

# HM514400B/BL Series

# HM514400C/CL Series

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

# HITACHI

Rev. 1.0  
Nov. 29, 1994

The Hitachi HM514400B/BL, HM514400C/CL are CMOS dynamic RAM organized 1,048,576-word × 4-bit. HM514400B/BL, HM514400C/CL have realized higher density, higher performance and various functions by employing 0.8 μm CMOS process technology and some new CMOS circuit design technologies. The HM514400B/BL, HM514400C/CL offer Fast Page Mode as a high speed access mode. Multiplexed address input permits the HM514400B/BL, HM514400C/CL to be packaged in standard 300-mil 26-pin plastic SOJ, standard 400-mil 20-pin plastic ZIP and 26-pin plastic TSOP II.

- Test function
- Battery back up operation
  - HM514400BL Series (L-version)
  - HM514400CL Series (L-version)

## 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
  - RAS-only refresh
  - CAS-before-RAS refresh
  - Hidden refresh

---

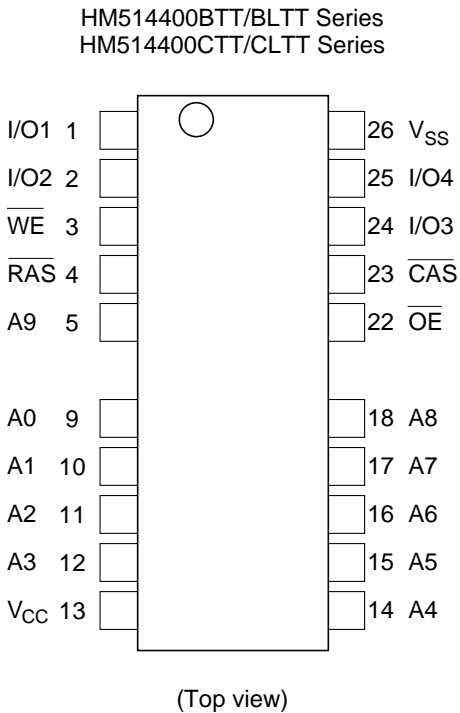
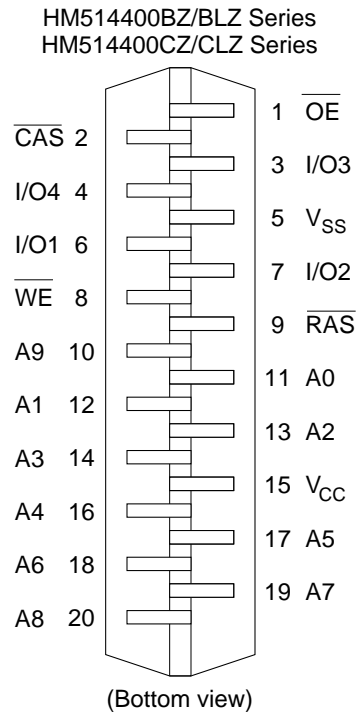
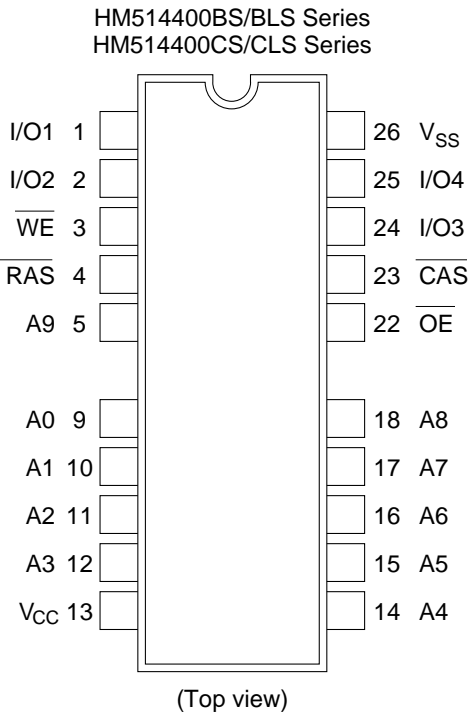
## HM514400B/BL, HM514400C/CL Series

---

### Ordering Information

Type No.	Access time	Package	Type No.	Access time	Package
HM514400BS-6	60 ns	300-mil 26-pin plastic SOJ (CP-26/20D)	HM514400CZ-6	60 ns	400-mil 20-pin plastic ZIP (ZP-20)
HM514400BS-7	70 ns				
HM514400BS-8	80 ns				
HM514400BLS-6	60 ns		HM514400CLZ-6	60 ns	
HM514400BLS-7	70 ns				
HM514400BLS-8	80 ns				
HM514400CS-6	60 ns		HM514400BTT-6	60 ns	26-pin plastic TSOPII (TTP-26/20D)
HM514400CS-7	70 ns				
HM514400CS-8	80 ns				
HM514400CLS-6	60 ns		HM514400BLTT-6	60 ns	
HM514400CLS-7	70 ns				
HM514400CLS-8	80 ns				
HM514400BZ-6	60 ns	400-mil 20-pin plastic ZIP (ZP-20)	HM514400CTT-6	60 ns	
HM514400BZ-7	70 ns				
HM514400BZ-8	80 ns				
HM514400BLZ-6	60 ns		HM514400CLTT-6	60 ns	
HM514400BLZ-7	70 ns				
HM514400BLZ-8	80 ns				

## Pin Arrangement



---

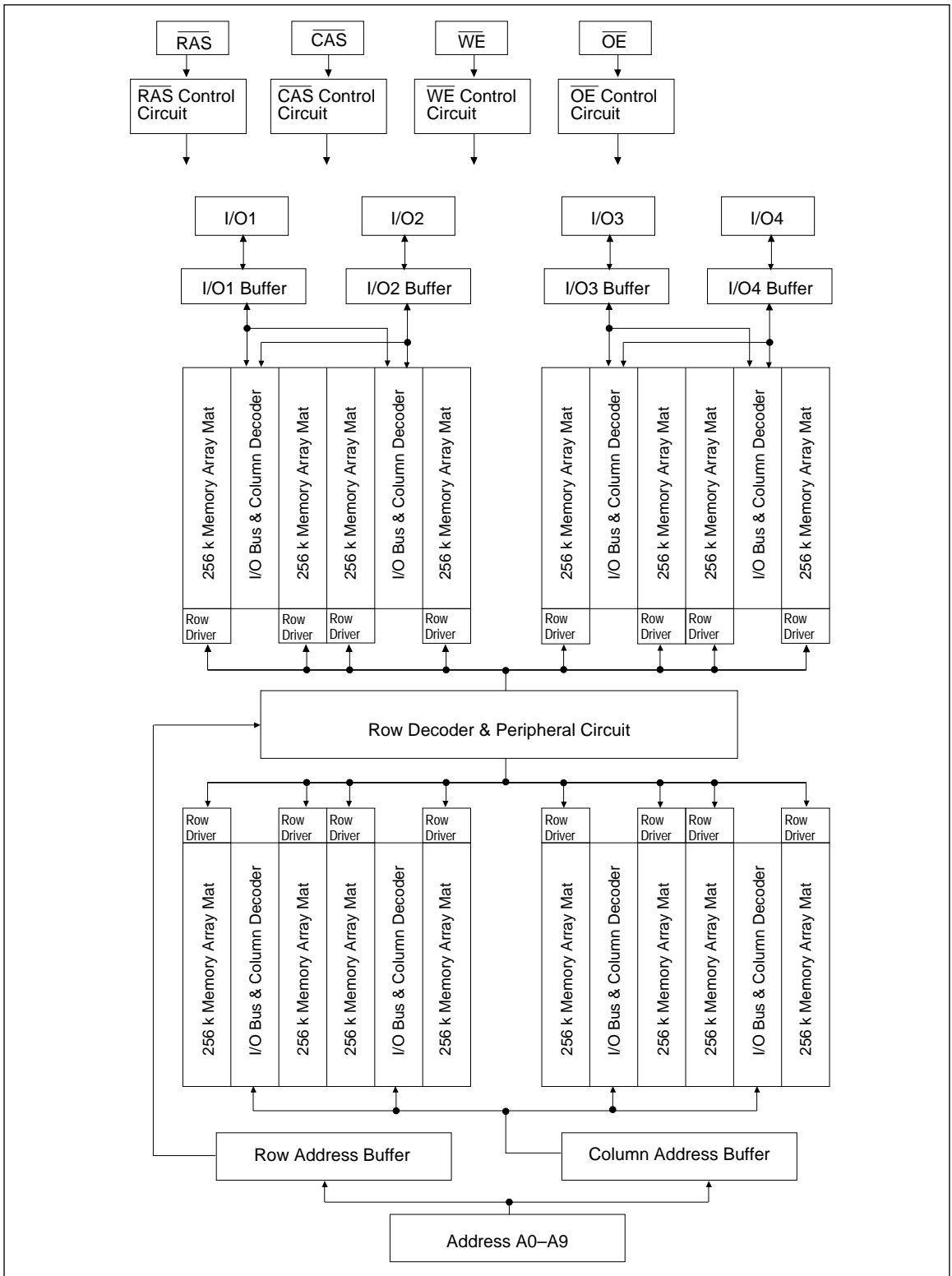
## HM514400B/BL, HM514400C/CL Series

---

### 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
$\overline{\text{RAS}}$	Row address strobe
$\overline{\text{CAS}}$	Column address strobe
$\overline{\text{WE}}$	Read/Write enable
$\overline{\text{OE}}$	Output enable
V <sub>CC</sub>	Power (+5 V)
V <sub>SS</sub>	Ground

Block Diagram



## HM514400B/BL, HM514400C/CL Series

### 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°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  $V_{SS}$ .

