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# HB56SW864ESN-6B/7B/8B

8,388,608-word × 64-bit High Density Dynamic RAM Module  
168-pin JEDEC Standard Outline Unbuffered 8 byte DIMM

## HITACHI

ADE-203-561 (B) (Z)  
Preliminary Rev. 0.2  
Jun. 17, 1996

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### Description

The HB56SW864ESN belongs to 8 Byte DIMM (Dual In-line Memory Module) family, and has been developed as an optimized main memory solution for 4 and 8 Byte processor applications.

The HB56SW864ESN is a 8M × 64 dynamic RAM module, mounted 32 pieces of 16-Mbit DRAM (HM51W16405) sealed in TCP package and 1 pieces of serial EEPROM (24C02) for Presence Detect (PD).

The HB56SW864ESN offers Extended Data Out (EDO) Page Mode as a high speed access mode. An outline of the HB56SW864ESN is 168-pin socket type package (dual lead out). Therefore, the HB56SW864ESN makes high density mounting possible without surface mount technology. The HB56SW864ESN provides common data inputs and outputs. Decoupling capacitors are mounted beneath each TCP on the module board.

### Features

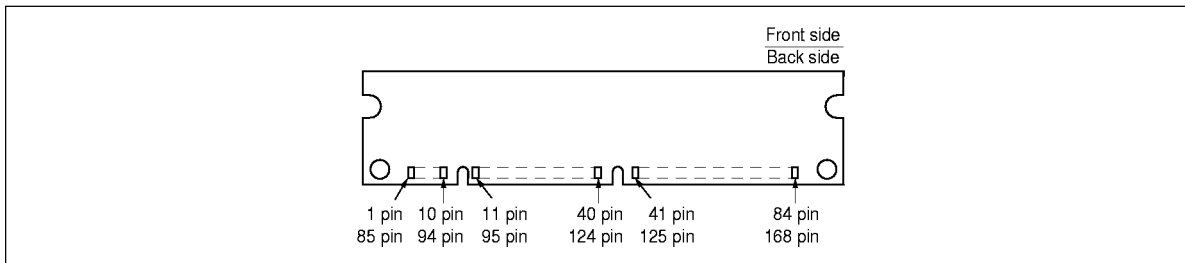
- 168-pin socket type package (Dual lead out)
  - Lead pitch: 1.27 mm
- Single 3.3 V (+0.3, -0.15 V) supply
- High speed
  - Access time:  $t_{RAC} = 60/70/80$  ns (Max)
  - Access time:  $t_{CAC} = 15/18/20$  ns (Max)
- Low power dissipation
  - Active mode: 4.90/4.32/4.03 W (Max)
  - Standby mode (TTL): 230 mW (Max)
  - Standby mode (CMOS): 115 mW (Max)
- EDO page mode capability
- 4,096 refresh cycle: 64 ms
- 3 variations of refresh
  - $\overline{RAS}$ -only refresh
  - $\overline{CAS}$ -before- $\overline{RAS}$  refresh
  - Hidden refresh

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## Ordering Information

Type No.	Access time	Package	Contact pad
HB56SW864ESN-6B	60 ns	168-pin dual lead out socket type	Gold
HB56SW864ESN-7B	70 ns		
HB56SW864ESN-8B	80 ns		

## Pin Arrangement



## Pin Arrangement

Pin No.	Pin Name	Pin No.	Pin Name	Pin No.	Pin Name	Pin No.	Pin Name
1	V <sub>SS</sub>	13	DQ9	25	NC	37	A8
2	DQ0	14	DQ10	26	V <sub>CC</sub>	38	A10
3	DQ1	15	DQ11	27	$\overline{WE0}$	39	NC
4	DQ2	16	DQ12	28	$\overline{CAS0}$	40	V <sub>CC</sub>
5	DQ3	17	DQ13	29	$\overline{CAS1}$	41	V <sub>CC</sub>
6	V <sub>CC</sub>	18	V <sub>CC</sub>	30	$\overline{RAS0}$	42	NC
7	DQ4	19	DQ14	31	$\overline{OE0}$	43	V <sub>SS</sub>
8	DQ5	20	DQ15	32	V <sub>SS</sub>	44	$\overline{OE2}$
9	DQ6	21	NC	33	A0	45	$\overline{RAS2}$
10	DQ7	22	NC	34	A2	46	$\overline{CAS2}$
11	DQ8	23	V <sub>SS</sub>	35	A4	47	$\overline{CAS3}$
12	V <sub>SS</sub>	24	NC	36	A6	48	$\overline{WE2}$

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**Pin Arrangement (cont)**

Pin No.	Pin Name	Pin No.	Pin Name	Pin No.	Pin Name	Pin No.	Pin Name
49	V <sub>CC</sub>	79	NC	109	NC	139	DQ48
50	NC	80	NC	110	V <sub>CC</sub>	140	DQ49
51	NC	81	NC	111	NC	141	DQ50
52	NC	82	SDA	112	$\overline{\text{CAS4}}$	142	DQ51
53	NC	83	SCL	113	$\overline{\text{CAS5}}$	143	V <sub>CC</sub>
54	V <sub>SS</sub>	84	V <sub>CC</sub>	114	$\overline{\text{RAS1}}$	144	DQ52
55	DQ16	85	V <sub>SS</sub>	115	NC	145	NC
56	DQ17	86	DQ32	116	V <sub>SS</sub>	146	NC
57	DQ18	87	DQ33	117	A1	147	NC
58	DQ19	88	DQ34	118	A3	148	V <sub>SS</sub>
59	V <sub>CC</sub>	89	DQ35	119	A5	149	DQ53
60	DQ20	90	V <sub>CC</sub>	120	A7	150	DQ54
61	NC	91	DQ36	121	A9	151	DQ55
62	NC	92	DQ37	122	A11	152	V <sub>SS</sub>
63	NC	93	DQ38	123	NC	153	DQ56
64	V <sub>SS</sub>	94	DQ39	124	V <sub>CC</sub>	154	DQ57
65	DQ21	95	DQ40	125	NC	155	DQ58
66	DQ22	96	V <sub>SS</sub>	126	NC	156	DQ59
67	DQ23	97	DQ41	127	V <sub>SS</sub>	157	V <sub>CC</sub>
68	V <sub>SS</sub>	98	DQ42	128	NC	158	DQ60
69	DQ24	99	DQ43	129	$\overline{\text{RAS3}}$	159	DQ61
70	DQ25	100	DQ44	130	$\overline{\text{CAS6}}$	160	DQ62
71	DQ26	101	DQ45	131	$\overline{\text{CAS7}}$	161	DQ63
72	DQ27	102	V <sub>CC</sub>	132	NC	162	V <sub>SS</sub>
73	V <sub>CC</sub>	103	DQ46	133	V <sub>CC</sub>	163	NC
74	DQ28	104	DQ47	134	NC	164	NC
75	DQ29	105	NC	135	NC	165	SA0
76	DQ30	106	NC	136	NC	166	SA1
77	DQ31	107	V <sub>SS</sub>	137	NC	167	SA2
78	V <sub>SS</sub>	108	NC	138	V <sub>SS</sub>	168	V <sub>CC</sub>

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## HB56SW864ESN-6B/7B/8B

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### Pin Description

Pin Name	Function
A0 to A11	Address Input : A0 to A11 Row Address : A0 to A11 Column Address : A0 to A9 Refresh Address : A0 to A11
DQ0 to DQ63	Data-in/Data-out
$\overline{\text{RAS}}_0$ to $\overline{\text{RAS}}_3$	Row Address Strobe
$\overline{\text{CAS}}_0$ to $\overline{\text{CAS}}_7$	Column Address Strobe
$\overline{\text{WE}}_0, \overline{\text{WE}}_2$	Read/Write Enable
$\overline{\text{OE}}_0, \overline{\text{OE}}_2$	Output Enable
SDA	Serial Data Out (Bit0 to 7)
SCL	Clock for Presence Detect
SA0 to SA2	Serial Address Input
V <sub>cc</sub>	Power Supply
V <sub>ss</sub>	Ground
NC	No Connection

## HB56SW864ESN-6B/7B/8B

### Serial PD Matrix

Byte Number	Function Described	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	Note
0	Number Serial PD Bytes	0	0	0	0	1	1	0	1	13
1	Serial Memory	0	0	0	0	1	0	0	0	256 Byte
2	Fundamental Memory Type	0	0	0	0	0	0	1	0	EDO
3	Number of Rows	0	0	0	0	1	1	0	0	12
4	Number of Columns	0	0	0	0	1	0	1	0	10
5	Number of Banks	0	0	0	0	0	0	1	0	2
6	Data Width	0	1	0	0	0	0	0	0	64
7	Data Width (continued)	0	0	0	0	0	0	0	0	0 (+)
8	Voltage Interface	0	0	0	0	0	0	0	1	3.3 Volt
9	$\overline{\text{RAS}}$ Access Time 60 ns	0	0	1	1	1	1	0	0	
	$\overline{\text{RAS}}$ Access Time 70 ns	0	1	0	0	0	1	1	0	
	$\overline{\text{RAS}}$ Access Time 80 ns	0	1	0	1	0	0	0	0	
10	$\overline{\text{CAS}}$ Access Time 15 ns	0	0	0	0	1	1	1	1	
	$\overline{\text{CAS}}$ Access Time 18 ns	0	0	0	1	0	0	1	0	
	$\overline{\text{CAS}}$ Access Time 23 ns	0	0	0	1	0	1	1	1	
11	Error Detection/Correction	0	0	0	0	0	0	0	0	None-Parity
12	Refresh Period	0	0	0	0	0	0	0	0	Normal (15.625 $\mu\text{s}$ )

