

# MITSUBISHI LSIs M5M44800CJ, TP-5, -6, -7, -5S, -6S, -7S

**FAST PAGE MODE 4194304-BIT (524288-WORD BY 8-BIT) DYNAMIC RAM**

## DESCRIPTION

This is a family of 524288-word by 8-bit dynamic RAMs, fabricated with the high performance CMOS process, and is ideal for large-capacity memory systems where high speed, low power dissipation, and low costs are essential.

The use of double-layer metalization process technology and a single-transistor dynamic storage stacked capacitor cell provide high circuit density at reduced costs. Multiplexed address inputs permit both a reduction in pins and an increase in system densities. Self or extended refresh current is low enough for battery back-up application.

## FEATURES

Type name	RAS access time (max.ns)	CAS access time (max.ns)	Address access time (max.ns)	OE access time (max.ns)	Cycle time (min.ns)	Power dissipation (typ.mW)
M5M44800CXX-5,-5S	50	13	25	13	90	450
M5M44800CXX-6,-6S	60	15	30	15	110	375
M5M44800CXX-7,-7S	70	20	35	20	130	325

XX=J,TP

- Standard 28pin SOJ, 28pin TSOP (II)
  - Single 5V±10% supply
  - Low stand-by power dissipation
    - CMOS Input level ----- 5.5mW (Max)
    - CMOS Input level ----- 550µW (Max) \*
  - Operating power dissipation
    - M5M44800Cxx-5,-5S ----- 495mW (Max)
    - M5M44800Cxx-6,-6S ----- 413mW (Max)
    - M5M44800Cxx-7,-7S ----- 358mW (Max)
  - Self refresh capability \*
    - Self refresh current ----- 150µA(Max)
  - Extended refresh capability
    - Extended refresh current ----- 150µA(Max)
  - Fast page mode(1024-column random access), Read-modify-write, RAS-only refresh, CAS before RAS refresh, Hidden refresh capabilities.
  - Early-write mode, CAS and OE to control output buffer impedance
  - 1024 refresh cycles every 16.4ms (A<sub>0</sub> ~A<sub>9</sub>)
  - 1024 refresh cycles every 128ms (A<sub>0</sub> ~A<sub>9</sub>) \*
- \* :Applicable to self refresh version (M5M44800CJ,TP-5S,-6S,-7S :option) only

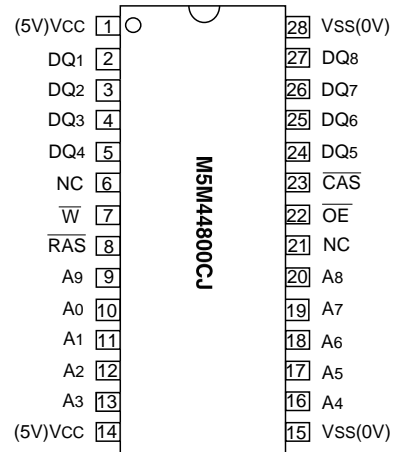
## APPLICATION

Microcomputer memory, Refresh memory for CRT

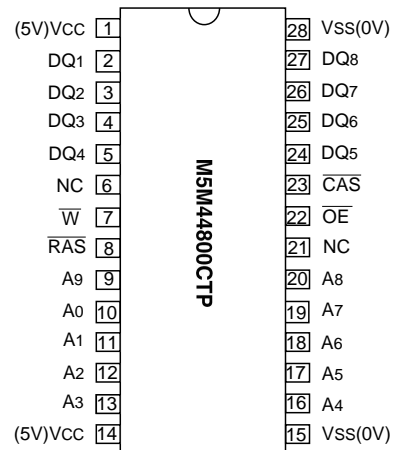
## PIN DESCRIPTION

Pin name	Function
A <sub>0</sub> ~A <sub>9</sub>	Address inputs
DQ <sub>1</sub> ~DQ <sub>8</sub>	Data inputs/outputs
RAS	Row address strobe input
CAS	Column address strobe input
W	Write control input
OE	Output enable input
Vcc	Power supply (+5V)
Vss	Ground (0V)

## PIN CONFIGURATION (TOP VIEW)



Outline 28P0K(400mil SOJ)



Outline 28P3Y-H(400mil TSOP Normal Bend)

NC:NO CONNECTION

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### FUNCTION

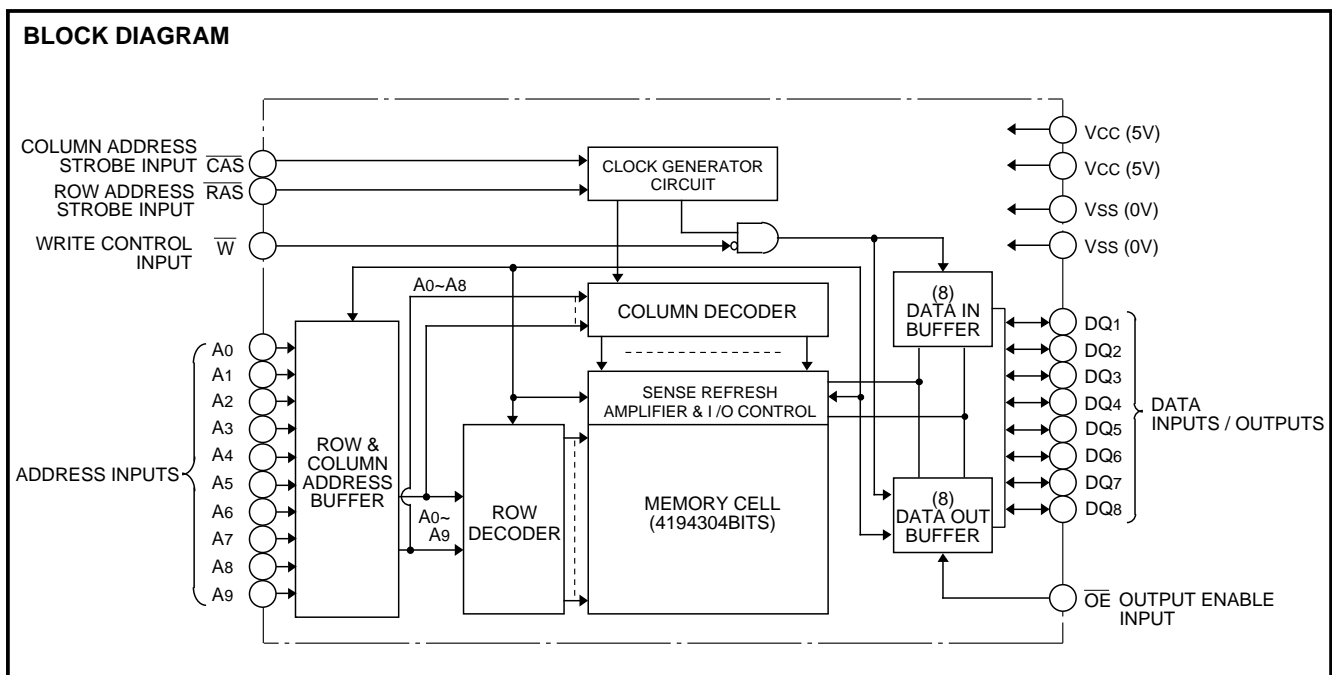
In addition to normal read, write, and read-modify-write operations the M5M44800CJ, TP provides a number of other functions, e.g.,

fast page mode,  $\overline{\text{RAS}}$ -only refresh, and delayed-write. The input conditions for each are shown in Table 1.

**Table 1 Input conditions for each mode**

Operation	Inputs						Input/Output		Refresh	Remark
	$\overline{\text{RAS}}$	$\overline{\text{CAS}}$	$\overline{\text{W}}$	$\overline{\text{OE}}$	Row address	Column address	Input	Output		
Read	ACT	ACT	NAC	ACT	APD	APD	OPN	VLD	YES	Fast page mode identical
Write (Early write)	ACT	ACT	ACT	DNC	APD	APD	VLD	OPN	YES	
Write (Delayed write)	ACT	ACT	ACT	DNC	APD	APD	VLD	IVD	YES	
Read-modify-write	ACT	ACT	ACT	ACT	APD	APD	VLD	VLD	YES	
$\overline{\text{RAS}}$ only refresh	ACT	NAC	DNC	DNC	APD	DNC	DNC	OPN	YES	
Hidden refresh	ACT	ACT	DNC	ACT	DNC	DNC	OPN	VLD	YES	
CAS before $\overline{\text{RAS}}$ (Extended *) refresh	ACT	ACT	DNC	DNC	DNC	DNC	DNC	OPN	YES	
Self refresh *	ACT	ACT	DNC	DNC	DNC	DNC	DNC	OPN	YES	
Stand-by	NAC	DNC	DNC	DNC	DNC	DNC	DNC	OPN	NO	

Note : ACT : active, NAC : nonactive, DNC : don't care, VLD : valid, IVD : invalid, APD : applied, OPN : open



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## ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
V <sub>CC</sub>	Supply voltage	With respect to V <sub>SS</sub>	-1~7	V
V <sub>I</sub>	Input voltage		-1~7	V
V <sub>O</sub>	Output voltage		-1~7	V
I <sub>O</sub>	Output current		50	mA
P <sub>d</sub>	Power dissipation	T <sub>a</sub> =25°C	1000	mW
T <sub>opr</sub>	Operating temperature		0~70	°C
T <sub>stg</sub>	Storage temperature		-65~150	°C

RECOMMENDED OPERATING CONDITIONS (T<sub>a</sub>=0~70°C, unless otherwise noted) (Note 1)

Symbol	Parameter	Limits			Unit
		Min	Nom	Max	
V <sub>CC</sub>	Supply voltage	4.5	5.0	5.5	V
V <sub>SS</sub>	Supply voltage	0	0	0	V
V <sub>IH</sub>	High-level input voltage, all inputs	2.4		6.0	V
V <sub>IL</sub>	Low-level input voltage, all inputs	-0.5 **		0.8	V

Note 1 : All voltage values are with respect to V<sub>SS</sub>.

\*\* : V<sub>IL</sub>(min) is -2.0V when pulse width is less than 25ns. (Pulse width is with respect to V<sub>SS</sub>.)