## HM514400B/BL, HM514400C/CL Series

**DC Characteristics** ( $T_a = 0$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 5\text{ V} \pm 10\%$ ,  $V_{SS} = 0\text{ V}$ )

Parameter	Symbol	HM514400B/BL, HM514400C/CL						Unit	Test conditions	Notes
		-6		-7		-8				
		Min	Max	Min	Max	Min	Max			
Operating current	$I_{CC1}$	—	110	—	100	—	90	mA	$\overline{\text{RAS}}$ , $\overline{\text{CAS}}$ cycling $t_{RC} = \text{min}$	1, 2
Standby current	$I_{CC2}$	—	2	—	2	—	2	mA	TTL interface $\overline{\text{RAS}}$ , $\overline{\text{CAS}} = V_{IH}$ Dout = High-Z	
		—	1	—	1	—	1	mA	CMOS interface $\overline{\text{RAS}}$ , $\overline{\text{CAS}}$ $\geq V_{CC} - 0.2\text{ V}$ Dout = High-Z	
Standby current (L-version)	$I_{CC2}$	—	100	—	100	—	100	$\mu\text{A}$	CMOS interface $\overline{\text{RAS}}$ , $\overline{\text{CAS}} = V_{IH}$ $\overline{\text{WE}}$ , $\overline{\text{OE}}$ , Address and Din = $V_{IH}$ or $V_{IL}$ Dout = High-Z	4
$\overline{\text{RAS}}$ -only refresh current	$I_{CC3}$	—	110	—	100	—	90	mA	$t_{RC} = \text{min}$	2
Standby current	$I_{CC5}$	—	5	—	5	—	5	mA	$\overline{\text{RAS}} = V_{IH}$ , $\overline{\text{CAS}} = V_{IL}$ Dout = enable	1
$\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh current	$I_{CC6}$	—	110	—	100	—	90	mA	$t_{RC} = \text{min}$	
Fast page mode current	$I_{CC7}$	—	110	—	100	—	90	mA	$t_{PC} = \text{min}$	1, 3
Battery back up current (Standby with CBR refresh) (L-version)	$I_{CC10}$	—	200	—	200	—	200	$\mu\text{A}$	$t_{RC} = 125\ \mu\text{s}$ $t_{RAS} \leq 1\ \mu\text{s}$ $\overline{\text{WE}} = V_{IH}$ , $\overline{\text{CAS}} = V_{IL}$ $\overline{\text{OE}}$ , Address and Din = $V_{IH}$ or $V_{IL}$ Dout = High-Z	4
Input leakage current	$I_{LI}$	-10	10	-10	10	-10	10	$\mu\text{A}$	$0\text{ V} \leq V_{in} \leq 7\text{ V}$	
Output leakage current	$I_{LO}$	-10	10	-10	10	-10	10	$\mu\text{A}$	$0\text{ V} \leq V_{out} \leq 7\text{ V}$ 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  $\overline{\text{RAS}} = V_{IL}$ .
3. Address can be changed once or less while  $\overline{\text{CAS}} = V_{IH}$ .
4.  $V_{CC} - 0.2\text{ V} \leq V_{IH} \leq 6.5\text{ V}$  and  $0\text{ V} \leq V_{IL} \leq 0.2\text{ V}$ .

---

## HM514400B/BL, HM514400C/CL Series

---

### 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.  $\overline{\text{CAS}} = V_{IH}$  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)



## HM514400B/BL, HM514400C/CL Series

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

Parameter	Symbol	HM514400B/BL, HM514400C/CL						Unit	Notes
		-6		-7		-8			
		Min	Max	Min	Max	Min	Max		
Random read or write cycle time	$t_{RC}$	110	—	130	—	150	—	ns	
$\overline{RAS}$ precharge time	$t_{RP}$	40	—	50	—	60	—	ns	
$\overline{RAS}$ pulse width	$t_{RAS}$	60	10000	70	10000	80	10000	ns	19
$\overline{CAS}$ 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	
$\overline{RAS}$ to $\overline{CAS}$ delay time	$t_{RCD}$	20	45	20	50	20	60	ns	8
$\overline{RAS}$ to column address delay time	$t_{RAD}$	15	30	15	35	15	40	ns	9
$\overline{RAS}$ hold time	$t_{RSH}$	15	—	20	—	20	—	ns	
$\overline{CAS}$ hold time	$t_{CSH}$	60	—	70	—	80	—	ns	
$\overline{CAS}$ to $\overline{RAS}$ precharge time	$t_{CRP}$	10	—	10	—	10	—	ns	
$\overline{OE}$ to Din delay time	$t_{ODD}$	15	—	20	—	20	—	ns	
$\overline{OE}$ delay time from Din	$t_{DZO}$	0	—	0	—	0	—	ns	
$\overline{CAS}$ 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	

## HM514400B/BL, HM514400C/CL Series

### Read Cycle

Parameter	Symbol	HM514400B/BL, HM514400C/CL						Unit	Notes
		-6		-7		-8			
		Min	Max	Min	Max	Min	Max		
Access time from $\overline{\text{RAS}}$	$t_{\text{RAC}}$	—	60	—	70	—	80	ns	2, 3, 17
Access time from $\overline{\text{CAS}}$	$t_{\text{CAC}}$	—	15	—	20	—	20	ns	3, 4, 13, 17
Access time from address	$t_{\text{AA}}$	—	30	—	35	—	40	ns	3, 5, 13, 17
Access time from $\overline{\text{OE}}$	$t_{\text{OAC}}$	—	15	—	20	—	20	ns	3, 17
Read command setup time	$t_{\text{RCS}}$	0	—	0	—	0	—	ns	
Read command hold time to $\overline{\text{CAS}}$	$t_{\text{RCH}}$	0	—	0	—	0	—	ns	18
Read command hold time to $\overline{\text{RAS}}$	$t_{\text{RRH}}$	0	—	0	—	0	—	ns	18
Column address to $\overline{\text{RAS}}$ lead time	$t_{\text{RAL}}$	30	—	35	—	40	—	ns	
Output buffer turn-off time	$t_{\text{OFF1}}$	0	15	0	20	0	20	ns	6
Output buffer turn-off time to $\overline{\text{OE}}$	$t_{\text{OFF2}}$	0	15	0	20	0	20	ns	6
$\overline{\text{CAS}}$ to Din delay time	$t_{\text{CDD}}$	15	—	20	—	20	—	ns	
$\overline{\text{OE}}$ pulse width	$t_{\text{OEP}}$	15	—	20	—	20	—	ns	

### Write Cycle

Parameter	Symbol	HM514400B/BL, HM514400C/CL						Unit	Notes
		-6		-7		-8			
		Min	Max	Min	Max	Min	Max		
Write command setup time	$t_{\text{WCS}}$	0	—	0	—	0	—	ns	10
Write command hold time	$t_{\text{WCH}}$	15	—	15	—	15	—	ns	
Write command pulse width	$t_{\text{WP}}$	10	—	10	—	10	—	ns	
Write command to $\overline{\text{RAS}}$ lead time	$t_{\text{RWL}}$	15	—	20	—	20	—	ns	
Write command to $\overline{\text{CAS}}$ lead time	$t_{\text{CWL}}$	15	—	20	—	20	—	ns	
Data-in setup time	$t_{\text{DS}}$	0	—	0	—	0	—	ns	11
Data-in hold time	$t_{\text{DH}}$	15	—	15	—	15	—	ns	11

**Read-Modify-Write Cycle**

		HM514400B/BL, HM514400C/CL							
		-6		-7		-8			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
Read-modify-write cycle time	t <sub>RWC</sub>	150	—	180	—	200	—	ns	
$\overline{\text{RAS}}$ to $\overline{\text{WE}}$ delay time	t <sub>RWD</sub>	80	—	95	—	105	—	ns	10
$\overline{\text{CAS}}$ to $\overline{\text{WE}}$ delay time	t <sub>CWD</sub>	35	—	45	—	45	—	ns	10
Column address to $\overline{\text{WE}}$ delay time	t <sub>AWD</sub>	50	—	60	—	65	—	ns	10
$\overline{\text{OE}}$ hold time from $\overline{\text{WE}}$	t <sub>OEH</sub>	15	—	20	—	20	—	ns	

**Refresh Cycle**

		HM514400B/BL, HM514400C/CL							
		-6		-7		-8			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
$\overline{\text{CAS}}$ setup time (CBR refresh cycle)	t <sub>CSR</sub>	10	—	10	—	10	—	ns	
$\overline{\text{CAS}}$ hold time (CBR refresh cycle)	t <sub>CHR</sub>	10	—	10	—	10	—	ns	
$\overline{\text{RAS}}$ precharge to $\overline{\text{CAS}}$ hold time	t <sub>RPC</sub>	10	—	10	—	10	—	ns	
$\overline{\text{CAS}}$ precharge time in normal mode	t <sub>CPN</sub>	10	—	10	—	10	—	ns	