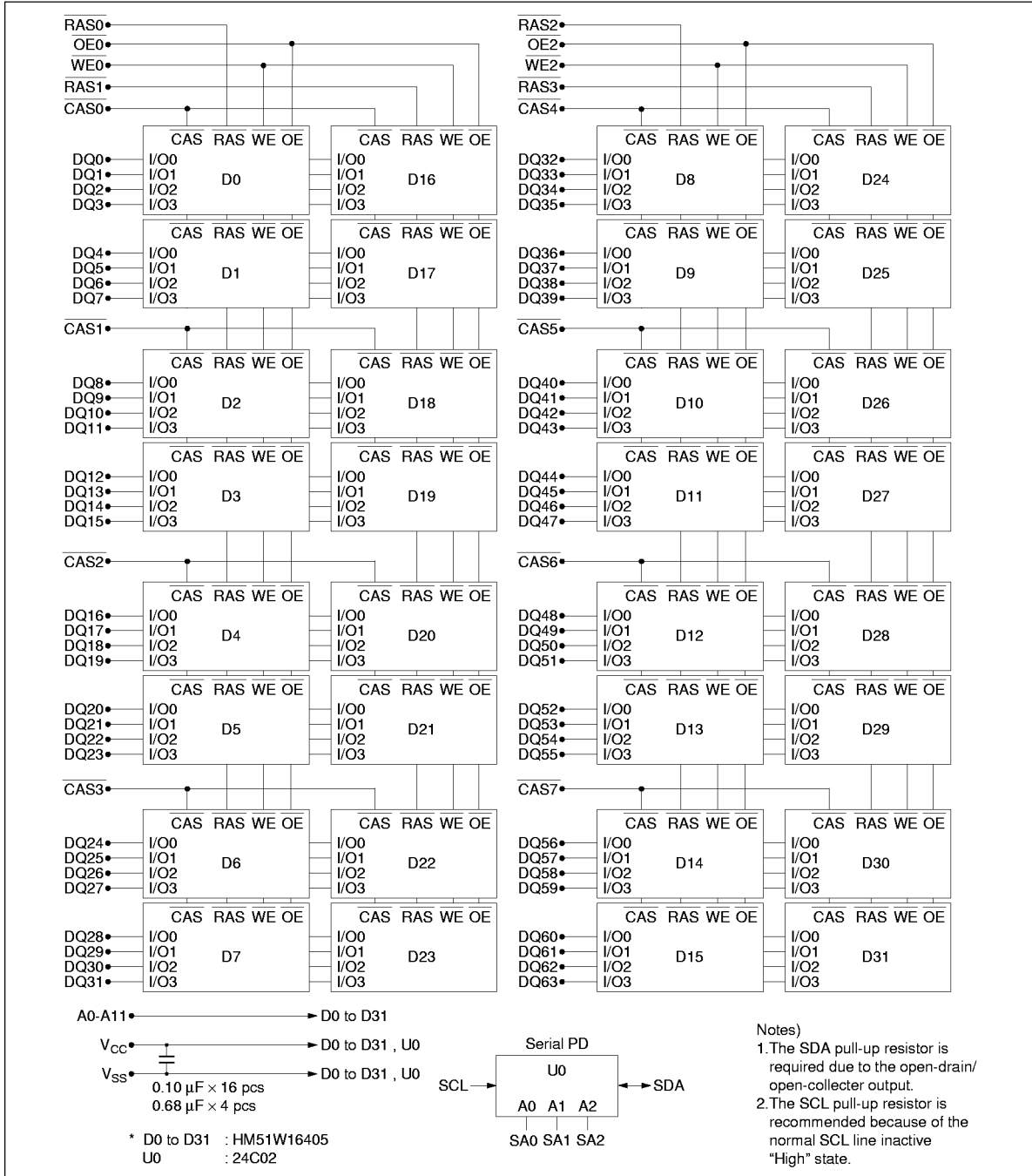
Note: Serial-PD Datas are not protected.

0: Serial Data, "driven to Low"

1: Serial Data, "driven to High"

# HB56SW864ESN-6B/7B/8B

## Block Diagram



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## HB56SW864ESN-6B/7B/8B

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### 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	$I_{out}$	50	mA
Power dissipation	$P_t$	32	W
Operating temperature	$T_{opr}$	0 to +70	°C
Storage temperature	$T_{stg}$	-55 to +125	°C

### Electrical Characteristics

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

Parameter	Symbol	Min	Typ	Max	Unit	Note
Supply voltage	$V_{SS}$	0	0	0	V	
	$V_{CC}$	3.15	3.3	3.6	V	1
Input high voltage	$V_{IH}$	2.0	—	$V_{CC} + 0.3$	V	1
Input low voltage	$V_{IL}$	-0.5	—	0.8	V	1

Note: All voltage referenced to  $V_{SS}$ .

## HB56SW864ESN-6B/7B/8B

DC Characteristics (Ta = 0 to 70°C, V<sub>CC</sub> = 3.3 V +0.3, -0.15 V, V<sub>SS</sub> = 0 V)

Parameter	Symbol	HB56SW864ESN						Unit	Test condition	Note
		-6B		-7B		-8B				
		Min	Max	Min	Max	Min	Max			
Operating current	I <sub>CC1</sub>	—	1360	—	1200	—	1120	mA	t <sub>RC</sub> = min	1, 2
Standby current	I <sub>CC2</sub>	—	64	—	64	—	64	mA	TTL interface R <sub>AS</sub> , C <sub>AS</sub> = V <sub>IH</sub> Dout = High-Z	
		—	32	—	32	—	32	mA	CMOS interface R <sub>AS</sub> , C <sub>AS</sub> ≥ V <sub>CC</sub> - 0.2 V Dout = High-Z	
R <sub>AS</sub> -only refresh current	I <sub>CC3</sub>	—	1360	—	1200	—	1120	mA	t <sub>RC</sub> = min	2
Standby current	I <sub>CC5</sub>	—	160	—	160	—	160	mA	R <sub>AS</sub> = V <sub>IH</sub> , C <sub>AS</sub> = V <sub>IL</sub> Dout = enable	1
CAS-before-RAS refresh current	I <sub>CC6</sub>	—	1360	—	1200	—	1120	mA	t <sub>RC</sub> = min	
EDO page mode current	I <sub>CC7</sub>	—	1680	—	1520	—	1360	mA	t <sub>HPC</sub> = min	1, 3
Input leakage current	I <sub>LI</sub>	-10	10	-10	10	-10	10	μA	0 V ≤ Vin ≤ 4.6 V	
Output leakage current	I <sub>LO</sub>	-10	10	-10	10	-10	10	μA	0 V ≤ Vout ≤ 4.6 V Dout = disable	
Output high voltage	V <sub>OH</sub>	2.4	V <sub>CC</sub>	2.4	V <sub>CC</sub>	2.4	V <sub>CC</sub>	V	High Iout = -2 mA	
Output low voltage	V <sub>OL</sub>	0	0.4	0	0.4	0	0.4	V	Low Iout = 2 mA	

Notes: 1. I<sub>CC</sub> depends on output load condition when the device is selected, I<sub>CC</sub> Max is specified at the output open condition.

2. Address can be changed once or less while R<sub>AS</sub> = V<sub>IL</sub>.

3. Address can be changed once or less while C<sub>AS</sub> = V<sub>IH</sub>.

Capacitance (Ta = 25°C, V<sub>CC</sub> = 3.3 V +0.3, -0.15 V)

Parameter	Symbol	Typ	Max	Unit	Notes
Input capacitance (Address)	C <sub>I1</sub>	—	180	pF	1
Input capacitance (C <sub>AS</sub> )	C <sub>I2</sub>	—	48	pF	1
Input capacitance (R <sub>AS</sub> )	C <sub>I3</sub>	—	76	pF	1
Input capacitance (W <sub>E</sub> , O <sub>E</sub> )	C <sub>I4</sub>	—	132	pF	1
Output capacitance (DQ)	C <sub>I/O</sub>	—	27	pF	1, 2

Notes: 1. Capacitance measured with Boonton Meter or effective capacitance measuring method.

2. C<sub>AS</sub> = V<sub>IH</sub> to disable Dout.



## HB56SW864ESN-6B/7B/8B

**AC Characteristics** ( $T_a = 0$  to  $70^\circ\text{C}$ ,  $V_{CC} = 3.3\text{ V} +0.3, -0.15\text{ V}$ ,  $V_{SS} = 0\text{ V}$ )<sup>\*1, \*2, \*18, \*19</sup>

- Input rise and fall times: 2 ns
- Input levels: 0 V, 3.0 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)

Parameter	Symbol	HB56SW864ESN						Unit	Notes
		-6B		-7B		-8B			
		Min	Max	Min	Max	Min	Max		
Random read or write cycle time	$t_{RC}$	104	—	124	—	144	—	ns	
$\overline{\text{RAS}}$ precharge time	$t_{RP}$	40	—	50	—	60	—	ns	
$\overline{\text{CAS}}$ precharge time	$t_{CP}$	10	—	13	—	15	—	ns	
$\overline{\text{RAS}}$ pulse width	$t_{RAS}$	60	10000	70	10000	80	10000	ns	
$\overline{\text{CAS}}$ pulse width	$t_{CAS}$	10	10000	13	10000	15	10000	ns	
Row address setup time	$t_{ASR}$	0	—	0	—	0	—	ns	
Row address hold time	$t_{RAH}$	10	—	10	—	10	—	ns	
Column address setup time	$t_{ASC}$	0	—	0	—	0	—	ns	
Column address hold time	$t_{CAH}$	10	—	13	—	15	—	ns	
$\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ delay time	$t_{RCD}$	20	45	20	52	20	60	ns	3
$\overline{\text{RAS}}$ to column address delay time	$t_{RAD}$	15	30	15	35	15	40	ns	4
$\overline{\text{RAS}}$ hold time	$t_{RSH}$	15	—	18	—	20	—	ns	
$\overline{\text{CAS}}$ hold time	$t_{CSH}$	48	—	58	—	68	—	ns	
$\overline{\text{CAS}}$ to $\overline{\text{RAS}}$ precharge time	$t_{CRP}$	5	—	5	—	5	—	ns	
$\overline{\text{OE}}$ to Din delay time	$t_{OED}$	15	—	18	—	20	—	ns	5
$\overline{\text{OE}}$ delay time from Din	$t_{DZO}$	0	—	0	—	0	—	ns	6
$\overline{\text{CAS}}$ delay time from Din	$t_{DZC}$	0	—	0	—	0	—	ns	6
Transition time (rise and fall)	$t_T$	2	50	2	50	2	50	ns	7
Refresh period	$t_{REF}$	—	64	—	64	—	64	ms	