ELECTRICAL CHARACTERISTICS (T<sub>a</sub>=0~70°C, V<sub>CC</sub>=5V±10%, V<sub>SS</sub>=0V, unless otherwise noted) (Note 2)

Symbol	Parameter	Test conditions	Limits			Unit
			Min	Typ	Max	
V <sub>OH</sub>	High-level output voltage	I <sub>OH</sub> =-5mA	2.4		V <sub>CC</sub>	V
V <sub>OL</sub>	Low-level output voltage	I <sub>OL</sub> =4.2mA	0		0.4	V
I <sub>OZ</sub>	Off-state output current	Q floating, 0V V <sub>OUT</sub> 5.5V	-10		10	μA
I <sub>I</sub>	Input current	0V V <sub>IN</sub> +6.0V, Other inputs pins=0V	-10		10	μA
I <sub>CC1</sub> (AV)	Average supply current from V <sub>CC</sub> , operating (Note 3,4,5)	M5M44800C-5,-5S	RAS, CAS cycling trc=twc=min. output open		90	mA
		M5M44800C-6,-6S			75	
		M5M44800C-7,-7S			65	
I <sub>CC2</sub>	Supply current from V <sub>CC</sub> , stand-by (Note 6)	RAS= CAS =V <sub>IH</sub> , output open			2	mA
		RAS= CAS V <sub>CC</sub> -0.5V output open			1.0	
					0.1 *	
I <sub>CC3</sub> (AV)	Average supply current from V <sub>CC</sub> , RAS only refresh mode (Note 3,5)	M5M44800C-5,-5S	RAS cycling, CAS= V <sub>IH</sub> trc=min. output open		90	mA
		M5M44800C-6,-6S			75	
		M5M44800C-7,-7S			65	
I <sub>CC4</sub> (AV)	Average supply current from V <sub>CC</sub> , Fast Page Mode (Note 3,4,5)	M5M44800C-5,-5S	RAS=V <sub>IL</sub> , CAS cycling tpc=min. output open		90	mA
		M5M44800C-6,-6S			75	
		M5M44800C-7,-7S			65	
I <sub>CC6</sub> (AV)	Average supply current from V <sub>CC</sub> , CAS before RAS refresh mode (Note 3,5)	M5M44800C-5,-5S	CAS before RAS refresh cycling trc=min. output open		80	mA
		M5M44800C-6,-6S			65	
		M5M44800C-7,-7S			55	
I <sub>CC8</sub> (AV) *	Average supply current from V <sub>CC</sub> , Extended-Refresh mode (Note 6)	RAS cycling CAS 0.2V or CAS before RAS refresh cycling RAS 0.2V or V <sub>CC</sub> -0.2V CAS 0.2V or V <sub>CC</sub> -0.2V W 0.2V or V <sub>CC</sub> -0.2V OE 0.2V or V <sub>CC</sub> -0.2V A <sub>0</sub> -A <sub>9</sub> 0.2V or V <sub>CC</sub> -0.2V, DQ=open trc=125μs, trAS=trASmin~1μs			150	μA
I <sub>CC9</sub> (AV) *	Average supply current from V <sub>CC</sub> , Self-Refresh mode (Note 6)	RAS=CAS 0.2V output open			150	μA

Note 2: Current flowing into an IC is positive, out is negative.

3: I<sub>CC1</sub> (AV), I<sub>CC3</sub> (AV), I<sub>CC4</sub> (AV) and I<sub>CC6</sub> (AV) are dependent on cycle rate. Maximum current is measured at the fastest cycle rate.

4: I<sub>CC1</sub> (AV) and I<sub>CC4</sub> (AV) are dependent on output loading. Specified values are obtained with the output open.

5: Column address can be changed once or less while RAS=V<sub>IL</sub> and CAS=V<sub>IH</sub>

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### CAPACITANCE (Ta=0~70°C, Vcc=5V±10%, Vss=0V, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min	Typ	Max	
Cl (A)	Input capacitance, address inputs	Vi=Vss			5	pF
Cl (CLK)	Input capacitance, clock inputs	f=1MHz			7	pF
Cl / o	Input/Output capacitance, data ports	Vi=25mVrms			7	pF

### SWITCHING CHARACTERISTICS (Ta=0~70°C, Vcc = 5V±10%, Vss=0V, unless otherwise noted, see notes 6,13,14)

Symbol	Parameter	Limits						Unit
		M5M44800C-5,-5S		M5M44800C-6,-6S		M5M44800C-7,-7S		
		Min	Max	Min	Max	Min	Max	
tCAC	Access time from CAS (Note 7,8)		13		15		20	ns
tRAC	Access time from RAS (Note 7,9)		50		60		70	ns
tAA	Column address access time (Note 7,10)		25		30		35	ns
tCPA	Access time from CAS precharge (Note 7,11)		30		35		40	ns
tOEA	Access time from OE (Note 7)		13		15		20	ns
tCLZ	Output low impedance time from CAS low (Note 7)	5		5		5		ns
tOFF	Output disable time after CAS high (Note 12)		13		15		20	ns
tOEZ	Output disable time after OE high (Note 12)		13		15		20	ns

Note 6: An initial pause of 500µs is required after power-up followed by a minimum of eight initialization cycles ( $\overline{RAS}$ -only refresh or  $\overline{CAS}$  before  $\overline{RAS}$  refresh cycles).

Note the  $\overline{RAS}$  may be cycled during the initial pause. And 8 initialization cycles are required after prolonged periods (greater than 16.4ms) of  $\overline{RAS}$  inactivity before proper device operation is achieved.

7: Measured with a load circuit equivalent to 2TTL loads and 100pF.

8: Assumes that  $t_{RCD} = t_{RCD(max)}$  and  $t_{ASC} = t_{ASC(max)}$ .

9: Assumes that  $t_{RCD} = t_{RCD(max)}$  and  $t_{RAD} = t_{RAD(max)}$ . If  $t_{RCD}$  or  $t_{RAD}$  is greater than the maximum recommended value shown in this table,  $t_{RAC}$  will increase by amount that  $t_{RCD}$  exceeds the value shown.

10: Assumes that  $t_{RAD} = t_{RAD(max)}$  and  $t_{ASC} = t_{ASC(max)}$ .

11: Assumes that  $t_{CP} = t_{CP(max)}$  and  $t_{ASC} = t_{ASC(max)}$ .

12:  $t_{OFF(max)}$ ,  $t_{OEZ(max)}$  defines the time at which the output achieves the high impedance state ( $I_{OUT} = \pm 10\mu A$ ) and is not reference to  $V_{OH(min)}$  or  $V_{OL(max)}$ .

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### TIMING REQUIREMENTS (For Read, Write, Read-Modify-Write, Refresh, and Fast-Page Mode Cycles)

(Ta=0~70°C, Vcc = 5V±10%, Vss=0V, unless otherwise noted, see notes 6,13,14)

Symbol	Parameter	Limits						Unit
		M5M44800C-5,-5S		M5M44800C-6,-6S		M5M44800C-7,-7S		
		Min	Max	Min	Max	Min	Max	
tREF	Refresh cycle time		16.4		16.4		16.4	ms
tREF	Refresh cycle time *		128		128		128	ms
tRP	RAS high pulse width	30		40		50		ns
tRCD	Delay time, $\overline{\text{RAS}}$ low to $\overline{\text{CAS}}$ low (Note 15)	18	37	20	45	20	50	ns
tCRP	Delay time, $\overline{\text{CAS}}$ high to $\overline{\text{RAS}}$ low	5		5		5		ns
tRPC	Delay time, $\overline{\text{RAS}}$ high to $\overline{\text{CAS}}$ low	0		0		0		ns
tCPN	$\overline{\text{CAS}}$ high pulse width	10		10		10		ns
tRAD	Column address delay time from RAS low (Note 16)	13	25	15	30	15	35	ns
tASR	Row address setup time before $\overline{\text{RAS}}$ low	0		0		0		ns
tASC	Column address setup time before $\overline{\text{CAS}}$ low (Note 17)	0	7	0	10	0	10	ns
tRAH	Row address hold time after $\overline{\text{RAS}}$ low	8		10		10		ns
tCAH	Column address hold time after $\overline{\text{CAS}}$ low	13		15		15		ns
tdZC	Delay time, data to $\overline{\text{CAS}}$ low (Note 18)	0		0		0		ns
tdZO	Delay time, data to $\overline{\text{OE}}$ low (Note 18)	0		0		0		ns
tcDD	Delay time, $\overline{\text{CAS}}$ high to data (Note 19)	13		15		20		ns
tODD	Delay time, $\overline{\text{OE}}$ high to data (Note 19)	13		15		20		ns
tT	Transition time (Note 20)	1	50	1	50	1	50	ns

Note 13: The timing requirements are assumed  $T_T=5\text{ns}$ .

14:  $V_{IH}(\text{min})$  and  $V_{IL}(\text{max})$  are reference levels for measuring timing of input signals.

15:  $t_{RCD}(\text{max})$  is specified as a reference point only. If  $t_{RCD}$  is less than  $t_{RCD}(\text{max})$ , access time is  $t_{RAC}$ . If  $t_{RCD}$  is greater than  $t_{RCD}(\text{max})$ , access time is controlled exclusively by  $t_{CAC}$  or  $t_{AA}$ .

16:  $t_{RAD}(\text{max})$  is specified as a reference point only. If  $t_{RAD}$   $t_{RAD}(\text{max})$  and  $t_{ASC}$   $t_{ASC}(\text{max})$ , access time is controlled exclusively by  $t_{AA}$ .

17:  $t_{ASC}(\text{max})$  is specified as a reference point only. If  $t_{RCD}$   $t_{RCD}(\text{max})$  and  $t_{ASC}$   $t_{ASC}(\text{max})$ , access time is controlled exclusively by  $t_{CAC}$ .

18: Either  $t_{dZC}$  or  $t_{dZO}$  must be satisfied.

19: Either  $t_{cDD}$  or  $t_{oDD}$  must be satisfied.

20:  $T_T$  is measured between  $V_{IH}(\text{min})$  and  $V_{IL}(\text{max})$ .

### Read and Refresh Cycles

Symbol	Parameter	Limits						Unit
		M5M44800C-5,-5S		M5M44800C-6,-6S		M5M44800C-7,-7S		
		Min	Max	Min	Max	Min	Max	
tRC	Read cycle time	90		110		130		ns
tRAS	$\overline{\text{RAS}}$ low pulse width	50	10000	60	10000	70	10000	ns
tCAS	$\overline{\text{CAS}}$ low pulse width	13	10000	15	10000	20	10000	ns
tCSH	$\overline{\text{CAS}}$ hold time after RAS low	50		60		70		ns
tRSH	$\overline{\text{RAS}}$ hold time after $\overline{\text{CAS}}$ low	13		15		20		ns
tRCS	Read Setup time before $\overline{\text{CAS}}$ low	0		0		0		ns
tRCH	Read hold time after $\overline{\text{CAS}}$ high (Note 21)	0		0		0		ns
tRRH	Read hold time after $\overline{\text{RAS}}$ high (Note 21)	0		0		0		ns
tRAL	Column address to $\overline{\text{RAS}}$ hold time	25		30		35		ns
tOCH	$\overline{\text{CAS}}$ hold time after $\overline{\text{OE}}$ low	13		15		20		ns
tORH	$\overline{\text{RAS}}$ hold time after $\overline{\text{OE}}$ low	13		15		20		ns

Note 21: Either  $t_{RCH}$  or  $t_{RRH}$  must be satisfied for a read cycle.

