

HM514400C/CL Series

1,048,576-word × 4-bit Dynamic Random Access Memory

HITACHI

Rev. 1.0
Nov. 29, 1994

The Hitachi HM514400C is a CMOS dynamic RAM organized 1,048,576-word × 4-bit. HM514400C has realized higher density, higher performance and various functions by employing 0.8 μm CMOS process technology and some new CMOS circuit design technologies. The HM514400C offers Fast Page Mode as a high speed access mode. Multiplexed address input permits the HM514400C to be packaged in standard 300-mil 26-pin plastic SOJ, standard 400-mil 20-pin plastic ZIP and 26-pin plastic TSOP II.

Features

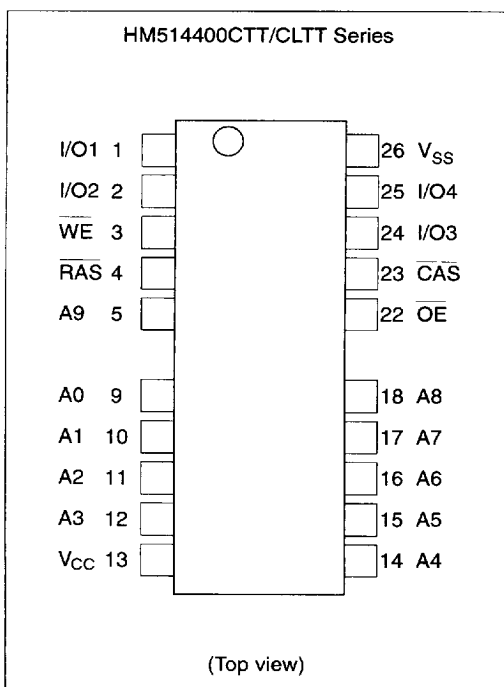
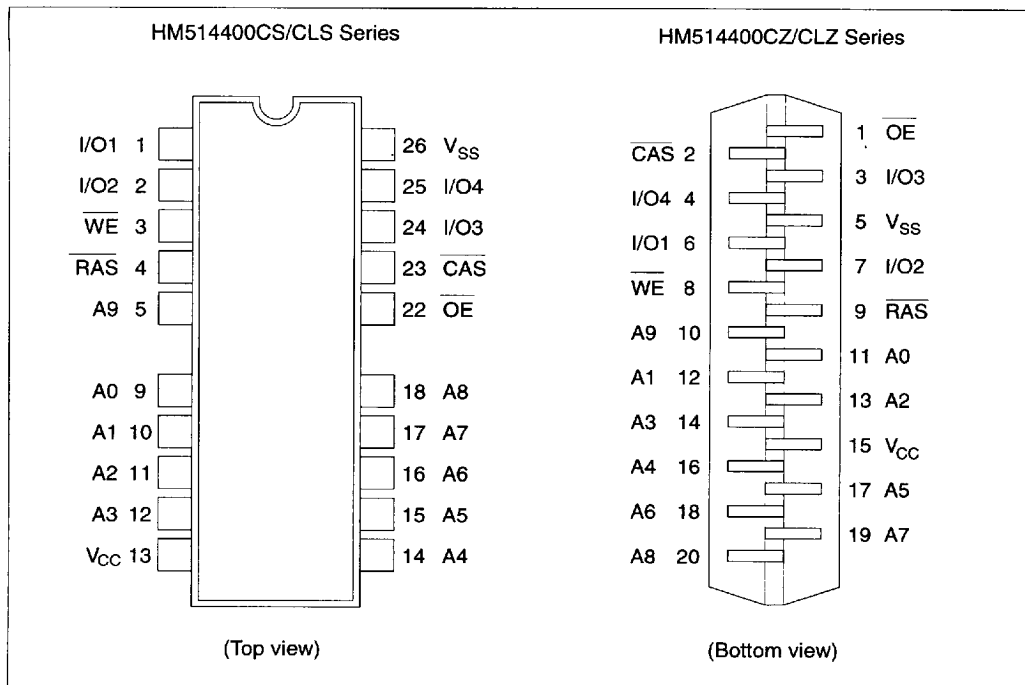
- Single 5 V (±10%)
- High speed
 - Access time
60 ns/70 ns/80 ns (max)
- Low power dissipation
 - Active mode
605 mW/550 mW/495 mW (max)
 - Standby mode 11 mW (max)
0.55 mW (max) (L-version)
- Fast page mode capability
- 1024 refresh cycles : 16 ms
1024 refresh cycles : 128 ms (L-version)
- 3 variations of refresh
 - $\overline{\text{RAS}}$ -only refresh
 - $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh
 - Hidden refresh
- Test function
- Battery back up operation
 - HM514400CL Series (L-version)

Ordering Information

Type No.	Access time	Package
HM514400CS/CLS-6	60 ns	300-mil 26-pin plastic SOJ (CP-26/20D)
HM514400CS/CLS-7	70 ns	
HM514400CS/CLS-8	80 ns	
HM514400CZ/CLZ-6	60 ns	400-mil 20-pin plastic ZIP (ZP-20)
HM514400CZ/CLZ-7	70 ns	
HM514400CZ/CLZ-8	80 ns	
HM514400CTT/CLTT-6	60 ns	26-pin plastic TSOPII (TTP-26/20D)
HM514400CTT/CLTT-7	70 ns	
HM514400CTT/CLTT-8	80 ns	

ADE-203-269A(Z)

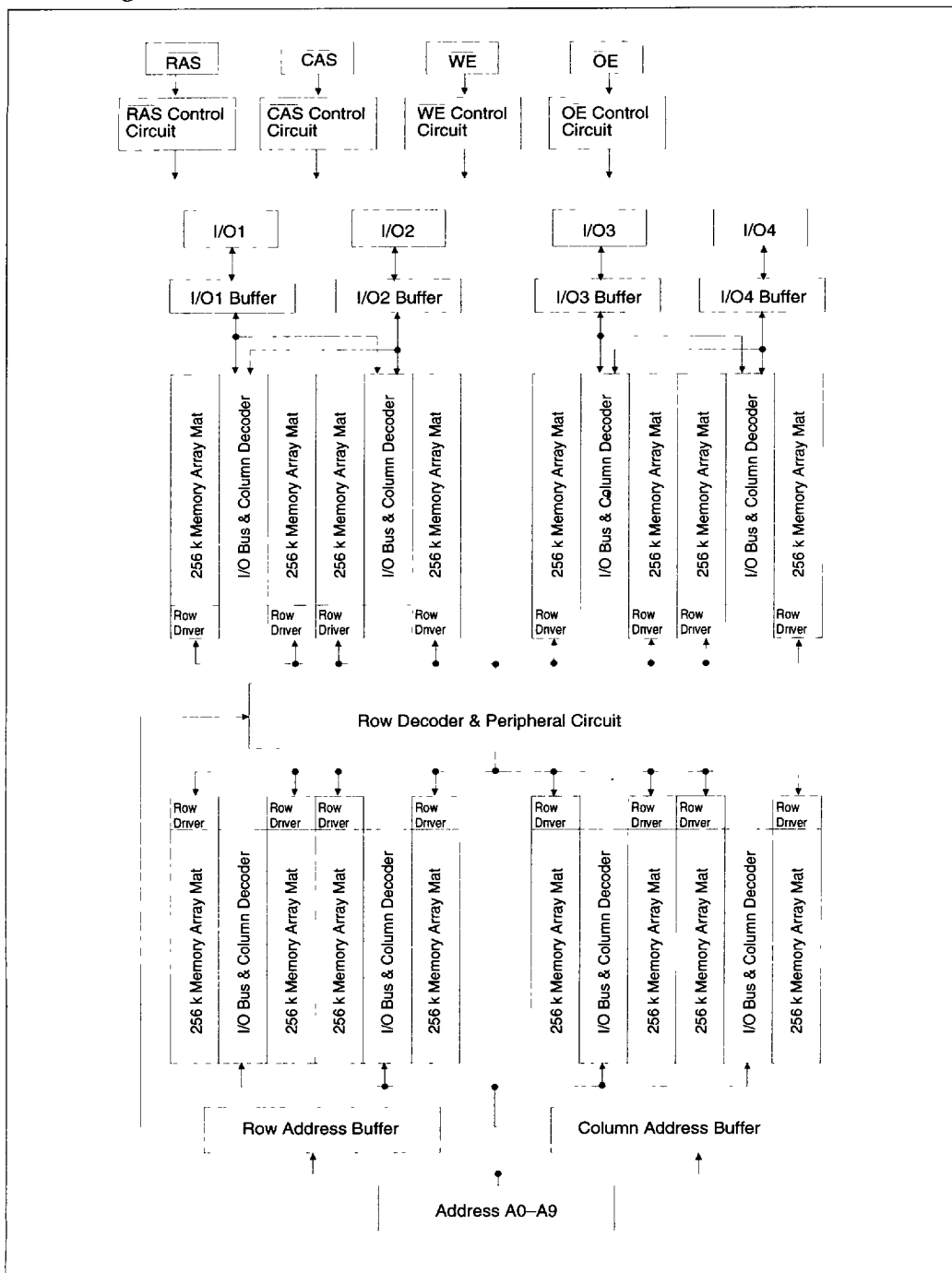
Pin Arrangement



Pin Description

Pin name	Function
A0 to A9	Address input
A0 to A9	Refresh address input
I/O1 to I/O4	Data-in/Data-out
RAS	Row address strobe
CAS	Column address strobe
WE	Read/Write enable
OE	Output enable
V _{CC}	Power (+5 V)
V _{SS}	Ground

Block Diagram



Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Voltage on any pin relative to V_{SS}	V_T	-1.0 to +7.0	V
Supply voltage relative to V_{SS}	V_{CC}	-1.0 to +7.0	V
Short circuit output current	I_{out}	50	mA
Power dissipation	P_T	1.0	W
Operating temperature	T_{opr}	0 to +70	°C
Storage temperature	T_{stg}	-55 to +125	°C

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

Parameter	Symbol	Min	Typ	Max	Unit	Note
Supply voltage	V_{SS}	0	0	0	V	
	V_{CC}	4.5	5.0	5.5	V	1
Input high voltage	V_{IH}	2.4	—	6.5	V	1
Input low voltage	V_{IL}	-1.0	—	0.8	V	1

Note : 1. All voltage referred to V_{SS} .

