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# HM5116160 Series

# HM5118160 Series

16 M FP DRAM (1-Mword × 16-bit)  
4 k Refresh/1 k Refresh

# HITACHI

ADE-203-634E (Z)  
Rev. 5.0  
Nov. 1997

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## Description

The Hitachi HM5116160 Series, HM5118160 Series are CMOS dynamic RAMs organized as 1,048,576-word × 16-bit. They employ the most advanced CMOS technology for high performance and low power. The HM5116160 Series, HM5118160 Series offer Fast Page Mode as a high speed access mode. They have package variations of 42-pin plastic SOJ and 50-pin plastic TSOP II.

## Features

- Single 5 V ( $\pm 10\%$ )
- Access time: 60 ns/70 ns (max)
- Power dissipation
  - Active mode : 550 mW/495 mW (max) (HM5116160 Series)  
935 mW/825 mW (max) (HM5118160 Series)
  - Standby mode : 11 mW (max)  
:0.83 mW (max) (L-version)
- Fast page mode capability
- Refresh cycles
  - 4096 refresh cycles : 64 ms (HM5116160 Series)  
: 128 ms (L-version)
  - 1024 refresh cycles : 16 ms (HM5118160 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)
- $2\overline{\text{CAS}}$ -byte control
- Battery backup operation (L-version)

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## HM5116160 Series, HM5118160 Series

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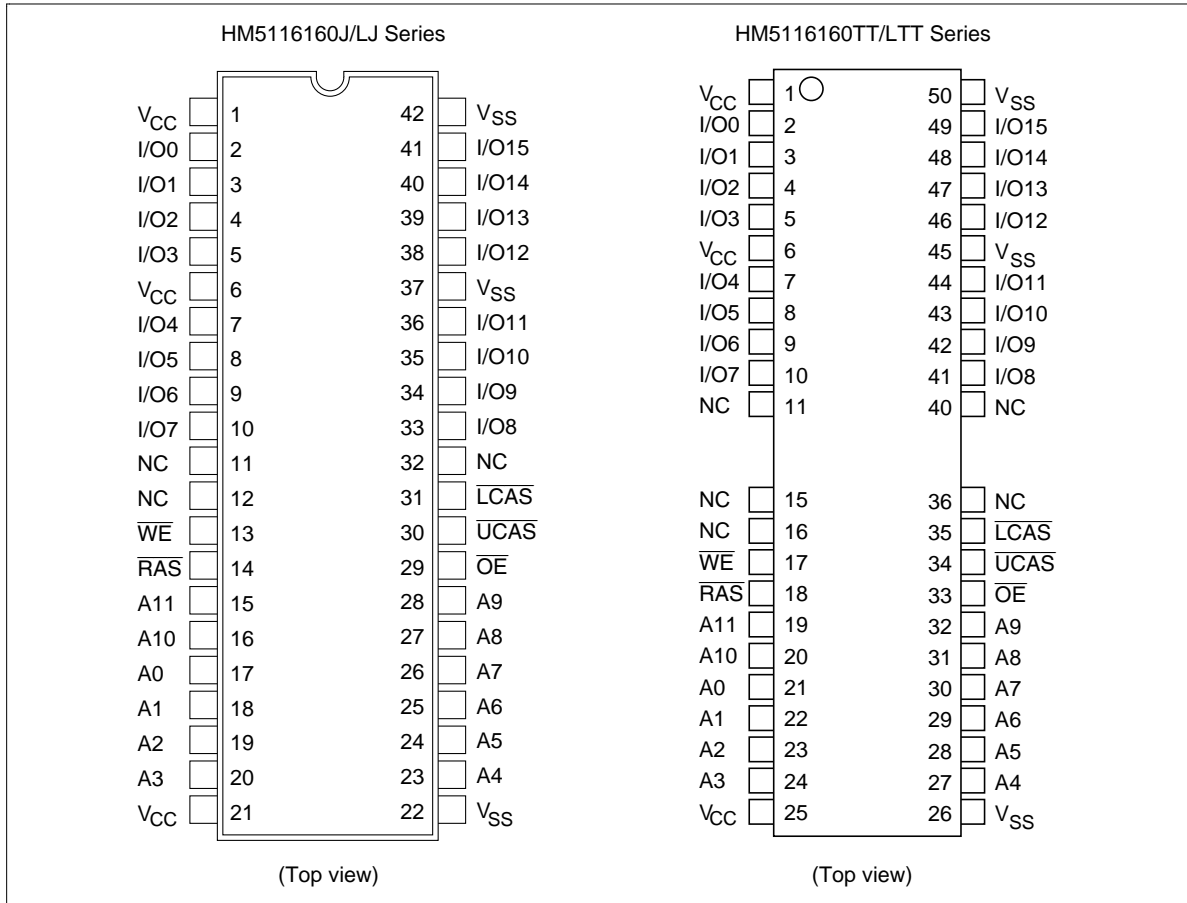
### Ordering Information

Type No.	Access time	Package
HM5116160J-6	60 ns	400-mil 42-pin plastic SOJ (CP-42D)
HM5116160J-7	70 ns	
HM5116160LJ-6	60 ns	
HM5116160LJ-7	70 ns	
HM5118160J-6	60 ns	
HM5118160J-7	70 ns	
HM5118160LJ-6	60 ns	
HM5118160LJ-7	70 ns	
HM5116160TT-6	60 ns	400-mil 50-pin plastic TSOP II (TTP-50/44DC)
HM5116160TT-7	70 ns	
HM5116160LTT-6	60 ns	
HM5116160LTT-7	70 ns	
HM5118160TT-6	60 ns	
HM5118160TT-7	70 ns	
HM5118160LTT-6	60 ns	
HM5118160LTT-7	70 ns	

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# HM5116160 Series, HM5118160 Series

## Pin Arrangement

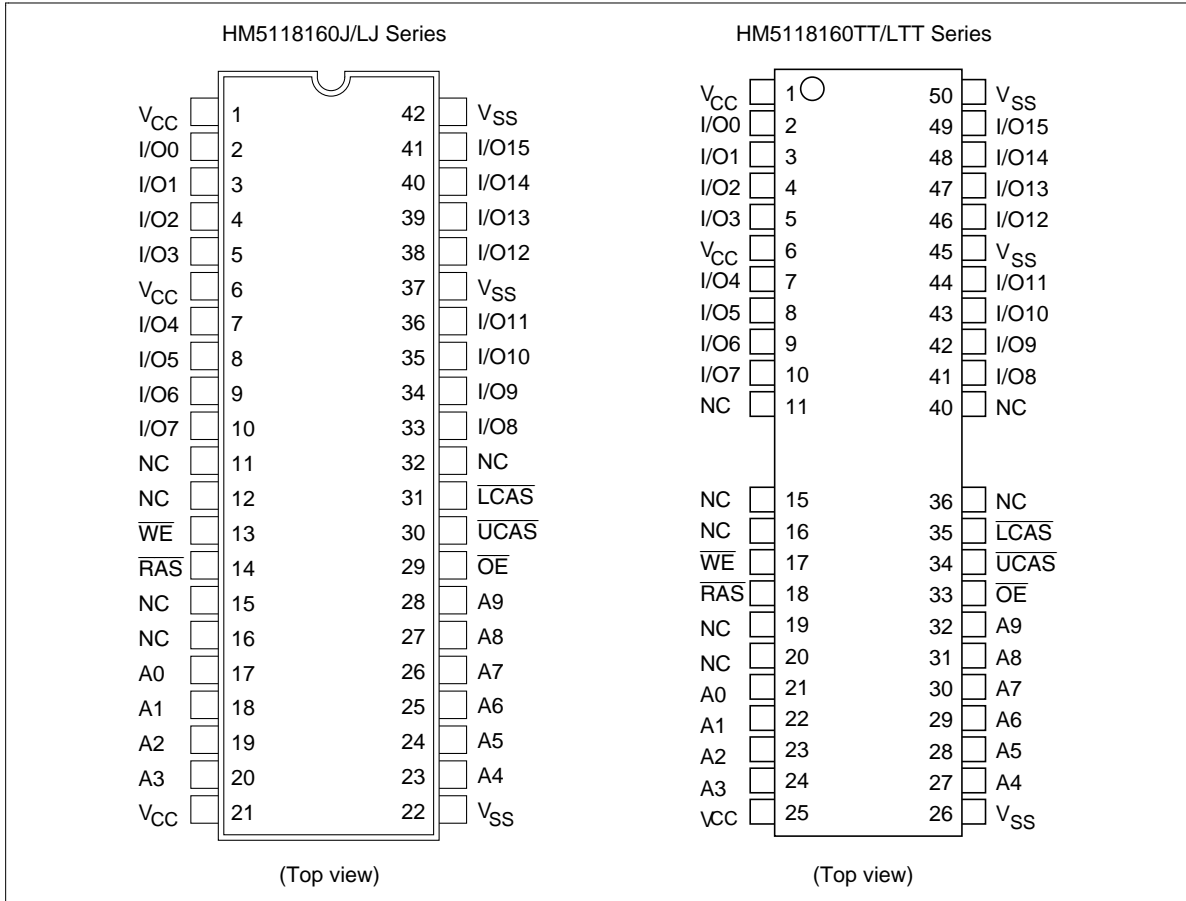


## Pin Description

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 A7</li> </ul>
I/O0 to I/O15	Data input/Data output
RAS	Row address strobe
UCAS, LCAS	Column address strobe
WE	Read/Write enable
OE	Output enable
V <sub>CC</sub>	Power supply
V <sub>SS</sub>	Ground
NC	No connection

