HB56HW164DB Series, HB56HW165DB Series

HB56HW164DB
8 MB EDO DRAM S.O.DIMM
1-Mword × 64-bit, 4 k Refresh, 1-Bank Module
(4 pcs of 1 M × 16 Components)
HB56HW165DB
8 MB EDO DRAM S.O.DIMM
1-Mword × 64-bit, 1 k Refresh, 1-Bank Module
(4 pcs of 1 M × 16 Components)

HITACHI

ADE-203-699C (Z)
Rev.3.0
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Description

The HB56HW164DB is a 1M × 64 dynamic RAM Small Outline Dual In-line Memory Module (S.O.DIMM), mounted 4 pieces of 16-Mbit DRAM (HM51W16165) sealed in TSOP package and 1 pieces of serial EEPROM (24C02) for Presence Detect (PD). The HB56HW165DB is a 1M × 64 dynamic RAM Small Outline Dual In-line Memory Module (S.O.DIMM), mounted 4 pieces of 16-Mbit DRAM (HM51W18165) sealed in TSOP package and 1 pieces of serial EEPROM (24C02) for Presence Detect (PD). The HB56HW164DB, HB56HW165DB offer Extended Data Out (EDO) Page Mode as a high speed access mode. An outline of the HB56HW164DB, HB56HW165DB is 144-pin Zig Zag Dual tabs socket type compact and thin package. Therefore, the HB56HW164DB, HB56HW165DB make high density mounting possible without surface mount technology. The HB56HW164DB, HB56HW165DB provide common data inputs and outputs. Decoupling capacitors are mounted on the module board.

Features

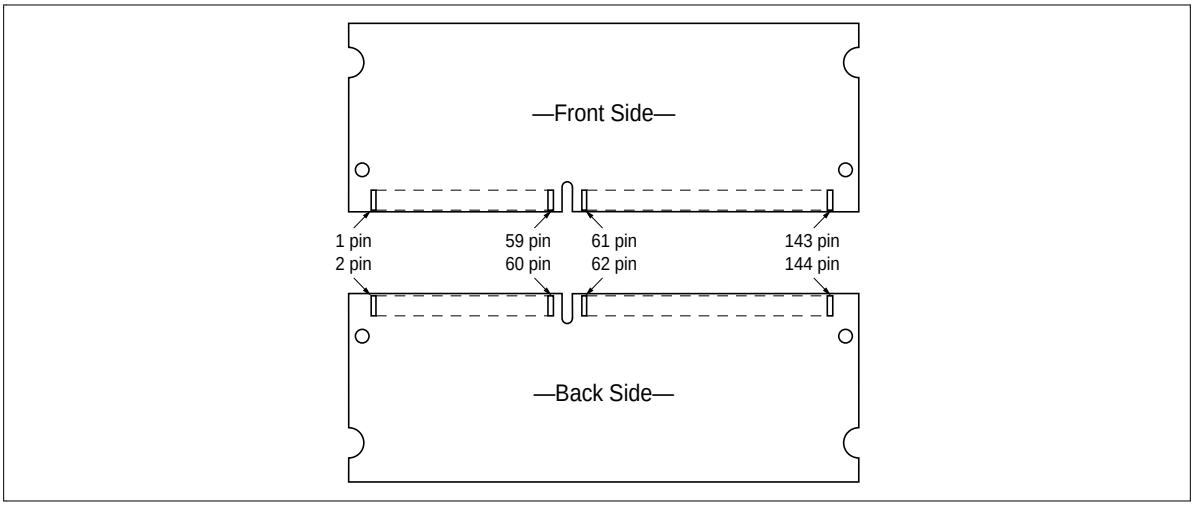
- 144-pin Zig Zag Dual tabs socket type
  - — Outline: 67.60 mm (Length) × 25.40 mm (Height) × 3.80 mm (Thickness)
  - — Lead pitch: 0.80 mm
- Single 3.3 V (±0.3 V) supply
- High speed
  - — Access time: t_{RAC} = 50/60/70 ns (max)
    t_{CAC} = 13/15/18 ns (max)

- Low power dissipation
  - Active mode: 1.58/1.44/1.30 W (max) (HB56HW164DB Series)
    2.74/2.45/2.16 W (max) (HB56HW165DB Series)
  - Standby mode (TTL): 28.8 mW (max)
    (CMOS): 2.16 mW (max) (L-version)
- EDO page mode capability
- Refresh period
  - 4096 refresh cycles: 64 ms (HB56HW164DB Series)
    128 ms (L-version)
  - 1024 refresh cycles: 16 ms (HB56HW165DB 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)

Ordering Information

Type No.	Access time	Package	Contact pad
HB56HW164DB-5	50 ns	144-pin small outline DIMM	Gold
HB56HW164DB-6	60 ns		
HB56HW164DB-7	70 ns		
HB56HW164DB-5L	50 ns		
HB56HW164DB-6L	60 ns		
HB56HW164DB-7L	70 ns		
HB56HW165DB-5	50 ns		
HB56HW165DB-6	60 ns		
HB56HW165DB-7	70 ns		
HB56HW165DB-5L	50 ns		
HB56HW165DB-6L	60 ns		
HB56HW165DB-7L	70 ns		

Pin Arrangement



Pin Arrangement

Front side				Back side			
Pin No.	**Pin name**	**Pin No.**	**Pin name**	**Pin No.**	**Pin name**	**Pin No.**	**Pin name**
1	V_{SS}	73	$\overline{OE}$	2	V_{SS}	74	NC
3	DQ0	75	V_{SS}	4	DQ32	76	V_{SS}
5	DQ1	77	NC	6	DQ33	78	NC
7	DQ2	79	NC	8	DQ34	80	NC
9	DQ3	81	V_{CC}	10	DQ35	82	V_{CC}
11	V_{CC}	83	DQ16	12	V_{CC}	84	DQ48
13	DQ4	85	DQ17	14	DQ36	86	DQ49
15	DQ5	87	DQ18	16	DQ37	88	DQ50
17	DQ6	89	DQ19	18	DQ38	90	DQ51
19	DQ7	91	V_{SS}	20	DQ39	92	V_{SS}
21	V_{SS}	93	DQ20	22	V_{SS}	94	DQ52
23	$\overline{CE0}$	95	DQ21	24	$\overline{CE4}$	96	DQ53
25	$\overline{CE1}$	97	DQ22	26	$\overline{CE5}$	98	DQ54
27	V_{CC}	99	DQ23	28	V_{CC}	100	DQ55
29	A0	101	V_{CC}	30	A3	102	V_{CC}
31	A1	103	A6	32	A4	104	A7
33	A2	105	A8	34	A5	106	A11 (NC)*[2]
35	V_{SS}	107	V_{SS}	36	V_{SS}	108	V_{SS}

Pin Arrangement (cont)

Front side				Back side			
Pin No.	**Pin name**	**Pin No.**	**Pin name**	**Pin No.**	**Pin name**	**Pin No.**	**Pin name**
37	DQ8	109	A9	38	DQ40	110	NC
39	DQ9	111	A10 (NC)*[1]	40	DQ41	112	NC
41	DQ10	113	V_{CC}	42	DQ42	114	V_{CC}
43	DQ11	115	$\overline{CE2}$	44	DQ43	116	$\overline{CE6}$
45	V_{CC}	117	$\overline{CE3}$	46	V_{CC}	118	$\overline{CE7}$
47	DQ12	119	V_{SS}	48	DQ44	120	V_{SS}
49	DQ13	121	DQ24	50	DQ45	122	DQ56
51	DQ14	123	DQ25	52	DQ46	124	DQ57
53	DQ15	125	DQ26	54	DQ47	126	DQ58
55	V_{SS}	127	DQ27	56	V_{SS}	128	DQ59
57	NC	129	V_{CC}	58	NC	130	V_{CC}
59	NC	131	DQ28	60	NC	132	DQ60
61	NC	133	DQ29	62	NC	134	DQ61
63	V_{CC}	135	DQ30	64	V_{CC}	136	DQ62
65	NC	137	DQ31	66	NC	138	DQ63
67	$\overline{WE}$	139	V_{SS}	68	NC	140	V_{SS}
69	$\overline{RE0}$	141	SDA	70	NC	142	SCL
71	NC	143	V_{CC}	72	NC	144	V_{CC}

Notes: 1. A10: HB56HW164DB, NC: HB56HW165DB
2. A11: HB56HW164DB, NC: HB56HW165DB

Pin Description

Pin name	Function
A0 to A11 (HB56HW164DB)	Address inputs: • Row address: A0 to A11 • Column address: A0 to A7 • Refresh address: A0 to A11
A0 to A9 (HB56HW165DB)	Address inputs: • Row address: A0 to A9 • Column address: A0 to A9 • Refresh address: A0 to A9
DQ0 to DQ63	Data-in/Data-out
$\overline{RE0}$	Row address strobe ($\overline{RAS}$)
$\overline{CE0}$ to $\overline{CE7}$	column address strobe ($\overline{CAS}$)
$\overline{WE}$	Read/Write enable
$\overline{OE}$	Output enable
V_{CC}	Power supply
V_{SS}	Ground
SDA	Serial data for PD
SCL	Serial clock for PD
NC	No connection

Serial PD Matrix*[1]

Byte No.	Function described	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	Hex value	Comments
0	Number of bytes used by module manufacturer	1	0	0	0	0	0	0	0	80	128 byte
1	Total SPD memory size	0	0	0	0	1	0	0	0	08	256 byte
2	Memory type	0	0	0	0	0	0	1	0	02	EDO
3	Number of row addresses bits										
	(HB56HW164DB)	0	0	0	0	1	1	0	0	0C	12
	(HB56HW165DB)	0	0	0	0	1	0	1	0	0A	10
4	Number of column addresses bits										
	(HB56HW164DB)	0	0	0	0	1	0	0	0	08	8
	(HB56HW165DB)	0	0	0	0	1	0	1	0	0A	10
5	Number of banks	0	0	0	0	0	0	0	1	01	1
6	Module data width	0	1	0	0	0	0	0	0	40	64
7	Module data width (continued)	0	0	0	0	0	0	0	0	00	0 (+)
8	Module interface signal levels	0	0	0	0	0	0	0	1	01	LVTTL
9	$\overline{RAS}$ access time										
	-5/-5L	0	0	1	1	0	0	1	0	32	t_{RAC} = 50 ns
	-6/-6L	0	0	1	1	1	1	0	0	3C	t_{RAC} = 60 ns
	-7/-7L	0	1	0	0	0	1	1	0	46	t_{RAC} = 70 ns
10	$\overline{CAS}$ access time										
	-5/-5L	0	0	0	0	1	1	0	1	0D	t_{CAC} = 13 ns
	-6/-6L	0	0	0	0	1	1	1	1	0F	t_{CAC} = 15 ns
	-7/-7L	0	0	0	1	0	0	1	0	12	t_{CAC} = 18 ns
11	Module configuration type	0	0	0	0	0	0	0	0	00	Non parity
12	Refresh rate/type										
	-5/-6/-7	0	0	0	0	0	0	0	0	00	Normal (15.625 µs)
	(HB56HW164DB-5L/-6L/-7L)	1	0	0	0	0	0	1	1	83	Self refresh (31.3 µs)
	(HB56HW165DB-5L/-6L/-7L)	1	0	0	0	0	1	0	1	85	Self refresh (125 µs)
13	DRAM width	0	0	0	1	0	0	0	0	10	1M× 16
14	Error checking DRAM width	0	0	0	0	0	0	0	0	00	—
15 to 31	Reserved for future offerings	0	0	0	0	0	0	0	0	00	
32 to 61	Superset information	0	0	0	0	0	0	0	0	00	Future offerings
62	SPD data revision code	0	0	0	0	0	0	0	1	01	Rev.1

