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	$\overline{RAS}$ access time (max.ns)	$\overline{CAS}$ access time (max.ns)	Address access time (max.ns)	$\overline{OE}$ 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

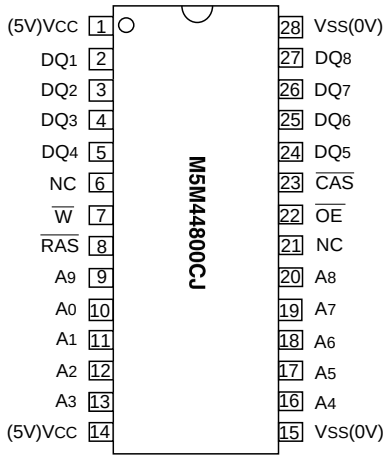
- Standard 28pin SOJ, 28pin TSOP (II)
- Single 5V±10% supply
- Low stand-by power dissipation
  - CMOS Input level ---------- 5.5mW (Max)
  - CMOS Input level ---------- 550µW (Max) *
- Operating power dissipation
  - M5M44800Cxx-5,-5S ---------- 495mW (Max)
  - M5M44800Cxx-6,-6S ---------- 413mW (Max)
  - 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, $\overline{RAS}$-only refresh, $\overline{CAS}$ before $\overline{RAS}$ refresh, Hidden refresh capabilities.
- Early-write mode, $\overline{CAS}$ and $\overline{OE}$ to control output buffer impedance
- 1024 refresh cycles every 16.4ms (A_0 ~A_9)
- 1024 refresh cycles every 128ms (A_0 ~A_9) *

* :Applicable to self refresh version (M5M44800CJ,TP-5S,-6S,-7S :option) only

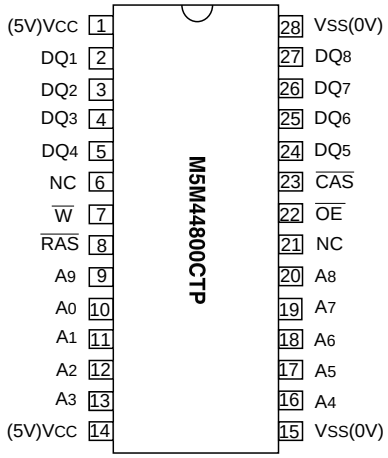
APPLICATION

Microcomputer memory, Refresh memory for CRT

PIN CONFIGURATION (TOP VIEW)



Outline 28P0K(400mil SOJ)



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

NC:NO CONNECTION

PIN DESCRIPTION

Pin name	Function
A_0~A_9	Address inputs
DQ_1~DQ_8	Data inputs/outputs
$\overline{RAS}$	Row address strobe input
$\overline{CAS}$	Column address strobe input
$\overline{W}$	Write control input
$\overline{OE}$	Output enable input
Vcc	Power supply (+5V)
Vss	Ground (0V)

M5M44800CJ,TP-5,-5S:Under development

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

FUNCTION

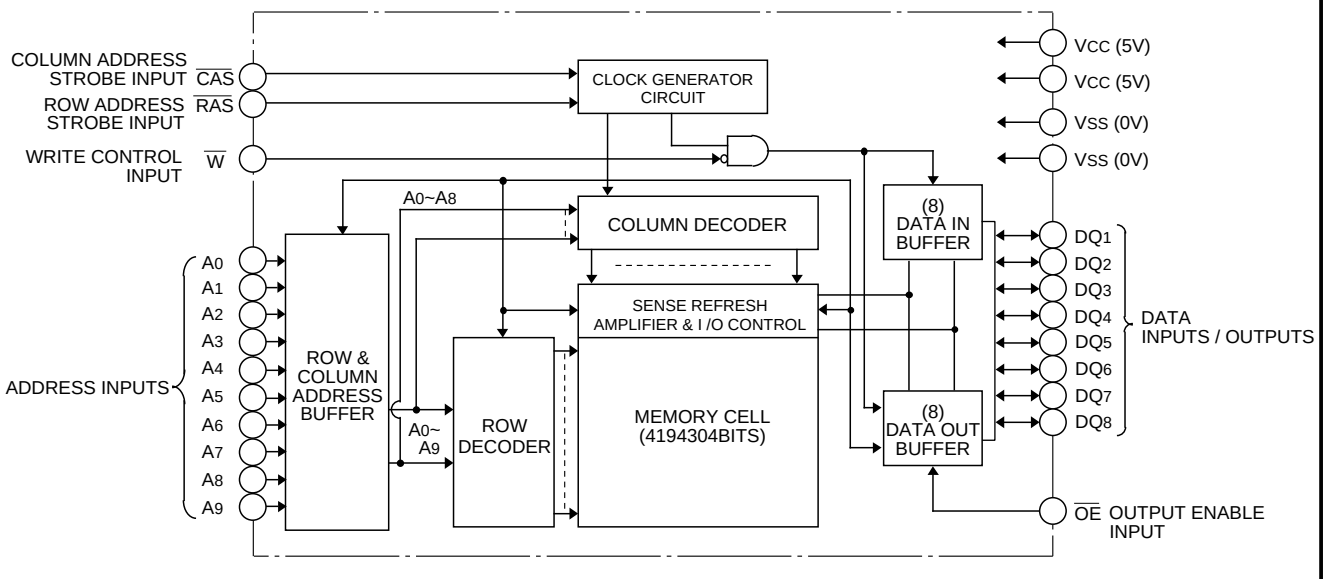
In addition to normal read, write, and read-modify-write operations the M5M44800CJ, TP provides a number of other functions, e.g., fast page mode, $\overline{RAS}$-only refresh, and delayed-write. The input conditions for each are shown in Table 1.

