HM5116405 Series
HM5117405 Series

16 M EDO DRAM (4-Mword × 4-bit)
4 k Refresh/2 k Refresh

HITACHI

ADE-203-633D (Z)
Rev. 4.0
Nov. 1997

Description

The Hitachi HM5116405 Series, HM5117405 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 HM5116405 Series, HM5117405 Series offer Extended Data Out (EDO) Page Mode as a high speed access mode. They have package variations of standard 26-pin plastic SOJ and standard 26-pin plastic TSOP II.

Features

- Single 5 V (±10%)
- Access time: 50 ns/60 ns/70 ns (max)
- Power dissipation
  - Active mode : 495 mW/440 mW/385 mW (max) (HM5116405 Series)
    : 550 mW/495 mW/440 mW (max) (HM5117405 Series)
  - Standby mode : 11 mW (max)
    : 0.83 mW (max) (L-version)
- EDO page mode capability
- Long refresh period
  - 4096 refresh cycles : 64 ms (HM5116405 Series)
    : 128 ms (L-version)
  - 2048 refresh cycles : 32 ms (HM5117405 Series)
    : 128 ms (L-version)
- 3 variations of refresh
  - $\overline{\text{RAS}}$-only refresh
  - $\overline{\text{CAS}}$-before-$\overline{\text{RAS}}$ refresh
  - Hidden refresh

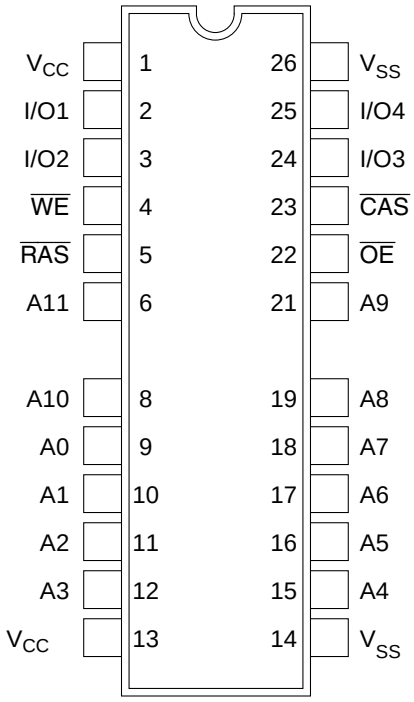
- Battery backup operation (L-version)
- Test function
  - 16-bit parallel test mode

Ordering Information

Type No.	Access time	Package
HM5116405S-5	50 ns	300-mil 26-pin plastic SOJ (CP-26/24DB)
HM5116405S-6	60 ns	
HM5116405S-7	70 ns	
HM5116405LS-5	50 ns	
HM5116405LS-6	60 ns	
HM5116405LS-7	70 ns	
HM5117405S-5	50 ns	
HM5117405S-6	60 ns	
HM5117405S-7	70 ns	
HM5117405LS-5	50 ns	
HM5117405LS-6	60 ns	
HM5117405LS-7	70 ns	
HM5116405TS-5	50 ns	300-mil 26-pin plastic TSOP II (TTP-26/24DA)
HM5116405TS-6	60 ns	
HM5116405TS-7	70 ns	
HM5116405LTS-5	50 ns	
HM5116405LTS-6	60 ns	
HM5116405LTS-7	70 ns	
HM5117405TS-5	50 ns	
HM5117405TS-6	60 ns	
HM5117405TS-7	70 ns	
HM5117405LTS-5	50 ns	
HM5117405LTS-6	60 ns	
HM5117405LTS-7	70 ns	

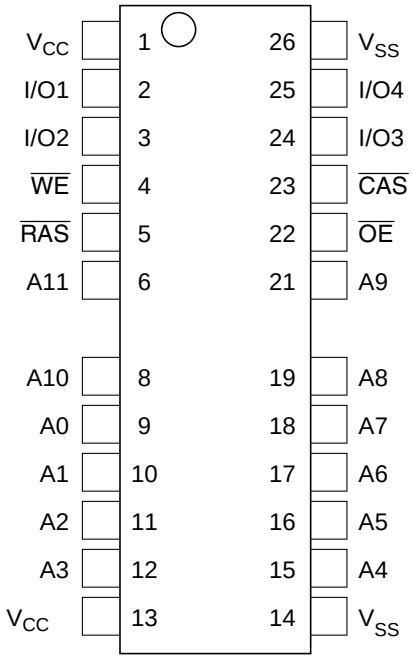
Pin Arrangement

HM5116405S/LS Series



(Top view)

HM5116405TS/LTS Series

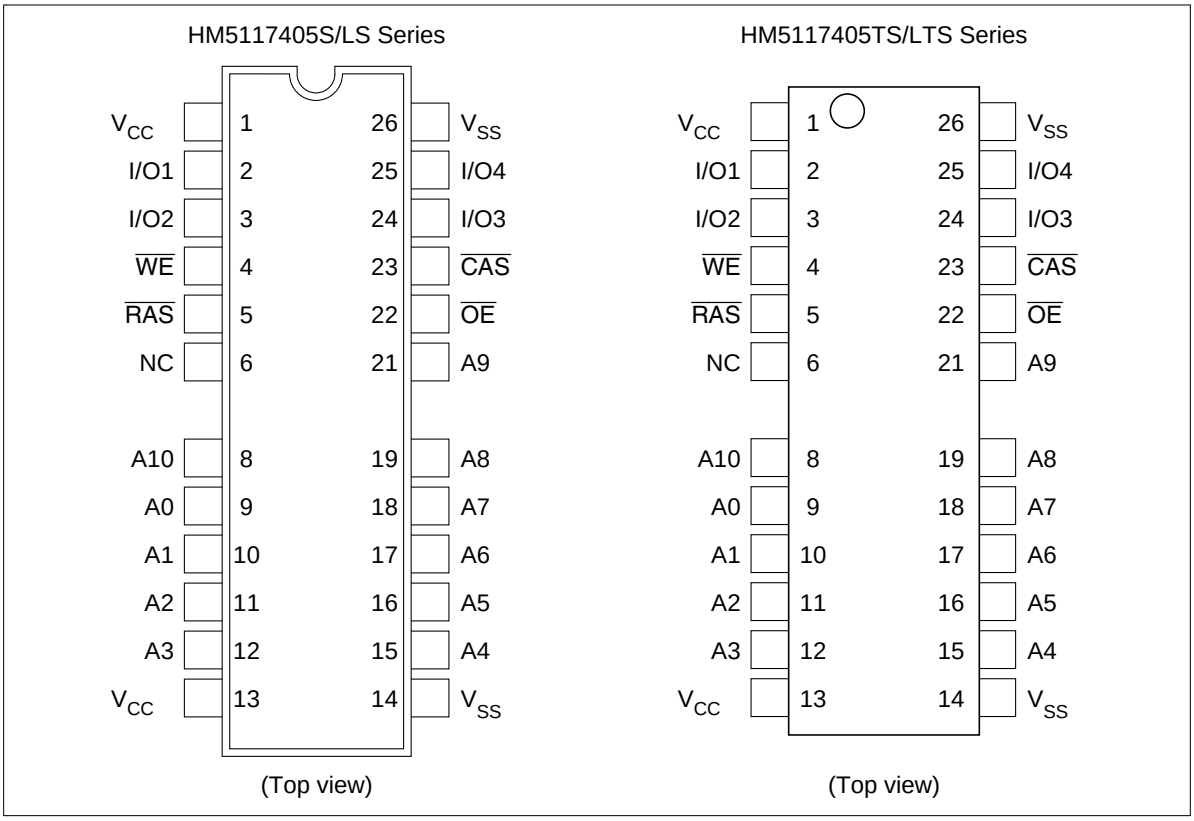


(Top view)

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	
$\overline{WE}$	Write enable	
$\overline{OE}$	Output enable	
V_{CC}	Power supply	
V_{SS}	Ground	

