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# HM5164400 Series

# HM5165400 Series

64 M FP DRAM (16-Mword × 4-bit)  
8 k Refresh/4 k Refresh

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ADE-203-812B (Z)  
Rev. 1.0  
Feb. 27, 1998

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## Description

The Hitachi HM5164400 Series, HM5165400 Series are 64M-bit dynamic RAMs organized as 16,777,216-word × 4-bit. They have realized high performance and low power by employing CMOS process technology. The HM5164400 Series, HM5165400 Series offer Fast Page Mode as a high speed access mode. They have the package variations of standard 32-pin plastic SOJ and standard 32-pin plastic TSOPII.

## Features

- Single 3.3 V supply: 3.3 V ± 0.3 V
- Access time: 50 ns/60 ns (max)
- Power dissipation
  - Active: 396 mW/360 mW (max) (HM5164400 Series)  
: 468 mW/396 mW (max) (HM5165400 Series)
  - Standby : 1.8 mW (max) (CMOS interface)  
: 0.54 mW (max) (L-version)
- Fast page mode capability
- Refresh cycles
  - $\overline{\text{RAS}}$ -only refresh
    - 8192 cycles /64 ms (HM5164400)  
/128 ms (HM5164400L) (L-version)
    - 4096 cycles /64 ms (HM5165400)  
/128 ms (HM5165400L) (L-version)
  - CBR/Hidden refresh
    - 4096 cycles /64 ms (HM5164400, HM5165400)  
/128 ms (HM5164400L, HM5165400L) (L-version)

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## HM5164400 Series, HM5165400 Series

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- 4 variations of refresh
  - $\overline{\text{RAS}}$ -only refresh
  - $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh
  - Hidden refresh
  - Self refresh (L-version)
- Battery backup operation (L-version)

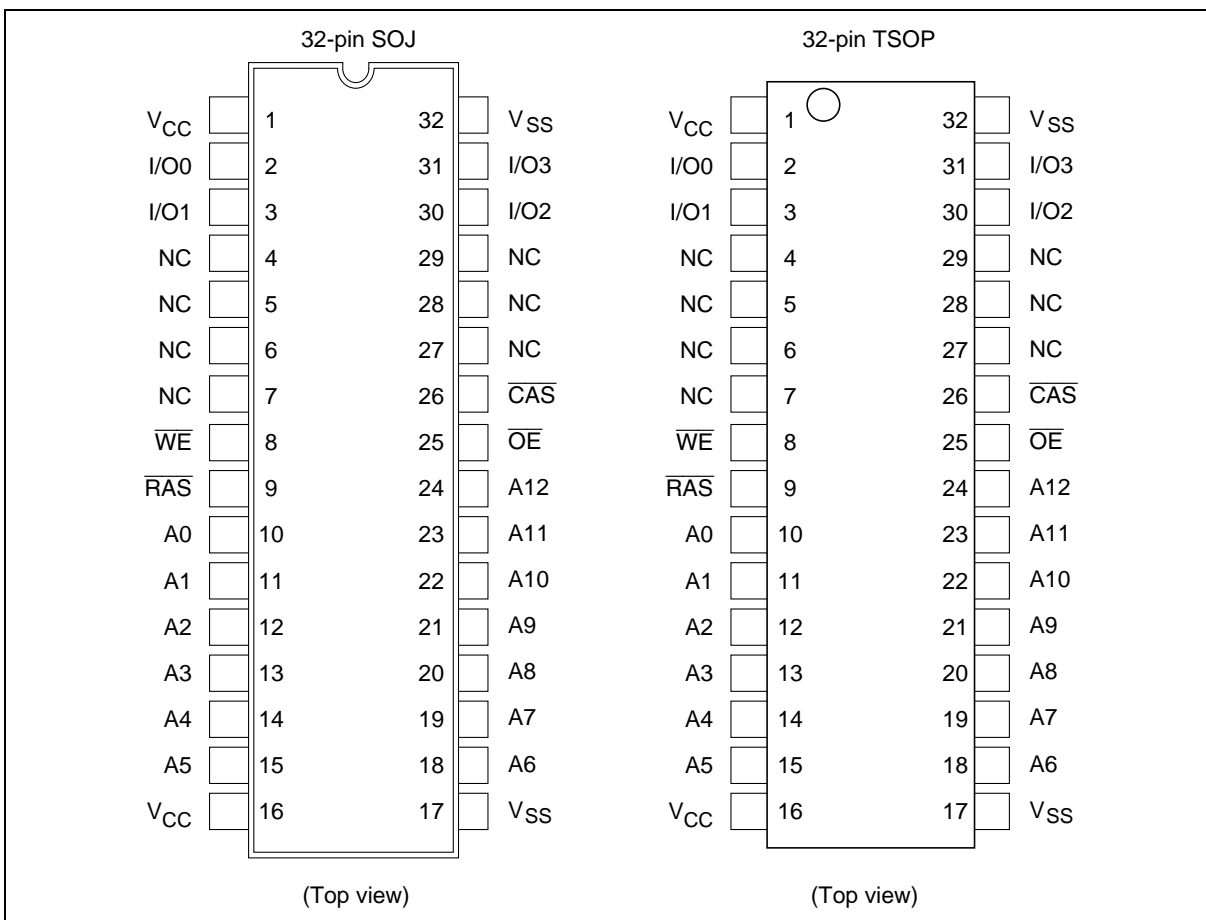
### Ordering Information

Type No.	Access time	Package
HM5164400J-5	50 ns	400-mil 32-pin plastic SOJ (CP-32DC)
HM5164400J-6	60 ns	
HM5164400LJ-5	50 ns	
HM5164400LJ-6	60 ns	
HM5165400J-5	50 ns	
HM5165400J-6	60 ns	
HM5165400LJ-5	50 ns	
HM5165400LJ-6	60 ns	
HM5164400TT-5	50 ns	400-mil 32-pin plastic TSOP II (TTP-32DC)
HM5164400TT-6	60 ns	
HM5164400LTT-5	50 ns	
HM5164400LTT-6	60 ns	
HM5165400TT-5	50 ns	
HM5165400TT-6	60 ns	
HM5165400LTT-5	50 ns	
HM5165400LTT-6	60 ns	

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## HM5164400 Series, HM5165400 Series

### Pin Arrangement (HM5164400 Series)

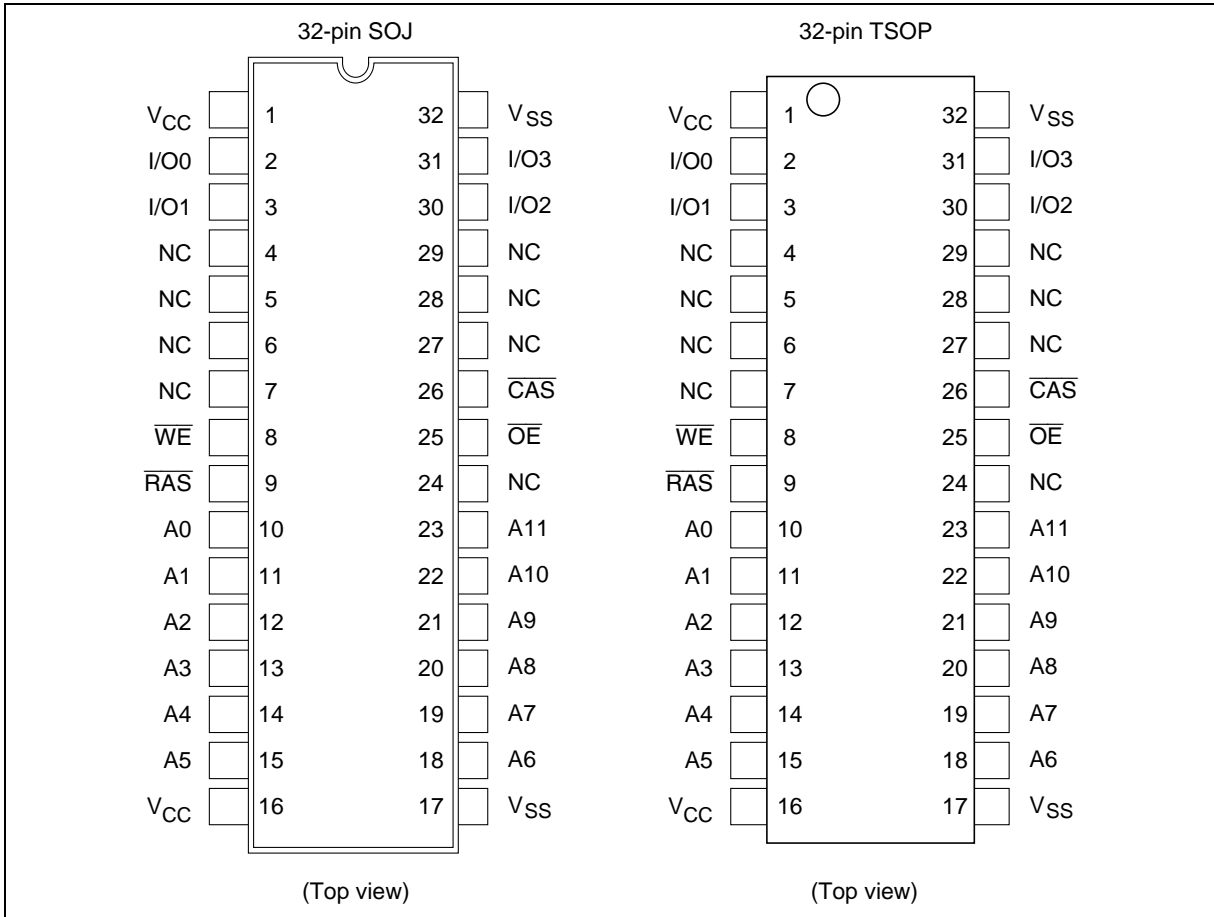


### Pin Description

Pin name	Function
A0 to A12	Address input <ul style="list-style-type: none"> <li>• Row/Refresh address A0 to A12</li> <li>• Column address A0 to A10</li> </ul>
I/O0 to I/O3	Data input/output
$\overline{\text{RAS}}$	Row address strobe
$\overline{\text{CAS}}$	Column address strobe
$\overline{\text{WE}}$	Write enable
$\overline{\text{OE}}$	Output enable
$V_{\text{CC}}$	Power supply
$V_{\text{SS}}$	Ground
NC	No connection