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DC Characteristics (Ta = 0 to +70°C, V_{CC} = 5 V ± 10%, V_{SS} = 0 V)

HM514400C/CL										
Parameter	Symbol	-6		-7		-8		Unit	Test condition	Notes
		Min	Max	Min	Max	Min	Max			
Operating current	I _{CC1}	—	110	—	100	—	90	mA	RAS, $\overline{\text{CAS}}$ cycling t _{RC} = min	1, 2
Standby current	I _{CC2}	—	2	—	2	—	2	mA	TTL interface RAS, $\overline{\text{CAS}}$ = V _{IH} Dout = High-Z	
		—	1	—	1	—	1	mA	CMOS interface RAS, $\overline{\text{CAS}}$ ≥ V _{CC} - 0.2 V Dout = High-Z	
Standby current (L-version)		—	100	—	100	—	100	μA	CMOS interface RAS, $\overline{\text{CAS}}$ = V _{IH} WE, $\overline{\text{OE}}$, Address and Din = V _{IH} or V _{IL} Dout = High-Z	4
RAS-only refresh current	I _{CC3}	—	110	—	100	—	90	mA	t _{RC} = min	2
Standby current	I _{CC5}	—	5	—	5	—	5	mA	RAS = V _{IH} , $\overline{\text{CAS}}$ = V _{IL} Dout = enable	1
$\overline{\text{CAS}}$ -before-RAS refresh current	I _{CC6}	—	110	—	100	—	90	mA	t _{RC} = min	
Fast page mode current	I _{CC7}	—	110	—	100	—	90	mA	t _{PC} = min	1, 3
Battery back up current (Standby with CBR refresh) (L-version)	I _{CC10}	—	200	—	200	—	200	μA	t _{RC} = 125 μs t _{BRAS} ≤ 1 μs WE = V _{IH} , $\overline{\text{CAS}}$ = V _{IL} $\overline{\text{OE}}$, Address and Din = V _{IH} or V _{IL} Dout = High-Z	4
Input leakage current	I _{LI}	-10	10	-10	10	-10	10	μA	0 V ≤ Vin ≤ 7 V	
Output leakage current	I _{LO}	-10	10	-10	10	-10	10	μA	0 V ≤ Vout ≤ 7 V Dout = disable	
Output high voltage	V _{OH}	2.4	V _{CC}	2.4	V _{CC}	2.4	V _{CC}	V	High Iout = -5 mA	
Output low voltage	V _{OL}	0	0.4	0	0.4	0	0.4	V	Low Iout = 4.2 mA	

Notes : 1. I_{CC} depends on output load condition when the device is selected. I_{CC} max is specified at the output open condition.

2. Address can be changed twice or less while RAS = V_{IL}.

3. Address can be changed once or less while $\overline{\text{CAS}}$ = V_{IH}.

4. V_{CC} - 0.2 V ≤ V_{IH} ≤ 6.5 V and 0 V ≤ V_{IL} ≤ 0.2 V.

Capacitance ($T_a = 25^\circ\text{C}$, $V_{CC} = 5\text{ V} \pm 10\%$)

Parameter	Symbol	Typ	Max	Unit	Notes
Input capacitance (Address)	C_{I1}	—	5	pF	1
Input capacitance (Clocks)	C_{I2}	—	7	pF	1
Output capacitance (Data-in, Data-out)	$C_{I/O}$	—	7	pF	1, 2

Notes : 1. Capacitance measured with Boonton Meter or effective capacitance measuring method.

2. $\overline{CAS} = V_{IH}$ to disable Dout.**AC Characteristics** ($T_a = 0$ to $+70^\circ\text{C}$, $V_{CC} = 5\text{ V} \pm 10\%$, $V_{SS} = 0\text{ V}$) *1, *14, *15, *16**Test Conditions**

Input rise and fall times : 5 ns

Input timing reference levels : 0.8 V, 2.4 V

Output load : 2 TTL gate + C_L (100 pF)

(Including scope and jig)

HM514400C/CL Series

Read, Write, Read-Modify-Write and Refresh Cycles (Common parameters)

		HM514400C/CL							
		-6		-7		-8			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
Random read or write cycle time	t _{RC}	110	—	130	—	150	—	ns	
$\overline{\text{RAS}}$ precharge time	t _{RP}	40	—	50	—	60	—	ns	
$\overline{\text{RAS}}$ pulse width	t _{RAS}	60	10000	70	10000	80	10000	ns	19
$\overline{\text{CAS}}$ pulse width	t _{CAS}	15	10000	20	10000	20	10000	ns	20
Row address setup time	t _{ASR}	0	—	0	—	0	—	ns	
Row address hold time	t _{RAH}	10	—	10	—	10	—	ns	
Column address setup time	t _{ASC}	0	—	0	—	0	—	ns	
Column address hold time	t _{CAH}	15	—	15	—	15	—	ns	
$\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ delay time	t _{RCD}	20	45	20	50	20	60	ns	8
$\overline{\text{RAS}}$ to column address delay time	t _{RAD}	15	30	15	35	15	40	ns	9
$\overline{\text{RAS}}$ hold time	t _{RSH}	15	—	20	—	20	—	ns	
$\overline{\text{CAS}}$ hold time	t _{CSH}	60	—	70	—	80	—	ns	
$\overline{\text{CAS}}$ to $\overline{\text{RAS}}$ precharge time	t _{CRP}	10	—	10	—	10	—	ns	
$\overline{\text{OE}}$ to Din delay time	t _{ODD}	15	—	20	—	20	—	ns	
$\overline{\text{OE}}$ delay time from Din	t _{DZO}	0	—	0	—	0	—	ns	
$\overline{\text{CAS}}$ setup time from Din	t _{DZC}	0	—	0	—	0	—	ns	
Transition time (rise and fall)	t _T	3	50	3	50	3	50	ns	7
Refresh period	t _{REF}	—	16	—	16	—	16	ms	
Refresh period (L-version)	t _{REF}	—	128	—	128	—	128	ms	

Read Cycle

		HM514400C/CL							
		-6		-7		-8			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
Access time from $\overline{\text{RAS}}$	t_{RAC}	—	60	—	70	—	80	ns	2, 3, 17
Access time from $\overline{\text{CAS}}$	t_{CAC}	—	15	—	20	—	20	ns	3, 4, 13, 17
Access time from address	t_{AA}	—	30	—	35	—	40	ns	3, 5, 13, 17
Access time from $\overline{\text{OE}}$	t_{OAC}	—	15	—	20	—	20	ns	3, 17
Read command setup time	t_{RCS}	0	—	0	—	0	—	ns	
Read command hold time to $\overline{\text{CAS}}$	t_{RCH}	0	—	0	—	0	—	ns	18
Read command hold time to $\overline{\text{RAS}}$	t_{RRH}	0	—	0	—	0	—	ns	18
Column address to $\overline{\text{RAS}}$ lead time	t_{RAL}	30	—	35	—	40	—	ns	
Output buffer turn-off time	t_{OFF1}	0	15	0	20	0	20	ns	6
Output buffer turn-off time to $\overline{\text{OE}}$	t_{OFF2}	0	15	0	20	0	20	ns	6
$\overline{\text{CAS}}$ to Din delay time	t_{CDD}	15	—	20	—	20	—	ns	
$\overline{\text{OE}}$ pulse width	t_{OEP}	15	—	20	—	20	—	ns	

Write Cycle

		HM514400C/CL							
		-6		-7		-8			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
Write command setup time	t_{WCS}	0	—	0	—	0	—	ns	10
Write command hold time	t_{WCH}	15	—	15	—	15	—	ns	
Write command pulse width	t_{WP}	10	—	10	—	10	—	ns	
Write command to $\overline{\text{RAS}}$ lead time	t_{RWL}	15	—	20	—	20	—	ns	
Write command to $\overline{\text{CAS}}$ lead time	t_{CWL}	15	—	20	—	20	—	ns	
Data-in setup time	t_{DS}	0	—	0	—	0	—	ns	11
Data-in hold time	t_{DH}	15	—	15	—	15	—	ns	11