## HM5116160 Series, HM5118160 Series

### Pin Arrangement

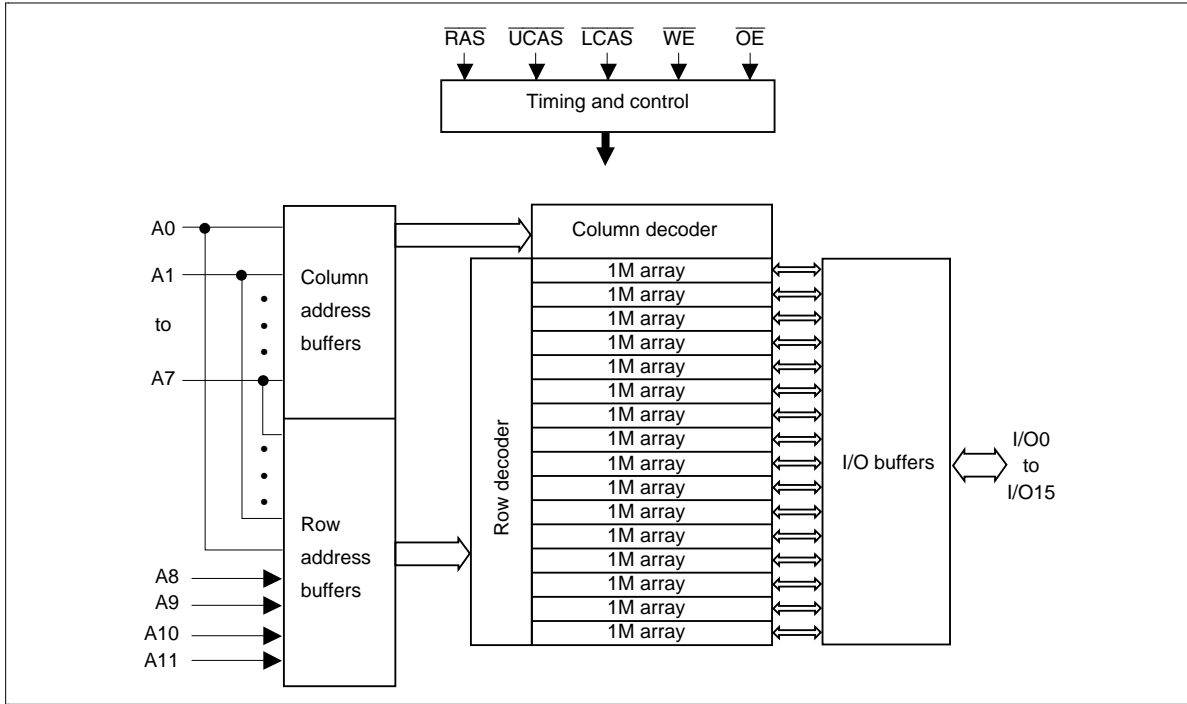


### Pin Description

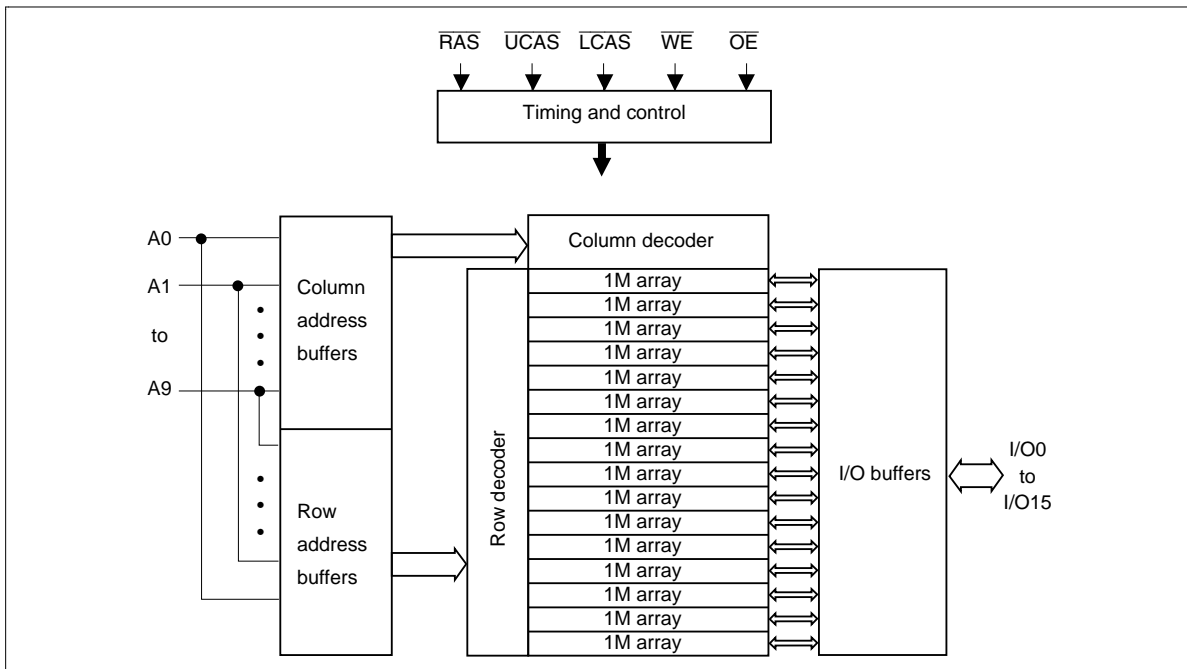
Pin name	Function
A0 to A9	Address input <ul style="list-style-type: none"> <li>Row/Refresh address    A0 to A9</li> <li>Column address        A0 to A9</li> </ul>
I/O0 to I/O15	Data input/Data output
$\overline{RAS}$	Row address strobe
$\overline{UCAS}$ , $\overline{LCAS}$	Column address strobe
$\overline{WE}$	Read/Write enable
$\overline{OE}$	Output enable
V <sub>CC</sub>	Power supply
V <sub>SS</sub>	Ground
NC	No connection

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**Block Diagram (HM5116160 Series)**



**Block Diagram (HM5118160 Series)**



**Truth Table**

## HM5116160 Series, HM5118160 Series

$\overline{\text{RAS}}$	$\overline{\text{LCAS}}$	$\overline{\text{UCAS}}$	$\overline{\text{WE}}$	$\overline{\text{OE}}$	Output	Operation
H	D	D	D	D	Open	Standby
L	L	H	H	L	Valid	Lower byte
L	H	L	H	L	Valid	Upper byte
L	L	L	H	L	Valid	Word
L	L	H	L* <sup>2</sup>	D	Open	Lower byte
L	H	L	L* <sup>2</sup>	D	Open	Upper byte
L	L	L	L* <sup>2</sup>	D	Open	Word
L	L	H	L* <sup>2</sup>	H	Undefined	Lower byte
L	H	L	L* <sup>2</sup>	H	Undefined	Upper byte
L	L	L	L* <sup>2</sup>	H	Undefined	Word
L	L	H	H to L	L to H	Valid	Lower byte
L	H	L	H to L	L to H	Valid	Upper byte
L	L	L	H to L	L to H	Valid	Word
L	H	H	D	D	Open	Word
H to L	H	L	D	D	Open	Word
H to L	L	H	D	D	Open	Word
H to L	L	L	D	D	Open	Word
L	L	L	H	H	Open	Read cycle (Output disabled)

Notes: 1. H: High (inactive) L: Low (active) D: H or L

2.  $t_{\text{WCS}} \geq 0 \text{ ns}$  Early write cycle

$t_{\text{WCS}} < 0 \text{ ns}$  Delayed write cycle

3. Mode is determined by the OR function of the  $\overline{\text{UCAS}}$  and  $\overline{\text{LCAS}}$ . (Mode is set by the earliest of  $\overline{\text{UCAS}}$  and  $\overline{\text{LCAS}}$  active edge and reset by the latest of  $\overline{\text{UCAS}}$  and  $\overline{\text{LCAS}}$  inactive edge.)  
However write OPERATION and output High-Z control are done independently by each  $\overline{\text{UCAS}}$ ,  $\overline{\text{LCAS}}$ .

ex. if  $\overline{\text{RAS}} = \text{H to L}$ ,  $\overline{\text{UCAS}} = \text{H}$ ,  $\overline{\text{LCAS}} = \text{L}$ , then  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh cycle is selected.

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## HM5116160 Series, HM5118160 Series

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### 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	Notes
Supply voltage	$V_{CC}$	4.5	5.0	5.5	V	1, 2
Input high voltage	$V_{IH}$	2.4	—	6.5	V	1
Input low voltage	$V_{IL}$	-1.0	—	0.8	V	1

- 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.

## HM5116160 Series, HM5118160 Series

### DC Characteristics

( $T_a = 0$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 5\text{ V} \pm 10\%$ ,  $V_{SS} = 0\text{ V}$ ) (HM5116160 Series)

Parameter	Symbol	HM5116160				Unit	Test conditions
		-6		-7			
		Min	Max	Min	Max		
Operating current <sup>*1, *2</sup>	$I_{CC1}$	—	100	—	90	mA	$t_{RC} = \text{min}$
Standby current	$I_{CC2}$	—	2	—	2	mA	TTL interface $\overline{\text{RAS}}, \overline{\text{UCAS}}, \overline{\text{LCAS}} = V_{IH}$ Dout = High-Z
		—	1	—	1	mA	CMOS interface $\overline{\text{RAS}}, \overline{\text{UCAS}},$ $\overline{\text{LCAS}} \geq V_{CC} - 0.2\text{ V}$ Dout = High-Z
Standby current (L-version)	$I_{CC2}$	—	150	—	150	$\mu\text{A}$	CMOS interface $\overline{\text{RAS}}, \overline{\text{UCAS}},$ $\overline{\text{LCAS}} \geq V_{CC} - 0.2\text{ V}$ Dout = High-Z
$\overline{\text{RAS}}$ -only refresh current <sup>*2</sup>	$I_{CC3}$	—	100	—	90	mA	$t_{RC} = \text{min}$
Standby current <sup>*1</sup>	$I_{CC5}$	—	5	—	5	mA	$\overline{\text{RAS}} = V_{IH}$ $\overline{\text{UCAS}}, \overline{\text{LCAS}} = V_{IL}$ Dout = enable
$\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh current	$I_{CC6}$	—	100	—	90	mA	$t_{RC} = \text{min}$
Fast page mode current <sup>*1, *3</sup>	$I_{CC7}$	—	95	—	85	mA	$t_{PC} = \text{min}$
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)	$I_{CC11}$	—	300	—	300	$\mu\text{A}$	CMOS interface $\overline{\text{RAS}}, \overline{\text{UCAS}}, \overline{\text{LCAS}} \leq 0.2\text{ V}$ Dout = High-Z
Input leakage current	$I_{LI}$	-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	$\mu\text{A}$	$0\text{ V} \leq V_{out} \leq 7\text{ V}$ Dout = disable
Output high voltage	$V_{OH}$	2.4	$V_{CC}$	2.4	$V_{CC}$	V	High Iout = -5 mA
Output low voltage	$V_{OL}$	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 once or less while  $\overline{\text{RAS}} = V_{IL}$ .

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

4.  $V_{IH} \geq V_{CC} - 0.2\text{ V}$ ,  $0\text{ V} \leq V_{IL} \leq 0.2\text{ V}$ .



## HM5116160 Series, HM5118160 Series

### DC Characteristics

( $T_a = 0$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 5\text{ V} \pm 10\%$ ,  $V_{SS} = 0\text{ V}$ ) (HM5118160 Series)

Parameter	Symbol	HM5118160				Unit	Test conditions
		-6		-7			
		Min	Max	Min	Max		
Operating current <sup>*1, *2</sup>	$I_{CC1}$	—	170	—	150	mA	$t_{RC} = \text{min}$
Standby current	$I_{CC2}$	—	2	—	2	mA	TTL interface $\overline{\text{RAS}}, \overline{\text{UCAS}}, \overline{\text{LCAS}} = V_{IH}$ Dout = High-Z
		—	1	—	1	mA	CMOS interface $\overline{\text{RAS}}, \overline{\text{UCAS}},$ $\overline{\text{LCAS}} \geq V_{CC} - 0.2\text{ V}$ Dout = High-Z
Standby current (L-version)	$I_{CC2}$	—	150	—	150	$\mu\text{A}$	CMOS interface $\overline{\text{RAS}}, \overline{\text{UCAS}},$ $\overline{\text{LCAS}} \geq V_{CC} - 0.2\text{ V}$ Dout = High-Z
$\overline{\text{RAS}}$ -only refresh current <sup>*2</sup>	$I_{CC3}$	—	170	—	150	mA	$t_{RC} = \text{min}$
Standby current <sup>*1</sup>	$I_{CC5}$	—	5	—	5	mA	$\overline{\text{RAS}} = V_{IH}$ $\overline{\text{UCAS}}, \overline{\text{LCAS}} = V_{IL}$ Dout = enable
$\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh current	$I_{CC6}$	—	170	—	150	mA	$t_{RC} = \text{min}$
Fast page mode current <sup>*1, *3</sup>	$I_{CC7}$	—	165	—	145	mA	$t_{PC} = \text{min}$
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: $t_{RC} = 125\ \mu\text{s}$ $t_{RAS} \leq 0.3\ \mu\text{s}$
Self refresh mode current (L-version)	$I_{CC11}$	—	300	—	300	$\mu\text{A}$	CMOS interface $\overline{\text{RAS}}, \overline{\text{UCAS}}, \overline{\text{LCAS}} \leq 0.2\text{ V}$ Dout = High-Z
Input leakage current	$I_{LI}$	-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	$\mu\text{A}$	$0\text{ V} \leq V_{out} \leq 7\text{ V}$ Dout = disable
Output high voltage	$V_{OH}$	2.4	$V_{CC}$	2.4	$V_{CC}$	V	High Iout = -5 mA
Output low voltage	$V_{OL}$	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 once or less while  $\overline{\text{RAS}} = V_{IL}$ .