Table 1 Input conditions for each mode

Operation	Inputs						Input/Output		Refresh	Remark
	$\overline{RAS}$	$\overline{CAS}$	$\overline{W}$	$\overline{OE}$	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	
$\overline{RAS}$ only refresh	ACT	NAC	DNC	DNC	APD	DNC	DNC	OPN	YES	
Hidden refresh	ACT	ACT	DNC	ACT	DNC	DNC	OPN	VLD	YES	
$\overline{CAS}$ before $\overline{RAS}$ (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

BLOCK DIAGRAM



M5M44800CJ,TP-5,-5S:Under development

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Conditions	Ratings	Unit
V_{CC}	Supply voltage	With respect to V_{SS}	-1~7	V
V_I	Input voltage		-1~7	V
V_O	Output voltage		-1~7	V
I_O	Output current		50	mA
P_d	Power dissipation	Ta=25˚C	1000	mW
T_{opr}	Operating temperature		0~70	˚C
T_{stg}	Storage temperature		-65~150	˚C

RECOMMENDED OPERATING CONDITIONS (Ta=0~70˚C, unless otherwise noted) (Note 1)

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

Note 1 : All voltage values are with respect to Vss.
* * : $V_{IL(min)}$ is -2.0V when pulse width is less than 25ns. (Pulse width is with respect to V_{SS}.)

ELECTRICAL CHARACTERISTICS (Ta=0~70˚C, V_{CC}=5V±10%, V_{SS}=0V, unless otherwise noted) (Note 2)