## HM5164400 Series, HM5165400 Series

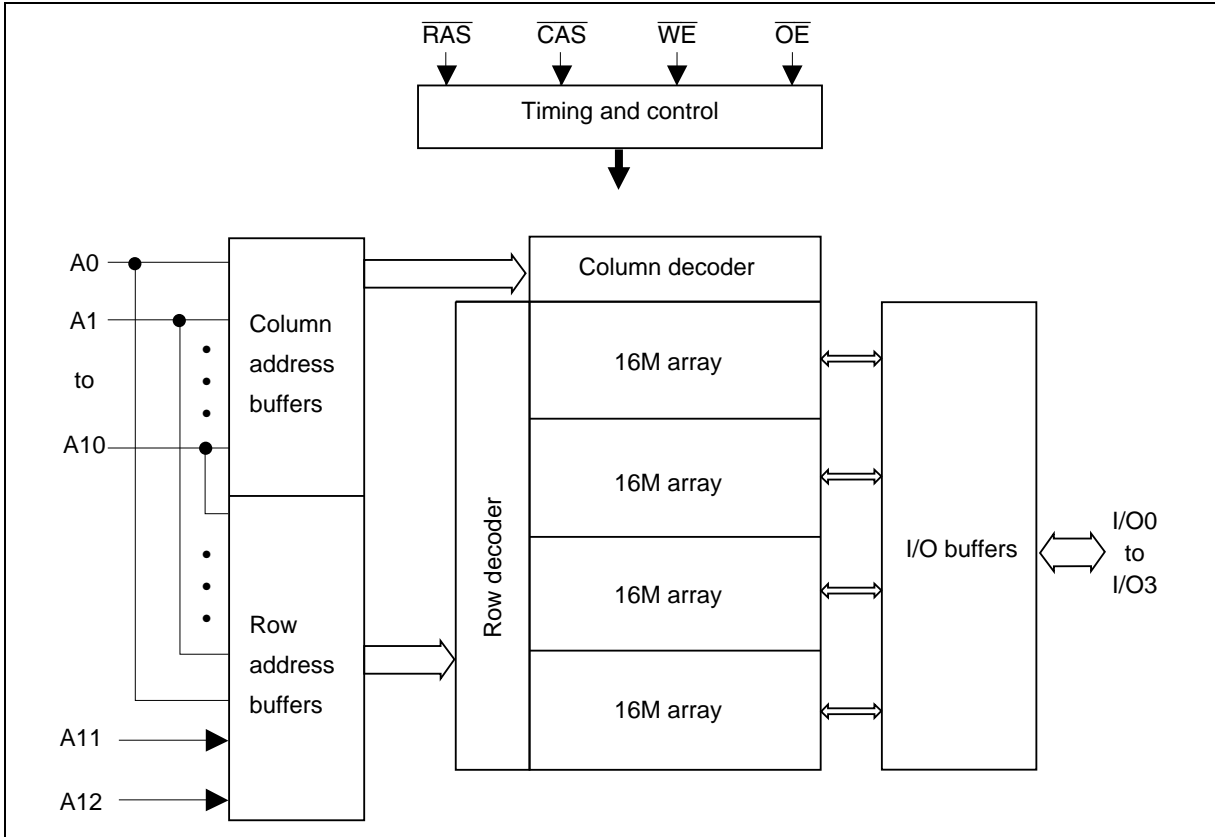
### Pin Arrangement (HM5165400 Series)



### Pin Description

Pin name	Function
A0 to A11	Address input <ul style="list-style-type: none"> <li>• Row/Refresh address A0 to A11</li> <li>• Column address A0 to A11</li> </ul>
I/O0 to I/O3	Data input/output
$\overline{\text{RAS}}$	Row address strobe
$\overline{\text{CAS}}$	Column address strobe
$\overline{\text{WE}}$	Write enable
$\overline{\text{OE}}$	Output enable
V <sub>CC</sub>	Power supply
V <sub>SS</sub>	Ground
NC	No connection

Block Diagram (HM5164400 Series)

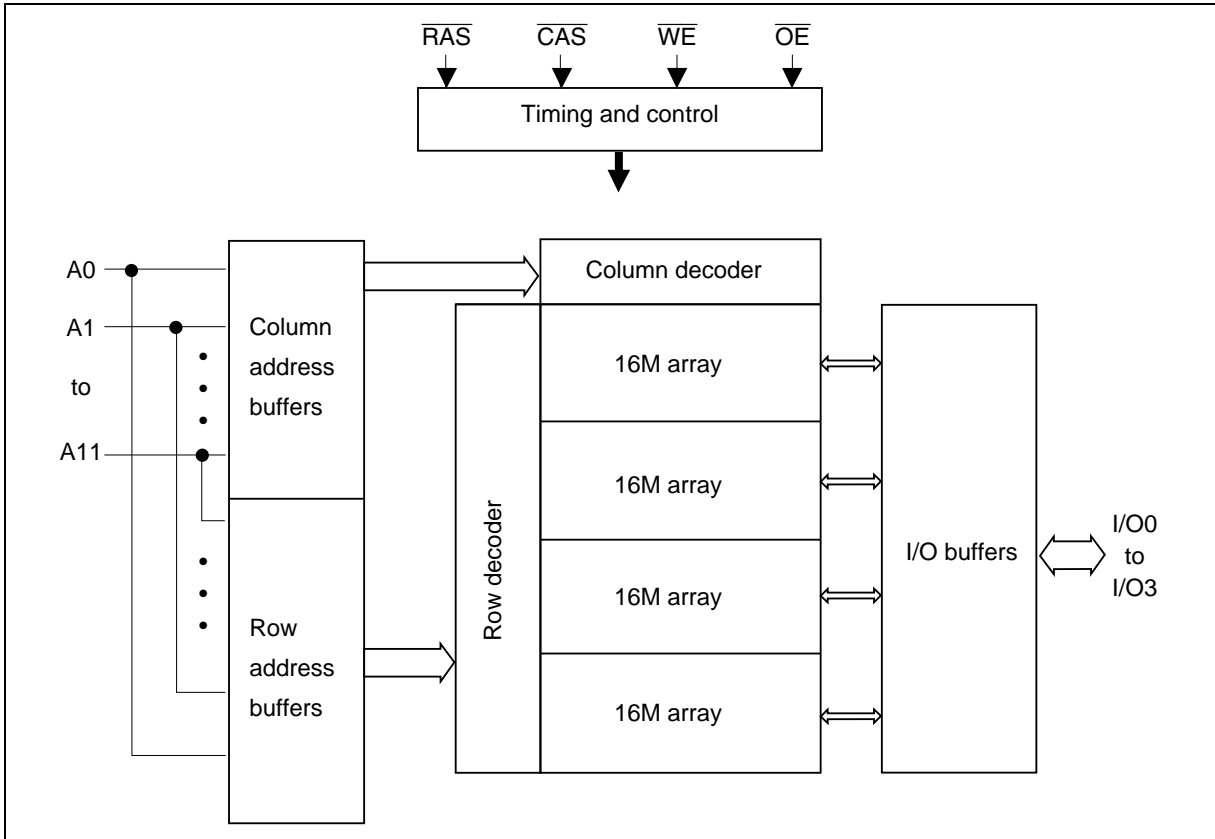


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## HM5164400 Series, HM5165400 Series

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### Block Diagram (HM5165400 Series)



## HM5164400 Series, HM5165400 Series

### Operation Table

$\overline{\text{RAS}}$	$\overline{\text{CAS}}$	$\overline{\text{WE}}$	$\overline{\text{OE}}$	I/O 0 to I/O 3	Operation
H	×	×	×	High-Z	Standby
L	L	H	L	Dout	Read cycle
L	L	L* <sup>2</sup>	×	Din	Early write cycle
L	L	L* <sup>2</sup>	H	Din	Delayed write cycle
L	L	H to L	L to H	Dout/Din	Read-modify-write cycle
L	H	×	×	High-Z	$\overline{\text{RAS}}$ -only refresh cycle
H to L	L	H	×	High-Z	$\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh cycle or Self refresh cycle (L-version)
L	L	H	H	High-Z	Read cycle (Output disabled)

Notes: 1. H:  $V_{IH}$  (inactive), L:  $V_{IL}$  (active), ×:  $V_{IH}$  or  $V_{IL}$

2.  $t_{wCS} \geq 0$  ns: Early write cycle

$t_{wCS} < 0$  ns: Delayed write cycle

### Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Terminal voltage on any pin relative to $V_{SS}$	$V_T$	-0.5 to $V_{CC} + 0.5$ ( $\leq 4.6$ V (max))	V
Power supply voltage relative to $V_{SS}$	$V_{CC}$	-0.5 to +4.6	V
Short circuit output current	$I_{out}$	50	mA
Power dissipation	$P_T$	1.0	W
Storage temperature	Tstg	-55 to +125	°C

### DC Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit	Notes
Supply voltage	$V_{CC}$	3.0	3.3	3.6	V	1, 2
	$V_{SS}$	0	0	0	V	2
Input high voltage	$V_{IH}$	2.0	—	$V_{CC} + 0.3$	V	1
Input low voltage	$V_{IL}$	-0.3	—	0.8	V	1
Ambient temperature range	Ta	0	—	70	°C	

Notes: 1. All voltage referred to  $V_{SS}$ .

2. The supply voltage with all  $V_{CC}$  pins must be on the same level. The supply voltage with all  $V_{SS}$  pins must be on the same level.

## HM5164400 Series, HM5165400 Series

### DC Characteristics (HM5164400 Series)

Parameter	Symbol	HM5164400				Unit	Test conditions
		-5		-6			
		Min	Max	Min	Max		
Operating current <sup>*1, *2</sup>	$I_{CC1}$	—	110	—	100	mA	$t_{RC} = \text{min}$
Standby current	$I_{CC2}$	—	2	—	2	mA	TTL interface $\overline{RAS}, \overline{CAS} = V_{IH}$ Dout = High-Z
		—	0.5	—	0.5	mA	CMOS interface $\overline{RAS}, \overline{CAS} \geq V_{CC} - 0.2 \text{ V}$ Dout = High-Z
Standby current (L-version)	$I_{CC2}$	—	150	—	150	$\mu\text{A}$	CMOS interface $\overline{RAS}, \overline{CAS} \geq V_{CC} - 0.2 \text{ V}$ Dout = High-Z
$\overline{RAS}$ -only refresh current <sup>*2</sup>	$I_{CC3}$	—	110	—	100	mA	$t_{RC} = \text{min}$
Standby current <sup>*1</sup>	$I_{CC5}$	—	5	—	5	mA	$\overline{RAS} = V_{IH}, \overline{CAS} = V_{IL}$ Dout = enable
$\overline{CAS}$ -before- $\overline{RAS}$ refresh current	$I_{CC6}$	—	110	—	100	mA	$t_{RC} = \text{min}$
Fast page mode current <sup>*1, *3</sup>	$I_{CC7}$	—	90	—	80	mA	$\overline{RAS} = V_{IL}, \overline{CAS}$ cycle, $t_{PC} = t_{PC \text{ min}}$
Battery backup current <sup>*4</sup> (Standby with CBR refresh) (L-version)	$I_{CC10}$	—	500	—	500	$\mu\text{A}$	CMOS interface Dout = High-Z CBR refresh: $t_{RC} = 31.3 \mu\text{s}$ $t_{RAS} \leq 0.3 \mu\text{s}$
Self refresh mode current (L-version)	$I_{CC11}$	—	400	—	400	$\mu\text{A}$	CMOS interface $\overline{RAS}, \overline{CAS} \leq 0.2 \text{ V}$ Dout = High-Z
Input leakage current	$I_{LI}$	-5	5	-5	5	$\mu\text{A}$	$0 \text{ V} \leq V_{in} \leq V_{CC} + 0.3 \text{ V}$
Output leakage current	$I_{LO}$	-5	5	-5	5	$\mu\text{A}$	$0 \text{ V} \leq V_{out} \leq V_{CC}$ Dout = disable
Output high voltage	$V_{OH}$	2.4	$V_{CC}$	2.4	$V_{CC}$	V	High Iout = -2 mA
Output low voltage	$V_{OL}$	0	0.4	0	0.4	V	Low Iout = 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 once or less while  $\overline{RAS} = V_{IL}$ .
3. Measured with one sequential address change per fast page mode cycle,  $t_{PC}$ .
4.  $V_{IH} \geq V_{CC} - 0.2 \text{ V}$ ,  $0 \text{ V} \leq V_{IL} \leq 0.2 \text{ V}$ .



