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# HM51W16405 Series

# HM51W17405 Series

4,194,304-word × 4-bit Dynamic RAM

# HITACHI

ADE-203-647 C(Z)

Rev. 3.0

Feb. 27, 1997

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## Description

The Hitachi HM51W16405 Series, HM51W17405 Series are CMOS dynamic RAMs organized 4,194,304-word × 4-bit. They employ the most advanced CMOS technology for high performance and low power. The HM51W16405 Series, HM51W17405 Series offer Extended Data Out (EDO) Page Mode as a high speed access mode. They have package variations of standard 300-mil 26-pin plastic SOJ and 300-mil 26-pin plastic TSOP.

## Features

- Single 3.3 V ( $\pm 0.3$  V)
- Access time: 50 ns/60 ns/70 ns (max)
- Power dissipation
  - Active mode : 324 mW /288 mW /252 mW (max) (HM51W16405 Series)  
: 360mW/324 mW/288 mW (max) (HM51W17405 Series)
  - Standby mode : 7.2 mW (max)  
: 0.36 mW (max) (L-version)
- EDO page mode capability
- Long refresh period
  - 4096 refresh cycles : 64 ms (HM51W16405 Series)  
: 128 ms (L-version)
  - 2048 refresh cycles : 32 ms (HM51W17405 Series)  
: 128 ms (L-version)
- 4 variations of refresh
  - $\overline{\text{RAS}}$ -only refresh
  - $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh
  - Hidden refresh
  - Self refresh (L-version)

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# HM51W16405 Series, HM51W17405 Series

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- Battery backup operation (L-version)
- Test function
  - 16-bit parallel test mode

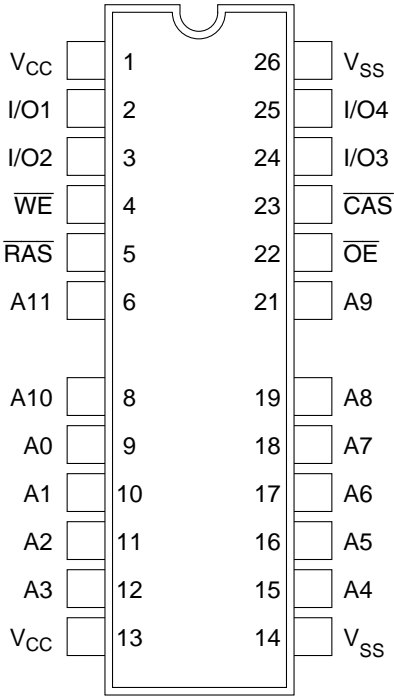
## Ordering Information

Type No.	Access time	Package
HM51W16405S-5	50 ns	300-mil 26-pin plastic SOJ (CP-26/24DB)
HM51W16405S-6	60 ns	
HM51W16405S-7	70 ns	
HM51W16405LS-5	50 ns	
HM51W16405LS-6	60 ns	
HM51W16405LS-7	70 ns	
HM51W17405S-5	50 ns	
HM51W17405S-6	60 ns	
HM51W17405S-7	70 ns	
HM51W17405LS-5	50 ns	
HM51W17405LS-6	60 ns	
HM51W17405LS-7	70 ns	
HM51W16405TS-5	50 ns	300-mil 26-pin plastic TSOP II (TTP-26/24DA)
HM51W16405TS-6	60 ns	
HM51W16405TS-7	70 ns	
HM51W16405LTS-5	50 ns	
HM51W16405LTS-6	60 ns	
HM51W16405LTS-7	70 ns	
HM51W17405TS-5	50 ns	
HM51W17405TS-6	60 ns	
HM51W17405TS-7	70 ns	
HM51W17405LTS-5	50 ns	
HM51W17405LTS-6	60 ns	
HM51W17405LTS-7	70 ns	

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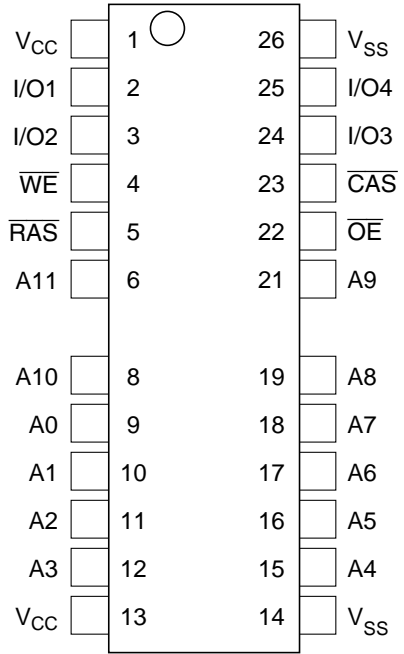
## Pin Arrangement

HM51W16405S/LS Series



(Top view)

HM51W16405TS/LTS Series



(Top view)

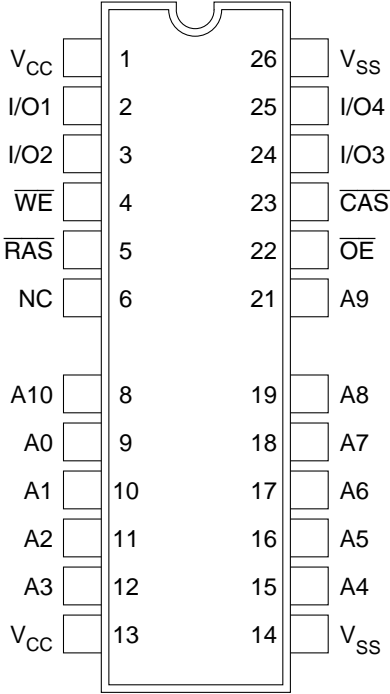
## Pin Description

Pin name	Function
A0 to A11	Address input — Row/Refresh address    A0 to A11 — Column address            A0 to A9
I/O1 to I/O4	Data input/Data output
$\overline{RAS}$	Row address strobe
$\overline{CAS}$	Column address strobe
$\overline{WE}$	Read/Write enable
$\overline{OE}$	Output enable
V <sub>CC</sub>	Power supply
V <sub>SS</sub>	Ground

# HM51W16405 Series, HM51W17405 Series

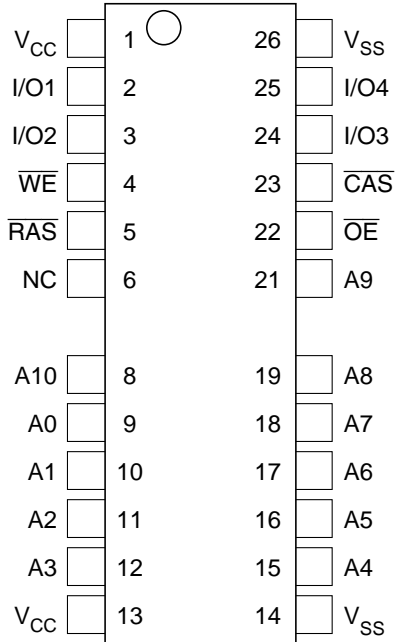
## Pin Arrangement

HM51W17405S/LS Series



(Top view)

HM51W17405TS/LTS Series

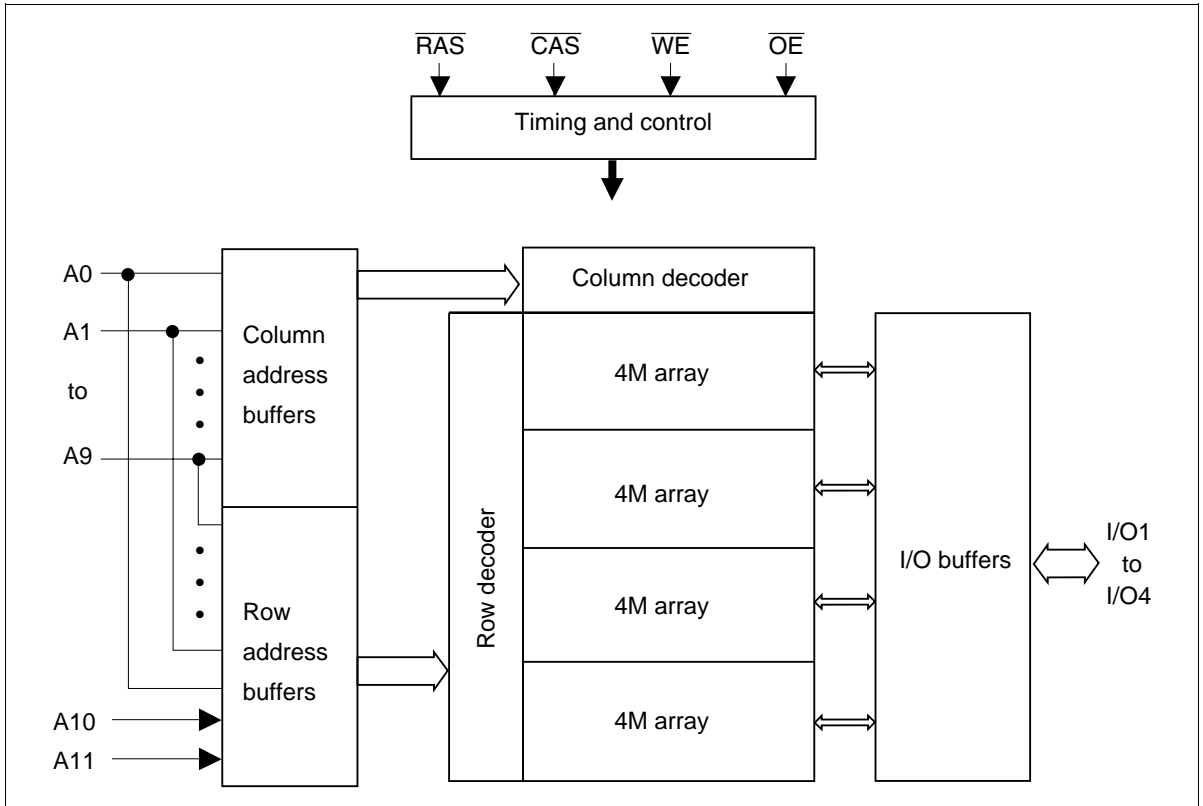


(Top view)

## Pin Description

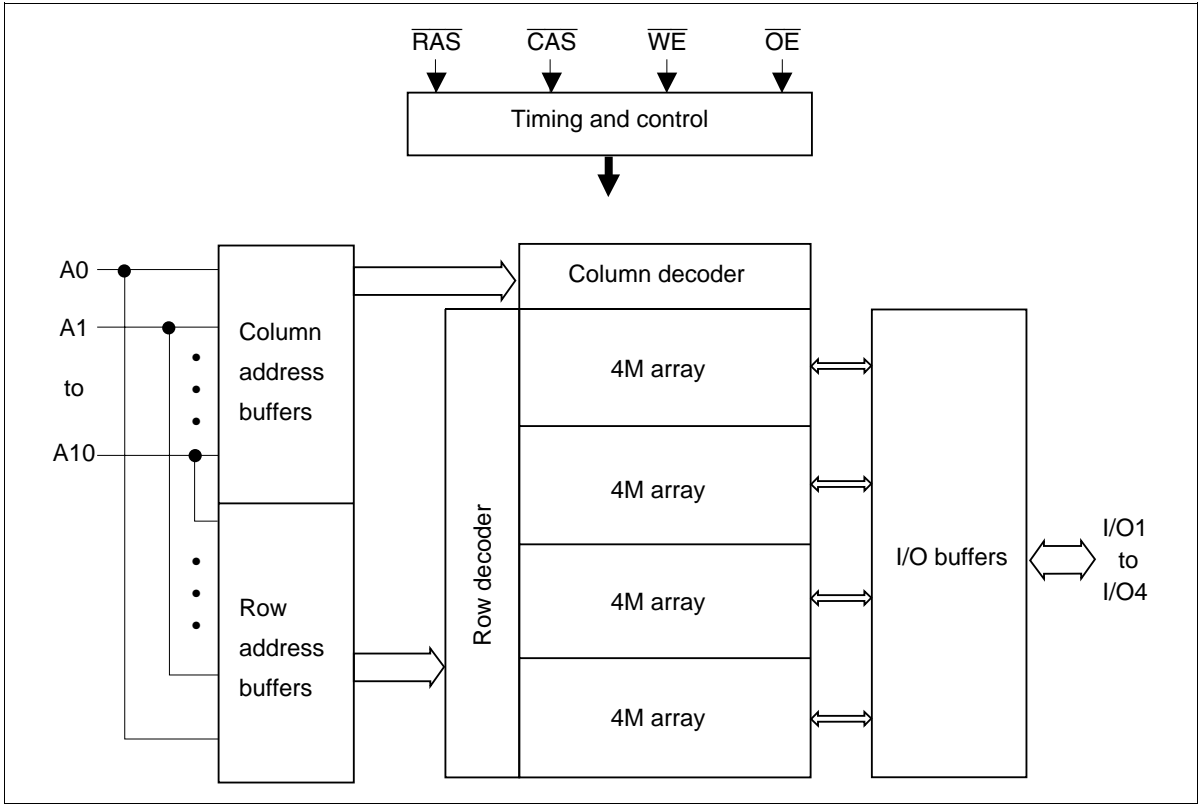
Pin name	Function
A0 to A10	Address input — Row/Refresh address A0 to A10 — Column address A0 to A10
I/O1 to I/O4	Data input/Data output
$\overline{\text{RAS}}$	Row address strobe
$\overline{\text{CAS}}$	Column address strobe
$\overline{\text{WE}}$	Read/Write enable
$\overline{\text{OE}}$	Output enable
$V_{\text{CC}}$	Power supply
$V_{\text{SS}}$	Ground
NC	No connection