## HB56SW864ESN-6B/7B/8B

### Read Cycle

Parameter	Symbol	HB56SW864ESN						Unit	Notes
		-6B		-7B		-8B			
		Min	Max	Min	Max	Min	Max		
Access time from $\overline{\text{RAS}}$	$t_{\text{RAC}}$	—	60	—	70	—	80	ns	8, 9
Access time from $\overline{\text{CAS}}$	$t_{\text{CAC}}$	—	15	—	18	—	20	ns	9, 10, 17
Access time from address	$t_{\text{AA}}$	—	30	—	35	—	40	ns	9, 11, 17
Access time from $\overline{\text{OE}}$	$t_{\text{OEA}}$	—	15	—	18	—	20	ns	9, 21
Read command setup time	$t_{\text{RCS}}$	0	—	0	—	0	—	ns	
Read command hold time to $\overline{\text{CAS}}$	$t_{\text{RCH}}$	0	—	0	—	0	—	ns	12
Read command hold time from $\overline{\text{RAS}}$	$t_{\text{RCHR}}$	60	—	70	—	80	—	ns	
Read command hold time to $\overline{\text{RAS}}$	$t_{\text{RRH}}$	0	—	0	—	0	—	ns	12
Column address to $\overline{\text{RAS}}$ lead time	$t_{\text{RAL}}$	30	—	35	—	40	—	ns	
Column address to $\overline{\text{CAS}}$ lead time	$t_{\text{CAL}}$	18	—	23	—	28	—	ns	
$\overline{\text{CAS}}$ to output in low-Z	$t_{\text{CLZ}}$	0	—	0	—	0	—	ns	
Output data hold time	$t_{\text{OH}}$	3	—	3	—	3	—	ns	
Output data hold time from $\overline{\text{OE}}$	$t_{\text{OHO}}$	3	—	3	—	3	—	ns	
Output buffer turn-off time	$t_{\text{OFF}}$	—	15	—	15	—	15	ns	13
Output buffer turn-off to $\overline{\text{OE}}$	$t_{\text{OEZ}}$	—	15	—	15	—	15	ns	13
$\overline{\text{CAS}}$ to Din delay time	$t_{\text{CDD}}$	15	—	18	—	20	—	ns	5
Output data hold time from $\overline{\text{RAS}}$	$t_{\text{OHR}}$	3	—	3	—	3	—	ns	
Output buffer turn-off time to $\overline{\text{RAS}}$	$t_{\text{OFR}}$	—	15	—	15	—	15	ns	
Output buffer turn-off to $\overline{\text{WE}}$	$t_{\text{WEZ}}$	—	15	—	15	—	15	ns	
$\overline{\text{WE}}$ to Din delay time	$t_{\text{WED}}$	15	—	18	—	20	—	ns	
$\overline{\text{RAS}}$ to Din delay time	$t_{\text{RDD}}$	15	—	18	—	20	—	ns	

## HB56SW864ESN-6B/7B/8B

### Write Cycle

Parameter	Symbol	HB56SW864ESN						Unit	Notes
		-6B		-7B		-8B			
		Min	Max	Min	Max	Min	Max		
Write command setup time	$t_{WCS}$	0	—	0	—	0	—	ns	14
Write command hold time	$t_{WCH}$	10	—	13	—	15	—	ns	
Write command pulse width	$t_{WP}$	10	—	10	—	10	—	ns	
Write command to $\overline{RAS}$ lead time	$t_{RWL}$	10	—	13	—	15	—	ns	
Write command to $\overline{CAS}$ lead time	$t_{CWL}$	10	—	13	—	15	—	ns	
Data-in setup time	$t_{DS}$	0	—	0	—	0	—	ns	15
Data-in hold time	$t_{DH}$	10	—	13	—	15	—	ns	15

### Read-Modify-Write Cycle

Parameter	Symbol	HB56SW864ESN						Unit	Notes
		-6B		-7B		-8B			
		Min	Max	Min	Max	Min	Max		
Read-modify-write cycle time	$t_{RWC}$	149	—	175	—	199	—	ns	
$\overline{RAS}$ to $\overline{WE}$ delay time	$t_{RWD}$	82	—	95	—	107	—	ns	14
$\overline{CAS}$ to $\overline{WE}$ delay time	$t_{CWD}$	37	—	43	—	47	—	ns	14
Column address to $\overline{WE}$ delay time	$t_{AWD}$	52	—	60	—	67	—	ns	14
$\overline{OE}$ hold time from $\overline{WE}$	$t_{OEH}$	15	—	18	—	20	—	ns	

### Refresh Cycle

Parameter	Symbol	HB56SW864ESN						Unit	Notes
		-6B		-7B		-8B			
		Min	Max	Min	Max	Min	Max		
$\overline{CAS}$ setup time (CBR refresh cycle)	$t_{CSR}$	5	—	5	—	5	—	ns	
$\overline{CAS}$ hold time (CBR refresh cycle)	$t_{CHR}$	10	—	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	$t_{RPC}$	0	—	0	—	0	—	ns	

## HB56SW864ESN-6B/7B/8B

### EDO Page Mode Cycle

Parameter	Symbol	HB56SW864ESN						Unit	Notes
		-6B		-7B		-8B			
		Min	Max	Min	Max	Min	Max		
EDO page mode cycle time	$t_{HPC}$	25	—	30	—	35	—	ns	20
EDO page mode $\overline{RAS}$ pulse width	$t_{RASP}$	—	100000	—	100000	—	100000	ns	16
Access time from $\overline{CAS}$ precharge	$t_{CPA}$	—	35	—	40	—	45	ns	9, 17
$\overline{RAS}$ hold time from $\overline{CAS}$ precharge	$t_{CPRH}$	35	—	40	—	45	—	ns	
Output data hold time from $\overline{CAS}$ low	$t_{DOH}$	3	—	3	—	3	—	ns	9, 17
$\overline{CAS}$ hold time referred $\overline{OE}$	$t_{COL}$	10	—	13	—	15	—	ns	
$\overline{CAS}$ to $\overline{OE}$ setup time	$t_{COP}$	5	—	5	—	5	—	ns	
Read command hold time from $\overline{CAS}$ precharge	$t_{RCHC}$	35	—	40	—	45	—	ns	

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

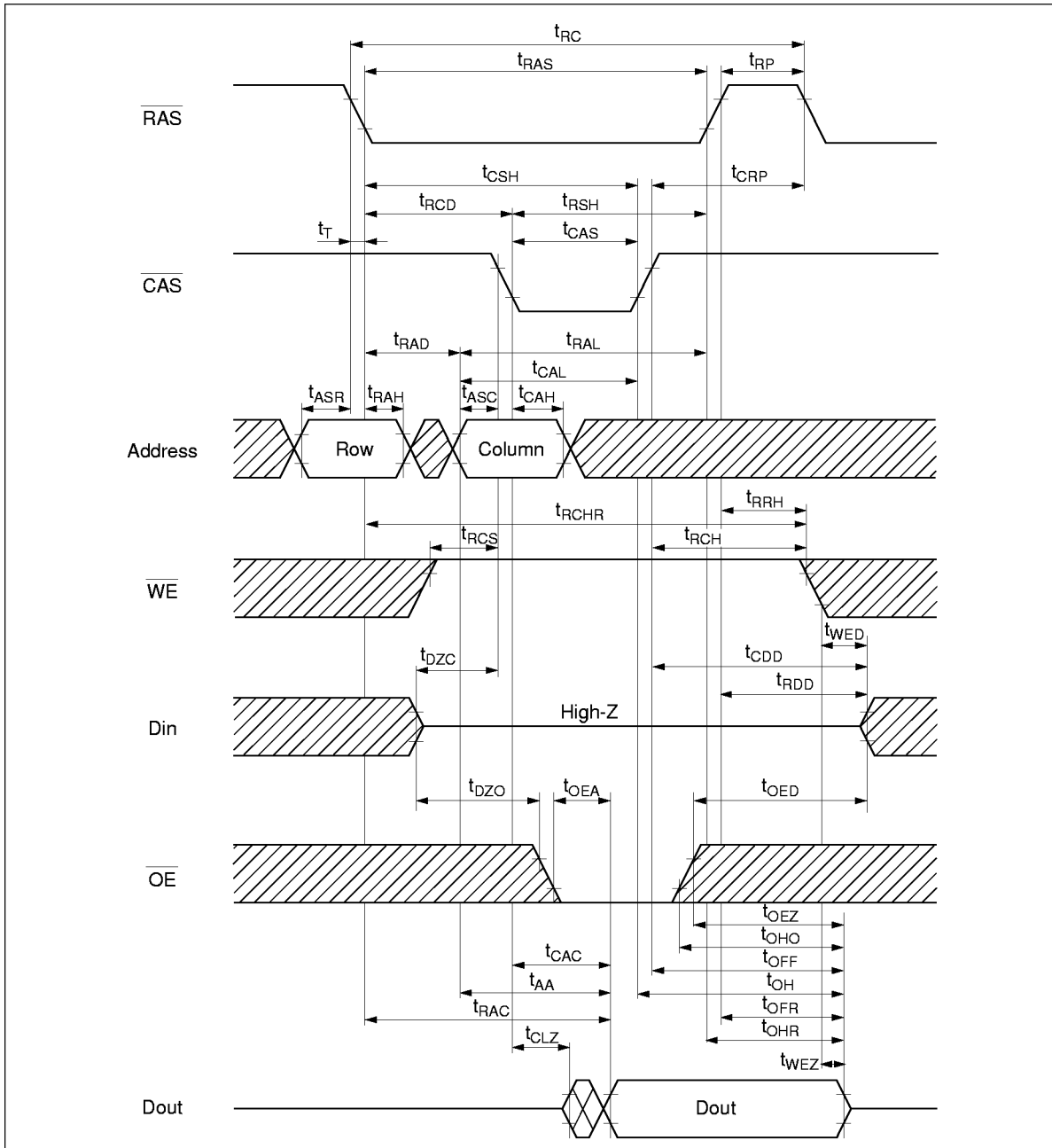
Parameter	Symbol	HB56SW864ESN						Unit	Notes
		-6B		-7B		-8B			
		Min	Max	Min	Max	Min	Max		
EDO page mode read-modify-write cycle time	$t_{HPRWC}$	79	—	90	—	99	—	ns	
$\overline{WE}$ delay time from $\overline{CAS}$ precharge	$t_{CPW}$	54	—	62	—	69	—	ns	14