Symbol	Parameter		Test conditions	Limits			Unit
				Min	Typ	Max	
V_{OH}	High-level output voltage		I_{OH}=-5mA	2.4		Vcc	V
V_{OL}	Low-level output voltage		I_{OL}=4.2mA	0		0.4	V
I_{OZ}	Off-state output current		Q floating, 0V ≤ V_{OUT} ≤ 5.5V	-10		10	µA
I_I	Input current		0V ≤ V_{IN} ≤ +6.0V, Other inputs pins=0V	-10		10	µA
$I_{CC1\ (AV)}$	Average supply current from V_{CC}, operating (Note 3,4,5)	**M5M44800C-5,-5S**	$\overline{RAS}$, $\overline{CAS}$ cycling t_{RC}=t_{WC}=min. output open			90	mA
		M5M44800C-6,-6S				75	
		M5M44800C-7,-7S				65	
I_{CC2}	Supply current from V_{CC}, stand-by (Note 6)		$\overline{RAS}$= $\overline{CAS}$ =V_{IH}, output open			2	mA
			$\overline{RAS}$= $\overline{CAS}$ ≥ V_{CC} -0.5V output open			1.0	
						0.1 *	
$I_{CC3\ (AV)}$	Average supply current from V_{CC}, $\overline{RAS}$ only refresh mode (Note 3,5)	**M5M44800C-5,-5S**	$\overline{RAS}$ cycling, $\overline{CAS}$= V_{IH} t_{RC}=min. output open			90	mA
		M5M44800C-6,-6S				75	
		M5M44800C-7,-7S				65	
$I_{CC4(AV)}$	Average supply current from V_{CC}, Fast Page Mode (Note 3,4,5)	**M5M44800C-5,-5S**	$\overline{RAS}$=V_{IL}, $\overline{CAS}$ cycling t_{PC}=min. output open			90	mA
		M5M44800C-6,-6S				75	
		M5M44800C-7,-7S				65	
$I_{CC6(AV)}$	Average supply current from V_{CC}, $\overline{CAS}$ before $\overline{RAS}$ refresh mode (Note 3,5)	**M5M44800C-5,-5S**	$\overline{CAS}$ before $\overline{RAS}$ refresh cycling t_{RC}=min. output open			80	mA
		M5M44800C-6,-6S				65	
		M5M44800C-7,-7S				55	
$I_{CC8(AV)}$ *	Average supply current from V_{CC}, Extended-Refresh mode (Note 6)		$\overline{RAS}$ cycling $\overline{CAS}$ ≤ 0.2V or $\overline{CAS}$ before $\overline{RAS}$ refresh cycling $\overline{RAS}$ ≤ 0.2V or ≥ V_{CC}-0.2V $\overline{CAS}$ ≤ 0.2V or ≥ V_{CC}-0.2V $\overline{W}$ ≤ 0.2V or ≥ V_{CC}-0.2V $\overline{OE}$ ≤ 0.2V or ≥ V_{CC}-0.2V A_0~A_9 ≤ 0.2V or ≥ V_{CC}-0.2V, DQ=open t_{RC}=125µs, t_{RAS}=t_{RAS}min~1µs			150	µA
$I_{CC9(AV)}$ *	Average supply current from V_{CC}, Self-Refresh mode (Note 6)		$\overline{RAS}$=$\overline{CAS}$ ≤ 0.2V output open			150	µA

Note 2: Current flowing into an IC is positive, out is negative.
3: $I_{CC1\ (AV)}$, $I_{CC3\ (AV)}$, $I_{CC4\ (AV)}$ and $I_{CC6\ (AV)}$ are dependent on cycle rate. Maximum current is measured at the fastest cycle rate.
4: $I_{CC1\ (AV)}$ and $I_{CC4\ (AV)}$ are dependent on output loading. Specified values are obtained with the output open.
5: Column address can be changed once or less while $\overline{RAS}$=V_{IL} and $\overline{CAS}$=V_{IH}

CAPACITANCE (T_a=0~70˚C, V_{CC}=5V±10%, V_{SS}=0V, unless otherwise noted)

Symbol	Parameter	Test conditions	Limits			Unit
			Min	Typ	Max	
$C_{I\ (A)}$	Input capacitance, address inputs	V_I=V_{SS}			5	pF
$C_{I\ (CLK)}$	Input capacitance, clock inputs	f=1MHz			7	pF
$C_{I\ /\ O}$	Input/Output capacitance, data ports	V_I=25mVrms			7	pF

SWITCHING CHARACTERISTICS (T_a=0~70˚C, V_{CC} = 5V±10%, V_{SS}=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	
t_{CAC}	Access time from $\overline{CAS}$	(Note 7,8)		13		15		20	ns
t_{RAC}	Access time from $\overline{RAS}$	(Note 7,9)		50		60		70	ns
t_{AA}	Column address access time	(Note 7,10)		25		30		35	ns
t_{CPA}	Access time from $\overline{CAS}$ precharge	(Note 7,11)		30		35		40	ns
t_{OEA}	Access time from $\overline{OE}$	(Note 7)		13		15		20	ns
t_{CLZ}	Output low impedance time from $\overline{CAS}$ low	(Note 7)	5		5		5		ns
t_{OFF}	Output disable time after $\overline{CAS}$ high	(Note 12)		13		15		20	ns
t_{OEZ}	Output disable time after $\overline{OE}$ 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 $t_{RCD} \geq t_{RCD(max)}$ and $t_{ASC} \geq t_{ASC(max)}$.

9: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} will increase by amount that t_{RCD} exceeds the value shown.

10:Assumes that $t_{RAD} \geq t_{RAD(max)}$ and $t_{ASC} \leq t_{ASC(max)}$.

11:Assumes that $t_{CP} \leq t_{CP(max)}$ and $t_{ASC} \geq t_{ASC(max)}$.