Block Diagram(HM51W16405 Series)



# HM51W16405 Series, HM51W17405 Series

## Block Diagram(HM51W17405 Series)



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**Absolute Maximum Ratings**

Parameter	Symbol	Value	Unit
Voltage on any pin relative to $V_{SS}$	$V_T$	$-0.5$ to $V_{CC} + 0.5$ ( $\leq +4.6$ V (max))	V
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
Operating temperature	$T_{opr}$	0 to $+70$	$^{\circ}C$
Storage temperature	$T_{stg}$	$-55$ to $+125$	$^{\circ}C$

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

Parameter	Symbol	Min	Typ	Max	Unit	Notes
Supply voltage	$V_{CC}$	3.0	3.3	3.6	V	1, 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

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

# HM51W16405 Series, HM51W17405 Series

## DC Characteristics

( $T_a = 0$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$ ,  $V_{SS} = 0 \text{ V}$ ) (HM51W16405 Series)

Parameter	Symbol	HM51W16405						Unit	Test conditions
		-5		-6		-7			
		Min	Max	Min	Max	Min	Max		
Operating current* <sup>1</sup> , * <sup>2</sup>	$I_{CC1}$	—	90	—	80	—	70	mA	$t_{RC} = \text{min}$
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 $\overline{\text{RAS}}, \overline{\text{CAS}} \geq V_{CC} - 0.2 \text{ V}$ Dout = High-Z
$\overline{\text{RAS}}$ -only refresh current* <sup>2</sup>	$I_{CC3}$	—	90	—	80	—	70	mA	$t_{RC} = \text{min}$
Standby current* <sup>1</sup>	$I_{CC5}$	—	5	—	5	—	5	mA	$\overline{\text{RAS}} = V_{IH}$ $\overline{\text{CAS}} = V_{IL}$ Dout = enable
$\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh current	$I_{CC6}$	—	90	—	80	—	70	mA	$t_{RC} = \text{min}$
EDO page mode current* <sup>1</sup> , * <sup>3</sup>	$I_{CC7}$	—	80	—	70	—	65	mA	$t_{HPC} = \text{min}$
Battery backup current	$I_{CC10}$	—	300	—	300	—	300	$\mu\text{A}$	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)	$I_{CC11}$	—	200	—	200	—	200	$\mu\text{A}$	CMOS interface $\overline{\text{RAS}}, \overline{\text{CAS}} \leq 0.2 \text{ V}$ Dout = High-Z
Input leakage current	$I_{LI}$	-10	10	-10	10	-10	10	$\mu\text{A}$	$0 \text{ V} \leq V_{in} \leq 4.6 \text{ V}$
Output leakage current	$I_{LO}$	-10	10	-10	10	-10	10	$\mu\text{A}$	$0 \text{ V} \leq V_{in} \leq 4.6 \text{ V}$ Dout = disable
Output high voltage	$V_{OH}$	2.4	$V_{CC}$	2.4	$V_{CC}$	2.4	$V_{CC}$	V	High Iout = -2 mA
Output low voltage	$V_{OL}$	0	0.4	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  $\overline{\text{RAS}} = V_{IL}$ .

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



# HM51W16405 Series, HM51W17405 Series

## DC Characteristics

( $T_a = 0$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$ ,  $V_{SS} = 0 \text{ V}$ ) (HM51W17405 Series)

Parameter	Symbol	HM51W17405						Unit	Test conditions
		-5		-6		-7			
		Min	Max	Min	Max	Min	Max		
Operating current <sup>*1, *2</sup>	$I_{CC1}$	—	100	—	90	—	80	mA	$t_{RC} = \text{min}$
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 $\overline{\text{RAS}}, \overline{\text{CAS}} \geq V_{CC} - 0.2 \text{ V}$ Dout = High-Z
$\overline{\text{RAS}}$ -only refresh current <sup>**2</sup>	$I_{CC3}$	—	100	—	90	—	80	mA	$t_{RC} = \text{min}$
Standby current <sup>*1</sup>	$I_{CC5}$	—	5	—	5	—	5	mA	$\overline{\text{RAS}} = V_{IH}$ $\overline{\text{CAS}} = V_{IL}$ Dout = enable
$\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh current	$I_{CC6}$	—	100	—	90	—	80	mA	$t_{RC} = \text{min}$
EDO page mode current <sup>*1, *3</sup>	$I_{CC7}$	—	90	—	80	—	75	mA	$t_{HPC} = \text{min}$
Battery backup current	$I_{CC10}$	—	300	—	300	—	300	$\mu\text{A}$	CMOS interface Dout = High-Z, CBR refresh: $t_{RC} = 62.5 \mu\text{s}$ $t_{RAS} \leq 0.3 \mu\text{s}$
Self refresh mode current (L-version)	$I_{CC11}$	—	200	—	200	—	200	$\mu\text{A}$	CMOS interface $\overline{\text{RAS}}, \overline{\text{CAS}} \leq 0.2 \text{ V}$ Dout = High-Z
Input leakage current	$I_{LI}$	-10	10	-10	10	-10	10	$\mu\text{A}$	$0 \text{ V} \leq V_{in} \leq 4.6 \text{ V}$
Output leakage current	$I_{LO}$	-10	10	-10	10	-10	10	$\mu\text{A}$	$0 \text{ V} \leq V_{in} \leq 4.6 \text{ V}$ Dout = disable
Output high voltage	$V_{OH}$	2.4	$V_{CC}$	2.4	$V_{CC}$	2.4	$V_{CC}$	V	High Iout = -2 mA
Output low voltage	$V_{OL}$	0	0.4	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  $\overline{\text{RAS}} = V_{IL}$ .

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

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## HM51W16405 Series, HM51W17405 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.  $\overline{\text{CAS}} = V_{IH}$  to disable Dout.

# HM51W16405 Series, HM51W17405 Series

**AC Characteristics** ( $T_a = 0$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$ ,  $V_{SS} = 0\text{ V}$ ) \*1, \*2, \*18

## Test Conditions

- Input rise and fall time: 2 ns
- Input levels:  $V_{IL} = 0\text{ V}$ ,  $V_{IH} = 3\text{ V}$
- 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	HM51W16405/HM51W17405						Unit	Notes
		-5		-6		-7			
		Min	Max	Min	Max	Min	Max		
Random read or write cycle time	$t_{RC}$	84	—	104	—	124	—	ns	
$\overline{\text{RAS}}$ precharge time	$t_{RP}$	30	—	40	—	50	—	ns	
$\overline{\text{CAS}}$ precharge time	$t_{CP}$	8	—	10	—	13	—	ns	
$\overline{\text{RAS}}$ pulse width	$t_{RAS}$	50	10000	60	10000	70	10000	ns	
$\overline{\text{CAS}}$ pulse width	$t_{CAS}$	8	10000	10	10000	13	10000	ns	
Row address setup time	$t_{ASR}$	0	—	0	—	0	—	ns	
Row address hold time	$t_{RAH}$	8	—	10	—	10	—	ns	
Column address setup time	$t_{ASC}$	0	—	0	—	0	—	ns	
Column address hold time	$t_{CAH}$	8	—	10	—	13	—	ns	
$\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ delay time	$t_{RCD}$	12	37	14	45	14	52	ns	3
$\overline{\text{RAS}}$ to column address delay time	$t_{RAD}$	10	25	12	30	12	35	ns	4
$\overline{\text{RAS}}$ hold time	$t_{RSH}$	10	—	13	—	13	—	ns	
$\overline{\text{CAS}}$ hold time	$t_{CSH}$	35	—	40	—	45	—	ns	
$\overline{\text{CAS}}$ to $\overline{\text{RAS}}$ precharge time	$t_{CRP}$	5	—	5	—	5	—	ns	
$\overline{\text{OE}}$ to Din delay time	$t_{OED}$	13	—	15	—	18	—	ns	5
$\overline{\text{OE}}$ delay time from Din	$t_{DZO}$	0	—	0	—	0	—	ns	6
$\overline{\text{CAS}}$ delay time from Din	$t_{DZC}$	0	—	0	—	0	—	ns	6
Transition time (rise and fall)	$t_T$	2	50	2	50	2	50	ns	7

# HM51W16405 Series, HM51W17405 Series

## Read Cycle

Parameter	Symbol	HM51W16405/HM51W17405						Unit	Notes
		-5		-6		-7			
		Min	Max	Min	Max	Min	Max		
Access time from $\overline{\text{RAS}}$	$t_{\text{RAC}}$	—	50	—	60	—	70	ns	8, 9, 20
Access time from $\overline{\text{CAS}}$	$t_{\text{CAC}}$	—	13	—	15	—	18	ns	9, 10, 17, 20
Access time from address	$t_{\text{AA}}$	—	25	—	30	—	35	ns	9, 11, 17, 20
Access time from $\overline{\text{OE}}$	$t_{\text{OEA}}$	—	13	—	15	—	18	ns	9, 20
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	12
Read command hold time from $\overline{\text{RAS}}$	$t_{\text{RCHR}}$	50	—	60	—	70	—	ns	
Read command hold time to $\overline{\text{RAS}}$	$t_{\text{RRH}}$	0	—	0	—	0	—	ns	12
Column address to $\overline{\text{RAS}}$ lead time	$t_{\text{RAL}}$	25	—	30	—	35	—	ns	
Column address to $\overline{\text{CAS}}$ lead time	$t_{\text{CAL}}$	15	—	18	—	23	—	ns	
$\overline{\text{CAS}}$ to output in low-Z	$t_{\text{CLZ}}$	0	—	0	—	0	—	ns	
Output data hold time	$t_{\text{OH}}$	3	—	3	—	3	—	ns	22
Output data hold time from $\overline{\text{OE}}$	$t_{\text{OHO}}$	3	—	3	—	3	—	ns	
Output buffer turn-off time	$t_{\text{OFF}}$	—	13	—	15	—	15	ns	13, 22
Output buffer turn-off to $\overline{\text{OE}}$	$t_{\text{OEZ}}$	—	13	—	15	—	15	ns	13
$\overline{\text{CAS}}$ to Din delay time	$t_{\text{CDD}}$	13	—	15	—	18	—	ns	5
Output data hold time from $\overline{\text{RAS}}$	$t_{\text{OHR}}$	3	—	3	—	3	—	ns	22
Output buffer turn-off to $\overline{\text{RAS}}$	$t_{\text{OFR}}$	—	13	—	15	—	15	ns	22
Output buffer turn-off to $\overline{\text{WE}}$	$t_{\text{WEZ}}$	—	13	—	15	—	15	ns	
$\overline{\text{WE}}$ to Din delay time	$t_{\text{WED}}$	13	—	15	—	18	—	ns	
$\overline{\text{RAS}}$ to Din delay time	$t_{\text{RDD}}$	13	—	15	—	18	—	ns	
$\overline{\text{RAS}}$ next $\overline{\text{CAS}}$ delay time	$t_{\text{RNCD}}$	50	—	60	—	70	—	ns	