**Fast Page Mode Cycle**

		HM514400B/BL, HM514400C/CL							
		-6		-7		-8			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
Fast page mode cycle time	t <sub>PC</sub>	40	—	45	—	50	—	ns	
Fast page mode $\overline{\text{CAS}}$ precharge time	t <sub>CP</sub>	10	—	10	—	10	—	ns	
Fast page mode $\overline{\text{RAS}}$ pulse width	t <sub>RASC</sub>	—	100000	—	100000	—	100000	ns	12
Access time from $\overline{\text{CAS}}$ precharge	t <sub>ACP</sub>	—	35	—	40	—	45	ns	3, 13, 17
$\overline{\text{RAS}}$ hold time from $\overline{\text{CAS}}$ precharge	t <sub>RHCP</sub>	35	—	40	—	45	—	ns	

## HM514400B/BL, HM514400C/CL Series

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

Parameter	Symbol	HM514400B/BL, HM514400C/CL						Unit	Notes
		-6		-7		-8			
		Min	Max	Min	Max	Min	Max		
Fast page mode read-modify-write cycle time	t <sub>PCM</sub>	80	—	95	—	100	—	ns	
Fast page mode read-modify-write cycle $\overline{\text{CAS}}$ precharge to $\overline{\text{WE}}$ delay time	t <sub>CPW</sub>	55	—	65	—	70	—	ns	10

### Test Mode Cycle

Parameter	Symbol	HM514400B/BL, HM514400C/CL						Unit	Notes
		-6		-7		-8			
		Min	Max	Min	Max	Min	Max		
Test mode $\overline{\text{WE}}$ setup time	t <sub>WS</sub>	0	—	0	—	0	—	ns	
Test mode $\overline{\text{WE}}$ hold time	t <sub>WH</sub>	10	—	10	—	10	—	ns	

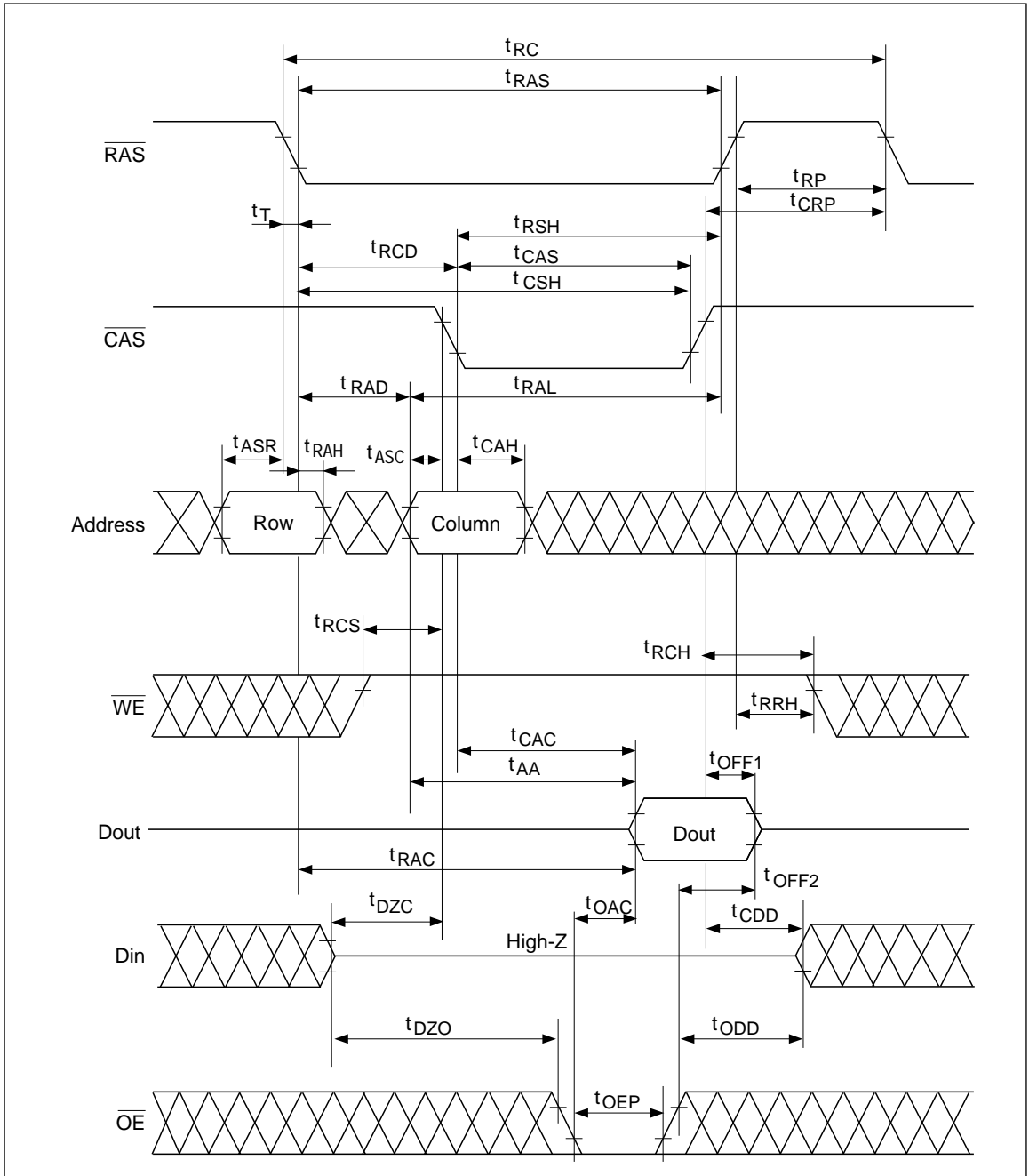
### Counter Test Cycle

Parameter	Symbol	HM514400B/BL, HM514400C/CL						Unit	Notes
		-6		-7		-8			
		Min	Max	Min	Max	Min	Max		
$\overline{\text{CAS}}$ precharge time in counter test cycle	t <sub>CPT</sub>	40	—	40	—	40	—	ns	

- Notes:
1. AC measurements assume  $t_T = 5$  ns.
  2. Assumes that  $t_{RCD} \leq t_{RCD}(\max)$  and  $t_{RAD} \leq t_{RAD}(\max)$ . 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  $t_{RCD} \geq t_{RCD}(\max)$  and  $t_{RAD} \leq t_{RAD}(\max)$ .
  5. Assumes that  $t_{RCD} \leq t_{RCD}(\max)$  and  $t_{RAD} \geq t_{RAD}(\max)$ .
  6.  $t_{OFF}(\max)$  defines the time at which the output achieves the open circuit condition and is not referred to output voltage levels.
  7.  $V_{IH}(\min)$  and  $V_{IL}(\max)$  are reference levels for measuring timing of input signals. Also, transition times are measured between  $V_{IH}$  and  $V_{IL}$ .
  8. Operation with the  $t_{RCD}(\max)$  limit insures that  $t_{RAC}(\max)$  can be met,  $t_{RCD}(\max)$  is specified as a reference point only, if  $t_{RCD}$  is greater than the specified  $t_{RCD}(\max)$  limit, then access time is controlled exclusively by  $t_{CAC}$ .
  9. Operation with the  $t_{RAD}(\max)$  limit insures that  $t_{RAC}(\max)$  can be met,  $t_{RAD}(\max)$  is specified as a reference point only, if  $t_{RAD}$  is greater than the specified  $t_{RAD}(\max)$  limit, then access time is controlled 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  $t_{WCS} \geq t_{WCS}(\min)$ , the cycle is an early write cycle and the data out pin will remain open circuit (high impedance) throughout the entire cycle; if  $t_{RWD} \geq t_{RWD}(\min)$ ,  $t_{CWD} \geq t_{CWD}(\min)$ ,  $t_{CPW} \geq t_{CPW}(\min)$  and  $t_{AWD} \geq t_{AWD}(\min)$ , 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  $\overline{CAS}$  leading edge in an early write cycle and to  $\overline{WE}$  leading edge in a delayed write or read-modify-write cycle.
  12.  $t_{RASC}$  defines  $\overline{RAS}$  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  $\mu$ s is required after power up followed by a minimum of eight initialization cycles ( $\overline{RAS}$ -only refresh cycle or  $\overline{CAS}$ -before- $\overline{RAS}$  refresh cycle). If the internal refresh counter is used, a minimum of eight  $\overline{CAS}$ -before- $\overline{RAS}$  refresh cycles is required.
  15. In delayed write or read-modify-write cycles,  $\overline{OE}$  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  $\overline{WE}$ -and- $\overline{CAS}$ -before- $\overline{RAS}$  (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  $\overline{RAS}$ -only refresh cycle or a  $\overline{CAS}$ -before- $\overline{RAS}$  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.  $t_{RAS}(\min) = t_{RWD}(\min) + t_{RWL}(\min) + t_T$  in read-modify-write cycle.
  20.  $t_{CAS}(\min) = t_{CWD}(\min) + t_{CWL}(\min) + t_T$  in read-modify-write cycle.

