Preliminary

1M x 64 DRAM MODULE

Features

- 168 Pin JEDEC Standard, 8 Byte Dual In-line Memory Module
- 1Mx64 Extended Data Out Page Mode DIMM
- Performance:

		-60	-70
t_{RAC}	$\overline{RAS}$ Access Time	60ns	70ns
t_{CAC}	$\overline{CAS}$ Access Time	20ns	25ns
t_{AA}	Access Time From Address	35ns	40ns
t_{RC}	Cycle Time	104ns	124ns
t_{HPC}	EDO Mode Cycle Time	25ns	30ns

- All inputs and outputs are TTL (5.0V) compatible
- Single 5.0V ± 0.5V Power Supply
- Au contacts
- Optimized for byte-write non-parity applications
- System Performance Benefits:
  -Buffered inputs (except $\overline{RAS}$, Data)
  -Reduced noise (32 V_{SS}/V_{CC} pins)
  -4 Byte Interleave enabled
  -Byte write, byte read accesses
  -Buffered PDs
- Extended Data Out (EDO) Mode, Read-Modify-Write Cycles
- Refresh Modes: $\overline{RAS}$-Only, CBR and Hidden Refresh
- 1024 refresh cycles distributed across 16ms
- 10/10 addressing (Row/Column)
- Card size::
  -5.25" x 1.0" x 0.111" (TSOP)
  -5.25" x 1.0" x 0.212" (SOJ)
- DRAMS in TSOP or SOJ Package

Description

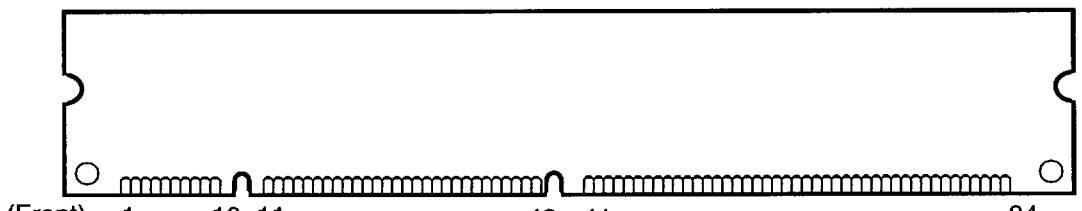
IBM11M1645L is an industry standard 168-pin 8-byte Dual In-line Memory Module (DIMM) which is organized as a 1Mx64 high speed memory array designed with EDO DRAMs for non-parity applications. The DIMM uses 4 1Mx16 EDO DRAMs in TSOP or SOJ packages. The use of EDO DRAMs allows for a reduction in Page Mode Cycle time from 40ns (Fast Page) to 25ns for 60ns DRAM modules.

Improved system performance is provided by the on-DIMM buffering of selected input signals. The specified timings include all buffer, net and skew delays, which simplifies the memory subsystem design analysis. The data and $\overline{RAS}$ signals are not buffered, which preserves the DRAM access specifications of 60ns and 70ns.

Presence Detect (PD) and Identification Detect (ID) bits provide information about the DIMM density, addressing, performance and features. PD bits can be dotted at the system level and activated for each DIMM position using the PD enable ($\overline{PDE}$) signal. ID bits also allow detection of card features, and may be dot-or'd at the system level to provide information for the entire DIMM bank. For example, if a x64 parity DIMM were inserted into a bank of x72 parity DIMMs, ID0 (grounded) would indicate that at least one DIMM in that memory bank is x64, and if the memory controller is designed to do so, all DIMMs in that memory bank will function as x64s.

All IBM 168-pin DIMMs provide a high performance, flexible 8-byte interface in a 5.25" long space-saving footprint. Related products are the x72 parity (5V) and ECC DIMMs (5V and 3.3V).

Card Outline



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Pin Description

$\overline{RAS0}$, $\overline{RAS2}$	Row Address Strobe
$\overline{CAS0}$ - $\overline{CAS7}$	Column Address Strobe (Buffered)
$\overline{WE0}$, $\overline{WE2}$	Read/write Input (Buffered)
$\overline{OE0}$, $\overline{OE2}$	Output Enable (Buffered)
A0, B0, A1 - A9	Address Inputs (Buffered)
DQx	Data Input/Output
V_{CC}	Power (5.0V)
V_{SS}	Ground
NC	No Connect
PD1 - PD8	Presence Detects (Buffered)
$\overline{PDE}$	Presence Detect Enable
ID0 - ID1	ID Bits

Pinout

Pin#	Front Side	Pin#	Back Side	Pin#	Front Side	Pin#	Back Side
1	V_{SS}	85	V_{SS}	43	V_{SS}	127	V_{SS}
2	DQ0	86	DQ36	44	$\overline{OE2}$	128	NC
3	DQ1	87	DQ37	45	$\overline{RAS2}$	129	NC
4	DQ2	88	DQ38	46	$\overline{CAS4}$	130	$\overline{CAS5}$
5	DQ3	89	DQ39	47	$\overline{CAS6}$	131	$\overline{CAS7}$
6	V_{CC}	90	V_{CC}	48	$\overline{WE2}$	132	$\overline{PDE}$
7	DQ4	91	DQ40	49	V_{CC}	133	V_{CC}
8	DQ5	92	DQ41	50	NC	134	NC
9	DQ6	93	DQ42	51	NC	135	NC
10	DQ7	94	DQ43	52	DQ18	136	DQ54
11	DQ8	95	DQ44	53	DQ19	137	DQ55
12	V_{SS}	96	V_{SS}	54	V_{SS}	138	V_{SS}
13	DQ9	97	DQ45	55	DQ20	139	DQ56
14	DQ10	98	DQ46	56	DQ21	140	DQ57
15	DQ11	99	DQ47	57	DQ22	141	DQ58
16	DQ12	100	DQ48	58	DQ23	142	DQ59
17	DQ13	101	DQ49	59	V_{CC}	143	V_{CC}
18	V_{CC}	102	V_{CC}	60	DQ24	144	DQ60
19	DQ14	103	DQ50	61	NC	145	NC
20	DQ15	104	DQ51	62	NC	146	NC
21	DQ16	105	DQ52	63	NC	147	NC
22	DQ17	106	DQ53	64	NC	148	NC
23	V_{SS}	107	V_{SS}	65	DQ25	149	DQ61
24	NC	108	NC	66	DQ26	150	DQ62
25	NC	109	NC	67	DQ27	151	DQ63
26	V_{CC}	110	V_{CC}	68	V_{SS}	152	V_{SS}
27	$\overline{WE0}$	111	NC	69	DQ28	153	DQ64
28	$\overline{CAS0}$	112	$\overline{CAS1}$	70	DQ29	154	DQ65
29	$\overline{CAS2}$	113	$\overline{CAS3}$	71	DQ30	155	DQ66
30	$\overline{RAS0}$	114	NC	72	DQ31	156	DQ67
31	$\overline{OE0}$	115	NC	73	V_{CC}	157	V_{CC}
32	V_{SS}	116	V_{SS}	74	DQ32	158	DQ68
33	A0	117	A1	75	DQ33	159	DQ69
34	A2	118	A3	76	DQ34	160	DQ70
35	A4	119	A5	77	DQ35	161	DQ71
36	A6	120	A7	78	V_{SS}	162	V_{SS}
37	A8	121	A9	79	PD1	163	PD2
38	NC	122	NC	80	PD3	164	PD4
39	NC	123	NC	81	PD5	165	PD6
40	V_{CC}	124	V_{CC}	82	PD7	166	PD8
41	NC	125	NC	83	ID0	167	ID1
42	NC	126	B0	84	V_{CC}	168	V_{CC}

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

Ordering Information

Part Number	Organization	Speed	Leads	Dimension	Power	DRAM Die Revision	Notes
IBM11M1645LE-60	1Mx64	60ns	Au	5.25"x1.0"x 0.111"	5.0V	D	
IBM11M1645LE-70	1Mx64	70ns	Au	5.25"x1.0"x 0.111"	5.0V	D	
IBM11M1645LF-60	1Mx64	60ns	Au	5.25"x1.0"x 0.212"	5.0V	E	
IBM11M1645LF-70	1Mx64	70ns	Au	5.25"x1.0"x 0.212"	5.0V	E	

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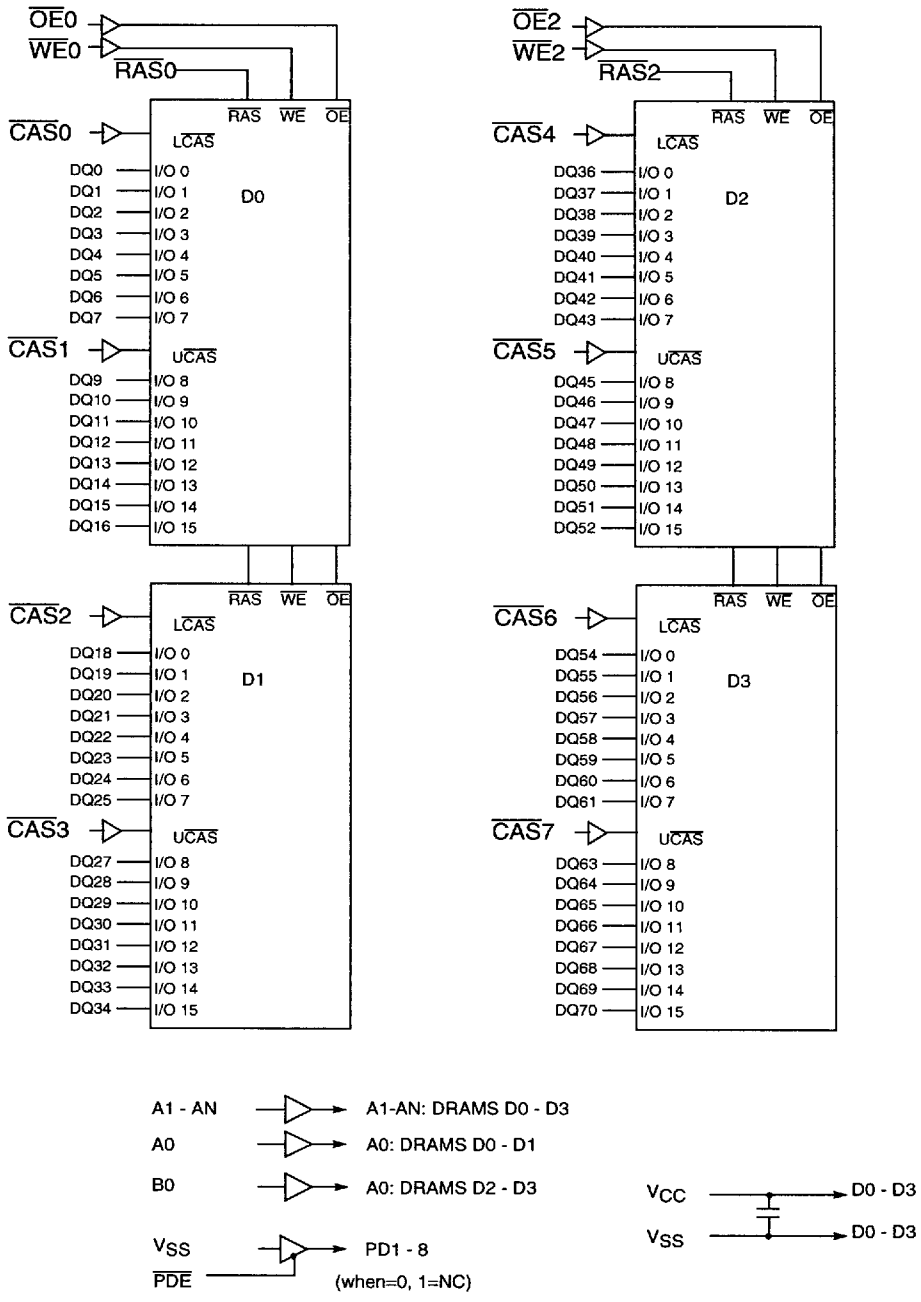
Block Diagram