# HM51W16405 Series, HM51W17405 Series

## Write Cycle

		HM51W16405/HM51W17405							
		-5		-6		-7			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
Write command setup time	$t_{WCS}$	0	—	0	—	0	—	ns	14
Write command hold time	$t_{WCH}$	8	—	10	—	13	—	ns	
Write command pulse width	$t_{WP}$	8	—	10	—	10	—	ns	
Write command to $\overline{RAS}$ lead time	$t_{RWL}$	8	—	10	—	13	—	ns	
Write command to $\overline{CAS}$ lead time	$t_{CWL}$	8	—	10	—	13	—	ns	
Data-in setup time	$t_{DS}$	0	—	0	—	0	—	ns	15
Data-in hold time	$t_{DH}$	8	—	10	—	13	—	ns	15

## Read-Modify-Write Cycle

		HM51W16405/HM51W17405							
		-5		-6		-7			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
Read-modify-write cycle time	$t_{RWC}$	111	—	135	—	161	—	ns	
$\overline{RAS}$ to $\overline{WE}$ delay time	$t_{RWD}$	67	—	79	—	92	—	ns	14
$\overline{CAS}$ to $\overline{WE}$ delay time	$t_{CWD}$	30	—	34	—	40	—	ns	14
Column address to $\overline{WE}$ delay time	$t_{AWD}$	42	—	49	—	57	—	ns	14
$\overline{OE}$ hold time from $\overline{WE}$	$t_{OEh}$	13	—	15	—	18	—	ns	

## Refresh Cycle

		HM51W16405/HM51W17405							
		-5		-6		-7			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
$\overline{CAS}$ setup time (CBR refresh cycle)	$t_{CSR}$	5	—	5	—	5	—	ns	
$\overline{CAS}$ hold time (CBR refresh cycle)	$t_{CHR}$	8	—	10	—	10	—	ns	
$\overline{WE}$ setup time (CBR refresh cycle)	$t_{WRP}$	0	—	0	—	0	—	ns	
$\overline{WE}$ hold time (CBR refresh cycle)	$t_{WRH}$	8	—	10	—	10	—	ns	
$\overline{RAS}$ precharge to $\overline{CAS}$ hold time	$t_{RPC}$	5	—	5	—	5	—	ns	

# HM51W16405 Series, HM51W17405 Series

## EDO Page Mode Cycle

Parameter	Symbol	HM51W16405/HM51W17405						Unit	Notes
		-5		-6		-7			
		Min	Max	Min	Max	Min	Max		
EDO page mode cycle time	$t_{HPC}$	20	—	25	—	30	—	ns	21
EDO page mode $\overline{RAS}$ pulse width	$t_{RASP}$	—	100000	—	100000	—	100000	ns	16
Access time from $\overline{CAS}$ precharge	$t_{CPA}$	—	30	—	35	—	40	ns	9, 17, 20
$\overline{RAS}$ hold time from $\overline{CAS}$ precharge	$t_{CPRH}$	30	—	35	—	40	—	ns	
Output data hold time from $\overline{CAS}$ low	$t_{DOH}$	3	—	3	—	3	—	ns	9, 17
$\overline{CAS}$ hold time referred $\overline{OE}$	$t_{COL}$	8	—	10	—	13	—	ns	
$\overline{CAS}$ to $\overline{OE}$ setup time	$t_{COP}$	5	—	5	—	5	—	ns	
Read command hold time from $\overline{CAS}$ precharge	$t_{RCHC}$	30	—	35	—	40	—	ns	

## EDO Page Mode Read-Modify-Write Cycle

Parameter	Symbol	HM51W16405/HM51W17405						Unit	Notes
		-5		-6		-7			
		Min	Max	Min	Max	Min	Max		
EDO page mode read- modify-write cycle time	$t_{HPRWC}$	57	—	68	—	79	—	ns	
$\overline{WE}$ delay time from $\overline{CAS}$ precharge	$t_{CPW}$	45	—	54	—	62	—	ns	14

## Test Mode Cycle \*19

Parameter	Symbol	HM51W16405/HM51W17405						Unit	Notes
		-5		-6		-7			
		Min	Max	Min	Max	Min	Max		
Test mode $\overline{WE}$ setup time	$t_{WTS}$	0	—	0	—	0	—	ns	
Test mode $\overline{WE}$ hold time	$t_{WTH}$	8	—	10	—	10	—	ns	

## Refresh (HM51W16405 Series)

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

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# HM51W16405 Series, HM51W17405 Series

## Refresh (HM51W17405 Series)

Parameter	Symbol	Max	Unit	Notes
Refresh period	$t_{REF}$	32	ms	2048 cycles
Refresh period (L-version)	$t_{REF}$	128	ms	2048 cycles

## Self Refresh Mode (L-version)

Parameter	Symbol	HM51W16405L/HM51W17405L						Unit	Notes
		-5		-6		-7			
		Min	Max	Min	Max	Min	Max		
$\overline{RAS}$ pulse width (self refresh)	$t_{RASS}$	100	—	100	—	100	—	$\mu s$	
$\overline{RAS}$ precharge time (self refresh)	$t_{RPS}$	90	—	110	—	130	—	ns	
$\overline{CAS}$ hold time (self refresh)	$t_{CHS}$	-50	—	-50	—	-50	—	ns	

Notes: 1. AC measurements assume  $t_T = 2$  ns.

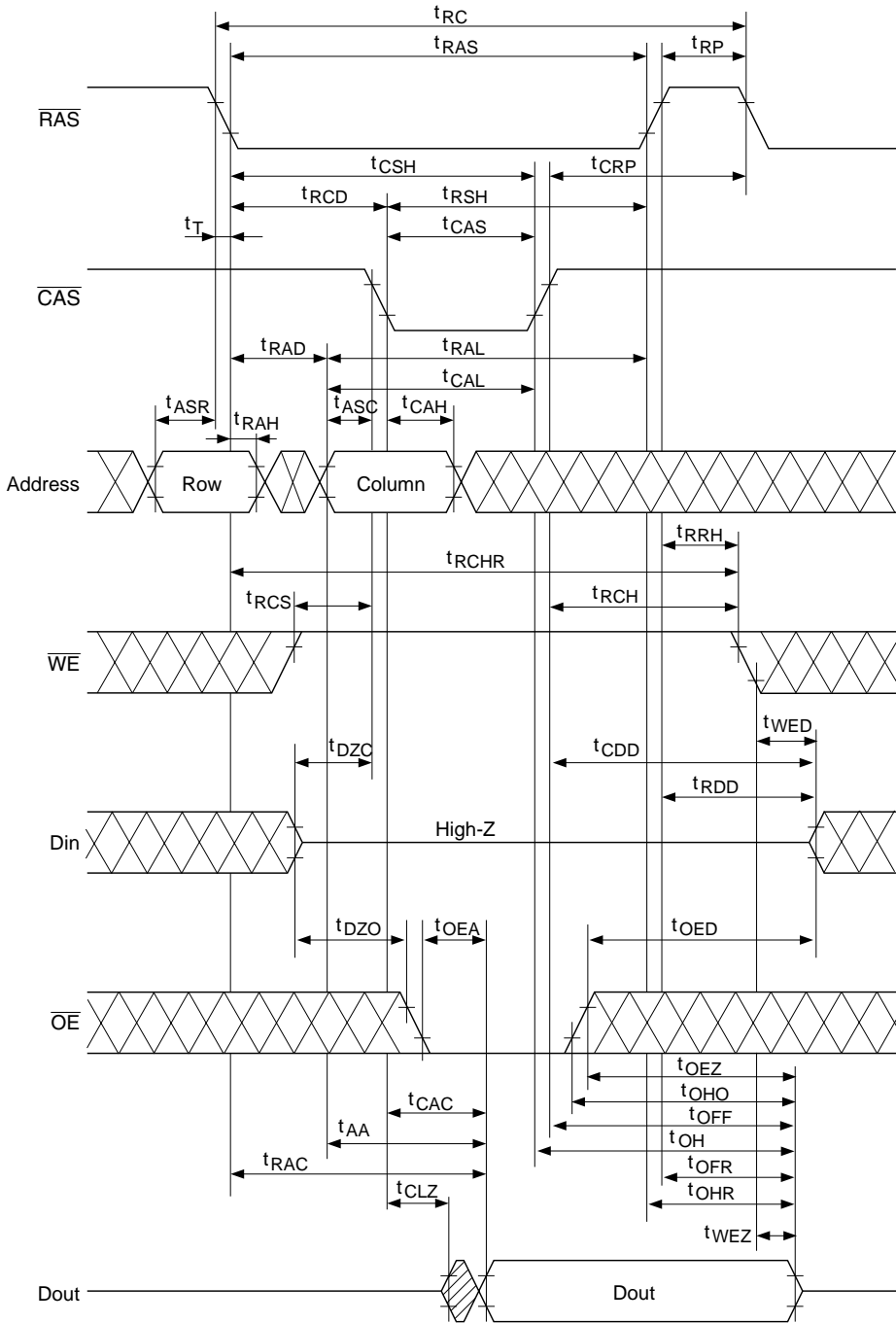
2. An initial pause of 200  $\mu s$  is required after power up followed by a minimum of eight initialization cycles (any combination of cycles containing  $\overline{RAS}$ -only refresh or  $\overline{CAS}$ -before- $\overline{RAS}$  refresh). If the internal refresh counter is used, a minimum of eight  $\overline{CAS}$ -before- $\overline{RAS}$  refresh cycles are required.
3. 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  $t_{CAC}$ .
4. 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  $t_{OED}$  or  $t_{CDD}$  must be satisfied.
6. Either  $t_{DZO}$  or  $t_{DZC}$  must be satisfied.
7.  $V_{IH}$  (min) and  $V_{IL}$  (max) are reference levels for measuring timing of input signals. Also, transition times are measured between  $V_{IH}$  (min) and  $V_{IL}$  (max).
8. 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.
9. Measured with a load circuit equivalent to 1 TTL loads and 100 pF.
10. Assumes that  $t_{RCD} \geq t_{RCD}$  (max) and  $t_{RCD} + t_{CAC}$  (max)  $\geq t_{RAD} + t_{AA}$  (max).
11. Assumes that  $t_{RAD} \geq t_{RAD}$  (max) and  $t_{RCD} + t_{CAC}$  (max)  $\leq t_{RAD} + t_{AA}$  (max).
12. Either  $t_{RCH}$  or  $t_{RRH}$  must be satisfied for a read cycles.
13.  $t_{OFF}$  (max) and  $t_{OEZ}$  (max) define the time at which the outputs achieve the open circuit condition and are not referred to output voltage levels.
14.  $t_{WCS}$ ,  $t_{RWD}$ ,  $t_{CWD}$ ,  $t_{AWD}$  and  $t_{CPW}$  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), and  $t_{AWD} \geq t_{AWD}$  (min), or  $t_{CWD} \geq t_{CWD}$  (min),  $t_{AWD} \geq t_{AWD}$  (min) and  $t_{CPW} \geq t_{CPW}$  (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. These parameters 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 EDO 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 device.
19. The 16M DRAM offers a 16-bit time saving parallel test mode. Address CA0 and CA1 for the 4M  $\times$ 4 are don't care during test mode. Test mode is set by performing a  $\overline{\text{WE}}$ -and- $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  (WCBR) cycle. In 16-bit parallel test mode, data is written into 4 bits in parallel at each I/O (I/O1 to I/O4) and read out from each I/O.  
If 4 bits of each I/O are equal (all 1s or 0s), data output pin is a high state during test mode read cycle, then the device has passed. If they are not equal, data output pin is a low state, then the device has failed.  
Refresh during test mode operation can be performed by normal read cycles or by WCBR refresh cycles.  
To get out of test mode and enter a normal operation mode, perform either a regular  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh cycle or  $\overline{\text{RAS}}$ -only refresh cycle.
20. In a test mode read cycle, the value of  $t_{\text{RAC}}$ ,  $t_{\text{AA}}$ ,  $t_{\text{CAC}}$  and  $t_{\text{CPA}}$  is delayed by 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.
21.  $t_{\text{HPC}}$  (min) can be achieved during a series of EDO page mode write cycles or EDO page mode read cycles. If both write and read operation are mixed in a EDO page mode  $\overline{\text{RAS}}$  cycle (EDO page mode mix cycle (1), (2)), minimum value of  $\overline{\text{CAS}}$  cycle ( $t_{\text{CAS}} + t_{\text{CP}} + 2 t_r$ ) becomes greater than the specified  $t_{\text{HPC}}$  (min) value. The value of  $\overline{\text{CAS}}$  cycle time of mixed EDO page mode is shown in EDO page mode mix cycle (1) and (2).
22. Data output turns off and becomes high impedance from later rising edge of  $\overline{\text{RAS}}$  and  $\overline{\text{CAS}}$ . Hold time and turn off time are specified by the timing specifications of later rising edge of  $\overline{\text{RAS}}$  and  $\overline{\text{CAS}}$  between  $t_{\text{OHR}}$  and  $t_{\text{OH}}$ , and between  $t_{\text{OFR}}$  and  $t_{\text{OFF}}$ .
23. Please do not use  $t_{\text{RASS}}$  timing,  $10 \mu\text{s} \leq t_{\text{RASS}} \leq 100 \mu\text{s}$ . During this period, the device is in transition state from normal operation mode to self refresh mode. If  $t_{\text{RASS}} > 100 \mu\text{s}$ , then  $\overline{\text{RAS}}$  precharge time should use  $t_{\text{RPS}}$  instead of  $t_{\text{RP}}$ .
24. If you use distributed CBR refresh mode with 15.6  $\mu\text{s}$  interval in normal read/write cycle, CBR refresh should be executed within 15.6  $\mu\text{s}$  immediately after exiting from and before entering into self refresh mode.
25. If you use  $\overline{\text{RAS}}$  only refresh or CBR burst refresh mode in normal read/write cycle, 4096 or 2048 cycles (4096 cycles: HM51W16405 Series, 2048 cycles: HM51W17405 Series) of distributed CBR refresh with 15.6  $\mu\text{s}$  interval should be executed within 64 or 32 ms (64 ms: HM51W16405 Series, 32 ms: HM51W17405 Series) immediately after exiting from and before entering into the self refresh mode.
26. Repetitive self refresh mode without refreshing all memory is not allowed. Once you exit from self refresh mode, all memory cells need to be refreshed before re-entering the self refresh mode again.
27. 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  $V_{\text{IL}}$ .

