HM5164405A Series
HM5165405A Series

64M EDO DRAM (16-Mword × 4-bit)
8k refresh/4k refresh

HITACHI

ADE-203-459B (Z)
Rev. 2.0
Oct. 28, 1997

Description

The Hitachi HM5164405A Series, HM5165405A Series are CMOS dynamic RAMs organized 16,777,216-word × 4-bit. They employ the most advanced CMOS technology for high performance and low power. The HM5164405A Series, HM5165405A Series offer Extended Data Out (EDO) Page Mode as a high speed access mode. They have the package variations of standard 400-mil 32-pin plastic SOJ and standard 400-mil 32-pin plastic TSOPII.

Features

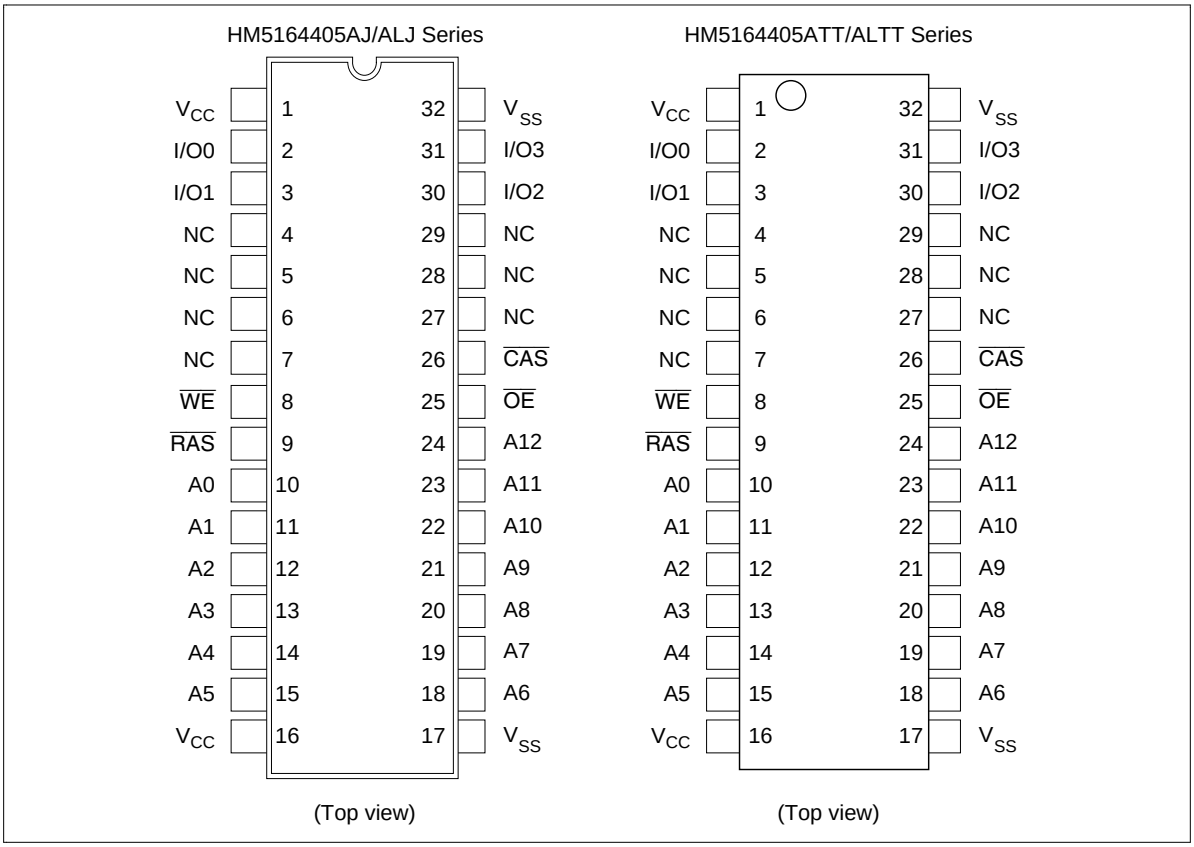
- Single 3.3 V supply: 3.3 V +0.3 V/–0.15 V (HM5165405A-5R)
  3.3 V ± 0.3 V (HM5164405A Series, HM5165405A/AL-6/7)
- Access time: 50 ns/60 ns/70 ns (max)
- Power dissipation
  - Active mode : TBD/396 mW/342 mW (max) (HM5164405A Series)
    : 684 mW/576 mW/504 mW (max) (HM5165405A Series)
  - Standby mode : 7.2 mW (max)
    : 1.08 mW (L-version)
- EDO page mode capability
- Refresh cycle
  - $\overline{\text{RAS}}$-only refresh
    8192 cycles /64 ms (HM5164405A)
    /128 ms (HM5164405AL) (L-version)
    4096 cycles /64 ms (HM5165405A)
    /128 ms (HM5165405AL) (L-version)
  - CBR/Hidden refresh
    4096 cycles /64 ms (HM5164405A, HM5165405A)
    /128 ms (HM5164405AL, HM5165405AL) (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)
- Battery backup operation (L-version)

Ordering Information

Type No.	Access time	Package
HM5164405AJ-6	60 ns	400-mil 32-pin plastic SOJ (CP-32DC)
HM5164405AJ-7	70 ns	
HM5164405ALJ-6	60 ns	
HM5164405ALJ-7	70 ns	
HM5165405AJ-6	60 ns	
HM5165405AJ-7	70 ns	
HM5165405ALJ-6	60 ns	
HM5165405ALJ-7	70 ns	
HM5164405ATT-6	60 ns	400-mil 32-pin plastic TSOP II (TTP-32DC)
HM5164405ATT-7	70 ns	
HM5164405ALTT-6	60 ns	
HM5164405ALTT-7	70 ns	
HM5165405ATT-5R	50 ns	
HM5165405ATT-6	60 ns	
HM5165405ATT-7	70 ns	
HM5165405ALTT-6	60 ns	
HM5165405ALTT-7	70 ns	

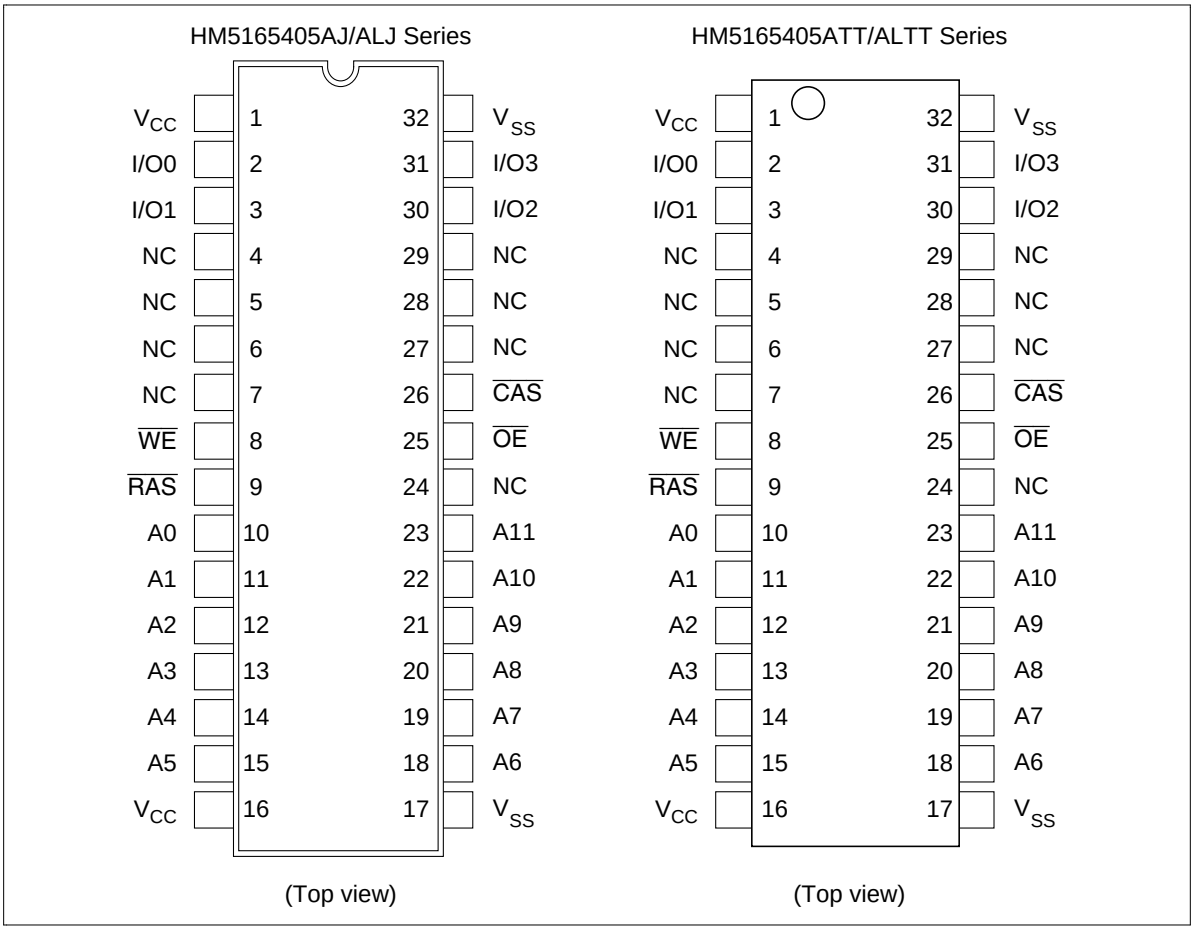
Pin Arrangement



Pin Description

Pin name	Function
A0 to A12	Address input • Row/Refresh address A0 to A12 • Column address A0 to A10
I/O0 to I/O3	Data input/Data output
$\overline{RAS}$	Row address strobe
$\overline{CAS}$	Column address strobe
$\overline{WE}$	Read/Write enable
$\overline{OE}$	Output enable
V_{CC}	Power supply
V_{SS}	Ground
NC	No connection