- Notes:
1. AC measurements assume  $t_T = 2 \text{ ns}$ .
  2. An initial pause of 200  $\mu\text{s}$  is required after power up followed by a minimum of eight initialization cycles (any combination of cycles containing  $\overline{\text{RAS}}$ -only refresh cycle or  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh).
  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  $t_{\text{RCD}} \geq t_{\text{RAD}} (\text{max}) + t_{\text{AA}} (\text{max}) - t_{\text{CAC}} (\text{max})$ , 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  $t_{\text{RCD}} \leq t_{\text{RCD}} (\text{max})$  and  $t_{\text{RAD}} \leq t_{\text{RAD}} (\text{max})$ . 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 1TTL loads and 100 pF.
  10. Assumes that  $t_{\text{RCD}} \geq t_{\text{RCD}} (\text{max})$  and  $t_{\text{RCD}} + t_{\text{CAC}} (\text{max}) \geq t_{\text{RAD}} + t_{\text{AA}} (\text{max})$ .
  11. Assumes that  $t_{\text{RAD}} \geq t_{\text{RAD}} (\text{max})$  and  $t_{\text{RCD}} + t_{\text{CAC}} (\text{max}) \leq t_{\text{RAD}} + t_{\text{AA}} (\text{max})$ .
  12. Either  $t_{\text{RCH}}$  or  $t_{\text{RRH}}$  must be satisfied for a read cycles.
  13.  $t_{\text{OFF}} (\text{max})$  and  $t_{\text{O EZ}} (\text{max})$  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  $t_{\text{WCS}} \geq t_{\text{WCS}} (\text{min})$ , the cycle is an early write cycle and the data out pin will remain open circuit (high impedance) throughout the entire cycle; if  $t_{\text{RWD}} \geq t_{\text{RWD}} (\text{min})$ ,  $t_{\text{CWD}} \geq t_{\text{CWD}} (\text{min})$ , and  $t_{\text{AWD}} \geq t_{\text{AWD}} (\text{min})$  or  $t_{\text{CWD}} \geq t_{\text{CWD}} (\text{min})$ ,  $t_{\text{AWD}} \geq t_{\text{AWD}} (\text{min})$  and  $t_{\text{CPW}} \geq t_{\text{CPW}} (\text{min})$ , the cycle is a read-modify-write and the data output will contain data read from the selected cell; if neither of the above sets of conditions is satisfied, the condition of the data out (at access time) is indeterminate.
  15. These parameters are referred to  $\overline{\text{CAS}}$  leading edge in early write cycles and to  $\overline{\text{WE}}$  leading edge in delayed write or read-modify-write cycles.
  16.  $t_{\text{RASP}}$  defines  $\overline{\text{RAS}}$  pulse width in EDO page mode cycles.
  17. Access time is determined by the longest among  $t_{\text{AA}}$ ,  $t_{\text{CAC}}$  and  $t_{\text{CPA}}$ .
  18. In delayed write or read-modify-write cycles,  $\overline{\text{OE}}$  must disable output buffer prior to applying data to the device. After  $\overline{\text{RAS}}$  is reset, if  $t_{\text{OEH}} \geq t_{\text{CWL}}$ , the DQ pin will remain open circuit (high impedance); if  $t_{\text{OEH}} < t_{\text{CWL}}$ , invalid data will be out at each DQ.
  19. All the  $V_{\text{CC}}$  and  $V_{\text{SS}}$  pins shall be supplied with the same voltages.
  20.  $t_{\text{HPC}} (\text{min})$  can be achieved during a series of EDO page mode write cycles or EDO page mode read cycles. If both write and read operation are mixed in a EDO page mode  $\overline{\text{RAS}}$  cycle (EDO page mode mix cycle (1), (2)), minimum value of  $\overline{\text{CAS}}$  cycle ( $t_{\text{CAS}} + t_{\text{CP}} + 2t_T$ ) becomes greater than the specified  $t_{\text{HPC}} (\text{min})$  value. The value of  $\overline{\text{CAS}}$  cycle time of mixed EDO page mode is shown in EDO page mode mix cycle (1) and (2).
  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  $V_{\text{CC}} / V_{\text{SS}}$  line noise, which causes to degrade  $V_{\text{IH}} \text{ min} / V_{\text{IL}} \text{ max}$  level.