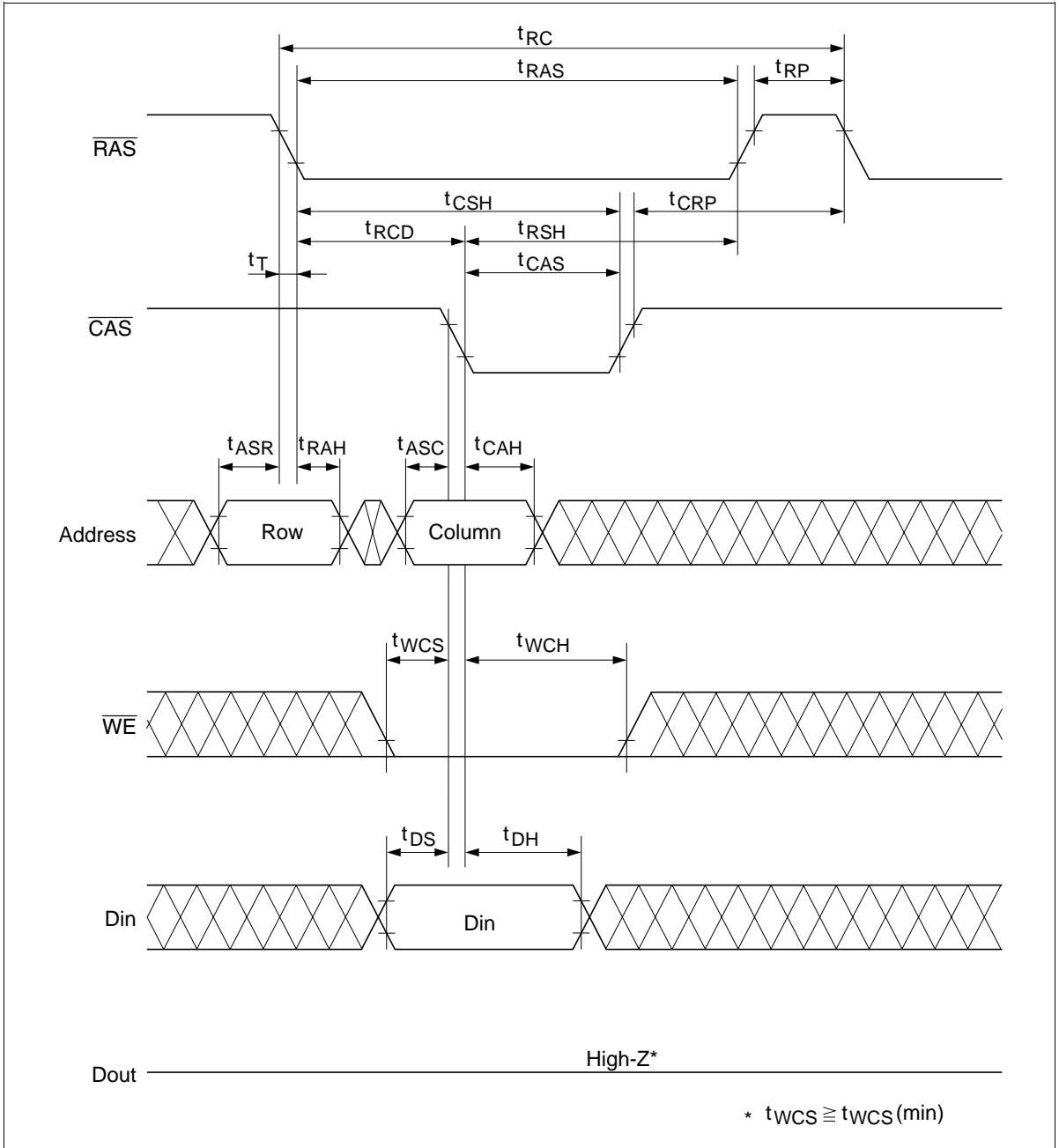


Timing Waveforms\*27

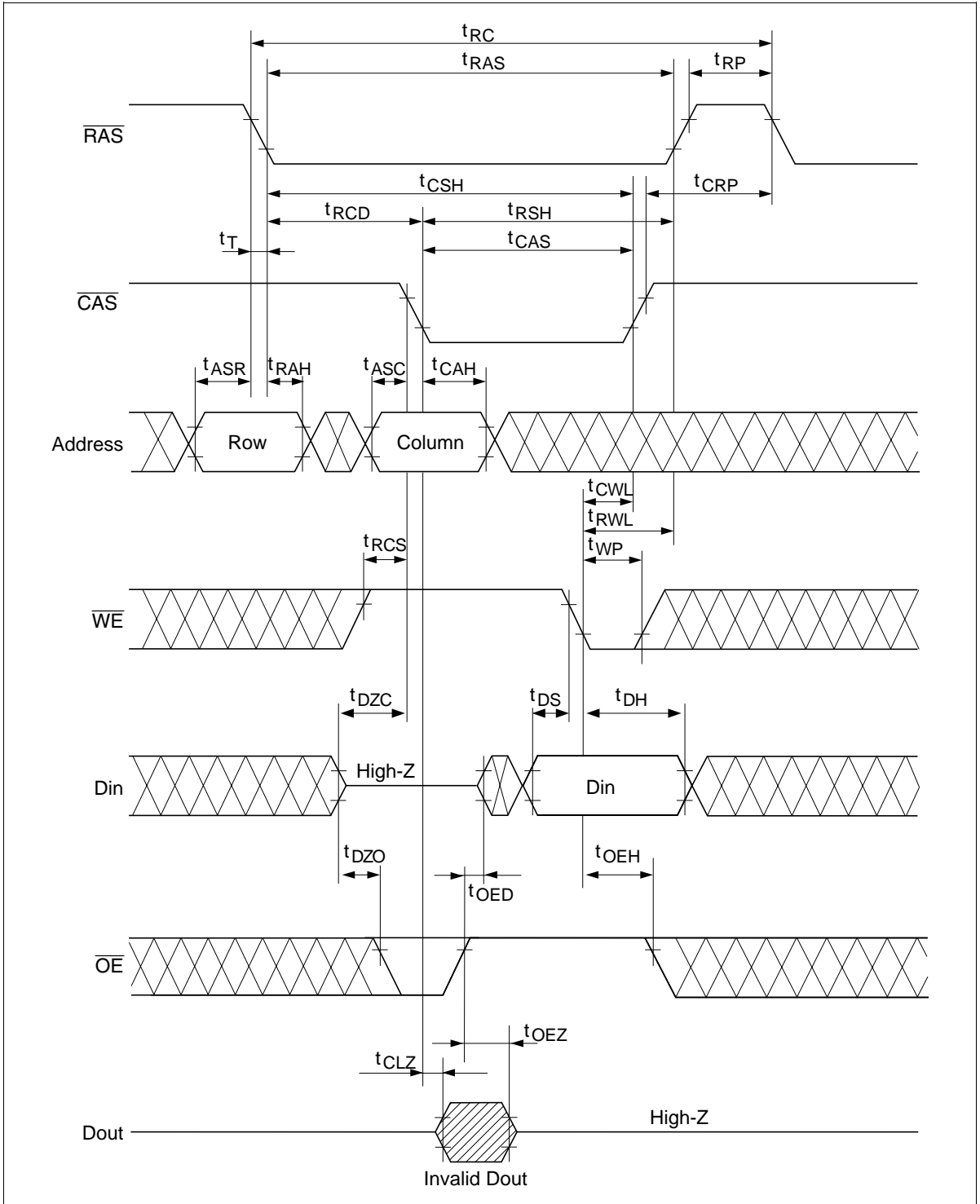
Read Cycle



Early Write Cycle

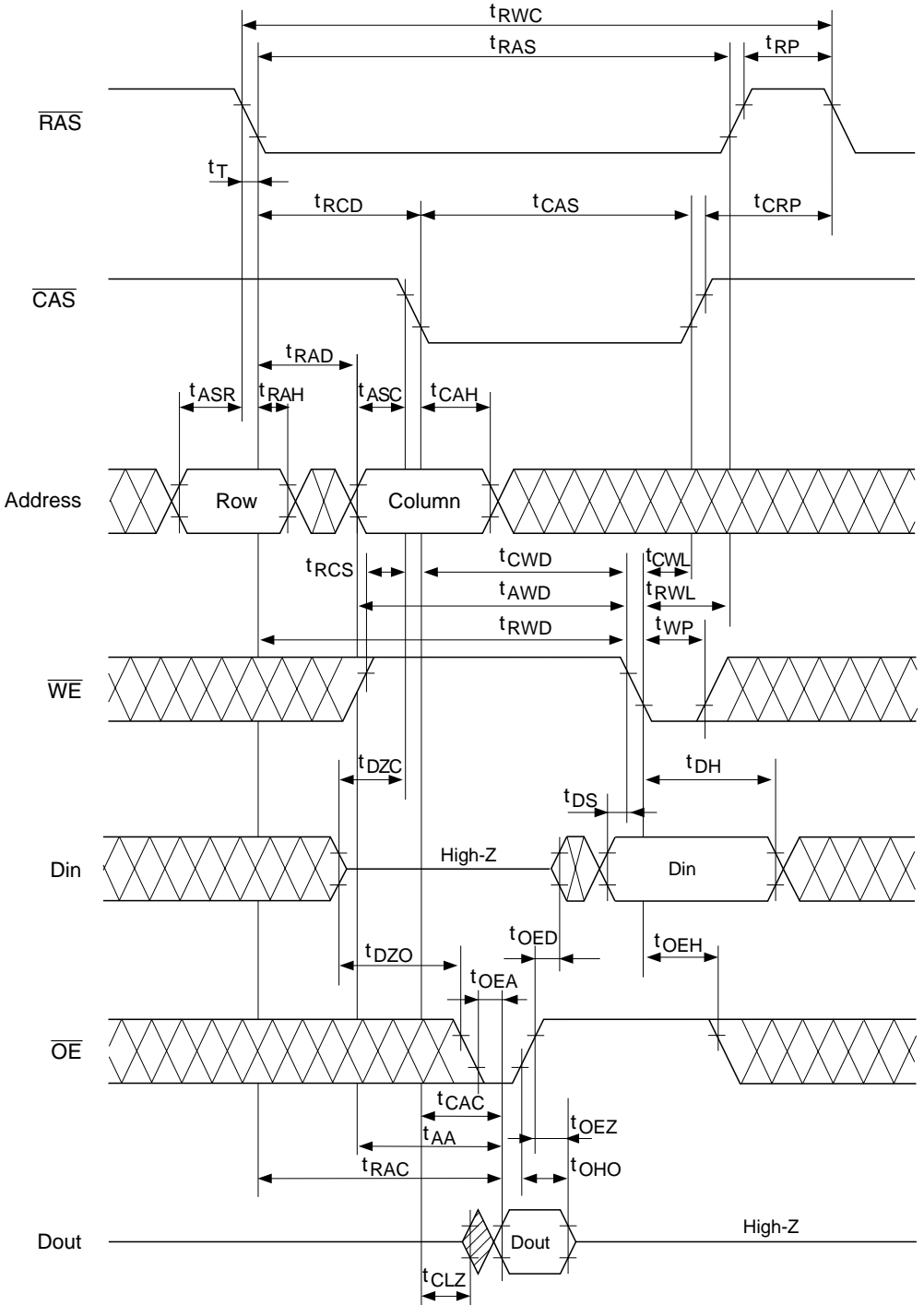


Delayed Write Cycle\*18



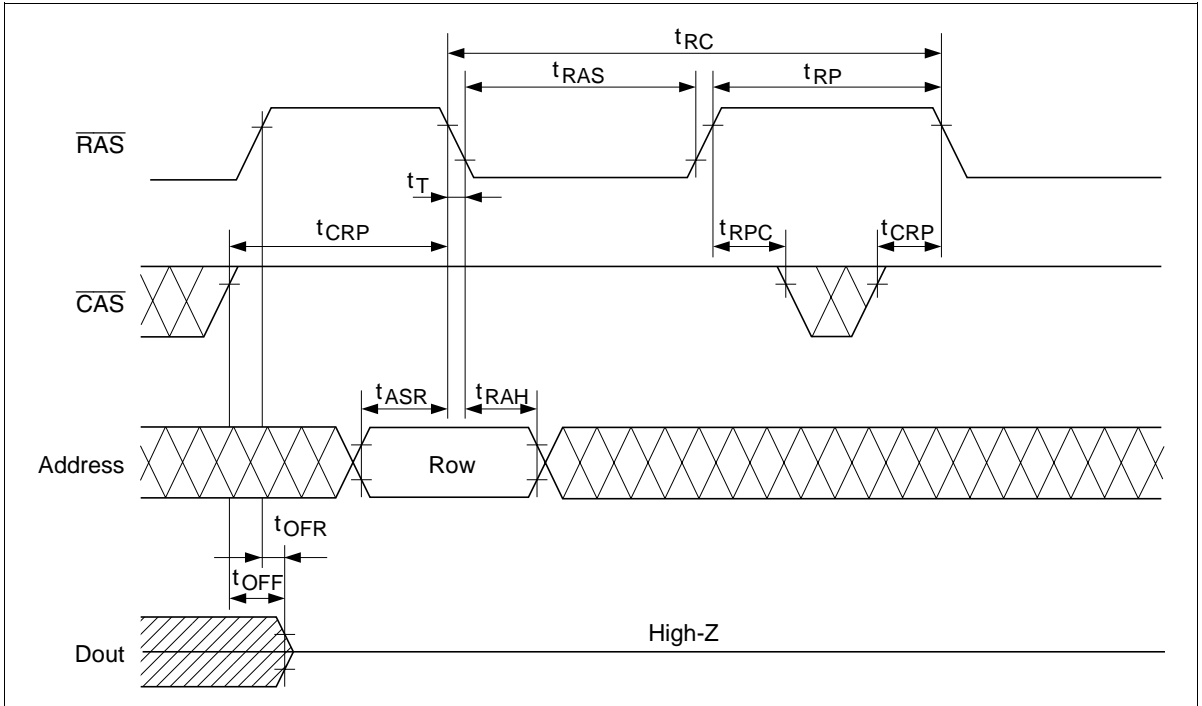