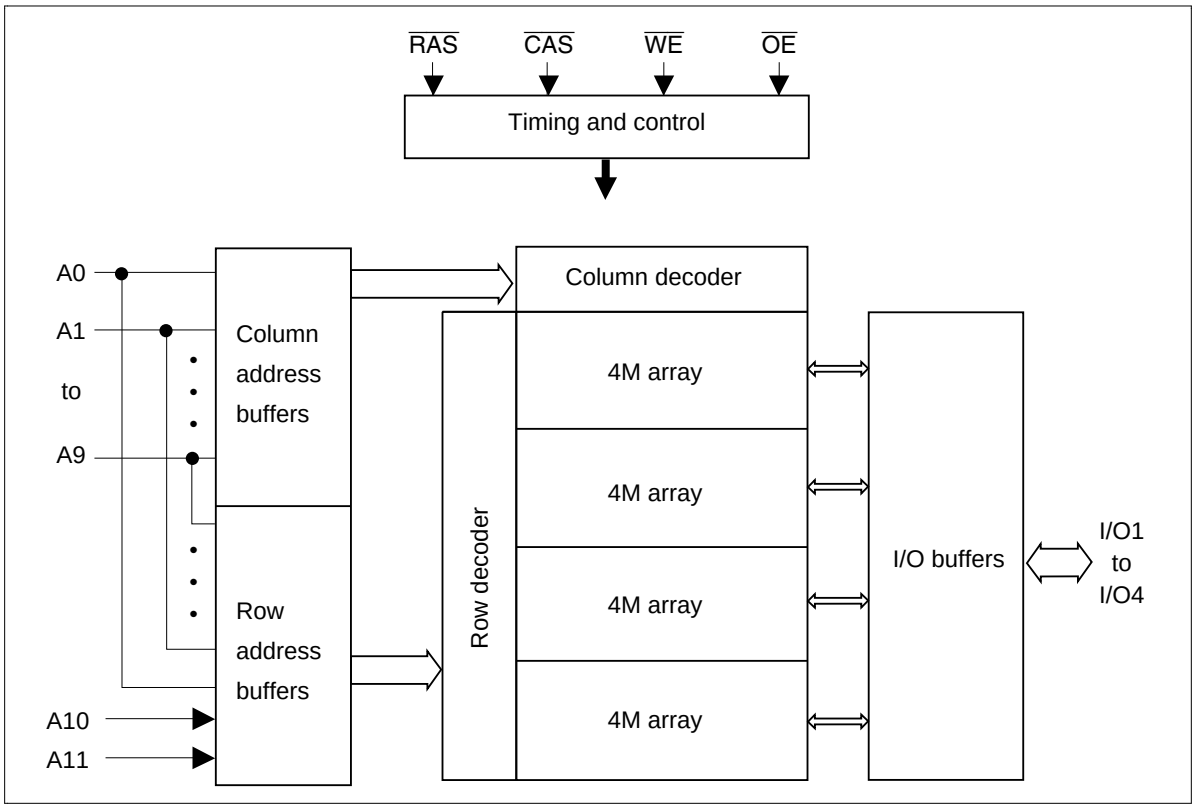
Pin Arrangement



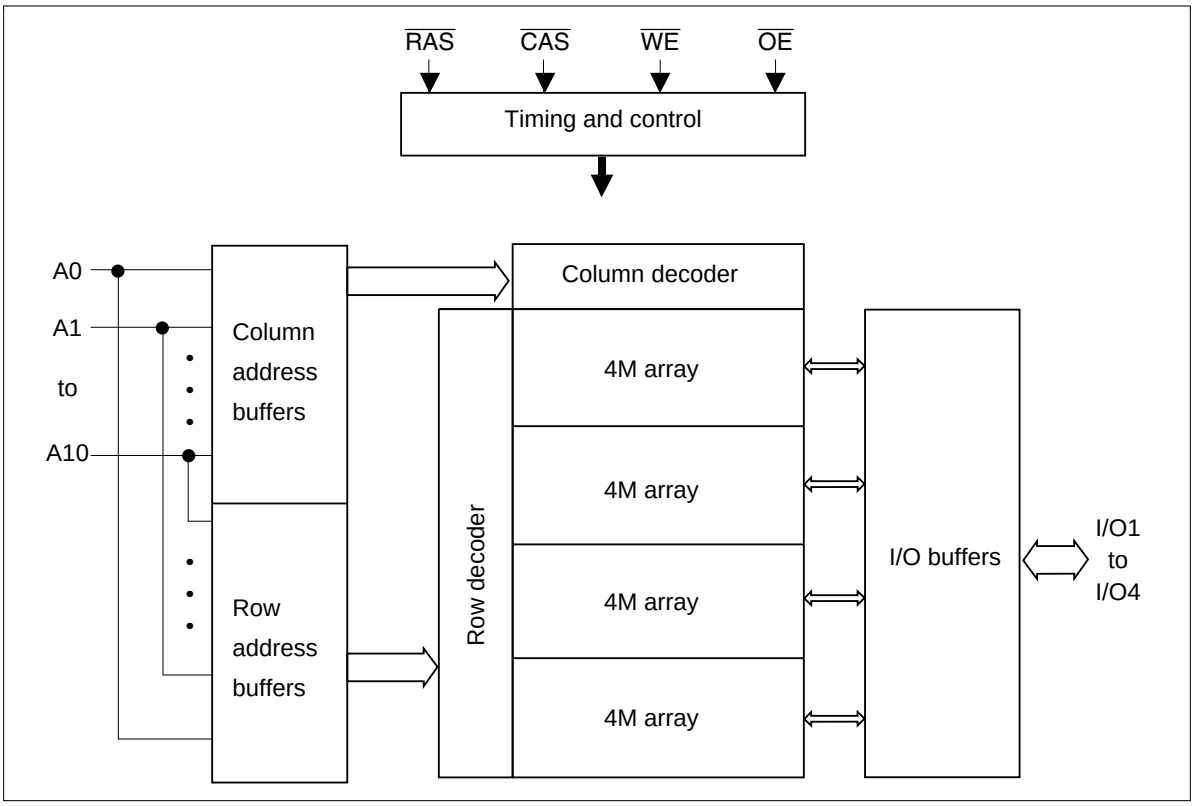
Pin Description

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	
$\overline{RAS}$	Row address strobe	
$\overline{CAS}$	Column address strobe	
$\overline{WE}$	Write enable	
$\overline{OE}$	Output enable	
V_{CC}	Power supply	
V_{SS}	Ground	
NC	No connection	

Block Diagram (HM5116405 Series)



Block Diagram (HM5117405 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	Iout	50	mA
Power dissipation	P_T	1.0	W
Operating temperature	Topr	0 to +70	°C
Storage temperature	Tstg	–55 to +125	°C

Recommended DC Operating Conditions (Ta = 0 to +70°C)

Parameter	Symbol	Min	Typ	Max	Unit	Note
Supply voltage	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}.

DC Characteristics

(Ta = 0 to +70°C, V_{CC} = 5 V ± 10%, V_{SS} = 0 V) (HM5116405 Series)

		HM5116405							
		-5		-6		-7			
Parameter	**Symbol**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Unit**	**Test conditions**
Operating current*[1], *[2]	I_{CC1}	—	90	—	80	—	70	mA	t_{RC} = min
Standby current	I_{CC2}	—	2	—	2	—	2	mA	TTL interface $\overline{RAS}$, $\overline{CAS}$ = V_{IH} Dout = High-Z
		—	1	—	1	—	1	mA	CMOS interface $\overline{RAS}$, $\overline{CAS}$ ≥ V_{CC} – 0.2 V Dout = High-Z
Standby current (L-version)	I_{CC2}	—	150	—	150	—	150	µA	CMOS interface $\overline{RAS}$, $\overline{CAS}$ ≥ V_{CC} – 0.2 V Dout = High-Z
$\overline{RAS}$-only refresh current*[2]	I_{CC3}	—	90	—	80	—	70	mA	t_{RC} = min
Standby current*[1]	I_{CC5}	—	5	—	5	—	5	mA	$\overline{RAS}$ = V_{IH} $\overline{CAS}$ = V_{IL} Dout = enable
$\overline{CAS}$-before-$\overline{RAS}$ refresh current	I_{CC6}	—	90	—	80	—	70	mA	t_{RC} = min
EDO page mode current*[1], *[3]	I_{CC7}	—	80	—	70	—	65	mA	t_{HPC} = min
Battery backup current	I_{CC10}	—	350	—	350	—	350	µA	CMOS interface Dout = High-Z, CBR refresh: t_{RC} = 31.3 µs t_{RAS} ≤ 0.3 µs
Input leakage current	I_{LI}	–10	10	–10	10	–10	10	µA	0 V ≤ Vin ≤ 7 V
Output leakage current	I_{LO}	–10	10	–10	10	–10	10	µA	0 V ≤ Vin ≤ 7 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 $\overline{RAS}$ = V_{IL}.

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

DC Characteristics

(Ta = 0 to +70°C, V_{CC} = 5 V ± 10%, V_{SS} = 0 V) (HM5117405 Series)

		HM5117405							
		-5		-6		-7			
Parameter	**Symbol**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Unit**	**Test conditions**
Operating current*1, *2	I_{CC1}	—	100	—	90	—	80	mA	t_{RC} = min
Standby current	I_{CC2}	—	2	—	2	—	2	mA	TTL interface $\overline{RAS}$, $\overline{CAS}$ = V_{IH} Dout = High-Z
		—	1	—	1	—	1	mA	CMOS interface $\overline{RAS}$, $\overline{CAS}$ ≥ V_{CC} – 0.2 V Dout = High-Z
Standby current (L-version)	I_{CC2}	—	150	—	150	—	150	µA	CMOS interface $\overline{RAS}$, $\overline{CAS}$ ≥ V_{CC} – 0.2 V Dout = High-Z
$\overline{RAS}$-only refresh current*2	I_{CC3}	—	100	—	90	—	80	mA	t_{RC} = min
Standby current*1	I_{CC5}	—	5	—	5	—	5	mA	$\overline{RAS}$ = V_{IH} $\overline{CAS}$ = V_{IL} Dout = enable
$\overline{CAS}$-before-$\overline{RAS}$ refresh current	I_{CC6}	—	100	—	90	—	80	mA	t_{RC} = min
EDO page mode current*1, *3	I_{CC7}	—	90	—	80	—	75	mA	t_{HPC} = min
Battery backup current	I_{CC10}	—	350	—	350	—	350	µA	CMOS interface Dout = High-Z, CBR refresh: t_{RC} = 62.5 µs t_{RAS} ≤ 0.3 µs
Input leakage current	I_{LI}	–10	10	–10	10	–10	10	µA	0 V ≤ Vin ≤ 7 V
Output leakage current	I_{LO}	–10	10	–10	10	–10	10	µA	0 V ≤ Vin ≤ 7 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 $\overline{RAS}$ = V_{IL}.

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

Capacitance (Ta = 25°C, V_{CC} = 5 V ±10%)

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

Notes : 1. Capacitance measured with Boonton Meter or effective capacitance measuring method.
2. $\overline{CAS}$ = V_{IH} to disable Dout.

AC Characteristics (Ta = 0 to +70°C, V_{CC} = 5 V ±10%, V_{SS} = 0 V) *[1], *[2], *[18]

Test Conditions

- Input rise and fall time: 2 ns
- Input levels: V_{IL} = 0 V, V_{IH} = 3 V
- Input timing reference levels: 0.8 V, 2.4 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)

		HM5116405/HM5117405							
		-5		-6		-7			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
Random read or write cycle time	t_{RC}	84	—	104	—	124	—	ns	
$\overline{RAS}$ precharge time	t_{RP}	30	—	40	—	50	—	ns	
$\overline{CAS}$ precharge time	t_{CP}	7	—	10	—	13	—	ns	
$\overline{RAS}$ pulse width	t_{RAS}	50	10000	60	10000	70	10000	ns	
$\overline{CAS}$ pulse width	t_{CAS}	7	10000	10	10000	13	10000	ns	
Row address setup time	t_{ASR}	0	—	0	—	0	—	ns	
Row address hold time	t_{RAH}	7	—	10	—	10	—	ns	
Column address setup time	t_{ASC}	0	—	0	—	0	—	ns	
Column address hold time	t_{CAH}	7	—	10	—	13	—	ns	
$\overline{RAS}$ to $\overline{CAS}$ delay time	t_{RCD}	11	37	14	45	14	52	ns	3
$\overline{RAS}$ to column address delay time	t_{RAD}	9	25	12	30	12	35	ns	4
$\overline{RAS}$ hold time	t_{RSH}	10	—	13	—	13	—	ns	
$\overline{CAS}$ hold time	t_{CSH}	35	—	40	—	45	—	ns	
$\overline{CAS}$ to $\overline{RAS}$ precharge time	t_{CRP}	5	—	5	—	5	—	ns	
$\overline{OE}$ to Din delay time	t_{OED}	13	—	15	—	18	—	ns	5
$\overline{OE}$ delay time from Din	t_{DZO}	0	—	0	—	0	—	ns	6
$\overline{CAS}$ 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

Read Cycle

		HM5116405/HM5117405							
		-5		-6		-7			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
Access time from $\overline{RAS}$	t_{RAC}	—	50	—	60	—	70	ns	8, 9, 20
Access time from $\overline{CAS}$	t_{CAC}	—	13	—	15	—	18	ns	9, 10, 17, 20
Access time from address	t_{AA}	—	25	—	30	—	35	ns	9, 11, 17, 20
Access time from $\overline{OE}$	t_{OEA}	—	13	—	15	—	18	ns	9, 20
Read command setup time	t_{RCS}	0	—	0	—	0	—	ns	
Read command hold time to $\overline{CAS}$	t_{RCH}	0	—	0	—	0	—	ns	12
Read command hold time from $\overline{RAS}$	t_{RCHR}	50	—	60	—	70	—	ns	
Read command hold time to $\overline{RAS}$	t_{RRH}	0	—	0	—	0	—	ns	12
Column address to $\overline{RAS}$ lead time	t_{RAL}	25	—	30	—	35	—	ns	
Column address to $\overline{CAS}$ lead time	t_{CAL}	15	—	18	—	23	—	ns	
$\overline{CAS}$ to output in low-Z	t_{CLZ}	0	—	0	—	0	—	ns	
Output data hold time	t_{OH}	3	—	3	—	3	—	ns	22
Output data hold time from $\overline{OE}$	t_{OHO}	3	—	3	—	3	—	ns	
Output buffer turn-off time	t_{OFF}	—	13	—	15	—	15	ns	13, 22
Output buffer turn-off to $\overline{OE}$	t_{OEZ}	—	13	—	15	—	15	ns	13
$\overline{CAS}$ to Din delay time	t_{CDD}	13	—	15	—	18	—	ns	5
Output data hold time from $\overline{RAS}$	t_{OHR}	3	—	3	—	3	—	ns	22
Output buffer turn-off to $\overline{RAS}$	t_{OFR}	—	13	—	15	—	15	ns	22
Output buffer turn-off to $\overline{WE}$	t_{WEZ}	—	13	—	15	—	15	ns	
$\overline{WE}$ to Din delay time	t_{WED}	13	—	15	—	18	—	ns	
$\overline{RAS}$ to Din delay time	t_{RDD}	13	—	15	—	18	—	ns	
$\overline{RAS}$ next $\overline{CAS}$ delay time	t_{RNCD}	50	—	60	—	70	—	ns	