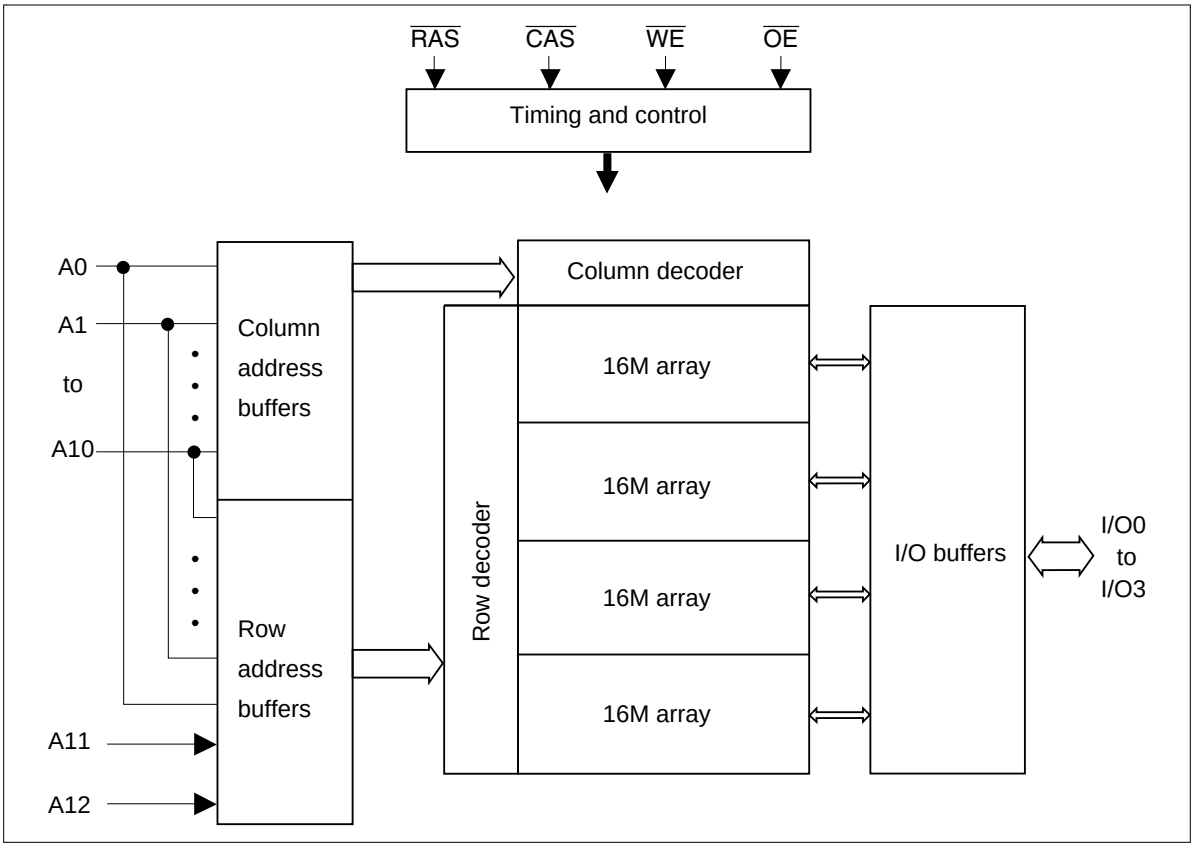
Pin Arrangement



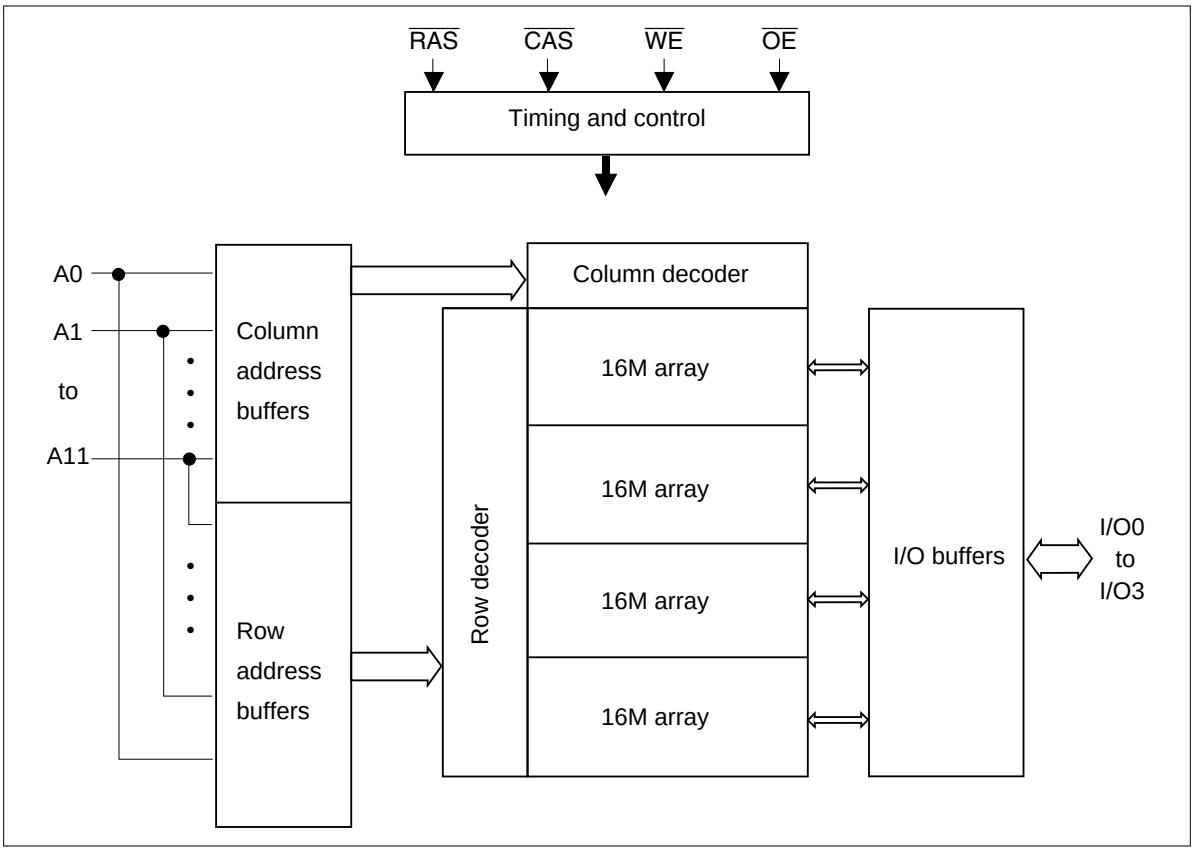
Pin Description

Pin name	Function
A0 to A11	Address input • Row/Refresh address A0 to A11 • Column address A0 to A11
I/O0 to I/O3	Data input/Data output
$\overline{RAS}$	Row address strobe
$\overline{CAS}$	Column address strobe
$\overline{WE}$	Read/Write enable
$\overline{OE}$	Output enable
V_{CC}	Power supply
V_{SS}	Ground
NC	No connection

Block Diagram (HM5164405A Series)



Block Diagram (HM5165405A Series)



Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Voltage on any pin relative to V_{SS}	V_T	–0.5 to V_{CC} + 0.5 (≤ 4.6 V (max))	V
Supply voltage relative to V_{SS}	V_{CC}	–0.5 to +4.6	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	Notes
Supply voltage	V_{SS}	0	0	0	V	2
	V_{CC} (HM5165405A-5R)	3.15	3.3	3.6	V	1, 2
	V_{CC} (HM5164/65405A/AL-6/7)	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}.
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.

DC Characteristics

(Ta = 0 to +70°C, V_{CC} = 3.3 V ± 0.3 V, V_{SS} = 0 V) (HM5164405A Series)

		HM5164405A							
		-5R		-6		-7			
Parameter	**Symbol**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Unit**	**Test conditions**
Operating current*1, *2	I_{CC1}	—	TBD	—	110	—	95	mA	t_{RC} = min
Standby current	I_{CC2}	—	TBD	—	2	—	2	mA	TTL interface $\overline{RAS}$, $\overline{CAS}$ = V_{IH} Dout = High-Z
		—	TBD	—	1	—	1	mA	CMOS interface $\overline{RAS}$, $\overline{CAS}$ ≥ V_{CC} – 0.2 V Dout = High-Z
Standby current (L-version)	I_{CC2}	—	TBD	—	300	—	300	µA	CMOS interface $\overline{RAS}$, $\overline{CAS}$ ≥ V_{CC} – 0.2 V Dout = High-Z
$\overline{RAS}$-only refresh current*2	I_{CC3}	—	TBD	—	110	—	95	mA	t_{RC} = min
Standby current*1	I_{CC5}	—	TBD	—	5	—	5	mA	$\overline{RAS}$ = V_{IH}, $\overline{CAS}$ = V_{IL} Dout = enable
$\overline{CAS}$-before-$\overline{RAS}$ refresh current	I_{CC6}	—	TBD	—	140	—	120	mA	t_{RC} = min
EDO page mode current*1, *3	I_{CC7}	—	TBD	—	105	—	90	mA	t_{HPC} = min
Battery backup current*4 (Standby with CBR refresh) (L-version)	I_{CC10}	—	TBD	—	650	—	650	µA	CMOS interface Dout = High-Z, CBR refresh: t_{RC} = 31.3 µs t_{RAS} ≤ 0.3 µs
Self refresh mode current (L-version)	I_{CC11}	—	TBD	—	500	—	500	µA	CMOS interface $\overline{RAS}$, $\overline{CAS}$ ≤ 0.2 V Dout = High-Z
Input leakage current	I_{LI}	TBD	TBD	–10	10	–10	10	µA	0 V ≤ Vin ≤ V_{CC} + 0.3 V
Output leakage current	I_{LO}	TBD	TBD	–10	10	–10	10	µA	0 V ≤ Vout ≤ V_{CC} Dout = disable
Output high voltage	V_{OH}	TBD	TBD	2.4	V_{CC}	2.4	V_{CC}	V	High Iout = –2 mA
Output low voltage	V_{OL}	TBD	TBD	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 within one page mode cycle t_{HPC}.
4. V_{IH} ≥ V_{CC} – 0.2 V, 0 V ≤ V_{IL} ≤ 0.2 V.

DC Characteristics

(Ta = 0 to +70°C, V_{CC} = 3.3 V +0.3 V/–0.15 V, V_{SS} = 0 V) (HM5165405A-5R)
(Ta = 0 to +70°C, V_{CC} = 3.3 V ± 0.3 V, V_{SS} = 0 V) (HM5165405A/AL-6/7)

		HM5165405A							
		-5R		-6		-7			
Parameter	**Symbol**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Unit**	**Test conditions**
Operating current*1, *2	I_{CC1}	—	190	—	160	—	140	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}	—	TBD	—	300	—	300	µA	CMOS interface $\overline{RAS}$, $\overline{CAS}$ ≥ V_{CC} – 0.2 V Dout = High-Z
$\overline{RAS}$-only refresh current*2	I_{CC3}	—	190	—	160	—	140	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}	—	170	—	140	—	120	mA	t_{RC} = min
EDO page mode current*1, *3	I_{CC7}	—	145	—	120	—	105	mA	t_{HPC} = min
Battery backup current*4 (Standby with CBR refresh) (L-version)	I_{CC10}	—	TBD	—	650	—	650	µA	CMOS interface Dout = High-Z, CBR refresh: t_{RC} = 31.3 µs t_{RAS} ≤ 0.3 µs
Self refresh mode current (L-version)	I_{CC11}	—	TBD	—	500	—	500	µA	CMOS interface $\overline{RAS}$, $\overline{CAS}$ ≤ 0.2 V Dout = High-Z
Input leakage current	I_{LI}	–10	10	–10	10	–10	10	µA	0 V ≤ Vin ≤ V_{CC} + 0.3 V
Output leakage current	I_{LO}	–10	10	–10	10	–10	10	µA	0 V ≤ Vout ≤ V_{CC} 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 within one page mode cycle t_{HPC}.
4. V_{IH} ≥ V_{CC} – 0.2 V, 0 V ≤ V_{IL} ≤ 0.2 V.