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### Write Cycle (Early Write and Delayed Write)

Symbol	Parameter	Limits						Unit
		M5M44800C-5,-5S		M5M44800C-6,-6S		M5M44800C-7,-7S		
		Min	Max	Min	Max	Min	Max	
tWC	Write cycle time	90		110		130		ns
tRAS	$\overline{\text{RAS}}$ low pulse width	50	10000	60	10000	70	10000	ns
tCAS	$\overline{\text{CAS}}$ low pulse width	13	10000	15	10000	20	10000	ns
tCSH	$\overline{\text{CAS}}$ hold time after $\overline{\text{RAS}}$ low	50		60		70		ns
tRSH	$\overline{\text{RAS}}$ hold time after $\overline{\text{CAS}}$ low	13		15		20		ns
twCS	Write setup time before $\overline{\text{CAS}}$ low (Note 23)	0		0		0		ns
twCH	Write hold time after $\overline{\text{CAS}}$ low	8		10		15		ns
tCWL	$\overline{\text{CAS}}$ hold time after $\overline{\text{W}}$ low	13		15		20		ns
tRWL	$\overline{\text{RAS}}$ hold time after $\overline{\text{W}}$ low	13		15		20		ns
tWP	Write pulse width	8		10		15		ns
tDS	Data setup time before $\overline{\text{CAS}}$ low or $\overline{\text{W}}$ low	0		0		0		ns
tDH	Data hold time after $\overline{\text{CAS}}$ low or $\overline{\text{W}}$ low	8		10		15		ns
tOEH	$\overline{\text{OE}}$ hold time after $\overline{\text{W}}$ low	13		15		20		ns

### Read-Write and Read-Modify-Write Cycles

Symbol	Parameter	Limits						Unit
		M5M44800C-5,-5S		M5M44800C-6,-6S		M5M44800C-7,-7S		
		Min	Max	Min	Max	Min	Max	
tRWC	Read write/read modify write cycle time (Note 22)	126		150		180		ns
tRAS	$\overline{\text{RAS}}$ low pulse width	86	10000	100	10000	120	10000	ns
tCAS	$\overline{\text{CAS}}$ low pulse width	49	10000	55	10000	70	10000	ns
tCSH	$\overline{\text{CAS}}$ hold time after $\overline{\text{RAS}}$ low	86		100		120		ns
tRSH	$\overline{\text{RAS}}$ hold time after $\overline{\text{CAS}}$ low	49		55		70		ns
tRCS	Read setup time before $\overline{\text{CAS}}$ low	0		0		0		ns
tCWD	Delay time, $\overline{\text{CAS}}$ low to $\overline{\text{W}}$ low (Note 23)	31		35		45		ns
tRWD	Delay time, $\overline{\text{RAS}}$ low to $\overline{\text{W}}$ low (Note 23)	68		80		95		ns
tAWD	Delay time, address to $\overline{\text{W}}$ low (Note 23)	43		50		60		ns
tCWL	$\overline{\text{CAS}}$ hold time after $\overline{\text{W}}$ low	13		15		20		ns
tRWL	$\overline{\text{RAS}}$ hold time after $\overline{\text{W}}$ low	13		15		20		ns
tWP	Write pulse width	8		10		15		ns
tDS	Data setup time before $\overline{\text{CAS}}$ low or $\overline{\text{W}}$ low	0		0		0		ns
tDH	Data hold time after $\overline{\text{CAS}}$ low or $\overline{\text{W}}$ low	8		10		15		ns
tOEH	$\overline{\text{OE}}$ hold time after $\overline{\text{W}}$ low	13		15		20		ns

Note 22: tRWC is specified as  $tRWC(\min)=tRAC(\max)+tODD(\min)+tRWL(\min)+tRP(\min)+4T$ .

23: twCS, tCWD, tRWD and tAWD and, tCPWD are specified as reference points only. If twCS twCS(min) the cycle is an early write cycle and the DQ pins will remain high impedance throughout the entire cycle. If tCWD tCWD(min), tRWD tRWD(min), tAWD tAWD(min) and tCPWD tCPWD(min) (for fast page mode cycle only), the cycle is a read-modify-write cycle and the DQ will contain the data read from the selected address. If neither of the above condition (delayed write) of the DQ (at access time and until  $\overline{\text{CAS}}$  or  $\overline{\text{OE}}$  goes back to VIH) is indeterminate.

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## FAST PAGE MODE 4194304-BIT (524288-WORD BY 8-BIT) DYNAMIC RAM

### Fast Page Mode Cycle (Read, Early Write, Read-Write, Read-Modify-Write Cycle) (Note 24)

Symbol	Parameter	Limits						Unit
		M5M44800C-5,-5S		M5M44800C-6,-6S		M5M44800C-7,-7S		
		Min	Max	Min	Max	Min	Max	
tPC	Fast page mode read/write cycle time	35		40		45		ns
tPRWC	Fast page mode read write/read modify write cycle time	71		80		95		ns
tRAS	$\overline{\text{RAS}}$ low pulse width for read or write cycle (Note 25)	85	100000	100	100000	115	100000	ns
tCP	$\overline{\text{CAS}}$ high pulse width (Note 26)	8	12	10	15	10	15	ns
tCPRH	$\overline{\text{RAS}}$ hold time after $\overline{\text{CAS}}$ precharge	30		35		40		ns
tCPWD	Delay time, $\overline{\text{CAS}}$ precharge to $\overline{\text{W}}$ low (Note 23)	48		55		65		ns

Note 24: All previously specified timing requirements and switching characteristics are applicable to their respective Fast page mode cycle.

25: tRAS(min) is specified as two cycles of  $\overline{\text{CAS}}$  input are performed.

26: tCP(max) is specified as a reference point only.

### $\overline{\text{CAS}}$ before $\overline{\text{RAS}}$ Refresh Cycle, Extended Refresh Cycle \* (Note 27)

Symbol	Parameter	Limits						Unit
		M5M44800C-5,-5S		M5M44800C-6,-6S		M5M44800C-7,-7S		
		Min	Max	Min	Max	Min	Max	
tCSR	$\overline{\text{CAS}}$ setup time before $\overline{\text{RAS}}$ low	5		5		5		ns
tCHR	$\overline{\text{CAS}}$ hold time after $\overline{\text{RAS}}$ low	10		10		15		ns
tCAS	$\overline{\text{CAS}}$ low pulse width	20		20		25		ns

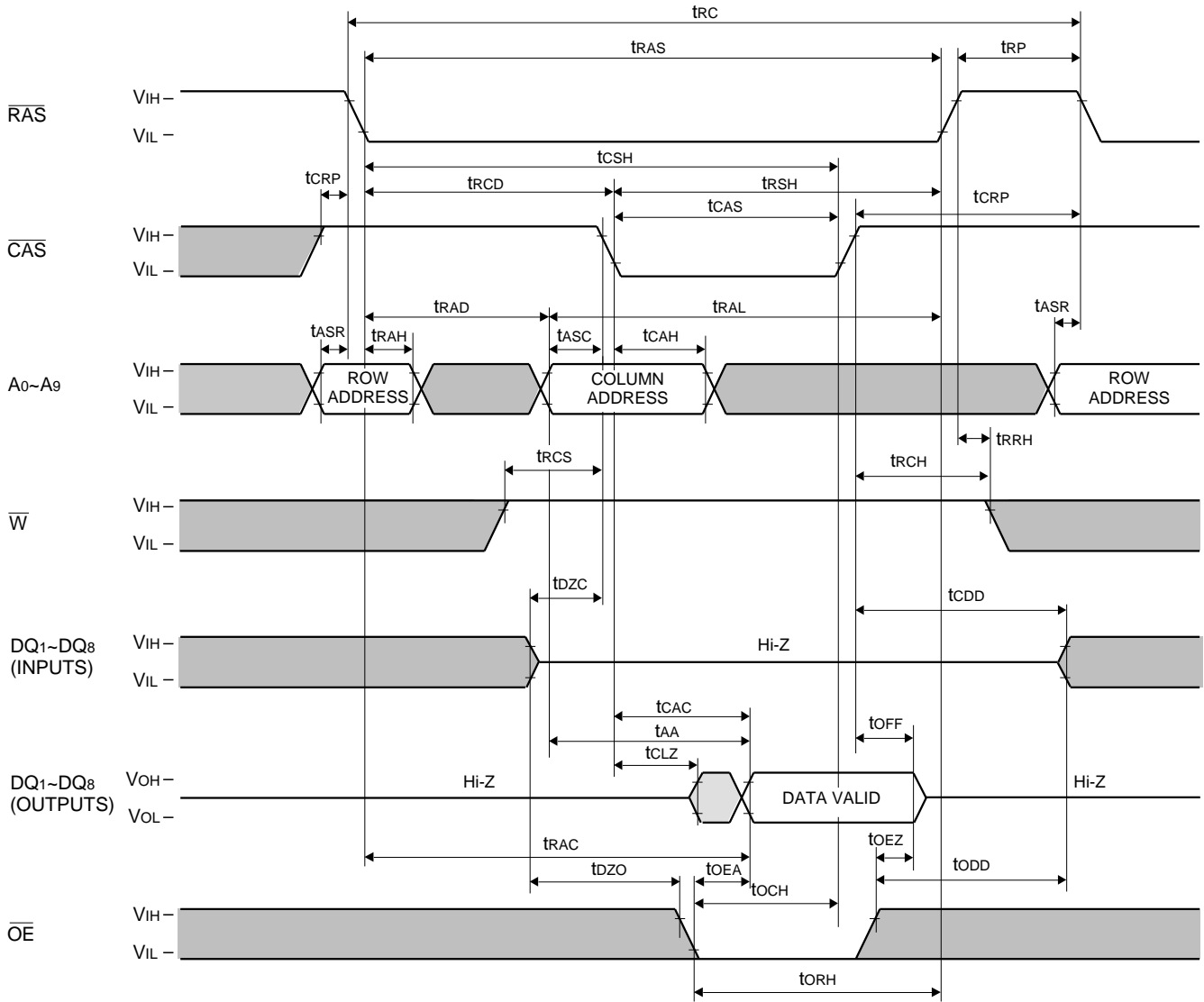
Note 27: Eight or more  $\overline{\text{CAS}}$  before  $\overline{\text{RAS}}$  cycles instead of eight  $\overline{\text{RAS}}$  cycles are necessary for proper operation of  $\overline{\text{CAS}}$  before  $\overline{\text{RAS}}$  refresh mode.