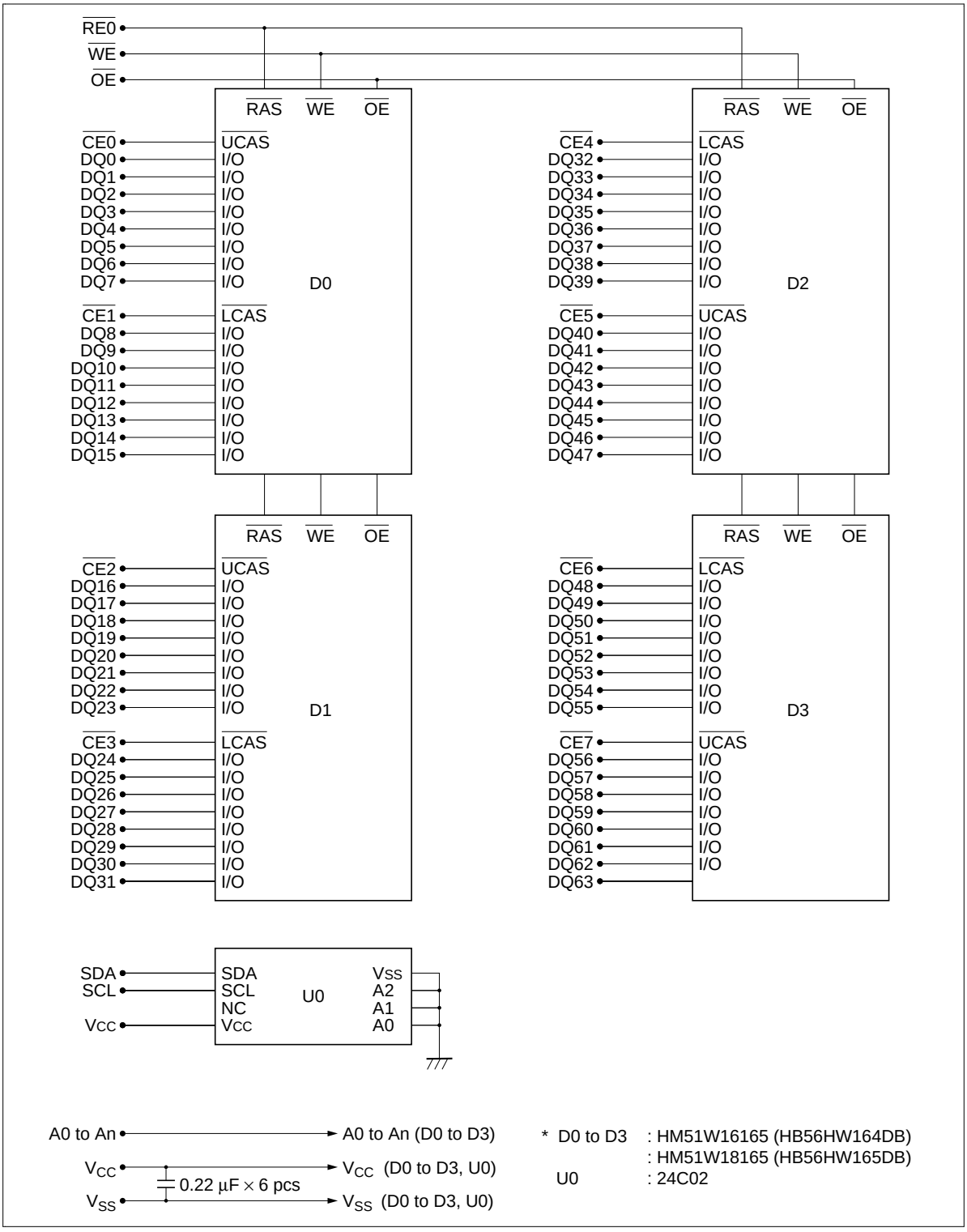
Byte No.	Function described	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	Hex value	Comments
63	Checksum for bytes 0 to 62 (HB56HW164DB-5)	0	0	1	1	0	0	0	0	30	
	(HB56HW164DB-6)	0	0	1	1	1	1	0	0	3C	
	(HB56HW164DB-7)	0	1	0	0	1	0	0	1	49	
	(HB56HW164DB-5L)	1	0	1	1	0	0	1	1	B3	
	(HB56HW164DB-6L)	1	0	1	1	1	1	1	1	BF	
	(HB56HW164DB-7L)	1	1	0	0	1	1	0	0	CC	
	(HB56HW165DB-5)	0	0	1	1	0	0	0	0	30	
	(HB56HW165DB-6)	0	0	1	1	1	1	0	0	3C	
	(HB56HW165DB-7)	0	1	0	0	1	0	0	1	49	
	(HB56HW165DB-5L)	1	0	1	1	0	1	0	1	B5	
	(HB56HW165DB-6L)	1	1	0	0	0	0	0	1	C1	
	(HB56HW165DB-7L)	1	1	0	0	1	1	1	0	CE	
64	Manufacturer's JEDEC ID code	0	0	0	0	0	1	1	1	07	HITACHI
65 to 71	Manufacturer's JEDEC ID code	0	0	0	0	0	0	0	0	00	
72	Manufacturing location	×	×	×	×	×	×	×	×	××	*[2] (ASCII-8bit code)
73	Manufacturer's part number	0	1	0	0	1	0	0	0	48	H
74	Manufacturer's part number	0	1	0	0	0	0	1	0	42	B
75	Manufacturer's part number	0	0	1	1	0	1	0	1	35	5
76	Manufacturer's part number	0	0	1	1	0	1	1	0	36	6
77	Manufacturer's part number	0	1	0	0	1	0	0	0	48	H
78	Manufacturer's part number	0	1	0	1	0	1	1	1	57	W
79	Manufacturer's part number	0	0	1	1	0	0	0	1	31	1
80	Manufacturer's part number	0	0	1	1	0	1	1	0	36	6
81	Manufacturer's part number (HB56HW164DB)	0	0	1	1	0	1	0	0	34	4
	(HB56HW165DB)	0	0	1	1	0	1	0	0	35	5
82	Manufacturer's part number	0	1	0	0	0	1	0	1	45	D
83	Manufacturer's part number	0	1	0	0	0	0	1	0	42	B
84	Manufacturer's part number	0	1	0	1	1	1	1	1	5F	—
85	Manufacturer's part number -5/-5L	0	0	1	1	0	1	0	1	35	5
	-6/-6L	0	0	1	1	0	1	1	0	36	6
	-7/-7L	0	0	1	1	0	1	1	1	37	7
86	Manufacturer's part number -5/-6/-7	0	0	1	0	0	0	0	0	20	(Space)
	-5L/-6L/-7L	0	1	0	0	1	1	0	0	4C	L

Byte No.	Function described	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	Hex value	Comments
87	Manufacturer's part number	0	0	1	0	0	0	0	0	20	(Space)
88	Manufacturer's part number	0	0	1	0	0	0	0	0	20	(Space)
89	Manufacturer's part number	0	0	1	0	0	0	0	0	20	(Space)
90	Manufacturer's part number	0	0	1	0	0	0	0	0	20	(Space)
91	Revision code	0	0	1	1	0	0	0	0	30	Initial
92	Revision code	0	0	1	0	0	0	0	0	20	(Space)
93	Manufacturing date	×	×	×	×	×	×	×	×	××	Year code (binary) *3
94	Manufacturing date	×	×	×	×	×	×	×	×	××	Week code (binary) *4
95 to 98	Assembly serial number	*5									
99 to 125	Manufacturer specific data	*6									
126	Reserved	0	0	0	0	0	0	0	0	00	Not use
127	Reserved	0	0	0	0	0	0	0	0	00	Not use

Notes: 1. All serial PD data are not protected. 0: Serial data, "driven Low", 1: Serial data, "driven High"

2. Byte72 is manufacturing location code. (ex: In case of Japan, byte72 is 4Ah. 4Ah shows "J" on ASCII code.)
3. Byte 93 (Manufacturing date-year code) ex: 61h shows year'97. 62h shows year'98.
4. Byte 94 (Manufacturing date-week code) ex: 0Bh shows week 11. 24h shows week 36.
5. Byte 95 through 98 are assembly serial number.
6. All bits of 99 through 125 are not defined ("1" or "0").

Block Diagram



Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Voltage on any pin relative to V_{SS}	V_T	–0.5 to +4.6	V
Supply voltage relative to V_{SS}	V_{CC}	–0.5 to +4.6	V
Short circuit output current	Iout	50	mA
Power dissipation	Pt	4	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_{SS}	0	0	0	V	
	V_{CC}	3.0	3.3	3.6	V	1
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}.

DC Characteristics (Ta = 0 to 70°C, V_{CC} = 3.3 V ± 0.3V, V_{SS} = 0 V) (HB56HW164DB)

		50 ns		60 ns		70 ns				
Parameter	**Symbol**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Unit**	**Test conditions**	**Notes**
Operating current	I_{CC1}	—	440	—	400	—	360	mA	t_{RC} = min	1, 2
Standby current	I_{CC2}	—	8	—	8	—	8	mA	TTL interface $\overline{RAS}$, $\overline{CAS}$ = V_{IH} Dout = High-Z	
		—	4	—	4	—	4	mA	CMOS interface $\overline{RAS}$, $\overline{CAS}$ ≥ V_{CC} – 0.2 V Dout = High-Z	
Standby current (L-version)	I_{CC2}	—	0.6	—	0.6	—	0.6	mA	CMOS interface $\overline{RAS}$, $\overline{CAS}$ ≥ V_{CC} – 0.2 V Dout = High-Z	
$\overline{RAS}$-only refresh current	I_{CC3}	—	440	—	400	—	360	mA	t_{RC} = min	2
Standby current	I_{CC5}	—	20	—	20	—	20	mA	$\overline{RAS}$ = V_{IH}, $\overline{CAS}$ = V_{IL} Dout = enable	1
$\overline{CAS}$-before-$\overline{RAS}$ refresh current	I_{CC6}	—	440	—	400	—	360	mA	t_{RC} = min	
EDO page mode current	I_{CC7}	—	420	—	380	—	340	mA	t_{HPC} = min	1, 3
Battery backup current (Standby with CBR refresh) (L-version)	I_{CC10}	—	1.6	—	1.6	—	1.6	mA	CMOS interface Dout = High-Z CBR refresh: t_{RC} = 31.3 µs t_{RAS} ≤ 0.3 µs	4
Self refresh mode current (L-version)	I_{CC11}	—	1	—	1	—	1	mA	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 ≤ 4.6 V	
Output leakage current	I_{LO}	–10	10	–10	10	–10	10	µA	0 V ≤ Vout ≤ 4.6 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}.
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 ± 0.3V, V_{SS} = 0 V) (HB56HW165DB)