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

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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## HM5116160 Series, HM5118160 Series

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**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.  $\overline{UCAS}$  and  $\overline{LCAS} = V_{IH}$  to disable Dout.

## HM5116160 Series, HM5118160 Series

**AC Characteristics** ( $T_a = 0$  to  $+70^\circ\text{C}$ ,  $V_{CC} = 5\text{ V} \pm 10\%$ ,  $V_{SS} = 0\text{ V}$ ) \*1, \*2, \*18, \*19, \*20

### Test Conditions

- Input rise and fall time: 5 ns
- Input timing reference levels: 0.8 V, 2.4 V
- Output timing reference levels: 0.4 V, 2.4 V
- Output load: 2 TTL gate +  $C_L$  (100 pF) (Including scope and jig)

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

Parameter	Symbol	HM5116160/HM5118160				Unit	Notes
		-6		-7			
		Min	Max	Min	Max		
Random read or write cycle time	$t_{RC}$	110	—	130	—	ns	
$\overline{\text{RAS}}$ precharge time	$t_{RP}$	40	—	50	—	ns	
$\overline{\text{CAS}}$ precharge time	$t_{CP}$	10	—	10	—	ns	
$\overline{\text{RAS}}$ pulse width	$t_{RAS}$	60	10000	70	10000	ns	
$\overline{\text{CAS}}$ pulse width	$t_{CAS}$	15	10000	18	10000	ns	
Row address setup time	$t_{ASR}$	0	—	0	—	ns	
Row address hold time	$t_{RAH}$	10	—	10	—	ns	
Column address setup time	$t_{ASC}$	0	—	0	—	ns	21
Column address hold time	$t_{CAH}$	10	—	15	—	ns	21
$\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ delay time	$t_{RCD}$	20	45	20	52	ns	3
$\overline{\text{RAS}}$ to column address delay time	$t_{RAD}$	15	30	15	35	ns	4
$\overline{\text{RAS}}$ hold time	$t_{RSH}$	15	—	18	—	ns	
$\overline{\text{CAS}}$ hold time	$t_{CSH}$	60	—	70	—	ns	
$\overline{\text{CAS}}$ to $\overline{\text{RAS}}$ precharge time	$t_{CRP}$	5	—	5	—	ns	22
$\overline{\text{OE}}$ to Din delay time	$t_{OED}$	15	—	18	—	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

## HM5116160 Series, HM5118160 Series

### Read Cycle

Parameter	Symbol	HM5116160/HM5118160				Unit	Notes
		-6		-7			
		Min	Max	Min	Max		
Access time from $\overline{\text{RAS}}$	$t_{\text{RAC}}$	—	60	—	70	ns	8, 9
Access time from $\overline{\text{CAS}}$	$t_{\text{CAC}}$	—	15	—	18	ns	9, 10, 17,
Access time from address	$t_{\text{AA}}$	—	30	—	35	ns	9, 11, 17,
Access time from $\overline{\text{OE}}$	$t_{\text{OEA}}$	—	15	—	18	ns	9, 25
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, 22
Read command hold time to $\overline{\text{RAS}}$	$t_{\text{RRH}}$	0	—	0	—	ns	12
Column address to $\overline{\text{RAS}}$ lead time	$t_{\text{RAL}}$	30	—	35	—	ns	
Column address to $\overline{\text{CAS}}$ lead time	$t_{\text{CAL}}$	30	—	35	—	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	$t_{\text{OFF}}$	—	15	—	15	ns	13
Output buffer turn-off to $\overline{\text{OE}}$	$t_{\text{OEZ}}$	—	15	—	15	ns	13
$\overline{\text{CAS}}$ to Din delay time	$t_{\text{CDD}}$	15	—	18	—	ns	5

### Write Cycle

Parameter	Symbol	HM5116160/HM5118160				Unit	Notes
		-6		-7			
		Min	Max	Min	Max		
Write command setup time	$t_{\text{WCS}}$	0	—	0	—	ns	14, 21
Write command hold time	$t_{\text{WCH}}$	10	—	15	—	ns	21
Write command pulse width	$t_{\text{WP}}$	10	—	10	—	ns	
Write command to $\overline{\text{RAS}}$ lead time	$t_{\text{RWL}}$	15	—	18	—	ns	
Write command to $\overline{\text{CAS}}$ lead time	$t_{\text{CWL}}$	15	—	18	—	ns	23
Data-in setup time	$t_{\text{DS}}$	0	—	0	—	ns	15, 23
Data-in hold time	$t_{\text{DH}}$	10	—	15	—	ns	15, 23

## HM5116160 Series, HM5118160 Series

### Read-Modify-Write Cycle

Parameter	Symbol	HM5116160/HM5118160				Unit	Notes
		-6		-7			
		Min	Max	Min	Max		
Read-modify-write cycle time	$t_{RWC}$	155	—	181	—	ns	
$\overline{RAS}$ to $\overline{WE}$ delay time	$t_{RWD}$	85	—	98	—	ns	14
$\overline{CAS}$ to $\overline{WE}$ delay time	$t_{CWD}$	40	—	46	—	ns	14
Column address to $\overline{WE}$ delay time	$t_{AWD}$	55	—	63	—	ns	14
$\overline{OE}$ hold time from $\overline{WE}$	$t_{OEH}$	15	—	18	—	ns	

### Refresh Cycle

Parameter	Symbol	HM5116160/HM5118160				Unit	Notes
		-6		-7			
		Min	Max	Min	Max		
$\overline{CAS}$ setup time (CBR refresh cycle)	$t_{CSR}$	5	—	5	—	ns	21
$\overline{CAS}$ hold time (CBR refresh cycle)	$t_{CHR}$	10	—	10	—	ns	22
$\overline{RAS}$ precharge to $\overline{CAS}$ hold time	$t_{RPC}$	5	—	5	—	ns	21

### Fast Page Mode Cycle

Parameter	Symbol	HM5116160/HM5118160				Unit	Notes
		-6		-7			
		Min	Max	Min	Max		
Fast page mode cycle time	$t_{PC}$	40	—	45	—	ns	
Fast page mode $\overline{RAS}$ pulse width	$t_{RASP}$	—	100000	—	100000	ns	16
Access time from $\overline{CAS}$ precharge	$t_{CPA}$	—	35	—	40	ns	9, 17, 22
$\overline{RAS}$ hold time from $\overline{CAS}$ precharge	$t_{CPRH}$	35	—	40	—	ns	

## HM5116160 Series, HM5118160 Series

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

Parameter	Symbol	HM5116160/HM5118160				Unit	Notes
		-6		-7			
		Min	Max	Min	Max		
Fast page mode read-modify-write cycle time	$t_{PRWC}$	85	—	96	—	ns	
$\overline{WE}$ delay time from $\overline{CAS}$ precharge	$t_{CPW}$	60	—	68	—	ns	14, 22

### Refresh (HM5116160 Series)

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

### Refresh (HM5118160 Series)

Parameter	Symbol	Max	Unit	Note
Refresh period	$t_{REF}$	16	ms	1024 cycles
Refresh period (L-version)	$t_{REF}$	128	ms	1024 cycles

### Self Refresh Mode (L-version)

Parameter	Symbol	HM5116160L/HM5118160L				Unit	Notes
		-6		-7			
		Min	Max	Min	Max		
$\overline{RAS}$ pulse width (self refresh)	$t_{RASS}$	100	—	100	—	$\mu$ s	26, 27, 28, 29
$\overline{RAS}$ precharge time (self refresh)	$t_{RPS}$	110	—	130	—	ns	
$\overline{CAS}$ hold time (self refresh)	$t_{CHS}$	-50	—	-50	—	ns	

## HM5116160 Series, HM5118160 Series

- Notes:
1. AC measurements assume  $t_r = 5$  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  $\overline{\text{RAS}}$ -only refresh or  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh). If the internal refresh counter is used, a minimum of eight  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh cycles are required.
  3. Operation with the  $t_{\text{RCD}}$  (max) limit insures that  $t_{\text{RAC}}$  (max) can be met,  $t_{\text{RCD}}$  (max) is specified as a reference point only; if  $t_{\text{RCD}}$  is greater than the specified  $t_{\text{RCD}}$  (max) limit, then access time is controlled exclusively by  $t_{\text{CAC}}$ .
  4. Operation with the  $t_{\text{RAD}}$  (max) limit insures that  $t_{\text{RAC}}$  (max) can be met,  $t_{\text{RAD}}$  (max) is specified as a reference point only; if  $t_{\text{RAD}}$  is greater than the specified  $t_{\text{RAD}}$  (max) limit, then access time is controlled exclusively by  $t_{\text{AA}}$ .
  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  $t_{\text{RCD}} \leq t_{\text{RCD}}$  (max) and  $t_{\text{RAD}} \leq t_{\text{RAD}}$  (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 2 TTL loads and 100 pF. ( $V_{\text{OH}} = 2.4$  V,  $V_{\text{OL}} = 0.4$  V)
  10. Assumes that  $t_{\text{RCD}} \geq t_{\text{RCD}}$  (max) and  $t_{\text{RCD}} + t_{\text{CAC}}$  (max)  $\geq t_{\text{RAD}} + t_{\text{AA}}$  (max).
  11. Assumes that  $t_{\text{RAD}} \geq t_{\text{RAD}}$  (max) and  $t_{\text{RCD}} + t_{\text{CAC}}$  (max)  $\leq t_{\text{RAD}} + t_{\text{AA}}$  (max).
  12. Either  $t_{\text{RCH}}$  or  $t_{\text{RRH}}$  must be satisfied for a read cycles.
  13.  $t_{\text{OFF}}$  (max) and  $t_{\text{OEZ}}$  (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  $t_{\text{WCS}} \geq t_{\text{WCS}}$  (min), the cycle is an early write cycle and the data out pin will remain open circuit (high impedance) throughout the entire cycle; if  $t_{\text{RWD}} \geq t_{\text{RWD}}$  (min),  $t_{\text{CWD}} \geq t_{\text{CWD}}$  (min), and  $t_{\text{AWD}} \geq t_{\text{AWD}}$  (min), or  $t_{\text{CWD}} \geq t_{\text{CWD}}$  (min),  $t_{\text{AWD}} \geq t_{\text{AWD}}$  (min) and  $t_{\text{CPW}} \geq t_{\text{CPW}}$  (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  $\overline{\text{UCAS}}$  and  $\overline{\text{LCAS}}$  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 both  $\overline{\text{UCAS}}$  and  $\overline{\text{LCAS}}$  go low at the same time, all 16-bit data are written into the device.  $\overline{\text{UCAS}}$  and  $\overline{\text{LCAS}}$  cannot be staggered within the same write/read cycles.
  20. All the  $V_{\text{CC}}$  and  $V_{\text{SS}}$  pins shall be supplied with the same voltages.
  21.  $t_{\text{ASC}}$ ,  $t_{\text{CAH}}$ ,  $t_{\text{RCS}}$ ,  $t_{\text{WCS}}$ ,  $t_{\text{WCH}}$ ,  $t_{\text{CSR}}$  and  $t_{\text{RPC}}$  are determined by the earlier falling edge of  $\overline{\text{UCAS}}$  or  $\overline{\text{LCAS}}$ .
  22.  $t_{\text{CRP}}$ ,  $t_{\text{CHR}}$ ,  $t_{\text{RCH}}$ ,  $t_{\text{CPA}}$  and  $t_{\text{CPW}}$  are determined by the later rising edge of  $\overline{\text{UCAS}}$  or  $\overline{\text{LCAS}}$ .
  23.  $t_{\text{CWL}}$ ,  $t_{\text{DH}}$  and  $t_{\text{DS}}$  should be satisfied by both  $\overline{\text{UCAS}}$  and  $\overline{\text{LCAS}}$ .
  24.  $t_{\text{CP}}$  is determined by the time that both  $\overline{\text{UCAS}}$  and  $\overline{\text{LCAS}}$  are high.
  25. 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  $V_{\text{IH}}$  min/ $V_{\text{IL}}$  max level.
  26. 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  $t_{\text{RASS}} \geq 100 \mu\text{s}$ , then  $\overline{\text{RAS}}$  precharge time should use  $t_{\text{RPS}}$  instead of  $t_{\text{RP}}$ .