Write Cycle

		HM5116405/HM5117405							
		-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}	7	—	10	—	13	—	ns	
Write command pulse width	t_{WP}	7	—	10	—	10	—	ns	
Write command to $\overline{RAS}$ lead time	t_{RWL}	7	—	10	—	13	—	ns	
Write command to $\overline{CAS}$ lead time	t_{CWL}	7	—	10	—	13	—	ns	
Data-in setup time	t_{DS}	0	—	0	—	0	—	ns	15
Data-in hold time	t_{DH}	7	—	10	—	13	—	ns	15

Read-Modify-Write Cycle

		HM5116405/HM5117405							
		-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

		HM5116405/HM5117405							
		-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}	7	—	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}	7	—	10	—	10	—	ns	
$\overline{RAS}$ precharge to $\overline{CAS}$ hold time	t_{RPC}	5	—	5	—	5	—	ns	

EDO Page Mode Cycle

		HM51W16405/HM51W17405							
		-5		-6		-7			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
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}	—	28	—	35	—	40	ns	9, 17, 20
$\overline{RAS}$ hold time from $\overline{CAS}$ precharge	t_{CPRH}	28	—	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}	7	—	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}	28	—	35	—	40	—	ns	

EDO Page Mode Read-Modify-Write Cycle

		HM5116405/HM5117405							
		-5		-6		-7			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
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]

		HM5116405/HM5117405							
		-5		-6		-7			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
Test mode $\overline{WE}$ setup time	t_{WTS}	0	—	0	—	0	—	ns	
Test mode $\overline{WE}$ hold time	t_{WTH}	7	—	10	—	10	—	ns	

Refresh (HM5116405 Series)

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

Refresh (HM5117405 Series)

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

Notes:
1. AC measurements assume t_T = 2 ns.
2. An initial pause of 200 µs 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 $\overline{CAS}$ leading edge in early write cycles and to $\overline{WE}$ leading edge in delayed write or read-modify-write cycles.
16. t_{RASP} defines $\overline{RAS}$ pulse width in EDO page mode cycles.
17. Access time is determined by the longest among t_{AA}, t_{CAC} and t_{CPA}.
18. In delayed write or read-modify-write cycles, $\overline{OE}$ 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 ×4 are don't care during test mode. Test mode is set by performing a $\overline{WE}$-and-$\overline{CAS}$-before-$\overline{RAS}$ (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 $\overline{CAS}$-before-$\overline{RAS}$ refresh cycle or $\overline{RAS}$-only refresh cycle.

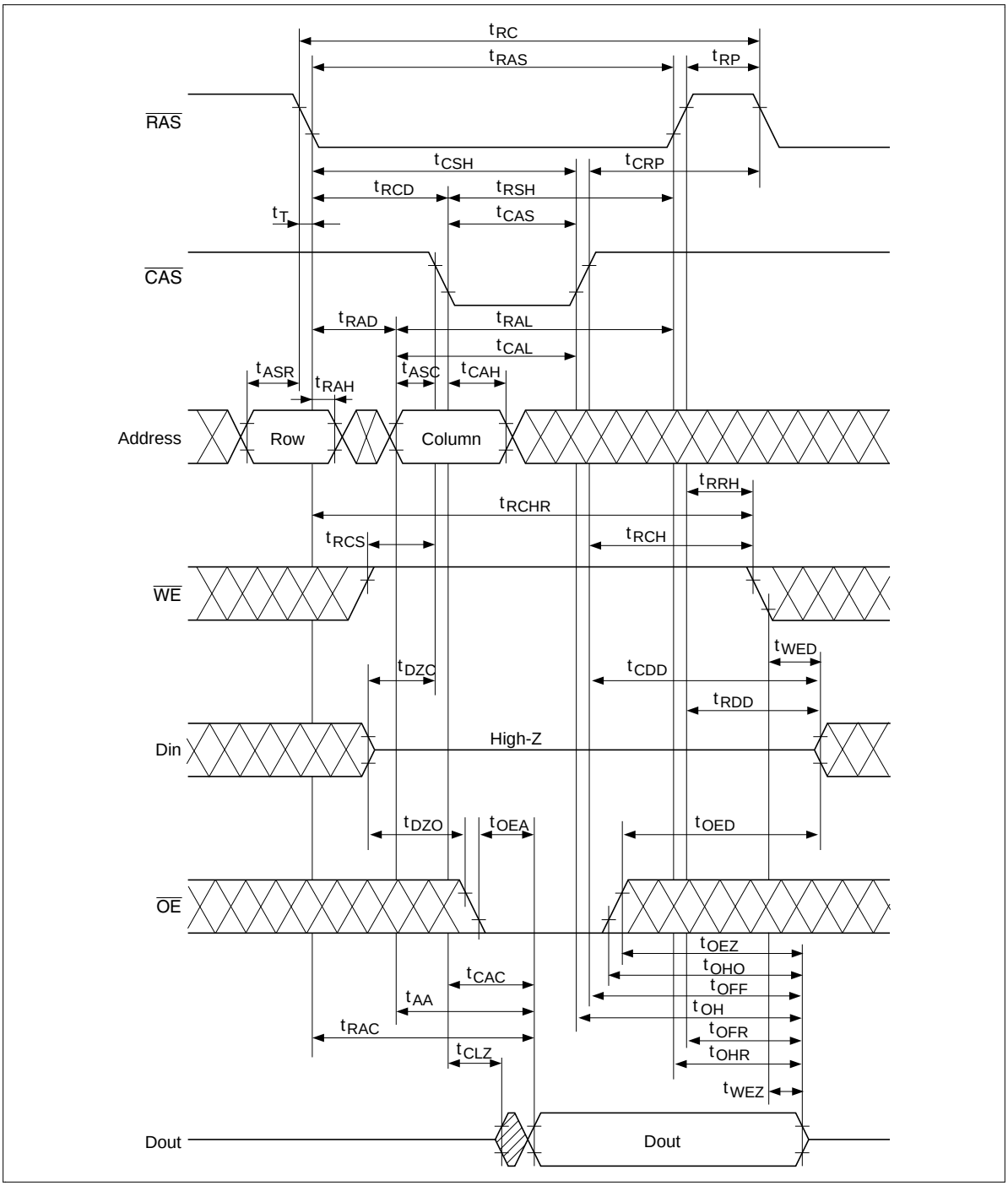
20. In a test mode read cycle, the value of t_{RAC}, t_{AA}, t_{CAC} and t_{CPA} is delayed by 2 ns to 5 ns for the specified value. These parameters should be specified in test mode cycles by adding the above value to the specified value in this data sheet.
21. t_{HPC} (min) can be achieved during a 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 $\overline{RAS}$ cycle (EDO page mode mix cycle (1), (2)), minimum value of $\overline{CAS}$ cycle ($t_{CAS} + t_{CP} + 2\ t_T$) becomes greater than the specified t_{HPC} (min) value. The value of $\overline{CAS}$ cycle time of mixed EDO page mode is shown in EDO page mode mix cycle (1) and (2).
    Data output turns off and becomes high impedance from later risting edge of $\overline{RAS}$ and $\overline{CAS}$. Hold time and turn off time are specified by the timing specifications of later rising edge of $\overline{RAS}$ and $\overline{CAS}$ between t_{OHR} and t_{OH}, and between t_{OFR} and t_{OFF}.
22. Data output turns off and becomes high impedance from later rising edge of $\overline{RAS}$ and $\overline{CAS}$. Hold time and turn off time are specified by the timing specifications of later rising edge of $\overline{RAS}$ and $\overline{CAS}$ between t_{OHR} and t_{OH} and between t_{OFR} and t_{OFF}.
23. XXX: H or L (H: V_{IH} (min) ≤ V_{IN} ≤ V_{IH} (max), L: V_{IL} (min) ≤ V_{IN} ≤ V_{IL} (max))

    ///////: Invalid Dout

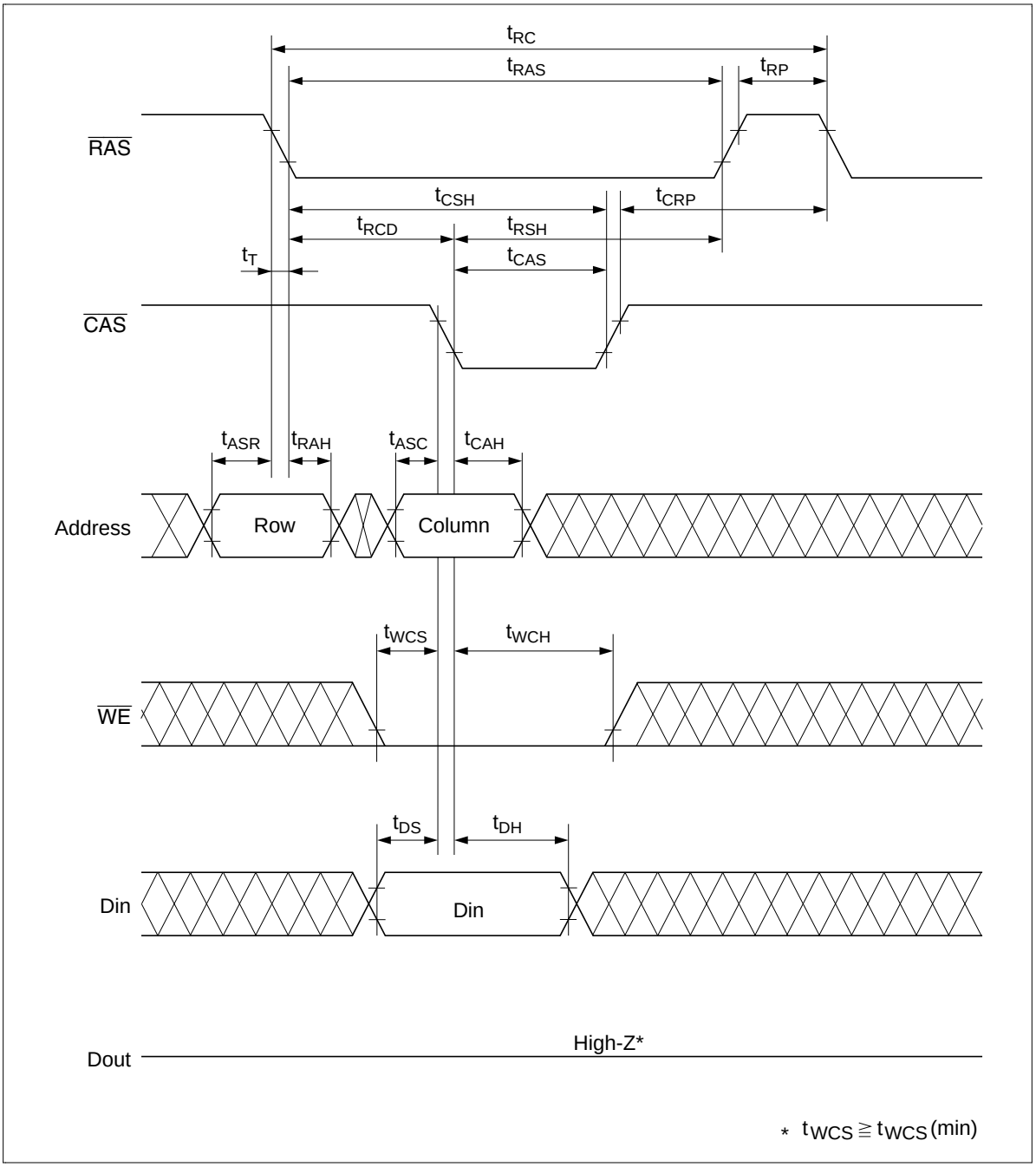
    When the address, clock and input pins are not described on timing waveforms, their pins must be applied V_{IH} or V_{IL}.