		50 ns		60 ns		70 ns				
Parameter	**Symbol**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Unit**	**Test conditions**	**Notes**
Operating current	I_{CC1}	—	760	—	680	—	600	mA	t_{RC} = min	1, 2
Standby current	I_{CC2}	—	8	—	8	—	8	mA	TTL interface $\overline{RAS}$, $\overline{CAS}$ = V_{IH} Dout = High-Z	
		—	4	—	4	—	4	mA	CMOS interface $\overline{RAS}$, $\overline{CAS}$ ≥ V_{CC} – 0.2 V Dout = High-Z	
Standby current (L-version)	I_{CC2}	—	0.6	—	0.6	—	0.6	mA	CMOS interface $\overline{RAS}$, $\overline{CAS}$ ≥ V_{CC} – 0.2 V Dout = High-Z	
$\overline{RAS}$-only refresh current	I_{CC3}	—	760	—	680	—	600	mA	t_{RC} = min	2
Standby current	I_{CC5}	—	20	—	20	—	20	mA	$\overline{RAS}$ = V_{IH}, $\overline{CAS}$ = V_{IL} Dout = enable	1
$\overline{CAS}$-before-$\overline{RAS}$ refresh current	I_{CC6}	—	760	—	680	—	600	mA	t_{RC} = min	
EDO page mode current	I_{CC7}	—	740	—	660	—	580	mA	t_{HPC} = min	1, 3
Battery backup current (Standby with CBR refresh) (L-version)	I_{CC10}	—	1.6	—	1.6	—	1.6	mA	CMOS interface Dout = High-Z CBR refresh: t_{RC} = 125 µs t_{RAS} ≤ 0.3 µs	4
Self refresh mode current (L-version)	I_{CC11}	—	1	—	1	—	1	mA	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 ≤ 4.6 V	
Output leakage current	I_{LO}	–10	10	–10	10	–10	10	µA	0 V ≤ Vout ≤ 4.6 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}.
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)

Parameter	Symbol	Typ	Max	Unit	Notes
Input capacitance (Address)	C_{I1}	—	40	pF	1
Input capacitance ($\overline{RAS}$, $\overline{WE}$, $\overline{OE}$)	C_{I2}	—	48	pF	1
Input capacitance ($\overline{CAS}$)	C_{I3}	—	22	pF	1
I/O capacitance (DQ)	$C_{I/O}$	—	17	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} = 3.3 V ±0.3 V, V_{SS} = 0 V) *[1], *[2], *[18], *[19]

Test Conditions

- Input rise and fall times: 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 (100 pF) (Including scope and jig)

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

		50 ns		60 ns		70 ns			
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}	5	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	14	45	14	52	ns	3
$\overline{RAS}$ to column address delay time	t_{RAD}	10	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
Refresh period (HB56HW164DB: 4,096 cycles)	t_{REF}	—	64	—	64	—	64	ms	
Refresh period (HB56HW164DB: 4,096 cycles) (L-version)	t_{REF}	—	128	—	128	—	128	ms	
Refresh period (HB56HW165DB: 1,024 cycles)	t_{REF}	—	16	—	16	—	16	ms	
Refresh period (HB56HW165DB: 1,024 cycles) (L-version)	t_{REF}	—	128	—	128	—	128	ms	

Read Cycle

		50 ns		60 ns		70 ns			
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, 17
Access time from address	t_{AA}	—	25	—	30	—	35	ns	9, 11, 17
Access time from $\overline{OE}$	t_{OEA}	—	13	—	15	—	18	ns	9, 21
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	—	5	—	5	—	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 time 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

		50 ns		60 ns		70 ns			
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

		50 ns		60 ns		70 ns			
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 $\overline{WE}$	t_{OEH}	13	—	15	—	18	—	ns	

Refresh Cycle

		50 ns		60 ns		70 ns			
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	
$\overline{RAS}$ precharge to $\overline{CAS}$ hold time	t_{RPC}	5	—	5	—	5	—	ns	

EDO Page Mode Cycle

		50 ns		60 ns		70 ns			
Parameter	**Symbol**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Unit**	**Notes**
EDO page mode cycle time	t_{HPC}	20	—	25	—	30	—	ns	20
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
$\overline{RAS}$ hold time from $\overline{CAS}$ precharge	t_{CPRH}	30	—	35	—	40	—	ns	
Output data hole 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

		50 ns		60 ns		70 ns			
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

Self Refresh Mode (L-version)

		50 ns		60 ns		70 ns			
Parameter	**Symbol**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Unit**	**Notes**
$\overline{RAS}$ pulse width (Self refresh)	t_{RASS}	100	—	100	—	100	—	µs	
$\overline{RAS}$ 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 µs is required after power up followed by a minimum of eight initialization cycles (any combination of cycles containing $\overline{RAS}$-only refresh cycle 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 $t_{RCD} \geq t_{RAD}$ (max) + t_{AA} (max)- t_{CAC} (max), 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 the device. After $\overline{RAS}$ is reset, if $t_{OEH} \geq t_{CWL}$, the DQ pin will remain open circuit (high impedance); $t_{OEH} < t_{OEH}$, invalid data will be out at each DQ.
19. All the V_{CC} and V_{SS} pins shall be supplied with the same voltages.
20. 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} + 2t_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).
21. 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_{CC} / V_{SS} line noise, which causes to degrade V_{IH} min./ V_{IL} max level.
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. Please do not use t_{RASS} timing, 10 µs $\leq t_{RASS} \leq$ 100 µs. During this period, the device is in transition state from normal operation mode to self refresh mode. If $t_{RASS} \geq$ 100 µs, then $\overline{RAS}$ precharge time should use t_{RPS} instead of t_{RP}.

24. If you use distributed CBR refresh mode with 15.6 μs interval in normal read/write cycle, CBR refresh should be executed within 15.6 μs immediately after exiting from and before entering into self refresh mode.
25. If you use $\overline{RAS}$ only refresh or CBR burst refresh mode in normal read/write cycle, 4096 or 1024 cycles (4096 cycles: HB56HW164DB Series, 1024 cycles: HB56HW165DB Series) of distributed CBR refresh with 15.6 μs interval should be executed within 64 or 16 ms (64 ms: HB56HW164DB Series, 16 ms: HB56HW165DB 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 fresh mode, all memory cells need to be refreshed before re-entering the self refresh mode again.
27. XXX: H or L (H: V_{IH} (min) ≤ V_{IN} ≤ V_{IH} (max), L: V_{IL} (min) ≤ V_{IN} ≤ V_{IL} (max))

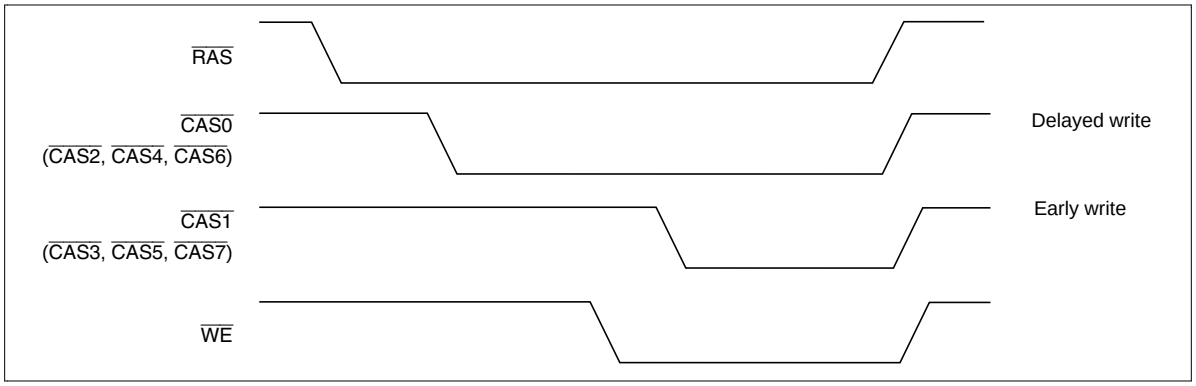
    ///////: Invalid Dout

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

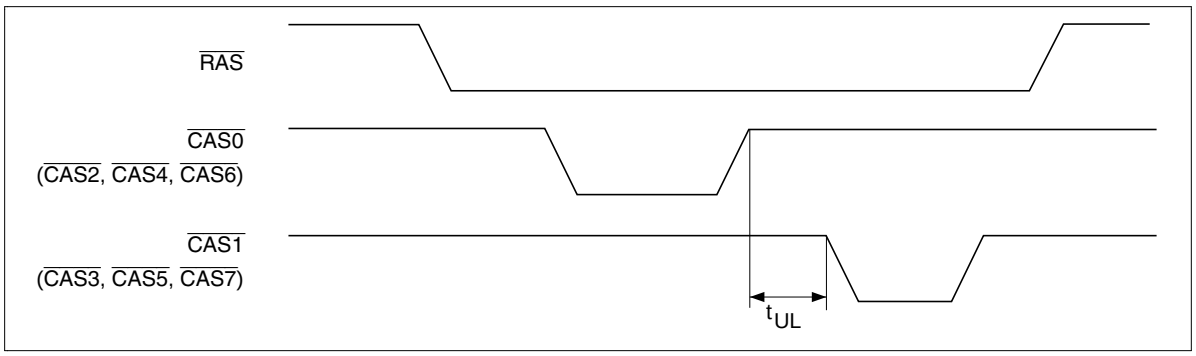
Notes concerning 2$\overline{CAS}$ control

Please do not separate the 2$\overline{CAS}$s ($\overline{CAS}$0 and $\overline{CAS}$1 (or $\overline{CAS}$2, $\overline{CAS}$4, $\overline{CAS}$6 and $\overline{CAS}$3, $\overline{CAS}$5, $\overline{CAS}$7)) operation timing intentionally. However skew between 2$\overline{CAS}$s are allowed under the following conditions.