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## HM5116160 Series, HM5118160 Series

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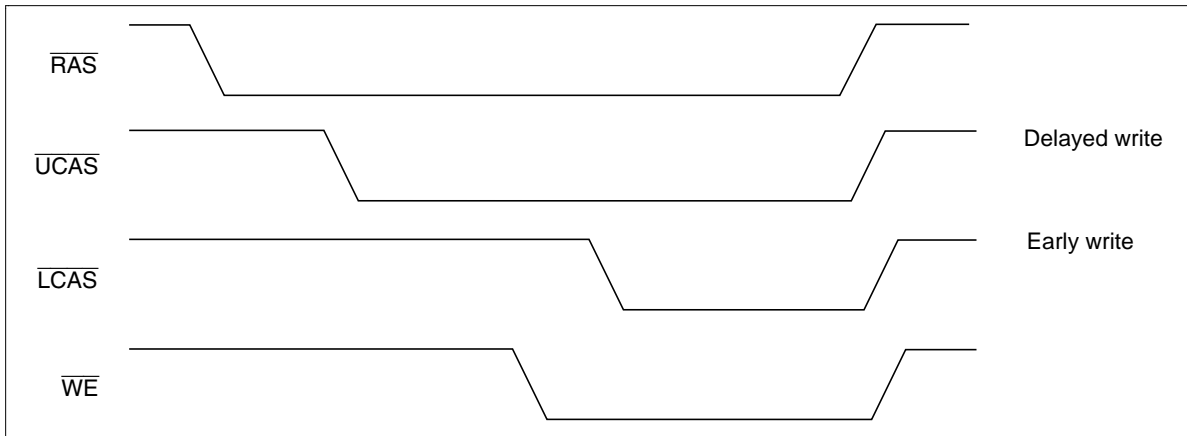
27. If you use distributed CBR refresh mode with 15.6  $\mu\text{s}$  interval in normal read/write cycle, CBR refresh should be executed within 15.6  $\mu\text{s}$  immediately after exiting from and before entering into self refresh mode.
28. If you use  $\overline{\text{RAS}}$  only refresh or CBR burst refresh mode in normal read/write cycle, 4096 or 1024 cycles (4096 cycles: HM5116160 Series, 1024 cycles: HM5118160 Series) of distributed CBR refresh with 15.6  $\mu\text{s}$  interval should be executed within 64 or 16 ms (64 ms: HM5116160, 16 ms: HM5118160) immediately after exiting from and before entering into the self refresh mode.
29. 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.
30. 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  $V_{\text{IL}}$ .



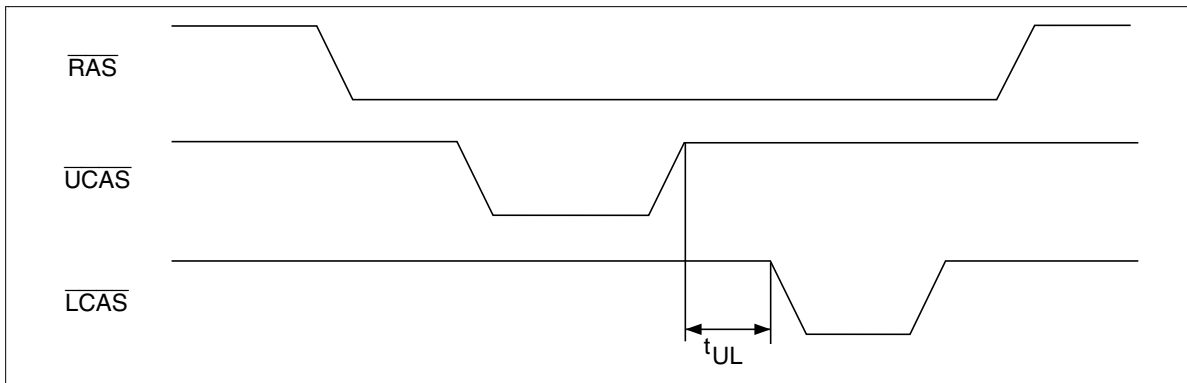
**Notes concerning  $\overline{2CAS}$  control**

Please do not separate the  $\overline{UCAS/LCAS}$  operation timing intentionally. However skew between  $\overline{UCAS/LCAS}$  are allowed under the following conditions.

1. Each of the  $\overline{UCAS/LCAS}$  should satisfy the timing specifications individually.
2. Different operation mode for upper/lower byte is not allowed; such as following.



3. Closely separated upper/lower byte control is not allowed. However when the condition ( $t_{CP} \leq t_{UL}$ ) is satisfied, fast page mode can be performed.