Timing Waveforms*[23]

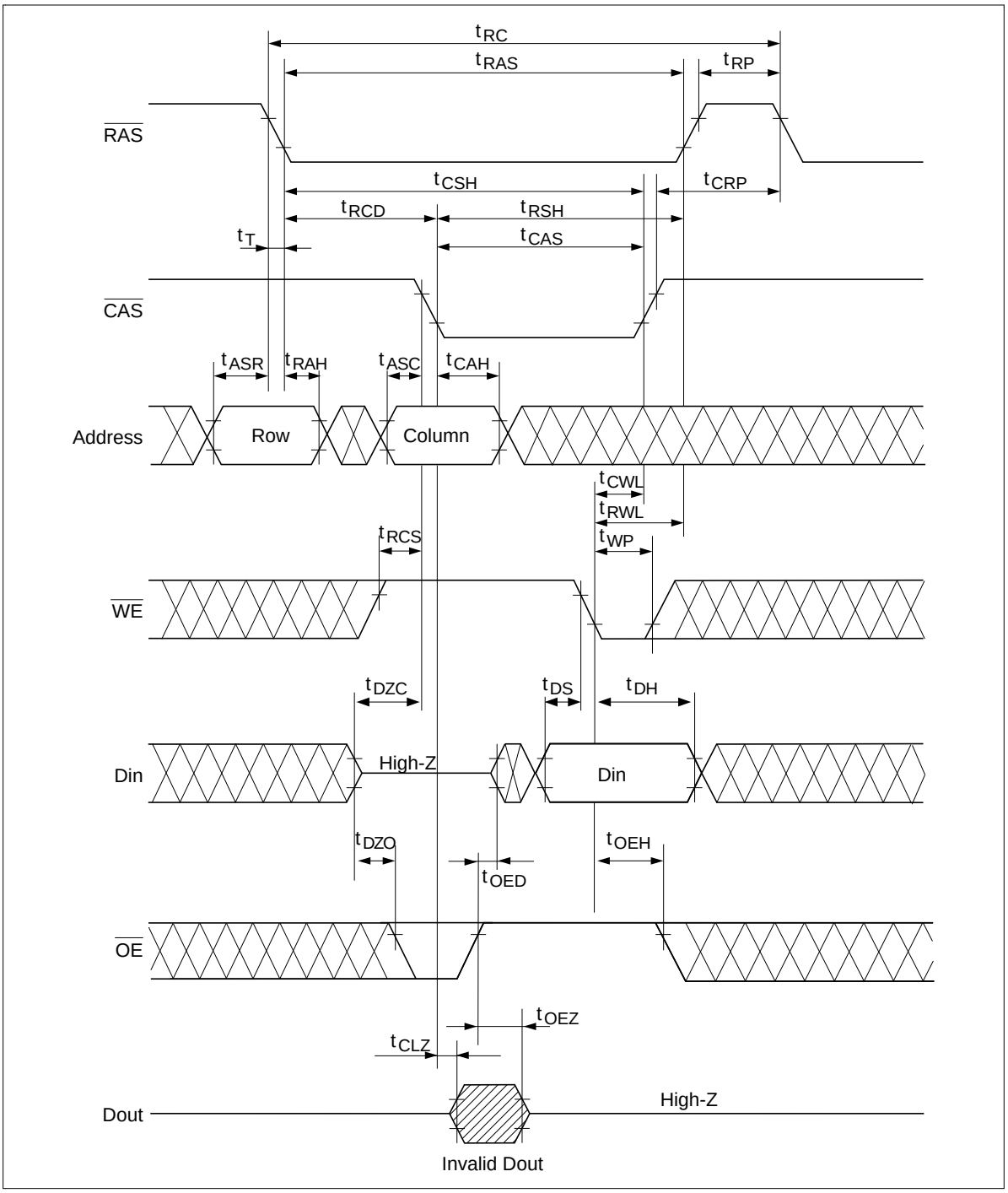
Read Cycle



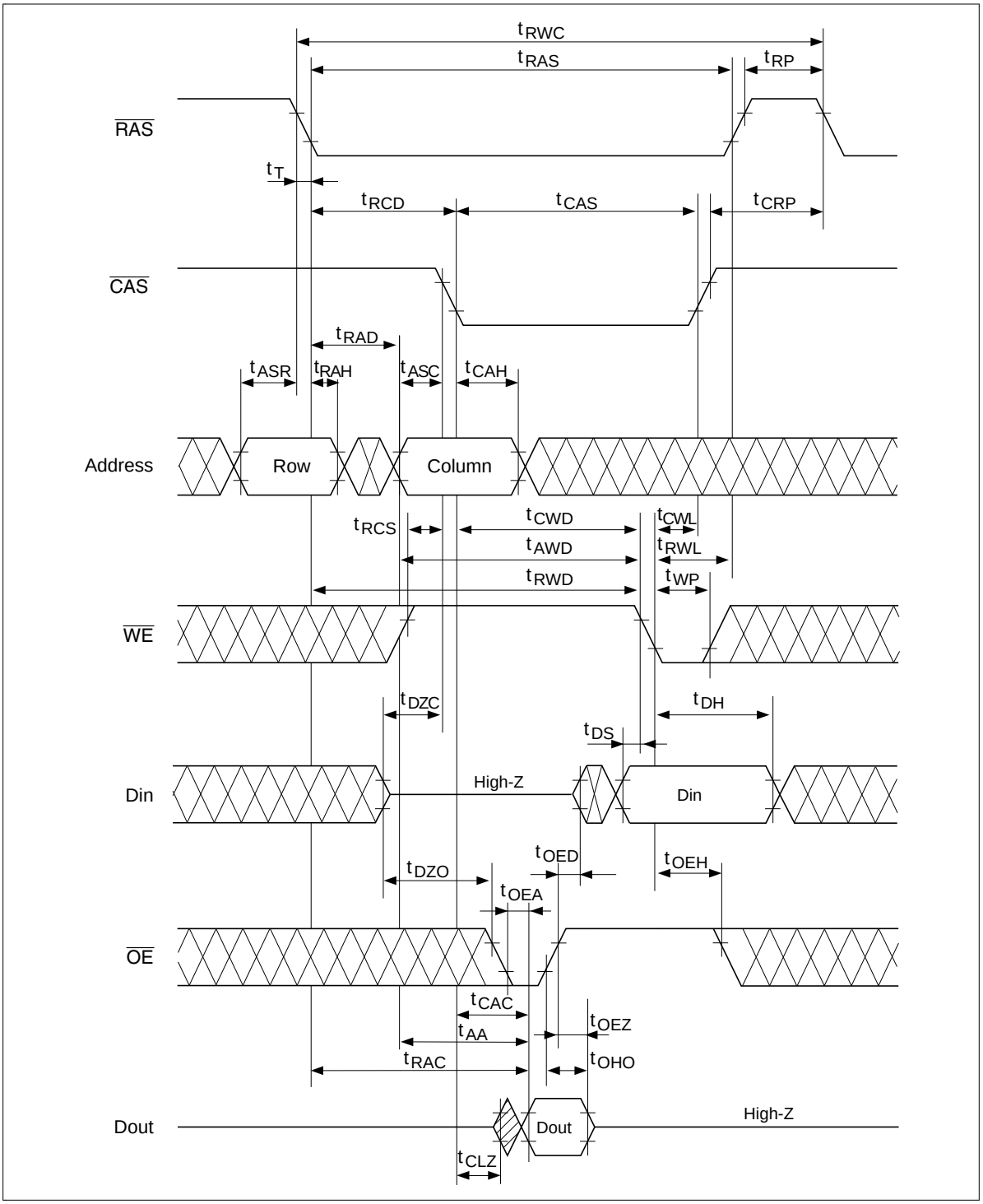
Early Write Cycle


tRC
tRAS
tRP
RAS
tCSH
tCRP
tRCD
tRSH
tT
tCAS
CAS
tASR
tRAH
tASC
tCAH
Address
Row
Column
tWCS
tWCH
WE
tDS
tDH
Din
Din
Dout
High-Z*
* tWCS ≧ tWCS (min)

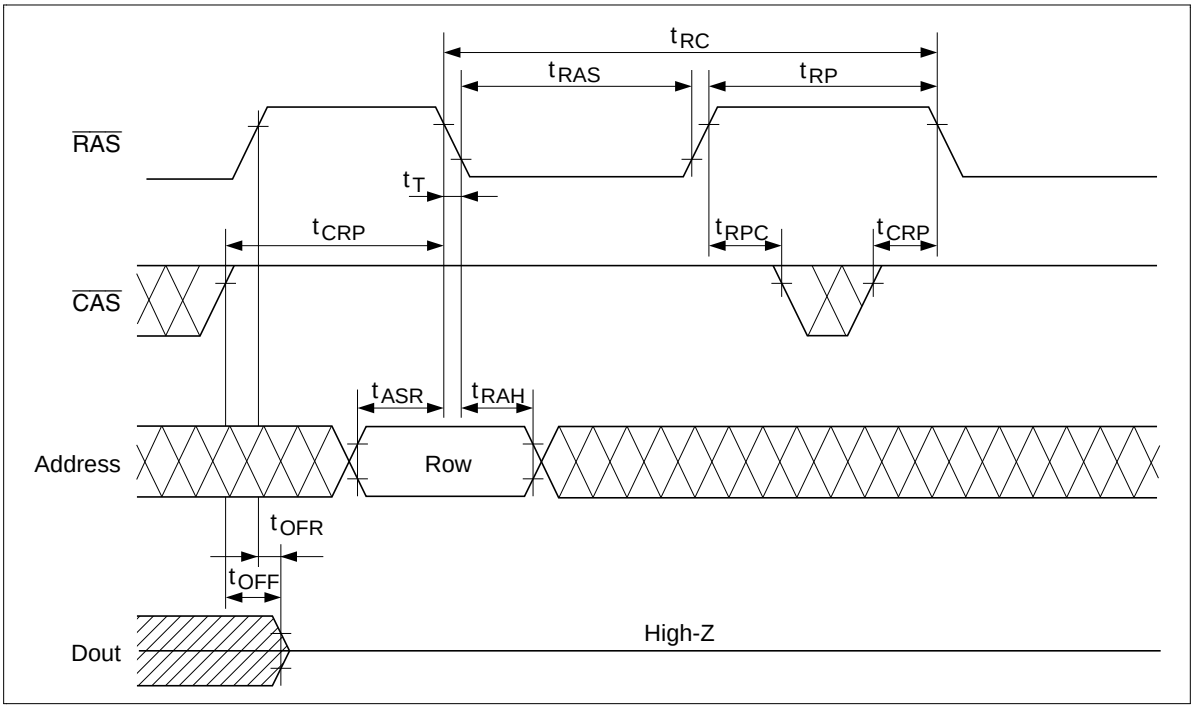
Delayed Write Cycle*[18]