# HB56SW864ESN-6B/7B/8B

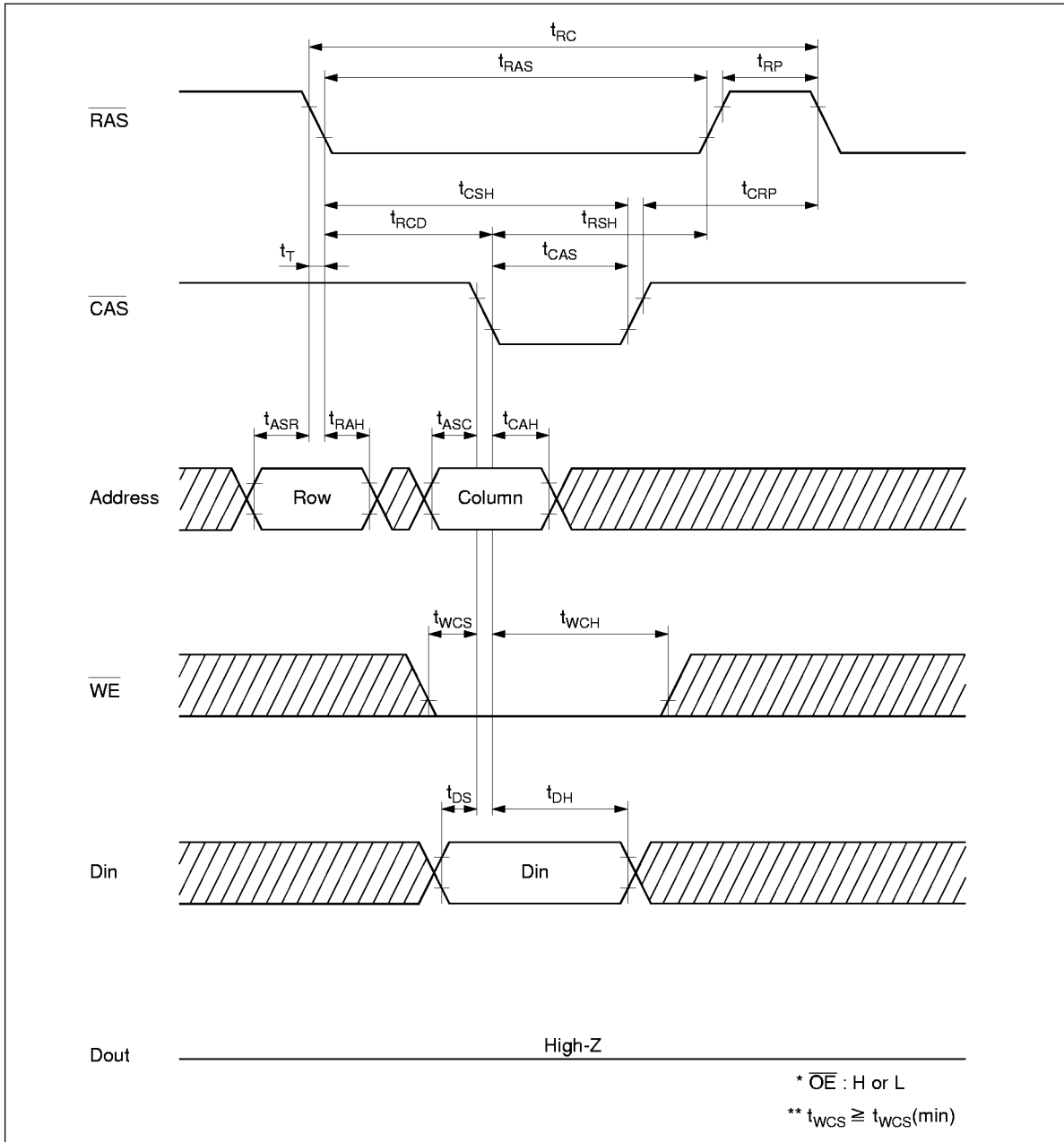
## Timing Waveforms

### Read Cycle



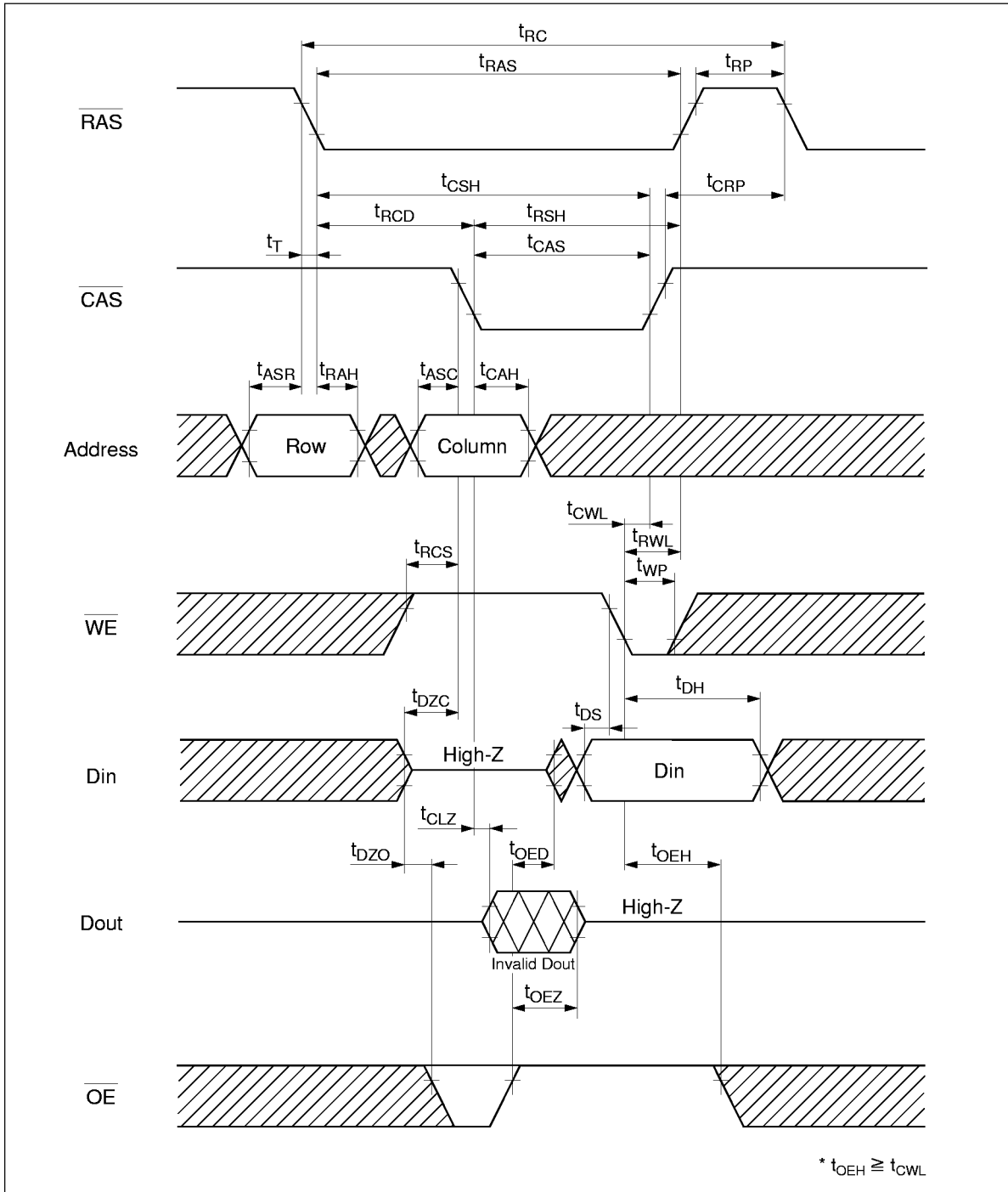
Note : ///: H or L (H:  $V_{IH}(\min) \leq V_{IN} \leq V_{IH}(\max)$ , L:  $V_{IL}(\min) \leq V_{IN} \leq V_{IL}(\max)$ )  
 XXX: Invalid Dout