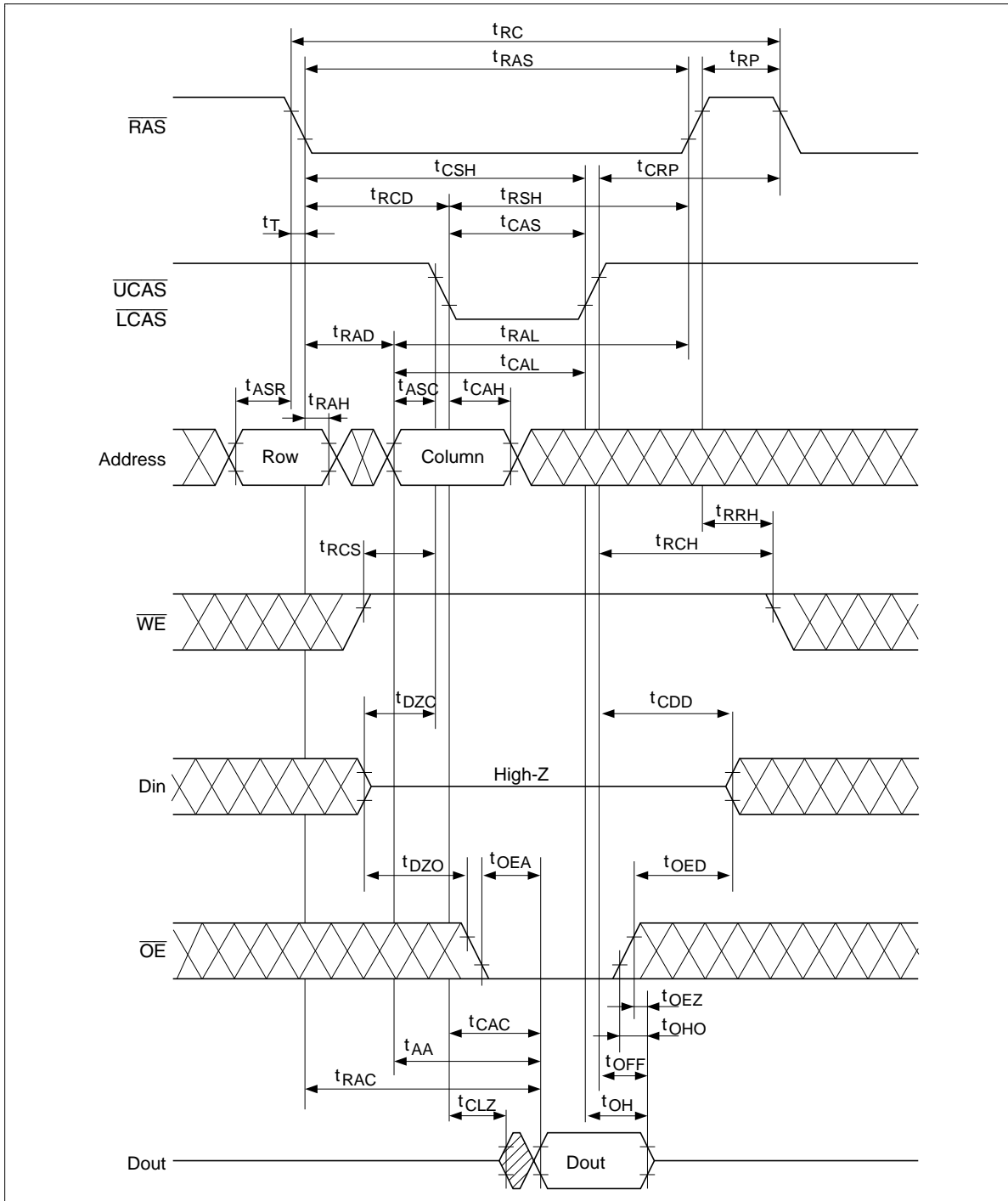


4. Byte control operation by remaining  $\overline{UCAS}$  or  $\overline{LCAS}$  high is guaranteed.

# HM5116160 Series, HM5118160 Series

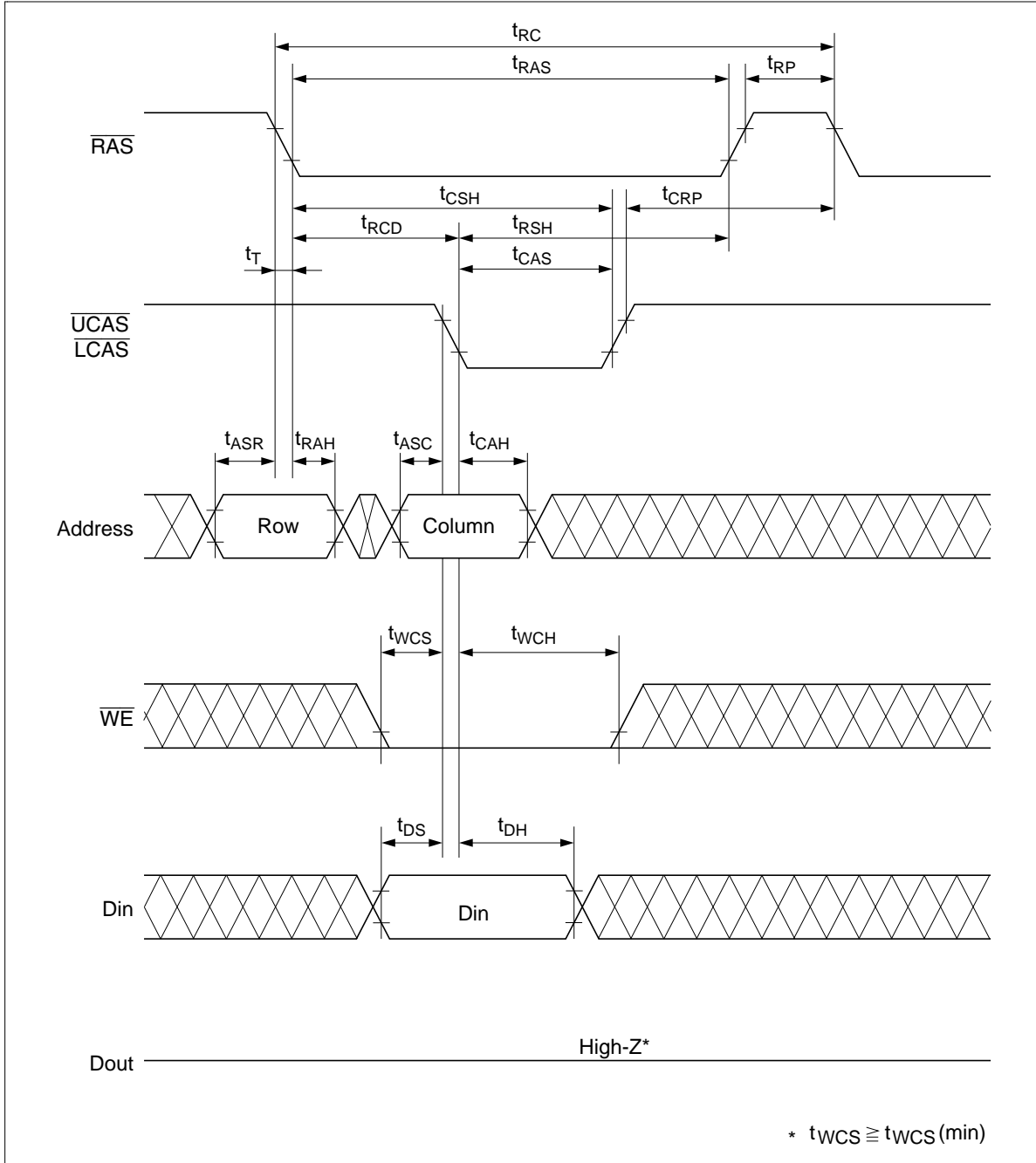
## Timing Waveforms\*30

### Read Cycle



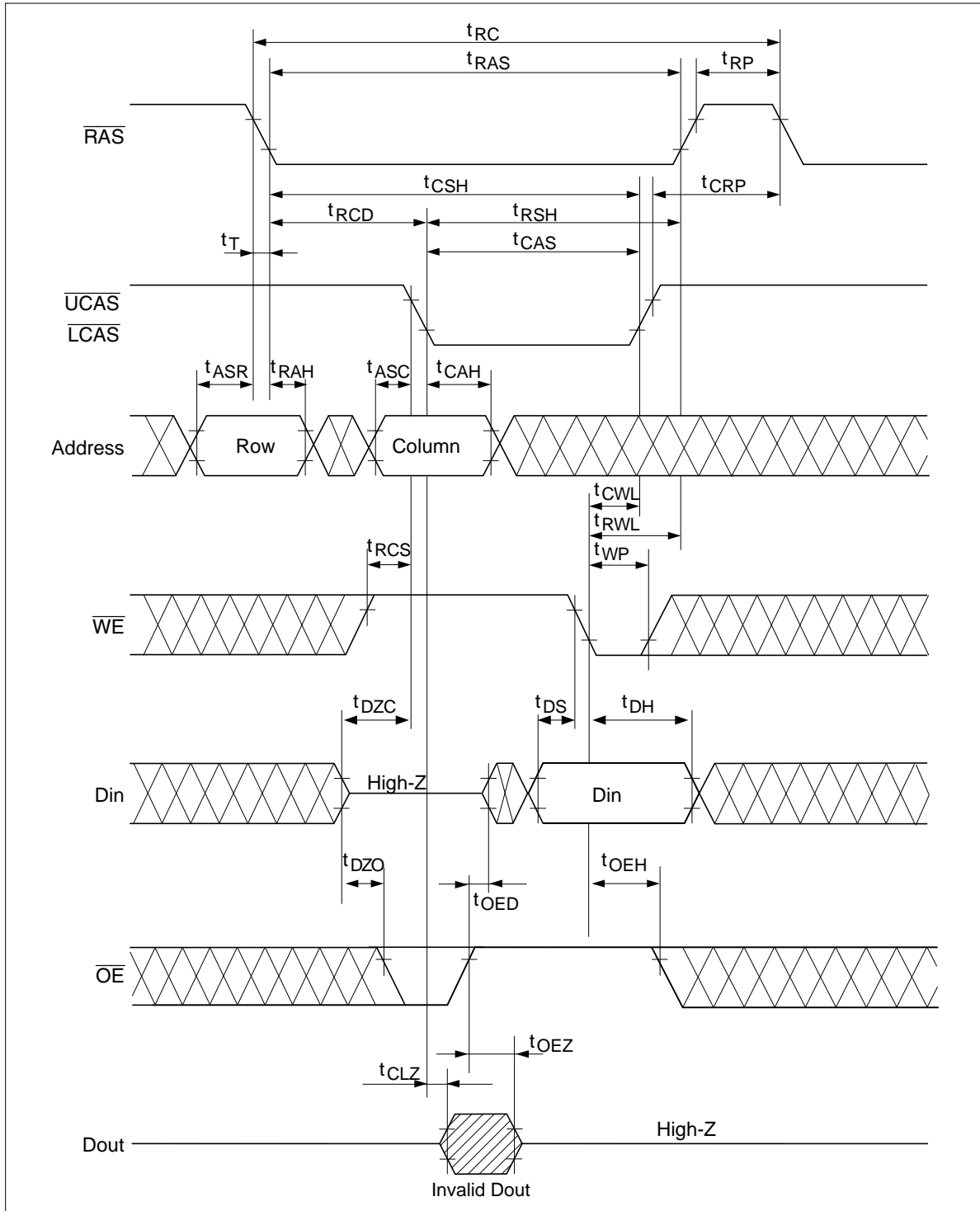
# HM5116160 Series, HM5118160 Series

## Early Write Cycle



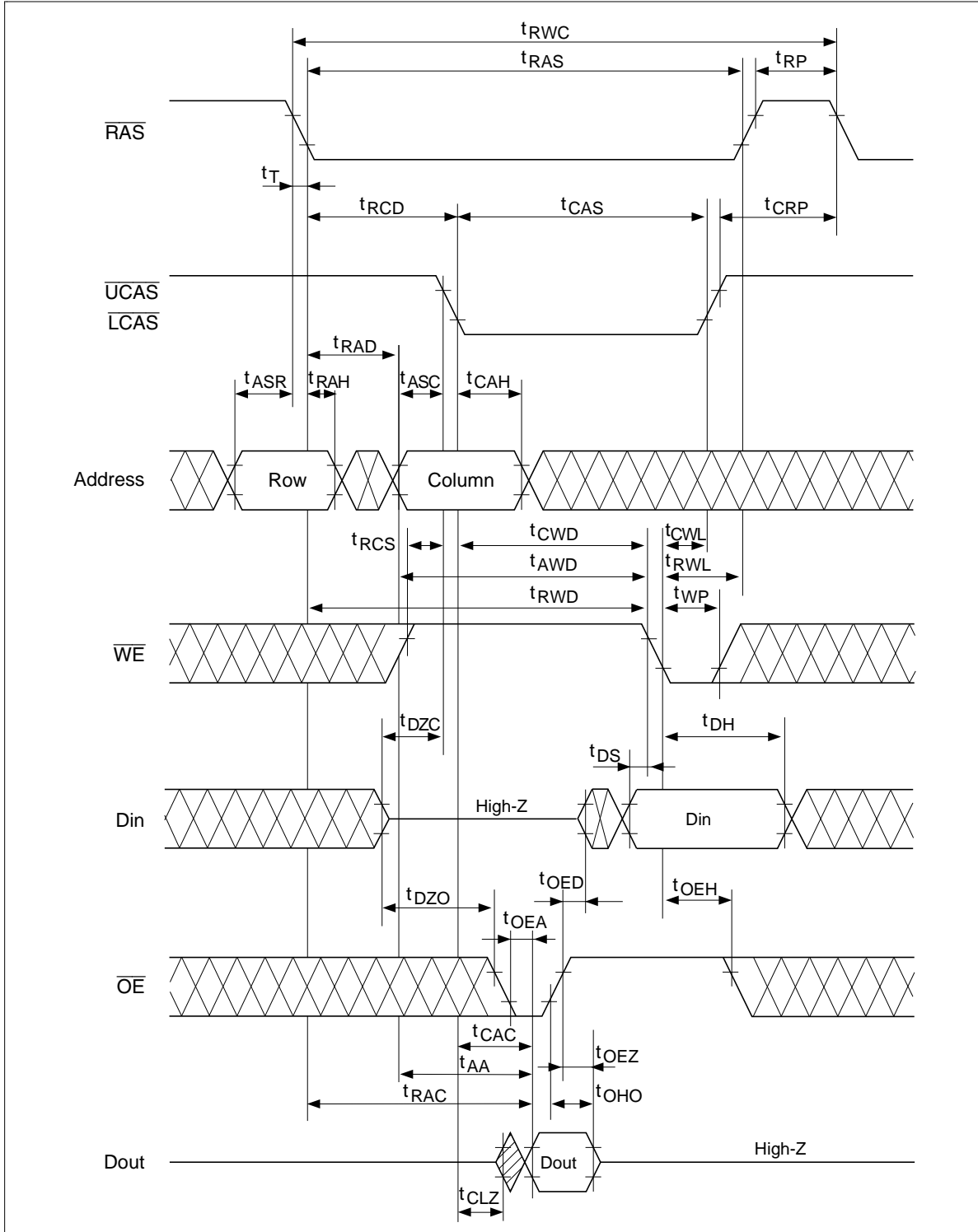
# HM5116160 Series, HM5118160 Series

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



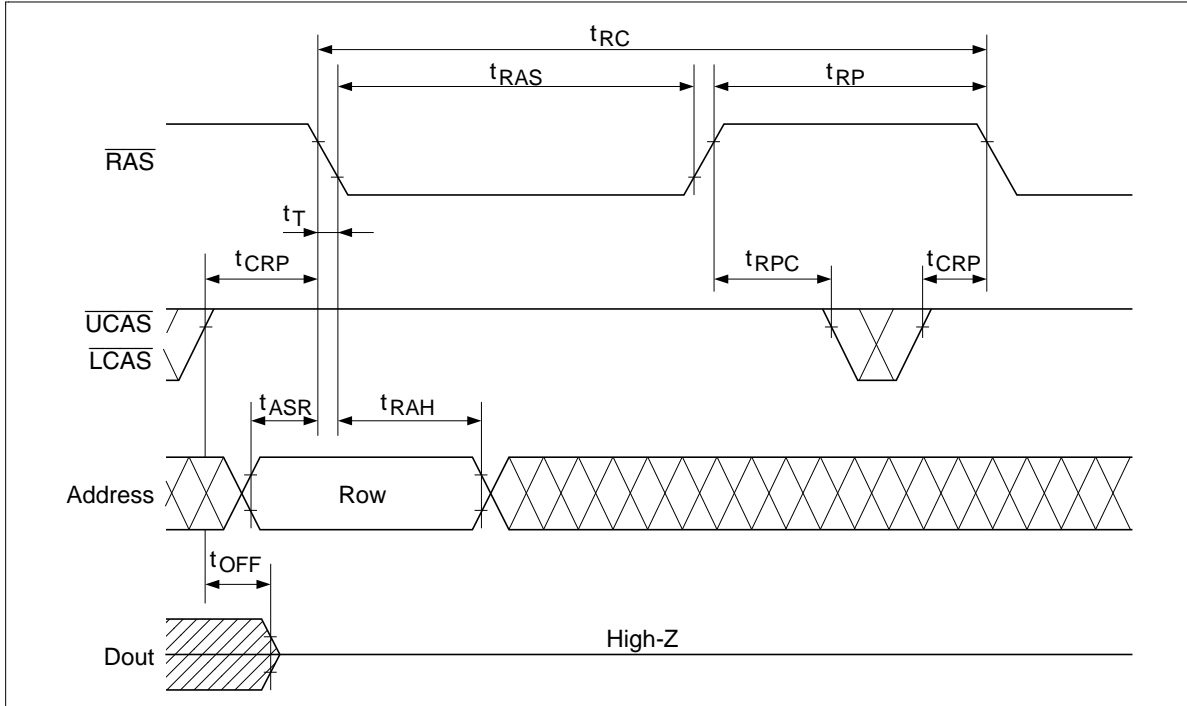
# HM5116160 Series, HM5118160 Series

## Read-Modify-Write Cycle\*18



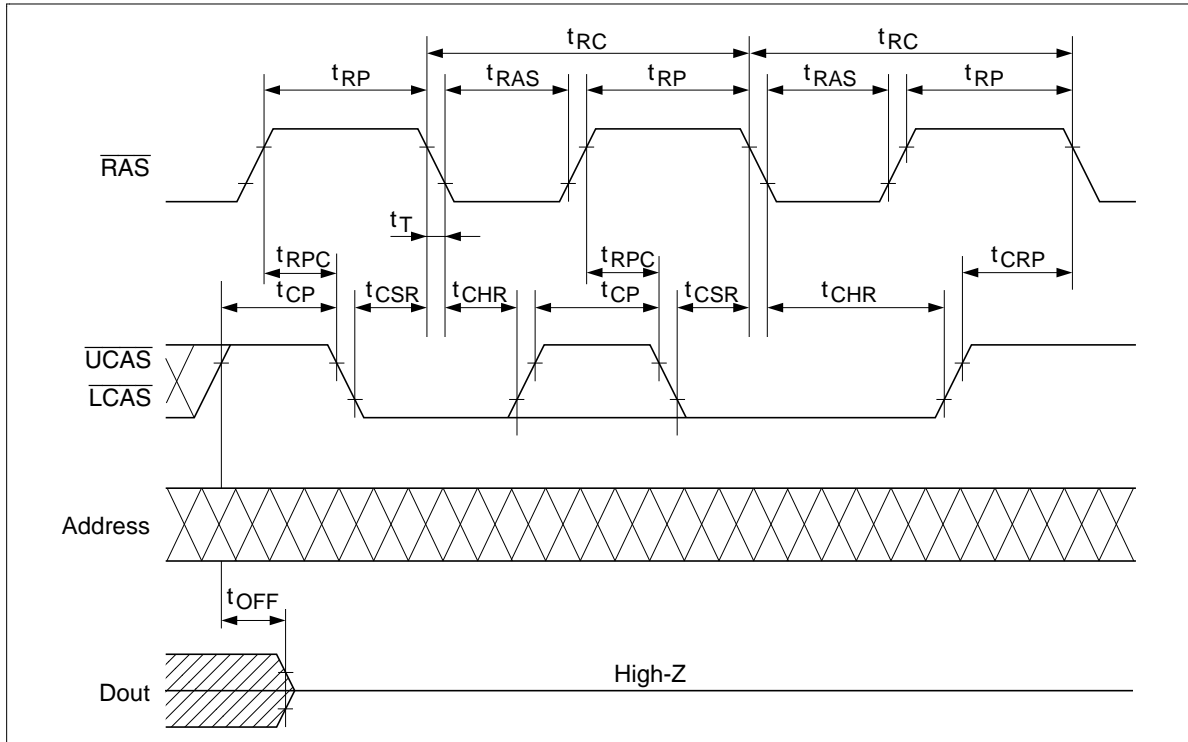
# HM5116160 Series, HM5118160 Series

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