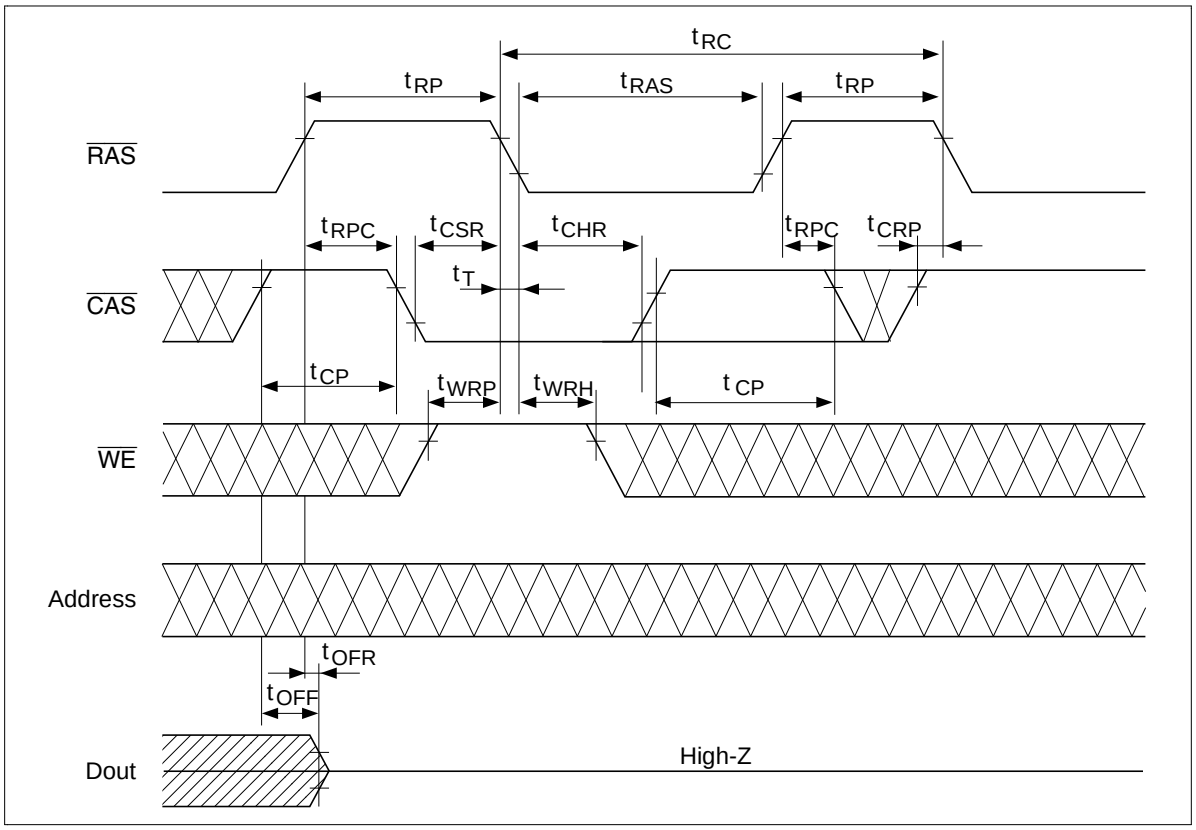
Read-Modify-Write Cycle*[18]



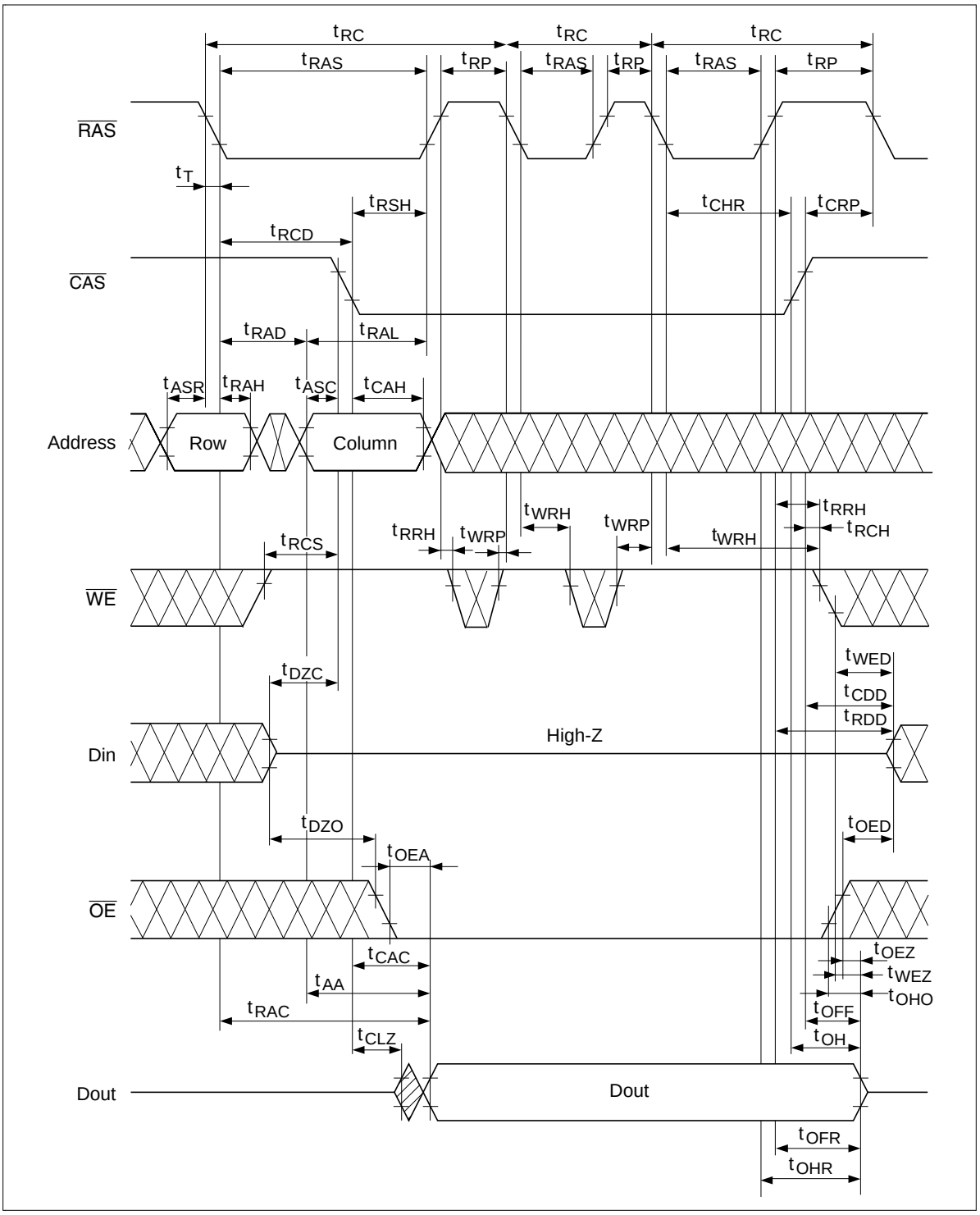
RAS-Only Refresh Cycle


tRC
tRAS
tRP
RAS
tT
tCRP
tRPC
tCRP
CAS
tASR
tRAH
Address
Row
tOFR
tOFF
Dout
High-Z

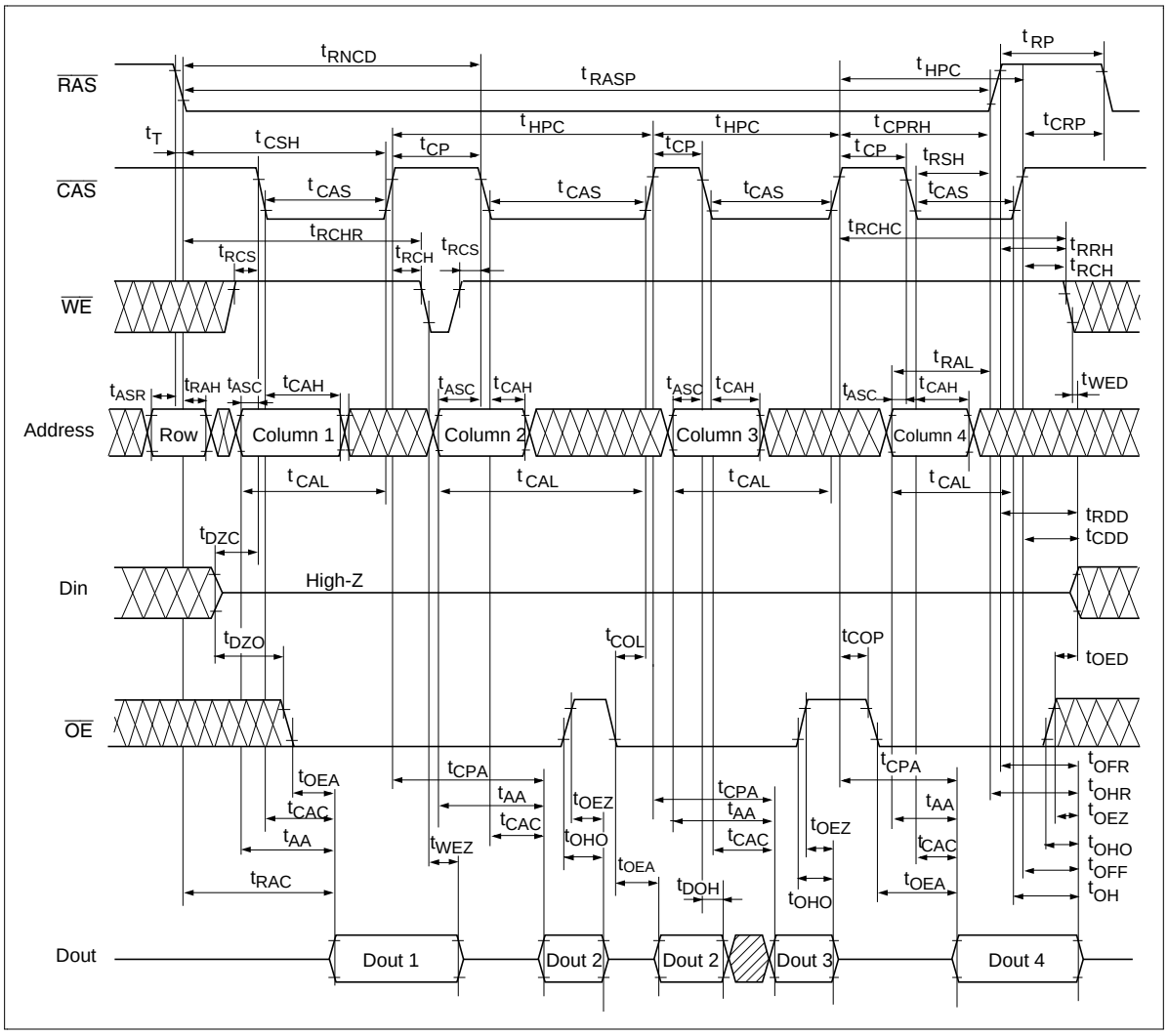
$\overline{\text{CAS}}$-Before-$\overline{\text{RAS}}$ Refresh Cycle