Capacitance

(Ta = 25°C, V_{CC} = 3.3 V +0.3 V/–0.15 V) (HM5165405A-5R)
(Ta = 25°C, V_{CC} = 3.3 V ± 0.3 V) (HM5164405A Series, HM5165405A/AL-6/7)

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

AC Characteristics*[1], *[2], *[17]

(Ta = 0 to +70°C, V_{CC} = 3.3 V +0.3 V/–0.15 V, V_{SS} = 0 V) (HM5165405A-5R)
(Ta = 0 to +70°C, V_{CC} = 3.3 V ± 0.3 V, V_{SS} = 0 V) (HM5164405A Series, HM5165405A/AL-6/7)

Test Conditions

- Input rise and fall time: 2 ns
- Input levels: 0 V, 3.0 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 (50 pF) (Including scope and jig) (HM5165405A-5R)
  1 TTL gate + C_L (100 pF) (Including scope and jig) (HM5164405A Series, HM5165405A/AL-6/7)

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

		HM5164405A/HM5165405A							
		-5R		-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}	8	—	10	—	13	—	ns	
$\overline{RAS}$ pulse width	t_{RAS}	50	10000	60	10000	70	10000	ns	
$\overline{CAS}$ 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	
$\overline{RAS}$ to $\overline{CAS}$ delay time	t_{RCD}	12	37	20	45	20	52	ns	3
$\overline{RAS}$ to column address delay time	t_{RAD}	10	25	14	30	14	35	ns	4
$\overline{RAS}$ hold time	t_{RSH}	13	—	15	—	18	—	ns	
$\overline{CAS}$ hold time	t_{CSH}	40	—	48	—	58	—	ns	21
$\overline{CAS}$ 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

		HM5164405A/HM5165405A							
		-5R		-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
Access time from $\overline{CAS}$	t_{CAC}	—	13	—	15	—	18	ns	9, 10, 16
Access time from address	t_{AA}	—	25	—	30	—	35	ns	9, 11, 16
Access time from $\overline{OE}$	t_{OEA}	—	13	—	15	—	18	ns	9
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}	5	—	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	20
Output data hold time from $\overline{OE}$	t_{OHO}	3	—	3	—	3	—	ns	
Output buffer turn-off time	t_{OFF}	—	15	—	15	—	15	ns	13, 20
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	20
Output buffer turn-off to $\overline{RAS}$	t_{OFR}	—	13	—	15	—	15	ns	13, 20
Output buffer turn-off to $\overline{WE}$	t_{WEZ}	—	13	—	15	—	15	ns	13
$\overline{WE}$ to Din delay time	t_{WED}	13	—	15	—	18	—	ns	
$\overline{RAS}$ to Din delay time	t_{RDD}	13	—	15	—	18	—	ns	

Write Cycle

		HM5164405A/HM5165405A							
		-5R		-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}	13	—	15	—	18	—	ns	
Write command to $\overline{CAS}$ lead time	t_{CWL}	10	—	10	—	13	—	ns	
Data-in setup time	t_{DS}	0	—	0	—	0	—	ns	
Data-in hold time	t_{DH}	8	—	10	—	13	—	ns	

Read-Modify-Write Cycle

		HM5164405A/HM5165405A							
		-5R		-6		-7			
Parameter	Symbol	Min	Max	Min	Max	Min	Max	Unit	Notes
Read-modify-write cycle time	t_{RWC}	111	—	149	—	175	—	ns	
$\overline{RAS}$ to $\overline{WE}$ delay time	t_{RWD}	67	—	78	—	91	—	ns	14
$\overline{CAS}$ to $\overline{WE}$ delay time	t_{CWD}	30	—	33	—	39	—	ns	14
Column address to $\overline{WE}$ delay time	t_{AWD}	42	—	48	—	56	—	ns	14
$\overline{OE}$ hold time from $\overline{WE}$	t_{OEH}	13	—	15	—	18	—	ns	

Refresh Cycle

		HM5164405A/HM5165405A							
		-5R		-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}	10	—	10	—	10	—	ns	
$\overline{RAS}$ precharge to $\overline{CAS}$ hold time	t_{RPC}	5	—	0	—	0	—	ns	

EDO Page Mode Cycle

		HM5164405A/HM5165405A							
		-5R		-6		-7			
Parameter	**Symbol**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Unit**	**Notes**
EDO page mode cycle time	t_{HPC}	20	—	25	—	30	—	ns	19
EDO page mode $\overline{RAS}$ pulse width	t_{RASP}	—	100000	—	100000	—	100000	ns	15
Access time from $\overline{CAS}$ precharge	t_{CPA}	—	28	—	35	—	40	ns	9, 16
$\overline{RAS}$ 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
$\overline{CAS}$ hold time referred $\overline{OE}$	t_{COL}	8	—	10	—	13	—	ns	
$\overline{CAS}$ to $\overline{OE}$ setup time	t_{COP}	8	—	10	—	10	—	ns	
Read command hold time from $\overline{CAS}$ precharge	t_{RCHC}	28	—	35	—	40	—	ns	
Write pulse width during $\overline{CAS}$ precharge	t_{WPE}	8	—	10	—	10	—	ns	
$\overline{OE}$ precharge time	t_{OEP}	8	—	10	—	10	—	ns	

EDO Page Mode Read-Modify-Write Cycle

		HM5164405A/HM5165405A							
		-5R		-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

Refresh (HM5164405A Series)

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

Refresh (HM5165405A Series)

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

Self Refresh Mode (L-version)

		HM5164405AL/HM5165405AL							
		-5R		-6		-7			
Parameter	**Symbol**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Unit**	**Notes**
$\overline{RAS}$ pulse width (self refresh)	t_{RASS}	TBD	—	100	—	100	—	µs	
$\overline{RAS}$ precharge time (self refresh)	t_{RPS}	TBD	—	110	—	130	—	ns	
$\overline{CAS}$ hold time (self refresh)	t_{CHS}	TBD	—	–50	—	–50	—	ns	

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).
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 50 pF (HM5165405A-5R) and 1 TTL loads and 100 pF (HM5164405A Series, HM5165405A/AL-6/7).
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), t_{OEZ} (max), t_{WEZ} (max) and t_{OFR} (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. t_{RASP} defines $\overline{RAS}$ pulse width in EDO page mode cycles.
16. Access time is determined by the longest among t_{AA}, t_{CAC} and t_{CPA}.
17. All the V_{CC} and V_{SS} pins shall be supplied with the same voltages.
18. In delayed write or read-modify-write cycles, $\overline{OE}$ must disable output buffer prior to applying data to the device.
19. 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).

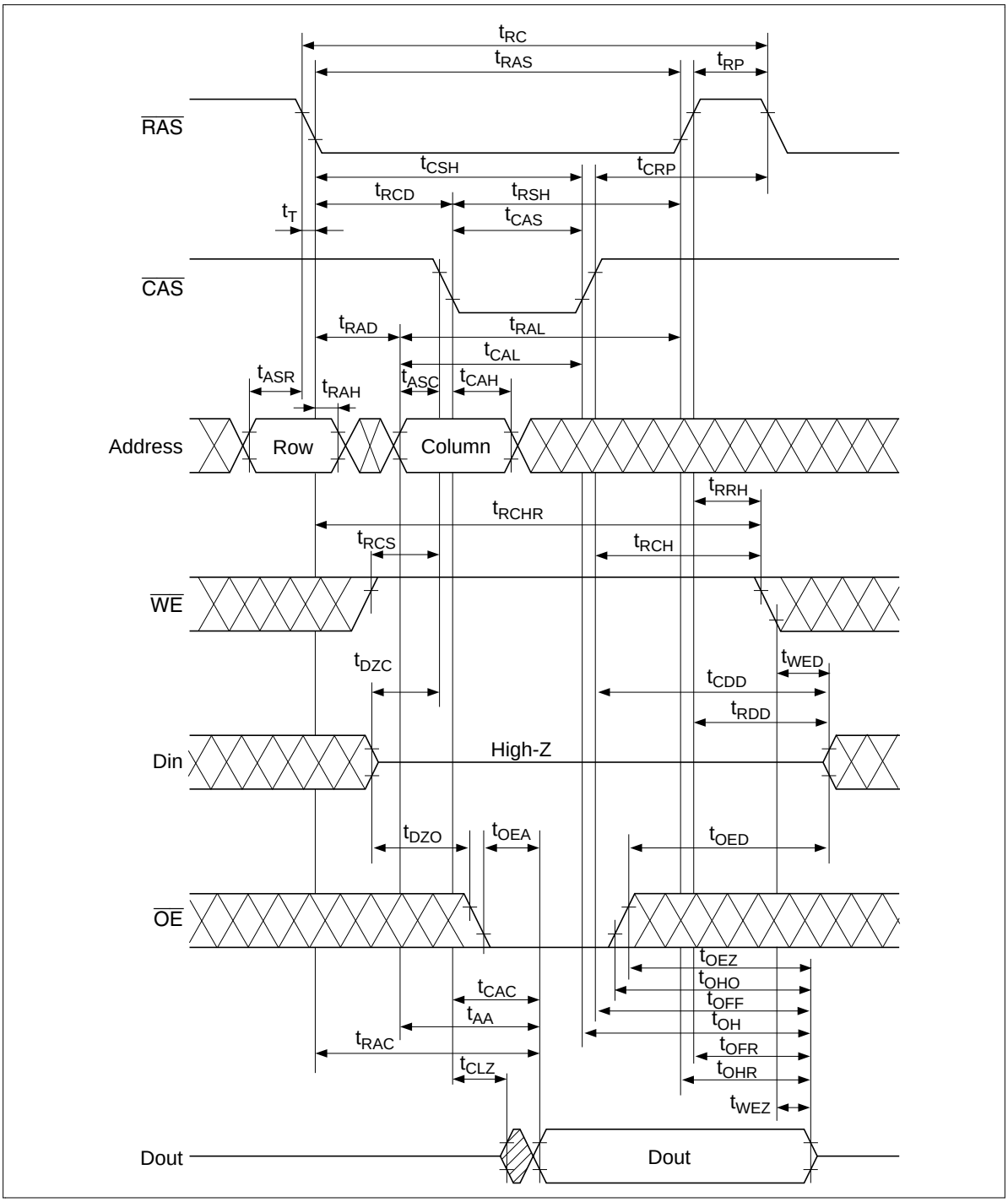
20. Data output turns off and becomes high impedance from later rising edge of $\overline{RAS}$ and $\overline{CAS}$. Hold time and turn off time are specified by the timing specifications of later rising edge of $\overline{RAS}$ and $\overline{CAS}$ between t_{OHR} and t_{OH} and between t_{OFR} and t_{OFF}.
21. t_{CSH} (min) can be achieved when $t_{RCD} \leq t_{CSH}$ (min) – t_{CAS} (min).
22. Please do not use t_{RASS} timing, 10 µs ≤ t_{RASS} ≤ 100 µs. During this period, the device is in transition state from normal operation mode to self refresh mode. If t_{RASS} > 100 µs, then $\overline{RAS}$ precharge time should use t_{RPS} instead of t_{RP}.
23. CBR burst refresh or 4096 cycles of distributed CBR refresh with 15.6 µs interval should be executed within 64 ms immediately after exiting from and before entering into the self refresh mode.
24. 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.
25. XXX: H or L (H: V_{IH} (min) ≤ V_{IN} ≤ V_{IH} (max), L: V_{IL} (min) ≤ V_{IN} ≤ V_{IL} (max))