## HM5164400 Series, HM5165400 Series

### DC Characteristics (HM5165400 Series)

Parameter	Symbol	HM5165400				Unit	Test conditions
		-5		-6			
		Min	Max	Min	Max		
Operating current <sup>*1, *2</sup>	$I_{CC1}$	—	130	—	110	mA	$t_{RC} = \text{min}$
Standby current	$I_{CC2}$	—	2	—	2	mA	TTL interface $\overline{RAS}, \overline{CAS} = V_{IH}$ Dout = High-Z
		—	0.5	—	0.5	mA	CMOS interface $\overline{RAS}, \overline{CAS} \geq V_{CC} - 0.2 \text{ V}$ Dout = High-Z
Standby current (L-version)	$I_{CC2}$	—	150	—	150	$\mu\text{A}$	CMOS interface $\overline{RAS}, \overline{CAS} \geq V_{CC} - 0.2 \text{ V}$ Dout = High-Z
$\overline{RAS}$ -only refresh current <sup>*2</sup>	$I_{CC3}$	—	130	—	110	mA	$t_{RC} = \text{min}$
Standby current <sup>*1</sup>	$I_{CC5}$	—	5	—	5	mA	$\overline{RAS} = V_{IH}, \overline{CAS} = V_{IL}$ Dout = enable
$\overline{CAS}$ -before- $\overline{RAS}$ refresh current	$I_{CC6}$	—	130	—	110	mA	$t_{RC} = \text{min}$
Fast page mode current <sup>*1, *3</sup>	$I_{CC7}$	—	90	—	80	mA	$\overline{RAS} = V_{IL}, \overline{CAS}$ cycle, $t_{PC} = t_{PC} \text{ min}$
Battery backup current <sup>*4</sup> (Standby with CBR refresh) (L-version)	$I_{CC10}$	—	500	—	500	$\mu\text{A}$	CMOS interface Dout = High-Z CBR refresh: $t_{RC} = 31.3 \mu\text{s}$ $t_{RAS} \leq 0.3 \mu\text{s}$
Self refresh mode current (L-version)	$I_{CC11}$	—	400	—	400	$\mu\text{A}$	CMOS interface $\overline{RAS}, \overline{CAS} \leq 0.2 \text{ V}$ Dout = High-Z
Input leakage current	$I_{LI}$	-5	5	-5	5	$\mu\text{A}$	$0 \text{ V} \leq V_{in} \leq V_{CC} + 0.3 \text{ V}$
Output leakage current	$I_{LO}$	-5	5	-5	5	$\mu\text{A}$	$0 \text{ V} \leq V_{out} \leq V_{CC}$ Dout = disable
Output high voltage	$V_{OH}$	2.4	$V_{CC}$	2.4	$V_{CC}$	V	High Iout = -2 mA
Output low voltage	$V_{OL}$	0	0.4	0	0.4	V	Low Iout = 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 once or less while  $\overline{RAS} = V_{IL}$ .  
 3. Measured with one sequential address change per fast page mode cycle,  $t_{PC}$ .  
 4.  $V_{IH} \geq V_{CC} - 0.2 \text{ V}$ ,  $0 \text{ V} \leq V_{IL} \leq 0.2 \text{ V}$ .

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## HM5164400 Series, HM5165400 Series

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Capacitance ( $T_a = 25^\circ\text{C}$ ,  $V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$ )

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.  $\overline{\text{RAS}}, \overline{\text{CAS}} = V_{IH}$  to disable Dout.

## HM5164400 Series, HM5165400 Series

**AC Characteristics** ( $T_a = 0$  to  $+70^\circ\text{C}$ ,  $V_{cc} = 3.3\text{ V} \pm 0.3\text{ V}$ ,  $V_{ss} = 0\text{ V}$ ) \*<sup>1</sup>, \*<sup>2</sup>, \*<sup>19</sup>

### Test Conditions

- Input rise and fall time: 5 ns
- Input timing reference levels: 0.8 V, 2.0 V
- Output timing reference levels: 0.8 V, 2.0 V
- Output load: 1 TTL gate +  $C_L$  (100 pF) (Including scope and jig)

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

Parameter	Symbol	HM5164400/HM5165400				Unit	Notes
		-5		-6			
		Min	Max	Min	Max		
Random read or write cycle time	$t_{RC}$	90	—	110	—	ns	
$\overline{\text{RAS}}$ precharge time	$t_{RP}$	30	—	40	—	ns	
$\overline{\text{CAS}}$ precharge time	$t_{CP}$	8	—	10	—	ns	
$\overline{\text{RAS}}$ pulse width	$t_{RAS}$	50	10000	60	10000	ns	
$\overline{\text{CAS}}$ pulse width	$t_{CAS}$	13	10000	15	10000	ns	
Row address setup time	$t_{ASR}$	0	—	0	—	ns	
Row address hold time	$t_{RAH}$	8	—	10	—	ns	
Column address setup time	$t_{ASC}$	0	—	0	—	ns	
Column address hold time	$t_{CAH}$	8	—	10	—	ns	
$\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ delay time	$t_{RCD}$	18	37	20	45	ns	3
$\overline{\text{RAS}}$ to column address delay time	$t_{RAD}$	13	25	15	30	ns	4
$\overline{\text{RAS}}$ hold time	$t_{RSH}$	13	—	15	—	ns	
$\overline{\text{CAS}}$ hold time	$t_{CSH}$	50	—	60	—	ns	
$\overline{\text{CAS}}$ to $\overline{\text{RAS}}$ precharge time	$t_{CRP}$	5	—	5	—	ns	
$\overline{\text{OE}}$ to Din delay time	$t_{OED}$	13	—	15	—	ns	5
$\overline{\text{OE}}$ delay time from Din	$t_{DZO}$	0	—	0	—	ns	6
$\overline{\text{CAS}}$ delay time from Din	$t_{DZC}$	0	—	0	—	ns	6
Transition time (rise and fall)	$t_T$	3	50	3	50	ns	7

## HM5164400 Series, HM5165400 Series

### Read Cycle

Parameter	Symbol	HM5164400/HM5165400				Unit	Notes
		-5		-6			
		Min	Max	Min	Max		
Access time from $\overline{\text{RAS}}$	$t_{\text{RAC}}$	—	50	—	60	ns	8, 9
Access time from $\overline{\text{CAS}}$	$t_{\text{CAC}}$	—	13	—	15	ns	9, 10, 17
Access time from address	$t_{\text{AA}}$	—	25	—	30	ns	9, 11, 17
Access time from $\overline{\text{OE}}$	$t_{\text{OEA}}$	—	13	—	15	ns	9
Read command setup time	$t_{\text{RCS}}$	0	—	0	—	ns	
Read command hold time to $\overline{\text{CAS}}$	$t_{\text{RCH}}$	0	—	0	—	ns	12
Read command hold time to $\overline{\text{RAS}}$	$t_{\text{RRH}}$	0	—	0	—	ns	12
Column address to $\overline{\text{RAS}}$ lead time	$t_{\text{RAL}}$	25	—	30	—	ns	
Column address to $\overline{\text{CAS}}$ lead time	$t_{\text{CAL}}$	25	—	30	—	ns	
$\overline{\text{CAS}}$ to output in low-Z	$t_{\text{CLZ}}$	0	—	0	—	ns	
Output data hold time	$t_{\text{OH}}$	3	—	3	—	ns	
Output data hold time from $\overline{\text{OE}}$	$t_{\text{OHO}}$	3	—	3	—	ns	
Output buffer turn-off time	$t_{\text{OFF}}$	—	13	—	15	ns	13
Output buffer turn-off to $\overline{\text{OE}}$	$t_{\text{OEZ}}$	—	13	—	15	ns	13
$\overline{\text{CAS}}$ to Din delay time	$t_{\text{CDD}}$	13	—	15	—	ns	5

### Write Cycle

Parameter	Symbol	HM5164400/HM5165400				Unit	Notes
		-5		-6			
		Min	Max	Min	Max		
Write command setup time	$t_{\text{WCS}}$	0	—	0	—	ns	14
Write command hold time	$t_{\text{WCH}}$	8	—	10	—	ns	
Write command pulse width	$t_{\text{WCP}}$	8	—	10	—	ns	
Write command to $\overline{\text{RAS}}$ lead time	$t_{\text{RWL}}$	13	—	15	—	ns	
Write command to $\overline{\text{CAS}}$ lead time	$t_{\text{CWL}}$	13	—	15	—	ns	
Data-in setup time	$t_{\text{DS}}$	0	—	0	—	ns	15
Data-in hold time	$t_{\text{DH}}$	8	—	10	—	ns	15

## HM5164400 Series, HM5165400 Series

### Read-Modify-Write Cycle

Parameter	Symbol	HM5164400/HM5165400				Unit	Notes
		-5		-6			
		Min	Max	Min	Max		
Read-modify-write cycle time	$t_{RWC}$	131	—	155	—	ns	
$\overline{RAS}$ to $\overline{WE}$ delay time	$t_{RWD}$	73	—	85	—	ns	14
$\overline{CAS}$ to $\overline{WE}$ delay time	$t_{CWD}$	36	—	40	—	ns	14
Column address to $\overline{WE}$ delay time	$t_{AWD}$	48	—	55	—	ns	14
$\overline{OE}$ hold time from $\overline{WE}$	$t_{OEH}$	13	—	15	—	ns	

### Refresh Cycle

Parameter	Symbol	HM5164400/HM5165400				Unit	Notes
		-5		-6			
		Min	Max	Min	Max		
$\overline{CAS}$ setup time (CBR refresh cycle)	$t_{CSR}$	5	—	5	—	ns	
$\overline{CAS}$ hold time (CBR refresh cycle)	$t_{CHR}$	8	—	10	—	ns	
$\overline{WE}$ setup time (CBR refresh cycle)	$t_{WRP}$	0	—	0	—	ns	
$\overline{WE}$ hold time (CBR refresh cycle)	$t_{WRH}$	8	—	10	—	ns	
$\overline{RAS}$ precharge to $\overline{CAS}$ hold time	$t_{RPC}$	5	—	5	—	ns	

### Fast Page Mode Cycle

Parameter	Symbol	HM5164400/HM5165400				Unit	Notes
		-5		-6			
		Min	Max	Min	Max		
Fast page mode cycle time	$t_{PC}$	35	—	40	—	ns	
Fast page mode $\overline{RAS}$ pulse width	$t_{RASP}$	—	100000	—	100000	ns	16
Access time from $\overline{CAS}$ precharge	$t_{CPA}$	—	30	—	35	ns	9, 17
$\overline{RAS}$ hold time from $\overline{CAS}$ precharge	$t_{CPRH}$	30	—	35	—	ns	

## HM5164400 Series, HM5165400 Series

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

Parameter	Symbol	HM5164400/HM5165400				Unit	Notes
		-5		-6			
		Min	Max	Min	Max		
Fast page mode read-modify-write cycle time	$t_{PRWC}$	76	—	85	—	ns	
$\overline{WE}$ delay time from $\overline{CAS}$ precharge	$t_{CPW}$	53	—	60	—	ns	14

### Refresh (HM5164400 Series)

Parameter	Symbol	Max	Unit	Note
Refresh period	$t_{REF}$	64	ms	8192 cycles
Refresh period (L-version)	$t_{REF}$	128	ms	8192 cycles

### Refresh (HM5165400 Series)

Parameter	Symbol	Max	Unit	Note
Refresh period	$t_{REF}$	64	ms	4096 cycles
Refresh period (L-version)	$t_{REF}$	128	ms	4096 cycles

### Self Refresh Mode (L-version)

Parameter	Symbol	HM5164400L/HM5165400L				Unit	Notes
		-5		-6			
		Min	Max	Min	Max		
$\overline{RAS}$ pulse width (Self refresh)	$t_{RASS}$	100	—	100	—	$\mu$ s	23
$\overline{RAS}$ precharge time (Self refresh)	$t_{RPS}$	90	—	110	—	ns	23
$\overline{CAS}$ hold time (Self refresh)	$t_{CHS}$	-50	—	-50	—	ns	

Notes: 1. AC measurements assume  $t_T = 5$  ns.