# HM51W16405 Series, HM51W17405 Series

## Read-Modify-Write Cycle \*18



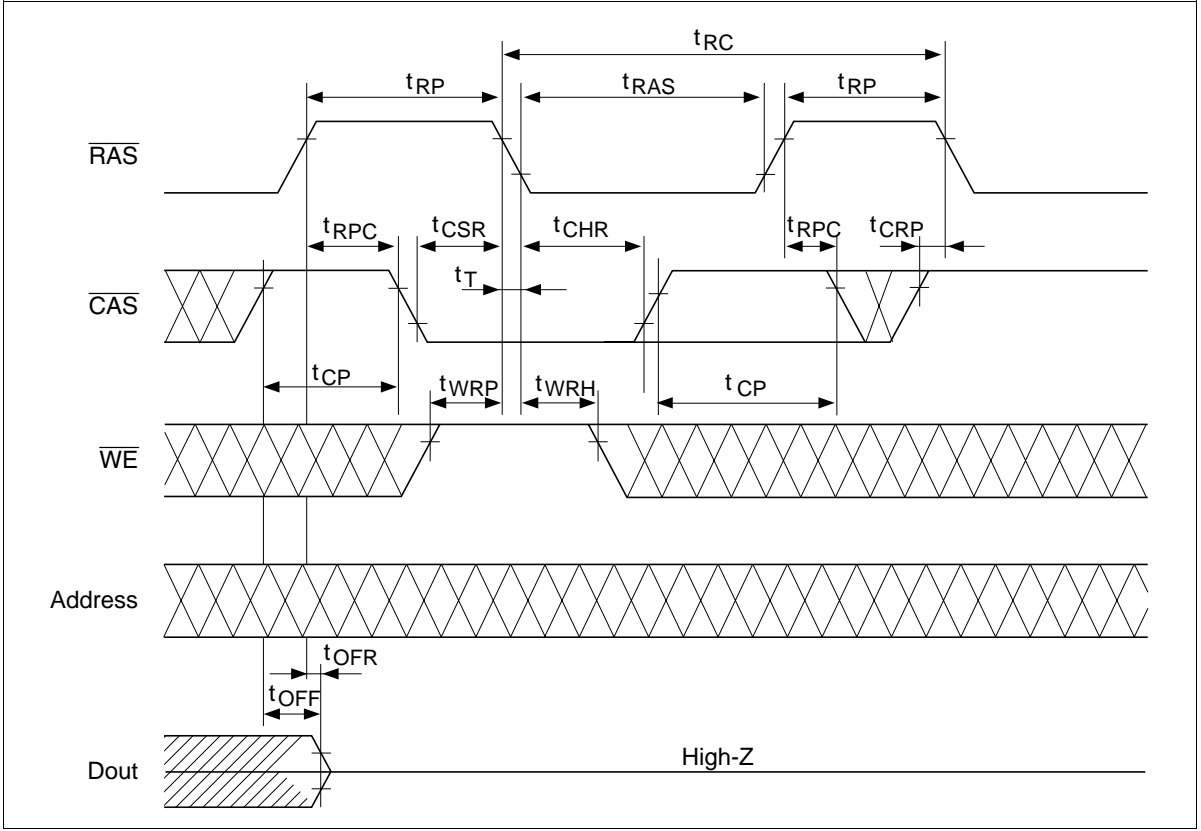
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$\overline{\text{RAS}}$ -Only Refresh Cycle