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Read-Modify-Write Cycle

		HM514400C/CL							
		-6		-7		-8			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
Read-modify-write cycle time	t _{RWC}	150	—	180	—	200	—	ns	
$\overline{RAS}$ to $\overline{WE}$ delay time	t _{RWD}	80	—	95	—	105	—	ns	10
$\overline{CAS}$ to $\overline{WE}$ delay time	t _{CWD}	35	—	45	—	45	—	ns	10
Column address to $\overline{WE}$ delay time	t _{AWD}	50	—	60	—	65	—	ns	10
$\overline{OE}$ hold time from $\overline{WE}$	t _{OEh}	15	—	20	—	20	—	ns	

Refresh Cycle

Parameter		HM514400C/CL						Unit	Notes
		-6		-7		-8			
Symbol	Min	Max	Min	Max	Min	Max			
$\overline{\text{CAS}}$ setup time (CBR refresh cycle)	t _{CSR}	10	—	10	—	10	—	ns	
$\overline{\text{CAS}}$ hold time (CBR refresh cycle)	t _{CHR}	10	—	10	—	10	—	ns	
$\overline{\text{RAS}}$ precharge to $\overline{\text{CAS}}$ hold time	t _{RPC}	10	—	10	—	10	—	ns	
$\overline{\text{CAS}}$ precharge time in normal mode	t _{CPN}	10	—	10	—	10	—	ns	

Fast Page Mode Cycle

Parameter		HM514400C/CL						Unit	Notes
		-6		-7		-8			
Symbol	Min	Max	Min	Max	Min	Max			
Fast page mode cycle time	t _{PC}	40	—	45	—	50	—	ns	
Fast page mode $\overline{\text{CAS}}$ precharge time	t _{CP}	10	—	10	—	10	—	ns	
Fast page mode $\overline{\text{RAS}}$ pulse width	t _{RASC}	—	100000	—	100000	—	100000	ns	12
Access time from $\overline{\text{CAS}}$ precharge	t _{ACP}	—	35	—	40	—	45	ns	3, 13, 17
$\overline{\text{RAS}}$ hold time from $\overline{\text{CAS}}$ precharge	t _{RHCP}	35	—	40	—	45	—	ns	

Fast Page Mode Read-Modify-Write Cycle

		HM514400C/CL							
		-6		-7		-8			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
Fast page mode read-modify-write cycle time	t _{PCM}	80	—	95	—	100	—	ns	
Fast page mode read-modify-write cycle CAS precharge to WE delay time	t _{CPW}	55	—	65	—	70	—	ns	10

Test Mode Cycle

		HM514400C/CL							
		-6		-7		-8			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
Test mode WE setup time	t _{WS}	0	—	0	—	0	—	ns	
Test mode WE hold time	t _{WH}	10	—	10	—	10	—	ns	

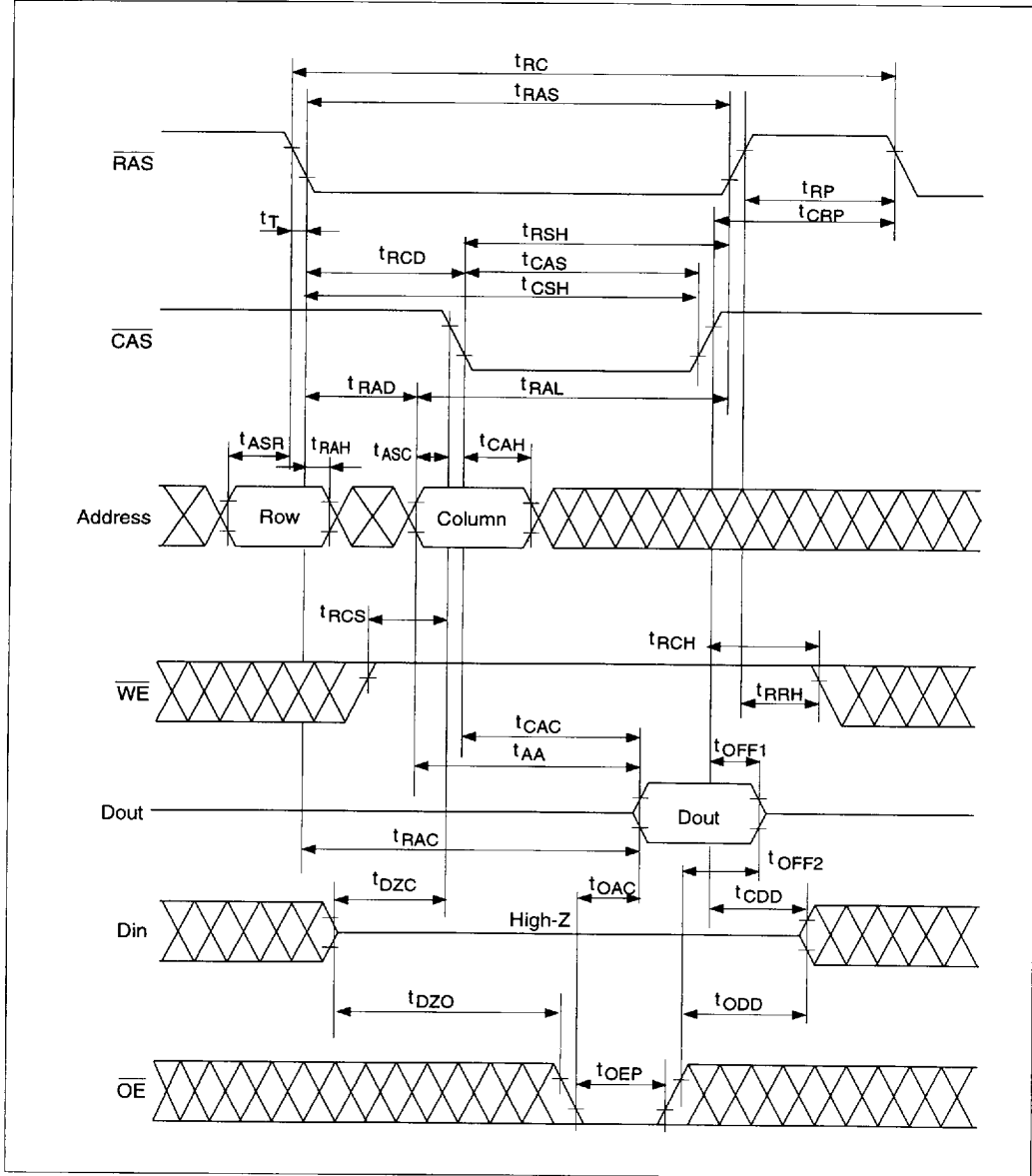
Counter Test Cycle

		HM514400C/CL							
		-6		-7		-8			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
CAS precharge time in counter test cycle	t _{CPT}	40	—	40	—	40	—	ns	

- Notes:
1. AC measurements assume $t_T = 5$ ns.
 2. Assumes that $t_{RCD} \leq t_{RCD}(\text{max})$ and $t_{RAD} \leq t_{RAD}(\text{max})$. If t_{RCD} or t_{RAD} is greater than the maximum recommended value shown in this table, t_{RAC} exceeds the value shown.
 3. Measured with a load circuit equivalent to 2 TTL loads and 100 pF.
 4. Assumes that $t_{RCD} \geq t_{RCD}(\text{max})$ and $t_{RAD} \leq t_{RAD}(\text{max})$.
 5. Assumes that $t_{RCD} \leq t_{RCD}(\text{max})$ and $t_{RAD} \geq t_{RAD}(\text{max})$.
 6. $t_{OFF}(\text{max})$ defines the time at which the output achieves the open circuit condition and is not referred to output voltage levels.
 7. $V_{IH}(\text{min})$ and $V_{IL}(\text{max})$ are reference levels for measuring timing of input signals. Also, transition times are measured between V_{IH} and V_{IL} .
 8. Operation with the $t_{RCD}(\text{max})$ limit insures that $t_{RAC}(\text{max})$ can be met, $t_{RCD}(\text{max})$ is specified as a reference point only, if t_{RCD} is greater than the specified $t_{RCD}(\text{max})$ limit, then access time is controlled exclusively by t_{CAC} .
 9. Operation with the $t_{RAD}(\text{max})$ limit insures that $t_{RAC}(\text{max})$ can be met, $t_{RAD}(\text{max})$ is specified as a reference point only, if t_{RAD} is greater than the specified $t_{RAD}(\text{max})$ limit, then access time is controlled exclusively by t_{AA} .
 10. t_{WCS} , t_{RWD} , t_{CWD} , t_{CPW} and t_{AWD} are not restrictive operating parameters. They are included in the data sheet as electrical characteristics only; if $t_{WCS} \geq t_{WCS}(\text{min})$, the cycle is an early write cycle and the data out pin will remain open circuit (high impedance) throughout the entire cycle; if $t_{RWD} \geq t_{RWD}(\text{min})$, $t_{CWD} \geq t_{CWD}(\text{min})$, $t_{CPW} \geq t_{CPW}(\text{min})$ and $t_{AWD} \geq t_{AWD}(\text{min})$, the cycle is a read-modify-write and the data output will contain data read from the selected cell; if neither of the above sets of conditions is satisfied, the condition of the data out (at access time) is indeterminate.
 11. These parameters are referred to $\overline{\text{CAS}}$ leading edge in an early write cycle and to $\overline{\text{WE}}$ leading edge in a delayed write or read-modify-write cycle.
 12. t_{RASC} defines RAS pulse width in fast page mode cycles.
 13. Access time is determined by the longest among t_{AA} , t_{CAC} and t_{ACP} .
 14. An initial pause of 100 μs is required after power up followed by a minimum of eight initialization cycles ($\overline{\text{RAS}}$ -only refresh cycle or $\overline{\text{CAS}}$ -before-RAS refresh cycle). If the internal refresh counter is used, a minimum of eight $\overline{\text{CAS}}$ -before-RAS refresh cycles is required.
 15. In delayed write or read-modify-write cycles, $\overline{\text{OE}}$ must disable output buffer prior to applying data to the device.
 16. Test mode operation specified in this data sheet is 2-bit test function controlled by control address bits - - - CA0. This test mode operation can be performed by $\overline{\text{WE}}$ -and- $\overline{\text{CAS}}$ -before-RAS (WCBR) refresh cycle. Refresh during test mode operation will be performed by normal read cycles or by WCBR refresh cycles. When the state of two test bits accord each other, the condition of the output data is high level. When the state of test bits do not accord, the condition of the output data is low level. In order to end this test mode operation, perform a $\overline{\text{RAS}}$ -only refresh cycle or a $\overline{\text{CAS}}$ -before-RAS refresh cycle.
 17. In a test mode read cycle, the value of t_{RAC} , t_{AA} , t_{CAC} , t_{OAC} and t_{ACP} is delayed for 2 ns to 5 ns for the specified value. These parameters should be specified in test mode cycles by adding the above value to the specified value in this data sheet.
 18. Either t_{RCH} or t_{RRH} must be satisfied.
 19. $t_{RAS}(\text{min}) = t_{RWD}(\text{min}) + t_{RWL}(\text{min}) + t_T$ in read-modify-write cycle.
 20. $t_{CAS}(\text{min}) = t_{CWD}(\text{min}) + t_{CWL}(\text{min}) + t_T$ in read-modify-write cycle.