Truth Table

Function		$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	$\overline{OE}$	Row Address	Column Address	$\overline{PDE}$	DQx
Standby		H	H→X	X	X	X	X	X	High Impedance
Read		L	L	H	L	Row	Col	X	Valid Data Out
Early-Write		L	L	L	X	Row	Col	X	Valid Data In
Late-Write		L	L	H→L	H	Row	Col	X	Valid Data In
RMW		L	L	H→L	L→H	Row	Col	X	Valid Data Out, Valid Data In
EDO Page Mode - Read 1st Cycle		L	H→L	H	L	Row	Col	X	Valid Data Out
Subsequent Cycles		L	H→L	H	L	N/A	Col	X	Valid Data Out
EDO Page Mode - Write 1st Cycle		L	H→L	L	X	Row	Col	X	Valid Data In
Subsequent Cycles		L	H→L	L	X	N/A	Col	X	Valid Data In
EDO Page Mode - RMW 1st Cycle		L	H→L	H→L	L→H	Row	Col	X	Valid Data Out, Valid Data In
Subsequent Cycles		L	H→L	H→L	L→H	N/A	Col	X	Valid Data Out, Valid Data In
$\overline{RAS}$-Only Refresh		L	H	X	X	Row	N/A	X	High Impedance
$\overline{CAS}$-Before-$\overline{RAS}$ Refresh		H→L	L	H	X	X	X	X	High Impedance
Hidden Refresh	Read	L→H→L	L	H	L	Row	Col	X	Data Out
	Write	L→H→L	L	H	X	Row	Col	X	Data In
Read Presence Detects		X	X	X	X	X	X	L	Not Affected (PD Bits Valid)

Presence Detect

Pin	-60	-70
PD1 (PD1 - PD4: Addressing/Density)	0	0
PD2	0	0
PD3	1	1
PD4	0	0
PD5 (EDO Detection)	1	1
PD6 (PD6 - PD7: Speed)	1	0
PD7	1	1
PD8 (Parity/ECC Designator)	1	1
ID0 (DIMM Type/Width)	0	0
ID1 (Refresh Mode)	0	0

1. PD1-8 are buffered outputs (0 = driven to V_{OL}, 1 = open)
2. ID0-1 are unbuffered outputs (0 = V_{SS}, 1 = open)
3. $\overline{PDE}$ should be tied high or low at system level if not used

Absolute Maximum Ratings

Symbol	Parameter	Rating (5.0V)	Units	Notes
V_{CC}	Power Supply Voltage	-1.0 to +7.0	V	1
V_{IN}	Input Voltage	-0.5 to min (V_{CC} + 0.5, 7.0)	V	1
V_{OUT}	Output Voltage	-0.5 to min (V_{CC} + 0.5, 7.0)	V	1
T_{OPR}	Operating Temperature	0 to +70	°C	1
T_{STG}	Storage Temperature	-55 to +125	°C	1
P_D	Power Dissipation	3.6	W	1
I_{OUT}	Short Circuit Output Current	50	mA	1
I_{OUTPD}	Short Circuit Output Current (PD)	60	mA	1

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.

Recommended DC Operating Conditions (T_A = 0 to 70°C)

Symbol	Parameter	5.0V			Units	Notes
		Min	Typ	Max		
V_{CC}	Supply Voltage	4.5	5.0	5.5	V	1
V_{IH}	Input High Voltage	2.4	—	V_{CC} + 0.5	V	1, 2
V_{IL}	Input Low Voltage	-0.5	—	0.8	V	1, 2

1. All voltages referenced to Vss.
2. V_{IH} may overshoot to V_{CC} + 2.0V for pulse widths of ≤ 4.0ns (or V_{CC} + 1.0V for ≤ 8.0ns). Additionally, V_{IL} may undershoot to -2.0V for pulse widths ≤ 4.0ns (or -1.0V for ≤ 8.0ns). Pulse widths measured at 50% points with amplitude measured peak to DC reference.

Capacitance (T_A = 0 to +70°C, V_{CC} = 5.0V ± 0.5V)

Symbol	Parameter	Max	Units	Notes
C_{I1}	Input Capacitance (A0, B0, A1-A10)	13	pF	
C_{I2}	Input Capacitance ($\overline{RAS}$)	25	pF	
C_{I3}	Input Capacitance ($\overline{CAS}$, $\overline{WE}$, $\overline{OE}$)	13	pF	
C_{I4}	Input Capacitance ($\overline{PDE}$)	18	pF	
C_{IO1}	Input/Output Capacitance (DQx)	15	pF	
C_{O1}	Output Capacitance (PD)	15	pF	
C_{O2}	Output Capacitance (ID)	5	pF	

DC Electrical Characteristics (T_A= 0 to +70°C, V_{CC}= 5.0V ± 0.5V)

Symbol	Parameter		5.0 Volt Min.	5.0 Volt Max.	Units	Notes
I_{CC1}	Operating Current Average Power Supply Operating Current ($\overline{RAS}$, $\overline{CAS}$, Address Cycling: t_{RC} = t_{RC} min.)	-60	—	660	mA	1, 2, 3
		-70	—	560		
I_{CC2}	Standby Current (TTL) Power Supply Standby Current ($\overline{RAS}$ = $\overline{CAS}$ = V_{IH})		—	8	mA	
I_{CC3}	$\overline{RAS}$ Only Refresh Current Average Power Supply Current, $\overline{RAS}$ Only Mode ($\overline{RAS}$ Cycling, $\overline{CAS}$ = V_{IH}: t_{RC} = t_{RC} min)	-60	—	660	mA	1, 3
		-70	—	560		
I_{CC4}	EDO Page Mode Current Average Power Supply Current, EDO Page Mode ($\overline{RAS}$ = V_{IL}, $\overline{CAS}$, Address Cycling: t_{HPC} = t_{HPC} min)	-60	—	360	mA	1, 2, 3
		-70	—	320		
I_{CC5}	Standby Current (CMOS) Power Supply Standby Current ($\overline{RAS}$ = $\overline{CAS}$ = V_{CC} - 0.2V)		—	4	mA	
I_{CC6}	$\overline{CAS}$ Before $\overline{RAS}$ Refresh Current Average Power Supply Current, $\overline{CAS}$ Before $\overline{RAS}$ Mode ($\overline{RAS}$, $\overline{CAS}$, Cycling: t_{RC} = t_{RC} min)	-60	—	660	mA	1, 3
		-70	—	560		
$I_{I(L)}$	Input Leakage Current Input Leakage Current, any input (0.0 ≤ V_{IN} ≤ (V_{CC} + 0.3V)), All Other Pins Not Under Test = 0V	All but $\overline{RAS}$	-10	+10	µA	
		$\overline{RAS}$	-20	+20		
$I_{O(L)}$	Output Leakage Current (D_{OUT} is disabled, 0.0 ≤ V_{OUT} ≤ V_{CC})		-10	+10	µA	
V_{OH}	Output Level (TTL) Output "H" Level Voltage (I_{OUT} = -5mA)		2.4	V_{CC}	V	
V_{OL}	Output Level (TTL) Output "L" Level Voltage (I_{OUT} = +4.2mA)		0.0	0.4	V	

1. I_{CC1}, I_{CC3}, I_{CC4} and I_{CC6} depend on cycle rate.
2. I_{CC1} and I_{CC4} depend on output loading. Specified values are obtained with the output open.
3. Address can be changed once or less while $\overline{RAS}$ =V_{IL}. In the case of I_{CC4}, it can be changed once or less when $\overline{CAS}$ =V_{IH}.

AC Characteristics (T_A = 0 to +70°C, V_{CC} = 5.0V ± 0.5V)

1. 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}.
2. An initial pause of 200µs is required after power-up followed by 8 $\overline{RAS}$ only refresh cycles before proper device operation is achieved. In case of using internal refresh counter, a minimum of 8 $\overline{CAS}$ before $\overline{RAS}$ refresh cycles instead of 8 $\overline{RAS}$ only refresh cycles is required..
3. The specified timings include buffer, loading and skew delay adders: 2ns minimum, 5ns maximum delay, no pulse shrinkage to the DRAM device timings. The data and $\overline{RAS}$ signals are not buffered, which preserves the DRAMs access specifications of 60ns and 70ns.
4. AC measurements assume t_T = 2ns.

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}	$\overline{RAS}$ Precharge Time	40	—	50	—	ns	
t_{CP}	$\overline{CAS}$ Precharge Time	10	—	10	—	ns	
t_{RAS}	$\overline{RAS}$ Pulse Width	60	10K	70	10K	ns	
t_{CAS}	$\overline{CAS}$ Pulse Width	10	10K	12	10K	ns	
t_{ASR}	Row Address Setup Time	5	—	5	—	ns	
t_{RAH}	Row Address Hold Time	8	—	8	—	ns	
t_{ASC}	Column Address Setup Time	2	—	2	—	ns	
t_{CAH}	Column Address Hold Time	10	—	10	—	ns	
t_{RCD}	$\overline{RAS}$ to $\overline{CAS}$ Delay Time	12	40	12	45	ns	1
t_{RAD}	$\overline{RAS}$ to Column Address Delay Time	10	25	10	30	ns	2
t_{RSH}	$\overline{RAS}$ Hold Time	15	—	17	—	ns	
t_{CSH}	$\overline{CAS}$ Hold Time	48	—	53	—	ns	
t_{CRP}	$\overline{CAS}$ to $\overline{RAS}$ Precharge Time	10	—	10	—	ns	
t_{ODD}	$\overline{OE}$ to D_{IN} Delay Time	20	—	25	—	ns	3
t_{DZO}	$\overline{OE}$ Delay Time from D_{IN}	-2	—	-2	—	ns	4
t_{DZC}	$\overline{CAS}$ Delay Time from D_{IN}	-2	—	-2	—	ns	4
t_T	Transition Time (Rise and Fall)	2	30	2	30	ns	

1. Operation within the t_{RCD}(max) limit ensures that t_{RAC}(max) can be met. The t_{RCD}(max) is specified as a reference point only: If t_{RCD} is greater than the specified t_{RCD}(max) limit, then access time is controlled by t_{CAC}.
2. Operation within the t_{RAD}(max) limit ensures that t_{RAC}(max) can be met. The t_{RAD}(max) is specified as a reference point only: If t_{RAD} is greater than the specified t_{RAD}(max) limit, then access time is controlled by t_{AA}.
3. Either t_{CDD} or t_{ODD} must be satisfied.
4. Either t_{DZC} or t_{DZO} must be satisfied.

Write Cycle

Symbol	Parameter	-60		-70		Unit	Notes
		Min	Max	Min	Max		
t_{WCS}	Write Command Set Up Time	2	—	2	—	ns	1
t_{WCH}	Write Command Hold Time	12	—	14	—	ns	
t_{WP}	Write Command Pulse Width	10	—	12	—	ns	
t_{RWL}	Write Command to $\overline{RAS}$ Lead Time	15	—	17	—	ns	
t_{CWL}	Write Command to $\overline{CAS}$ Lead Time	12	—	14	—	ns	
t_{DS}	D_{IN} Setup Time	-2	—	-2	—	ns	2
t_{DH}	D_{IN} Hold Time	15	—	17	—	ns	2

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 $t_{WCS} \geq t_{WCS}$(min.), the entire cycle is an early write cycle and the data pin will remain open circuit (high impedance) through the entire cycle; If $t_{RWD} \geq t_{RWD}$(min.), $t_{CWD} \geq t_{CWD}$(min.)and $t_{AWD} \geq t_{AWD}$(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.
2. Data-in set-up and hold is measured from the latter of the two timings, $\overline{CAS}$ or $\overline{WE}$.