    ///////: Invalid Dout

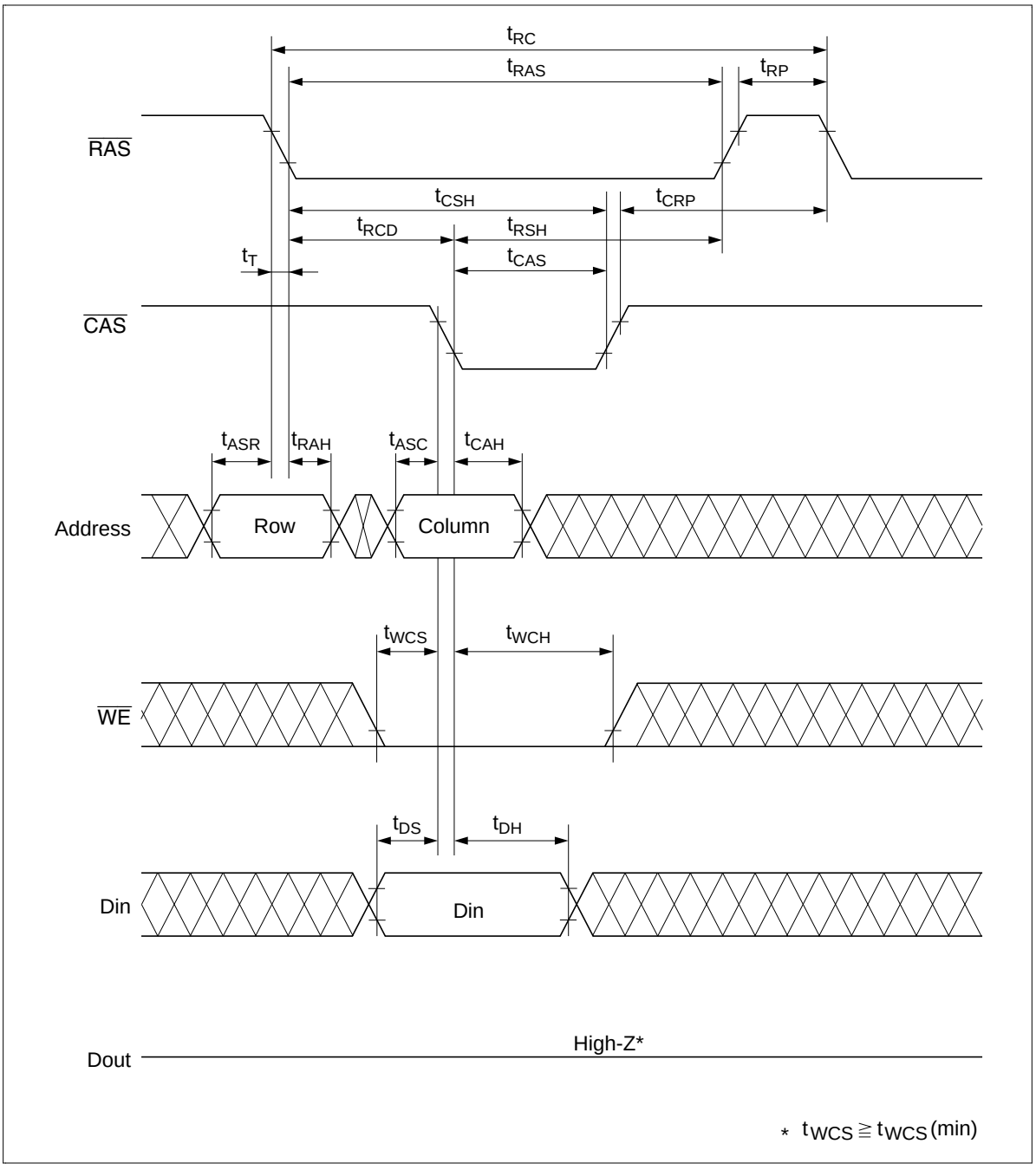
    When the address, clock and input pins are not described on timing waveforms, their pins must be applied V_{IH} or V_{IL}.

Timing Waveforms*[25]

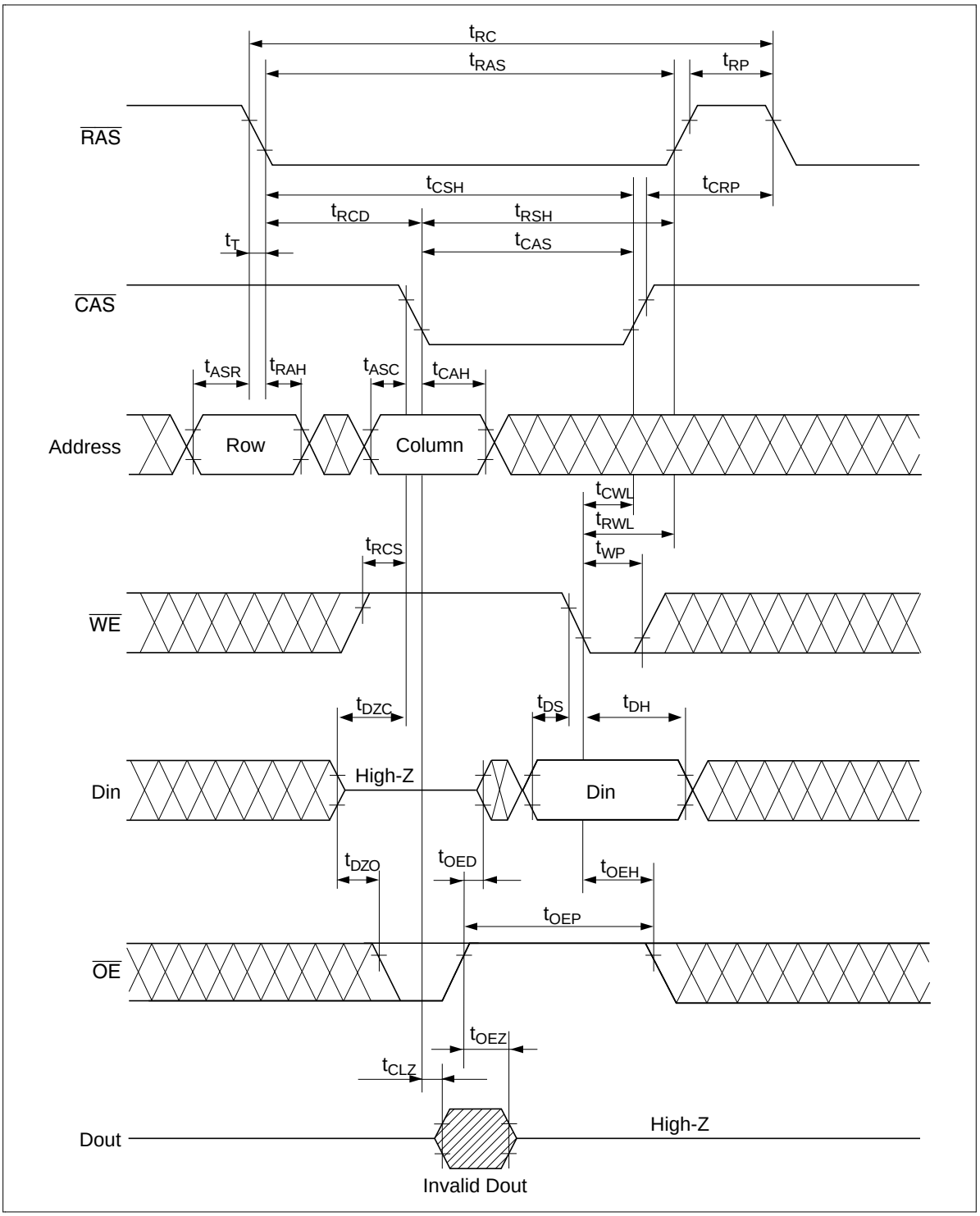
Read Cycle



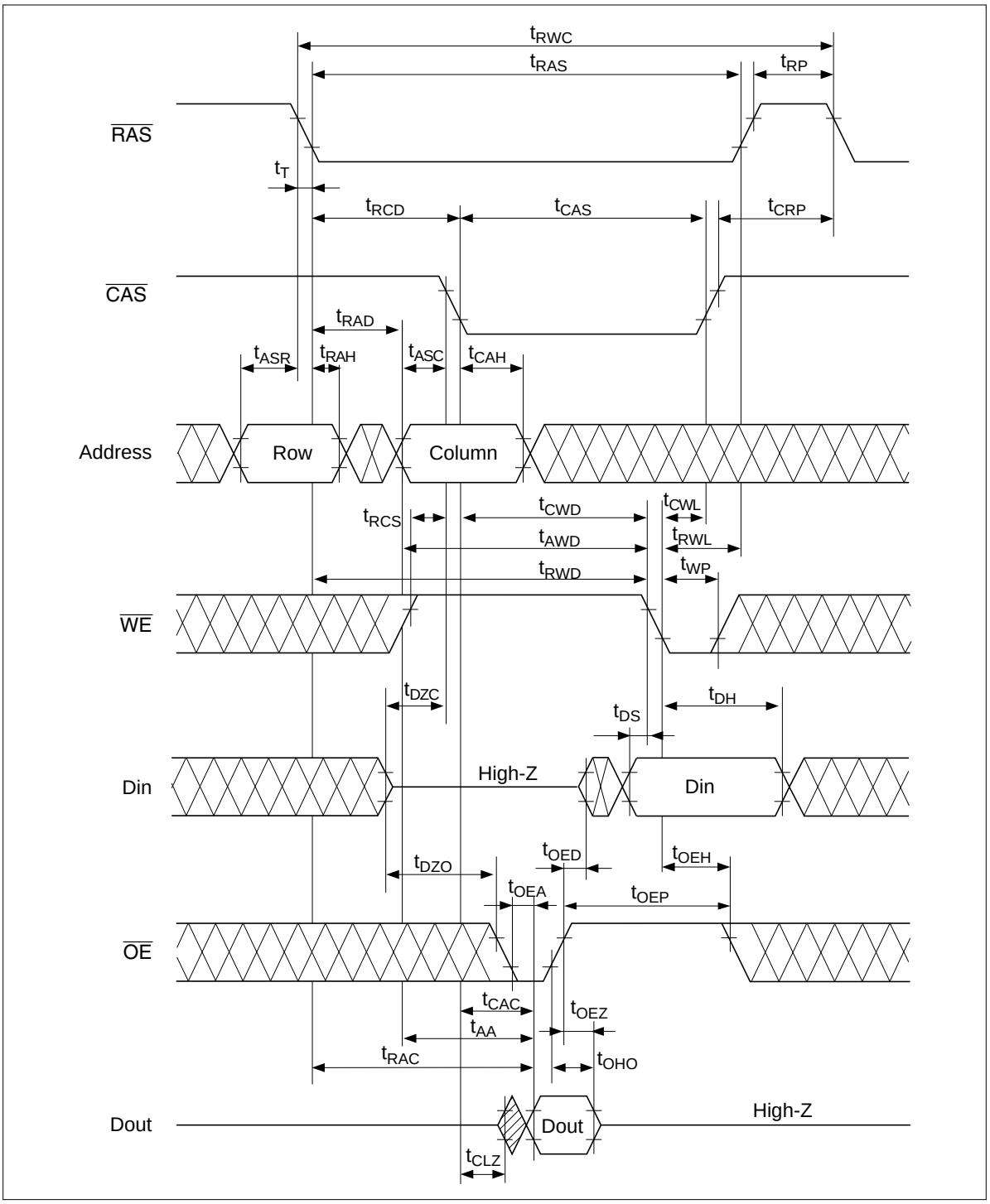
Early Write Cycle



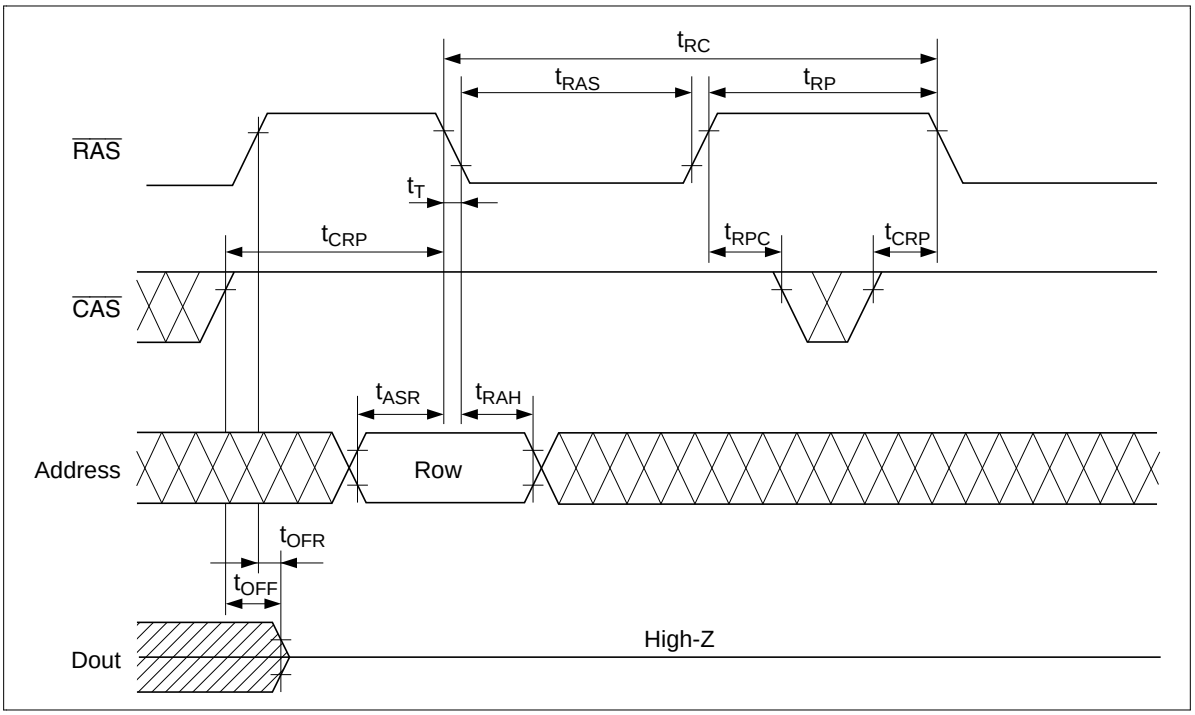
Delayed Write Cycle*[18]