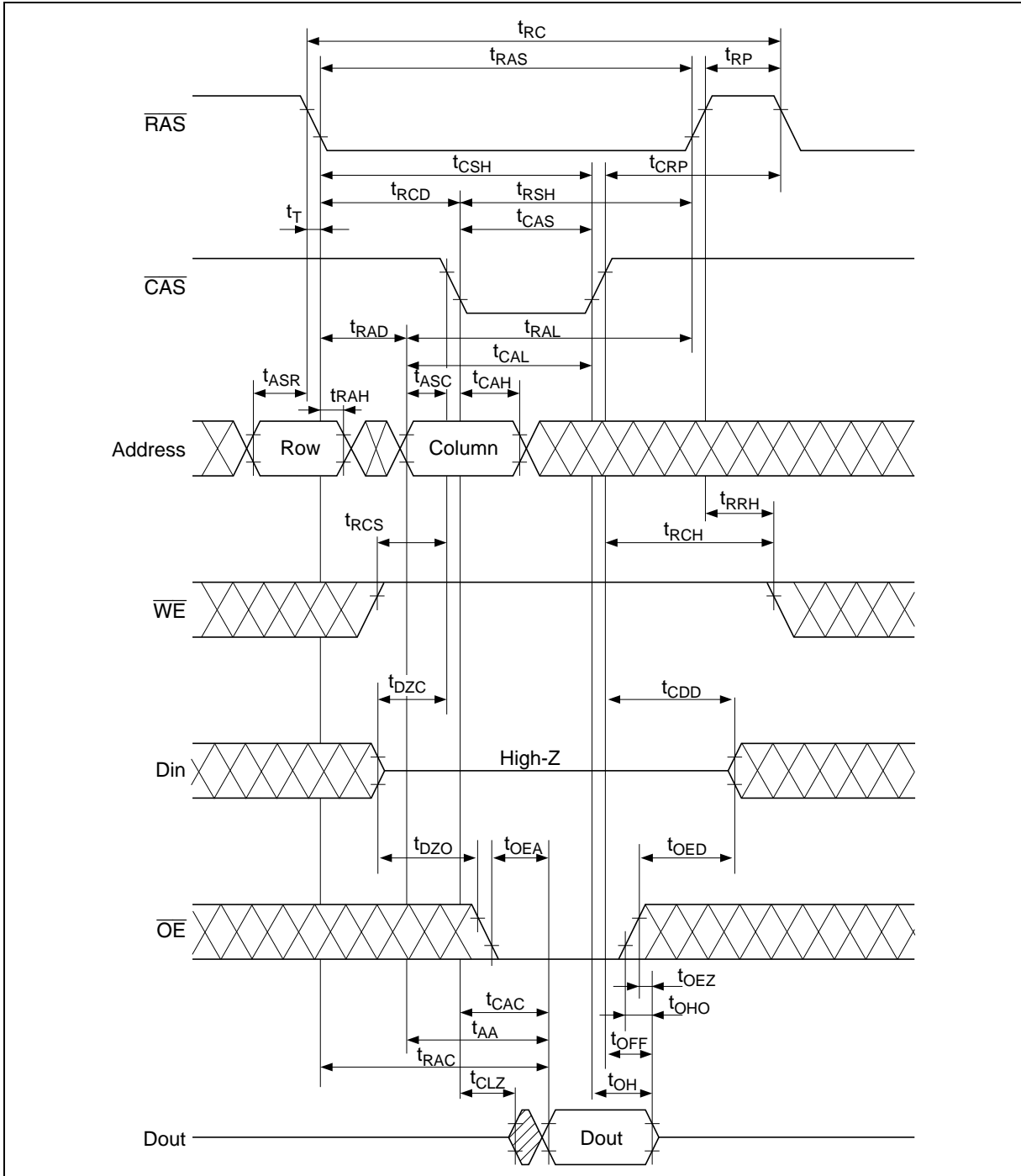
- An initial pause of 200  $\mu$ s is required after power up followed by a minimum of eight initialization cycles (any combination of cycles containing  $\overline{RAS}$ -only refresh or  $\overline{CAS}$ -before- $\overline{RAS}$  refresh).
- Operation with the  $t_{RCD}$  (max) limit insures that  $t_{RAC}$  (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  $t_{CAC}$ .
- 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  $t_{AA}$ .

5. Either  $t_{\text{OED}}$  or  $t_{\text{CDD}}$  must be satisfied.
6. Either  $t_{\text{DZO}}$  or  $t_{\text{DZC}}$  must be satisfied.
7.  $V_{\text{IH}}$  (min) and  $V_{\text{IL}}$  (max) are reference levels for measuring timing of input signals. Also, transition times are measured between  $V_{\text{IH}}$  (min) and  $V_{\text{IL}}$  (max).
8. Assumes that  $t_{\text{RCD}} \leq t_{\text{RCD}}(\text{max})$  and  $t_{\text{RAD}} \leq t_{\text{RAD}}(\text{max})$ . If  $t_{\text{RCD}}$  or  $t_{\text{RAD}}$  is greater than the maximum recommended value shown in this table,  $t_{\text{RAC}}$  exceeds the value shown.
9. Measured with a load circuit equivalent to 1 TTL loads and 100 pF.
10. Assumes that  $t_{\text{RCD}} \geq t_{\text{RCD}}(\text{max})$  and  $t_{\text{RCD}} + t_{\text{CAC}}(\text{max}) \geq t_{\text{RAD}} + t_{\text{AA}}(\text{max})$ .
11. Assumes that  $t_{\text{RAD}} \geq t_{\text{RAD}}(\text{max})$  and  $t_{\text{RCD}} + t_{\text{CAC}}(\text{max}) \leq t_{\text{RAD}} + t_{\text{AA}}(\text{max})$ .
12. Either  $t_{\text{RCH}}$  or  $t_{\text{RRH}}$  must be satisfied for a read cycles.
13.  $t_{\text{OFF}}(\text{max})$  and  $t_{\text{OEZ}}(\text{max})$  define the time at which the outputs achieve the open circuit condition and are not referred to output voltage levels.
14.  $t_{\text{WCS}}$ ,  $t_{\text{RWD}}$ ,  $t_{\text{CWD}}$ ,  $t_{\text{AWD}}$  and  $t_{\text{CPW}}$  are not restrictive operating parameters. They are included in the data sheet as electrical characteristics only; if  $t_{\text{WCS}} \geq t_{\text{WCS}}(\text{min})$ , the cycle is an early write cycle and the data out pin will remain open circuit (high impedance) throughout the entire cycle; if  $t_{\text{RWD}} \geq t_{\text{RWD}}(\text{min})$ ,  $t_{\text{CWD}} \geq t_{\text{CWD}}(\text{min})$ , and  $t_{\text{AWD}} \geq t_{\text{AWD}}(\text{min})$ , or  $t_{\text{CWD}} \geq t_{\text{CWD}}(\text{min})$ ,  $t_{\text{AWD}} \geq t_{\text{AWD}}(\text{min})$  and  $t_{\text{CPW}} \geq t_{\text{CPW}}(\text{min})$ , 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.
15.  $t_{\text{DS}}$ ,  $t_{\text{DH}}$  are referred to  $\overline{\text{CAS}}$  leading edge in early write cycles and to  $\overline{\text{WE}}$  leading edge in delayed write or read-modify-write cycles.
16.  $t_{\text{RASP}}$  defines  $\overline{\text{RAS}}$  pulse width in fast page mode cycles.
17. Access time is determined by the longest among  $t_{\text{AA}}$ ,  $t_{\text{CAC}}$  and  $t_{\text{CPA}}$ .
18. In delayed write or read-modify-write cycles,  $\overline{\text{OE}}$  must disable output buffer prior to applying data to the device.
19. When output buffers are enabled once, sustain the low impedance state until valid data is obtained. When output buffer is turned on and off within a very short time, generally it causes large  $V_{\text{CC}}/V_{\text{SS}}$  line noise, which causes to degrade  $V_{\text{IH}}(\text{min})/V_{\text{IL}}(\text{max})$  level.
20. Before and after self refresh mode, execute CBR refresh to all refresh addresses in or within 64 ms period on the condition a and b below.
  - a. Enter self refresh mode within 15.6  $\mu\text{s}$  after either burst refresh or distributed refresh at equal interval to all refresh addresses are completed.
  - b. Start burst refresh or distributed refresh at equal interval to all refresh addresses within 15.6  $\mu\text{s}$  after exiting from self refresh mode.
21. In case of entering from  $\overline{\text{RAS}}$ -only-refresh, it is necessary to execute CBR refresh before and after self refresh mode according as note 20.
22. For L-version, it is available to apply each 128 ms and 31.2  $\mu\text{s}$  instead of 64 ms and 15.6  $\mu\text{s}$  at note 20.
23. At  $t_{\text{RASS}} > 100 \mu\text{s}$ , self refresh mode is activated, and not activated at  $t_{\text{RASS}} < 10 \mu\text{s}$ . It is undefined within the range of  $10 \mu\text{s} \leq t_{\text{RASS}} \leq 100 \mu\text{s}$ . For  $t_{\text{RASS}} \geq 10 \mu\text{s}$ , it is necessary to satisfy  $t_{\text{RPS}}$ .
24. XXX: 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  
 When the address, clock and input pins are not described on timing waveforms, their pins must be applied  $V_{\text{IH}}$  or  $V_{\text{IL}}$ .