Timing Waveforms*21

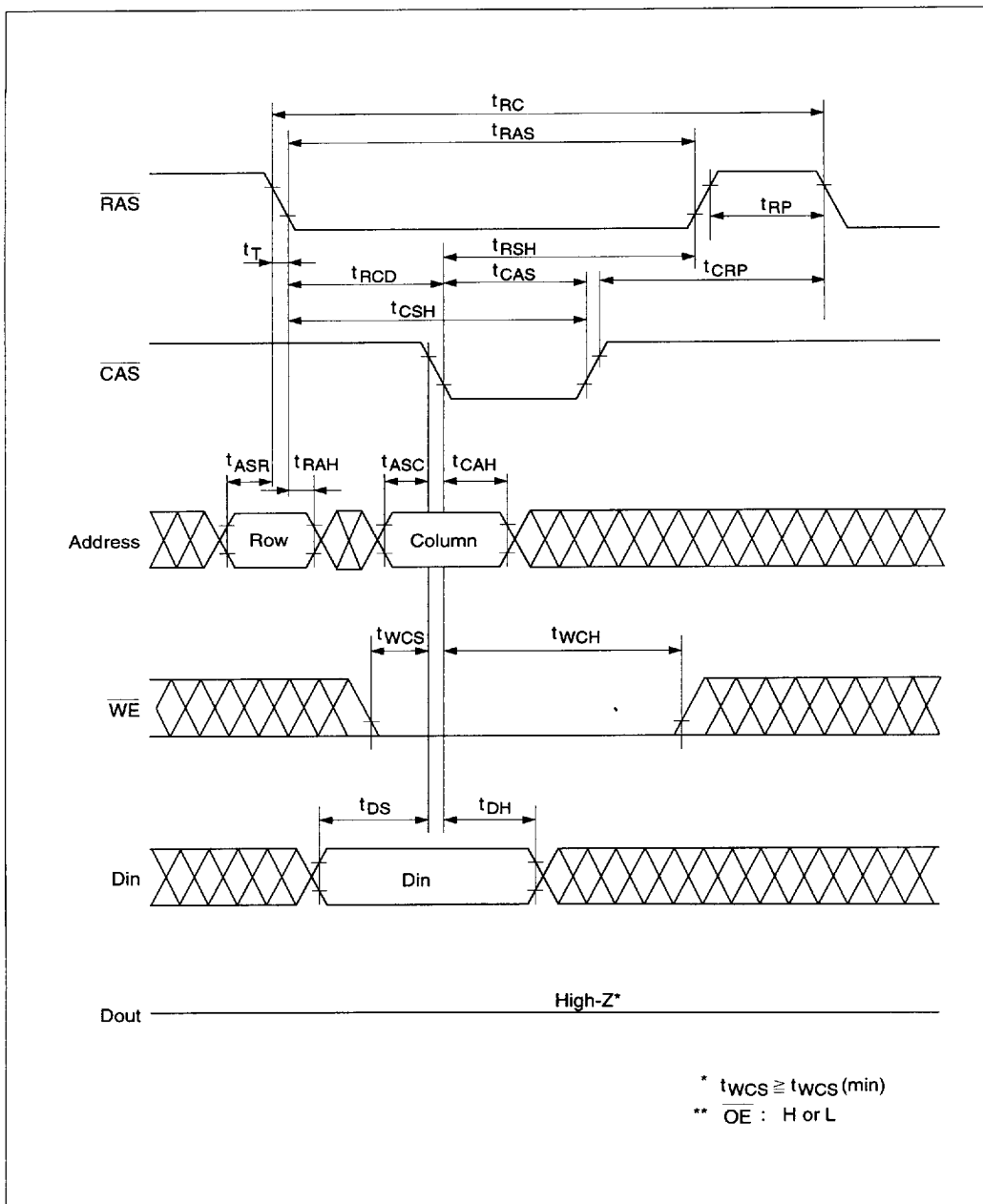
Read Cycle



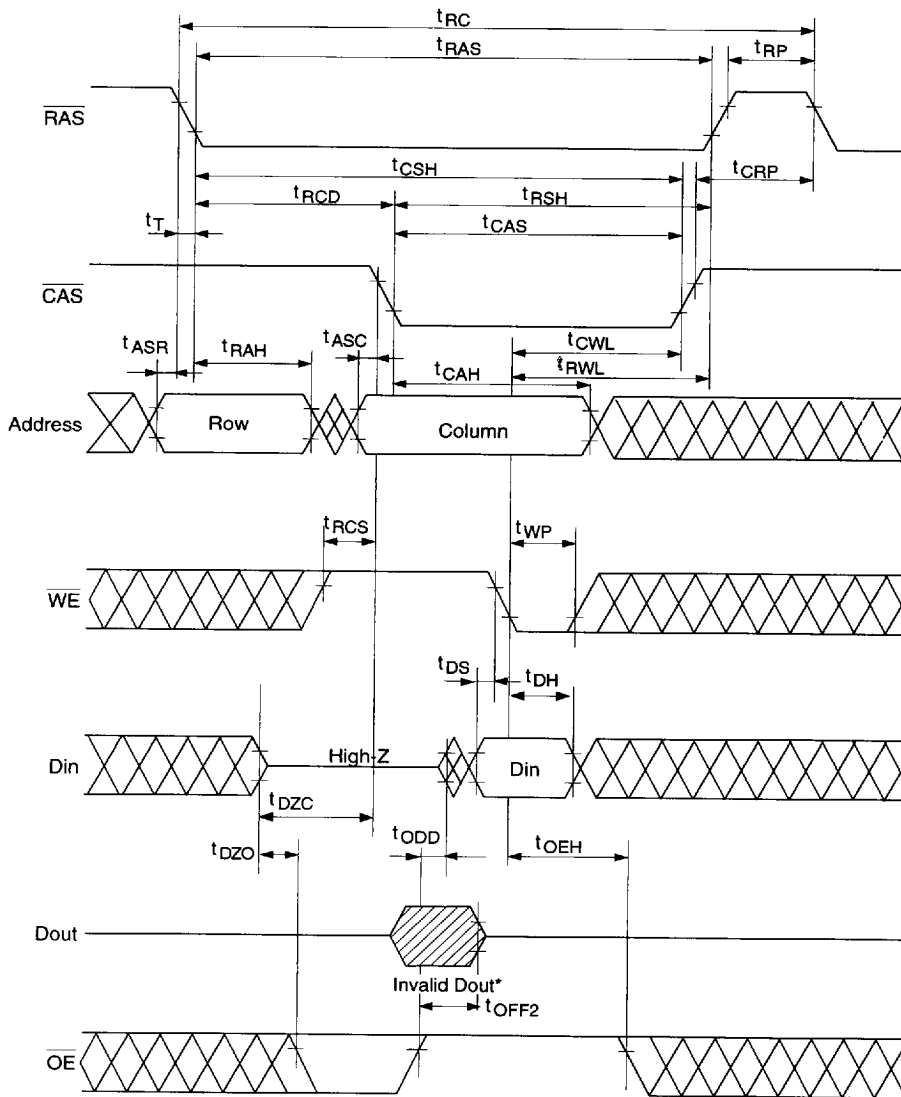
Note 21:  H or L (H: $V_{\text{IH}}(\text{min}) \leq V_{\text{IN}} \leq V_{\text{IH}}(\text{max})$, L: $V_{\text{IL}}(\text{min}) \leq V_{\text{IN}} \leq V_{\text{IL}}(\text{max})$)