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

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

(T_a=0~70°C, V_{CC} = 5V±10%, V_{SS}=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	
t_{REF}	Refresh cycle time			16.4		16.4		16.4	ms
t_{REF}	Refresh cycle time *			128		128		128	ms
t_{RP}	$\overline{RAS}$ high pulse width		30		40		50		ns
t_{RCD}	Delay time, $\overline{RAS}$ low to $\overline{CAS}$ low	(Note 15)	18	37	20	45	20	50	ns
t_{CRP}	Delay time, $\overline{CAS}$ high to $\overline{RAS}$ low		5		5		5		ns
t_{RPC}	Delay time, $\overline{RAS}$ high to $\overline{CAS}$ low		0		0		0		ns
t_{CPN}	$\overline{CAS}$ high pulse width		10		10		10		ns
t_{RAD}	Column address delay time from $\overline{RAS}$ low	(Note 16)	13	25	15	30	15	35	ns
t_{ASR}	Row address setup time before $\overline{RAS}$ low		0		0		0		ns
t_{ASC}	Column address setup time before $\overline{CAS}$ low	(Note 17)	0	7	0	10	0	10	ns
t_{RAH}	Row address hold time after $\overline{RAS}$ low		8		10		10		ns
t_{CAH}	Column address hold time after $\overline{CAS}$ low		13		15		15		ns
t_{DZC}	Delay time, data to $\overline{CAS}$ low	(Note 18)	0		0		0		ns
t_{DZO}	Delay time, data to $\overline{OE}$ low	(Note 18)	0		0		0		ns
t_{CDD}	Delay time, $\overline{CAS}$ high to data	(Note 19)	13		15		20		ns
t_{ODD}	Delay time, $\overline{OE}$ high to data	(Note 19)	13		15		20		ns
t_T	Transition time	(Note 20)	1	50	1	50	1	50	ns

Note 13: The timing requirements are assumed t_T=5ns.
14: $V_{IH(min)}$ and $V_{IL(max)}$ are reference levels for measuring timing of input signals.
15: $t_{RCD(max)}$ is specified as a reference point only. If t_{RCD} is less than $t_{RCD(max)}$, access time is t_{RAC}. If t_{RCD} is greater than $t_{RCD(max)}$, access time is controlled exclusively by t_{CAC} or t_{AA}.
16: $t_{RAD(max)}$ is specified as a reference point only. If $t_{RAD} \geq t_{RAD(max)}$ and $t_{ASC} \leq t_{ASC(max)}$, access time is controlled exclusively by t_{AA}.
17: $t_{ASC(max)}$ is specified as a reference point only. If $t_{RCD} \geq t_{RCD(max)}$ and $t_{ASC} \geq t_{ASC(max)}$, 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 $V_{IH(min)}$ and $V_{IL(max)}$.

Read and Refresh Cycles

Symbol	Parameter		Limits						Unit
			M5M44800C-5,-5S		M5M44800C-6,-6S		M5M44800C-7,-7S		
			Min	Max	Min	Max	Min	Max	
t_{RC}	Read cycle time		90		110		130		ns
t_{RAS}	$\overline{RAS}$ low pulse width		50	10000	60	10000	70	10000	ns
t_{CAS}	$\overline{CAS}$ low pulse width		13	10000	15	10000	20	10000	ns
t_{CSH}	$\overline{CAS}$ hold time after $\overline{RAS}$ low		50		60		70		ns
t_{RSH}	$\overline{RAS}$ hold time after $\overline{CAS}$ low		13		15		20		ns
t_{RCS}	Read Setup time before $\overline{CAS}$ low		0		0		0		ns
t_{RCH}	Read hold time after $\overline{CAS}$ high	(Note 21)	0		0		0		ns
t_{RRH}	Read hold time after $\overline{RAS}$ high	(Note 21)	0		0		0		ns
t_{RAL}	Column address to $\overline{RAS}$ hold time		25		30		35		ns
t_{OCH}	$\overline{CAS}$ hold time after $\overline{OE}$ low		13		15		20		ns
t_{ORH}	$\overline{RAS}$ hold time after $\overline{OE}$ low		13		15		20		ns