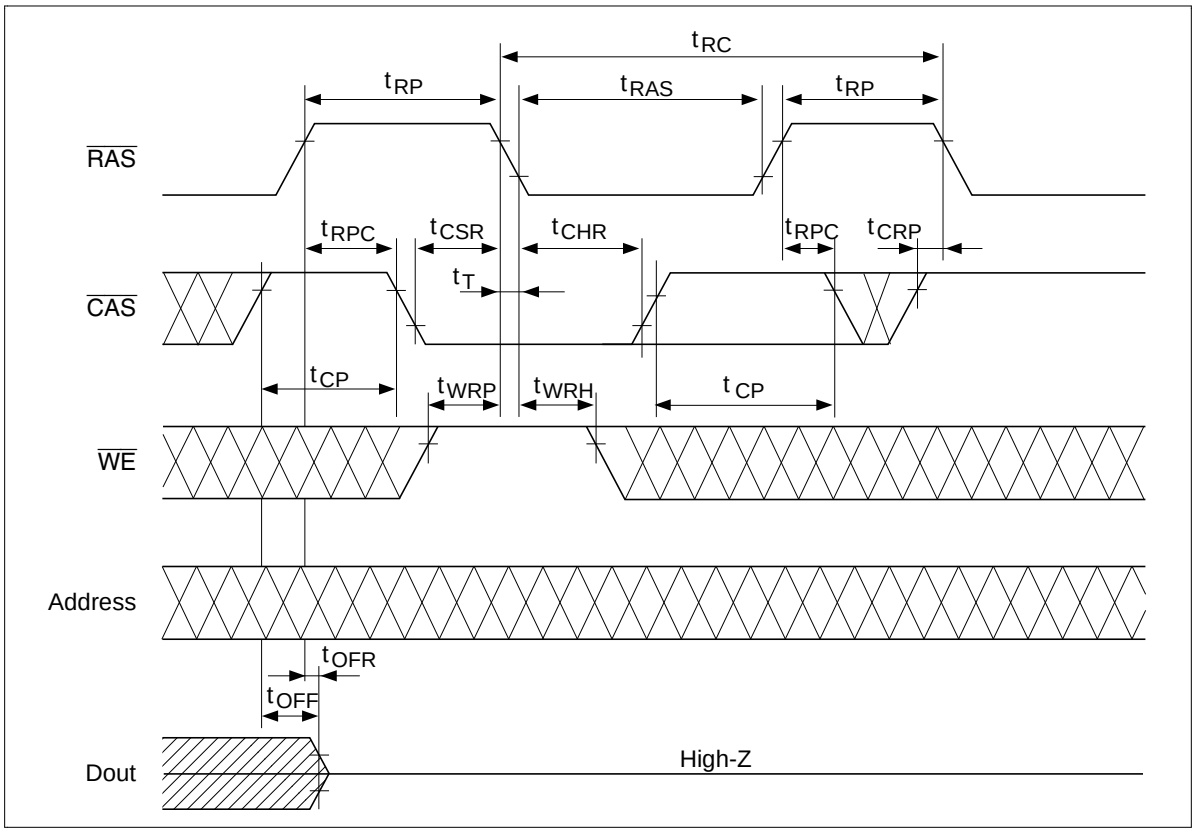
Read-Modify-Write Cycle*[18]



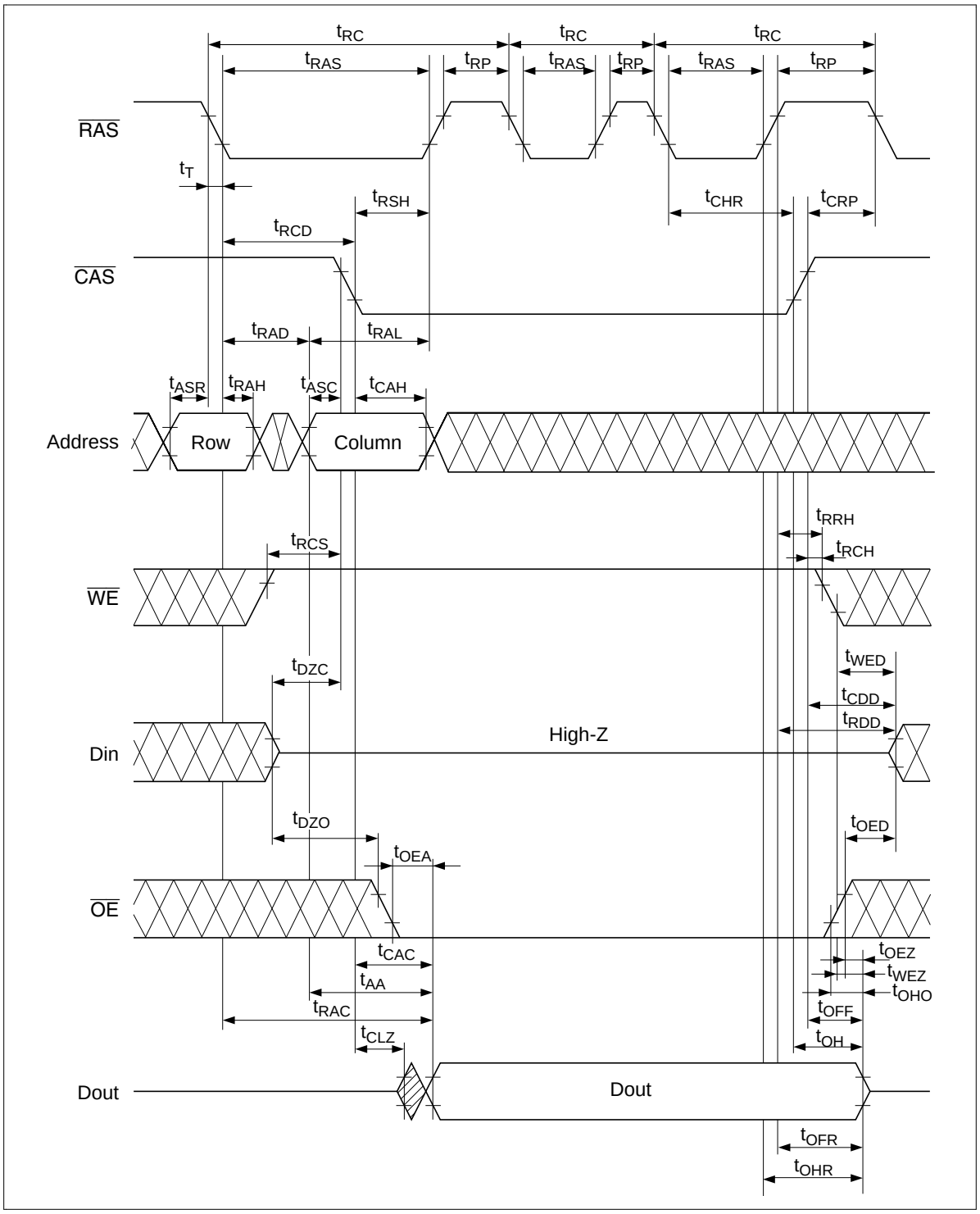
$\overline{\text{RAS}}$-Only Refresh Cycle



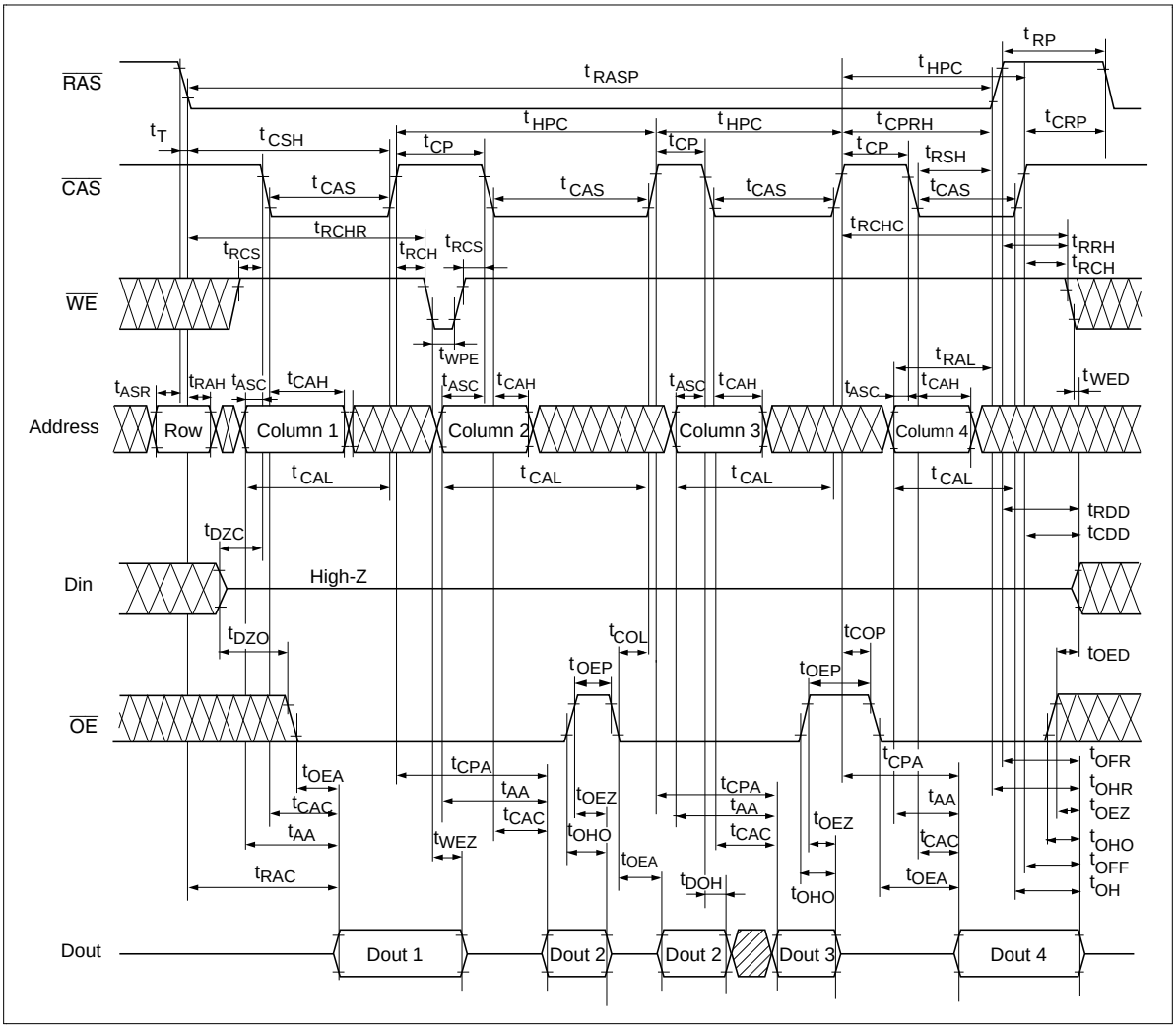
$\overline{\text{CAS}}$-Before-$\overline{\text{RAS}}$ Refresh Cycle