### Self Refresh Cycle \* (Note 28)

Symbol	Parameter	Limits						Unit
		M5M44800C-5,-5S		M5M44800C-6,-6S		M5M44800C-7,-7S		
		Min	Max	Min	Max	Min	Max	
tRASS	CBR self refresh $\overline{\text{RAS}}$ low pulse width	100		100		100		$\mu\text{s}$
tRPS	CBR self refresh $\overline{\text{RAS}}$ high precharge time	90		110		130		ns
tCHS	CBR self refresh $\overline{\text{CAS}}$ hold time	-50		-50		-50		ns

**FAST PAGE MODE 4194304-BIT (524288-WORD BY 8-BIT) DYNAMIC RAM**

**Timing Diagrams** (Note 29)  
**Read Cycle**



Note 29

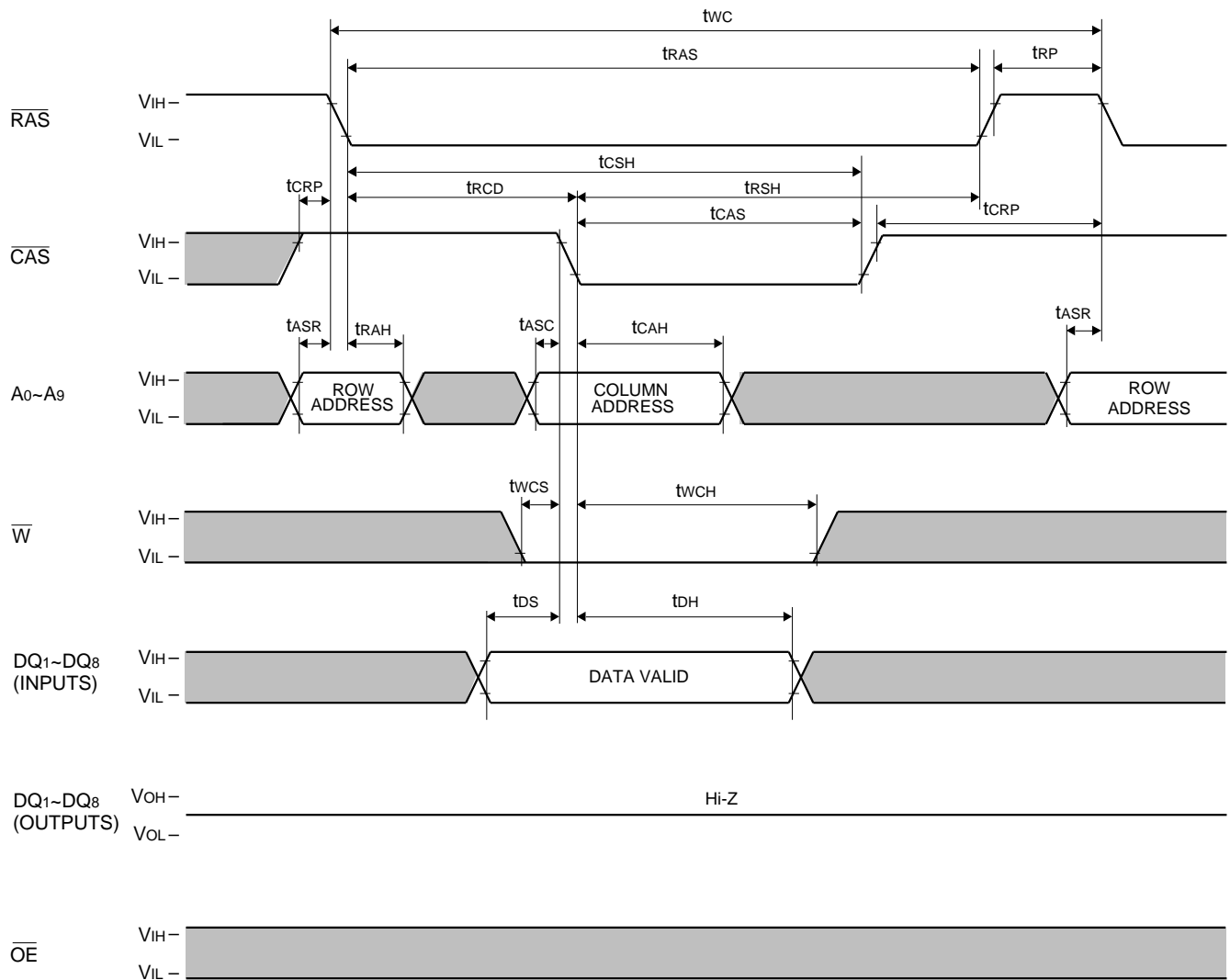
- Indicates the don't care input.  
 $V_{IH(min)}$   $V_{IN}$   $V_{IH(max)}$  or  $V_{IL(min)}$   $V_{IN}$   $V_{IL(max)}$
- Indicates the invalid output.



MITSUBISHI LSIs  
**M5M44800CJ,TP-5,-6,-7,-5S,-6S,-7S**

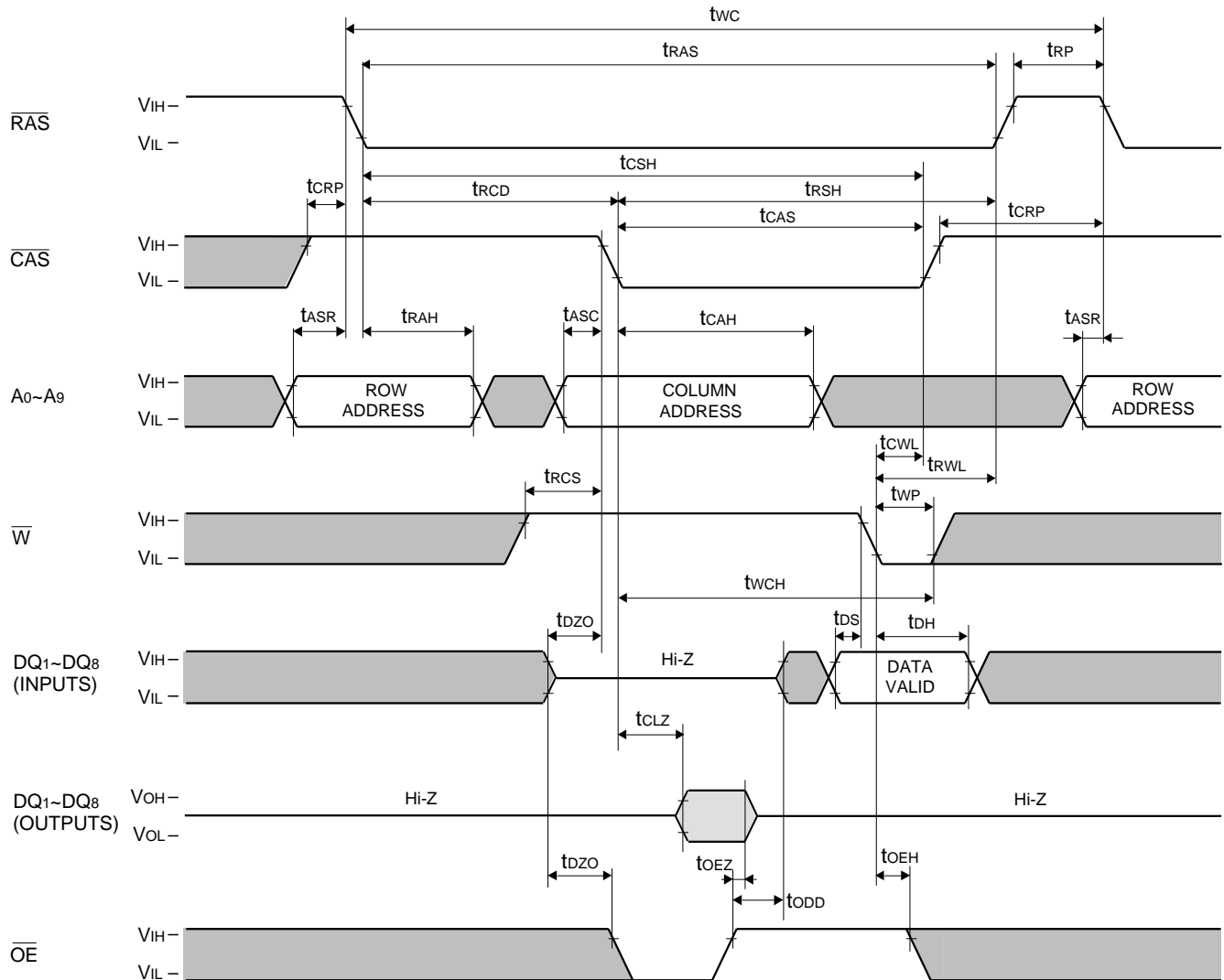
**FAST PAGE MODE 4194304-BIT (524288-WORD BY 8-BIT) DYNAMIC RAM**

**Write Cycle (Early write)**



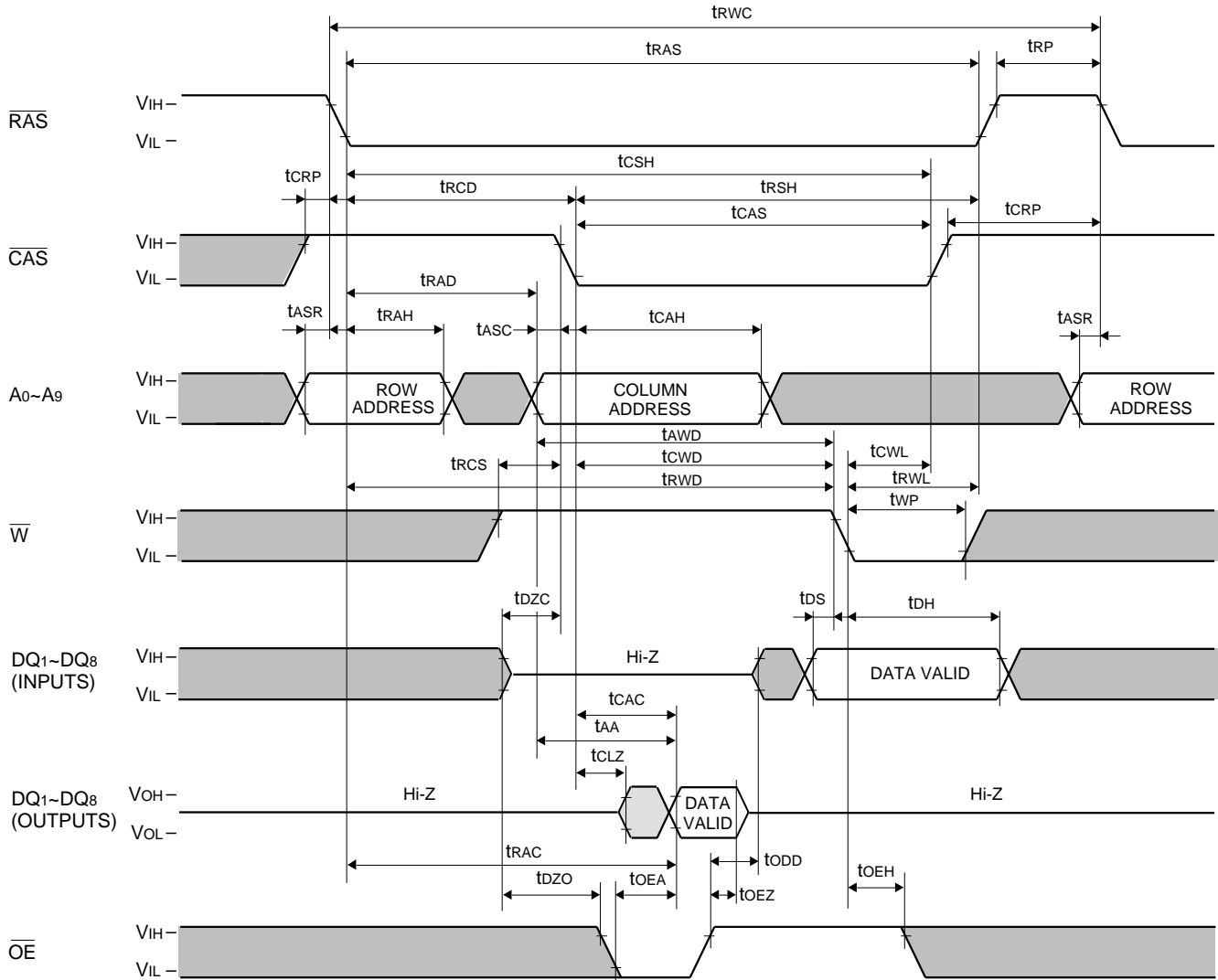
**FAST PAGE MODE 4194304-BIT (524288-WORD BY 8-BIT) DYNAMIC RAM**