 Invalid Dout

Early Write Cycle

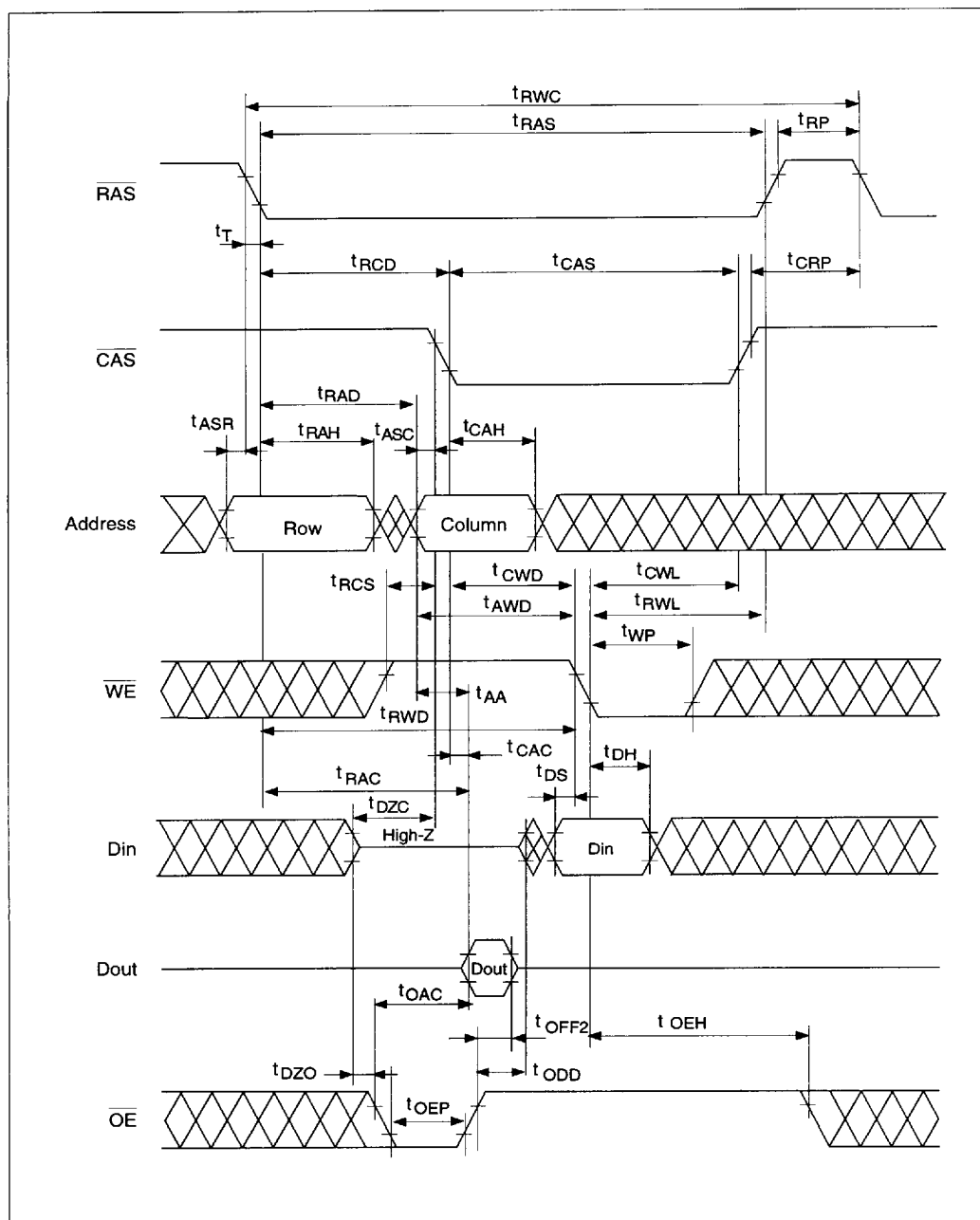


Delayed Write Cycle



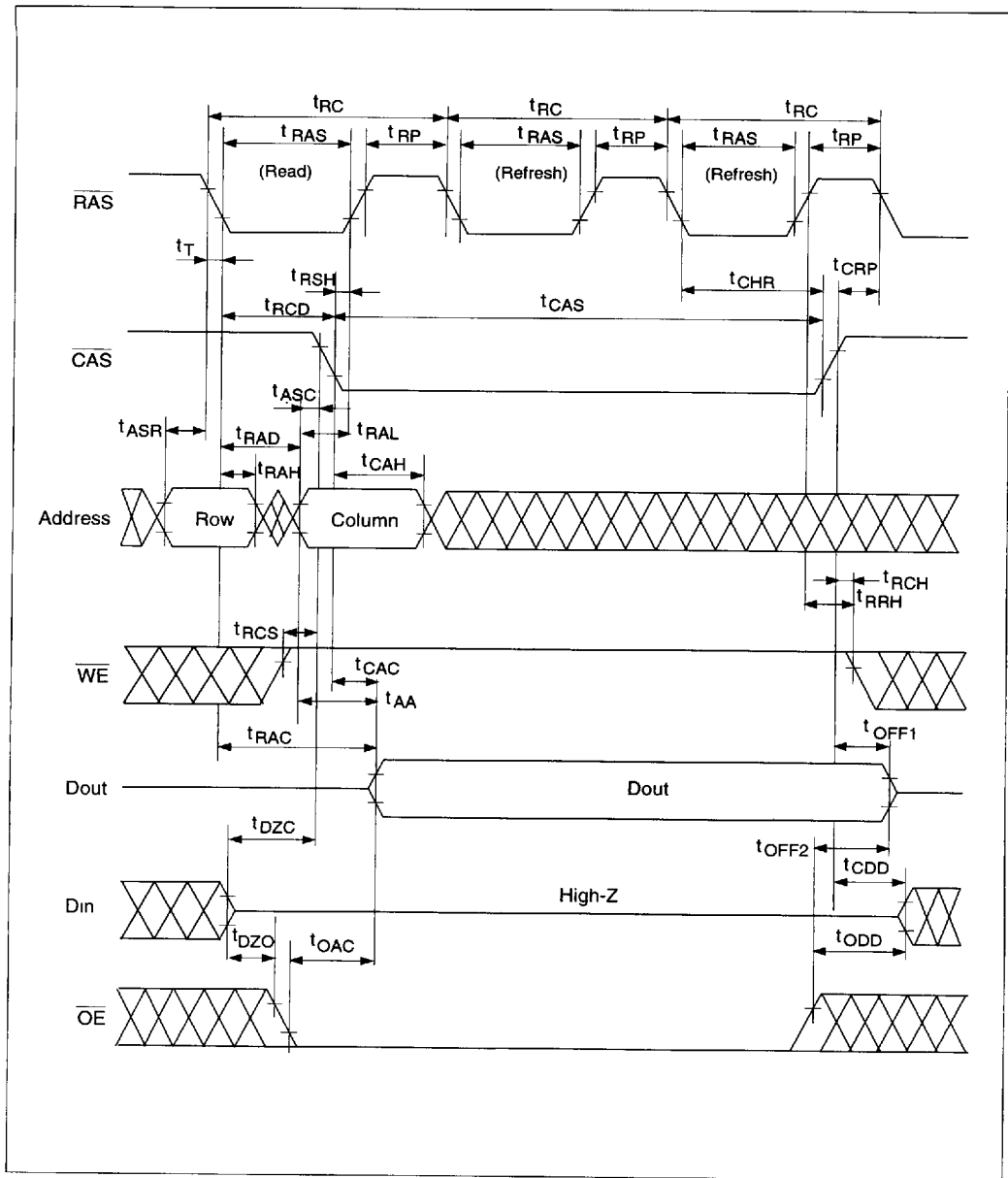
* Invalid Dout comes out, when $\overline{OE}$ is low level.