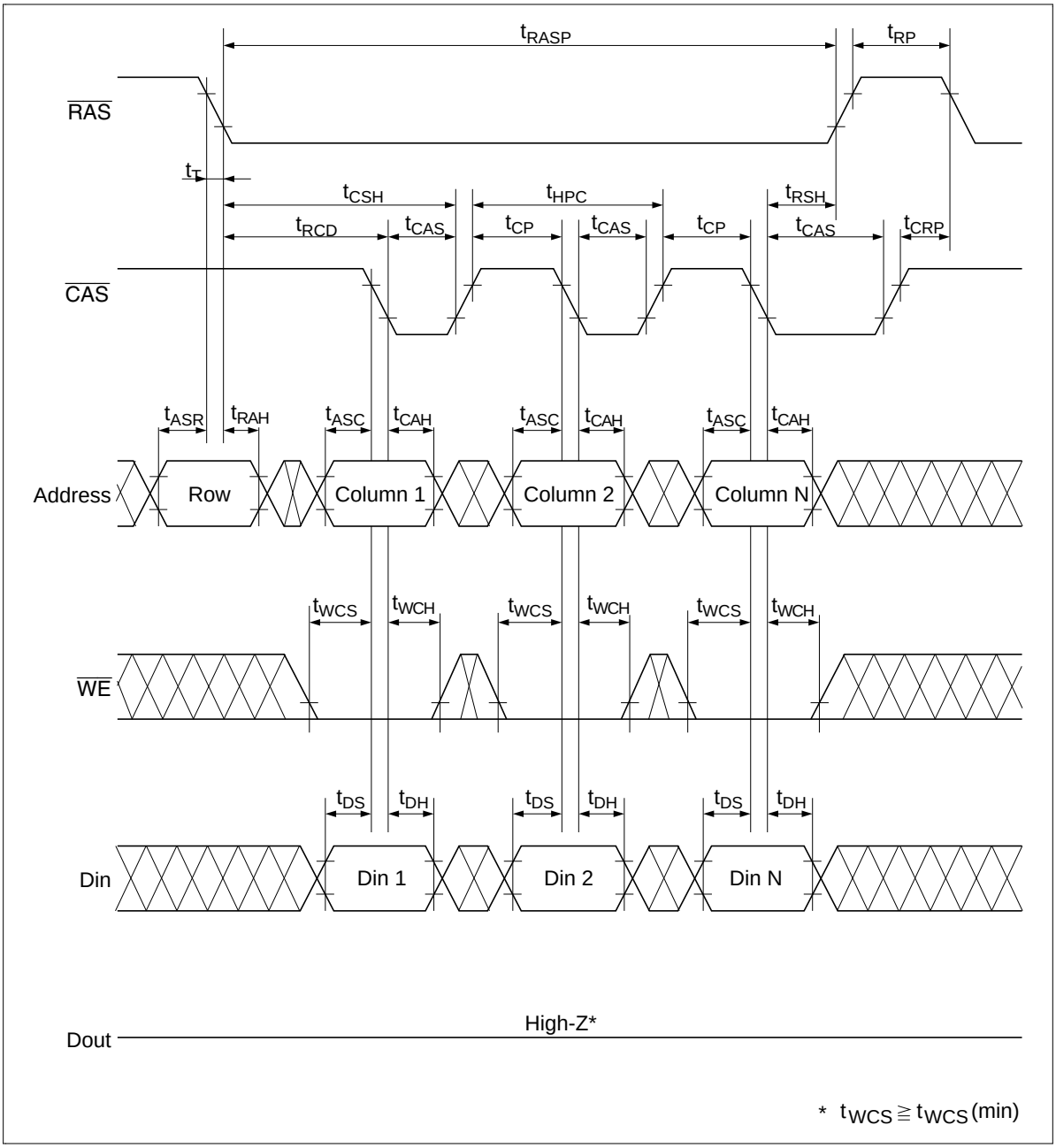
Hidden Refresh Cycle



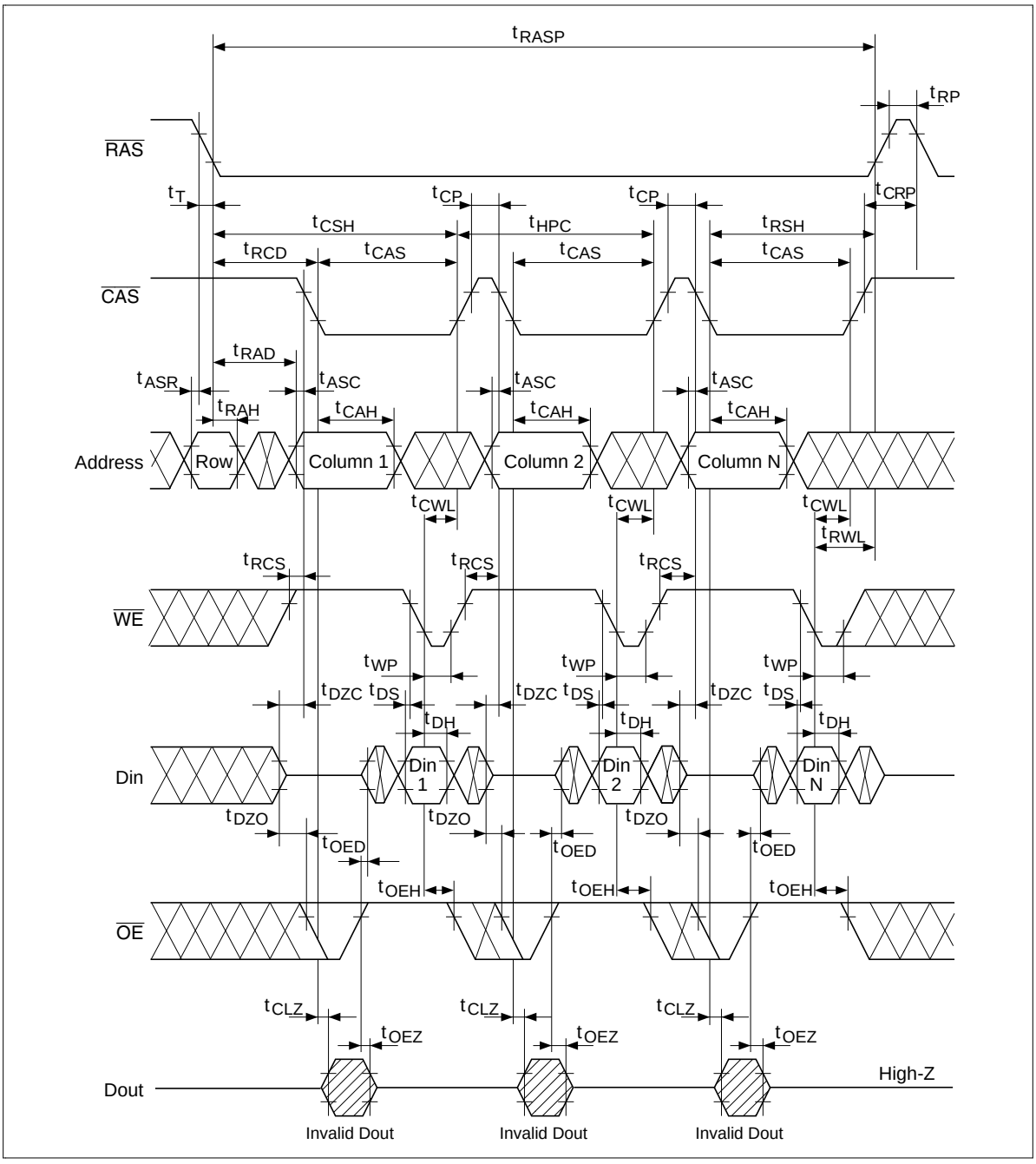
EDO Page Mode Read Cycle



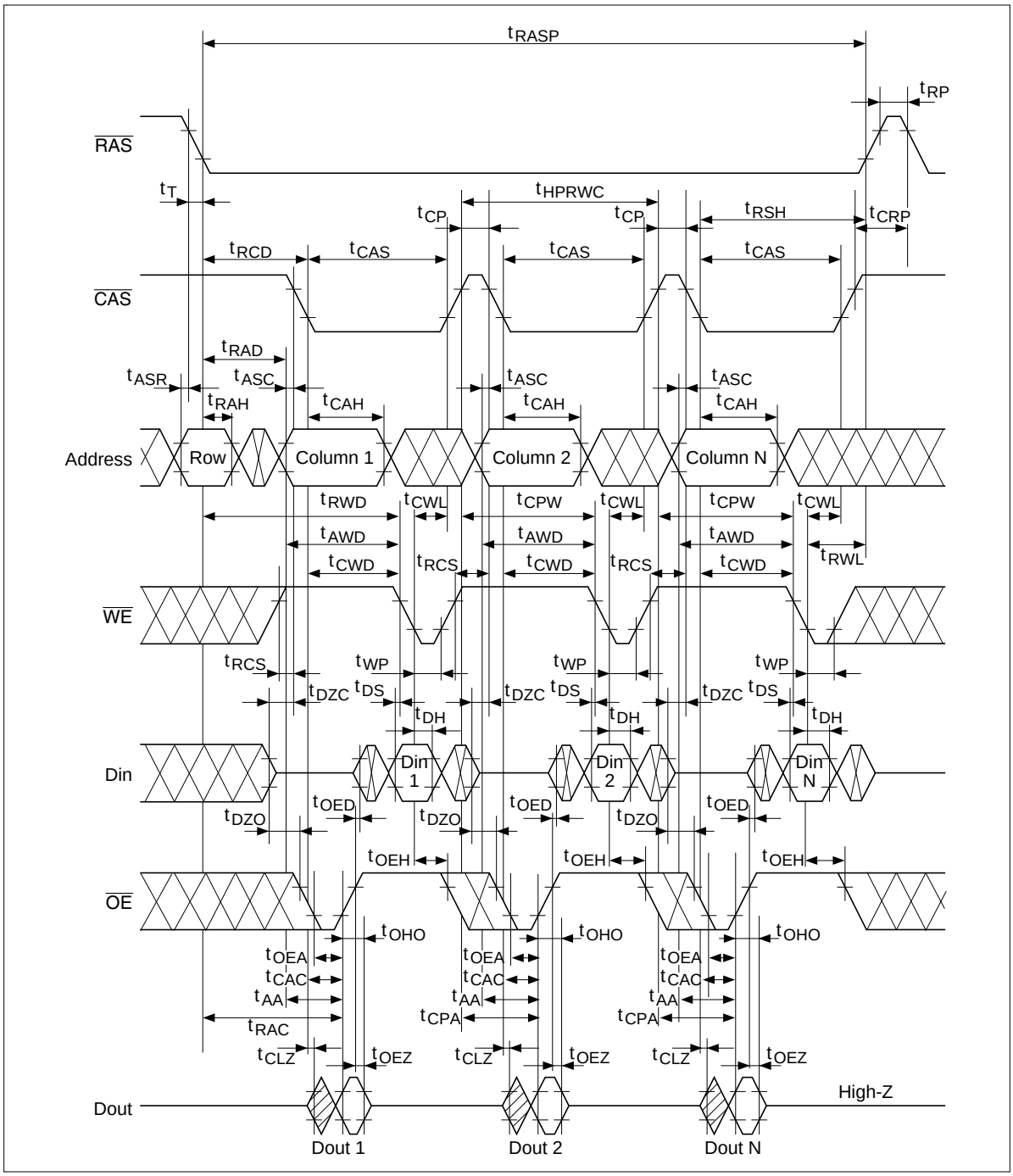
EDO Page Mode Early Write Cycle