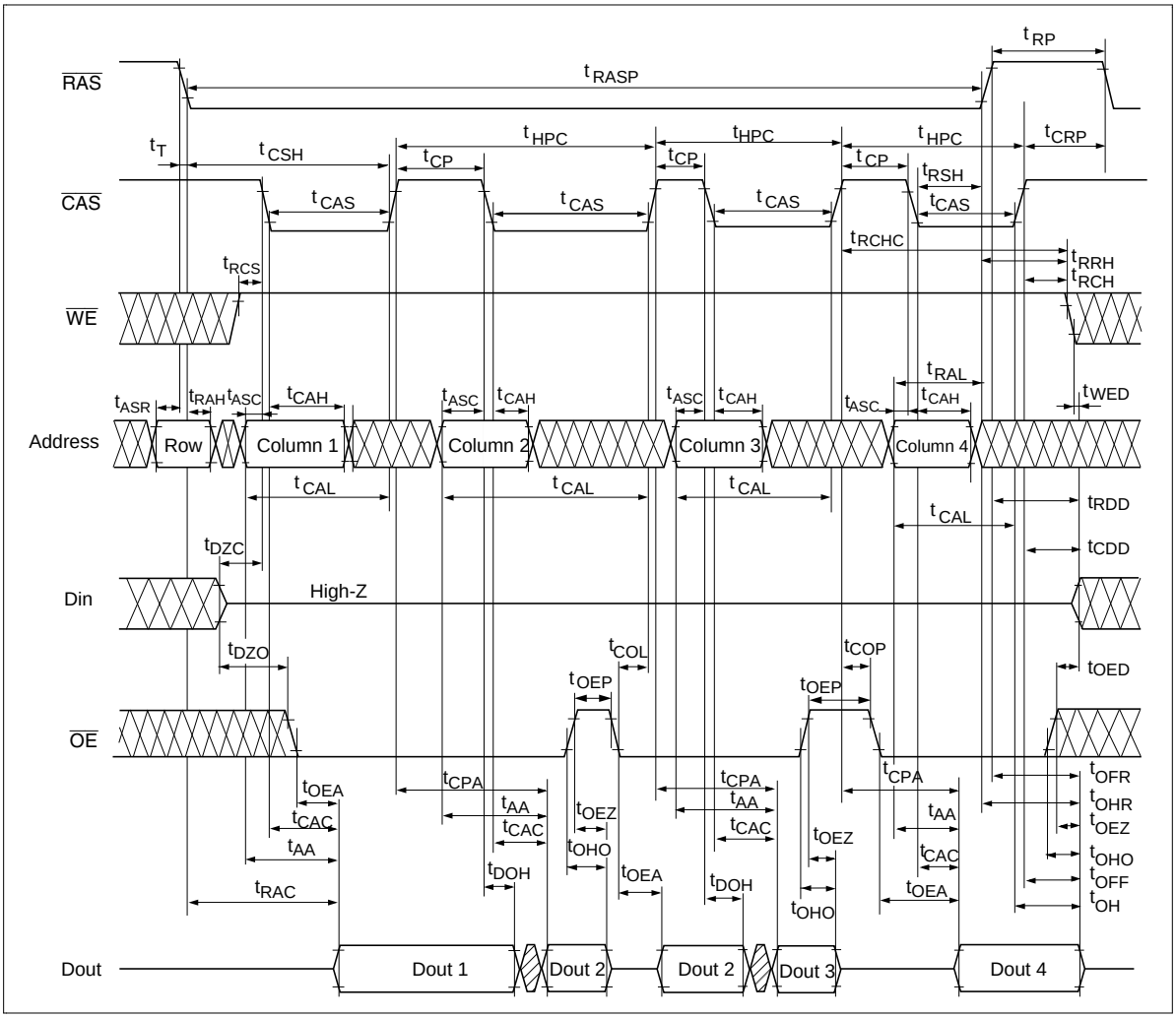
Hidden Refresh Cycle



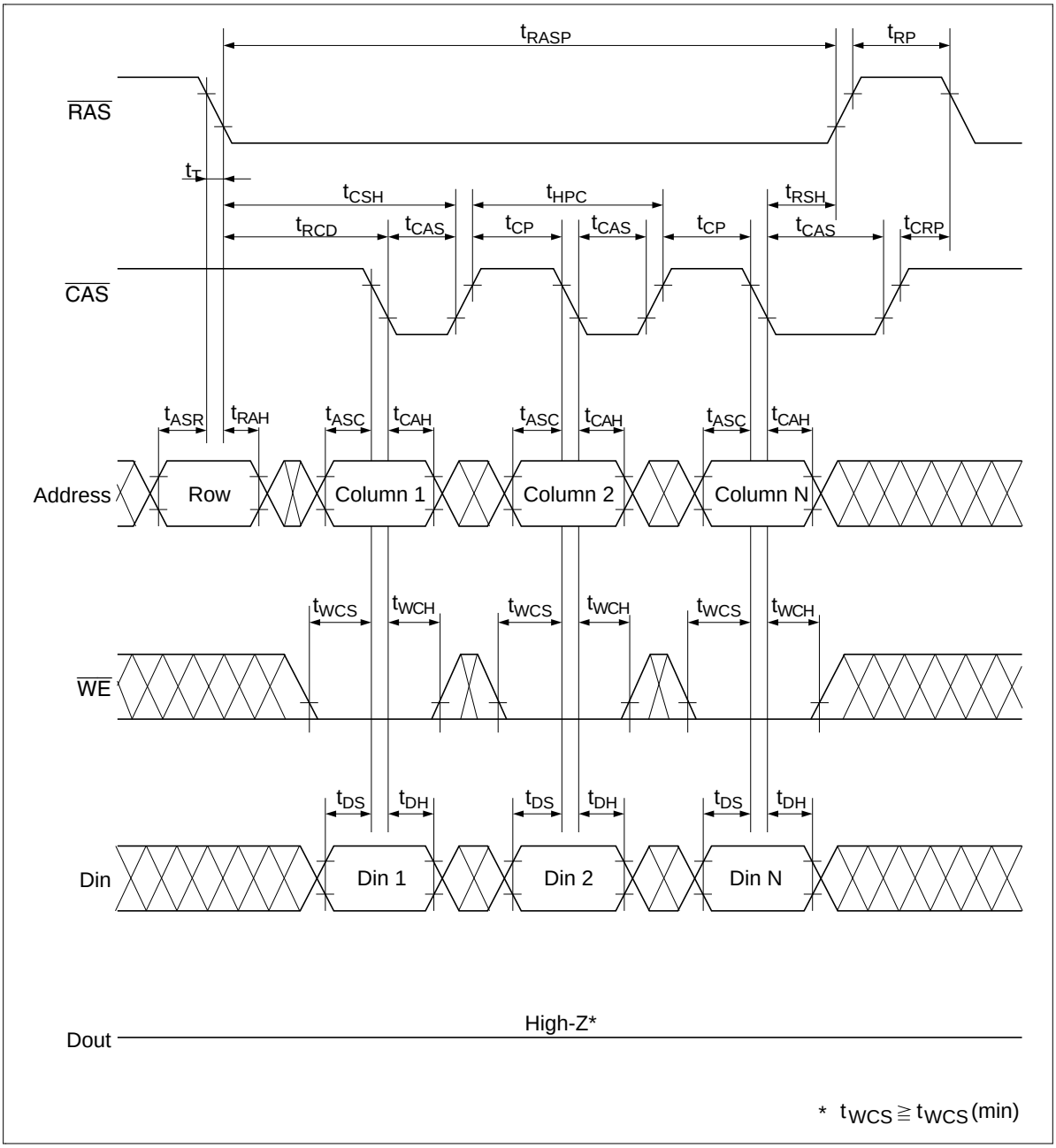
EDO Page Mode Read Cycle (1)



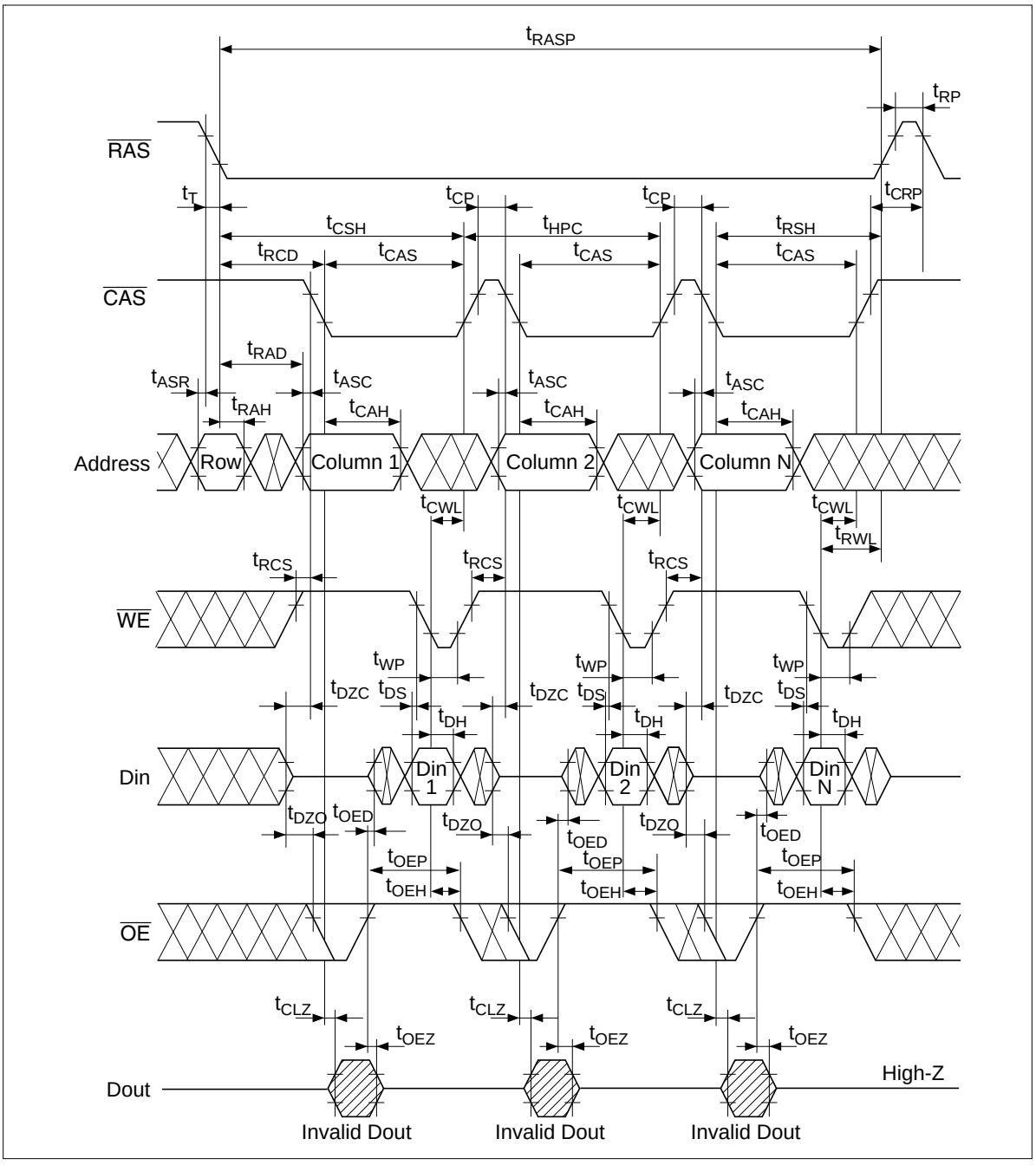
EDO Page Mode Read Cycle (2)