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 $\overline{CAS}$	—	20	—	25	ns	1, 2
t_{AA}	Access Time from Address	—	35	—	40	ns	1, 2
t_{OEA}	Access Time from $\overline{OE}$	—	20	—	25	ns	1, 2
t_{RCS}	Read Command Setup Time	2	—	2	—	ns	
t_{RCH}	Read Command Hold Time to $\overline{CAS}$	2	—	2	—	ns	3
t_{RRH}	Read Command Hold Time to $\overline{RAS}$	0	—	0	—	ns	3
t_{RAL}	Column Address to $\overline{RAS}$ Lead Time	35	—	40	—	ns	
t_{CLZ}	$\overline{CAS}$ to Output in Low-Z	2	—	2	—	ns	
t_{OES}	$\overline{OE}$ setup time prior to $\overline{CAS}$	10	—	10	—	ns	
t_{ORD}	$\overline{OE}$ setup time prior to $\overline{RAS}$ (Hidden Refresh)	5	—	5	—	ns	
t_{CDD}	$\overline{CAS}$ to D_{IN} Delay Time	20	—	20	—	ns	5
t_{OEZ}	Output Buffer Turn-off Delay from $\overline{OE}$	2	20	2	20	ns	4
t_{OFF}	Output Buffer Turn-off Delay	2	20	2	20	ns	4, 6

1. Measured with the specified current load and 100pF.
2. Access time is determined by the latter of t_{RAC}, t_{CAC}, t_{CPA}, t_{AA}, t_{OEA}.
3. Either t_{RCH} or t_{RRH} must be satisfied.
4. t_{OFF} (max) and t_{OEZ} (max) define the time at which the output achieves the open circuit condition and is not referenced to output voltage levels.
5. Either t_{CDD} or t_{ODD} must be satisfied.
6. t_{OFF} is referenced from the rising edge of $\overline{RAS}$ or $\overline{CAS}$, whichever is last.

Read-Modify-Write Cycle

Symbol	Parameter	-60		-70		Unit	Notes
		Min	Max	Min	Max		
t_{RWC}	Read-Modify-Write Cycle Time	143	—	170	—	ns	
t_{RWD}	$\overline{RAS}$ to $\overline{WE}$ Delay Time	82	—	97	—	ns	1
t_{CWD}	$\overline{CAS}$ to $\overline{WE}$ Delay Time	44	—	54	—	ns	1
t_{AWD}	Column Address to $\overline{WE}$ Delay Time	57	—	67	—	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 $t_{WCS} \geq t_{WCS}$(min.), the entire cycle is an early write cycle and the data pin will remain open circuit (high impedance) through the entire cycle; If $t_{RWD} \geq t_{RWD}$(min.), $t_{CWD} \geq t_{CWD}$(min.)and $t_{AWD} \geq t_{AWD}$(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	72	—	84	—	ns	
t_{DOH}	Data-out Hold Time from $\overline{CAS}$	10	—	10	—	ns	
t_{WHZ}	Output buffer Turn-Off Delay from $\overline{WE}$	2	15	2	20	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	40	—	45	—	ns	
t_{CPA}	Access Time from $\overline{CAS}$ Precharge	—	40	—	45	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}	$\overline{CAS}$ Hold Time ($\overline{CAS}$ before $\overline{RAS}$ Refresh Cycle)	8	—	8	—	ns	
t_{CSR}	$\overline{CAS}$ Setup Time ($\overline{CAS}$ before $\overline{RAS}$ Refresh Cycle)	10	—	10	—	ns	
t_{WRP}	$\overline{WE}$ Setup Time ($\overline{CAS}$ before $\overline{RAS}$ Refresh Cycle)	15	—	15	—	ns	
t_{WRH}	$\overline{WE}$ Hold Time ($\overline{CAS}$ before $\overline{RAS}$ Refresh Cycle)	8	—	8	—	ns	
t_{RPC}	$\overline{RAS}$ Precharge to $\overline{CAS}$ Hold Time	3	—	3	—	ns	
t_{REF}	Refresh Period	—	16	—	16	ms	1

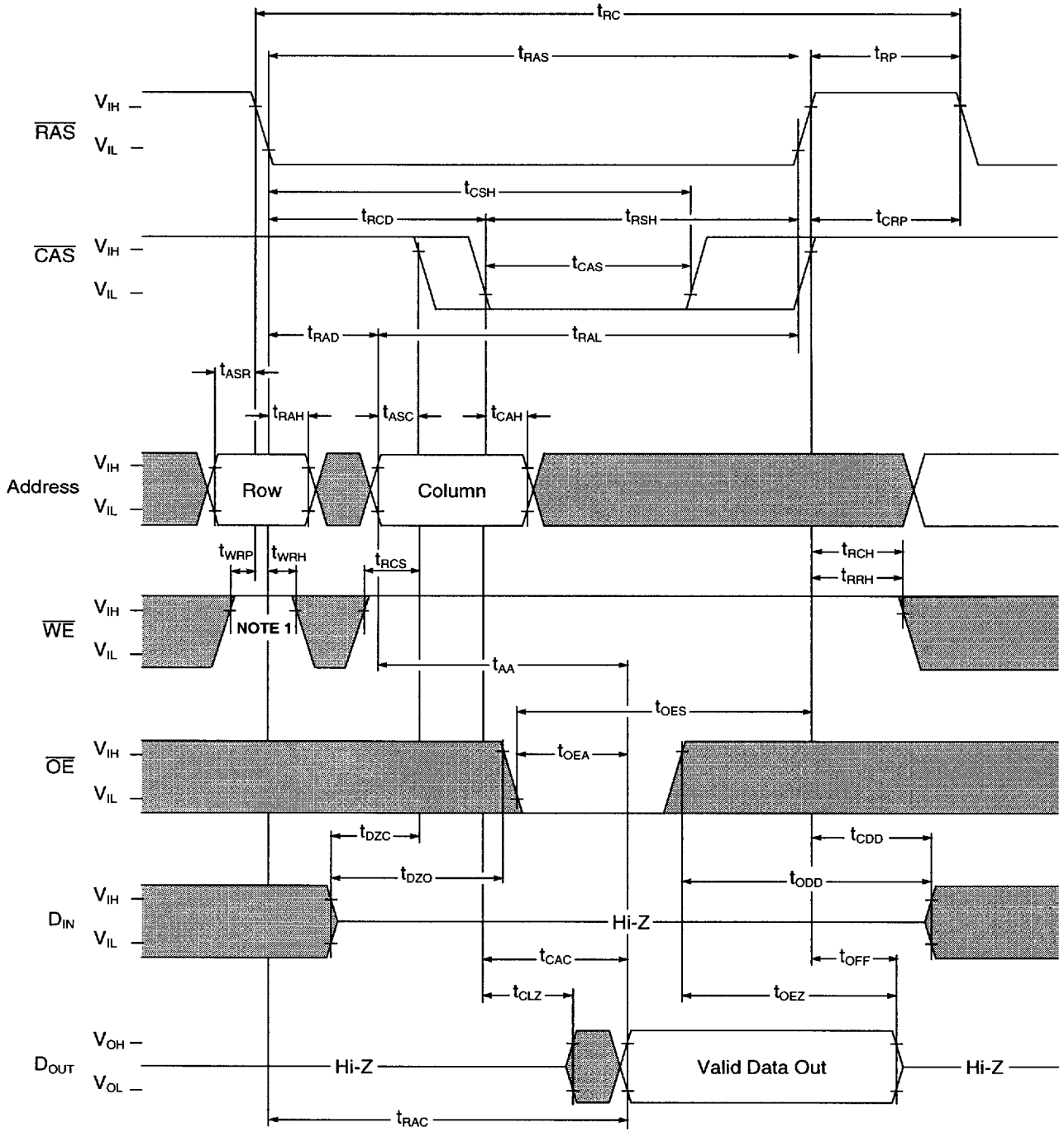
1. 1024 refreshes are required every 16ms.

Presence Detect Read Cycle

Symbol	Parameter	-60		-70		Unit	Notes
		Min	Max	Min	Max		
t_{PD}	$\overline{PDE}$ to Valid Presence Detect Data	—	10	—	10	ns	1
t_{PDOFF}	$\overline{PDE}$ Inactive to Presence Detects Inactive	0	10	0	10	ns	2

1. Measured with the specified current load and 100pF.
2. t_{PDOFF}(max) defines the time at which the output achieves the open circuit condition and is not referenced to output voltage levels.

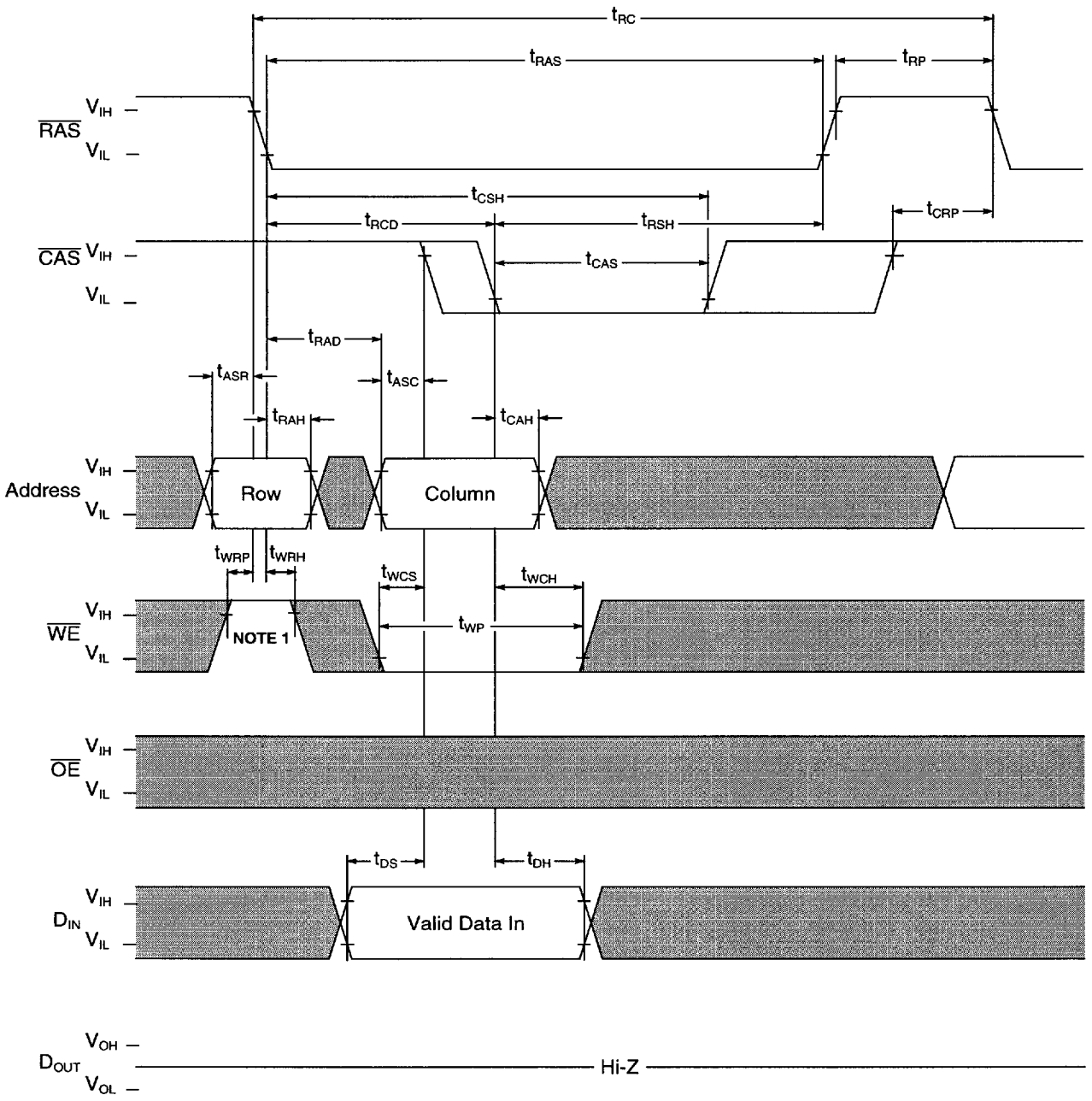
Read Cycle



: "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.