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



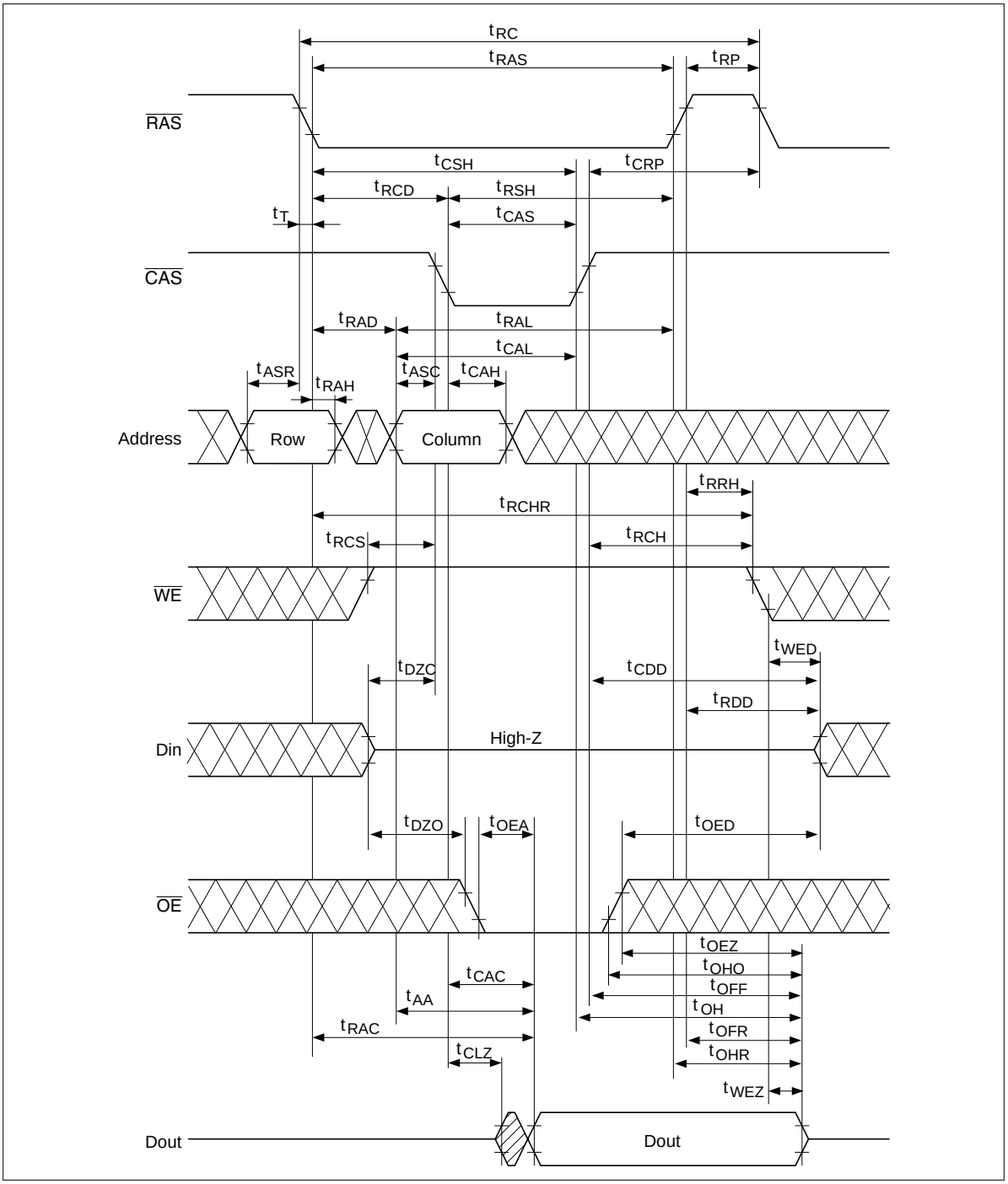
3. Closely separated upper/lower byte control is not allowed. However when the condition ($t_{CP} \leq t_{UL}$) is satisfied, page mode can be performed.



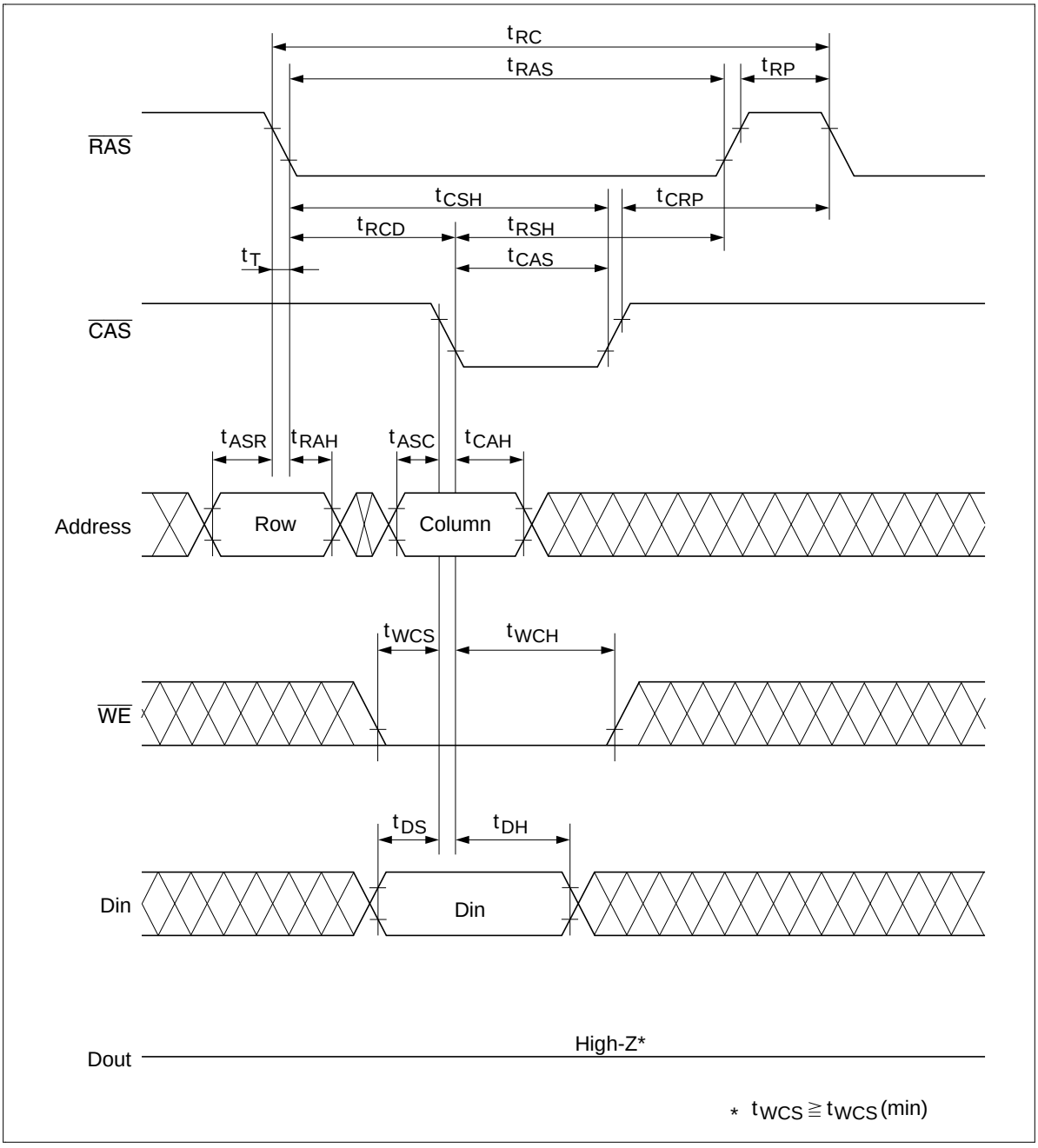
4. Byte control operation by remaining $\overline{CAS}$0 ($\overline{CAS}$2, $\overline{CAS}$4, $\overline{CAS}$6) or $\overline{CAS}$1 ($\overline{CAS}$3, $\overline{CAS}$5, $\overline{CAS}$7) high is guaranteed.

Timing Waveforms*[27]