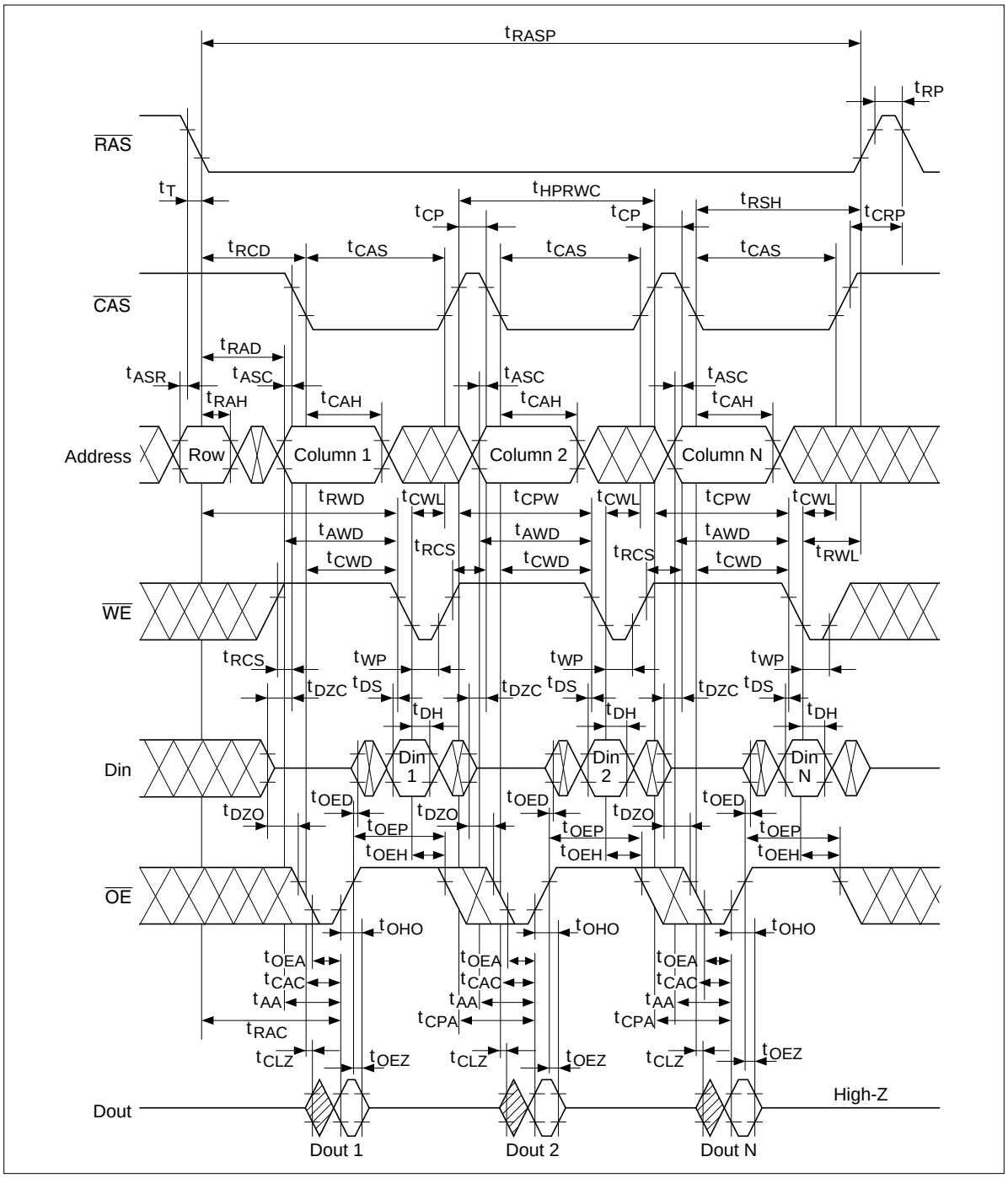
EDO Page Mode Early Write Cycle



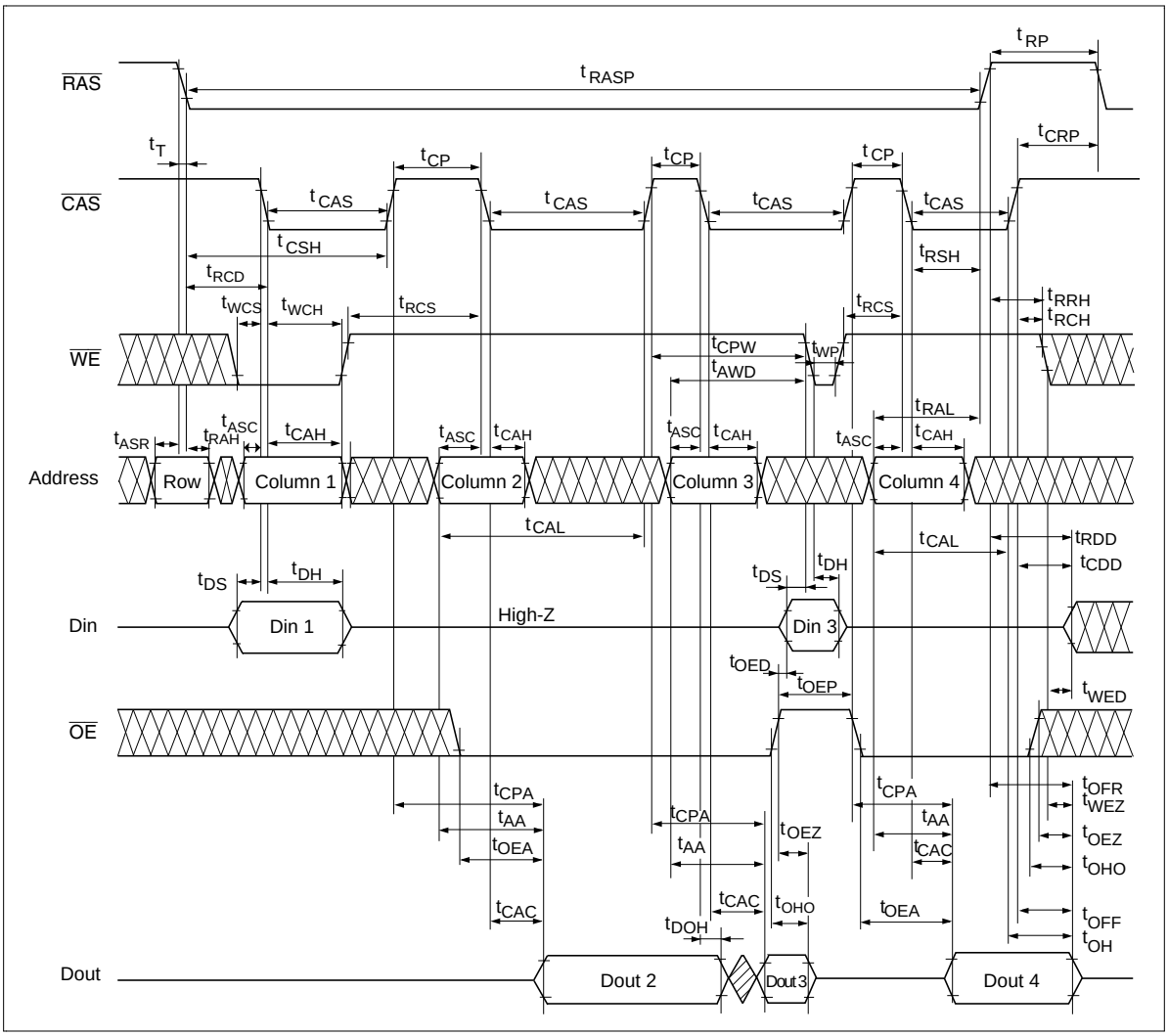
EDO Page Mode Delayed Write Cycle*[18]



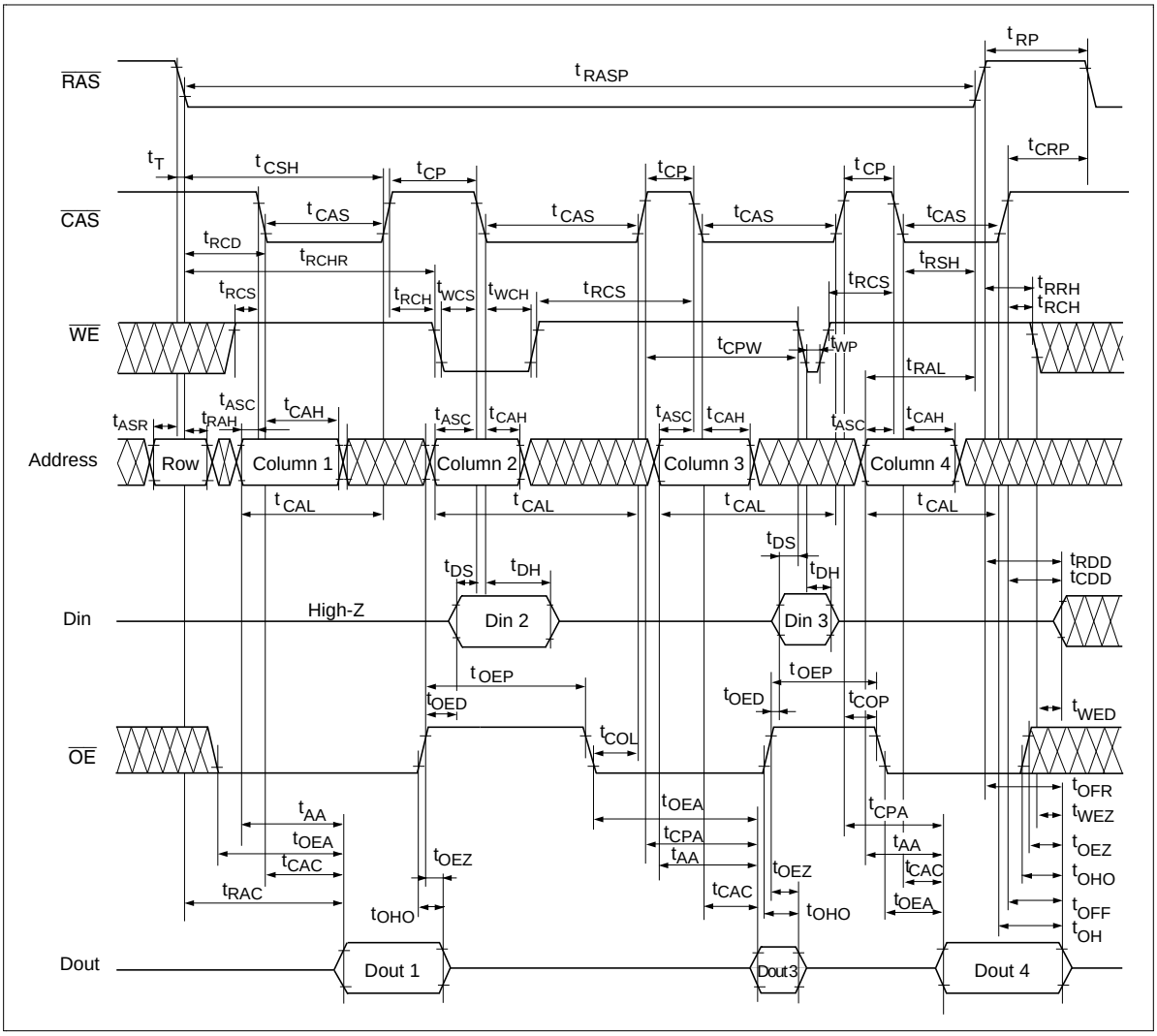
EDO Page Mode Read-Modify-Write Cycle*[18]