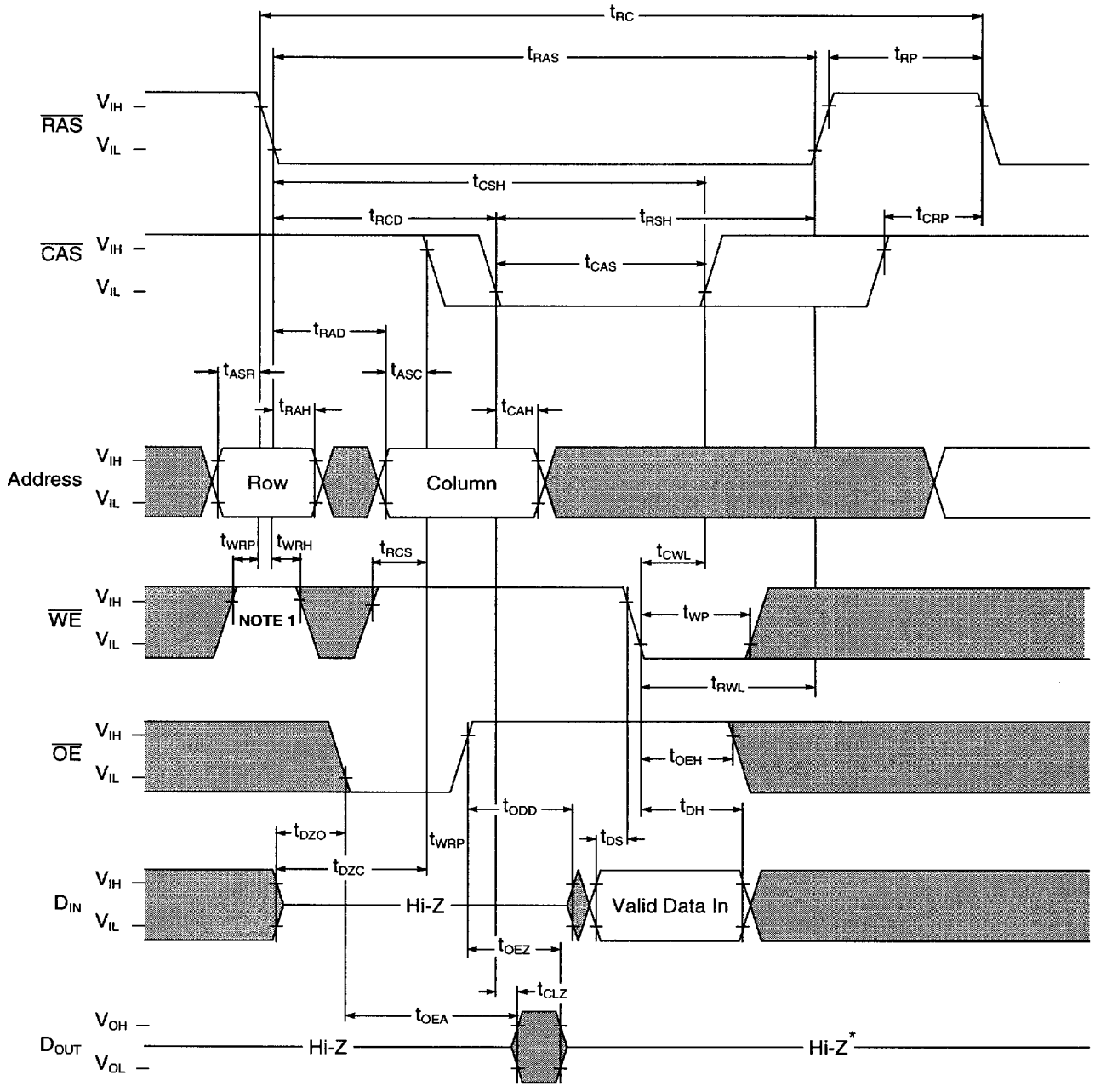
Write Cycle (Early Write)



: "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)

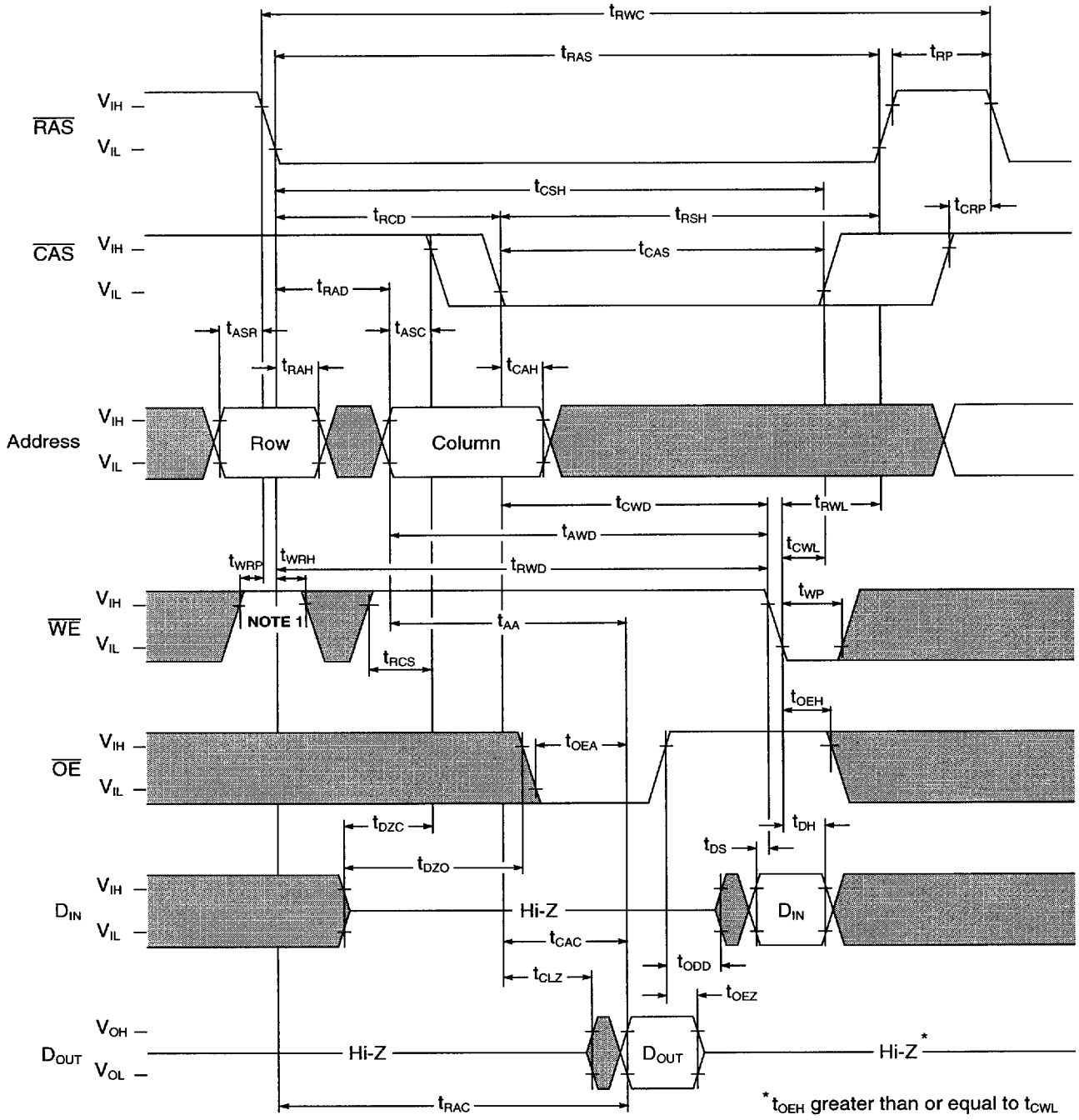


: "H" or "L"

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

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.

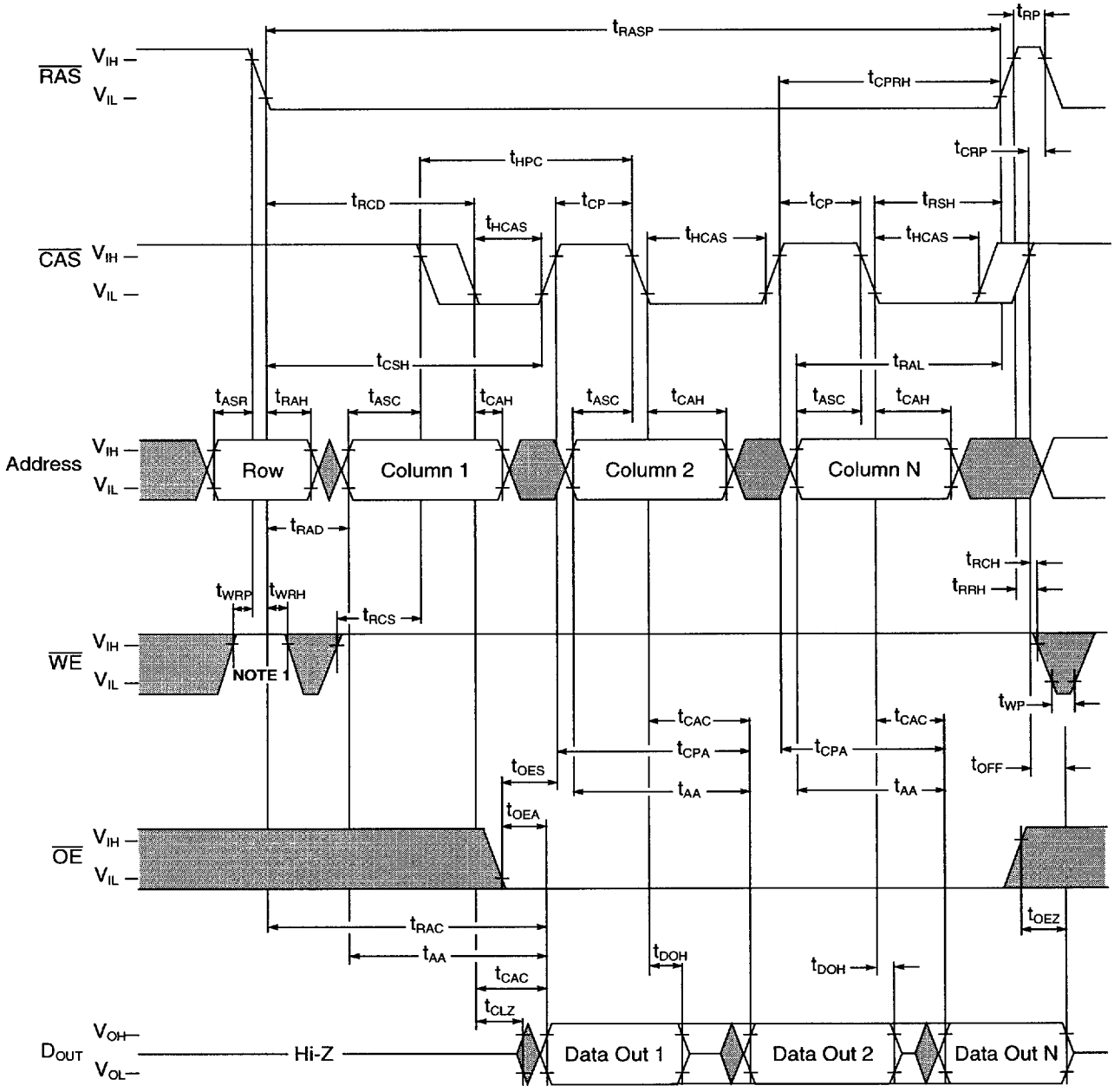
Read-Modify-Write-Cycle



: "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.