# HM5164400 Series, HM5165400 Series

## Timing Waveforms\*24

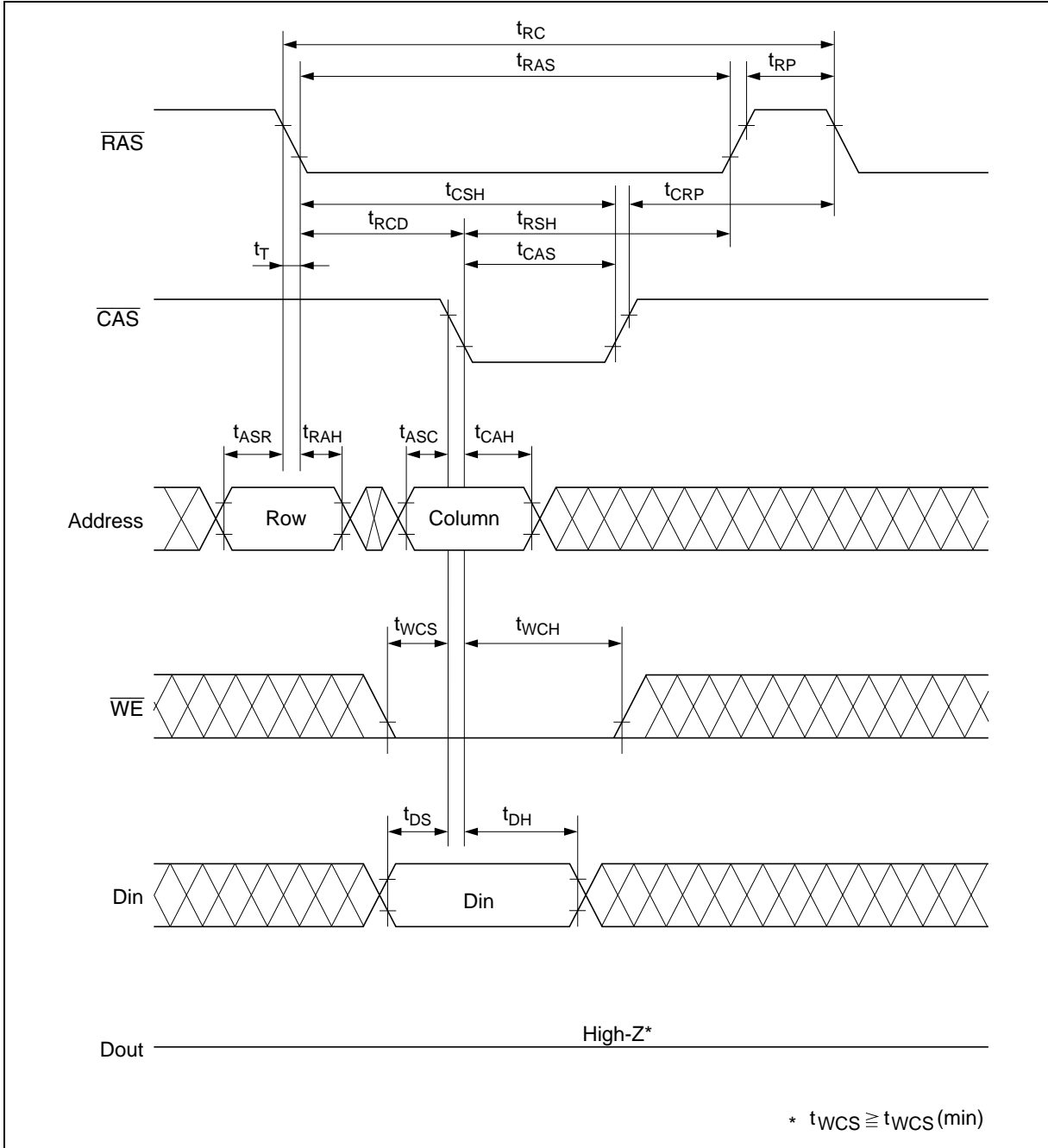
### Read Cycle





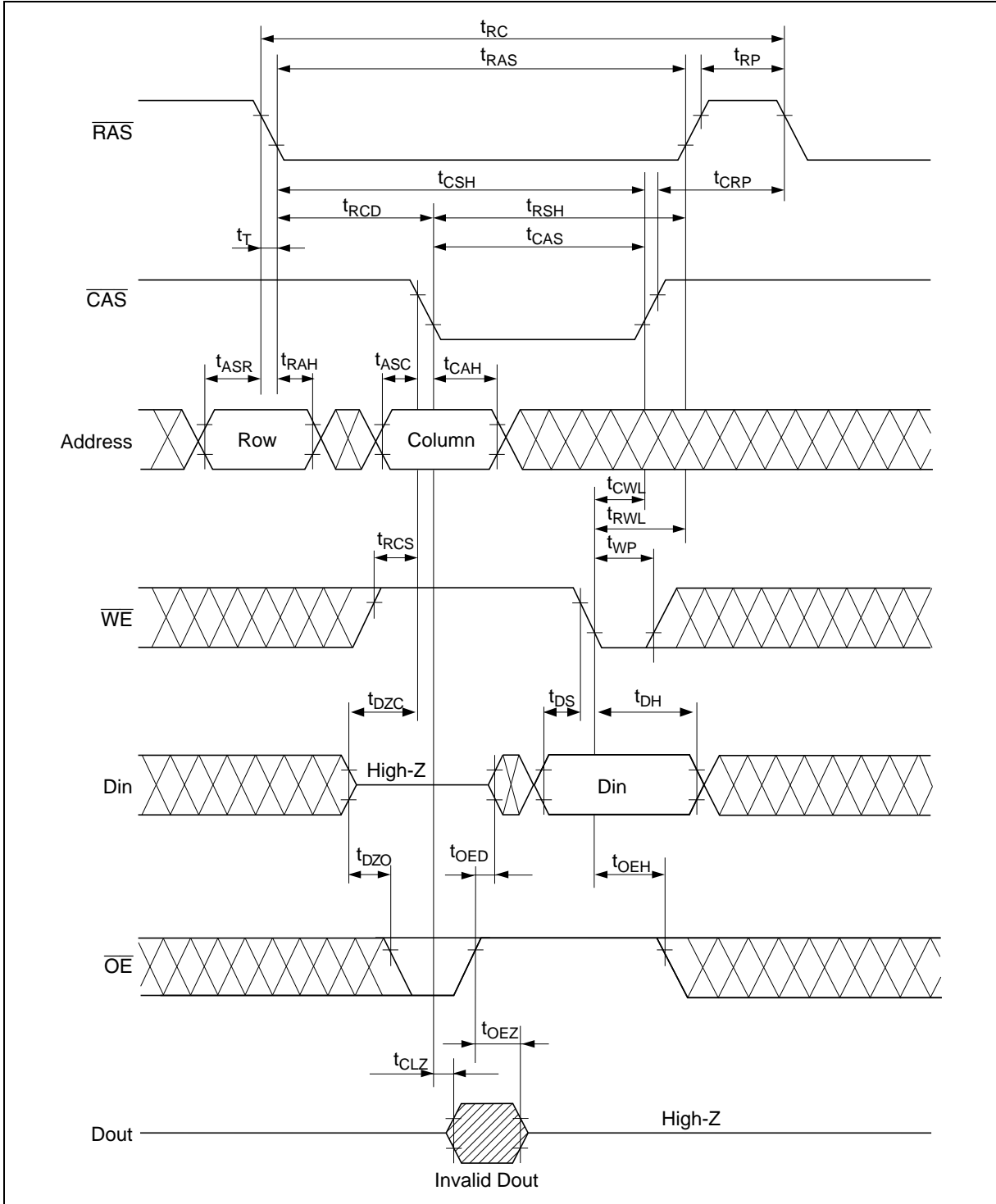
# HM5164400 Series, HM5165400 Series

## Early Write Cycle



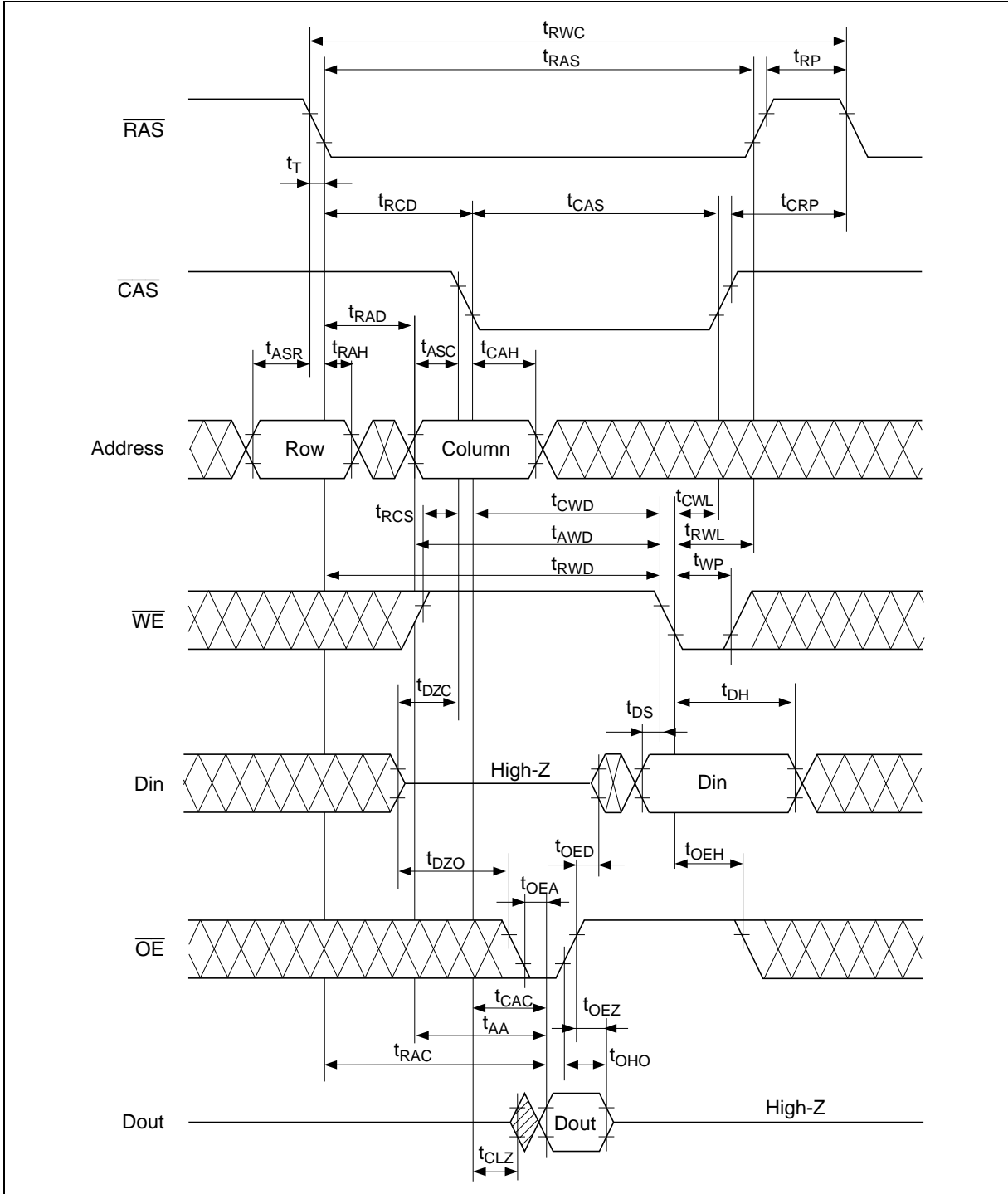
# HM5164400 Series, HM5165400 Series

## Delayed Write Cycle\*<sup>18</sup>