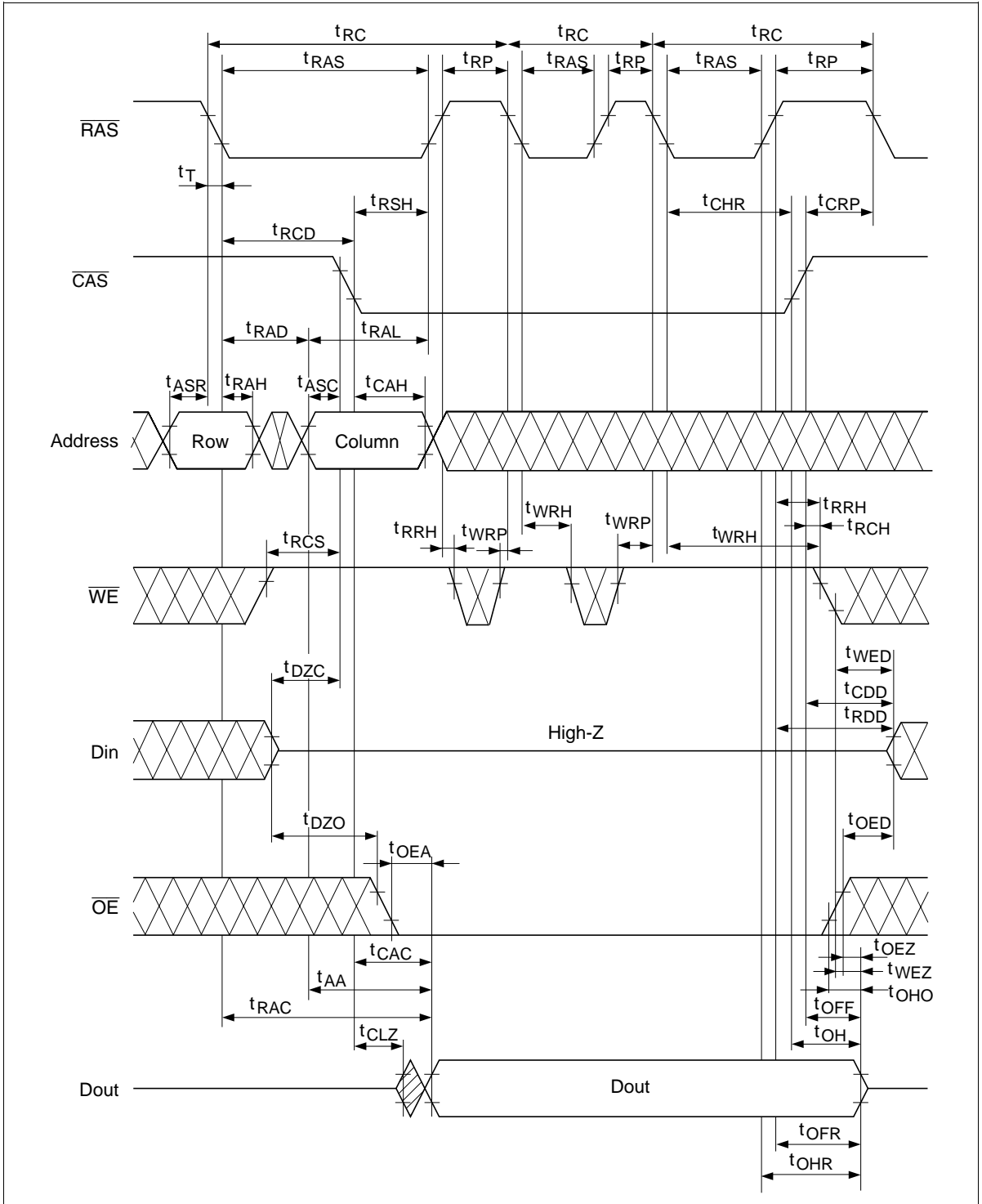


# HM51W16405 Series, HM51W17405 Series

## CAS-Before-RAS Refresh Cycle

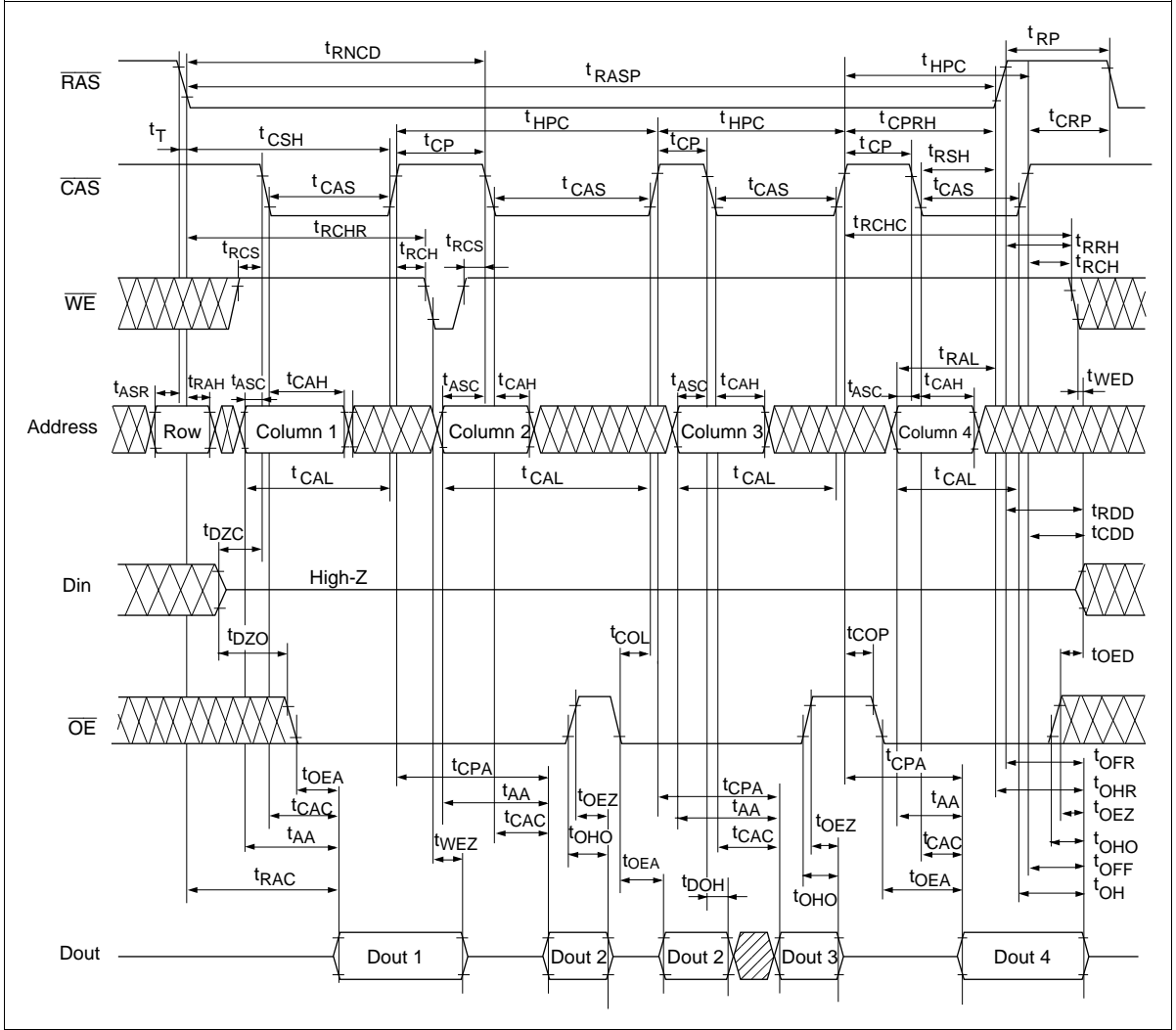


## Hidden Refresh Cycle



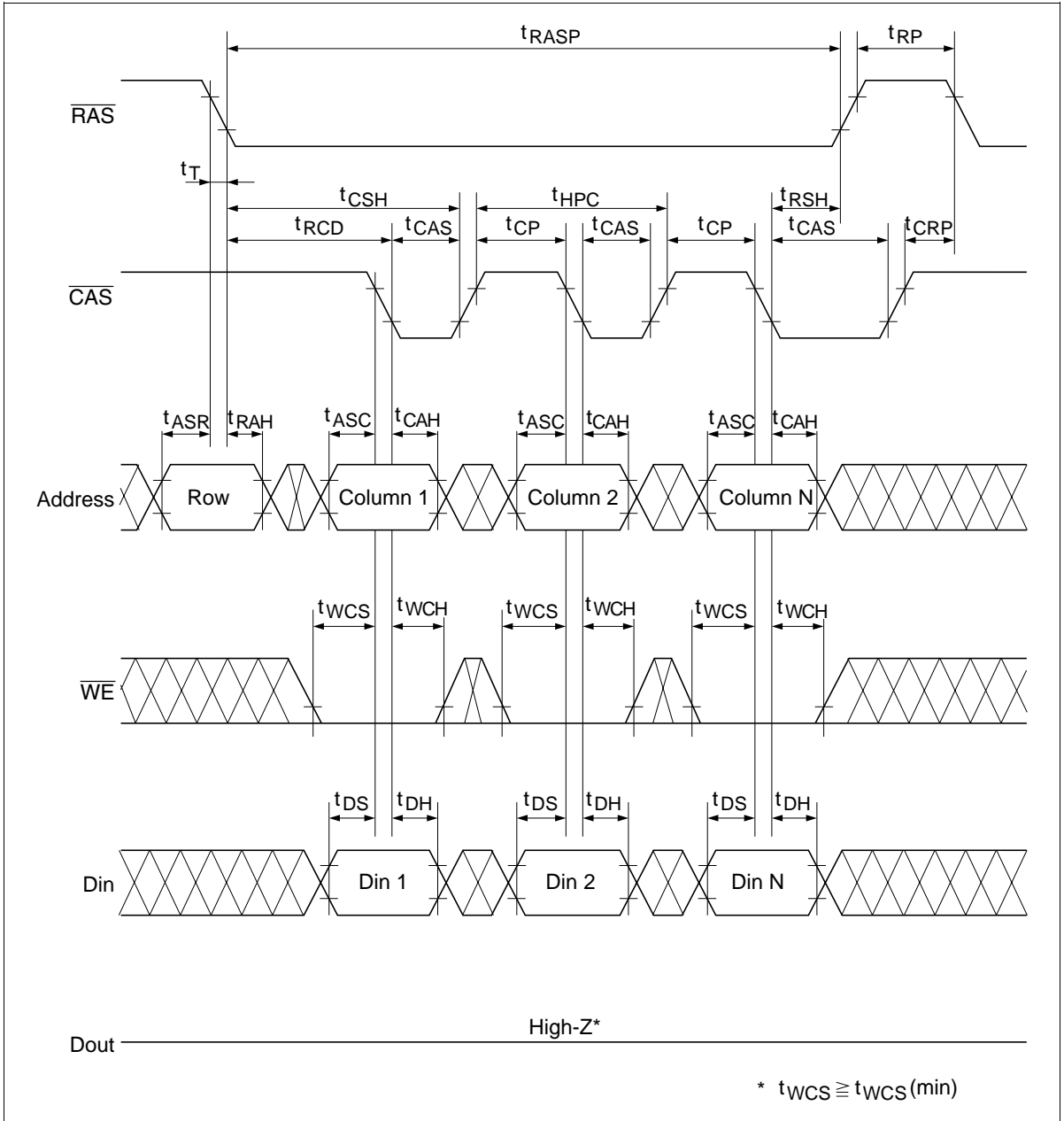
# HM51W16405 Series, HM51W17405 Series

## EDO Page Mode Read Cycle



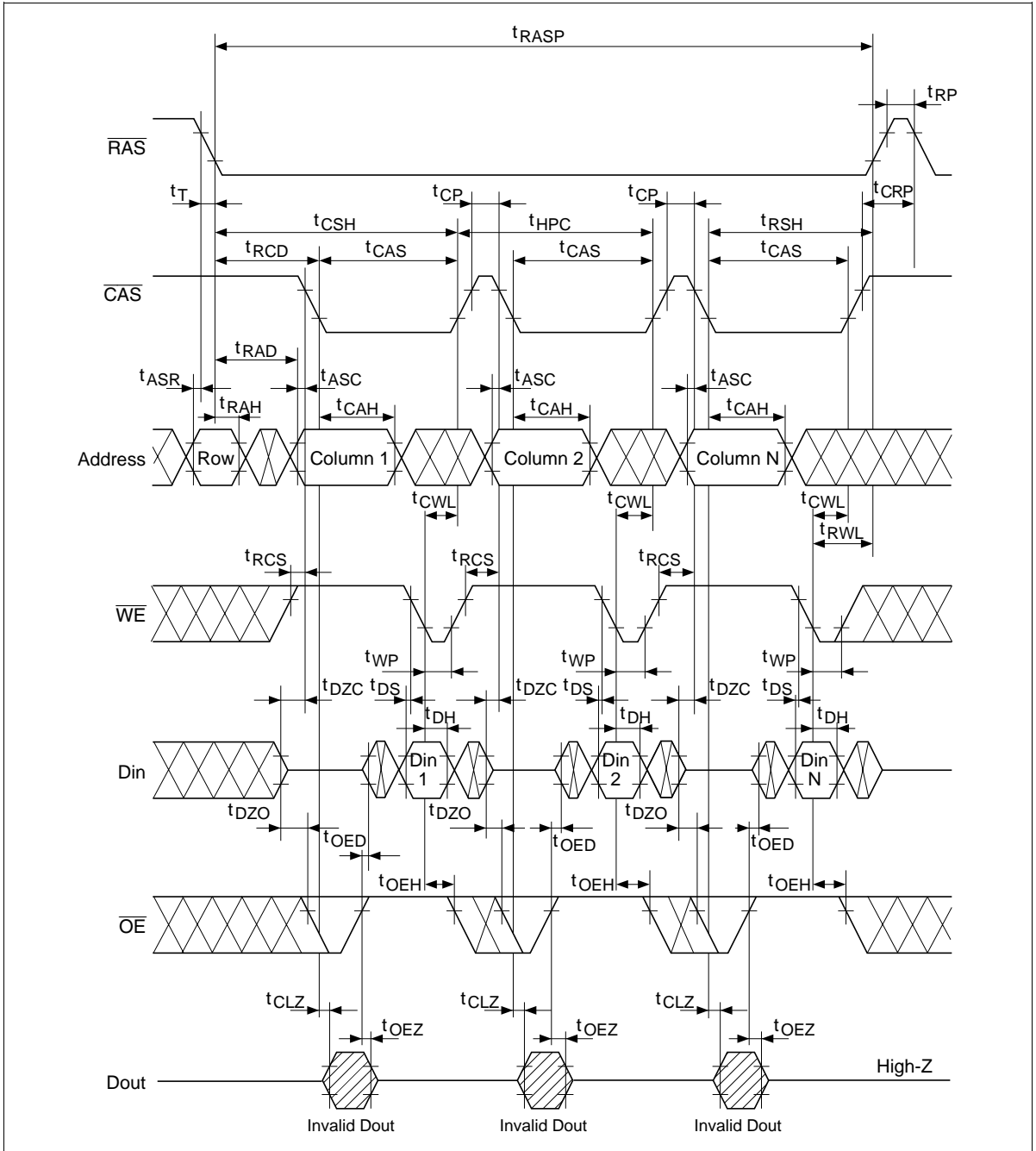


EDO Page Mode Early Write Cycle



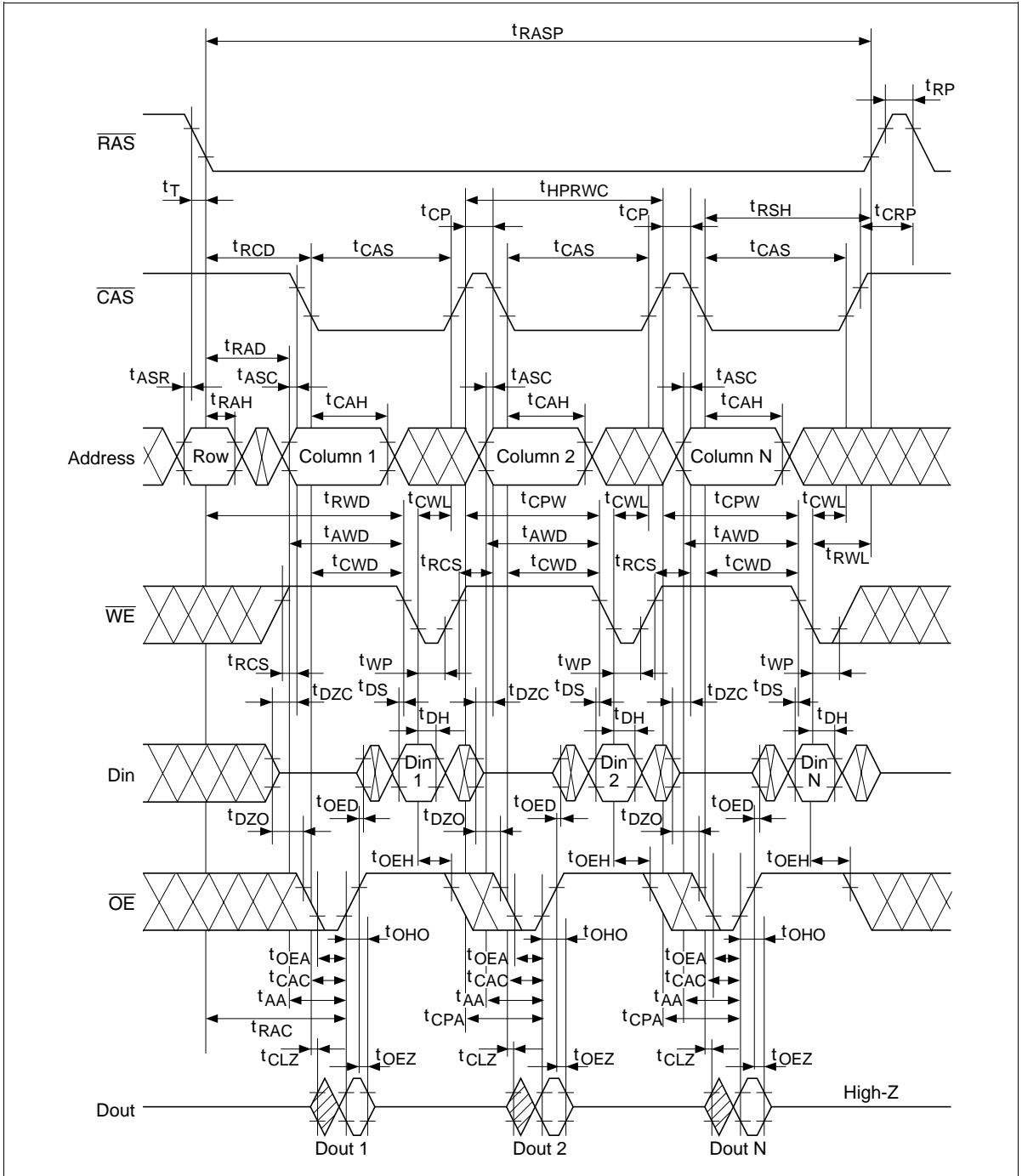