Timing Waveforms<sup>#21</sup>

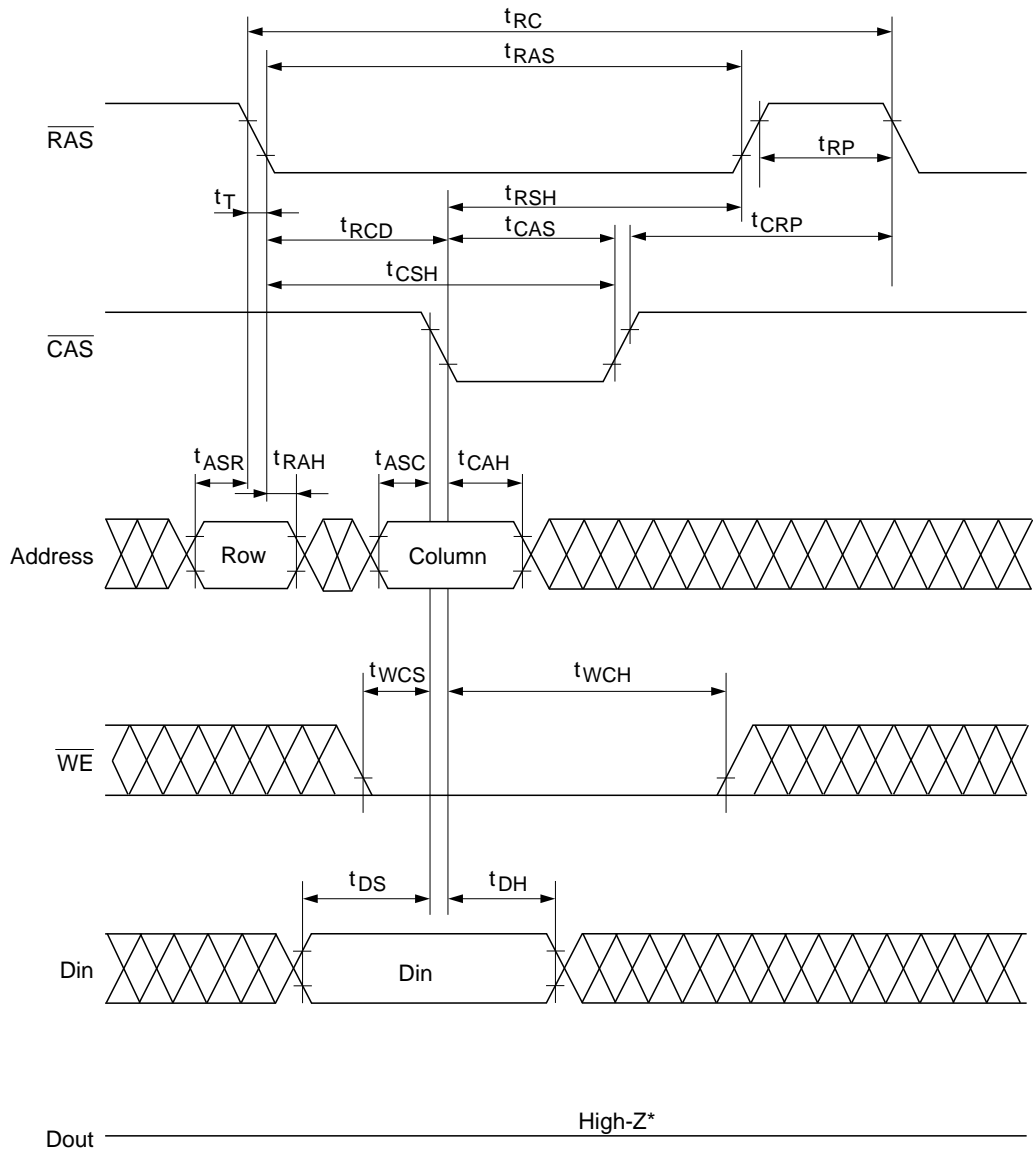
Read Cycle



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

Invalid Dout

Early Write Cycle

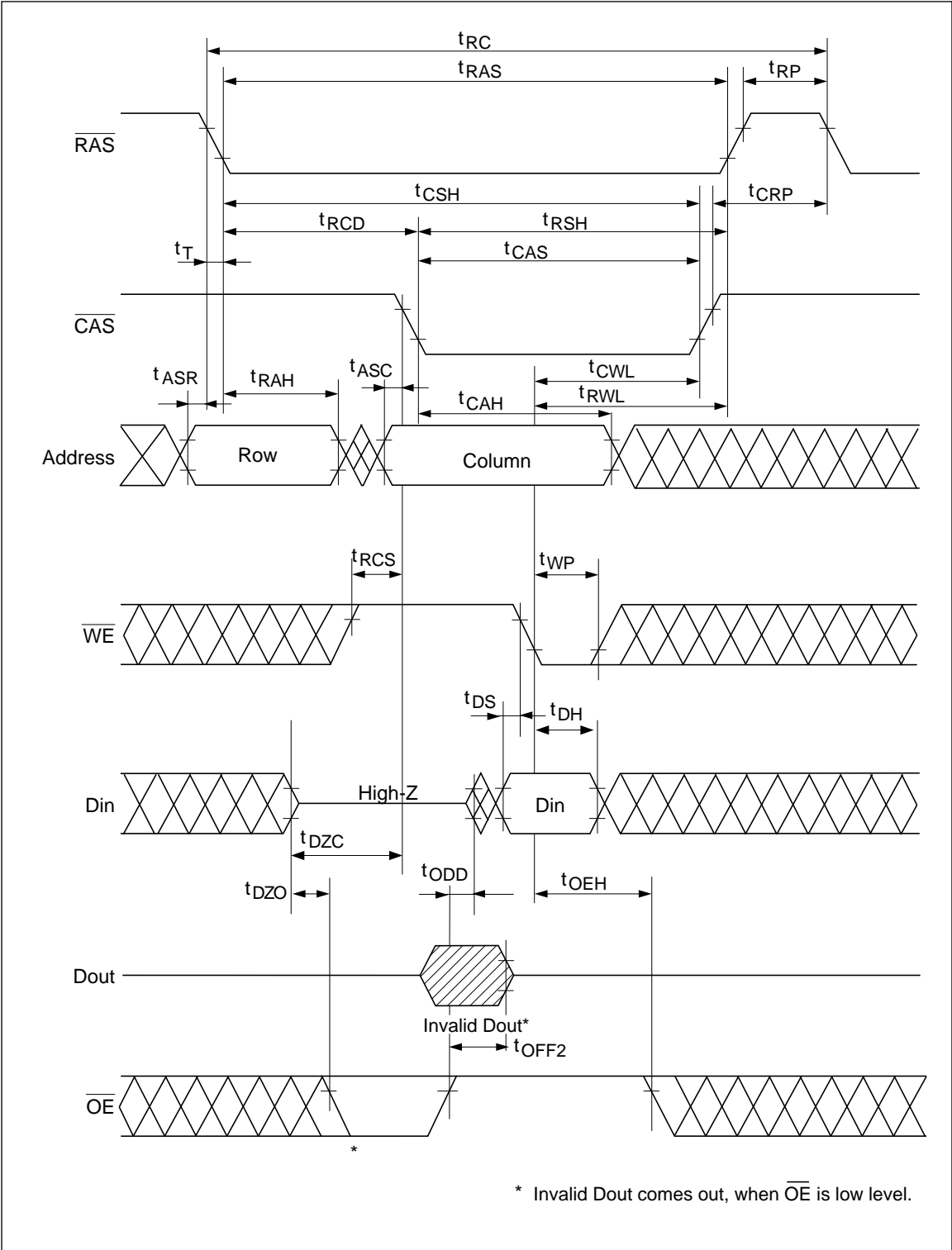


\*  $t_{WCS} \geq t_{WCS}(\text{min})$

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