**Write Cycle (Delayed write)**



**FAST PAGE MODE 4194304-BIT (524288-WORD BY 8-BIT) DYNAMIC RAM**

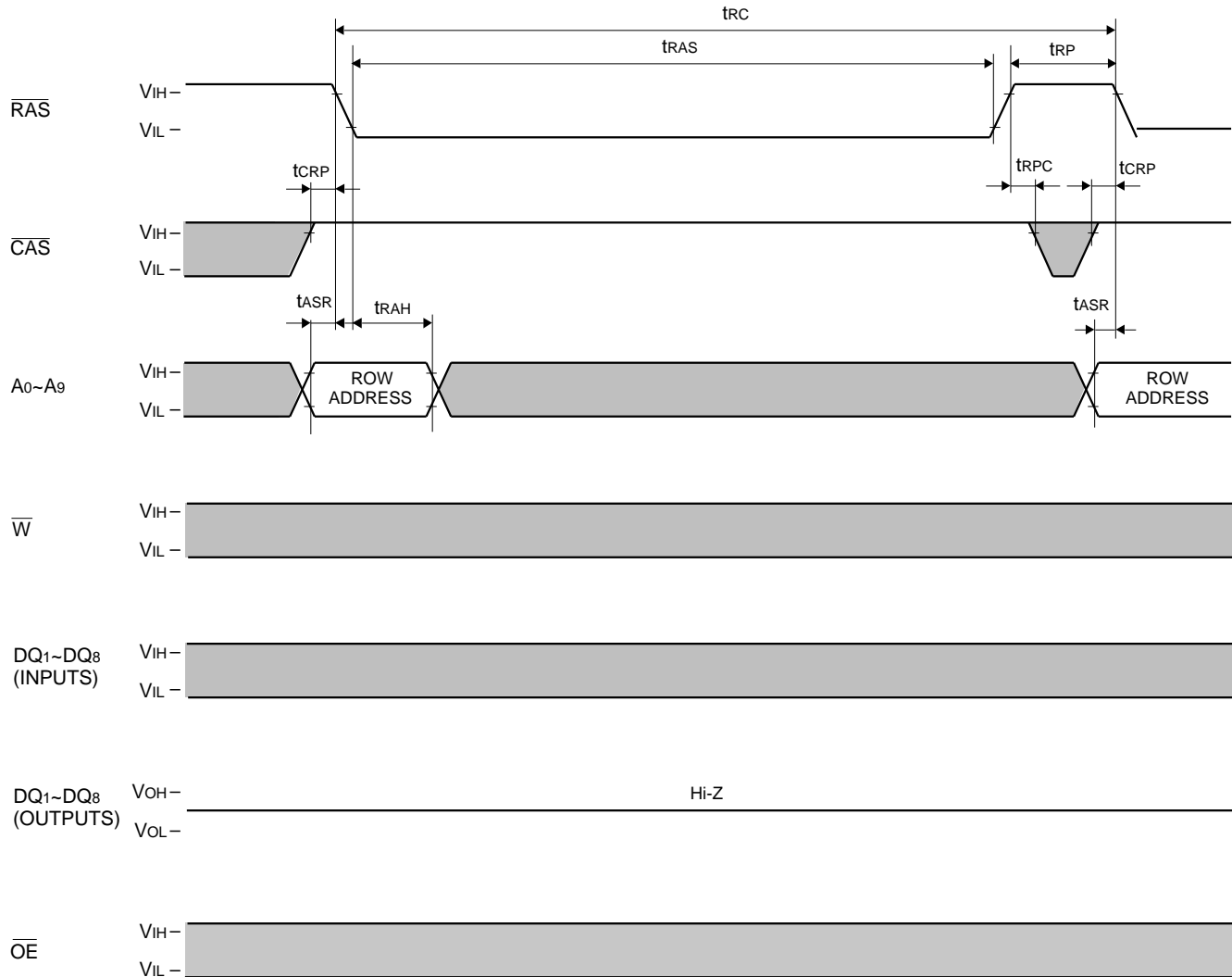
**Read-Write, Read-Modify-Write Cycle**



MITSUBISHI LSIs  
**M5M44800CJ,TP-5,-6,-7,-5S,-6S,-7S**

**FAST PAGE MODE 4194304-BIT (524288-WORD BY 8-BIT) DYNAMIC RAM**

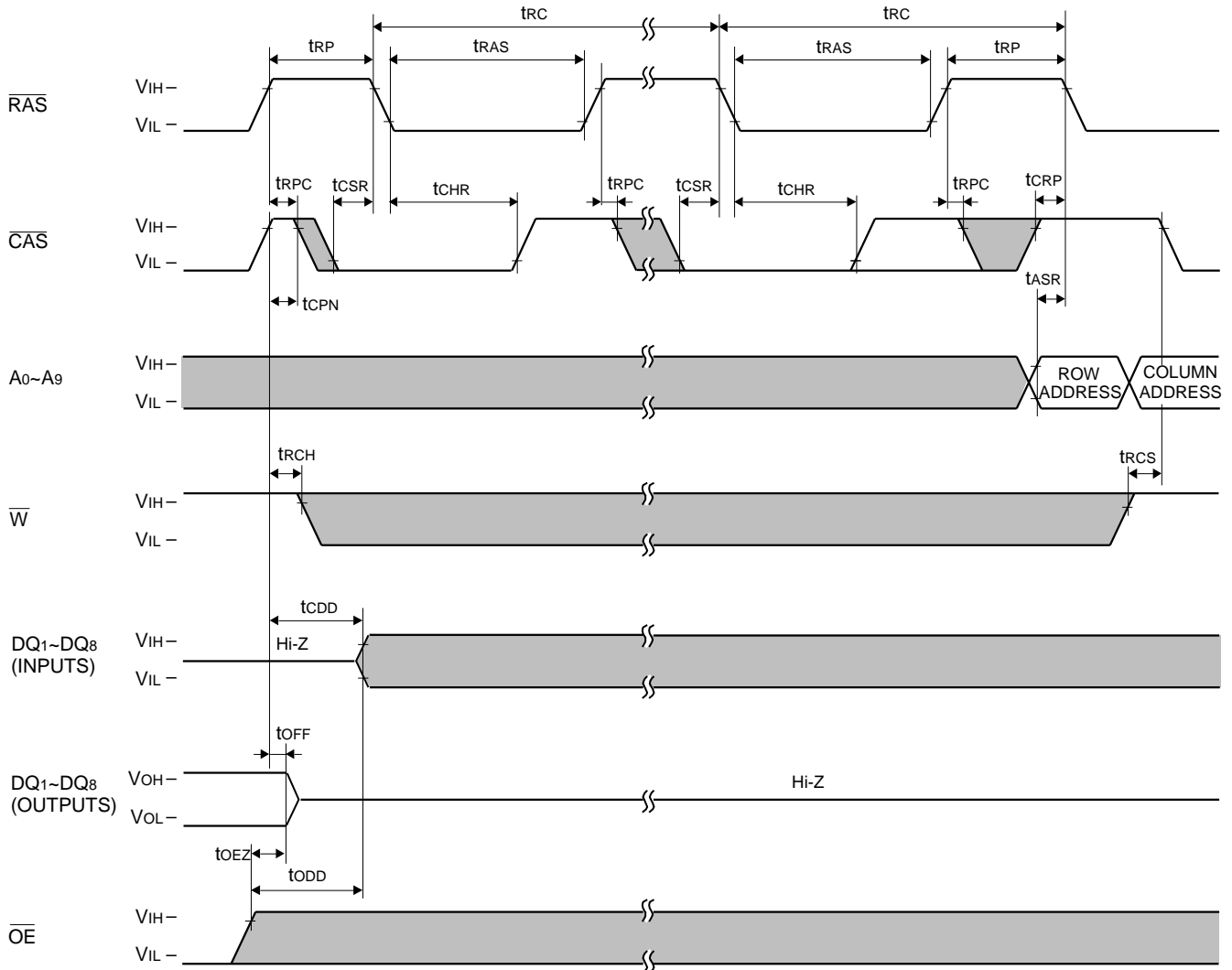
**$\overline{\text{RAS}}$ -only Refresh Cycle**