Read-Modify-Write Cycle



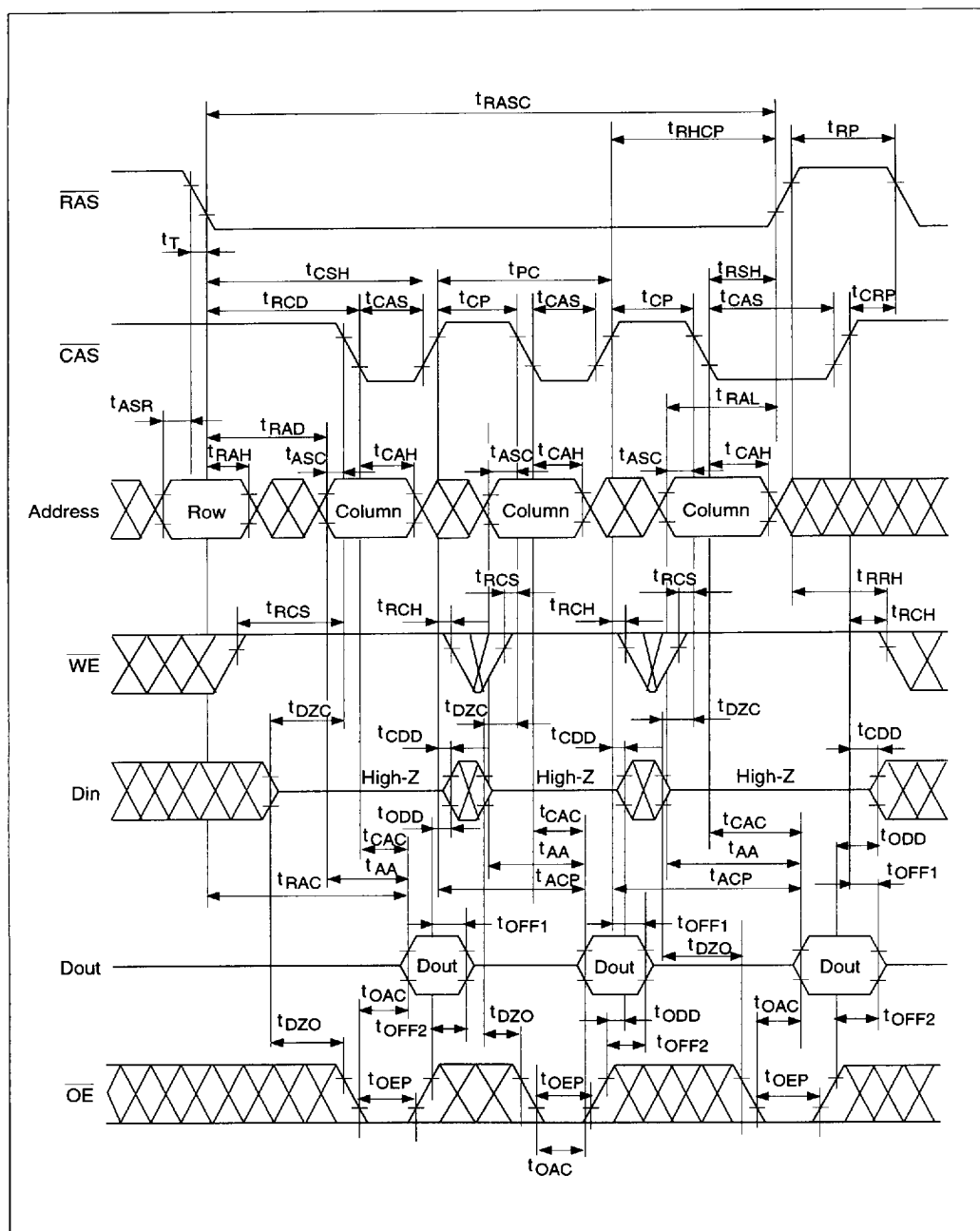
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Hidden Refresh Cycle

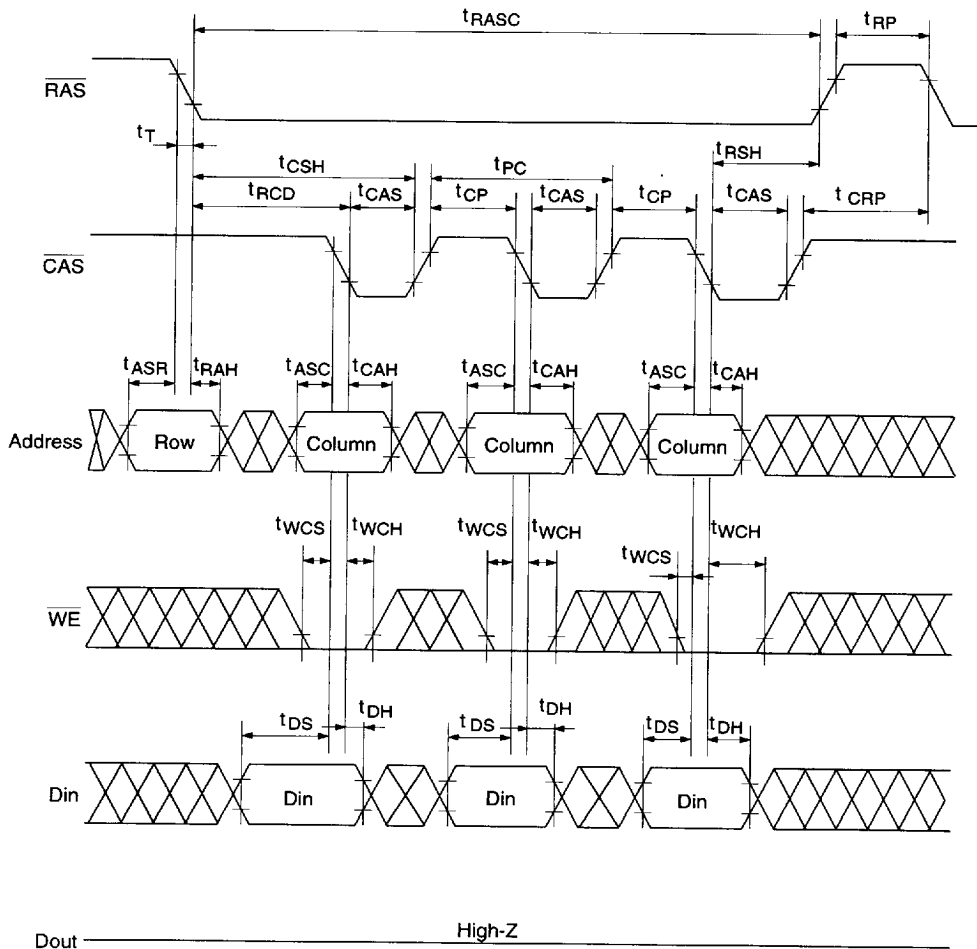


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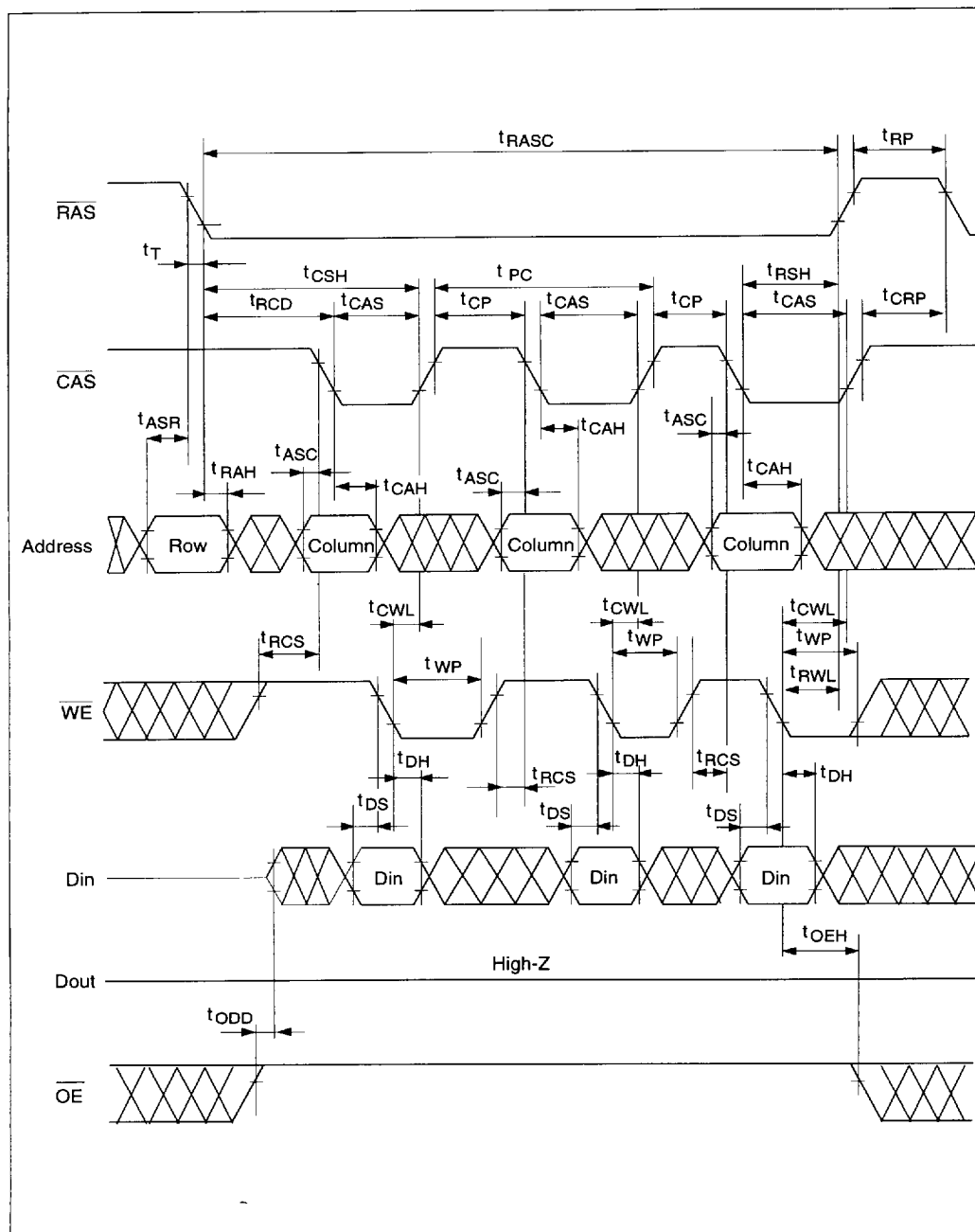
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Fast Page Mode Early Write Cycle