# HM51W16405 Series, HM51W17405 Series

## EDO Page Mode Delayed Write Cycle \*18



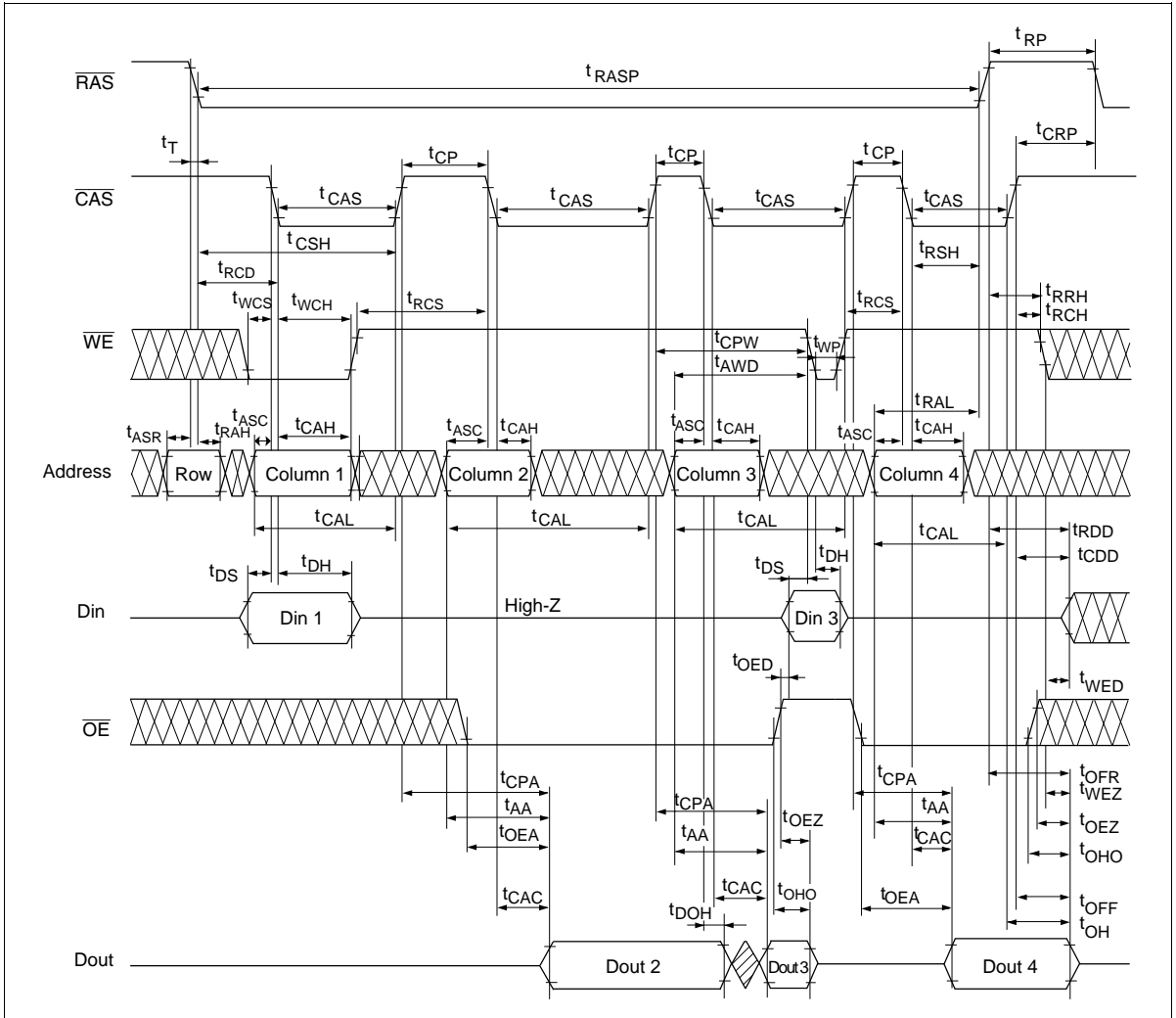
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## EDO Page Mode Read-Modify-Write Cycle \*18

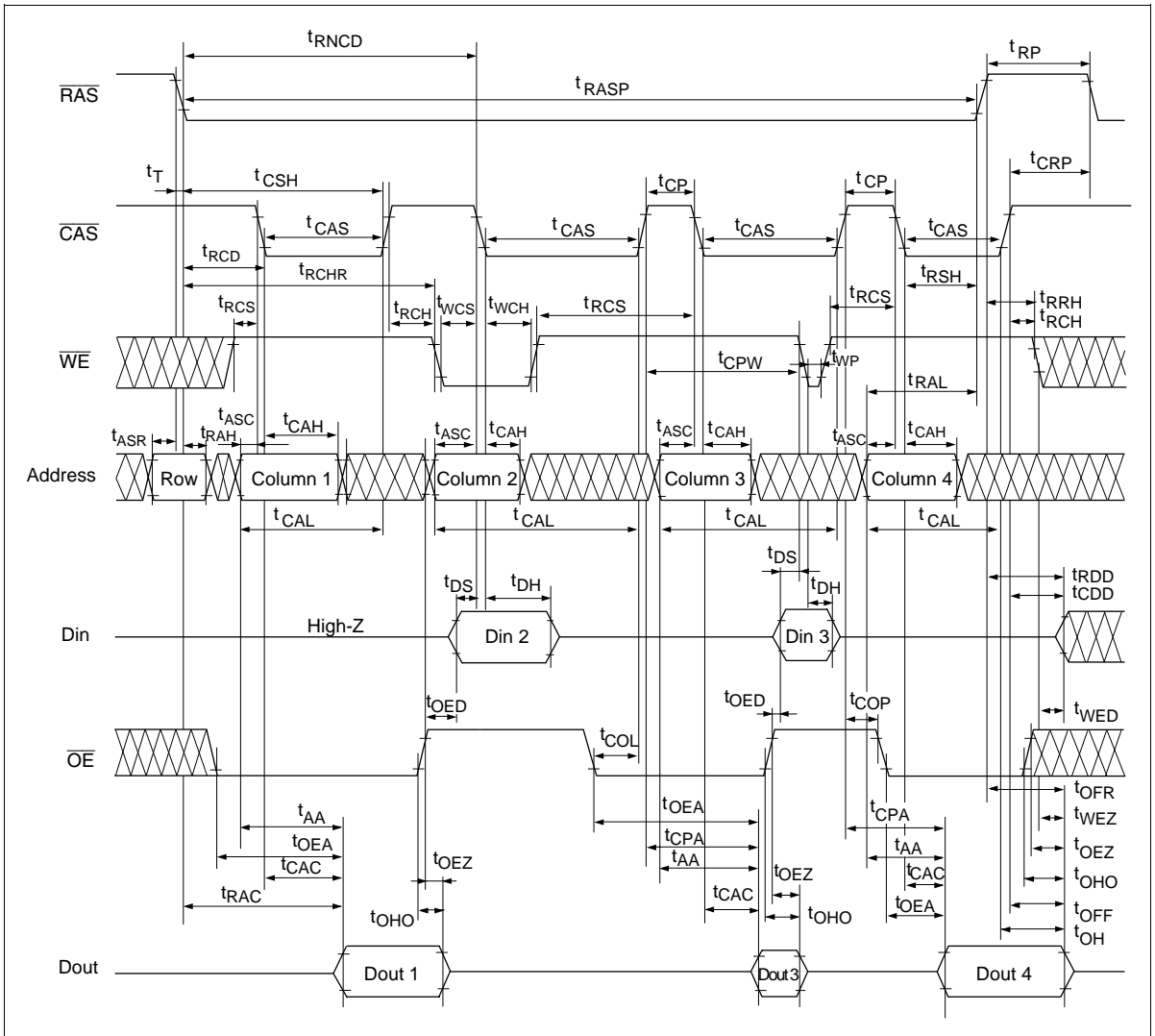


# HM51W16405 Series, HM51W17405 Series

## EDO Page Mode Mix Cycle (1)

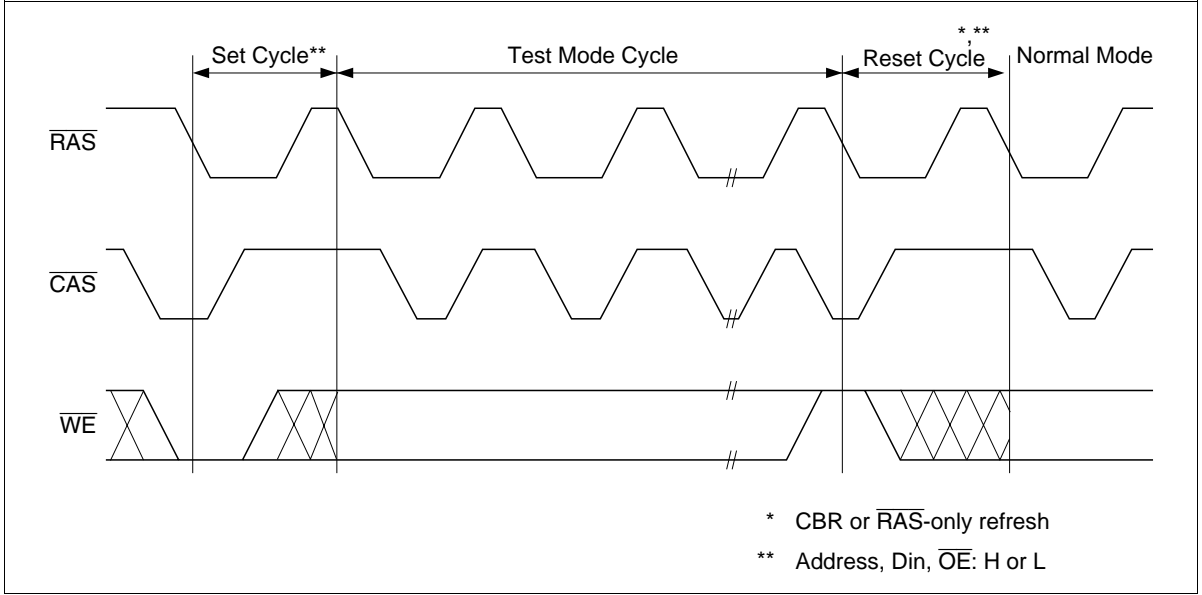


EDO Page Mode Mix Cycle (2)