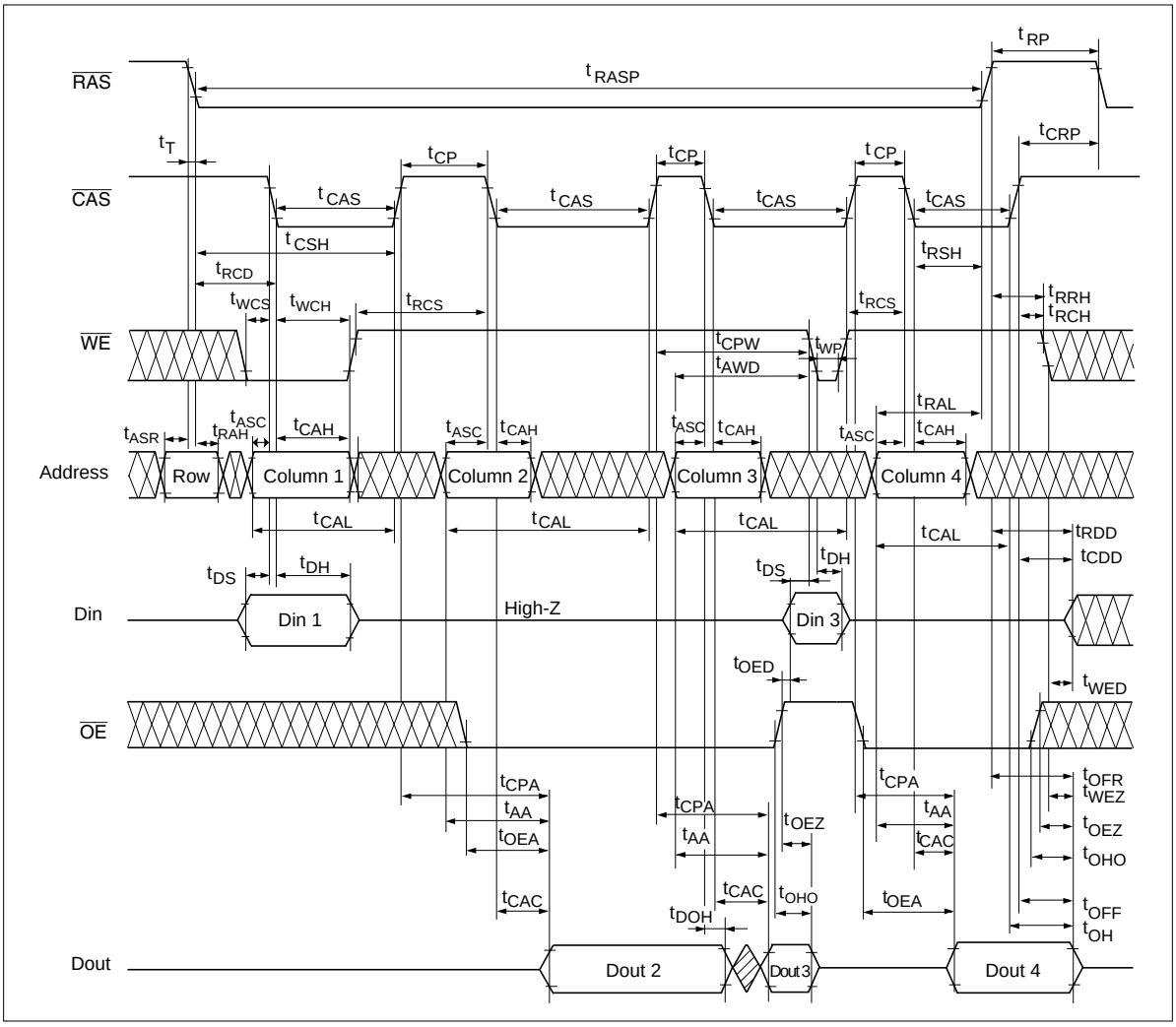
EDO Page Mode Delayed Write Cycle*[18]



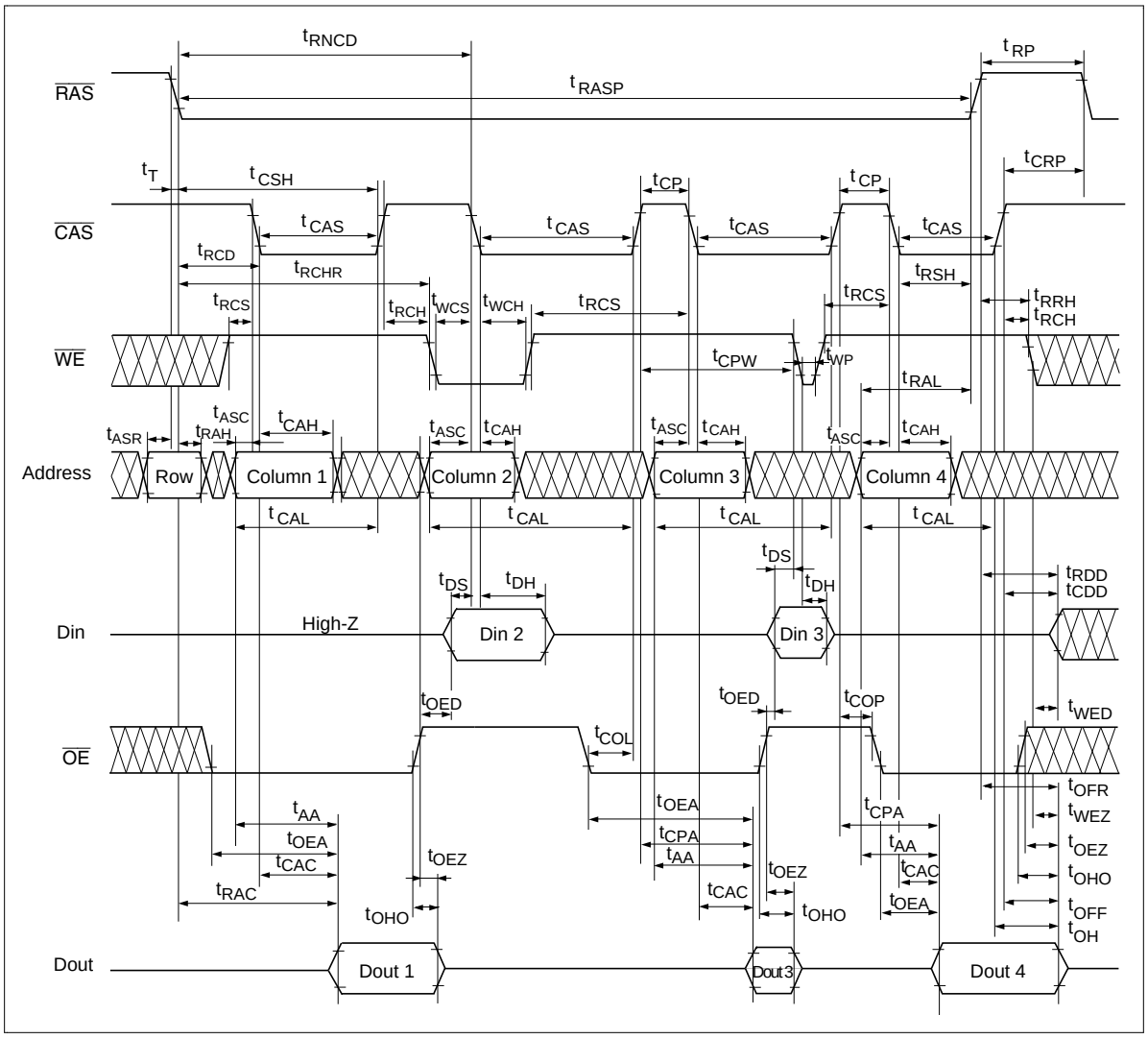
EDO Page Mode Read-Modify-Write Cycle*[18]



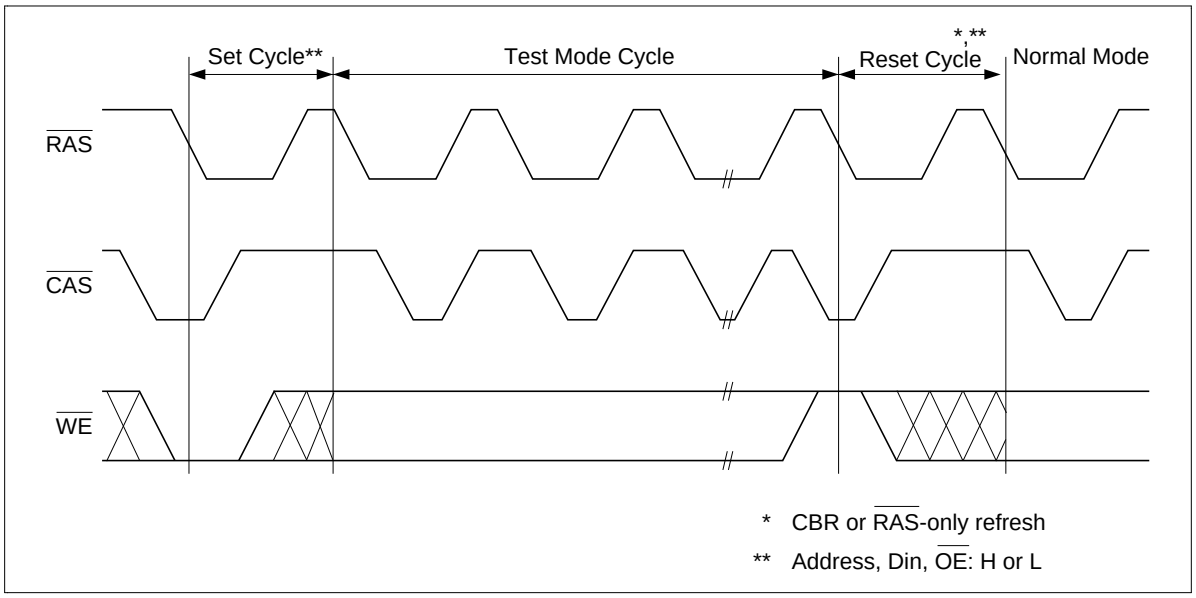
EDO Page Mode Mix Cycle (1)