Early Write Cycle



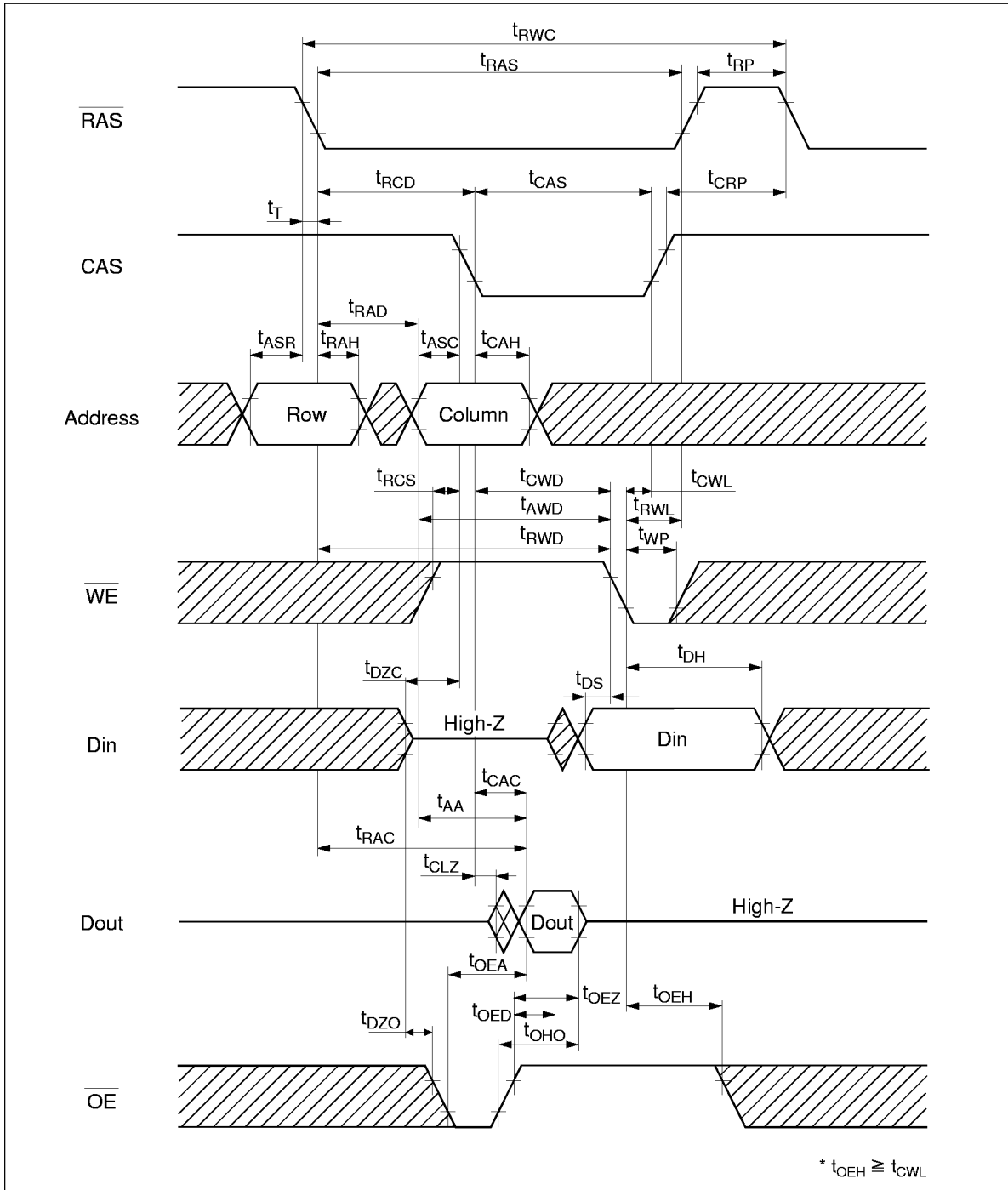
# HB56SW864ESN-6B/7B/8B

## Delayed Write Cycle



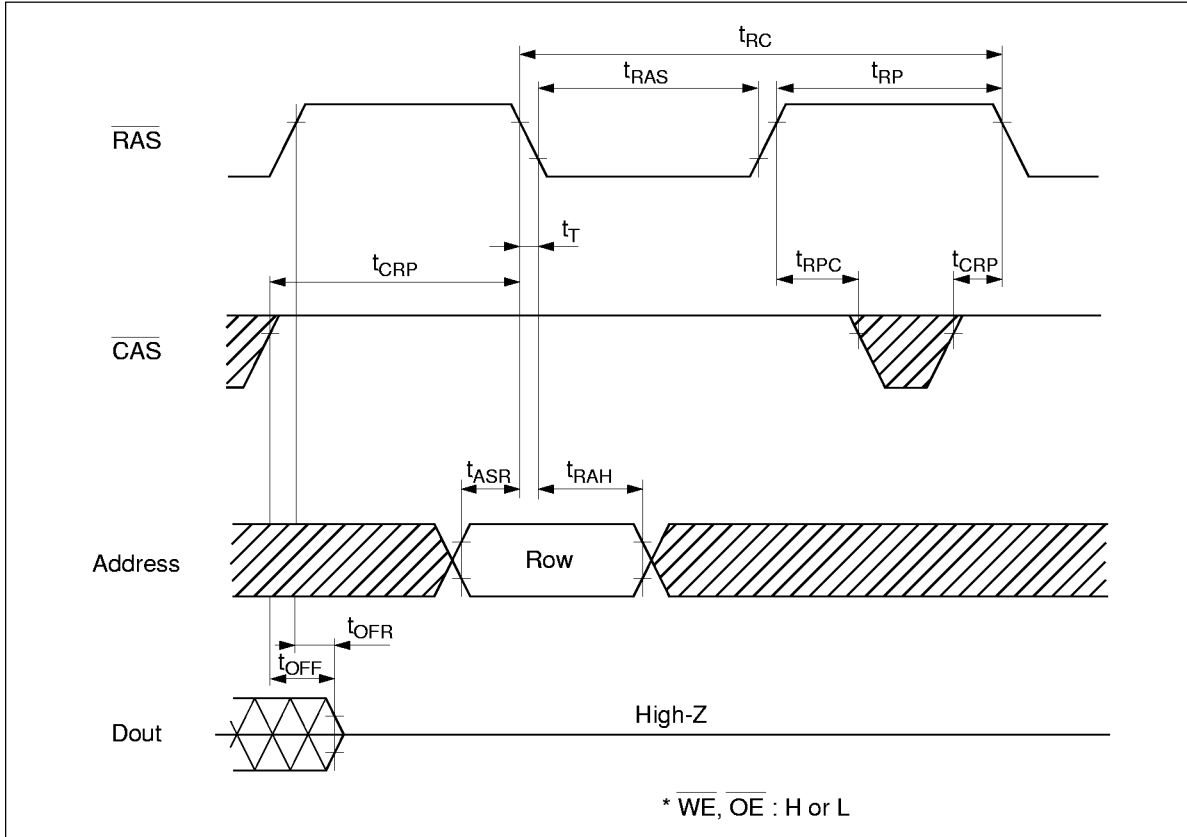


Read-Modify-Write Cycle

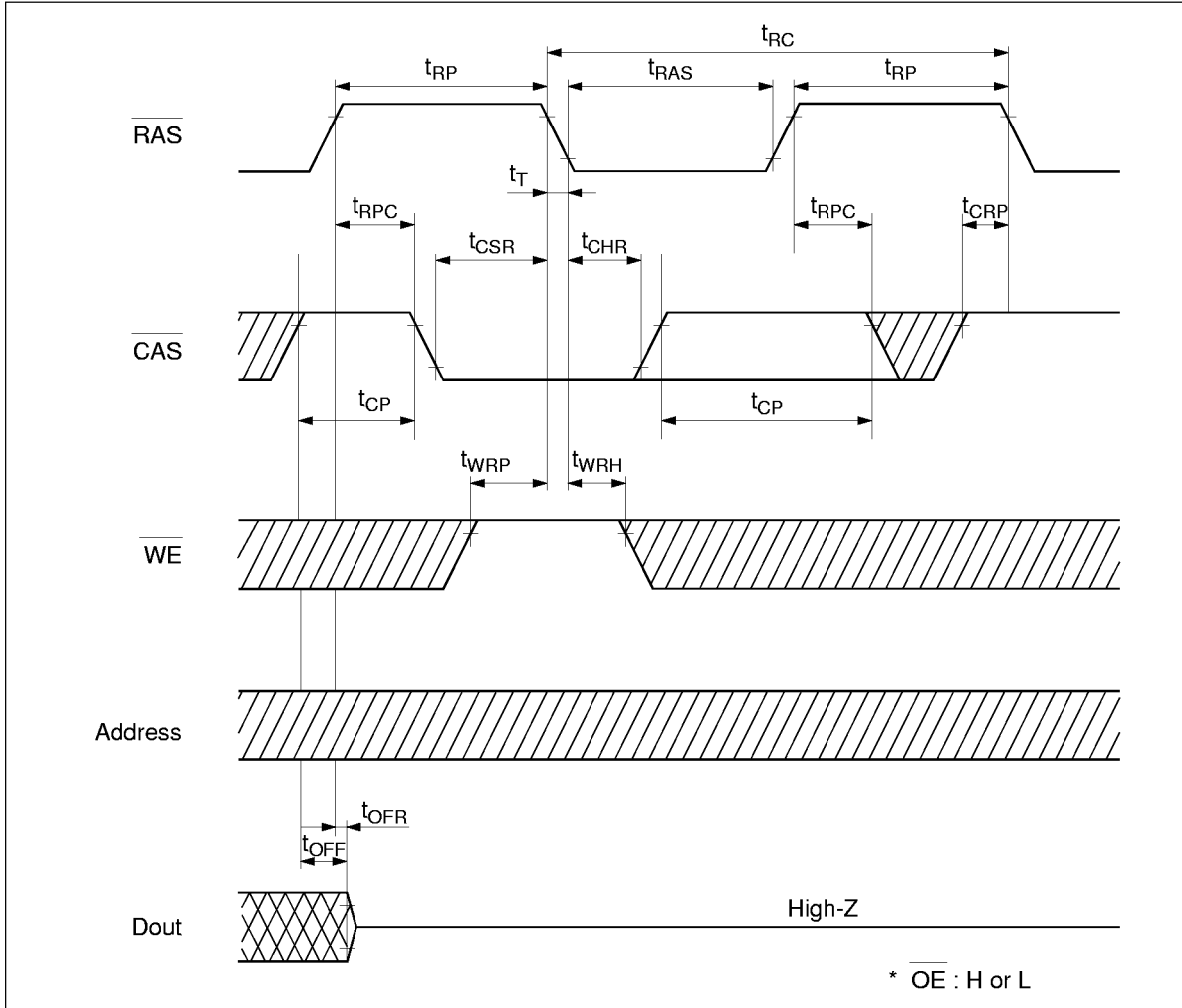


# HB56SW864ESN-6B/7B/8B

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

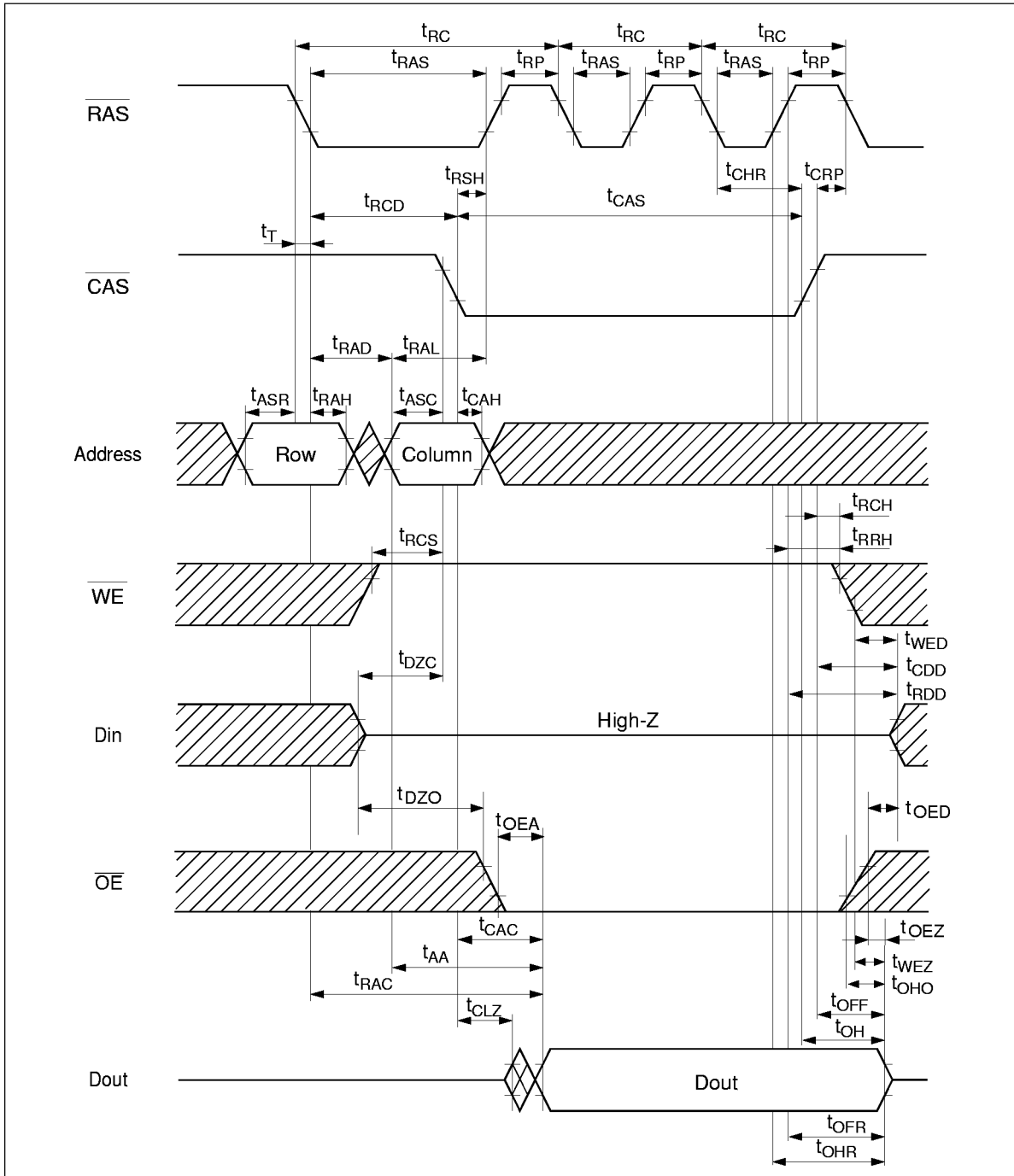