# HM5164400 Series, HM5165400 Series

## Read-Modify-Write Cycle\*18

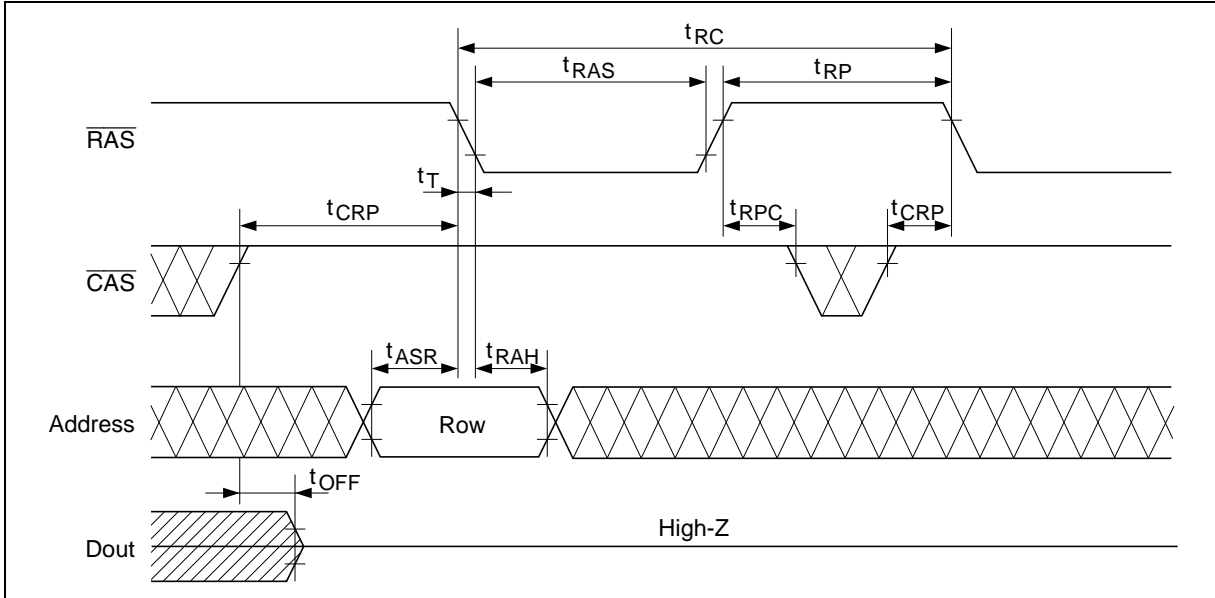


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## HM5164400 Series, HM5165400 Series

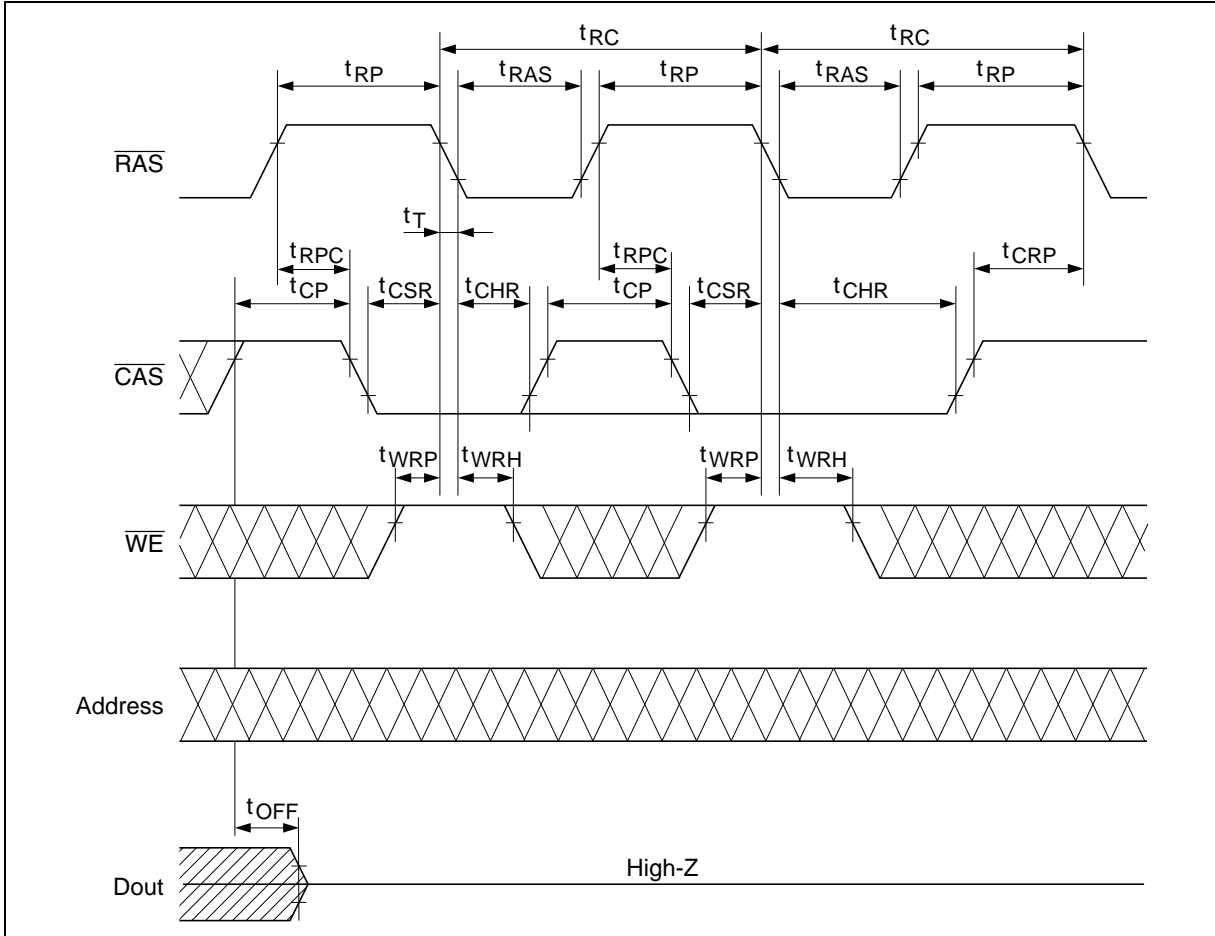
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### $\overline{\text{RAS}}$ -Only Refresh Cycle