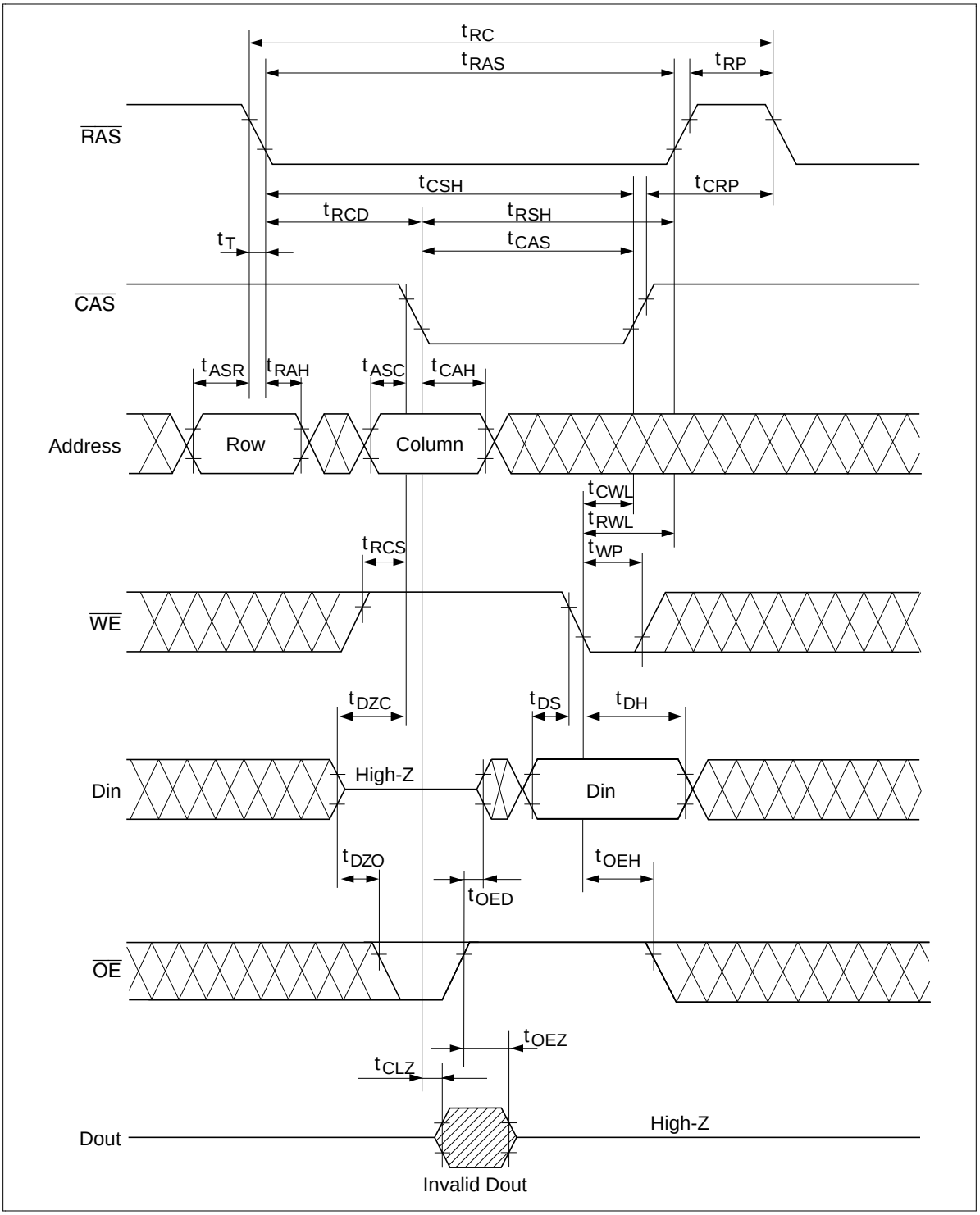
Read Cycle



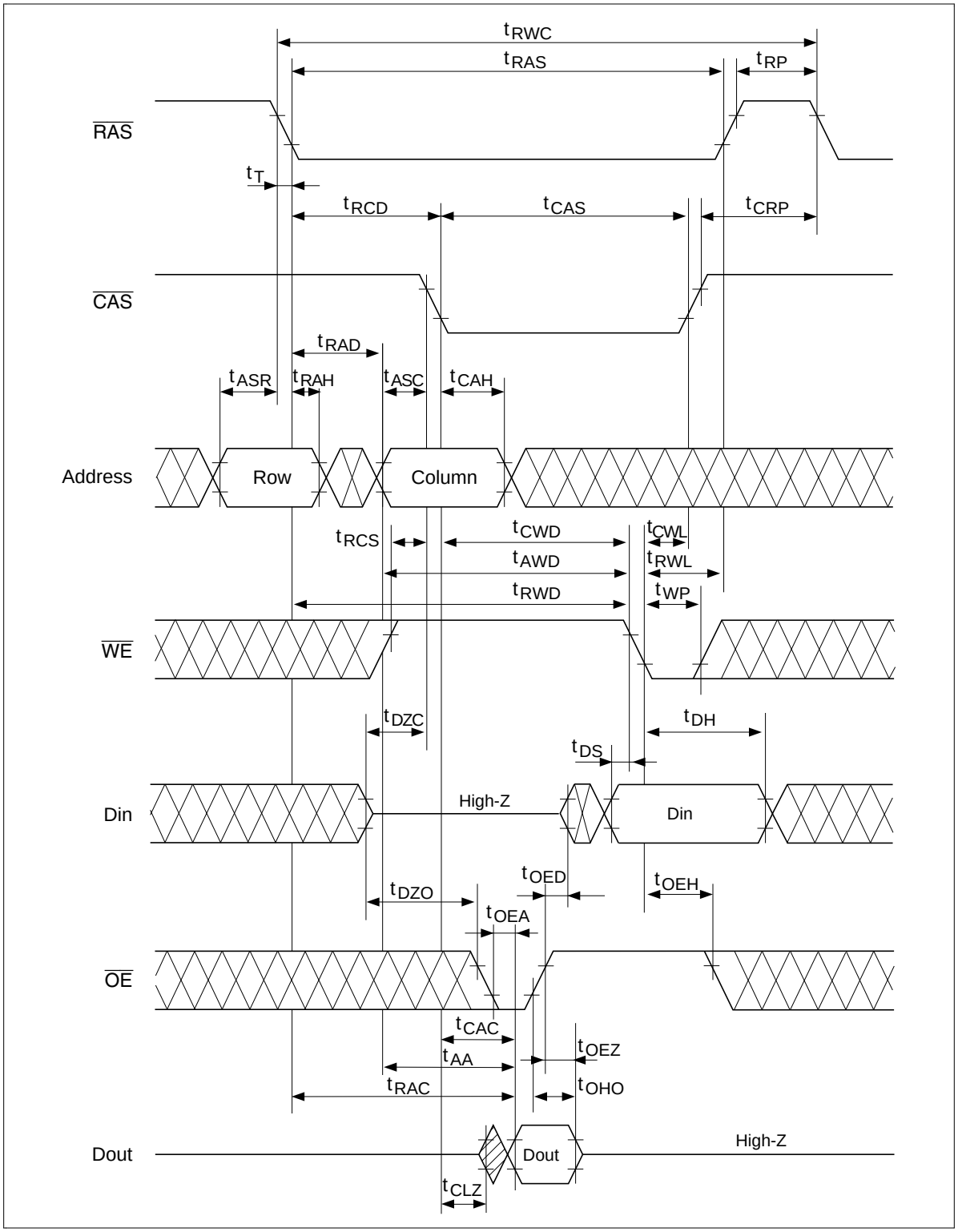
Early Write Cycle



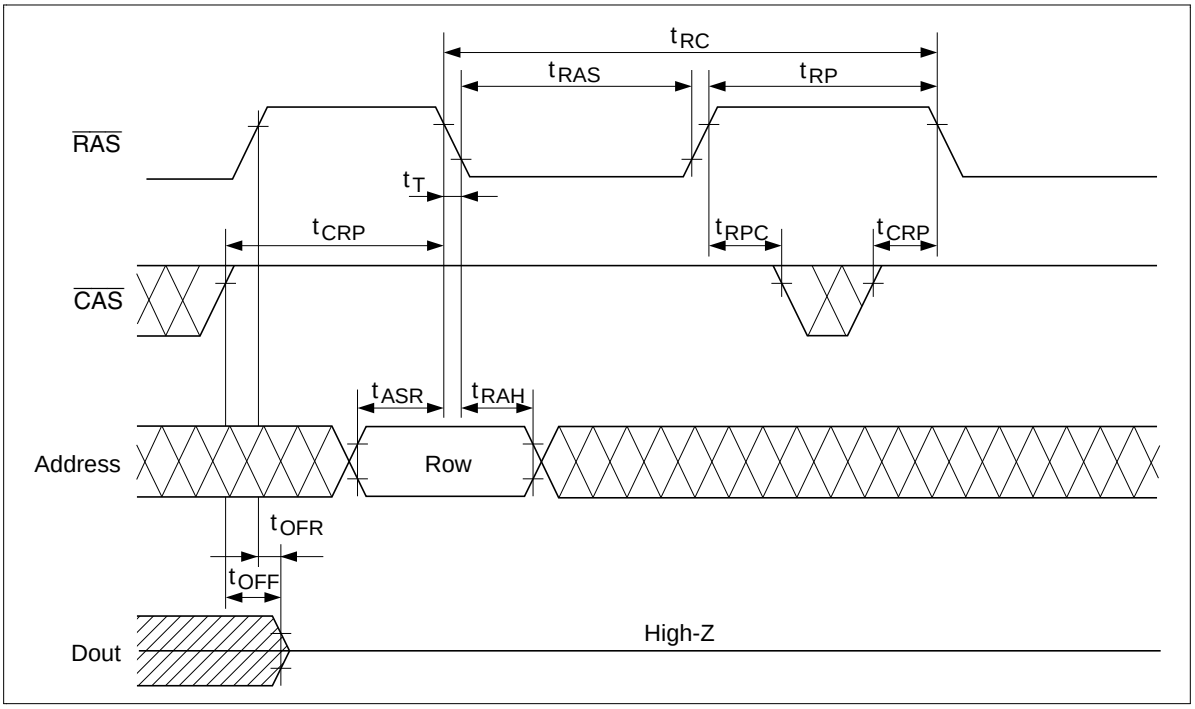
Delayed Write Cycle*[18]



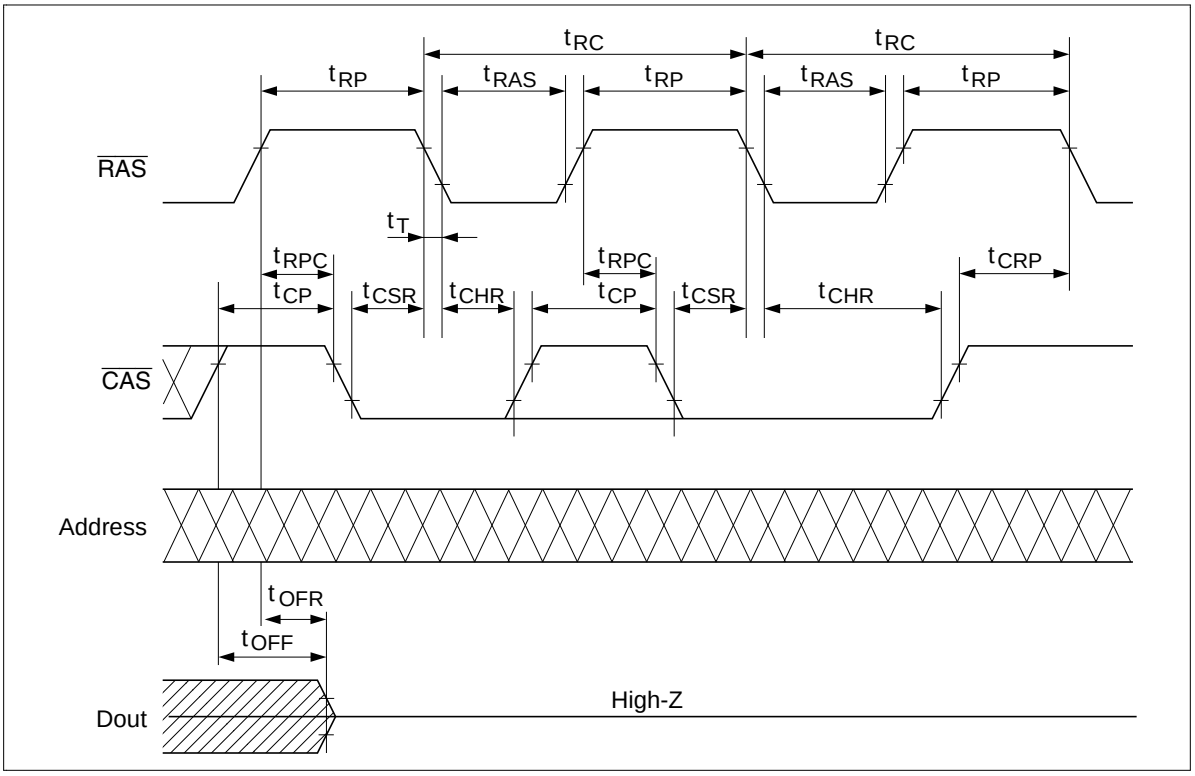
Read-Modify-Write Cycle*[18]