$\overline{\text{CAS}}$ -Before- $\overline{\text{RAS}}$  Refresh Cycle



# HB56SW864ESN-6B/7B/8B

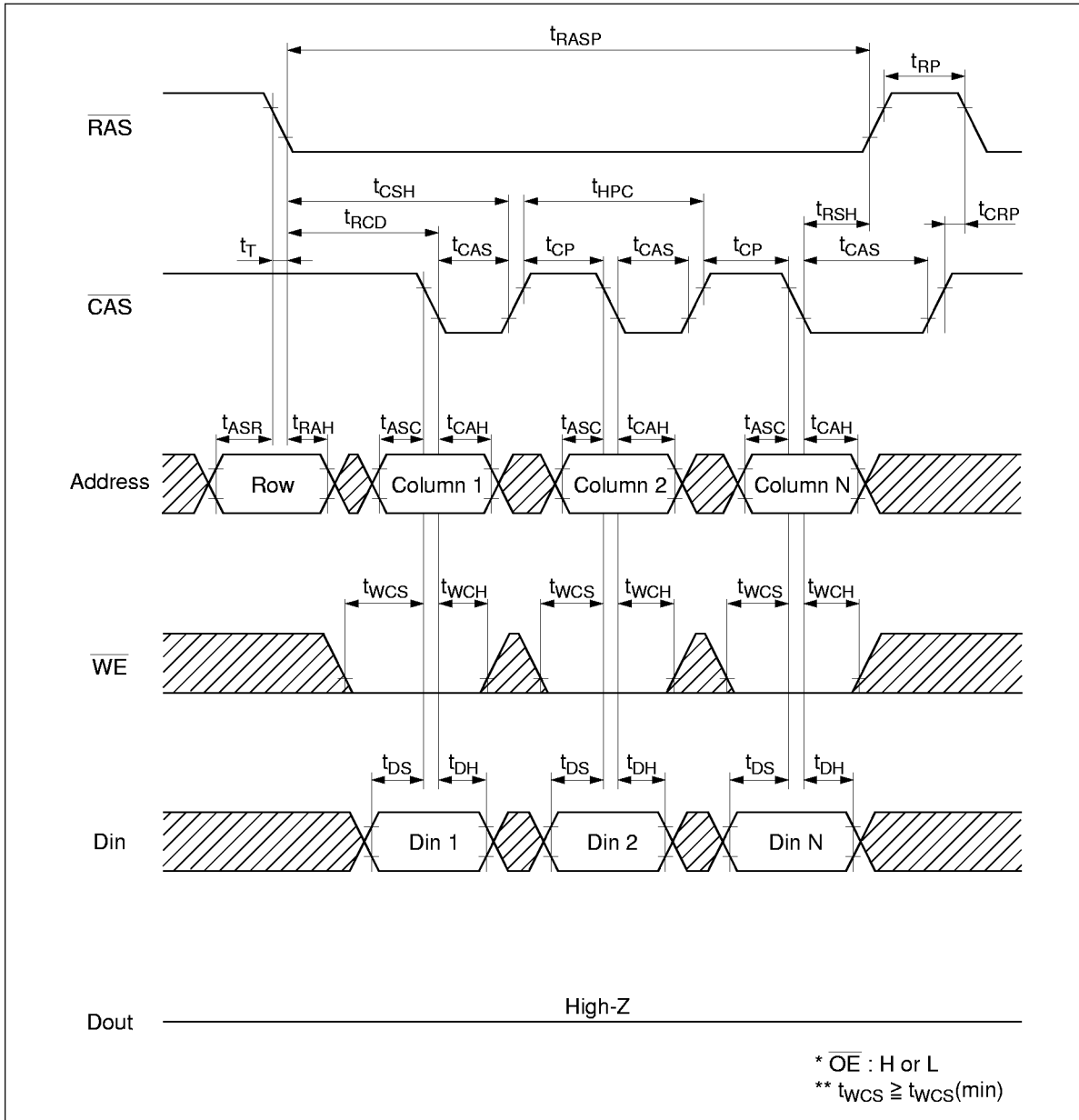
## Hidden Refresh Cycle





# HB56SW864ESN-6B/7B/8B

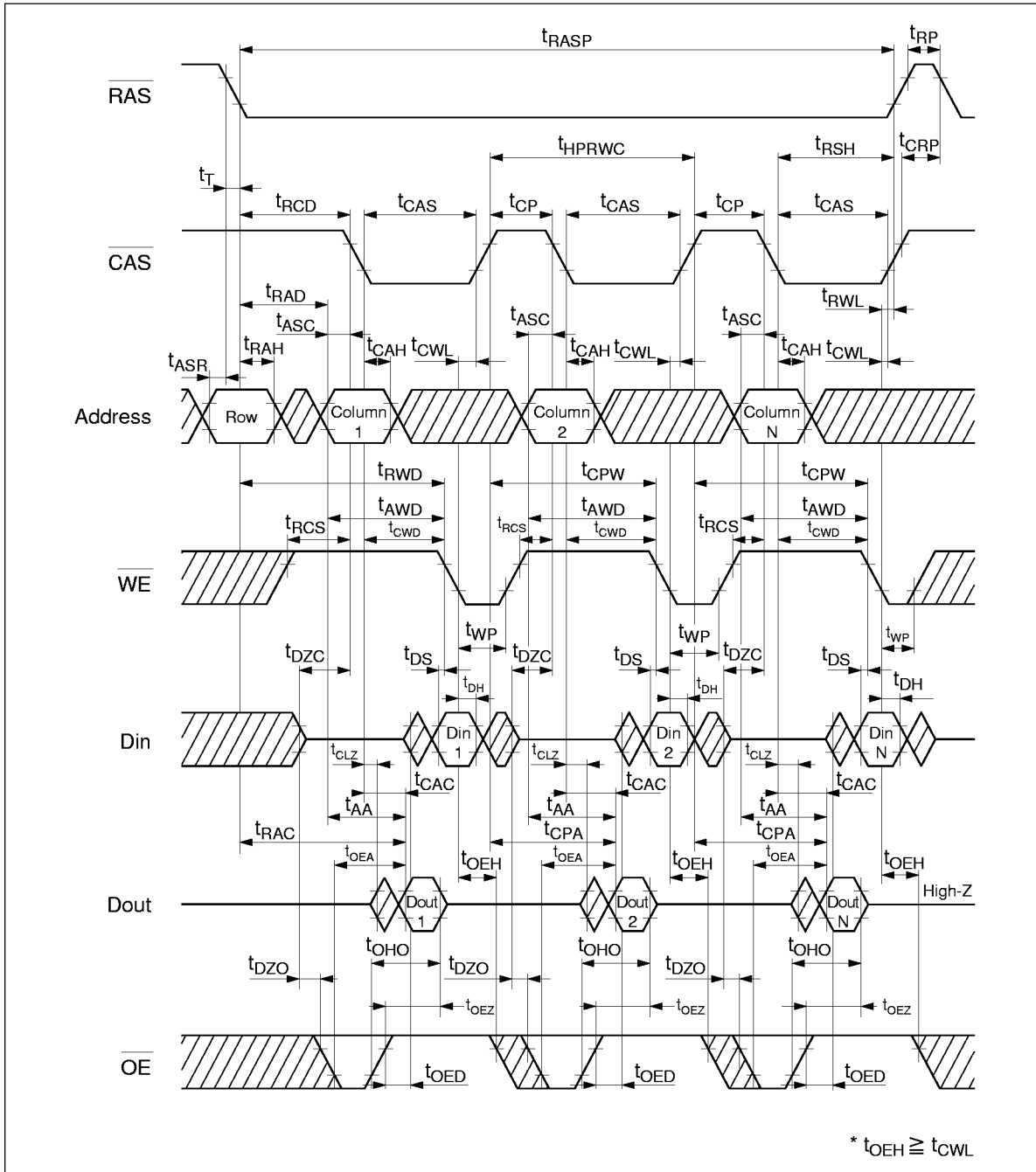
## EDO Page Mode Early Write Cycle





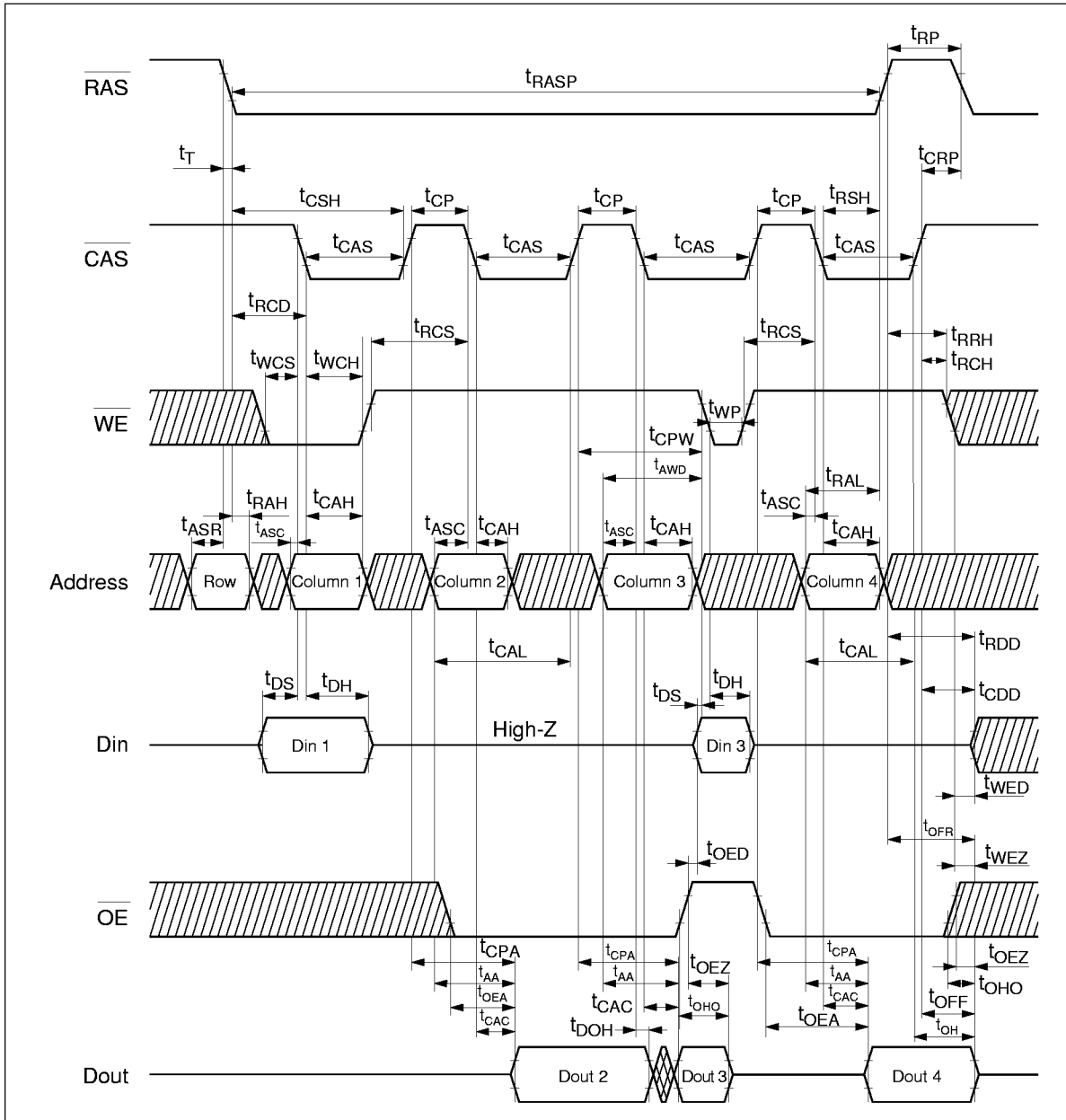
# HB56SW864ESN-6B/7B/8B

## EDO Page Mode Read-Modify-Write Cycle



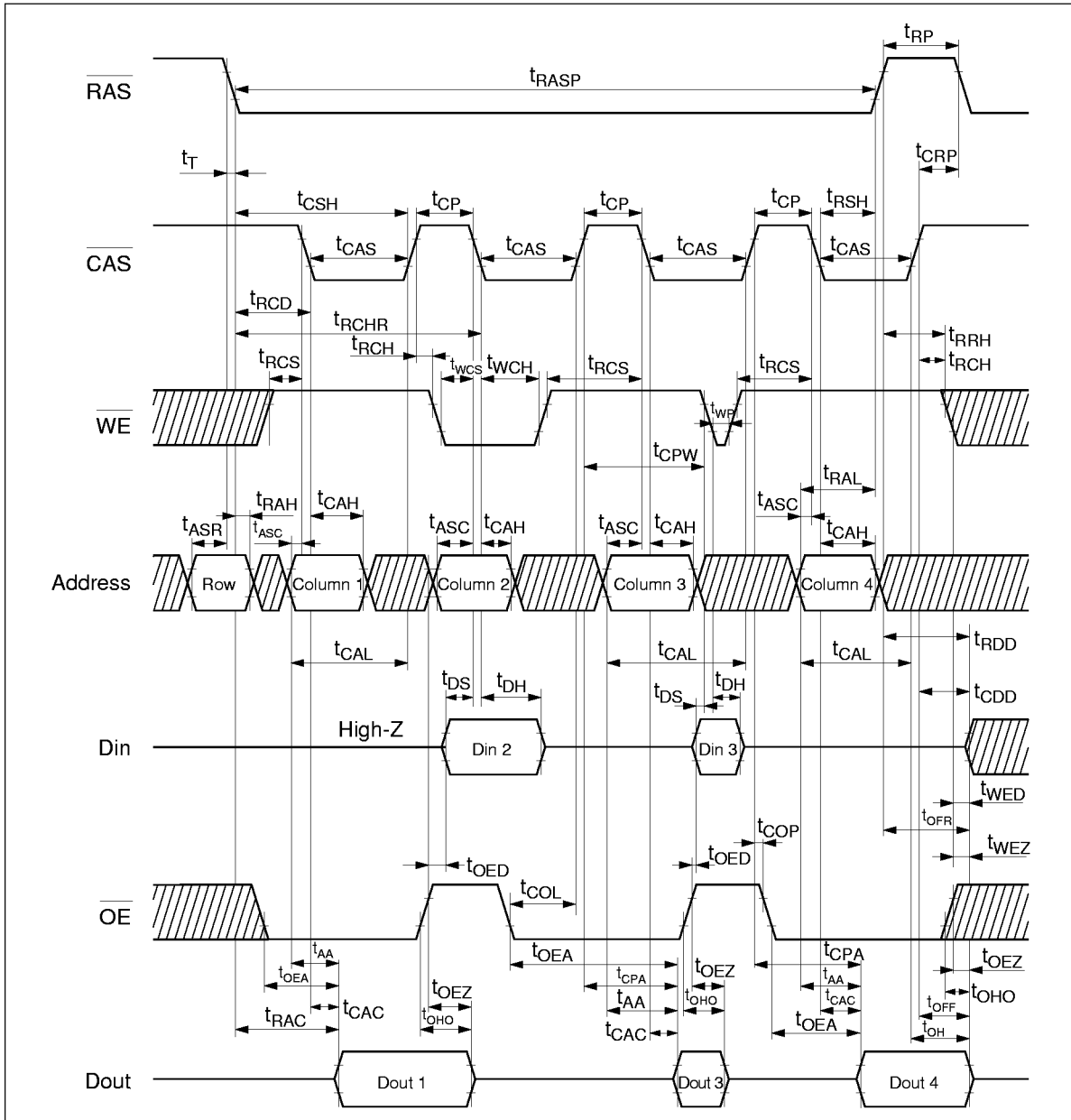