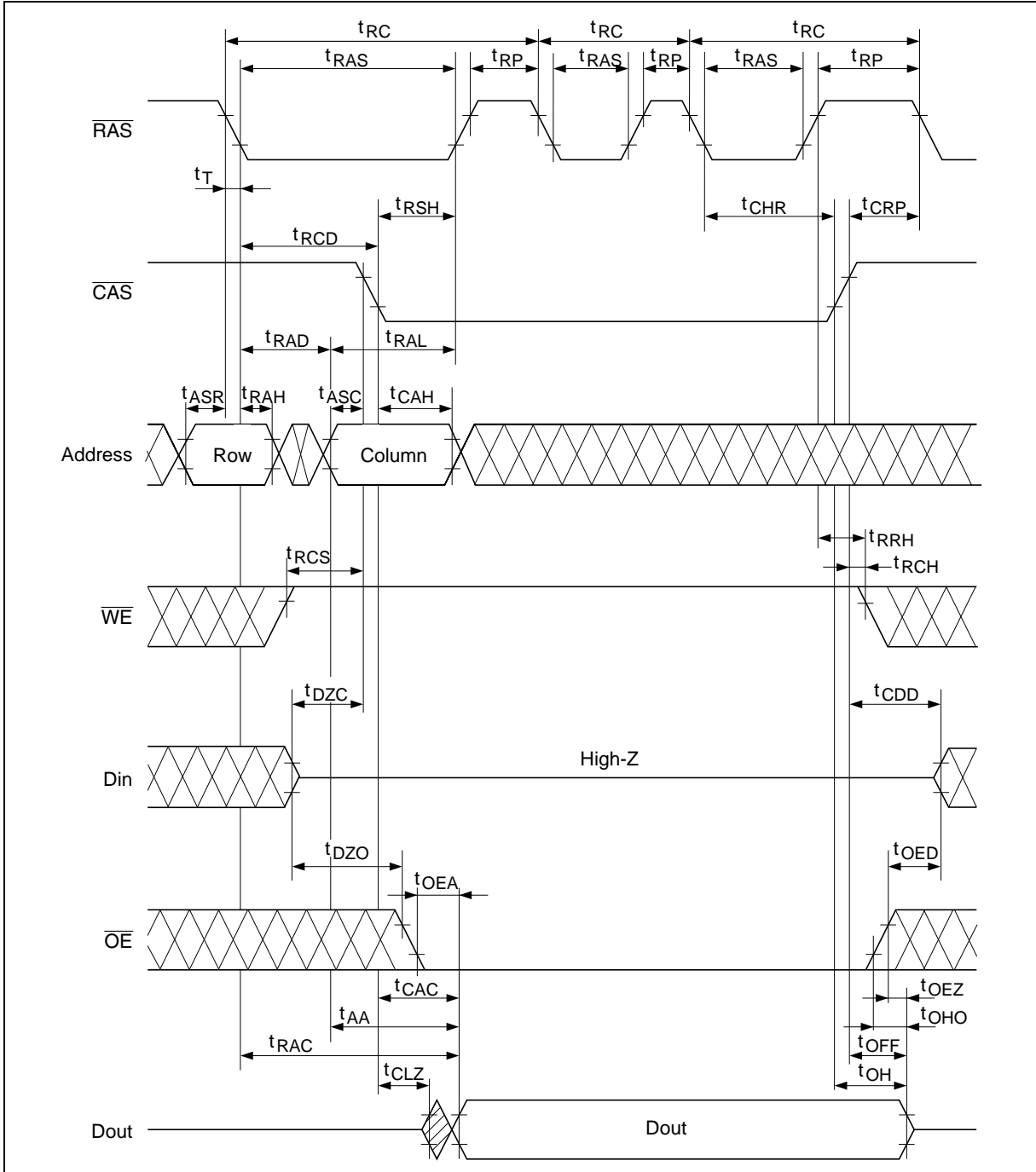
**HM5164400 Series, HM5165400 Series**

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



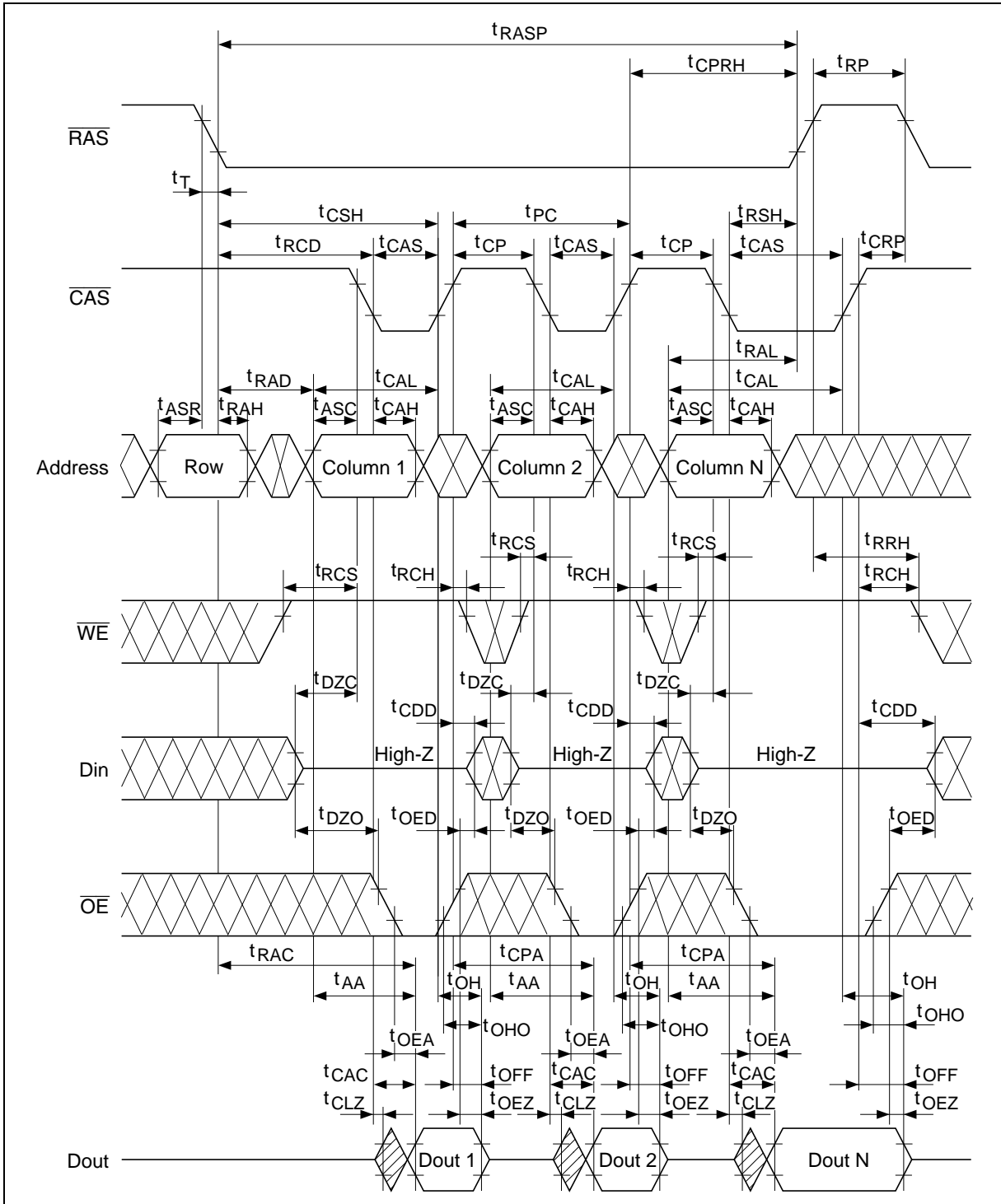
# HM5164400 Series, HM5165400 Series

## Hidden Refresh Cycle



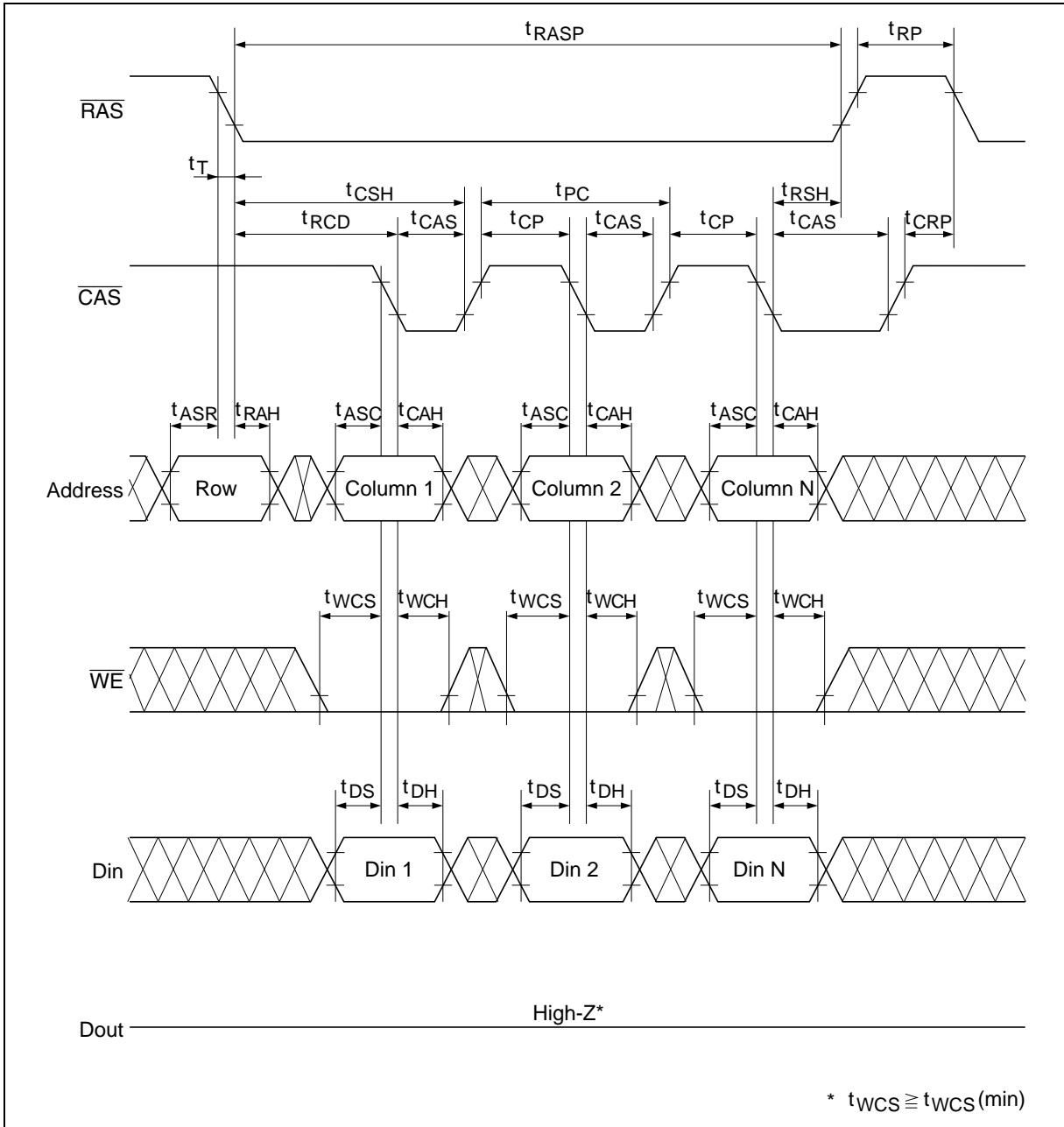
# HM5164400 Series, HM5165400 Series

## Fast Page Mode Read Cycle



# HM5164400 Series, HM5165400 Series

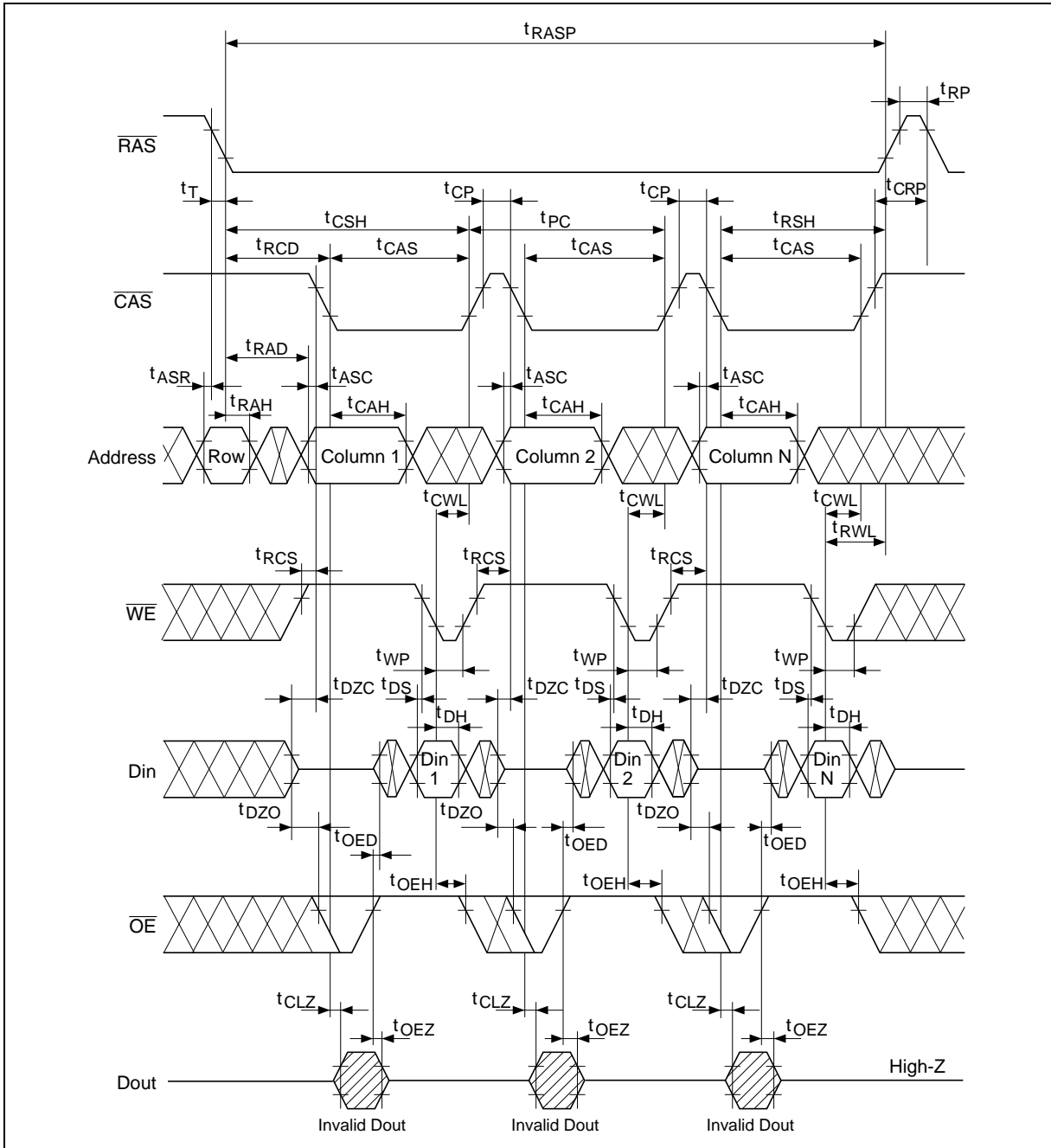
## Fast Page Mode Early Write Cycle





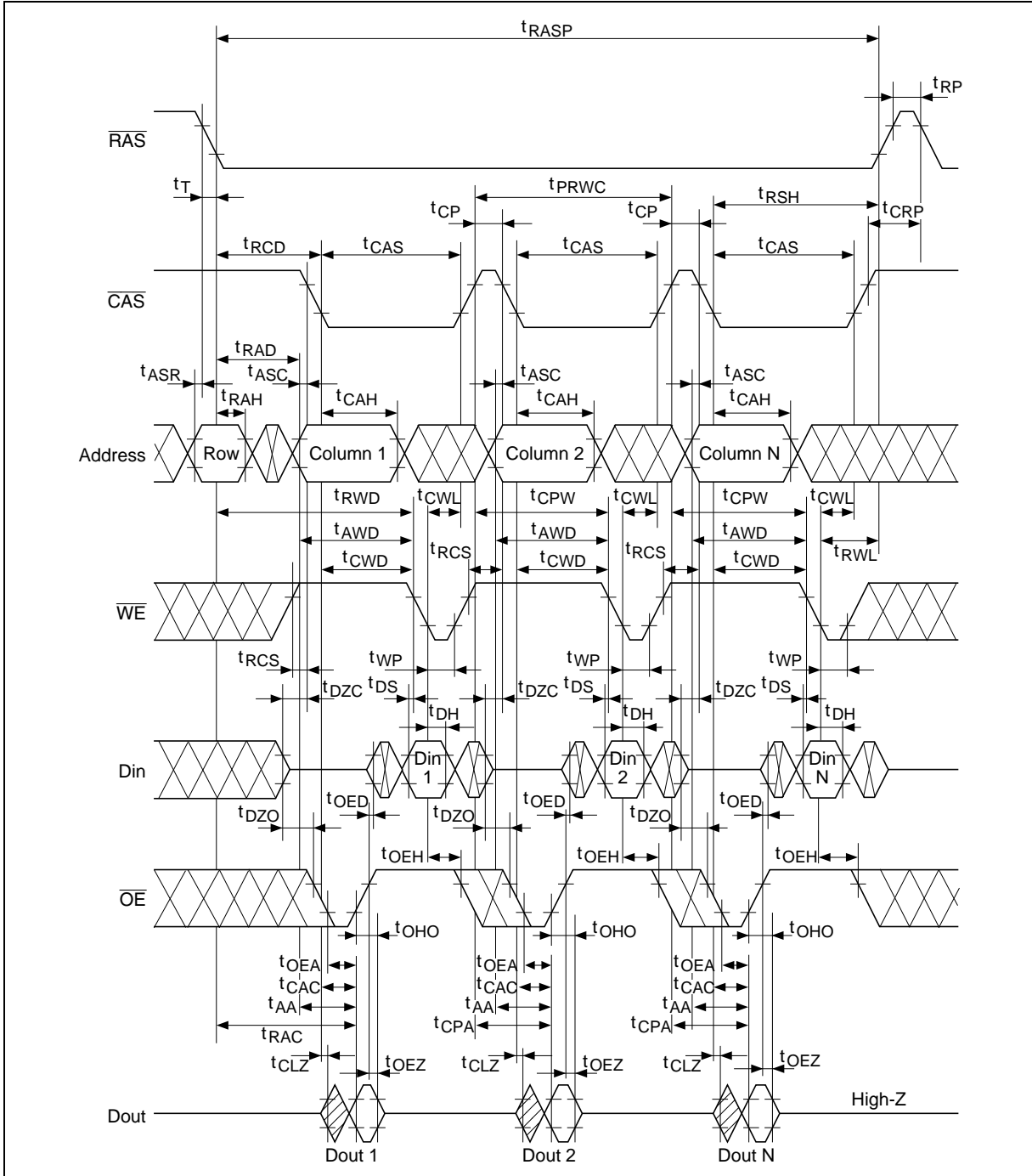
# HM5164400 Series, HM5165400 Series

## Fast Page Mode Delayed Write Cycle\*<sup>18</sup>



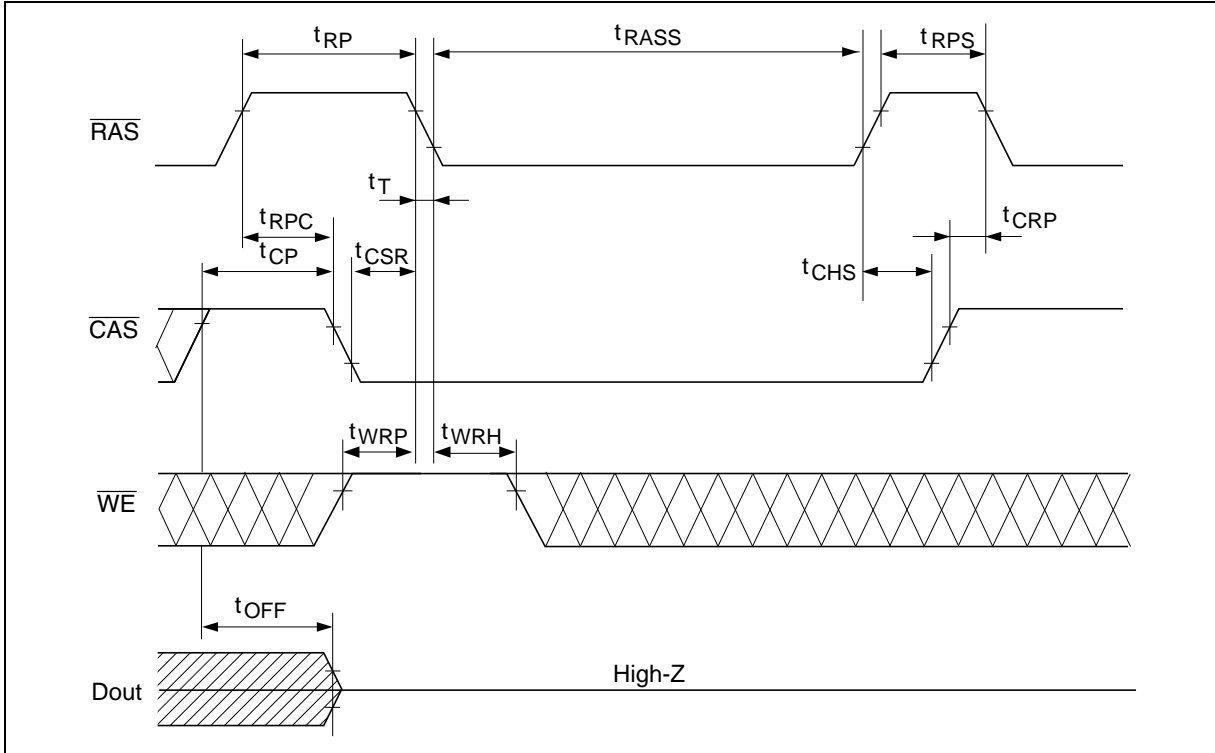
# HM5164400 Series, HM5165400 Series

## Fast Page Mode Read-Modify-Write Cycle\*18



# HM5164400 Series, HM5165400 Series

## Self Refresh Cycle (L-version)\*<sup>20, 21, 22, 23</sup>



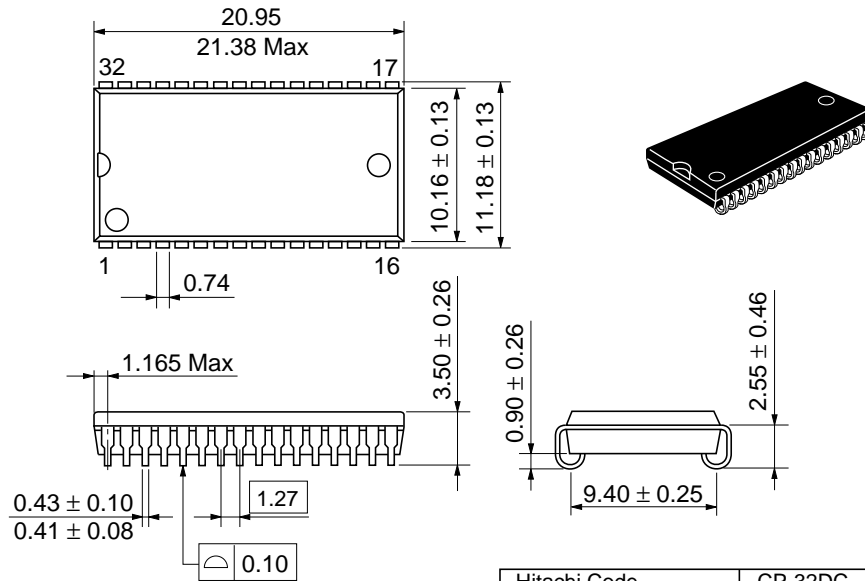