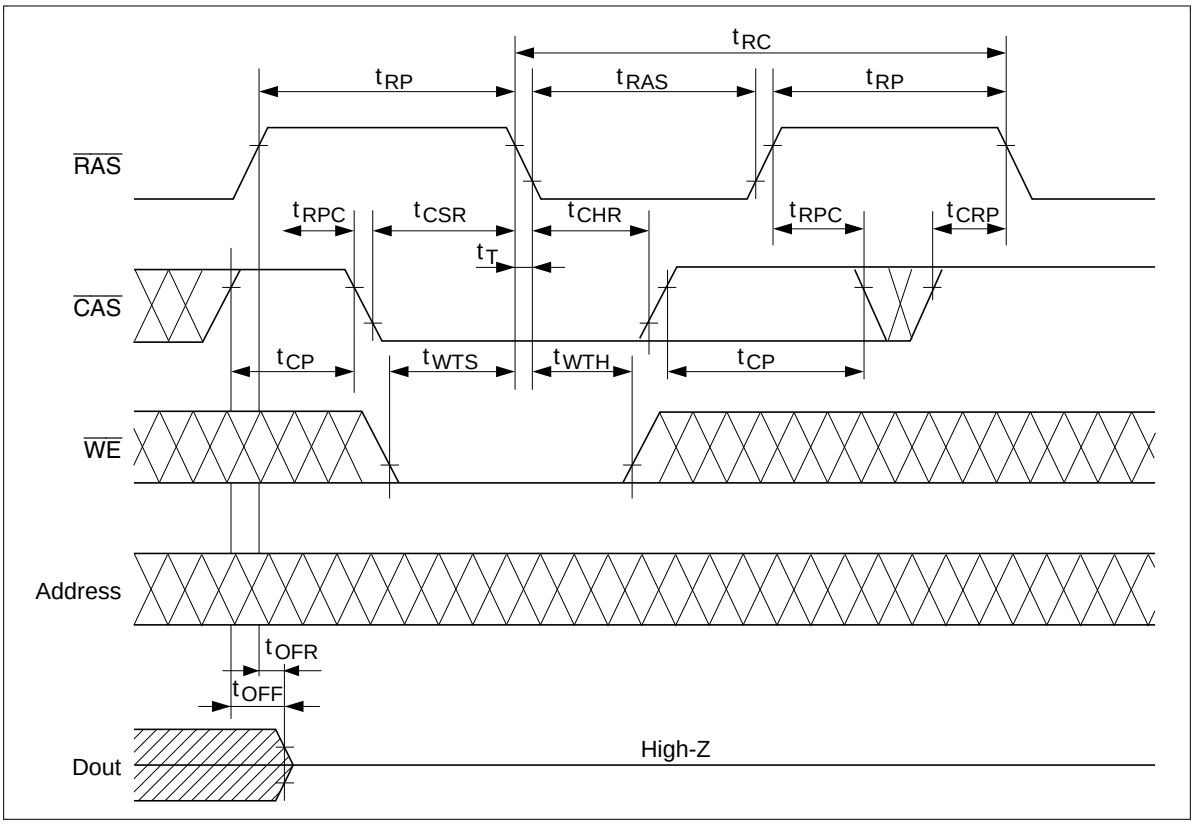
EDO Page Mode Mix Cycle (2)



Test Mode Cycle *[19]



Test Mode Set Cycle

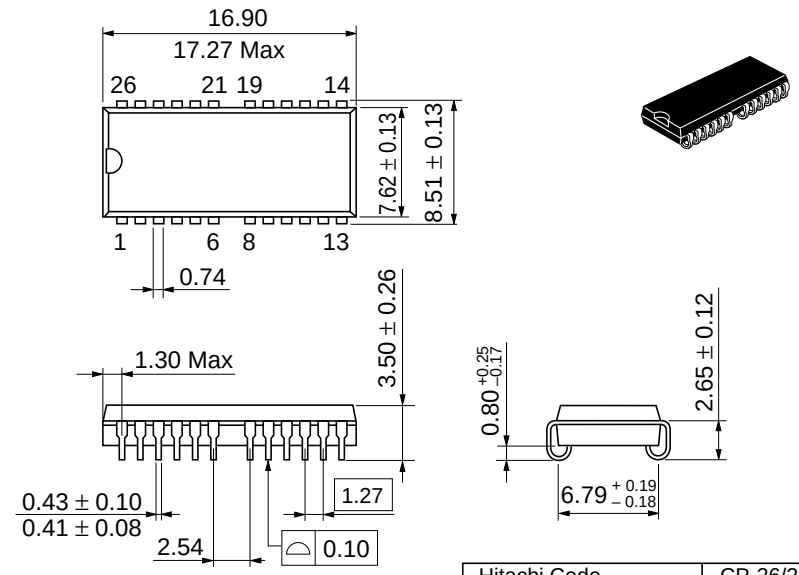


Package Dimensions

HM5116405S/LS Series

HM5117405S/LS Series (CP-26/24DB)

Unit: mm



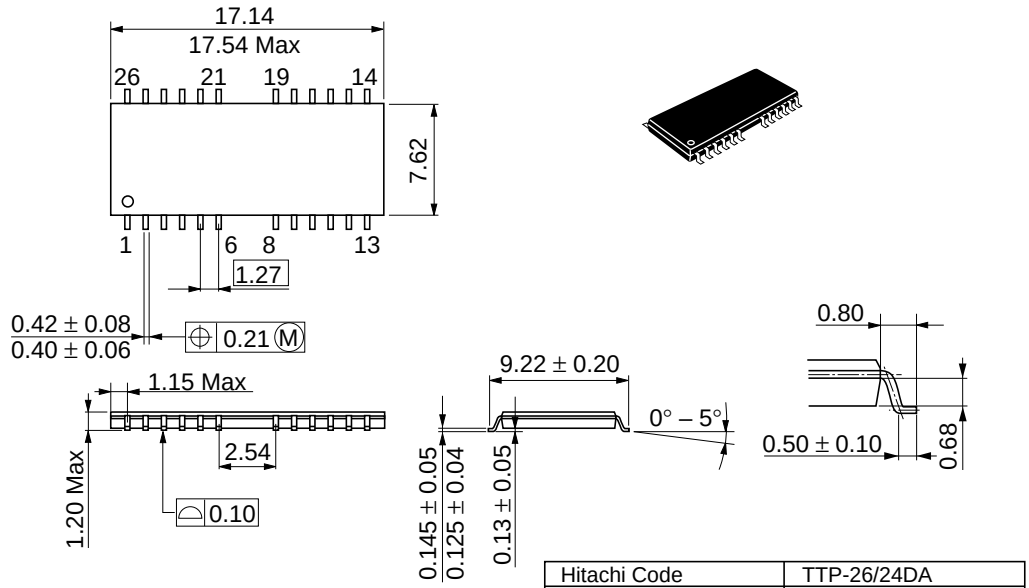
Dimension including the plating thickness
Base material dimension

Hitachi Code	CP-26/24DB
JEDEC	Conforms
EIAJ	Conforms
Weight (reference value)	0.8 g

HM5116405TS/LTS Series

HM5117405TS/LTS Series (TTP-26/24DA)

Unit: mm



Dimension including the plating thickness
Base material dimension

Hitachi Code	TTP-26/24DA
JEDEC	Conforms
EIAJ	—
Weight (reference value)	0.30 g

When using this document, keep the following in mind:

1. This document may, wholly or partially, be subject to change without notice.
2. All rights are reserved: No one is permitted to reproduce or duplicate, in any form, the whole or part of this document without Hitachi's permission.
3. Hitachi will not be held responsible for any damage to the user that may result from accidents or any other reasons during operation of the user's unit according to this document.
4. Circuitry and other examples described herein are meant merely to indicate the characteristics and performance of Hitachi's semiconductor products. Hitachi assumes no responsibility for any intellectual property claims or other problems that may result from applications based on the examples described herein.
5. No license is granted by implication or otherwise under any patents or other rights of any third party or Hitachi, Ltd.
6. MEDICAL APPLICATIONS: Hitachi's products are not authorized for use in MEDICAL APPLICATIONS without the written consent of the appropriate officer of Hitachi's sales company. Such use includes, but is not limited to, use in life support systems. Buyers of Hitachi's products are requested to notify the relevant Hitachi sales offices when planning to use the products in MEDICAL APPLICATIONS.

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 Semiconductor
(America) Inc.
2000 Sierra Point Parkway
Brisbane, CA. 94005-1897
U S A
Tel: 800-285-1601
Fax:303-297-0447

Hitachi Europe GmbH
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: 01628-585000
Fax: 01628-585160

Hitachi Asia Pte. Ltd.
16 Collyer Quay #20-00
Hitachi Tower
Singapore 049318
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. 8, 1996	Addition of HM5116405-5 Series Addition of HM5117405-5 Series Power dissipation (active) 550/495 mW(max) to 495/440/385 mW (max) (HM5116405 Series) 605/550 mW(max) to 550/495/440 mW (max) (HM5117405 Series) DC Characteristics (HM5116405 Series) I_{CC7} max: 110/100 mA to 80/70/65 mA DC Characteristics (HM5117405 Series) I_{CC1} max: 110/100 mA to 100/90/80 mA I_{CC3} max: 110/100 mA to 100/90/80 mA I_{CC6} max: 110/100 mA to 100/90/80 mA I_{CC7} max: 110/100 mA to 90/80/75 mA AC Characteristics t_{RCD} min: 20/20 ns to 11/14/14 ns t_{RAD} min: 15/15 ns to 9/12/12 ns t_{RSH} min: 15/18 ns to 10/13/13 ns t_{RRH} min: 0/0 ns to 5/5/5 ns t_{RWC} min: 149/175 ns to 111/135/161 ns t_{RWD} min: 82/95 ns to 67/79/92 ns t_{CWD} min: 37/43 ns to 30/34/40 ns t_{AWD} min: 52/60 ns to 42/49/57 ns t_{RPC} min: 0/0 ns to 5/5/5 ns t_{HPRWC} min: 79/90 ns to 57/68/79 ns Timing Waveforms Addition of t_{RNCD} timing to EDO page mode mix cycle (2)	Y. Kasama	Y. Matsuno
3.0	Feb. 27, 1997	AC Characteristics t_{RRH} min: 5/5/5 ns to 0/0/0 ns	Y. Kasama	Y. Matsuno
4.0	Nov. 1997	Change of Subtitle		