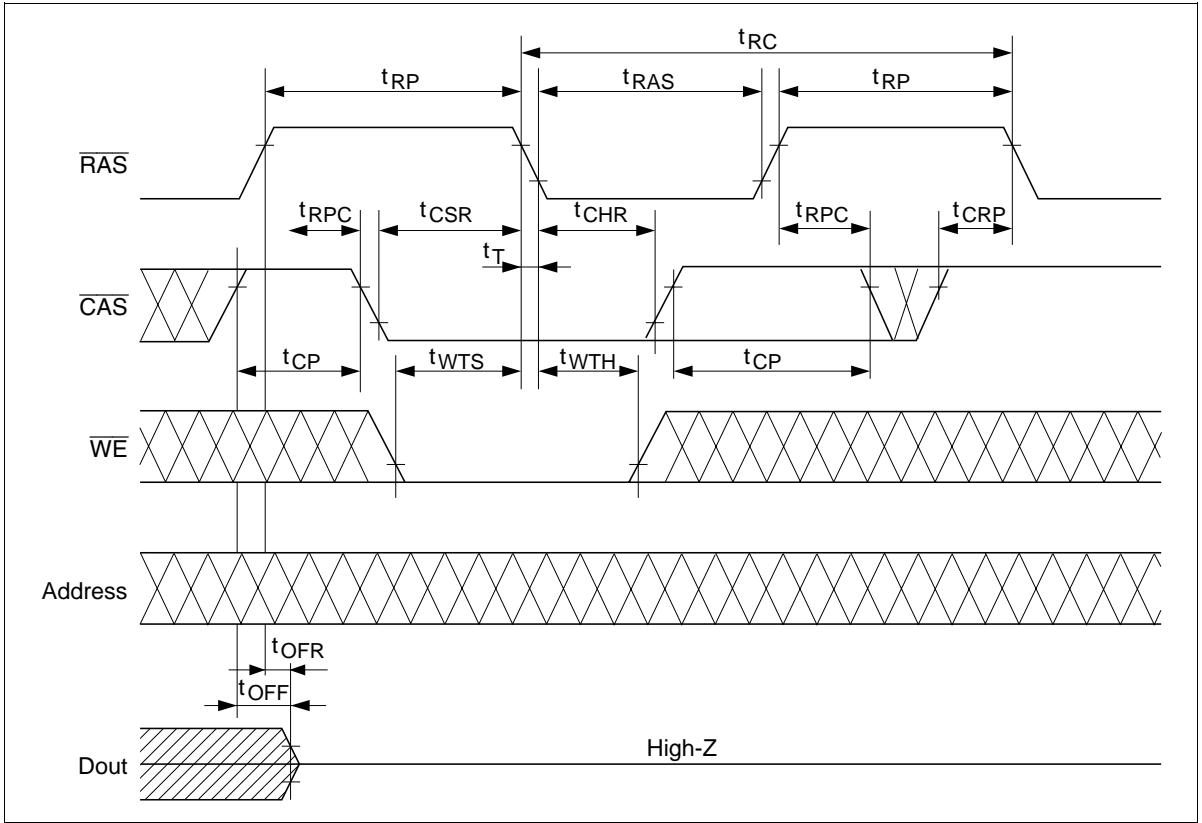


# HM51W16405 Series, HM51W17405 Series

## Test Mode Cycle \*<sup>19</sup>

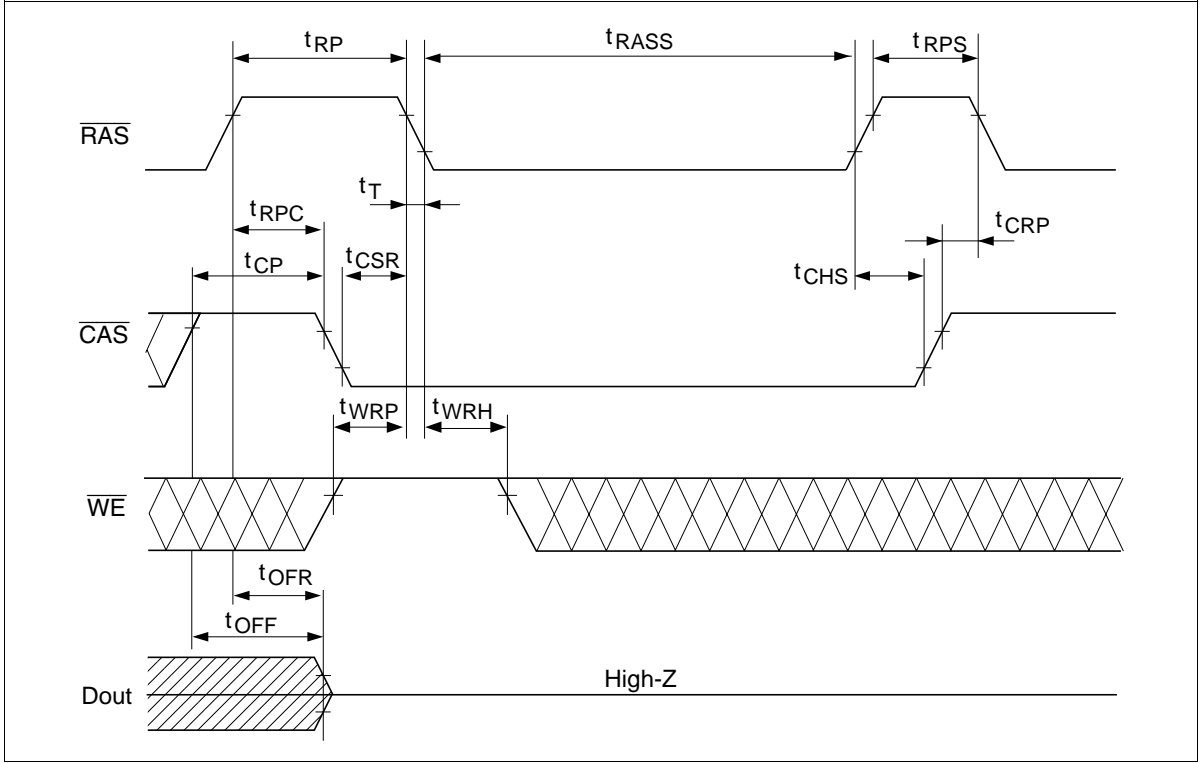


Test Mode Set Cycle



# HM51W16405 Series, HM51W17405 Series

Self Refresh Cycle (L-version)\*<sup>23</sup>, \*<sup>24</sup>, \*<sup>25</sup>, \*<sup>26</sup>



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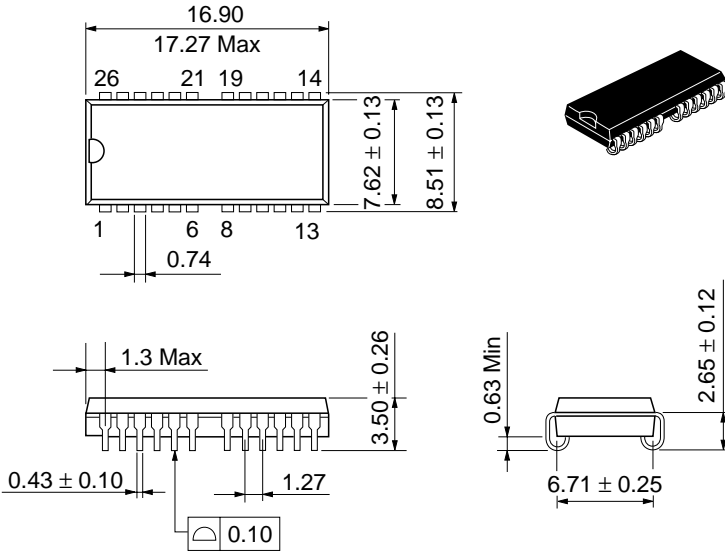


## Package Dimensions

HM51W16405S/LS Series

HM51W17405S/LS Series (CP-26/24DB)

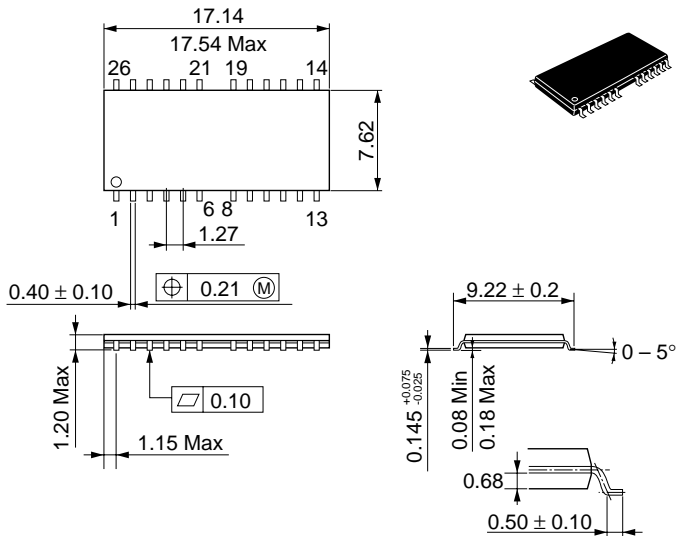
Unit: mm



HM51W16405TS/LTS Series

HM51W17405TS/LTS Series (TTP-26/24DA)

Unit: mm



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# HITACHI

## Hitachi, Ltd.

Semiconductor & IC Div.  
Nippon Bldg., 2-6-2, Ohte-machi, Chiyoda-ku, Tokyo 100, Japan  
Tel: Tokyo (03) 3270-2111  
Fax: (03) 3270-5109

### For further information write to:

Hitachi America, Ltd.  
Semiconductor & IC Div.  
2000 Sierra Point Parkway  
Brisbane, CA. 94005-1835  
U S A  
Tel: 415-589-8300  
Fax: 415-583-4207

Hitachi Europe GmbH  
Electronic Components Group  
Continental Europe  
Dornacher Straße 3  
D-85622 Feldkirchen  
München  
Tel: 089-9 91 80-0  
Fax: 089-9 29 30 00

Hitachi Europe Ltd.  
Electronic Components Div.  
Northern Europe Headquarters  
Whitebrook Park  
Lower Cookham Road  
Maidenhead  
Berkshire SL6 8YA  
United Kingdom  
Tel: 0628-585000  
Fax: 0628-778322

Hitachi Asia Pte. Ltd.  
16 Collyer Quay #20-00  
Hitachi Tower  
Singapore 0104  
Tel: 535-2100  
Fax: 535-1533

Hitachi Asia (Hong Kong) Ltd.  
Unit 706, North Tower,  
World Finance Centre,  
Harbour City, Canton Road  
Tsim Sha Tsui, Kowloon  
Hong Kong  
Tel: 27359218  
Fax: 27306071

## Revision Record

Rev.	Date	Contents of Modification	Drawn by	Approved by
1.0	Oct. 14, 1996	Initial issue	Y. Kasama	M. Mishima
2.0	Nov. 4, 1996	Addition of HM51W16405-5 Series Addition of HM51W17405-5 Series Power dissipation (active) 360/324 mW(max) to 324/288/252 mW (max) (HM51W16405 Series) 396/360 mW(max) to 360/324/288 mW (max) (HM51W17405 Series) DC Characteristics (HM51W16405 Series) I <sub>CC7</sub> max:100/90 mA to 80/70/65 mA DC Characteristics (HM51W17405 Series) I <sub>CC1</sub> max: 110/100 mA to 100/90/80 mA I <sub>CC3</sub> max: 110/100 mA to 100/90/80 mA I <sub>CC6</sub> max: 110/100 mA to 100/90/80 mA I <sub>CC7</sub> max: 110/100 mA to 90/80/75 mA AC Characteristics t <sub>RCD</sub> min: 20/20 ns to 12/14/14 ns t <sub>RAD</sub> min: 15/15 ns to 10/12/12 ns t <sub>RSH</sub> min: 15/18 ns to 10/13/13 ns t <sub>RRH</sub> min: 0/0 ns to 5/5/5 ns t <sub>RWC</sub> min: 149/175 ns to 111/135/161 ns t <sub>RWD</sub> min: 82/95 ns to 67/79/92 ns t <sub>CWD</sub> min: 37/43 ns to 30/34/40 ns t <sub>AWD</sub> min: 52/60 ns to 42/49/57 ns t <sub>RPC</sub> min: 0/0 ns to 5/5/5 ns t <sub>HPRWC</sub> min: 79/90 ns to 57/68/79 ns Timing Waveforms Addition of t <sub>RNCD</sub> timing to EDO page mode mix cycle (2)	Y. Kasama	Y. Matsuno
3.0	Feb. 27, 1997	AC Characteristics t <sub>RRH</sub> min: 5/5/5 ns to 0/0/0 ns		