# HM5164400 Series, HM5165400 Series

## Package Dimensions

HM5164400J/LJ Series

HM5165400J/LJ Series (CP-32DC)

Unit: mm



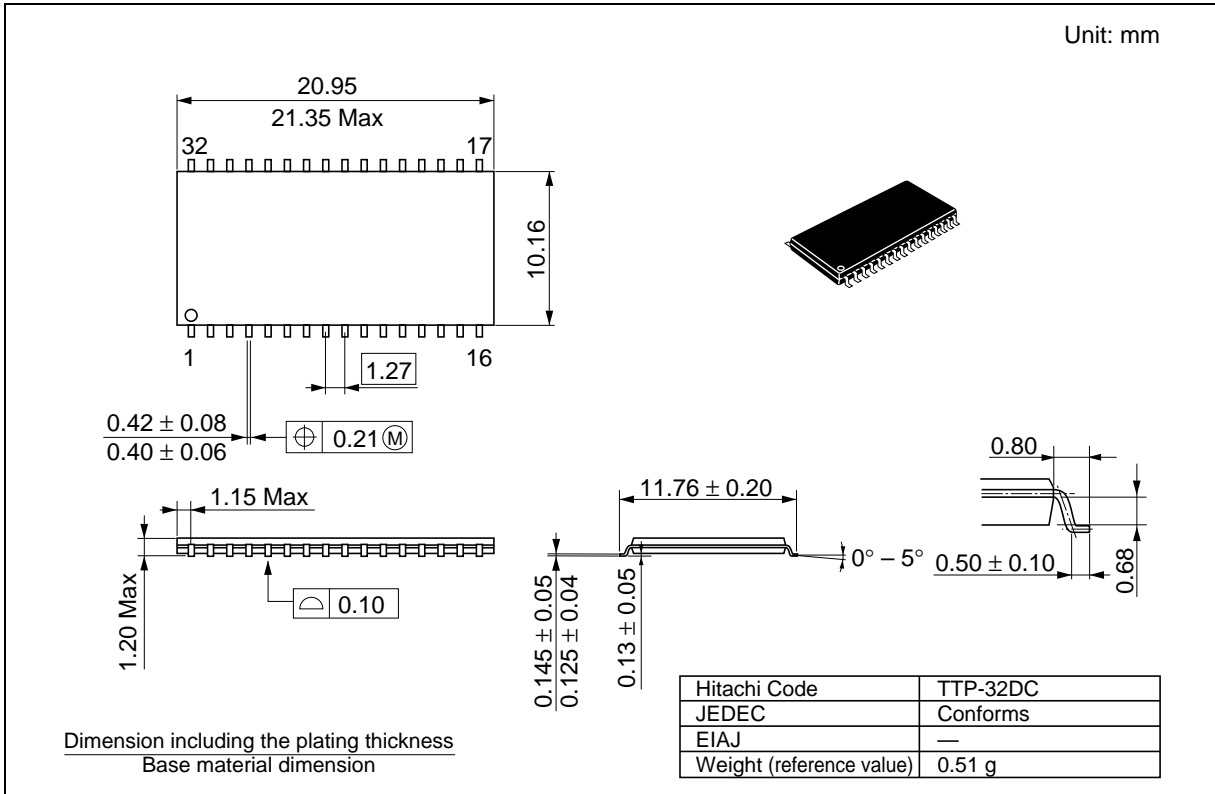
Dimension including the plating thickness  
Base material dimension

Hitachi Code	CP-32DC
JEDEC	—
EIAJ	Conforms
Weight (reference value)	1.2 g

# HM5164400 Series, HM5165400 Series

HM5164400TT/LTT Series

HM5165400TT/LTT Series (TTP-32DC)



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## HM5164400 Series, HM5165400 Series

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## HM5164400 Series, HM5165400 Series

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### Revision Record

Rev.	Date	Contents of Modification	Drawn by	Approved by
0.0	Jul. 23, 1997	Initial issue	J. Miyake	M. Saeki
0.1	Nov. 1997	Change of Subtitle	J. Miyake	Y. Takahashi
1.0	Feb. 27, 1998	Deletion of Preliminary		