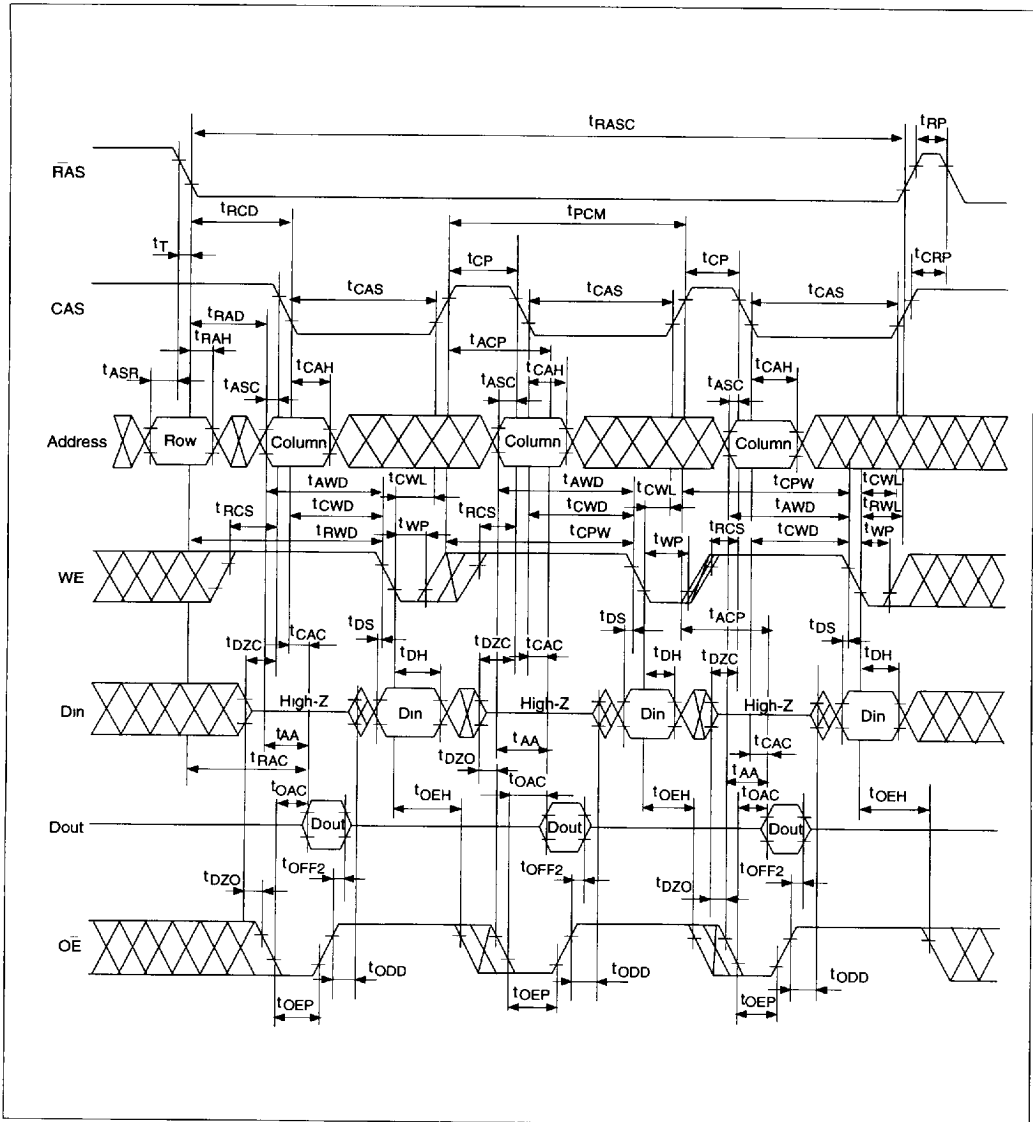


* $\overline{OE}$: H or L



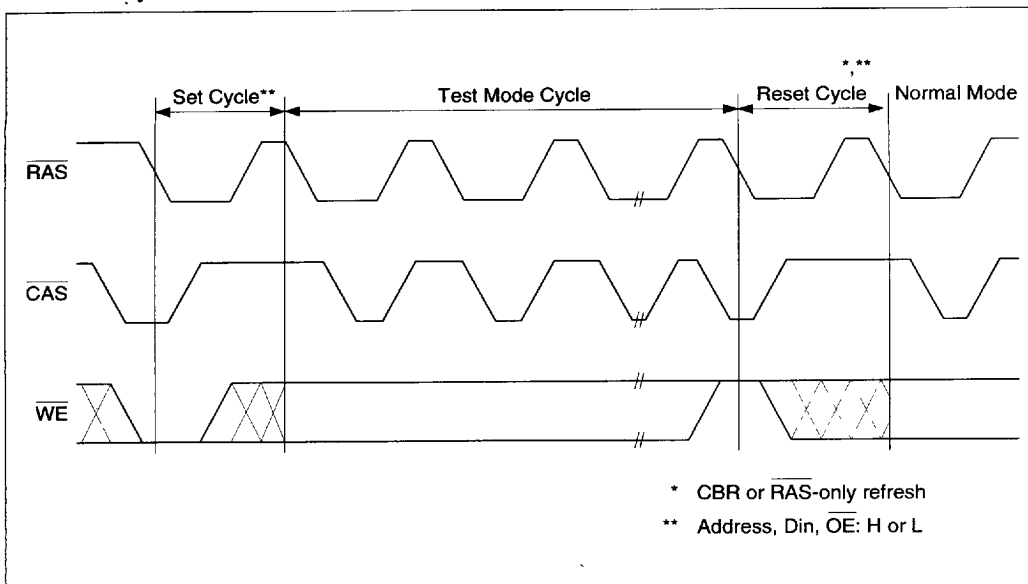
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Fast Page Mode Read-Modify-Write Cycle



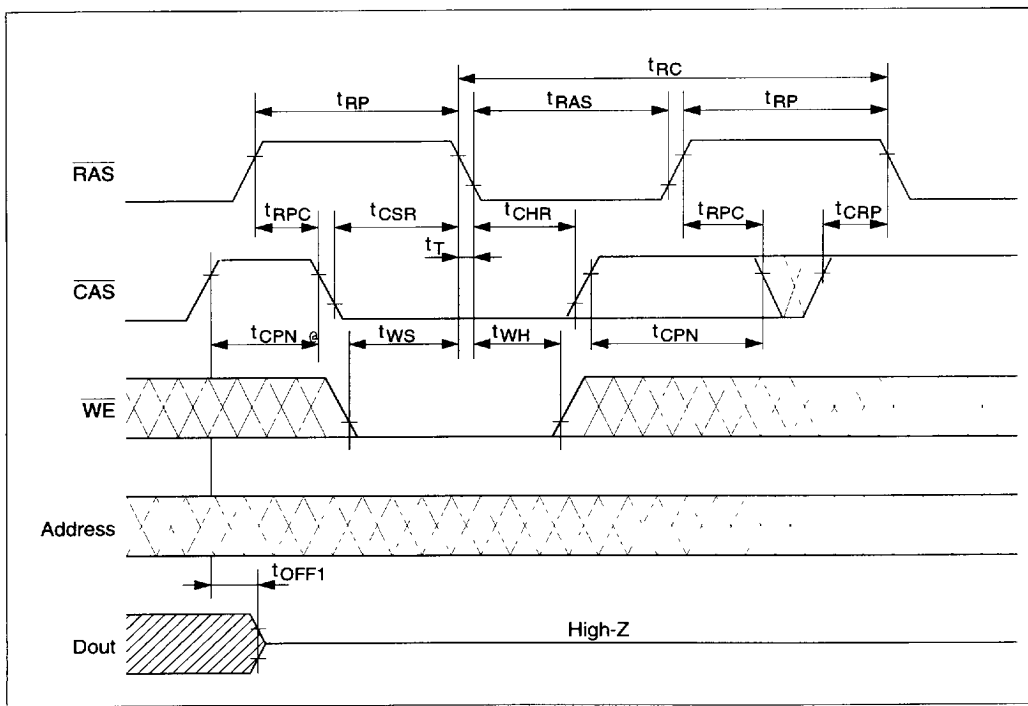
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Test Mode Cycle