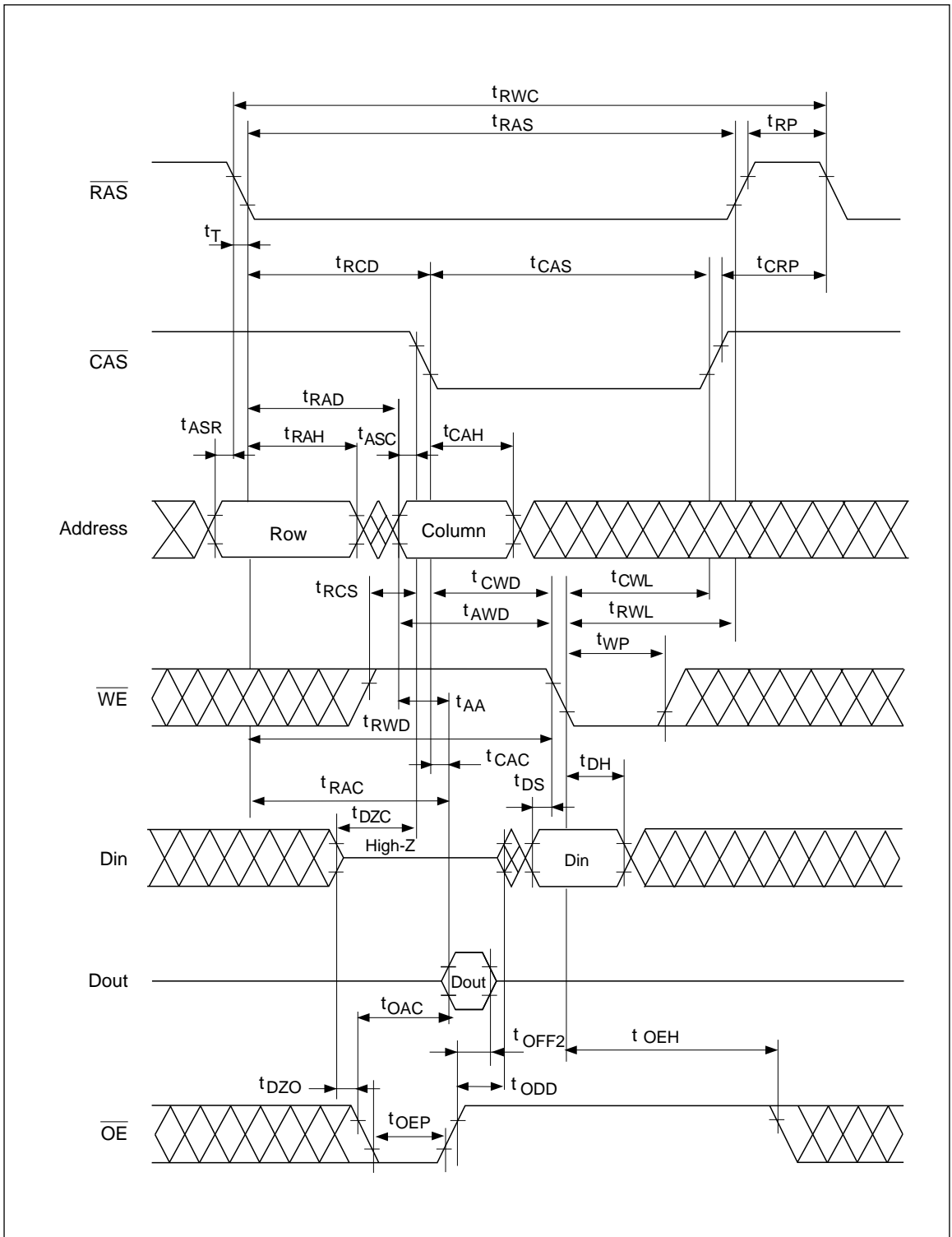
# HM514400B/BL, HM514400C/CL Series

## Delayed Write Cycle



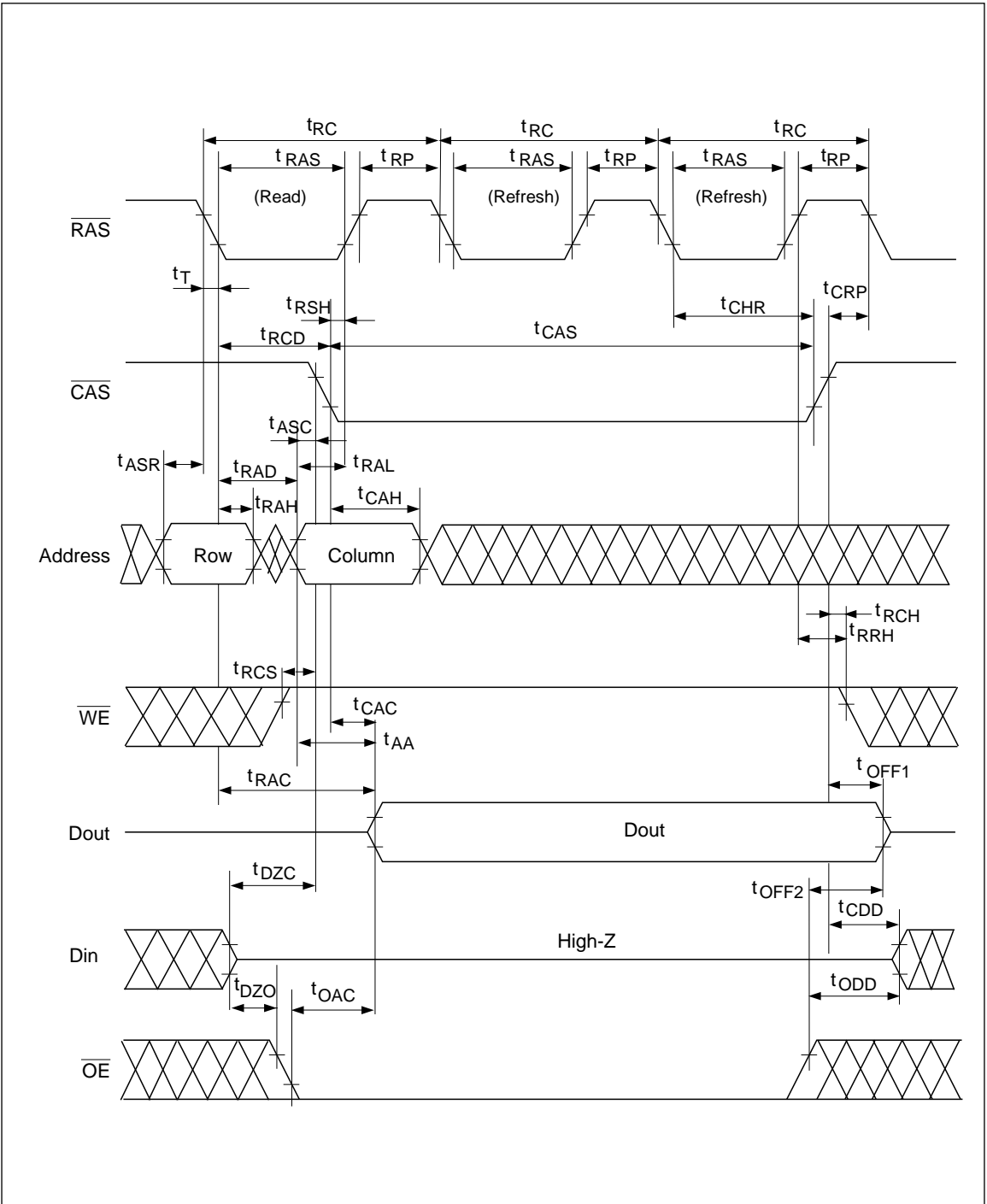


Read-Modify-Write Cycle

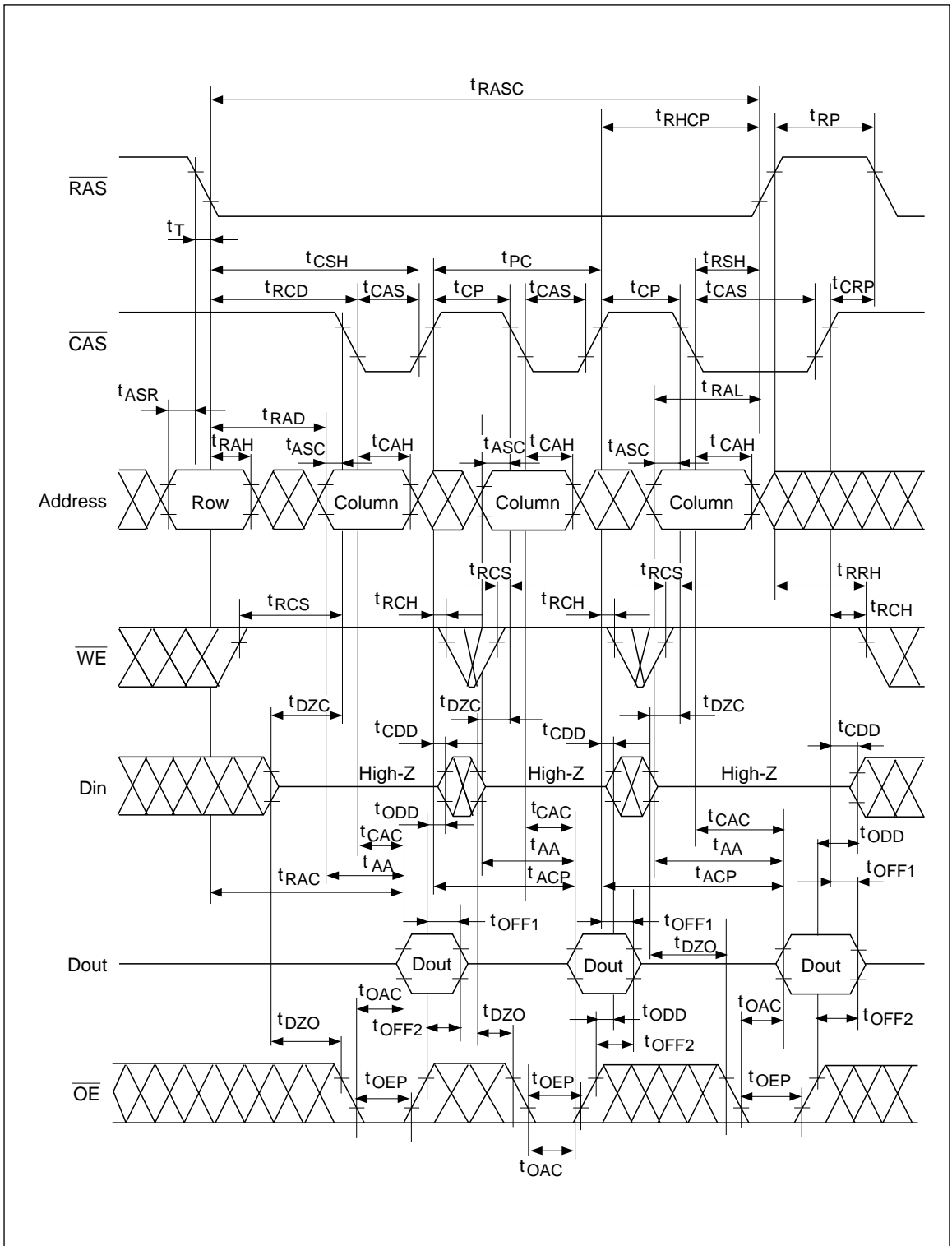


# HM514400B/BL, HM514400C/CL Series

## Hidden Refresh Cycle

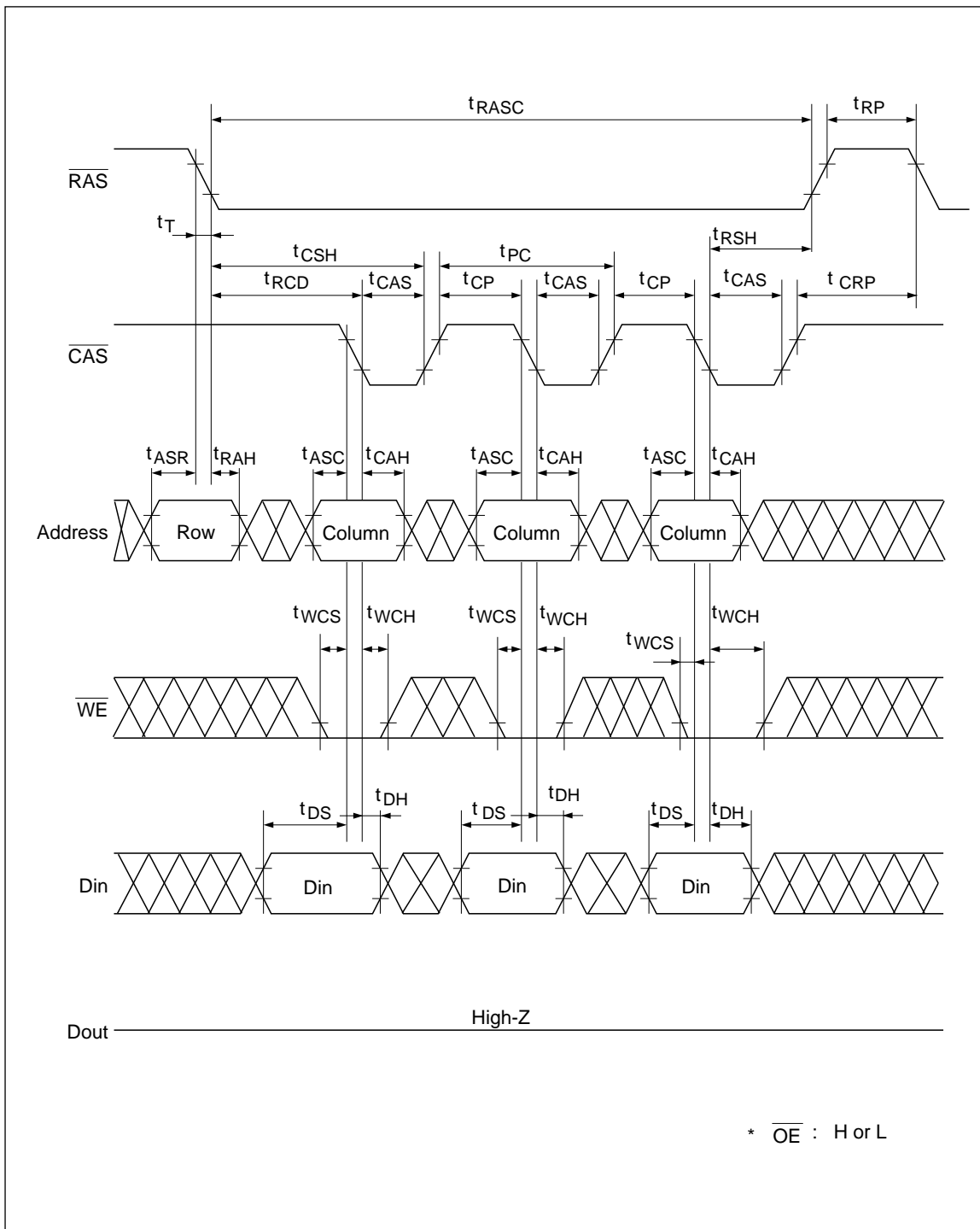


Fast Page Mode Read Cycle