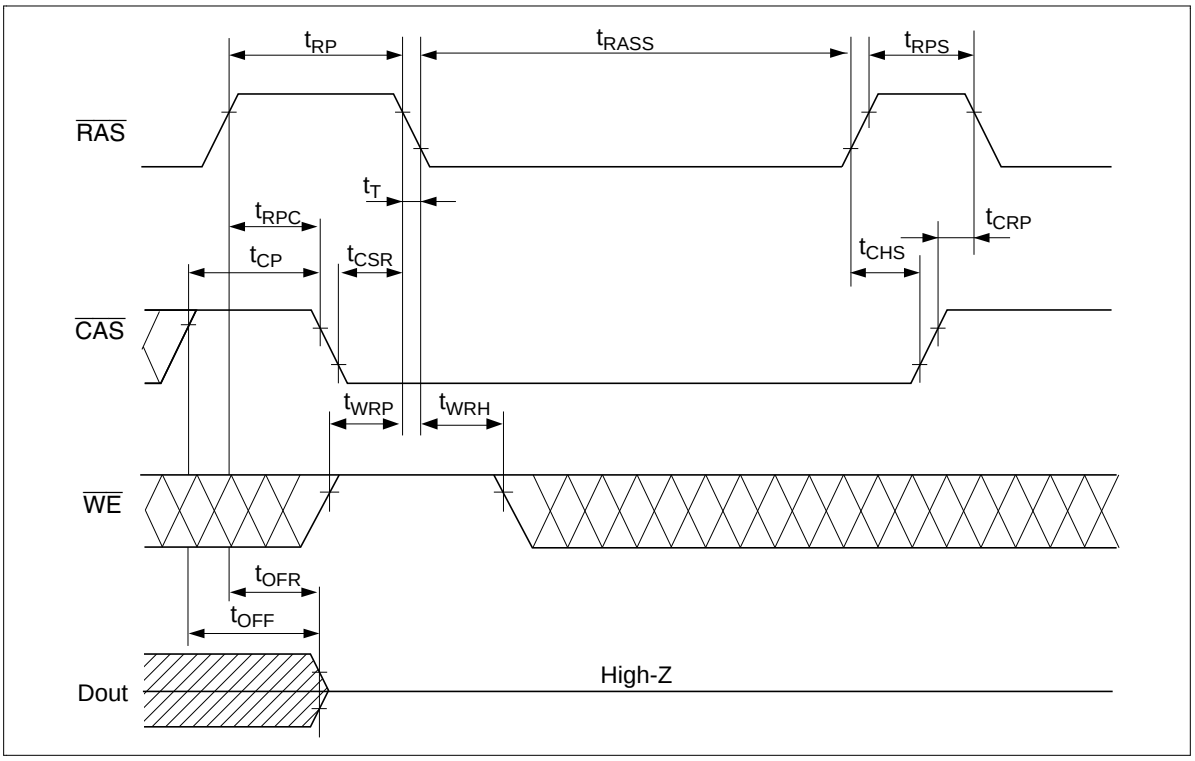
EDO Page Mode Mix Cycle (1)*[19]



EDO Page Mode Mix Cycle (2)*[19]



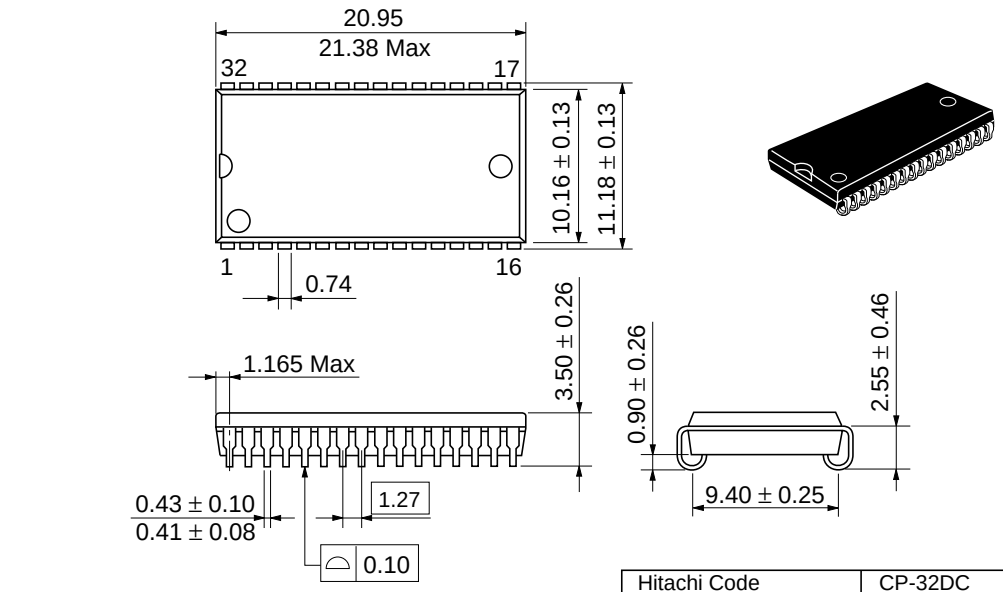
Self Refresh Cycle (L-version)* [22, 23, 24]



Package Dimensions

HM5164405AJ/ ALJ Series
HM5165405AJ/ ALJ Series (CP-32DC)

Unit: mm



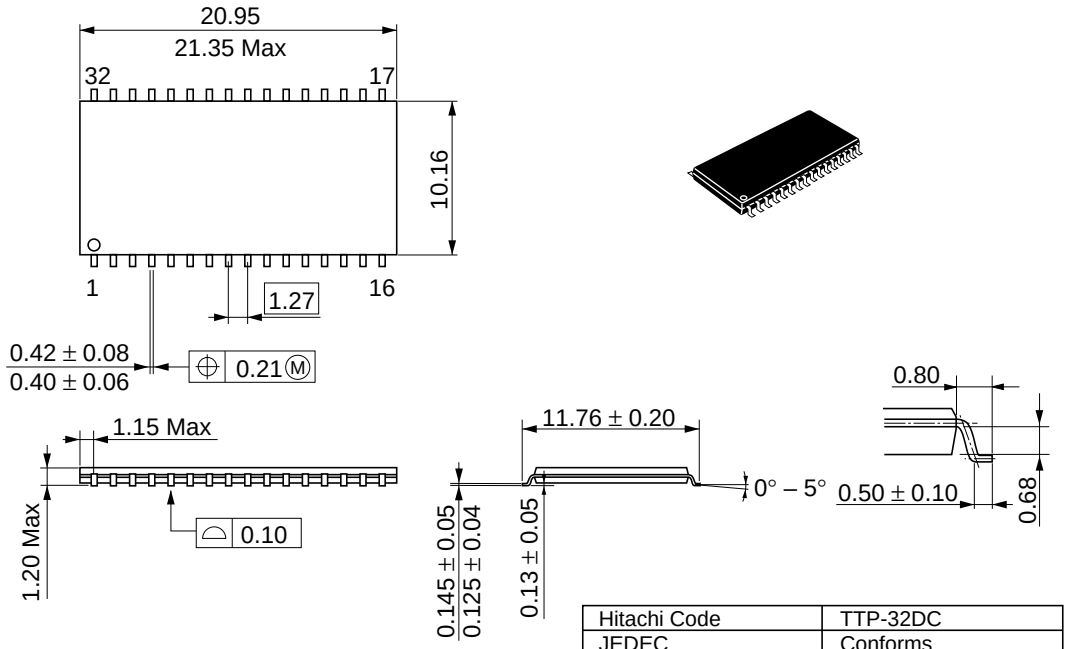
Dimension including the plating thickness
Base material dimension

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

HM5164405ATT/ALTT Series

HM5165405ATT/ALTT Series (TTP-32DC)

Unit: mm



Dimension including the plating thickness
Base material dimension

Hitachi Code	TTP-32DC
JEDEC	Conforms
EIAJ	—
Weight (reference value)	0.51 g

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Revision Record

Rev.	Date	Contents of Modification	Drawn by	Approved by
0.0	Oct. 13, 1995	Initial issue	S. Ikenaga	J. Kitano
0.1	Apr. 30, 1996	Change format Unification of HM5164405A Series and HM5165405A Series Addition of HM5164405A/HM5165405A-5 Series Addition of HM5164405AJ/ALJ Series, HM5165405AJ/ALJ Series (CP-32DC) Pin Descriptions Addition of Row/Refresh address and Column address to address input Addition of Block Diagrams DC Characteristics (HM5165405A) I_{CC1} max: 140/130 mA to TBD/180/160 mA I_{CC3} max: 120/105 mA to TBD/180/160 mA I_{CC6} max: 120/105 mA to TBD/150/130 mA I_{CC7} max: 120/105 mA to TBD/140/120 mA Addition of note 4 AC Characteristics t_{RCD} max: 38/45 ns to TBD/45/52 ns t_{COP} min: 5/5 ns to TBD/10/10 ns Addition of t_{WPE} and t_{OEP} t_{HPRWC} min: 79/90 ns to TBD/68/79 ns Addition of notes 20 to 24 Change of notes 3 and 13 Timing waveforms Addition of t_{WPE} and t_{OEP} timings Deletion of note: $t_{OEH} \geq t_{CWL}$	S. Ikenaga	J. Kitano
0.2	Jun. 12, 1996	AC Characteristics Change of notes 18 and 25 Timing waveforms Deletion of notes about undefined pins	S. Ikenaga	J. Kitano
0.3	Jan. 22, 1997	Power dissipation TBD/540/468 mW to TBD/396/342 mW (max) (HM5164405A Series) TBD/648/576 mW to TBD/576/504 mW (max) (HM5165405A Series)	J. Kitano	J. Kitano

Revision Record (cont)

Rev.	Date	Contents of Modification	Drawn by	Approved by
0.3	Jan. 22, 1997	DC Characteristics (HM5164405A Series) I_{CC1}(max): TBD/130/110 mA to TBD/110/95 mA I_{CC3}(max): TBD/130/110 mA to TBD/110/95 mA I_{CC6}(max): TBD/150/130 mA to TBD/140/120 mA I_{CC7}(max): TBD/140/120 mA to TBD/105/90 mA I_{LO} test conditions: 0 V ≤ Vout ≤ V_{CC} + 0.3 to 0 V ≤ Vout ≤ V_{CC} DC Characteristics (HM5165405A Series) I_{CC1}(max): TBD/180/160 mA to TBD/160/140 mA I_{CC3}(max): TBD/180/160 mA to TBD/160/140 mA I_{CC6}(max): TBD/150/130 mA to TBD/140/120 mA I_{CC7}(max): TBD/140/120 mA to TBD/120/105 mA I_{LO} test conditions: 0 V ≤ Vout ≤ V_{CC} + 0.3 to 0 V ≤ Vout ≤ V_{CC} AC Characteristics Change of note 20	J. Kitano	J. Kitano
1.0	Sep. 12, 1997	Deletion of preliminary AC Characteristics t_{RAD} (min): TBD/15/15 ns to TBD/14/15 ns t_{RWL} (min): TBD/10/13 ns to TBD/15/18 ns t_{REF} (L-version) (HM5164405A Series) 128 ms to TBD (for suspension of L-version), Correct errors (HM5164405A Series) t_{REF} (L-version): 4096 cycles to 8192 cycles	M. Tsunozaki	M. Saeki
2.0	Oct. 28, 1997	Deletion of HM5164405A/HM5165405A-5 Series Addition of HM5165405A-5R Addition of specification for HM5164405AL/ HM5165405AL Series Power dissipation TBD/576/504 mW to 684/576/504 mW (HM5165405A) Recommended DC Operating Conditions Addition of V_{CC} (HM5165405A-5R): 3.15/3.3/3.6 V DC Characteristics I_{CC2} max: TBD/TBD/TBD to TBD/300/300 µA I_{CC10} max: TBD/TBD/TBD to TBD/650/650 µA I_{CC11} max: TBD/TBD/TBD to TBD/500/500 µA AC Characteristics Test conditions Addition of output load condition (-5R): 1 TTL gate + C_L (50pF) t_{RAD} min: TBD/14/15 ns to 10/14/14 ns t_{REF} (L-version) (8k refresh): TBD to 128 ms		