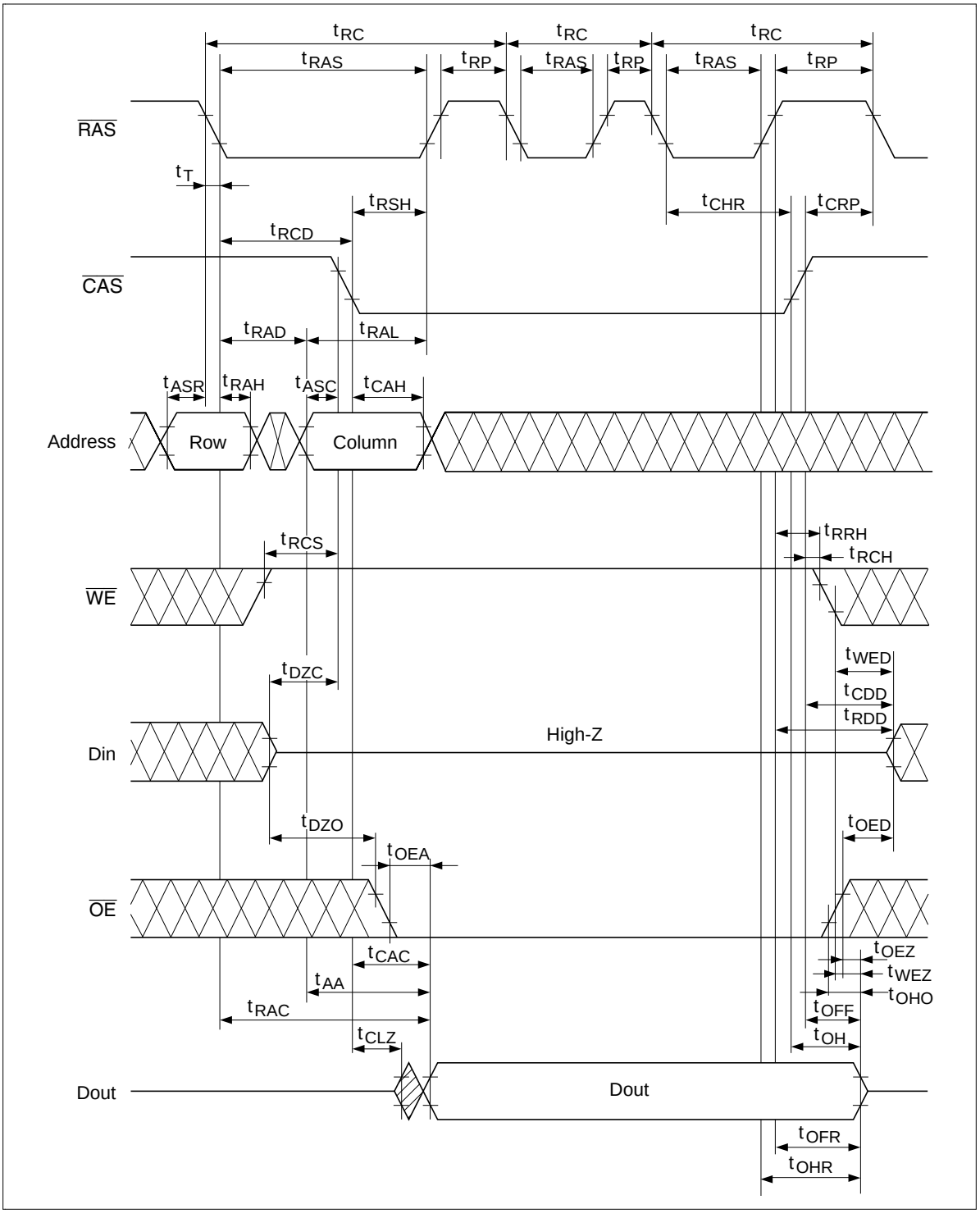
$\overline{\text{RAS}}$-Only Refresh Cycle



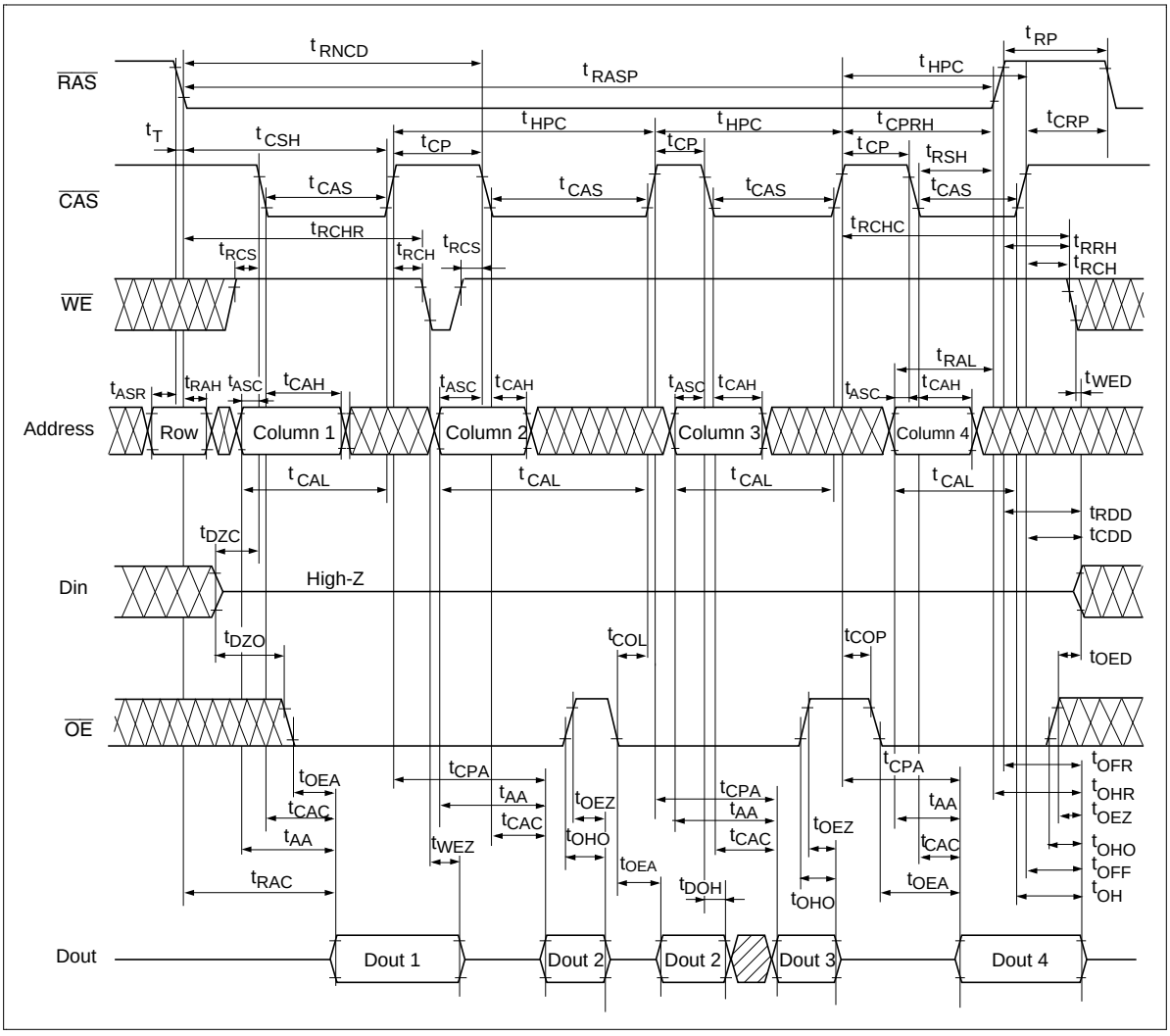
$\overline{\text{CAS}}$-Before-$\overline{\text{RAS}}$ Refresh Cycle