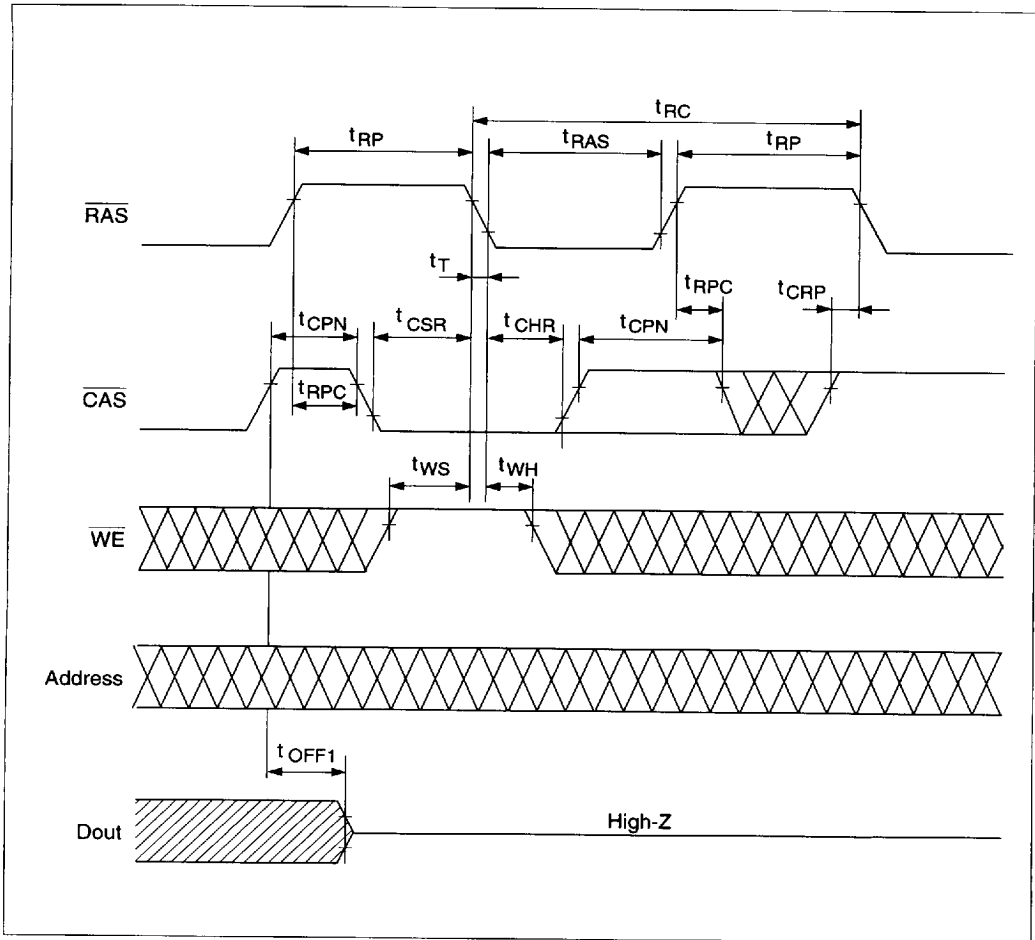


WE-and-CAS-Before RAS-Refresh Cycle

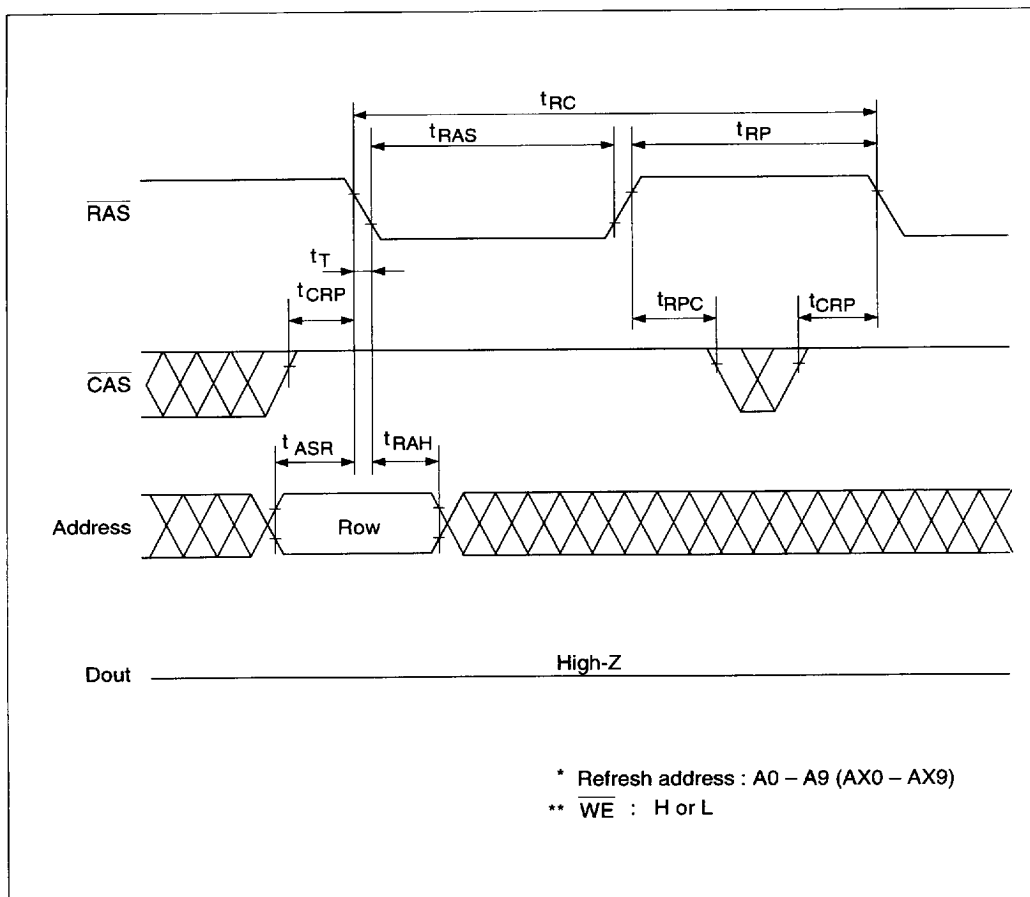
Test Mode Set Cycle



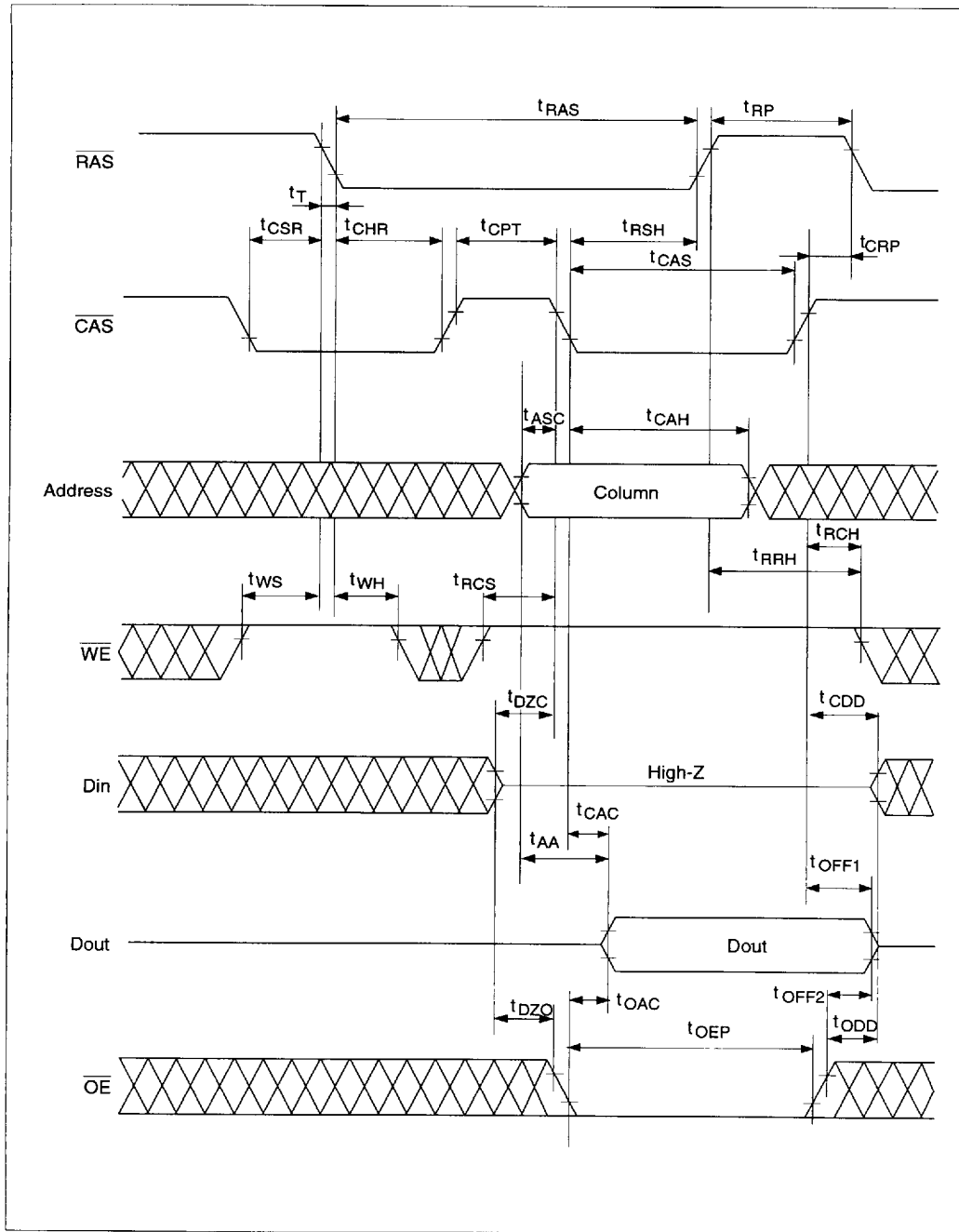
CAS-Before-RAS Refresh Cycle



RAS-Only Refresh Cycle



$\overline{\text{CAS}}$ -Before- $\overline{\text{RAS}}$ Refresh Counter Check Cycle (Read)



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$\overline{\text{CAS}}$ -Before- $\overline{\text{RAS}}$ Refresh Counter Check Cycle (Write)