MITSUBISHI LSIs  
**M5M44800CJ,TP-5,-6,-7,-5S,-6S,-7S**

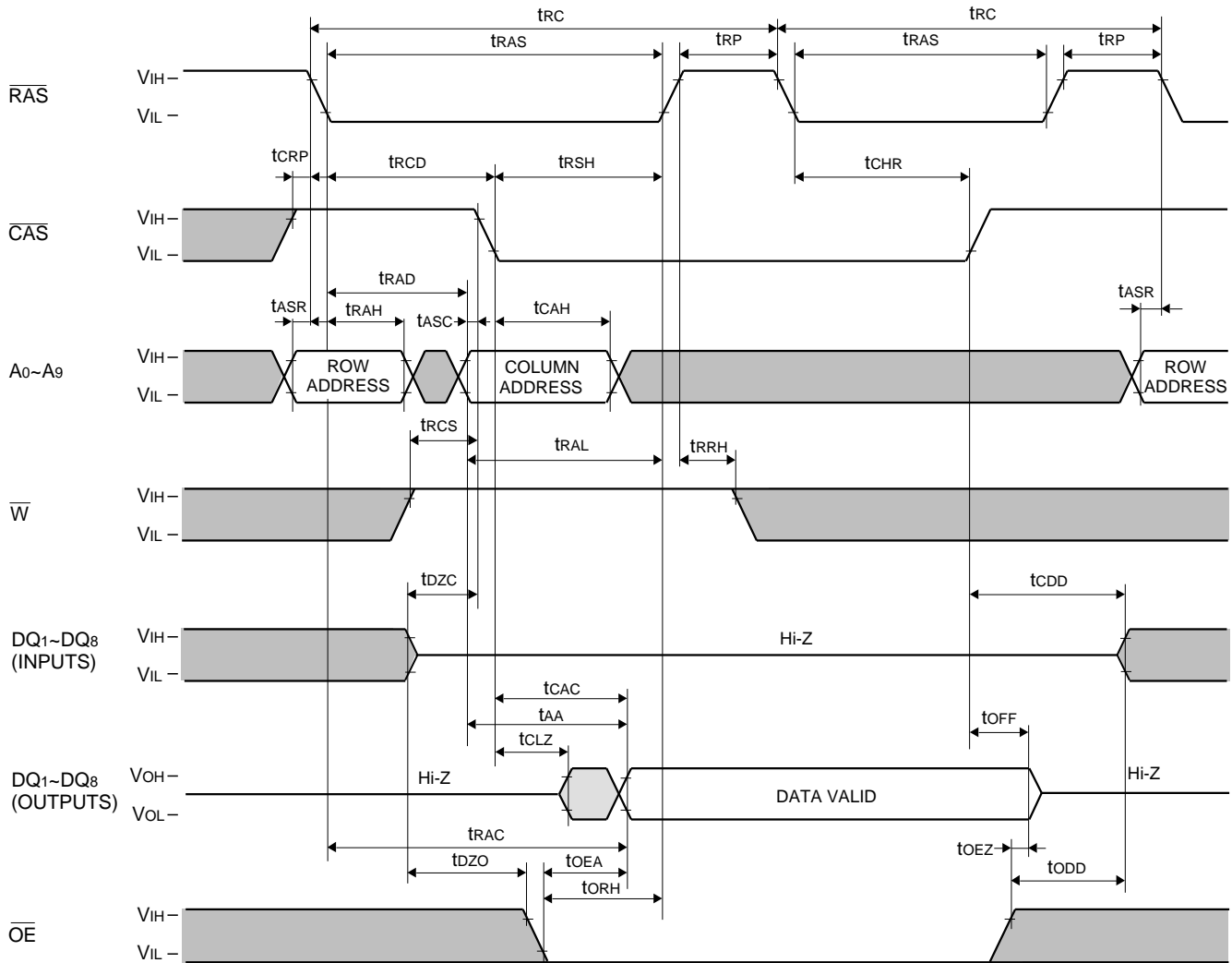
**FAST PAGE MODE 4194304-BIT (524288-WORD BY 8-BIT) DYNAMIC RAM**

**CAS before RAS Refresh Cycle, Extended Refresh Cycle \***



**FAST PAGE MODE 4194304-BIT (524288-WORD BY 8-BIT) DYNAMIC RAM**

**Hidden Refresh Cycle (Read)** (Note 30)

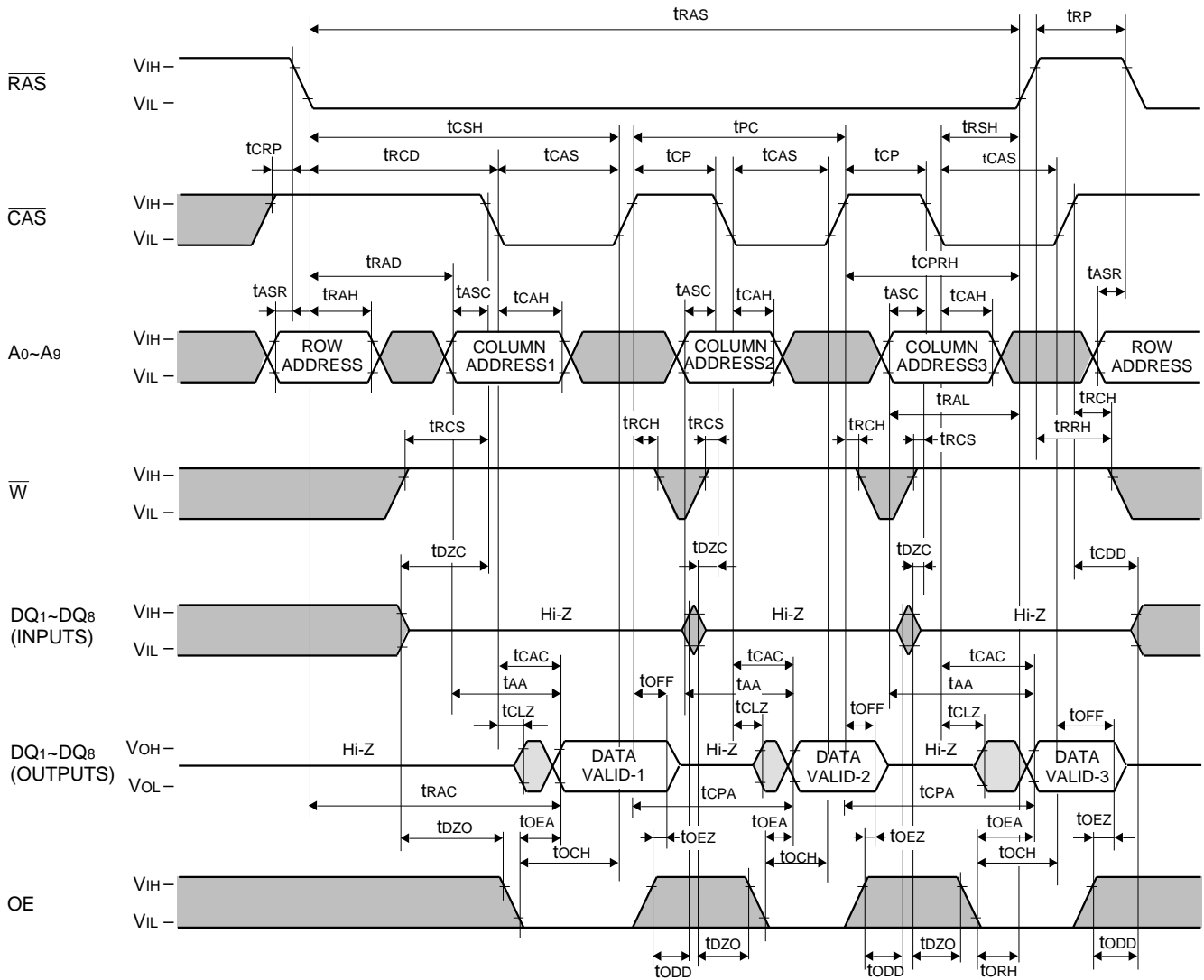


Note 30: Early write, delayed write, read write or read modify write cycle is applicable instead of read cycle.  
 Timing requirements and output state are the same as that of each cycle described above.

MITSUBISHI LSIs  
**M5M44800CJ,TP-5,-6,-7,-5S,-6S,-7S**

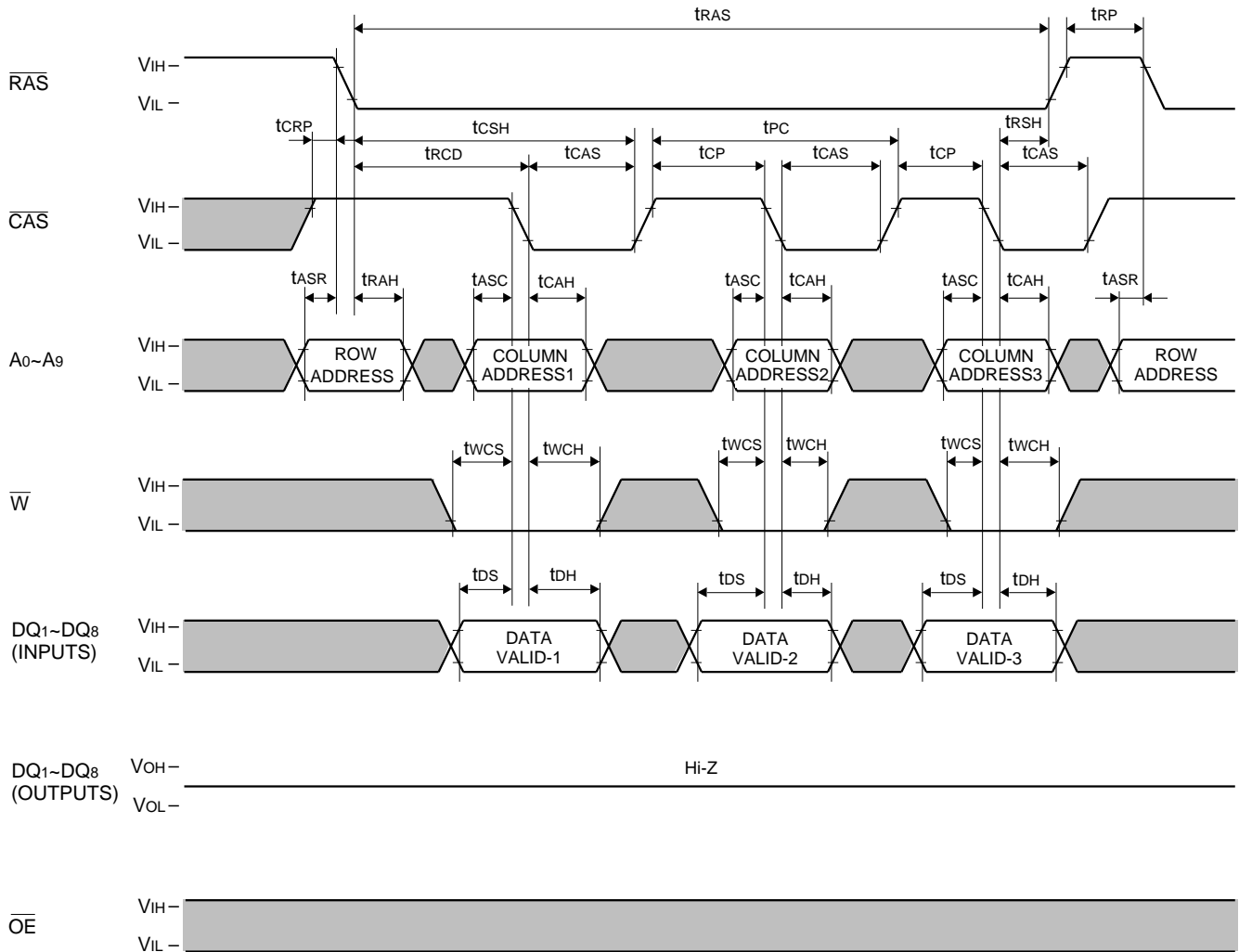
**FAST PAGE MODE 4194304-BIT (524288-WORD BY 8-BIT) DYNAMIC RAM**