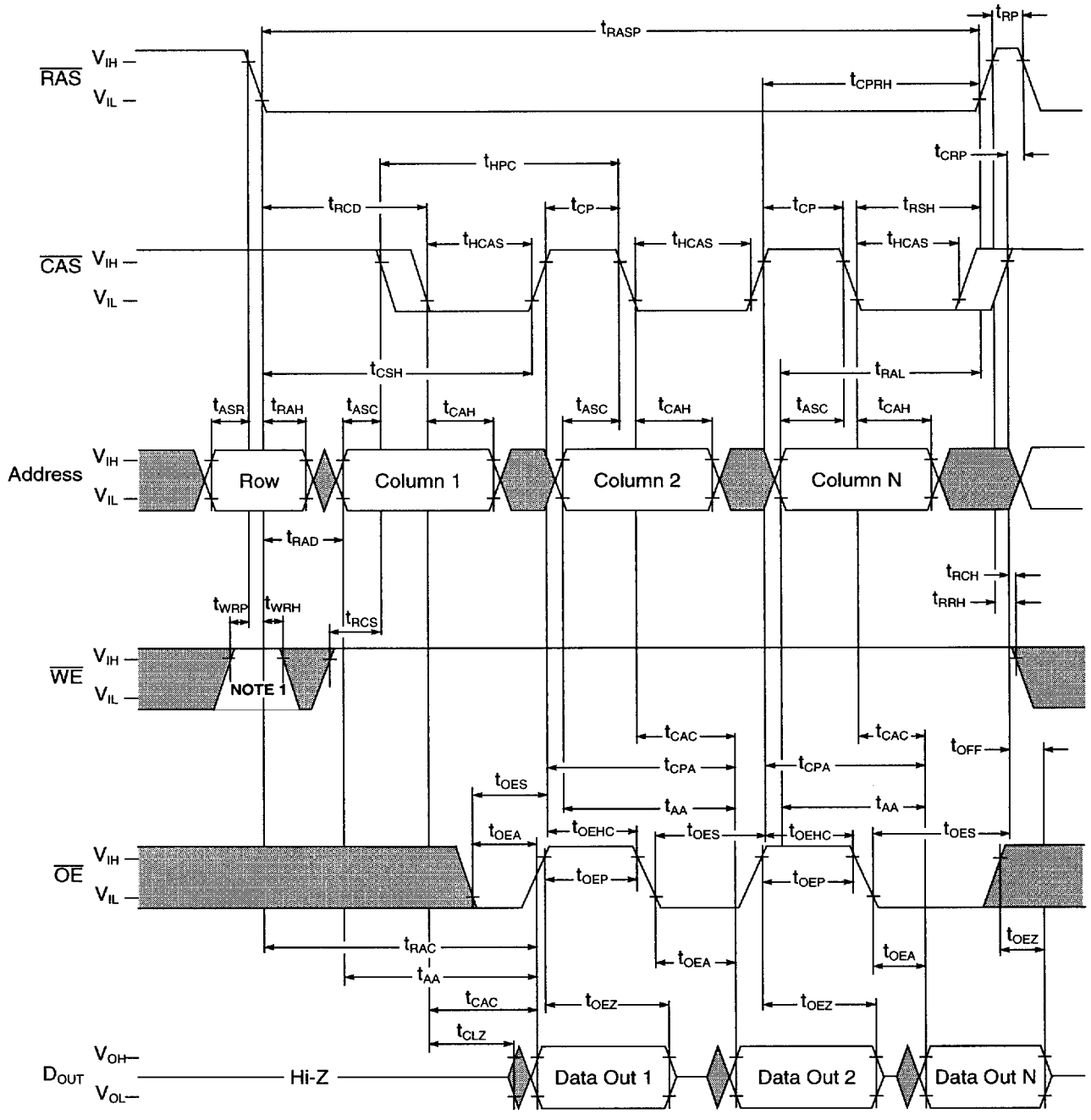
EDO Page Mode Read Cycle



: "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.

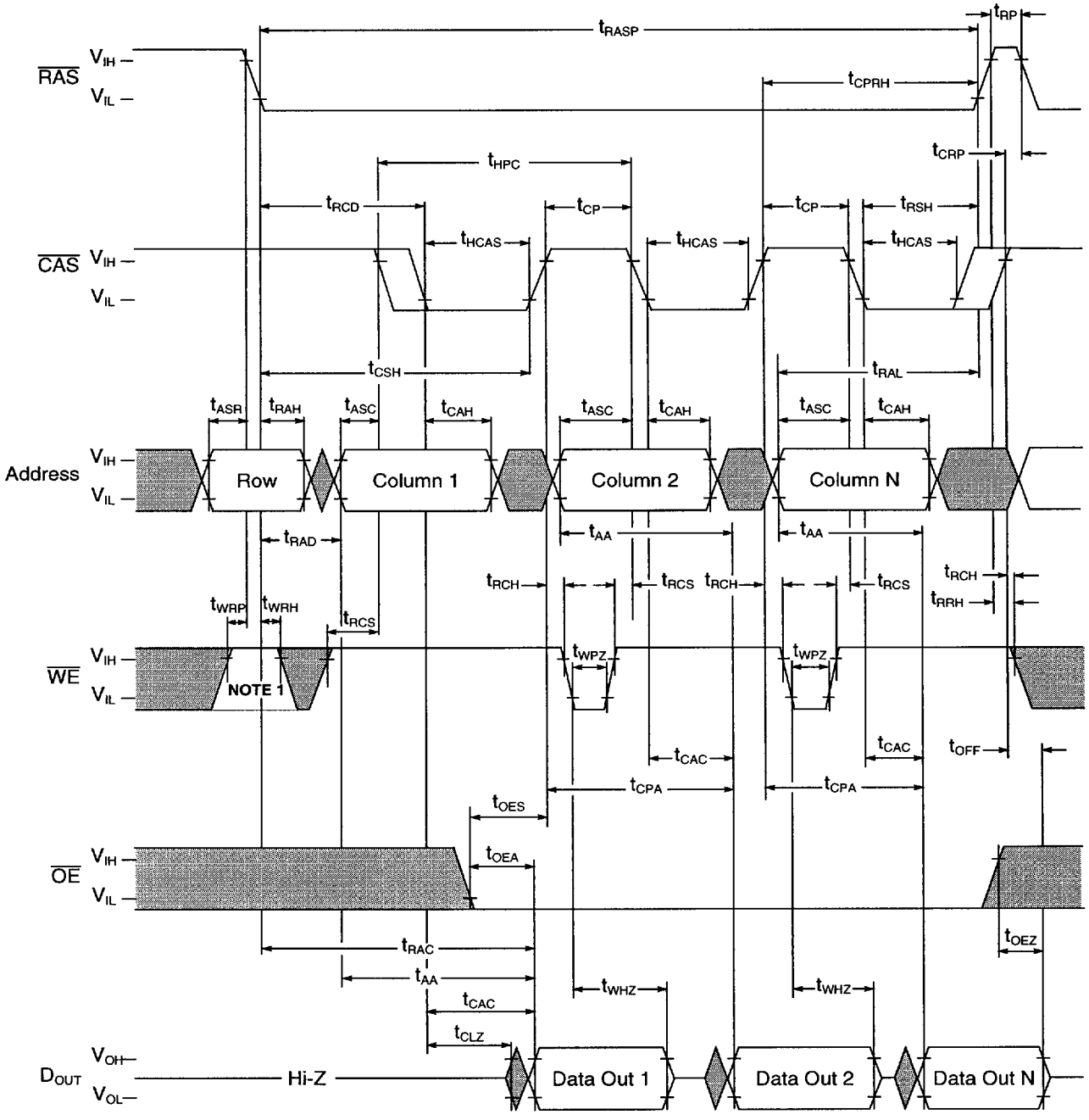
EDO Page Mode Read Cycle ($\overline{OE}$ Control)



: "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.

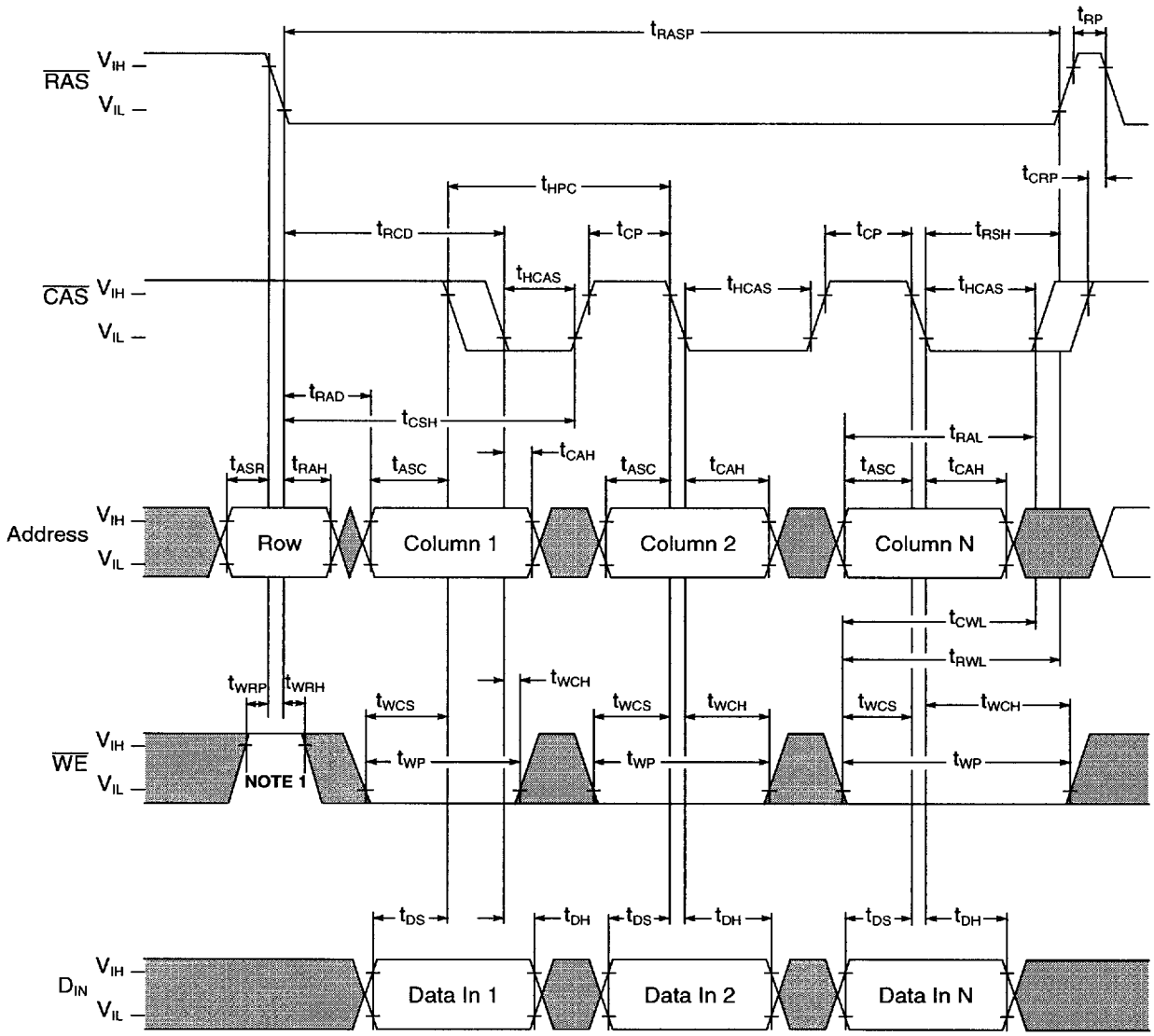
EDO Page Mode Read Cycle ($\overline{WE}$ Control)



: "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.