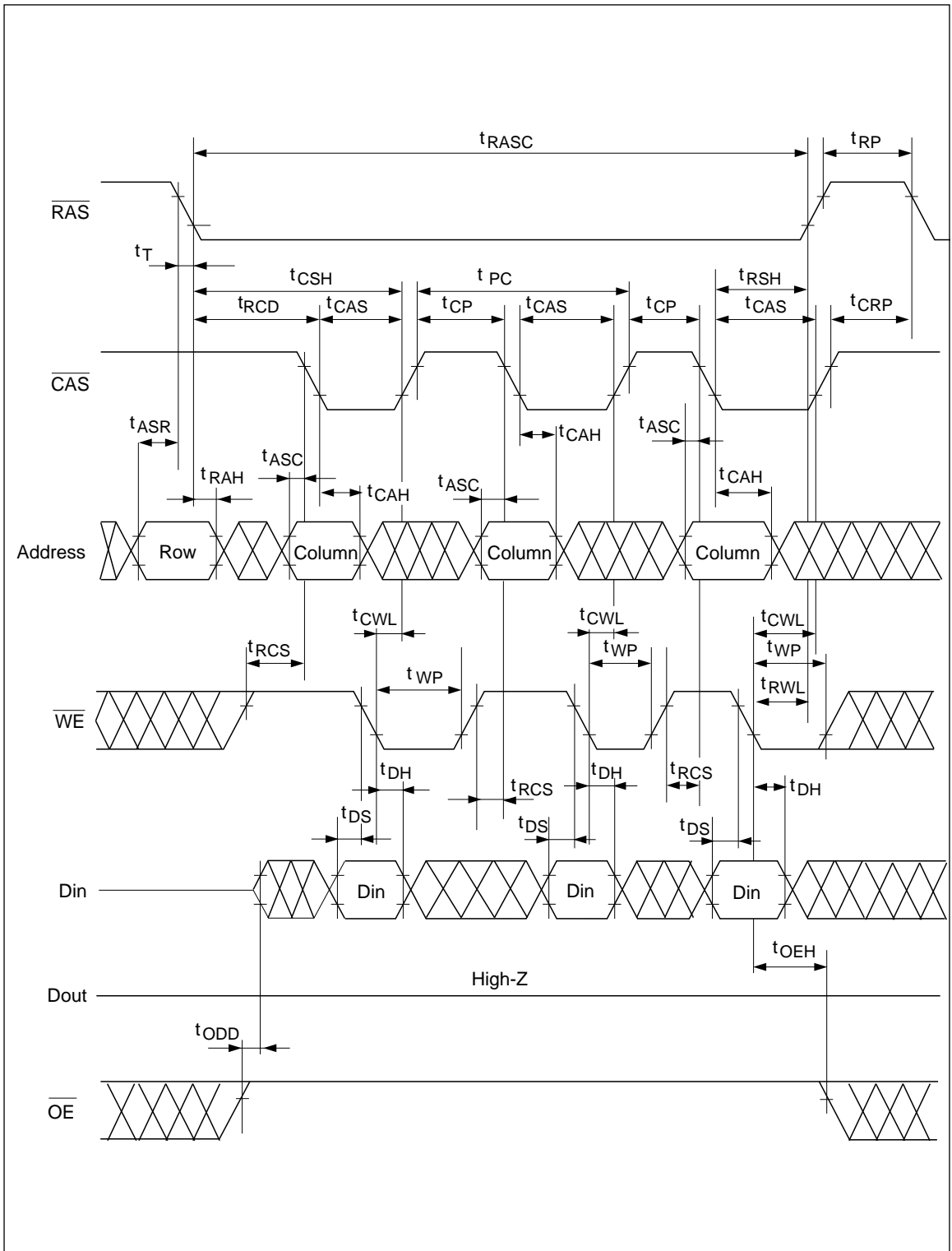


# HM514400B/BL, HM514400C/CL Series

## Fast Page Mode Early Write Cycle

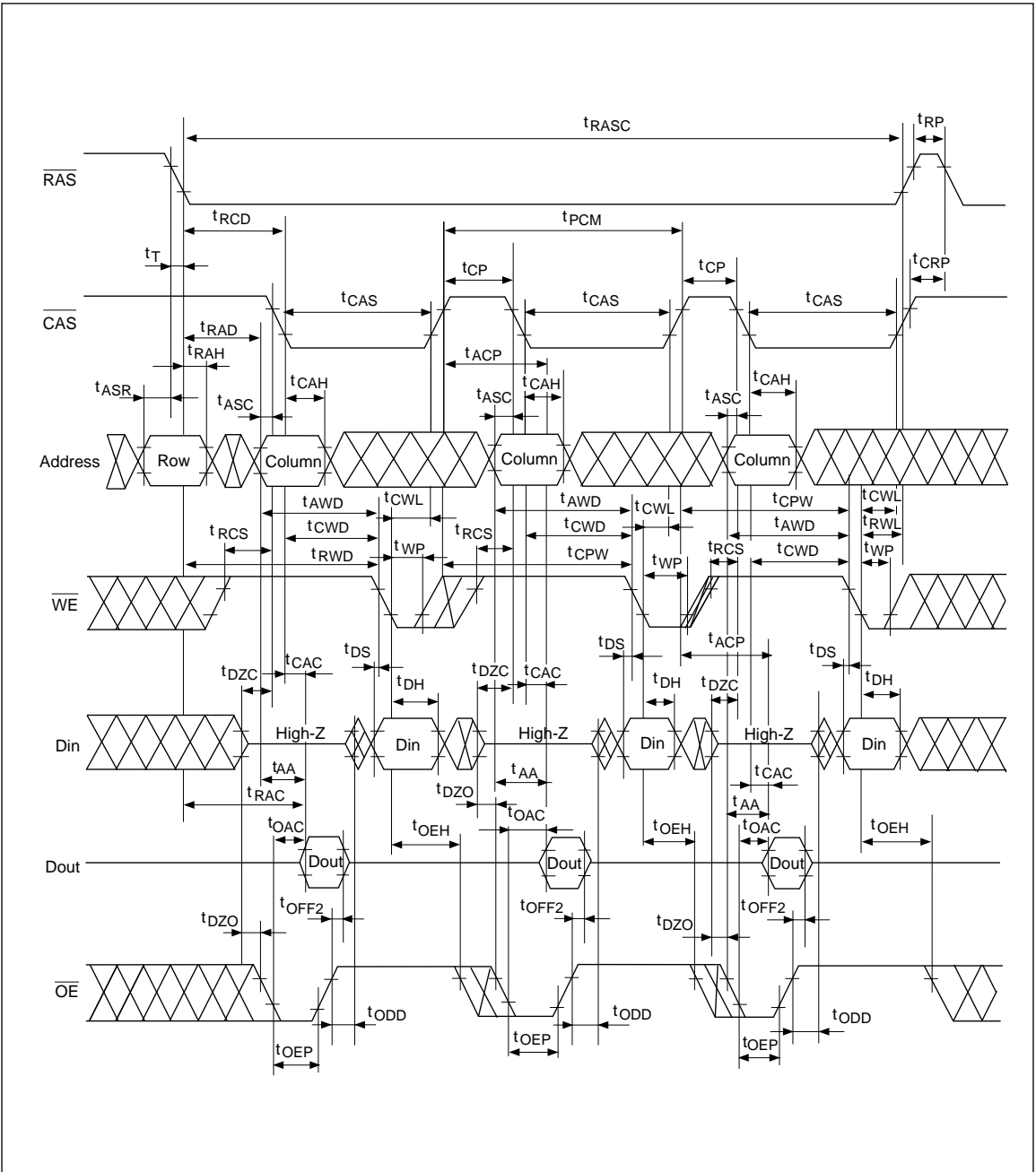


Fast Page Mode Delayed Write Cycle

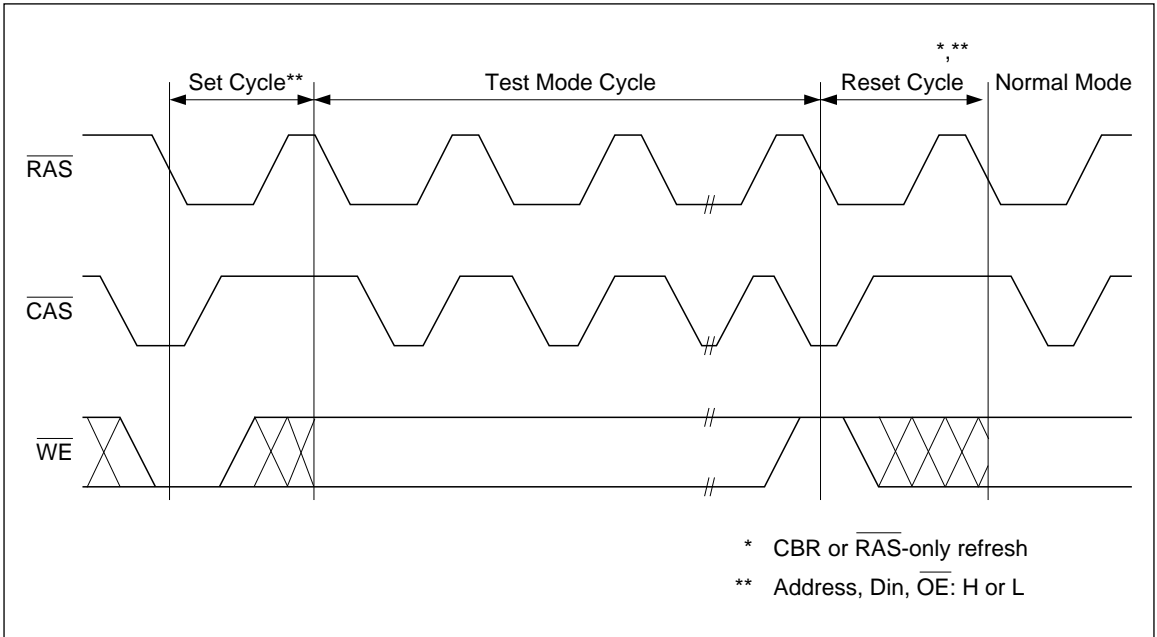


# HM514400B/BL, HM514400C/CL Series

## Fast Page Mode Read-Modify-Write Cycle

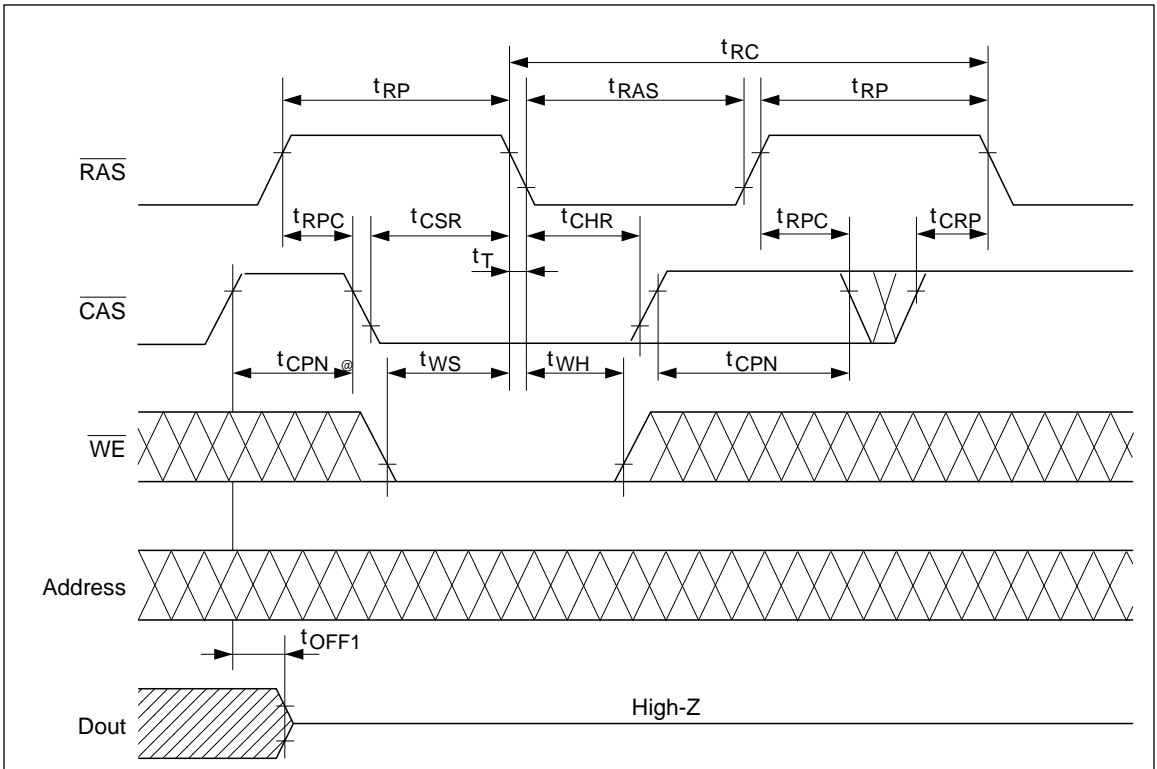