**Fast Page Mode Read Cycle**



**FAST PAGE MODE 4194304-BIT (524288-WORD BY 8-BIT) DYNAMIC RAM**

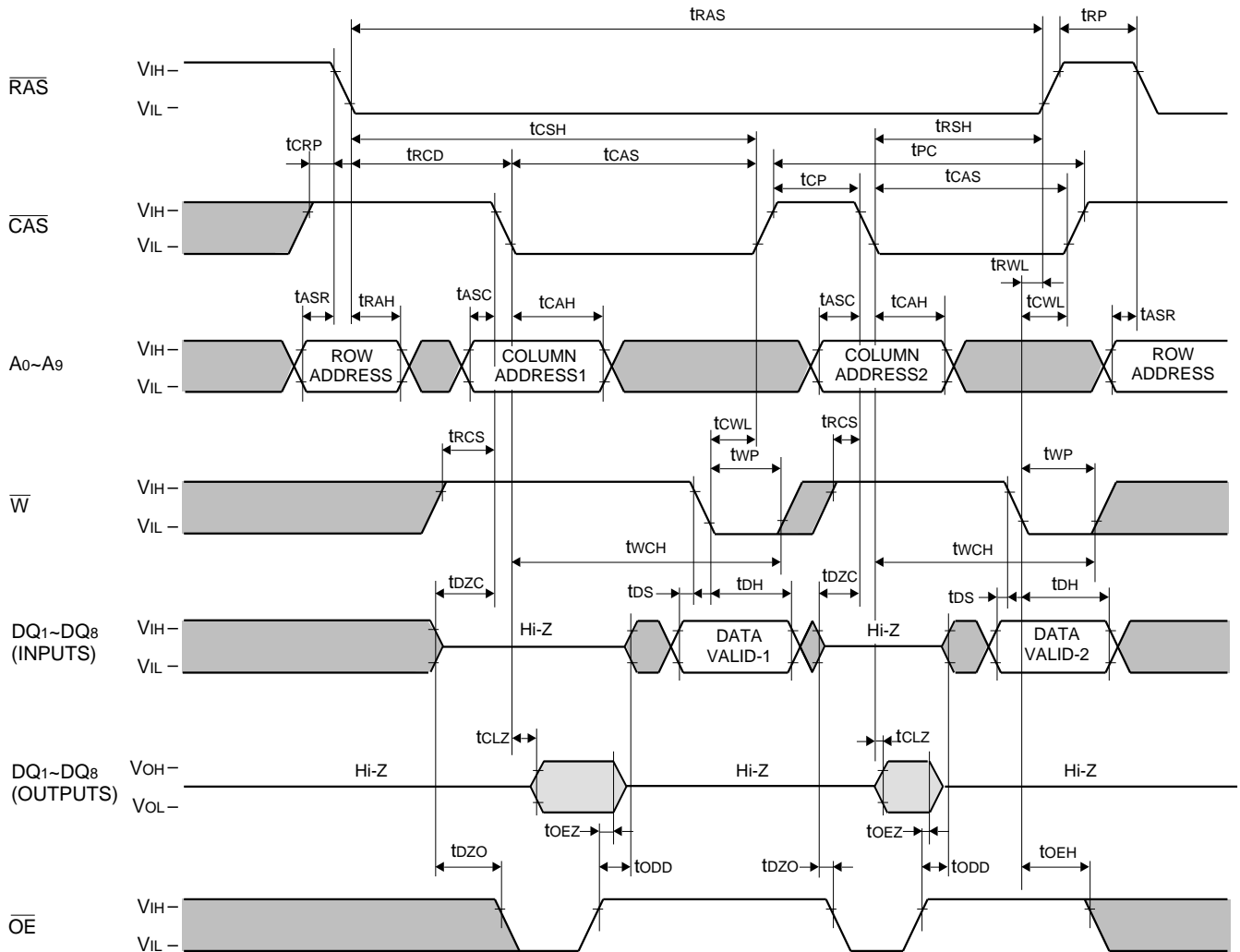
**Fast Page Mode Write Cycle (Early Write)**





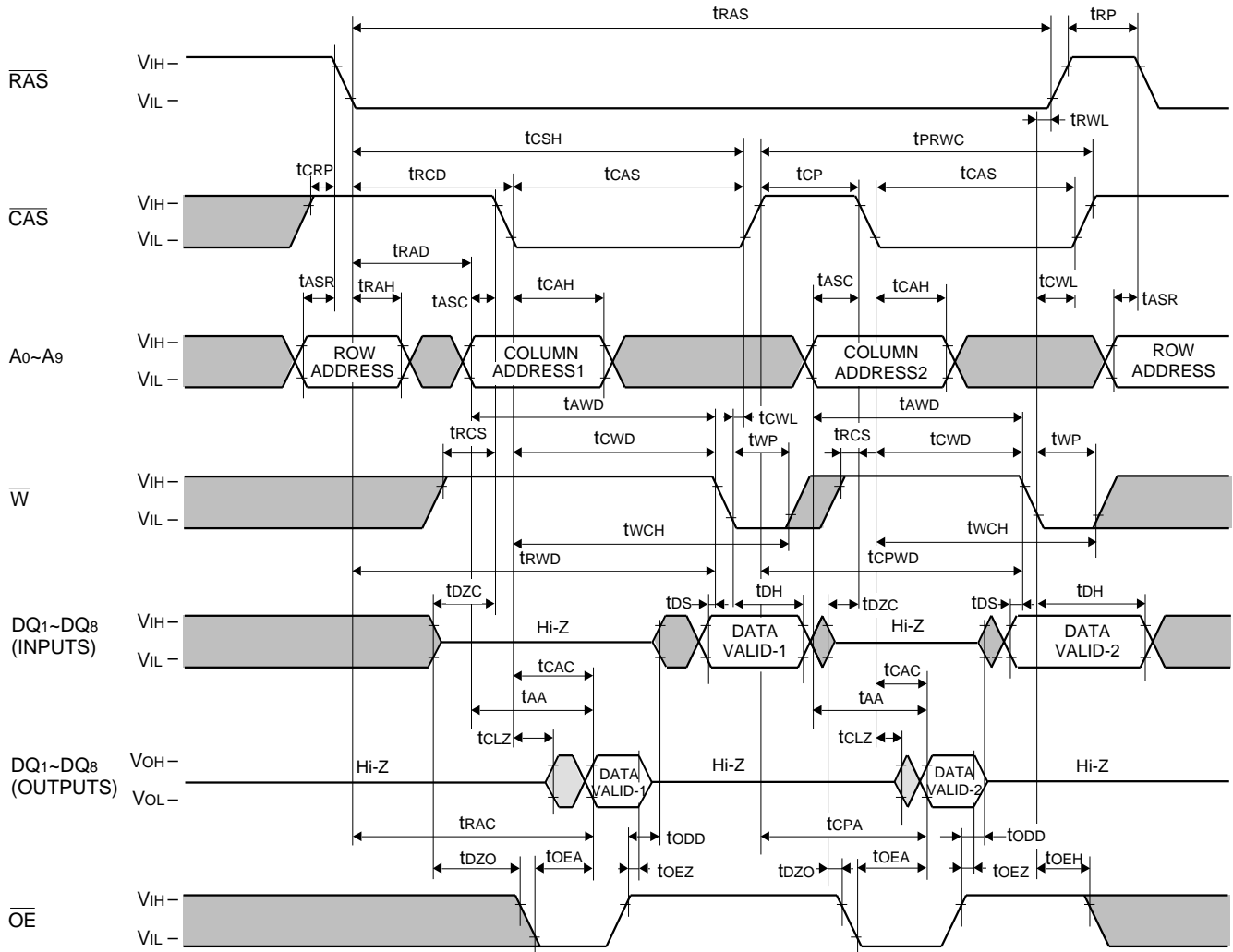
**FAST PAGE MODE 4194304-BIT (524288-WORD BY 8-BIT) DYNAMIC RAM**

**Fast-Page Mode Write Cycle (Delayed Write)**



**FAST PAGE MODE 4194304-BIT (524288-WORD BY 8-BIT) DYNAMIC RAM**

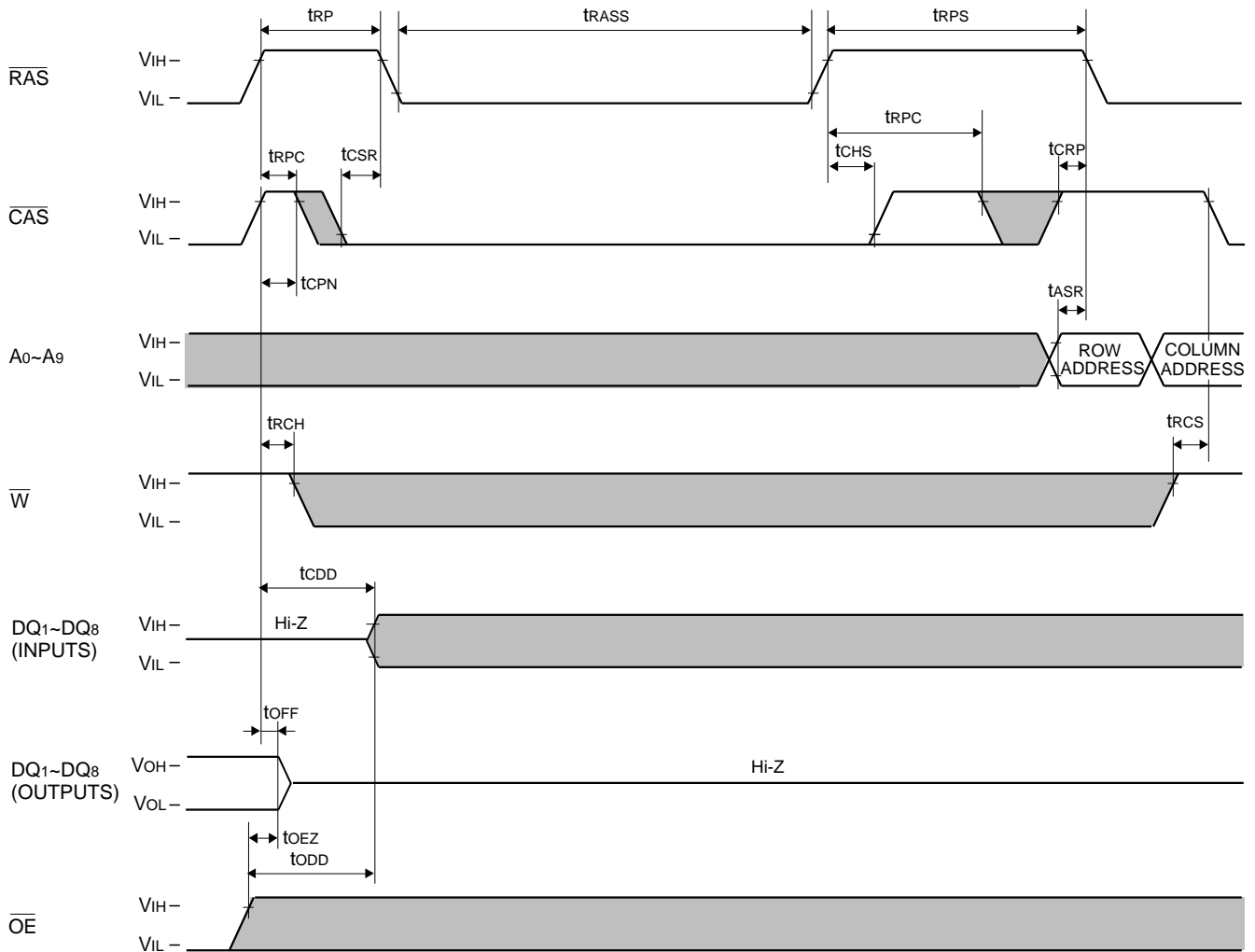
**Fast Page Mode Read-Write, Read-Modify-Write Cycle**