EDO Page Mode Early Write Cycle

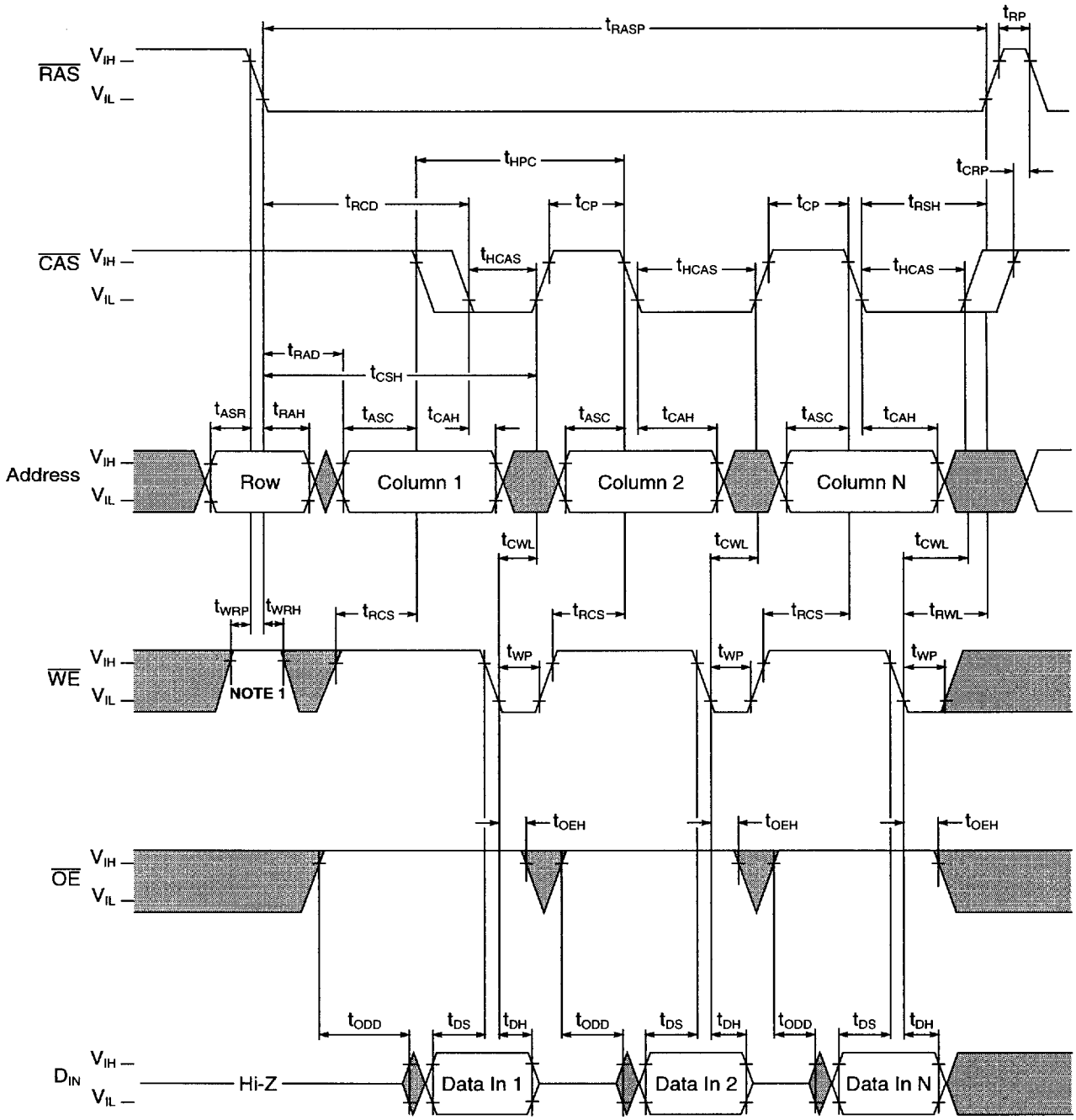


: "H" or "L"

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.

$\overline{OE}$ = Don't care

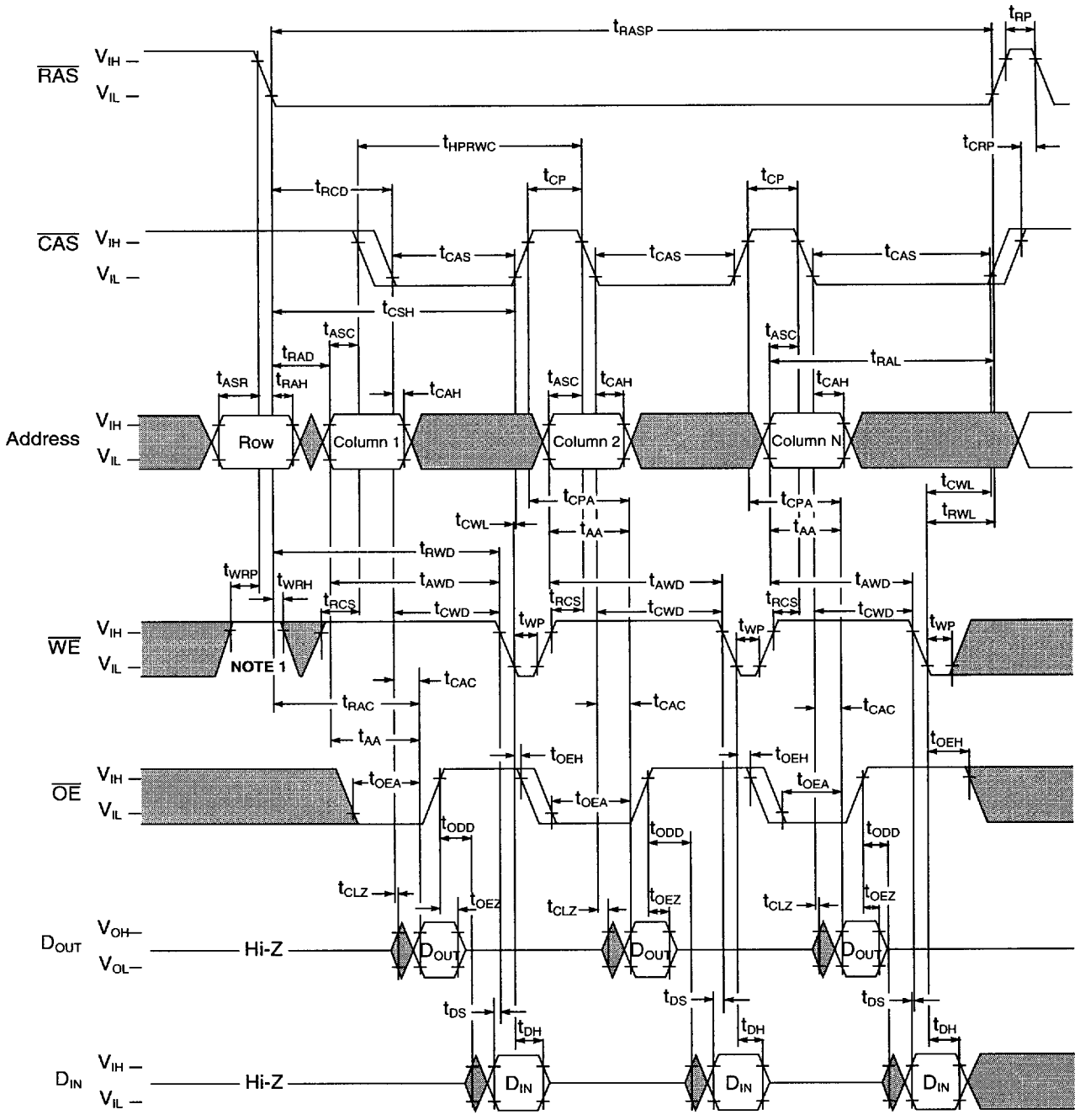
EDO Page Mode Late Write Cycle



: "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.

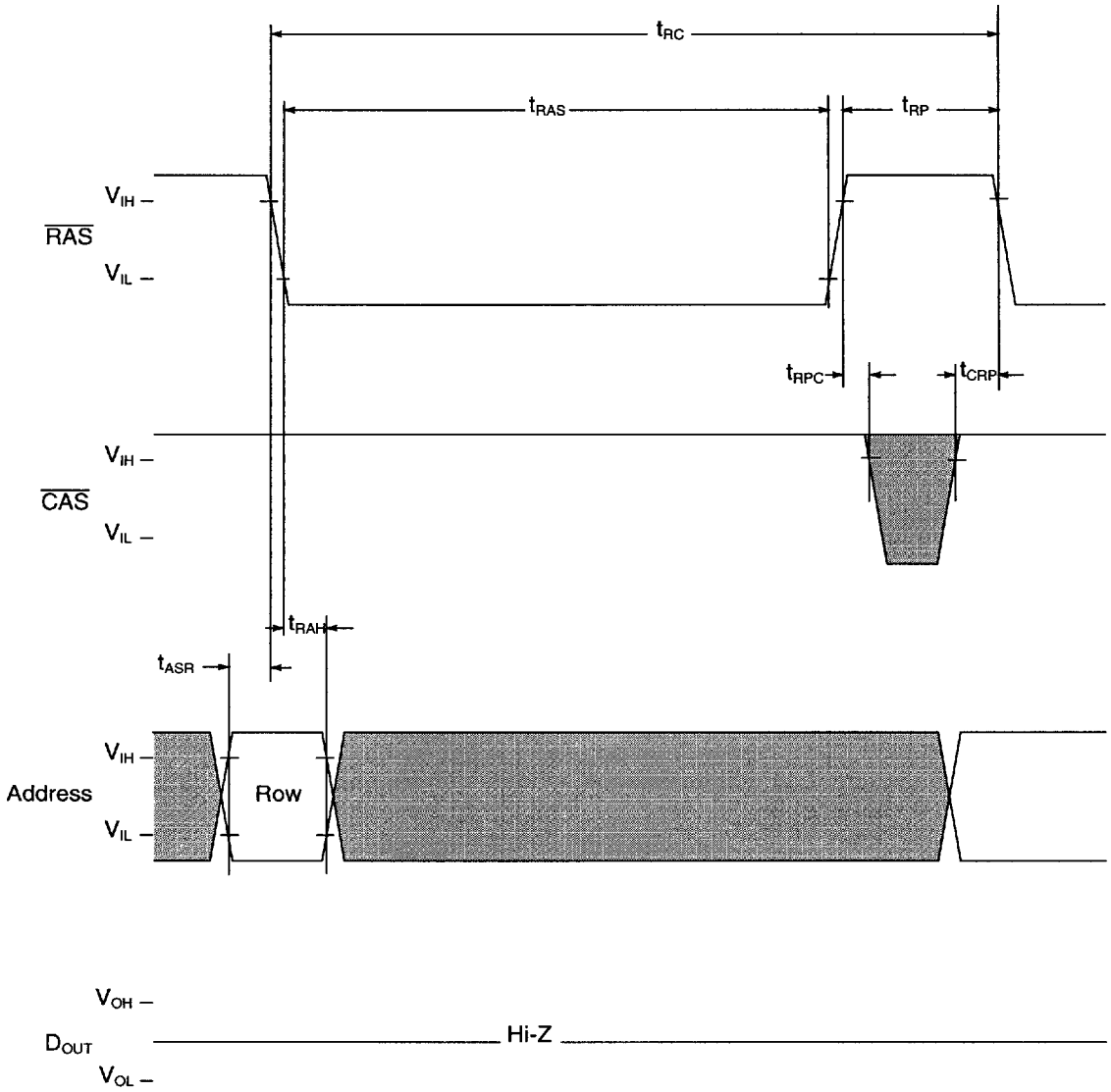
EDO Page Mode Read Modify Write Cycle



: "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.