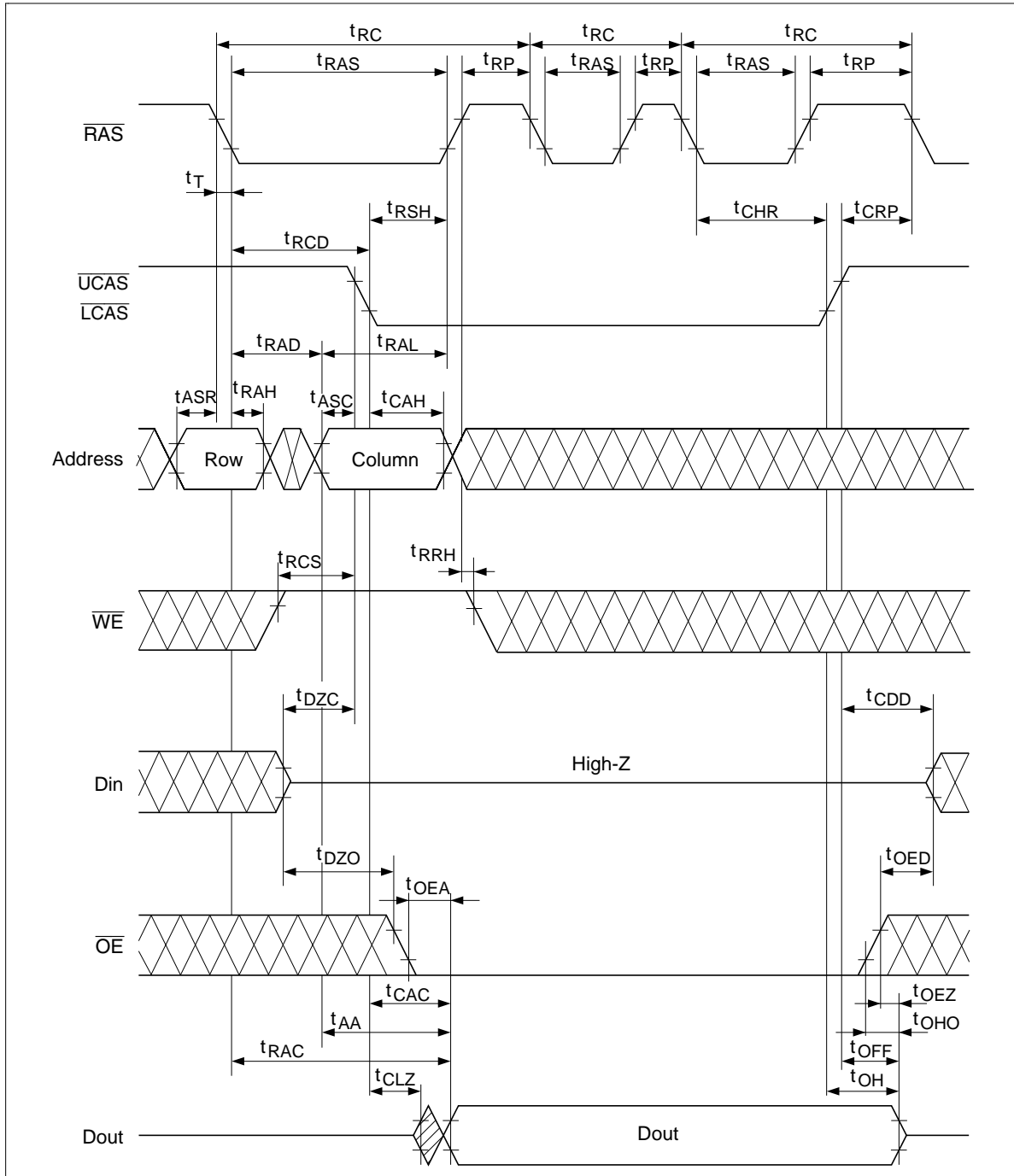
# HM5116160 Series, HM5118160 Series

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



# HM5116160 Series, HM5118160 Series

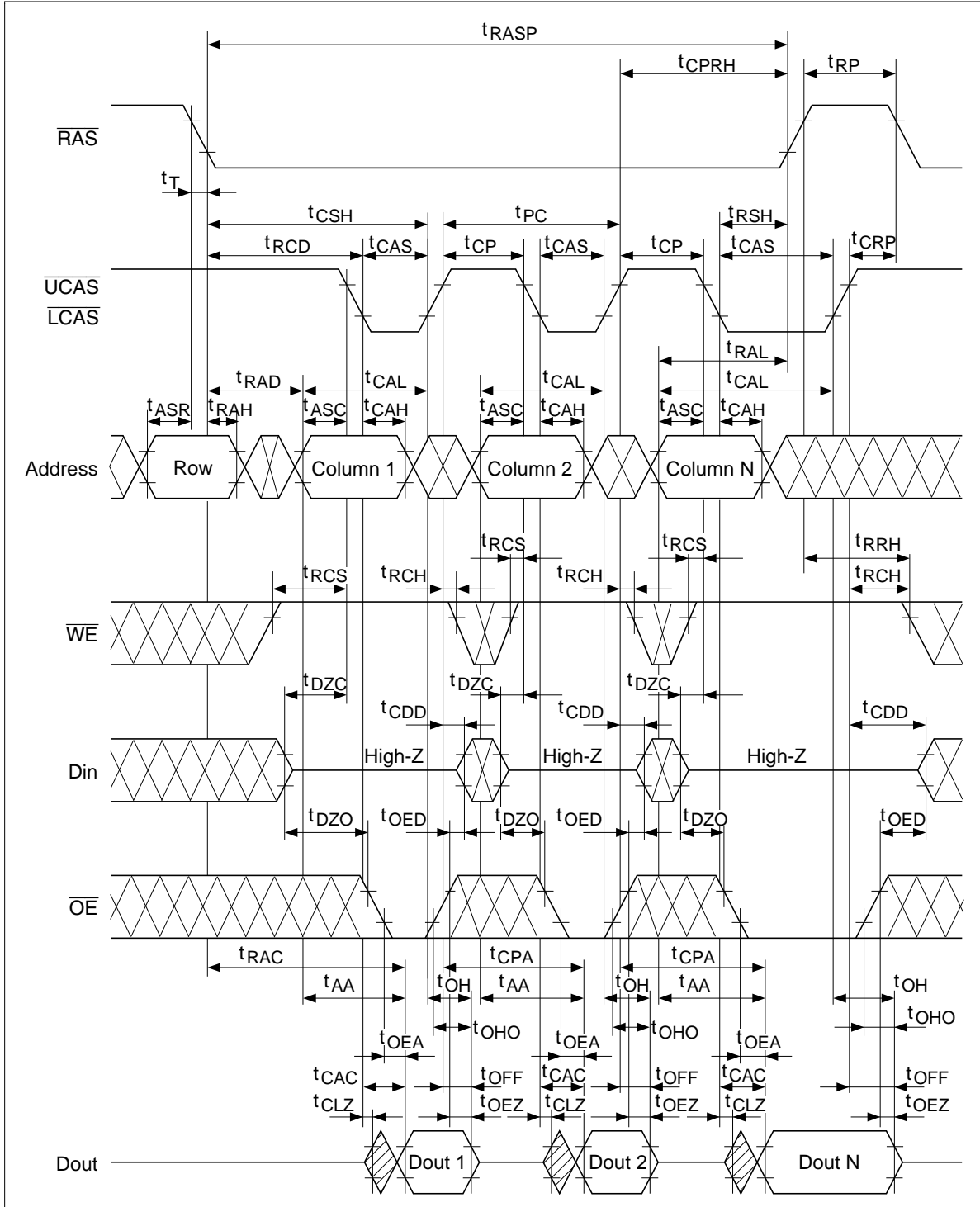
## Hidden Refresh Cycle





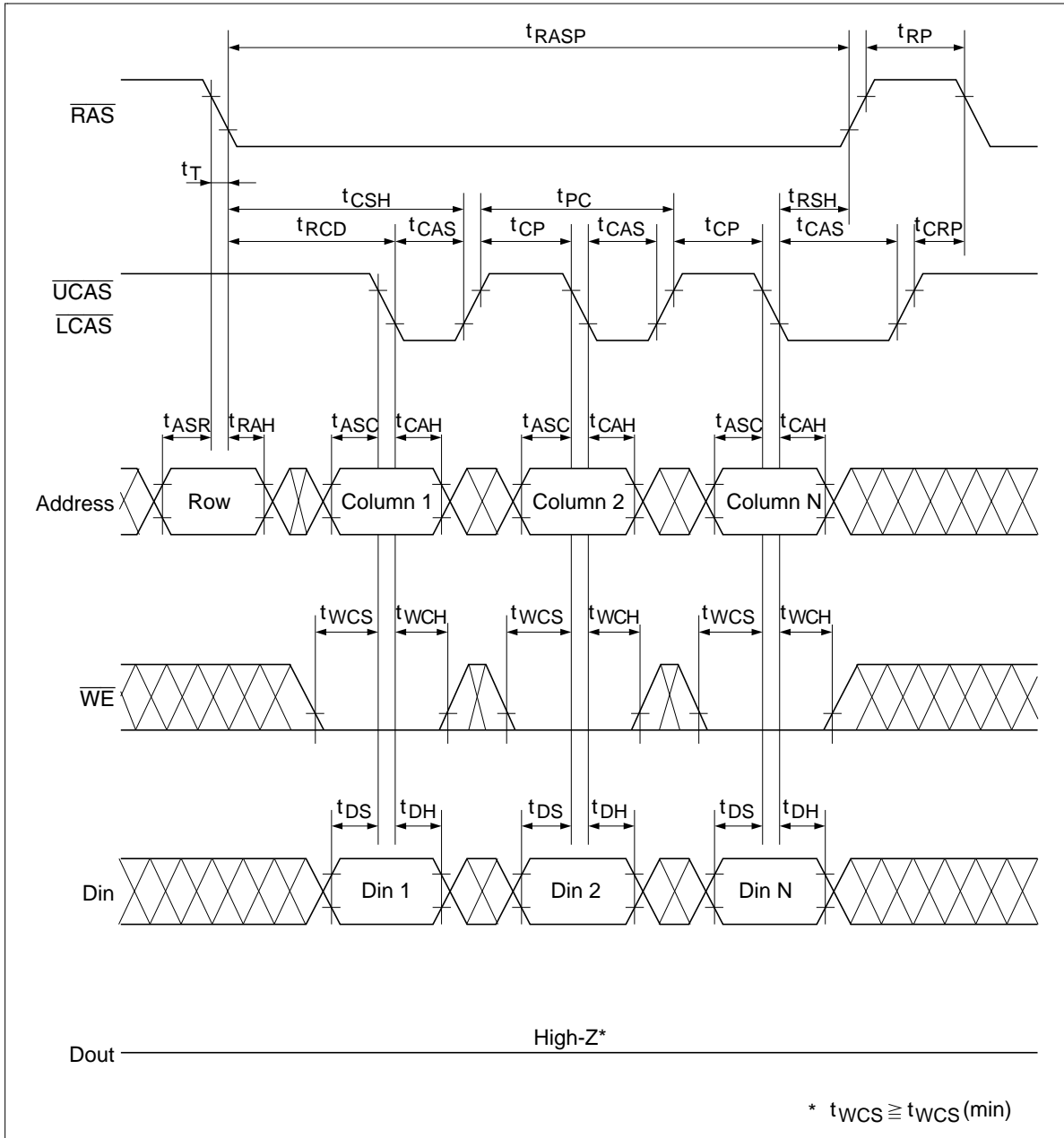
# HM5116160 Series, HM5118160 Series

## Fast Page Mode Read Cycle



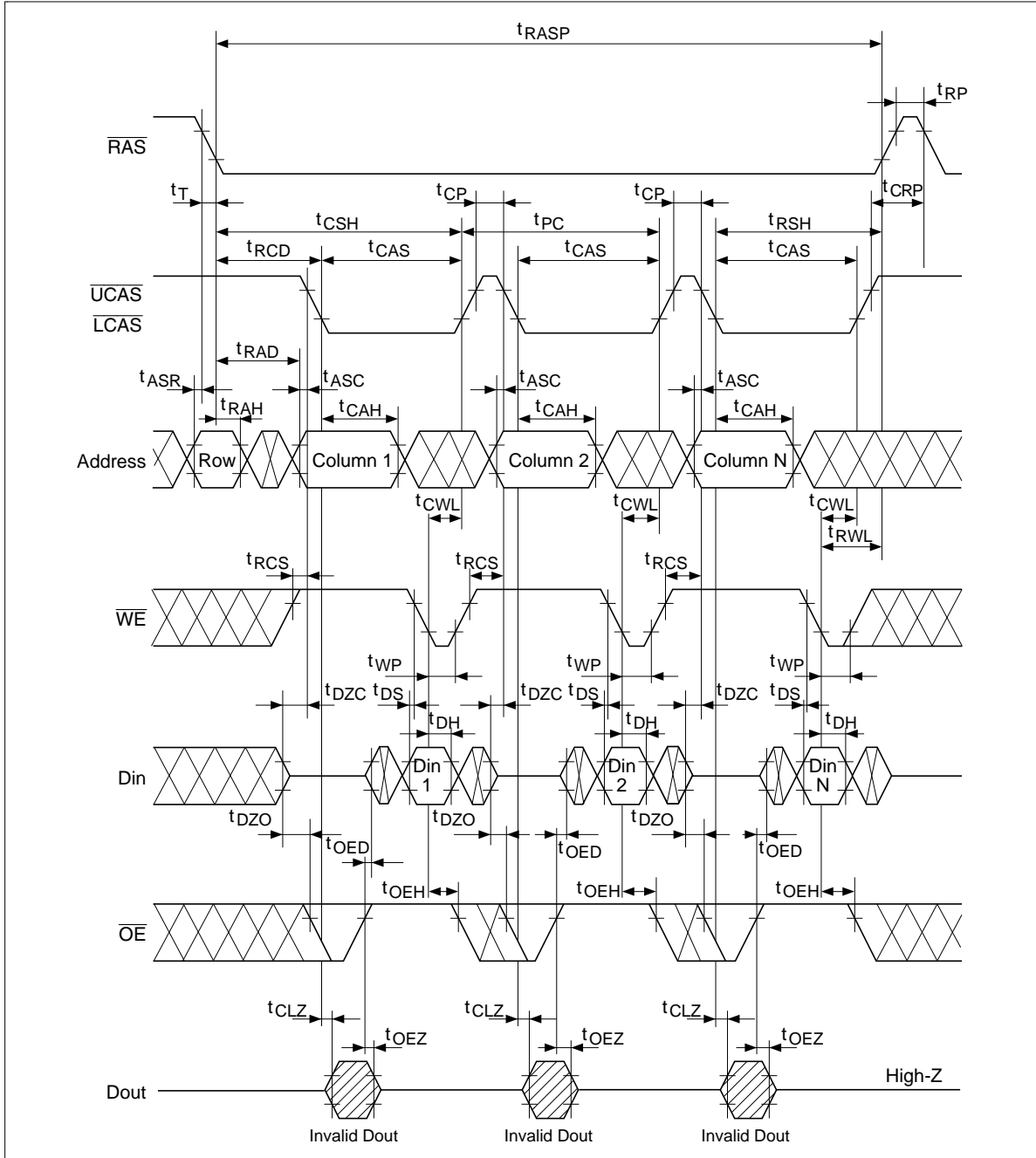
# HM5116160 Series, HM5118160 Series

## Fast Page Mode Early Write Cycle



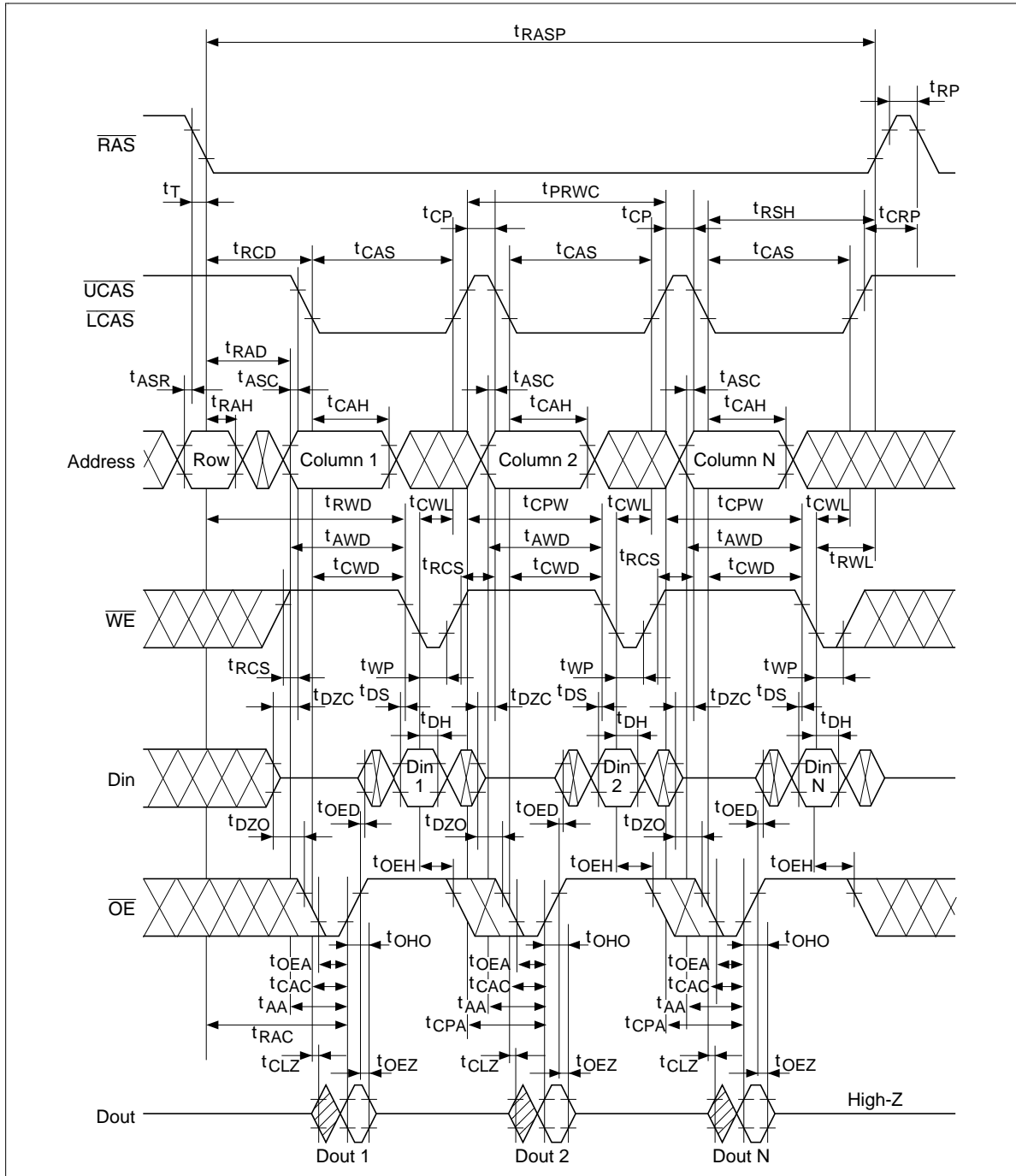
# HM5116160 Series, HM5118160 Series

## Fast Page Mode Delayed Write Cycle\*18



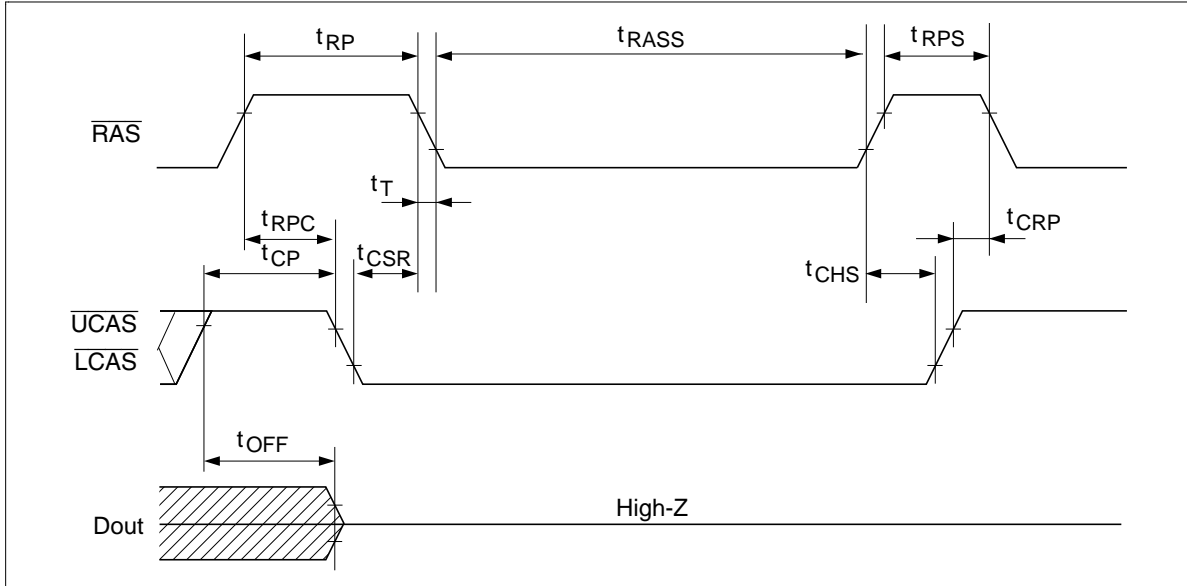