EDO Page Mode Mix Cycle (1)



# HB56SW864ESN-6B/7B/8B

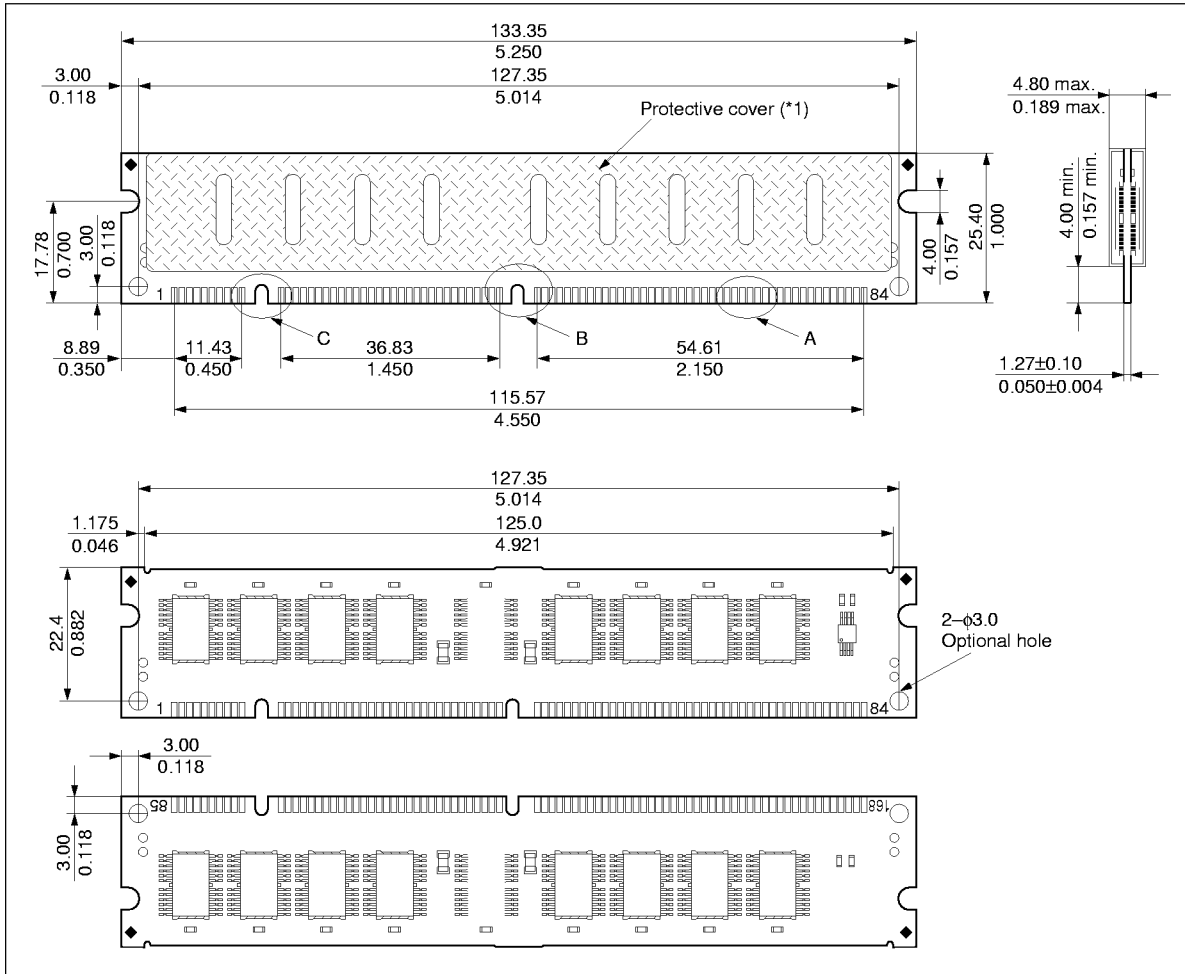
## EDO Page Mode Mix Cycle (2)



# HB56SW864ESN-6B/7B/8B

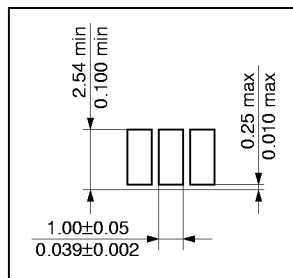
## Physical Outline

Unit: mm/inch

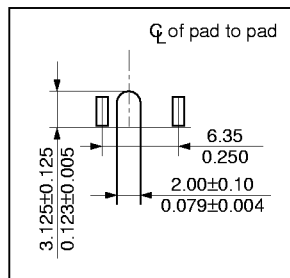


(\*1) Protective cover material will be Fe-Ni or stainless steel

Detail A



Detail B



Detail C