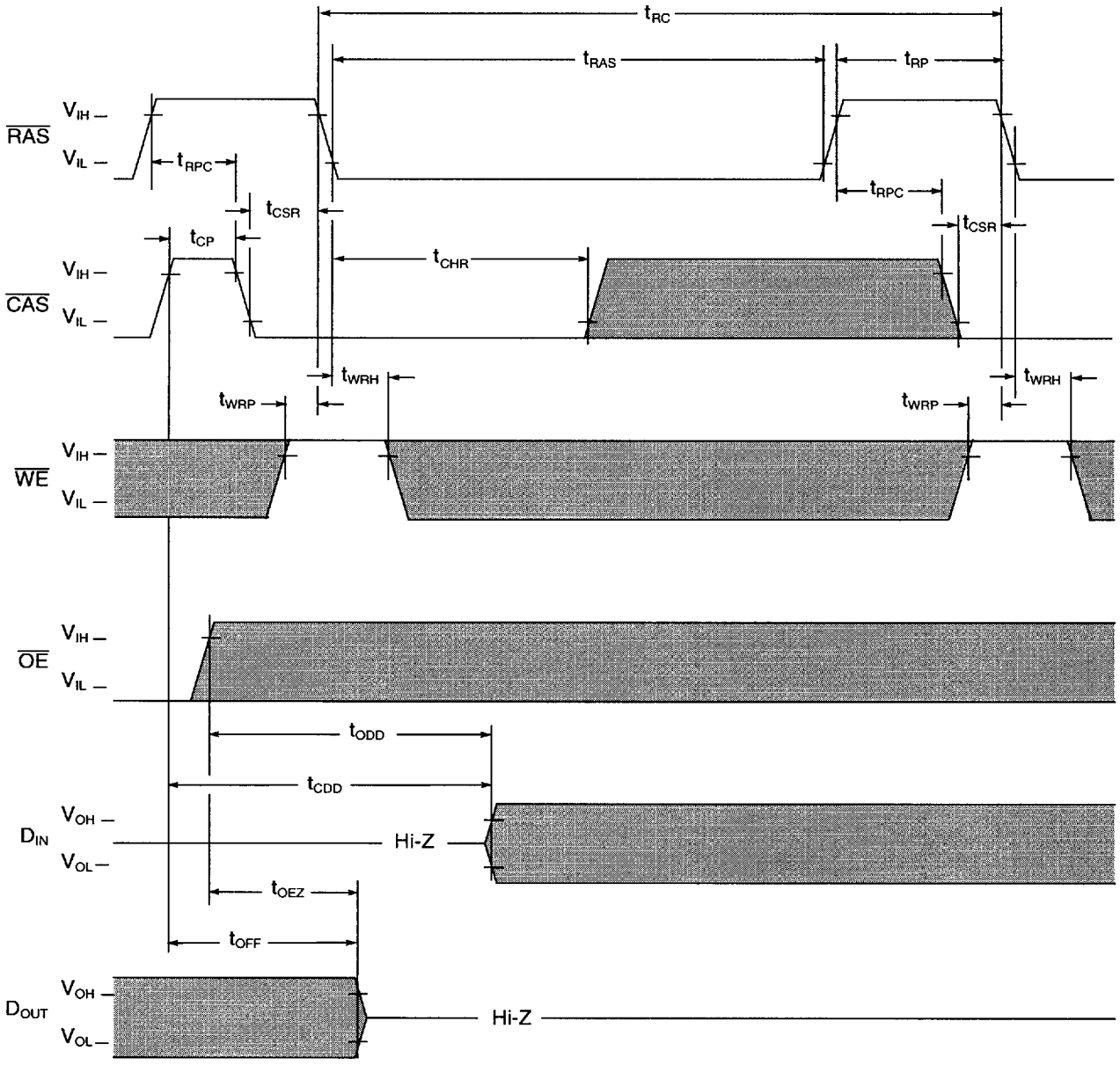
$\overline{RAS}$ Only Refresh Cycle



: "H" or "L"

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

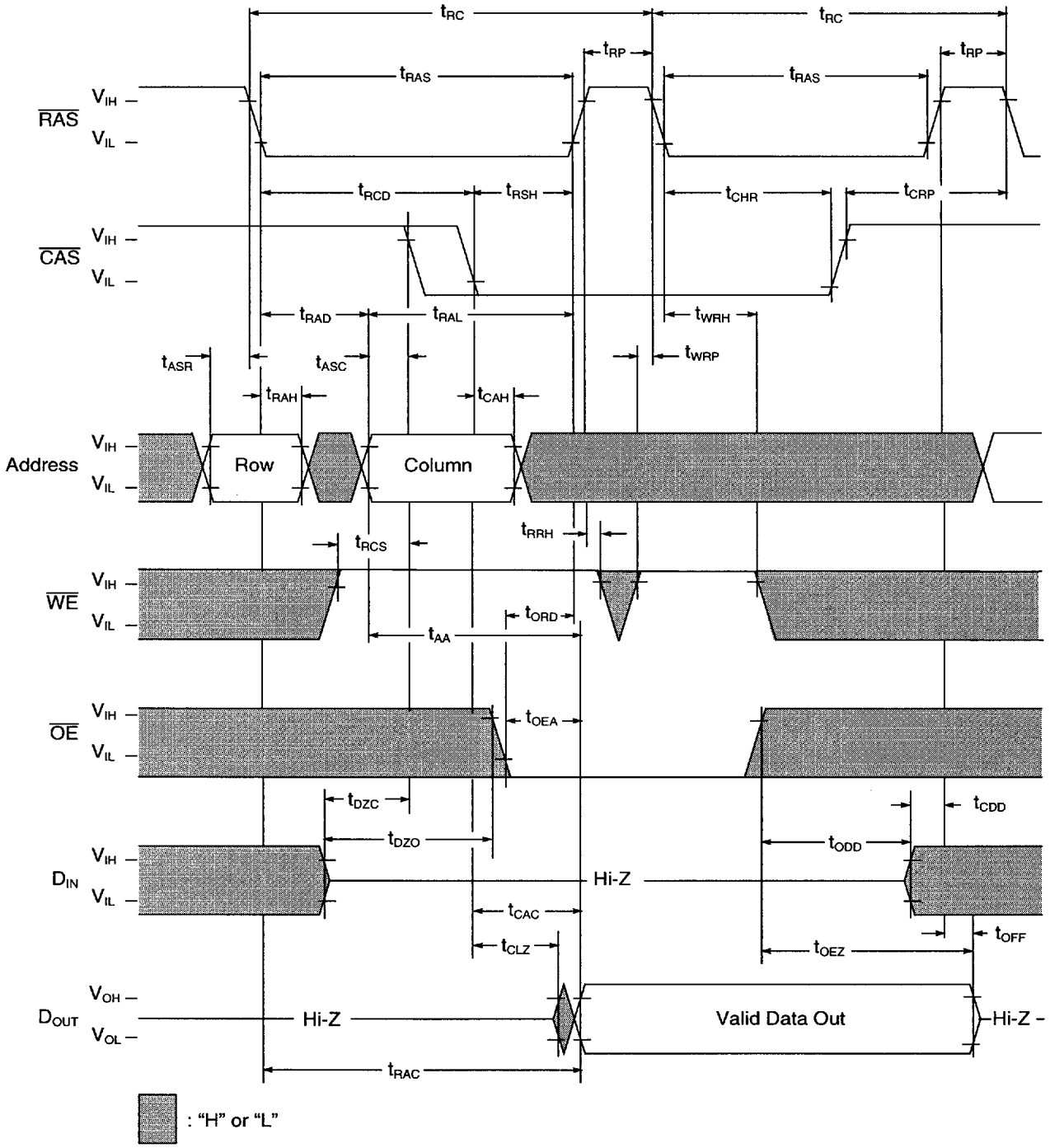
$\overline{CAS}$ Before $\overline{RAS}$ Refresh Cycle



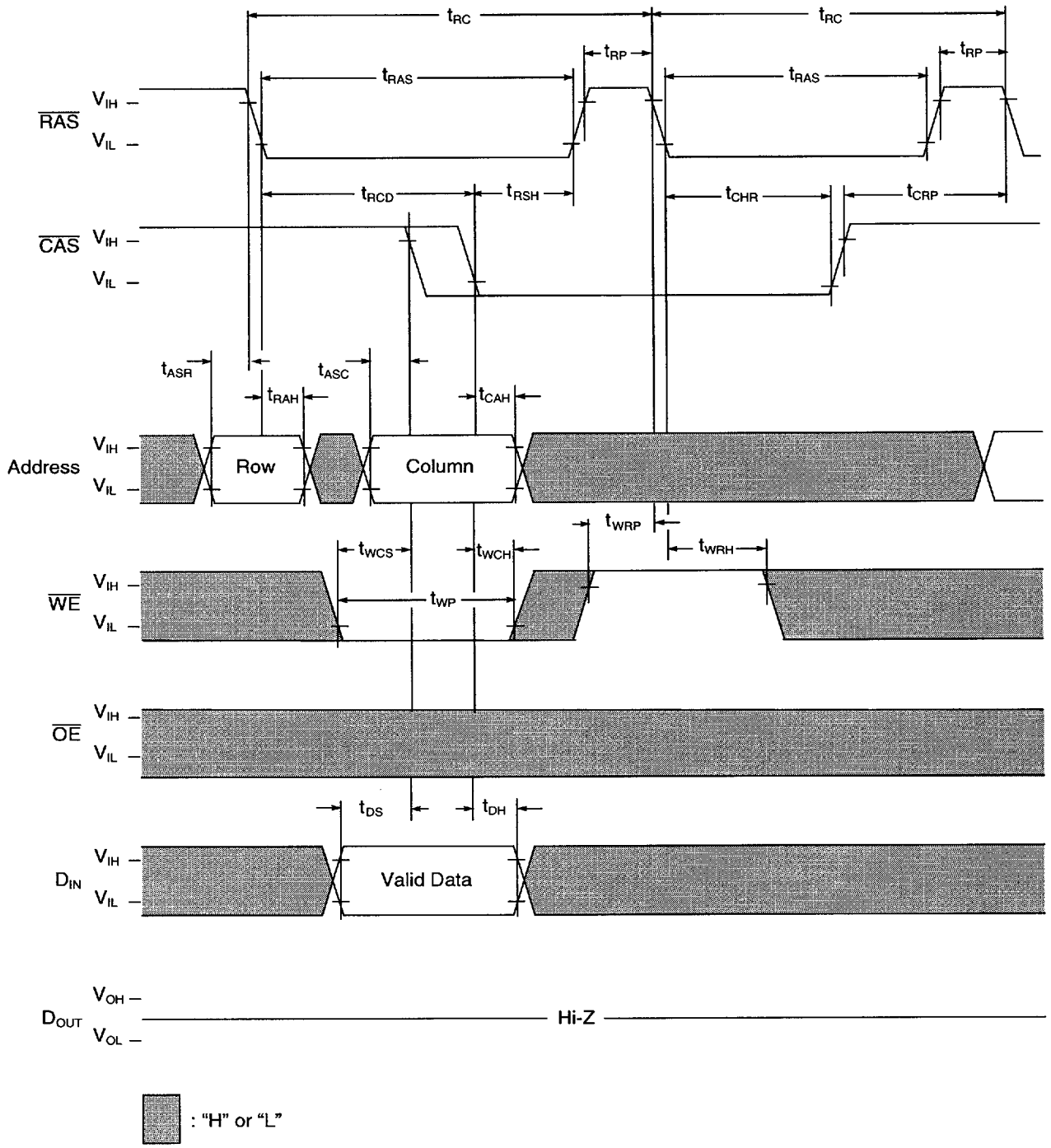
: "H" or "L"