Test Mode Cycle



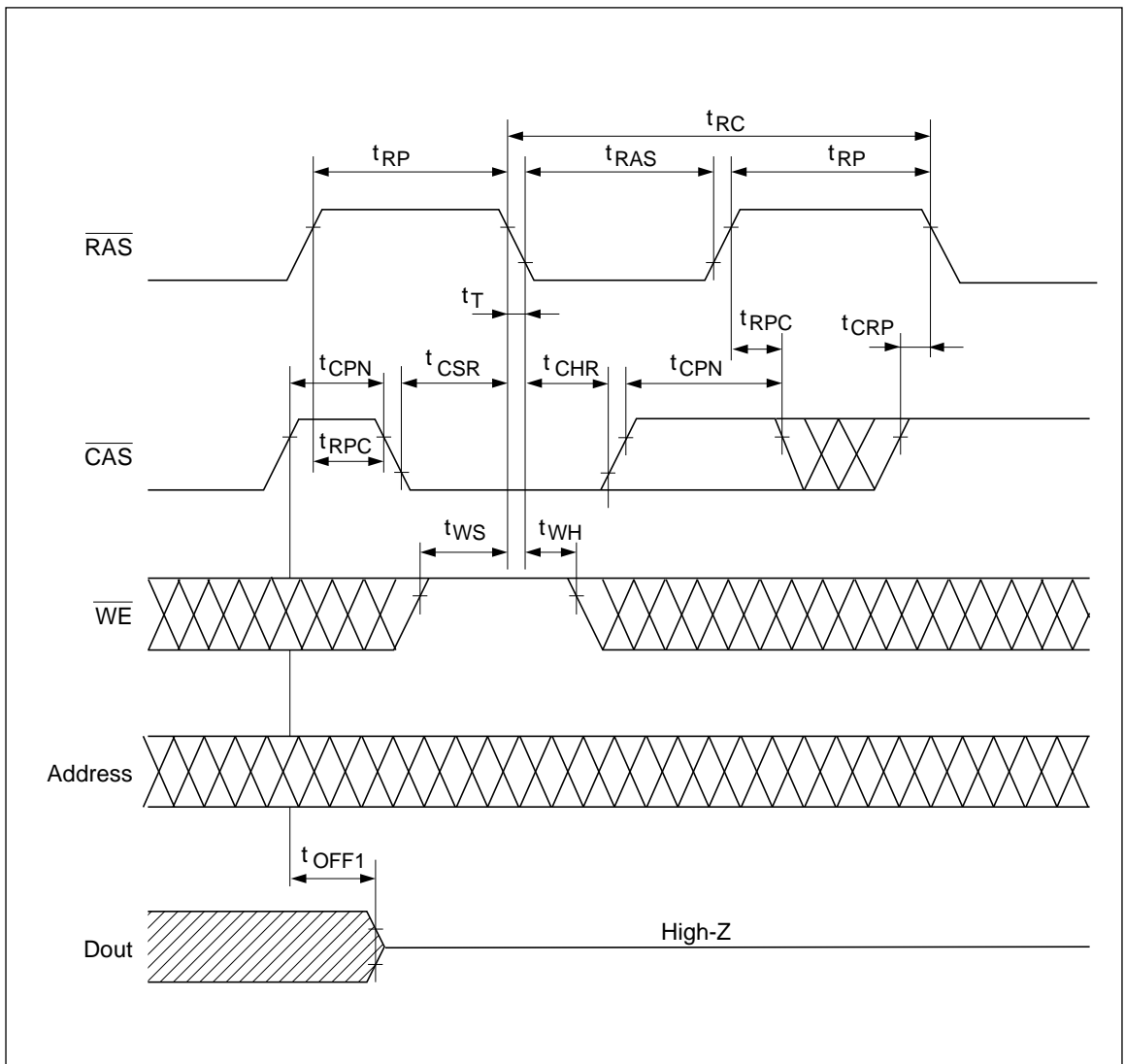
Test Mode Set Cycle

$\overline{\text{WE}}$ -and- $\overline{\text{CAS}}$ -Before  $\overline{\text{RAS}}$ -Refresh Cycle



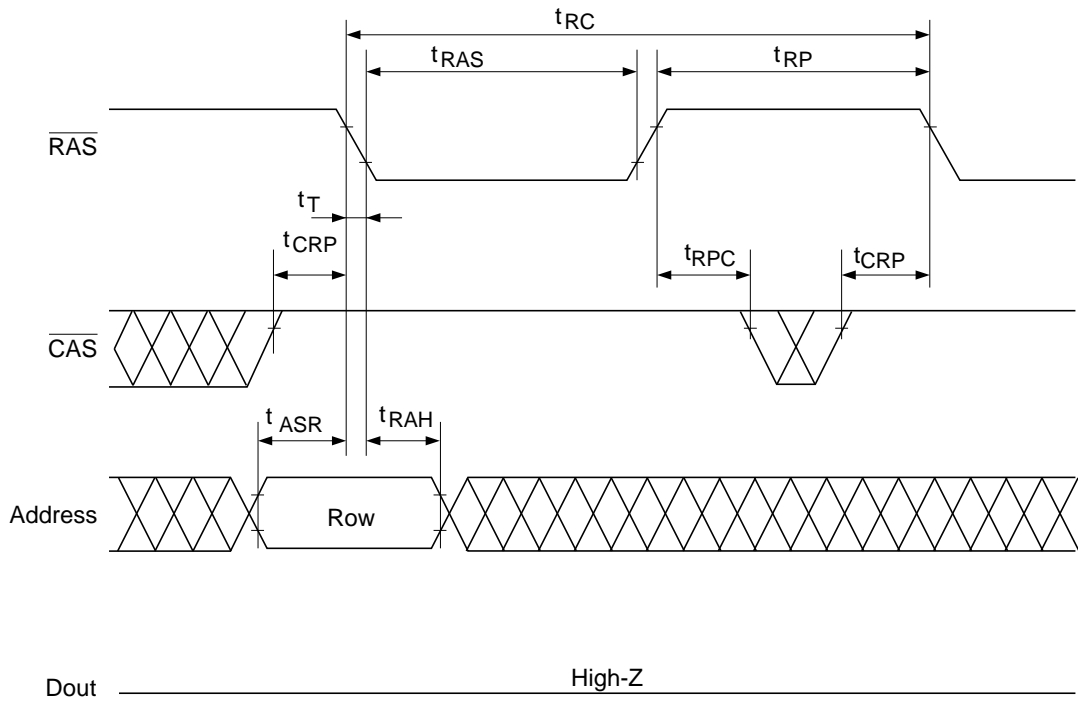
# HM514400B/BL, HM514400C/CL Series

## $\overline{\text{CAS}}$ -Before- $\overline{\text{RAS}}$ Refresh Cycle





**RAS-Only Refresh Cycle**

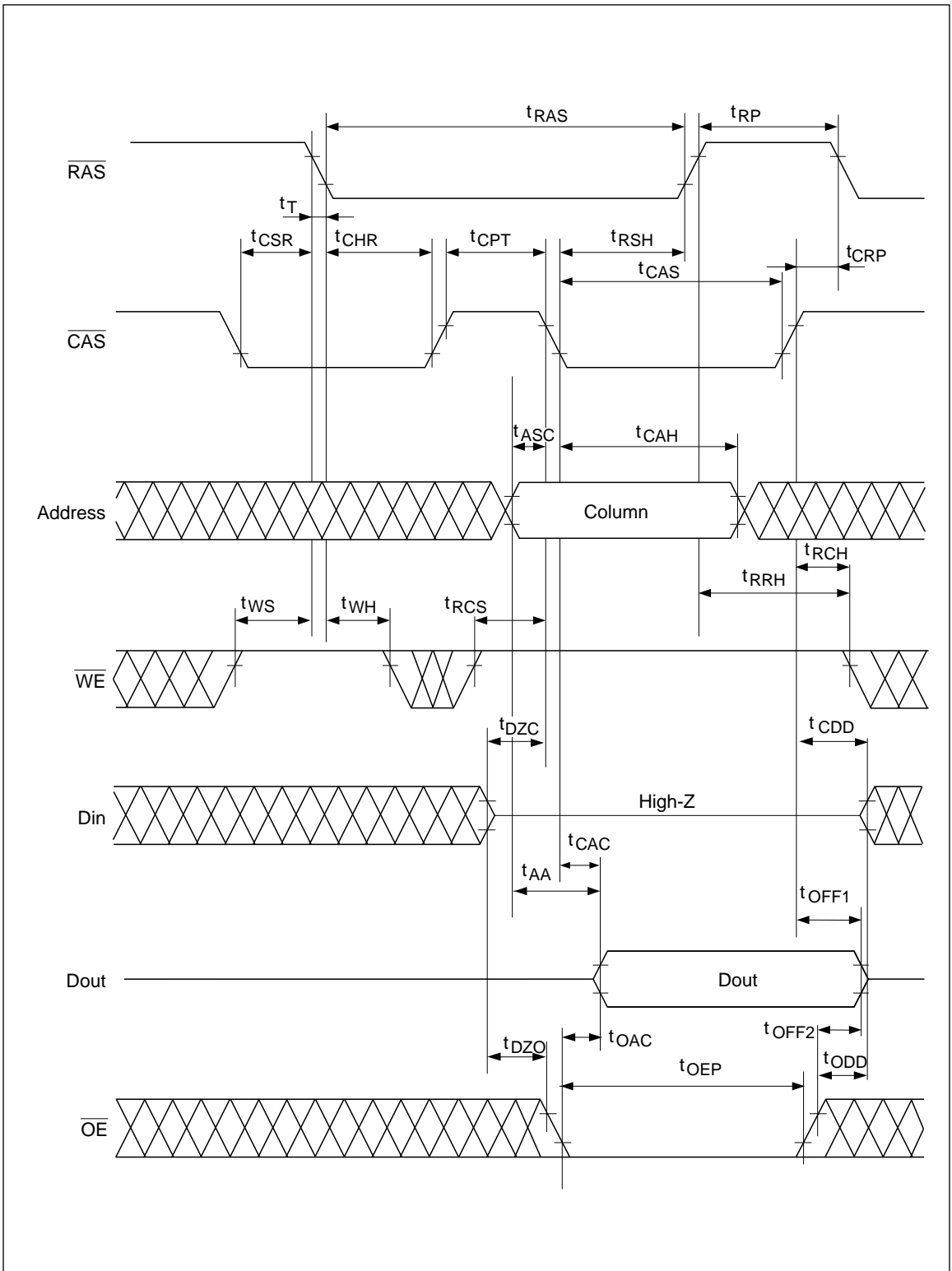


\* Refresh address : A0 – A9 (AX0 – AX9)

\*\*  $\overline{\text{WE}}$  : H or L

# HM514400B/BL, HM514400C/CL Series

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



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