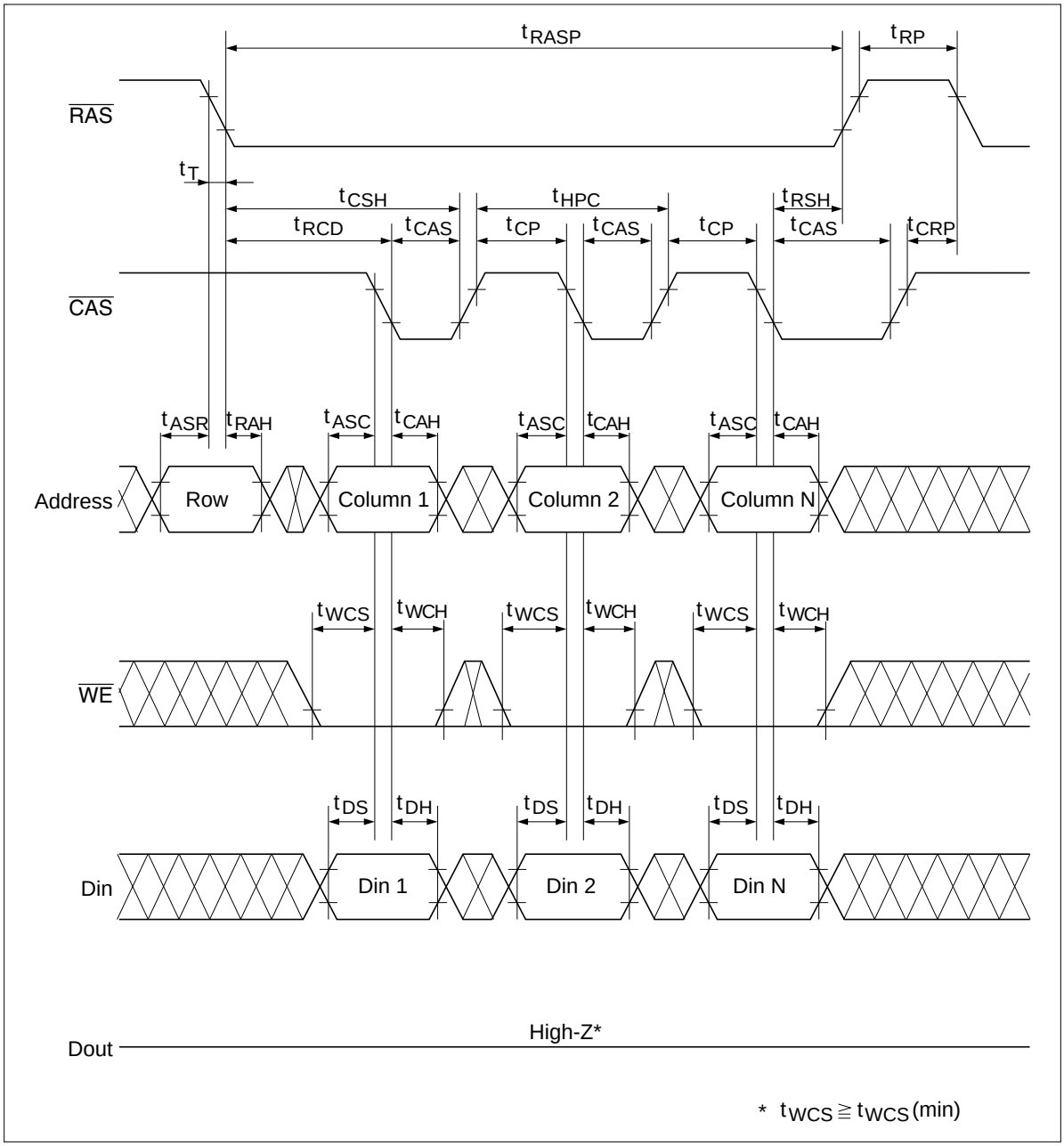
Hidden Refresh Cycle



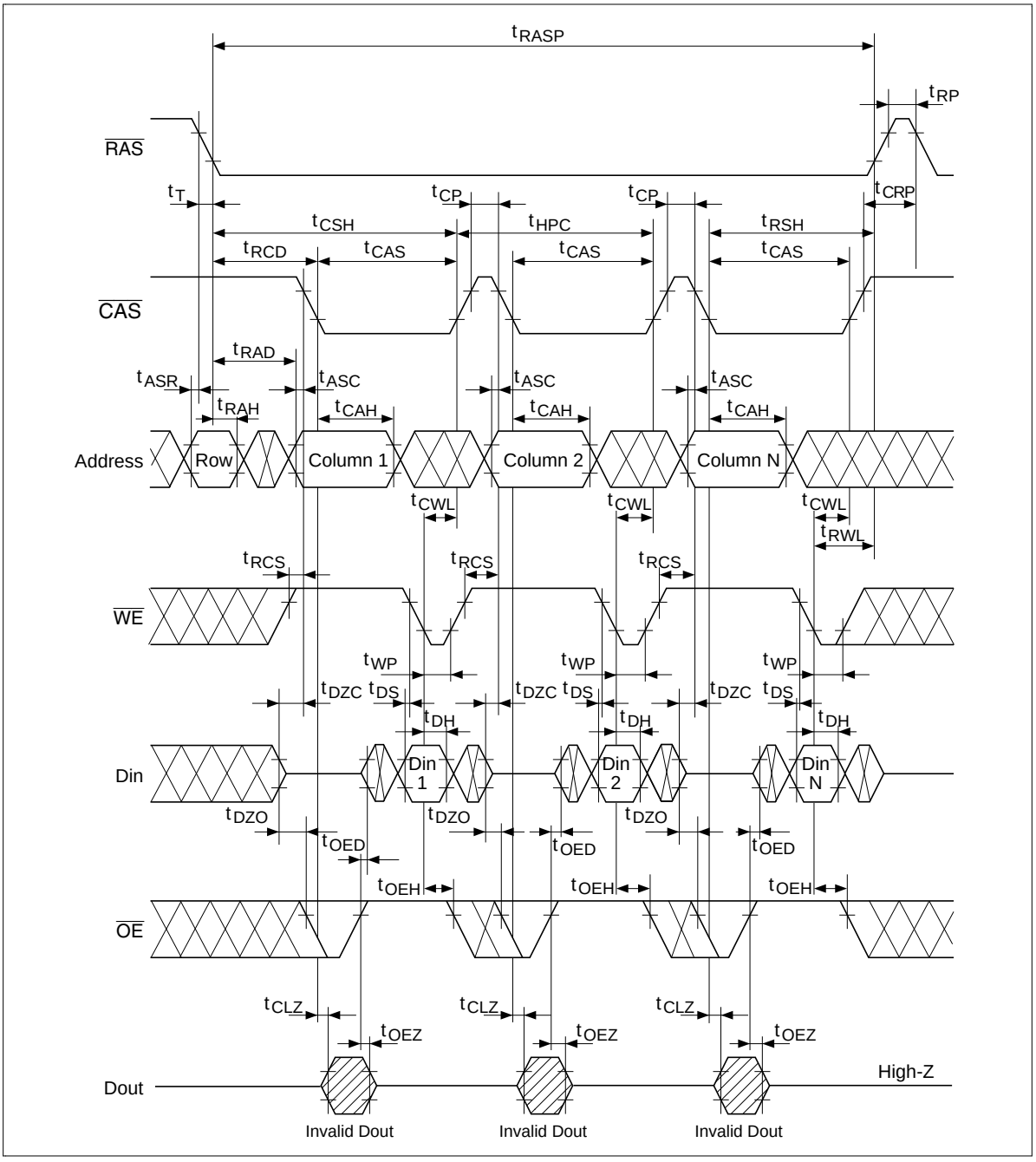
EDO Page Mode Read Cycle



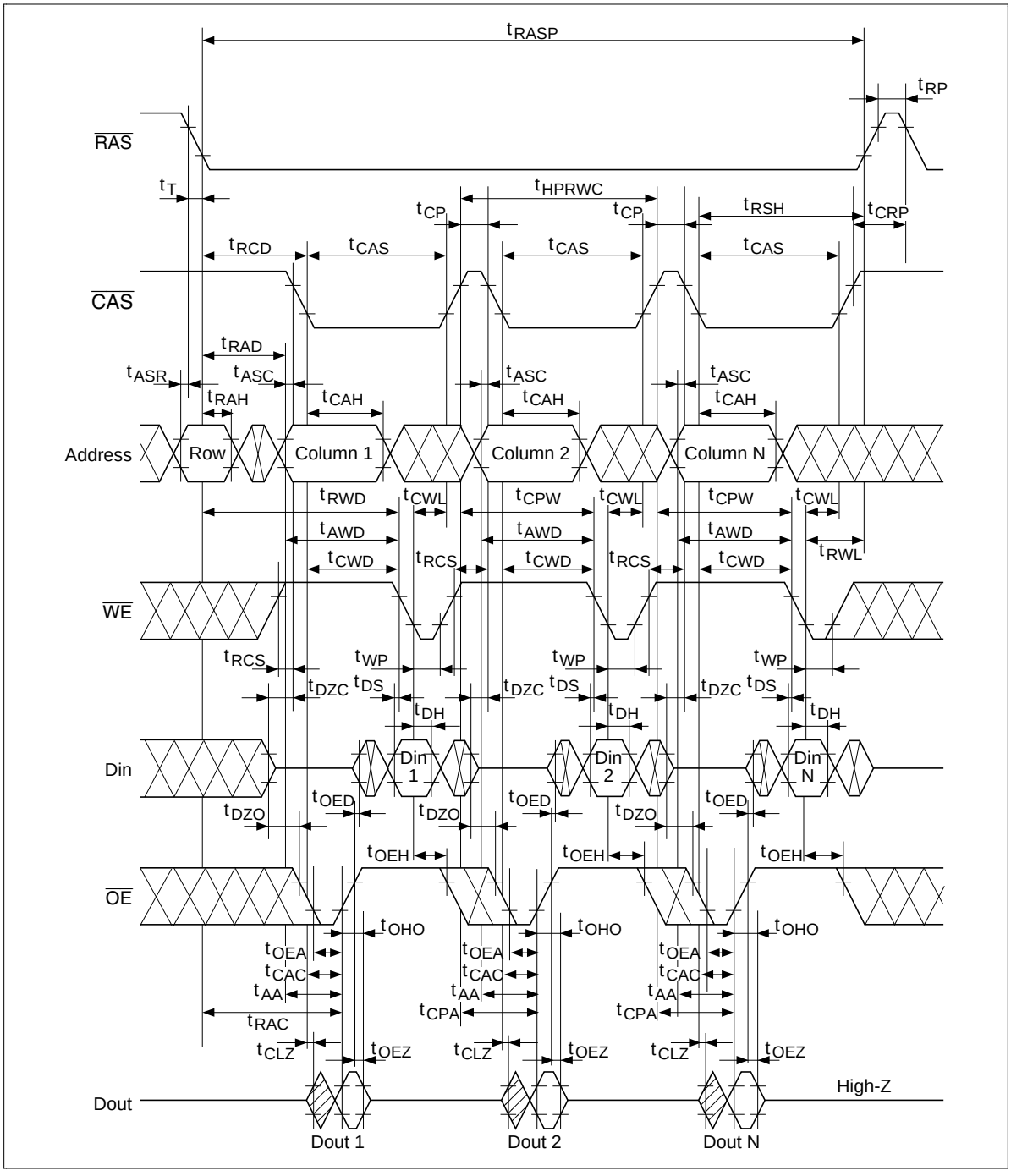
EDO Page Mode Early Write Cycle



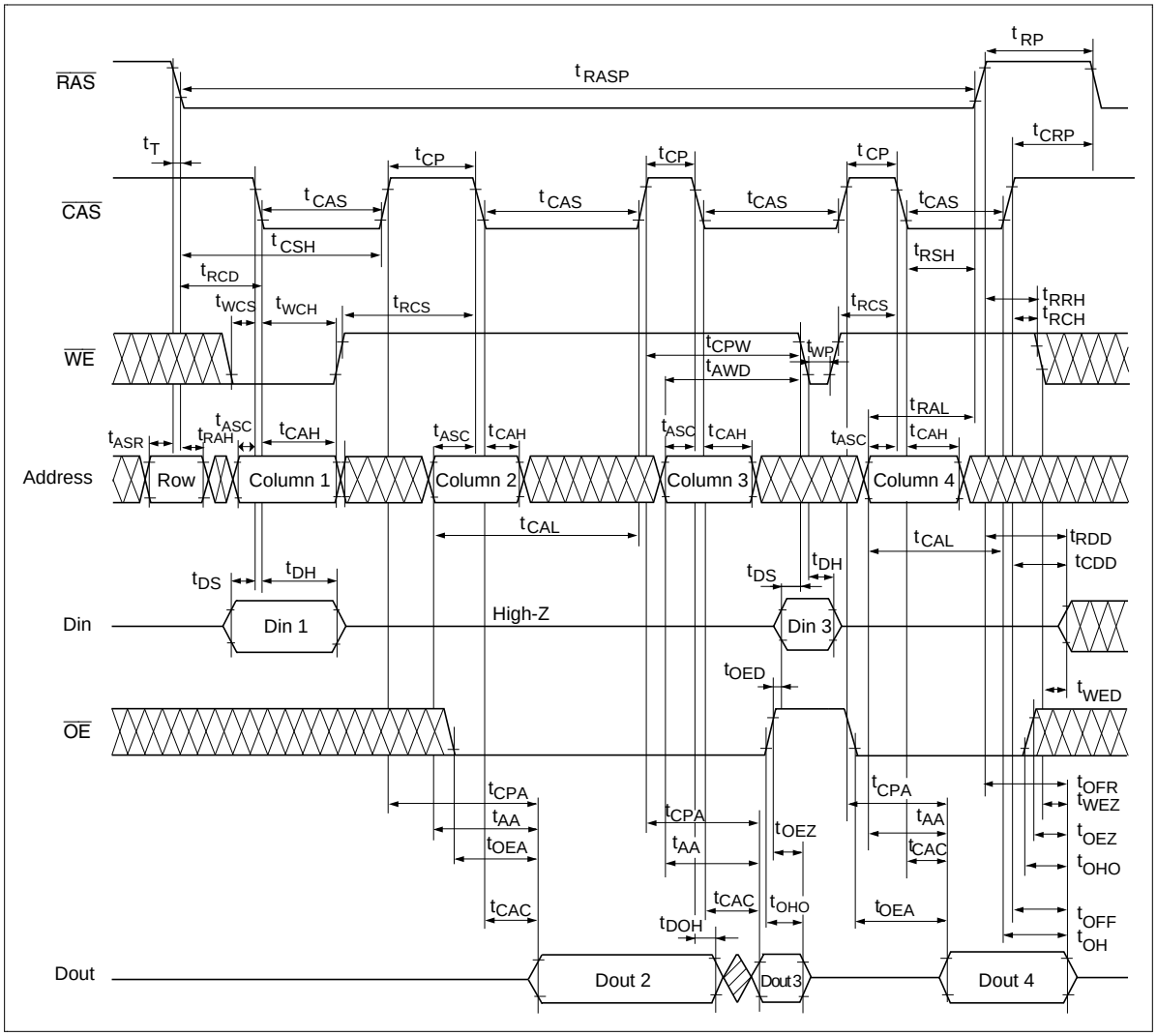
EDO Page Mode Delayed Write Cycle*[18]