NOTE: Address is "H" or "L"

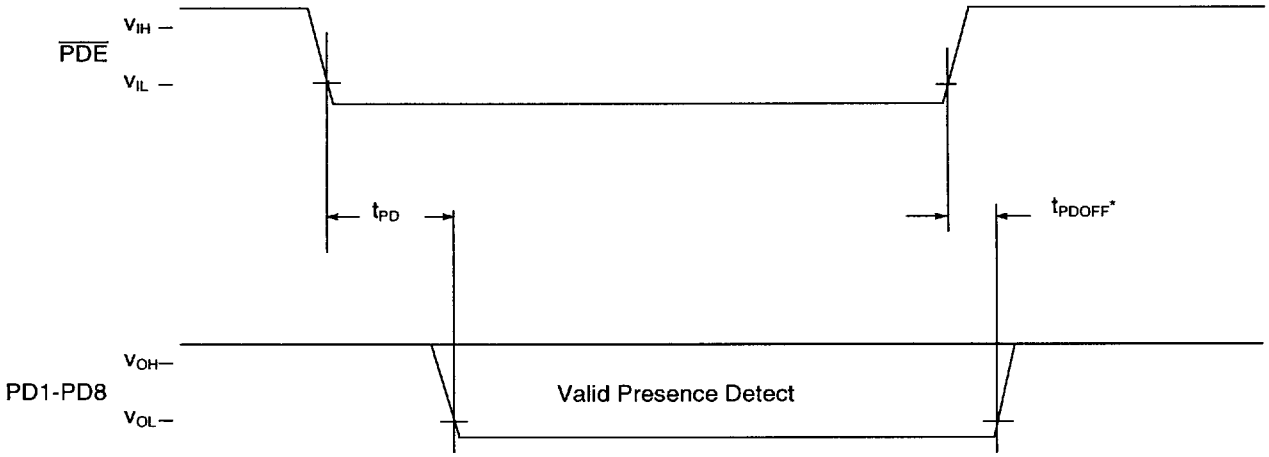
Hidden Refresh Cycle (Read)



Hidden Refresh Cycle (Write)

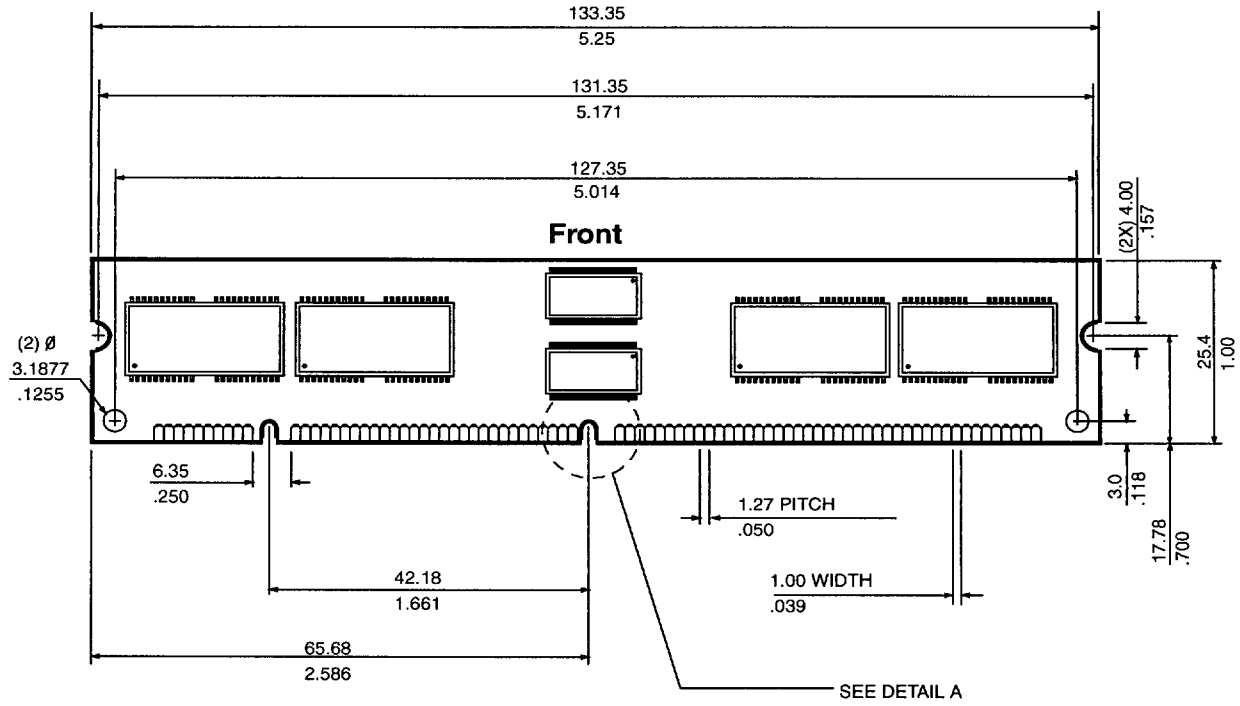


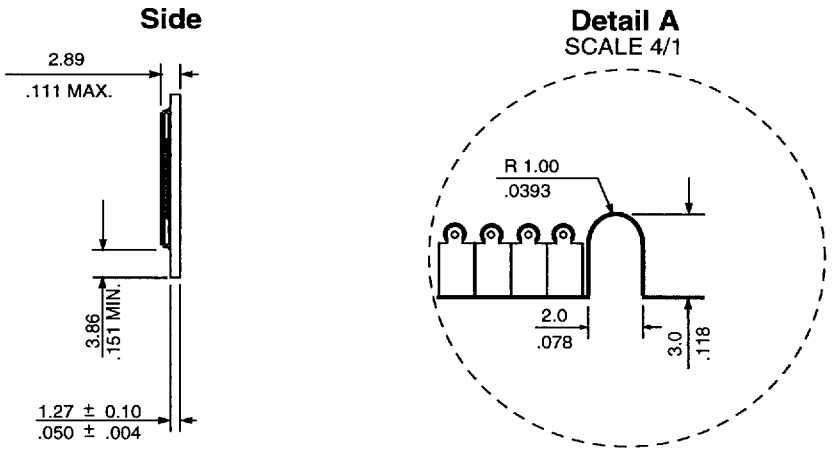
Presence Detect Read Cycle



*PD pins must be pulled high at next level of assembly

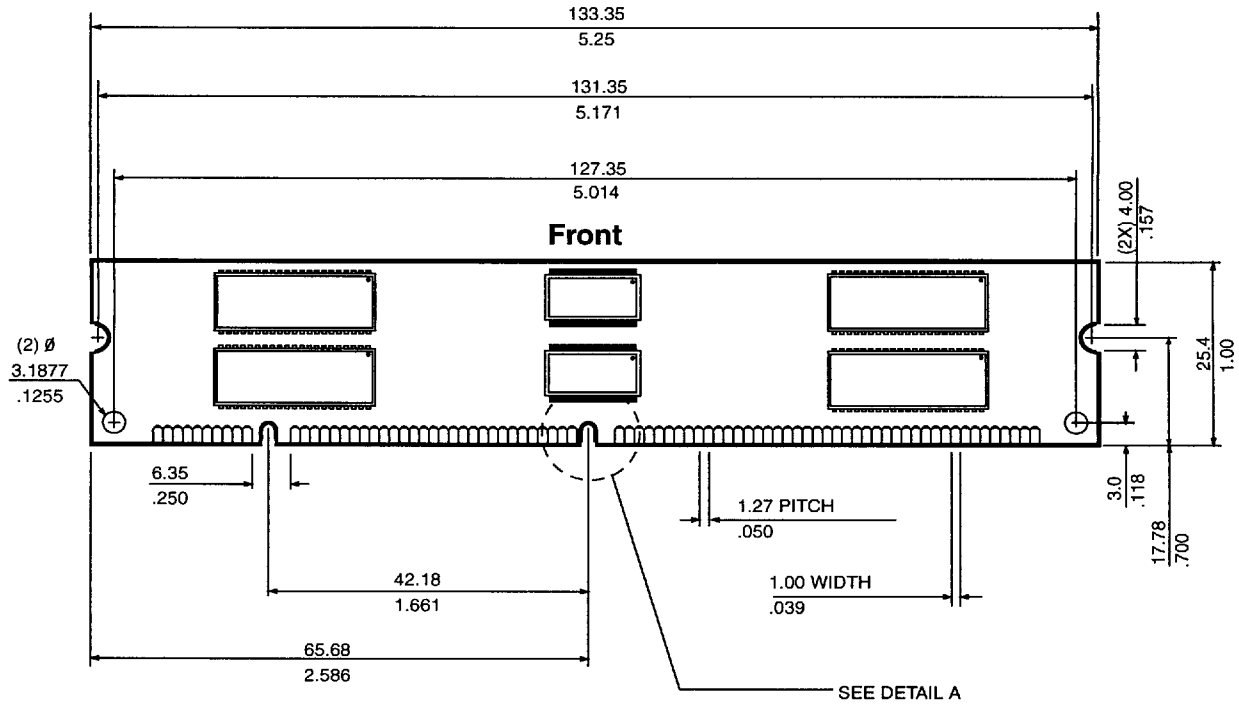
Layout Drawing (TSOP Version)

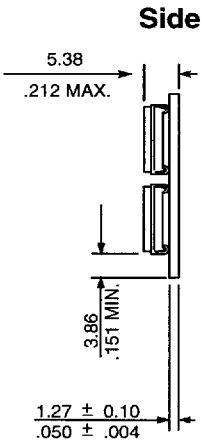


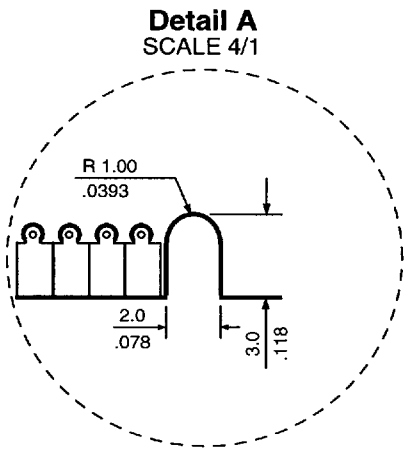


Note: All dimensions are typical unless otherwise stated. Millimeters / Inches

Layout Drawing (SOJ Version)







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

Revision Log

Rev	Contents of Modification
08/95	Initial Release.
3/96	Updated ordering information (added SOJ) Included layout drawing (SOJ) and corrected thickness for TSOP version Improved power dissipation Improved DC electrical characteristics: I_{CC1}, I_{CC3}, I_{CC6} Updated truth table Updated EDO timing notes Increased timings: t_{OES}, t_{ORD} Improved timings: t_{CAH}, t_{CDD}, t_{OEZ}, t_{OFF} The CBR timing diagram was changed to allow $\overline{CAS}$ to remain low for back-to-back CBR cycles Hidden Refresh Cycle (Read) timing diagram was changed to show data being turned off with $\overline{RAS}$ not $\overline{CAS}$