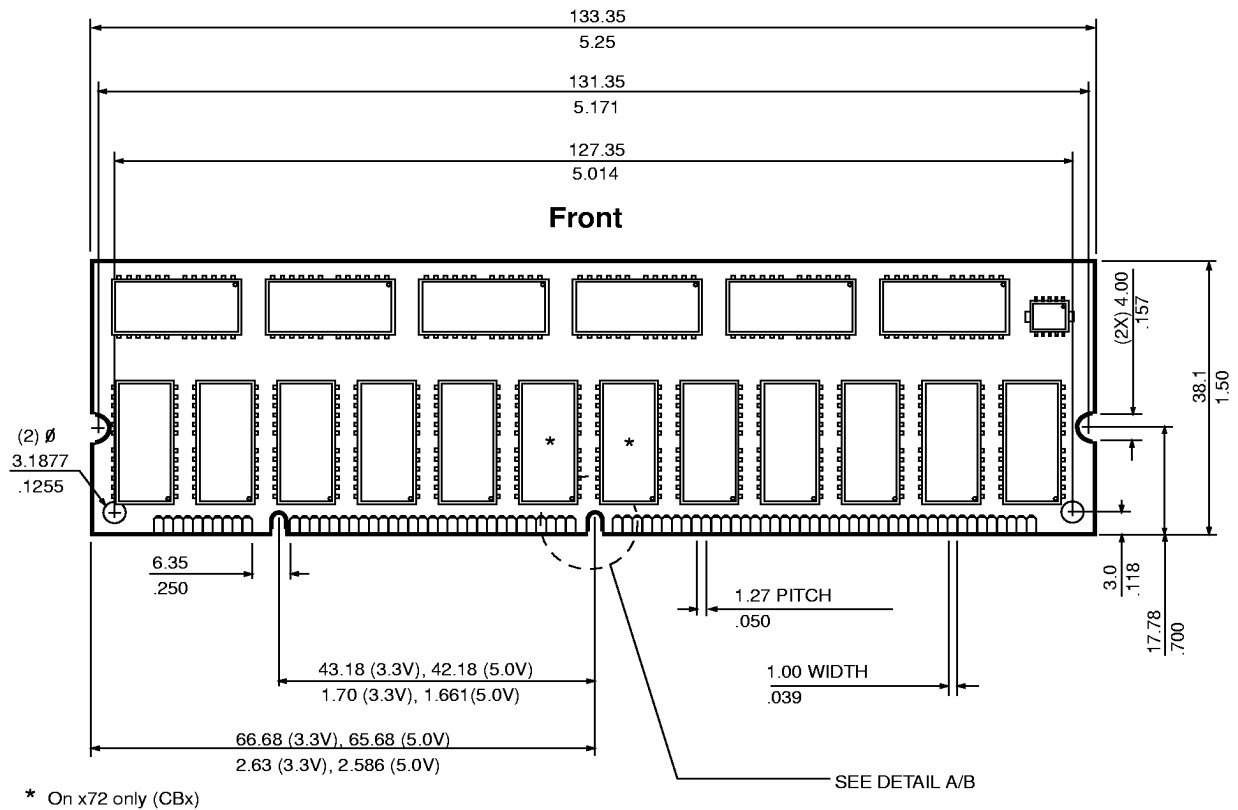


Figure 3. Acknowledge Response From Receiver



## Layout Drawing



**Note:** All dimensions are typical unless otherwise stated. Millimeters  
Inches



## Revision Log

| Rev   | Contents of Modification                                                                |
|-------|-----------------------------------------------------------------------------------------|
| 3/96  | Initial Release.                                                                        |
| 5/96  | Updated ordering information.<br>Added bytes 13 and 14 to Serial Presence Detect table. |
| 8/96  | Fixed typos.                                                                            |
| 12/96 | Added new Serial PD table.<br>Updated ordering information.                             |