# HM5116160 Series, HM5118160 Series

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



# HM5116160 Series, HM5118160 Series

## Self Refresh Cycle (L-version)\*26, 27, 28, 29

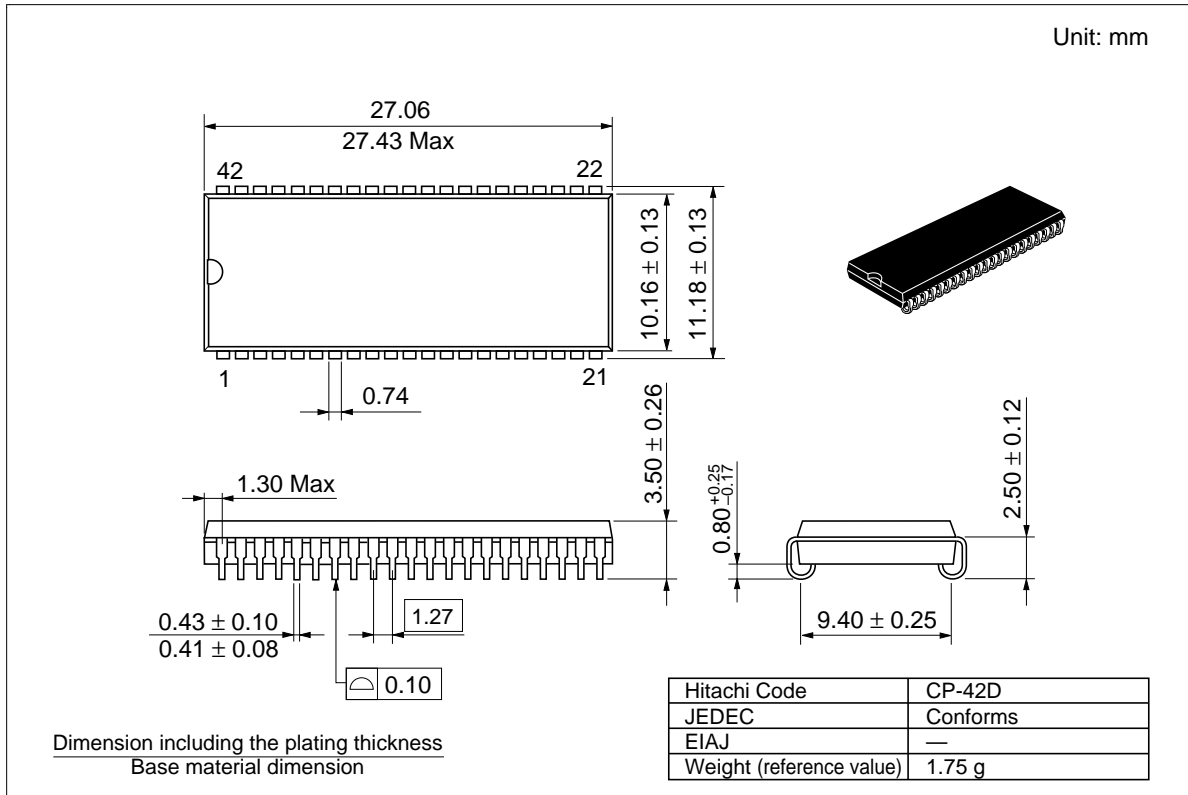


# HM5116160 Series, HM5118160 Series

## Package Dimensions

HM5116160J/LJ Series

HM5118160J/LJ Series (CP-42D)

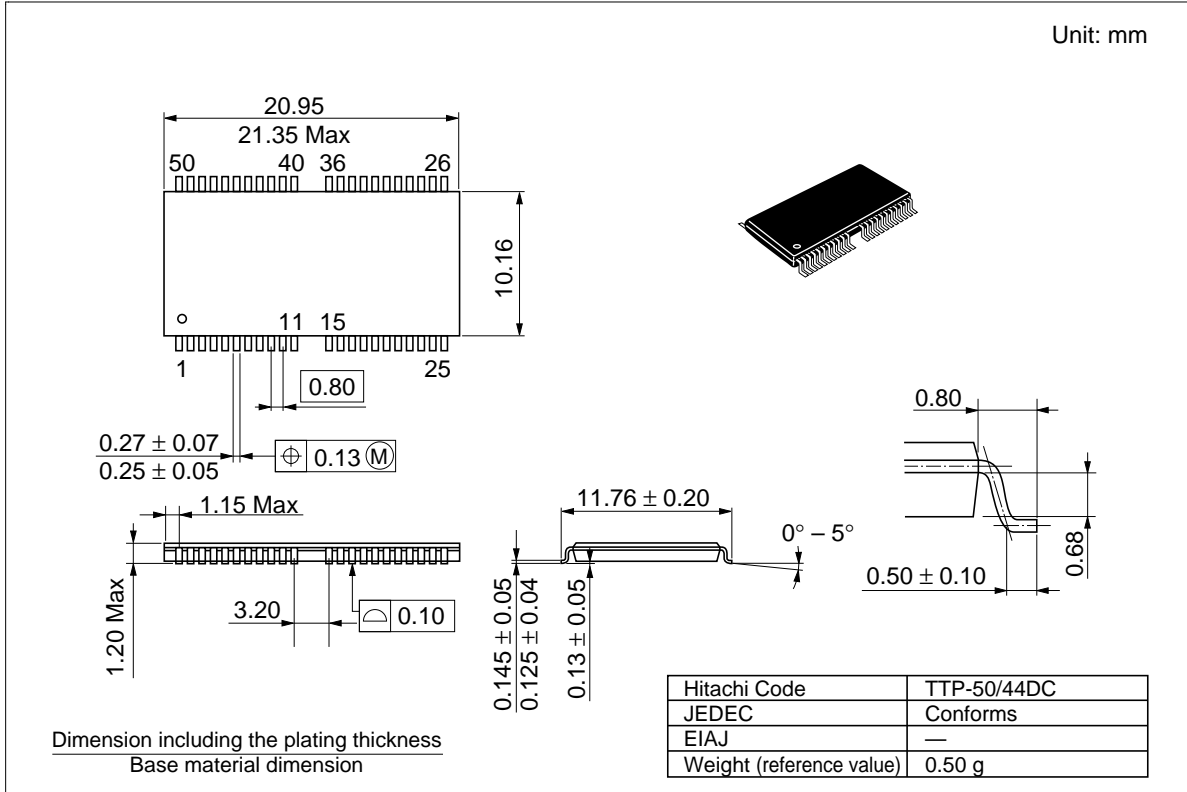


# HM5116160 Series, HM5118160 Series

HM5116160TT/LTT Series

HM5118160TT/LTT Series (TTP-50/44DC)

Unit: mm



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## HM5116160 Series, HM5118160 Series

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## HM5116160 Series, HM5118160 Series

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### Revision Record

Rev.	Date	Contents of Modification	Drawn by	Approved by
1.0	Sep. 30, 1996	Initial issue	Y. Kasama	M. Mishima
2.0	Dec. 5, 1996	Addition of HM5116160/HM5118160-5 Series DC Characteristics (HM5116160 Series) $I_{CC7}$ max: 105/95 mA to 105/95/85 mA DC Characteristics (HM5118160 Series) $I_{CC7}$ max: 170/150 mA to 185/165/145 mA AC Characteristics $t_{RRH}$ min: 0/0 ns to 5/5/5 ns $t_{RPC}$ min: 0/0 ns to 5/5/5 ns	Y. Kasama	M. Mishima
3.0	Feb. 21, 1997	AC Characteristics $t_{RRH}$ min: 5/5/5 ns to 0/0/0 ns	Y. Kasama	Y. Matsuno
4.0	Jun. 25, 1997	Deletion of HM5116160/HM5118160-5 Series Timing Waveforms Deletion of note: $t_{OEH} \geq t_{CWL}$	Y. Kasama	Y. Matsuno
5.0	Nov. 1997	Change of Subtitle		