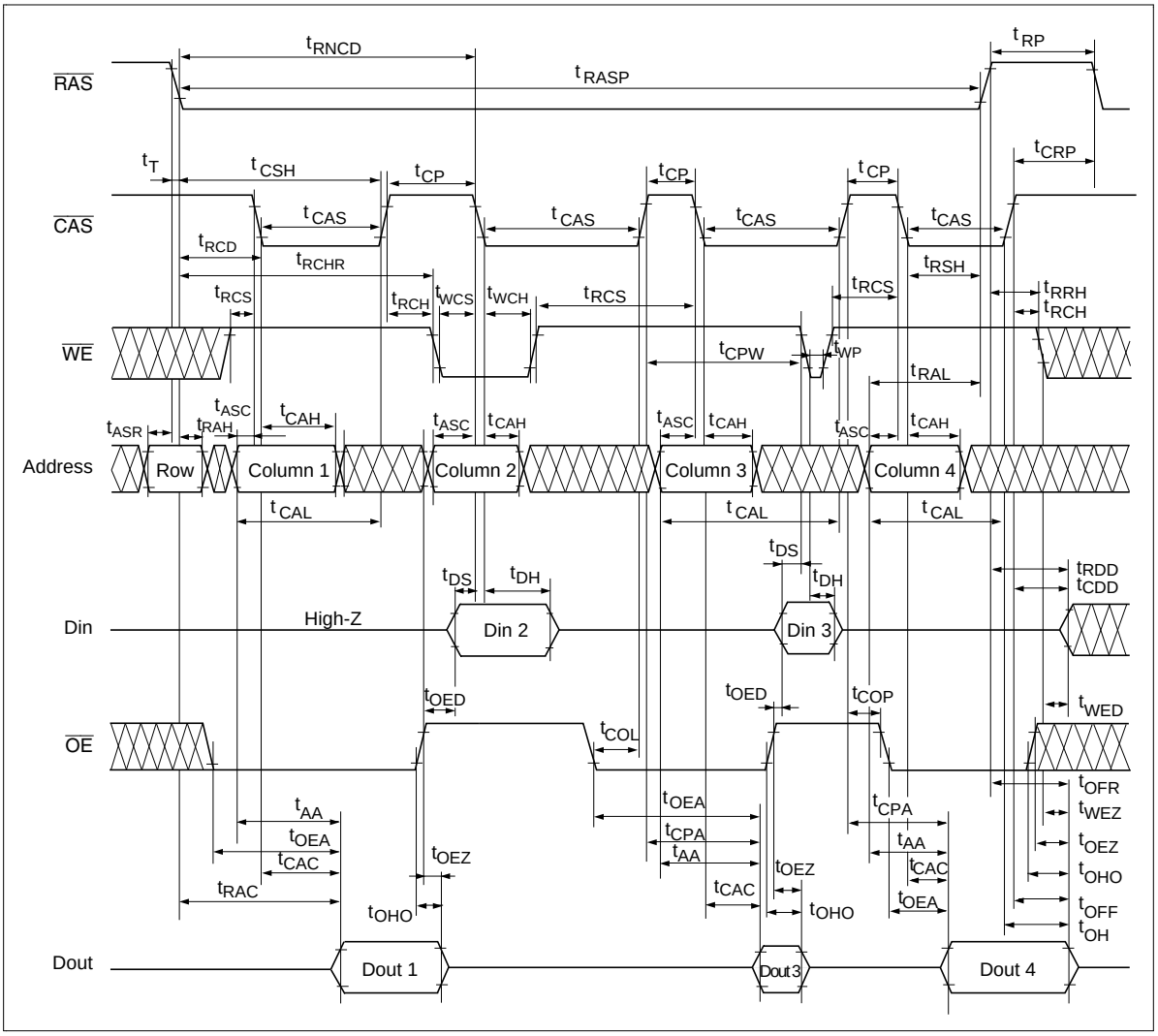
EDO Page Mode Read-Modify-Write Cycle*[18]



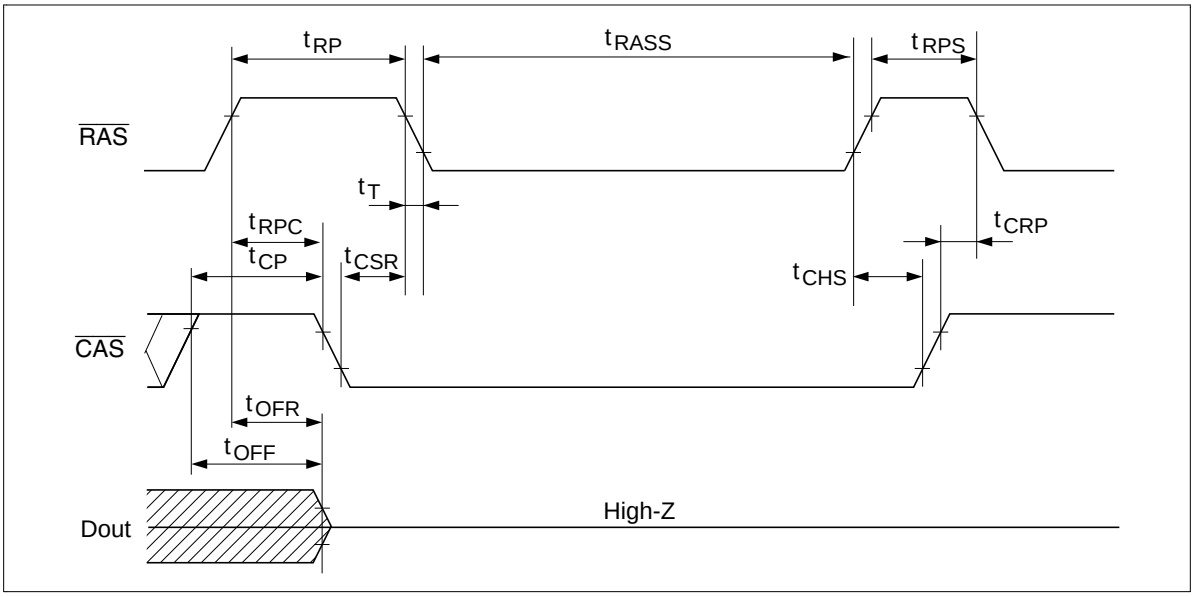
EDO Page Mode Mix Cycle (1)



EDO Page Mode Mix Cycle (2)

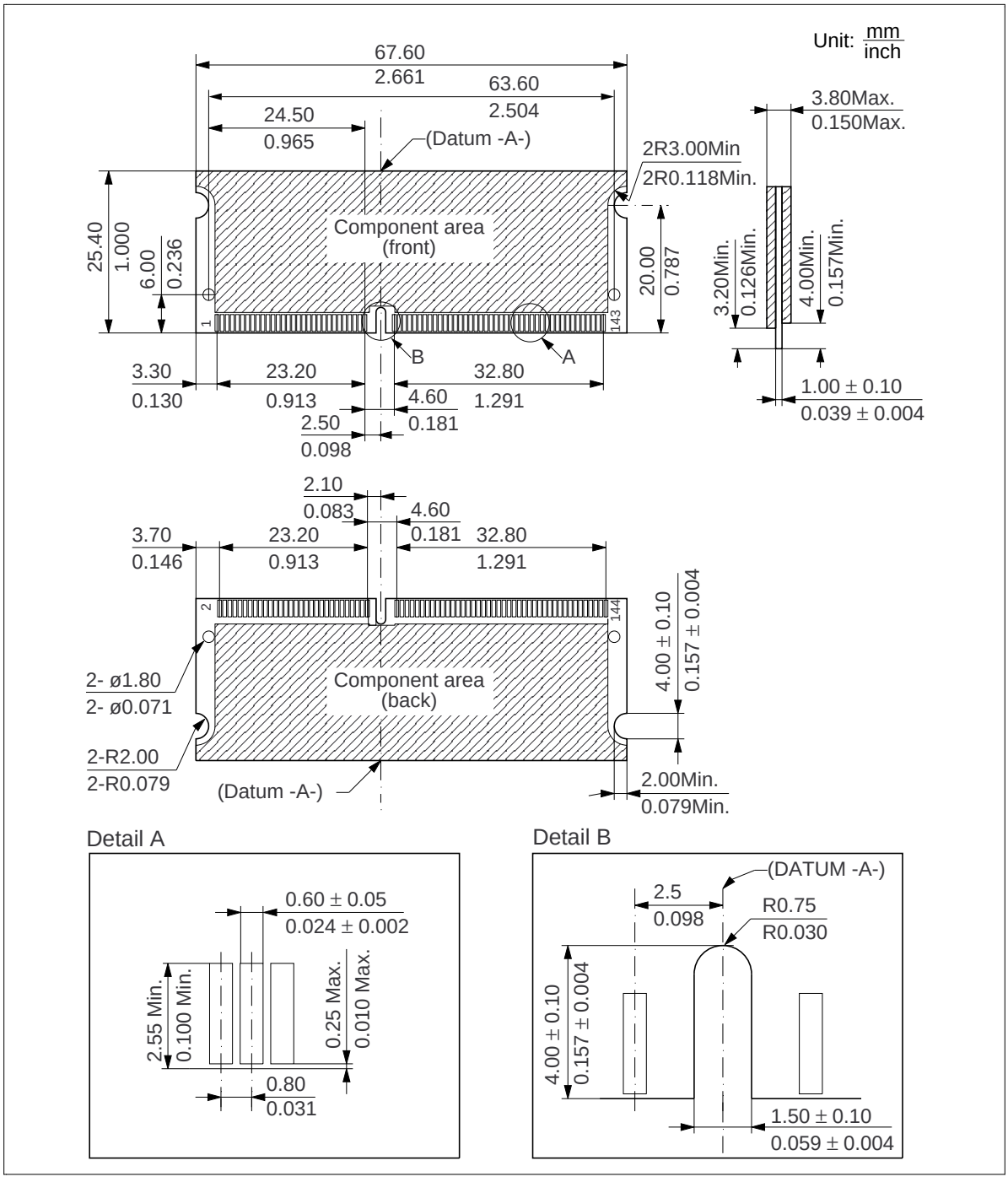


Self Refresh Cycle (L-version)* [23, 24, 25, 26]



Physical Outline

Unit: mm/inch



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Revision Record

Rev.	Date	Contents of Modification	Drawn by	Approved by
1.0	Dec. 27, 1996	Initial issue	S. Tsukui	K. Tsuneda
2.0	Jun. 5, 1997	(referred to HM51W16165/HM51W18165 rev 3.0) Addition of HB56HW164DB-5/5L, HB56HW165DB-5/5L Change of Serial PD Matrix DC Characteristics I_{CC7} max: 520/460 mA to 380/340 mA (HB56HW164DB) I_{CC7} max: 740/660 mA to 660/580 mA (HB56HW165DB) AC Characteristics t_{RCD} min: 20/20 ns to 14/14 ns t_{RAD} min: 15/15 ns to 12/12 ns t_{RSH} min: 15/18 ns to 13/13 ns t_{RWC} min: 136/161 ns to 135/161 ns t_{RPC} min: 0/0 ns to 5/5 ns	S. Tsukui	K. Yoshizaki
3.0	Nov. 1997	Change of Subtitle		