MITSUBISHI LSIs  
**M5M44800CJ,TP-5,-6,-7,-5S,-6S,-7S**

**FAST PAGE MODE 4194304-BIT (524288-WORD BY 8-BIT) DYNAMIC RAM**

**Self Refresh Cycle \*** (Note 28)



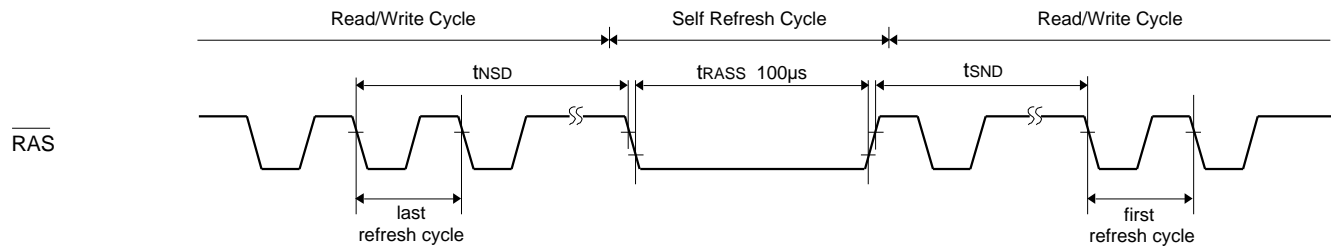
**FAST PAGE MODE 4194304-BIT (524288-WORD BY 8-BIT) DYNAMIC RAM**

Note 28:Self refresh sequence

Two refreshing methods should be used properly depending on the low pulse width( $t_{RASS}$ ) of  $\overline{RAS}$  signal during self refresh period.

1. Distributed refresh during Read/Write operation

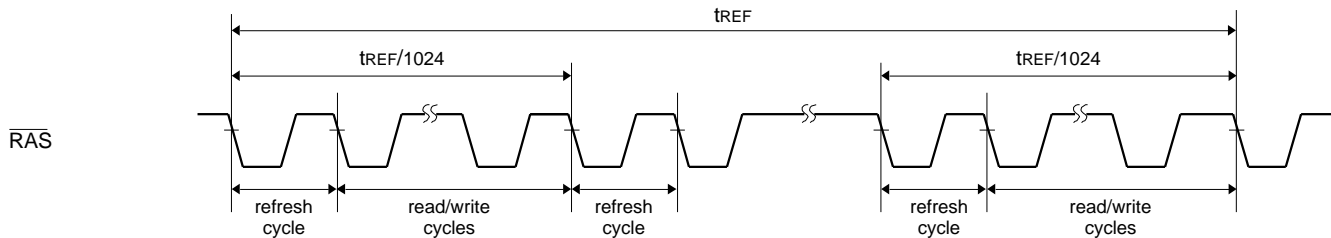
(A) Timing diagram



**Table 2**

Read/Write Cycle	Read/Write → Self Refresh	Self Refresh → Read/Write
CBR distributed refresh	$t_{NSD}$ 125µs	$t_{SND}$ 125µs
$\overline{RAS}$ only distributed refresh	$t_{NSD}$ 16µs	$t_{SND}$ 16µs

(B) Definition of distributed refresh



Definition of CBR distributed refresh

(Including extended refresh)

The CBR distributed refresh performs more than 1024 constant period (125µs max.) CBR cycles within 128ms.

Definition of  $\overline{RAS}$  only distributed refresh

All combinations of nine row address signals ( $A_0$ – $A_9$ ) are selected during 1024 constant period (16µs max.)  $\overline{RAS}$  only refresh cycles within 16.4ms.

Note:

Hidden refresh may be used instead of CBR refresh.

$\overline{RAS}/\overline{CAS}$  refresh may be used instead of  $\overline{RAS}$  only refresh.

1.1 CBR distributed refresh

- Switching from read/write operation to self refresh operation.

The time interval from the falling edge of  $\overline{RAS}$  signal in the last CBR refresh cycle during read/write operation period to the falling edge of  $\overline{RAS}$  signal at the start of self refresh operation should be set within  $t_{NSD}$  (shown in table 2).

- Switching from self refresh operation to read/write operation.

The time interval from the rising edge of  $\overline{RAS}$  signal at the end of self refresh operation to the falling edge of  $\overline{RAS}$  signal in the first CBR refresh cycle during read/write operation period should be set within  $t_{SND}$  (shown in table 2)

1.2  $\overline{RAS}$  only distributed refresh

- Switching from read/write operation to self refresh operation.

The time interval  $t_{NSD}$  from the falling edge of  $\overline{RAS}$  signal in the last  $\overline{RAS}$  only refresh cycle during read/write operation period to the falling edge of  $\overline{RAS}$  signal at the start of self refresh operation should be set within 16µs.

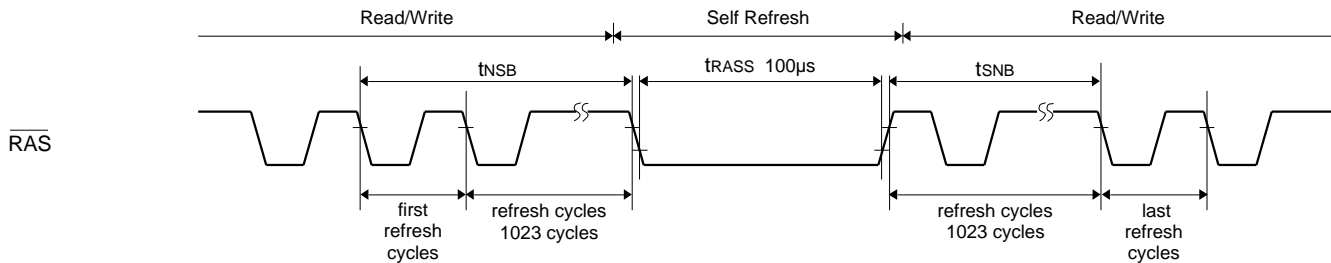
- Switching from self refresh operation to read/write operation.

The time interval  $t_{SND}$  from the rising edge of  $\overline{RAS}$  signal at the end of self refresh operation to the falling edge of  $\overline{RAS}$  signal in the first CBR refresh cycle during read/write operation period should be set within 16µs.

**FAST PAGE MODE 4194304-BIT (524288-WORD BY 8-BIT) DYNAMIC RAM**

2. Burst refresh during Read/Write operation

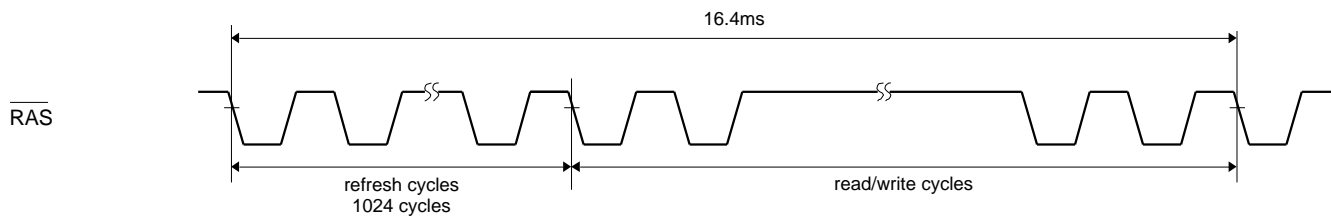
(A) Timing diagram



**Table 3**

Read/Write Cycle	Read/Write → Self Refresh	Self Refresh → Read/Write
CBR burst refresh	$t_{NSB} 16.4ms$	$t_{SNB} 16.4ms$
$\overline{RAS}$ only burst refresh	$t_{NSB}+t_{SNB} 16.4ms$	

(B) Definition of burst refresh



Definition of CBR burst refresh

The CBR burst refresh performs more than 1024 continuous CBR cycles within 16.4ms.

Definition of  $\overline{RAS}$  only burst refresh

All combination of nine row address signals ( $A_0$ – $A_9$ ) are selected during 1024 continuous  $\overline{RAS}$  only refresh cycles within 16.4ms.

2.1 CBR burst refresh

- Switching from read/write operation to self refresh operation.  
The time interval  $t_{NSB}$  from the falling edge of  $\overline{RAS}$  signal in the first CBR refresh cycle during read/write operation period to the falling edge of  $\overline{RAS}$  signal at the start of self refresh operation should be set within 16.4ms.
- Switching from self refresh operation to read/write operation.  
The time interval  $t_{SNB}$  from the rising edge of  $\overline{RAS}$  signal at the end of self refresh operation to the falling edge of  $\overline{RAS}$  signal in the last CBR refresh cycle during read/write operation period should be set within 16.4ms.

2.2  $\overline{RAS}$  only burst refresh

- Switching from read/write operation to self refresh operation.  
The time interval from the falling edge of  $\overline{RAS}$  signal in the first  $\overline{RAS}$  only refresh cycle during read/write operation period to the falling edge of  $\overline{RAS}$  signal at the start of self refresh operation should be set within  $t_{NSB}$  (shown in table 3).
- Switching from self refresh operation to read / write operation.  
The time interval from the rising edge of  $\overline{RAS}$  signal at the end of self refresh operation to the falling edge of  $\overline{RAS}$  signal in the last  $\overline{RAS}$  only refresh cycle during read/write operation period should be set within  $t_{SNB}$  (shown in table 3).