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

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	
t_{WC}	Write cycle time	90		110		130		ns
t_{RAS}	$\overline{RAS}$ low pulse width	50	10000	60	10000	70	10000	ns
t_{CAS}	$\overline{CAS}$ low pulse width	13	10000	15	10000	20	10000	ns
t_{CSH}	$\overline{CAS}$ hold time after $\overline{RAS}$ low	50		60		70		ns
t_{RSH}	$\overline{RAS}$ hold time after $\overline{CAS}$ low	13		15		20		ns
t_{WCS}	Write setup time before $\overline{CAS}$ low (Note 23)	0		0		0		ns
t_{WCH}	Write hold time after $\overline{CAS}$ low	8		10		15		ns
t_{CWL}	$\overline{CAS}$ hold time after $\overline{W}$ low	13		15		20		ns
t_{RWL}	$\overline{RAS}$ hold time after $\overline{W}$ low	13		15		20		ns
t_{WP}	Write pulse width	8		10		15		ns
t_{DS}	Data setup time before $\overline{CAS}$ low or $\overline{W}$ low	0		0		0		ns
t_{DH}	Data hold time after $\overline{CAS}$ low or $\overline{W}$ low	8		10		15		ns
t_{OEH}	$\overline{OE}$ hold time after $\overline{W}$ 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	
t_{RWC}	Read write/read modify write cycle time (Note 22)	126		150		180		ns
t_{RAS}	$\overline{RAS}$ low pulse width	86	10000	100	10000	120	10000	ns
t_{CAS}	$\overline{CAS}$ low pulse width	49	10000	55	10000	70	10000	ns
t_{CSH}	$\overline{CAS}$ hold time after $\overline{RAS}$ low	86		100		120		ns
t_{RSH}	$\overline{RAS}$ hold time after $\overline{CAS}$ low	49		55		70		ns
t_{RCS}	Read setup time before $\overline{CAS}$ low	0		0		0		ns
t_{CWD}	Delay time, $\overline{CAS}$ low to $\overline{W}$ low (Note 23)	31		35		45		ns
t_{RWD}	Delay time, $\overline{RAS}$ low to $\overline{W}$ low (Note 23)	68		80		95		ns
t_{AWD}	Delay time, address to $\overline{W}$ low (Note 23)	43		50		60		ns
t_{CWL}	$\overline{CAS}$ hold time after $\overline{W}$ low	13		15		20		ns
t_{RWL}	$\overline{RAS}$ hold time after $\overline{W}$ low	13		15		20		ns
t_{WP}	Write pulse width	8		10		15		ns
t_{DS}	Data setup time before $\overline{CAS}$ low or $\overline{W}$ low	0		0		0		ns
t_{DH}	Data hold time after $\overline{CAS}$ low or $\overline{W}$ low	8		10		15		ns
t_{OEH}	$\overline{OE}$ hold time after $\overline{W}$ low	13		15		20		ns

Note 22: t_{RWC} is specified as $t_{RWC(min)}=t_{RAC(max)}+t_{ODD(min)}+t_{RWL(min)}+t_{RP(min)}+4t_T$.

23: t_{WCS}, t_{CWD}, t_{RWD} and t_{AWD} and, t_{CPWD} are specified as reference points only. If $t_{WCS} \geq t_{WCS(min)}$ the cycle is an early write cycle and the DQ pins will remain high impedance throughout the entire cycle. If $t_{CWD} \geq t_{CWD(min)}$, $t_{RWD} \geq t_{RWD(min)}$, $t_{AWD} \geq t_{AWD(min)}$ and $t_{CPWD} \geq t_{CPWD(min)}$ (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 $\overline{CAS}$ or $\overline{OE}$ goes back to V_{IH}) is indeterminate.

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	
t_{PC}	Fast page mode read/write cycle time	35		40		45		ns
t_{PRWC}	Fast page mode read write/read modify write cycle time	71		80		95		ns
t_{RAS}	$\overline{RAS}$ low pulse width for read or write cycle (Note 25)	85	100000	100	100000	115	100000	ns
t_{CP}	$\overline{CAS}$ high pulse width (Note 26)	8	12	10	15	10	15	ns
t_{CPRH}	$\overline{RAS}$ hold time after $\overline{CAS}$ precharge	30		35		40		ns
t_{CPWD}	Delay time, $\overline{CAS}$ precharge to $\overline{W}$ 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: $t_{RAS(min)}$ is specified as two cycles of $\overline{CAS}$ input are performed.
26: $t_{CP(max)}$ is specified as a reference point only.

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

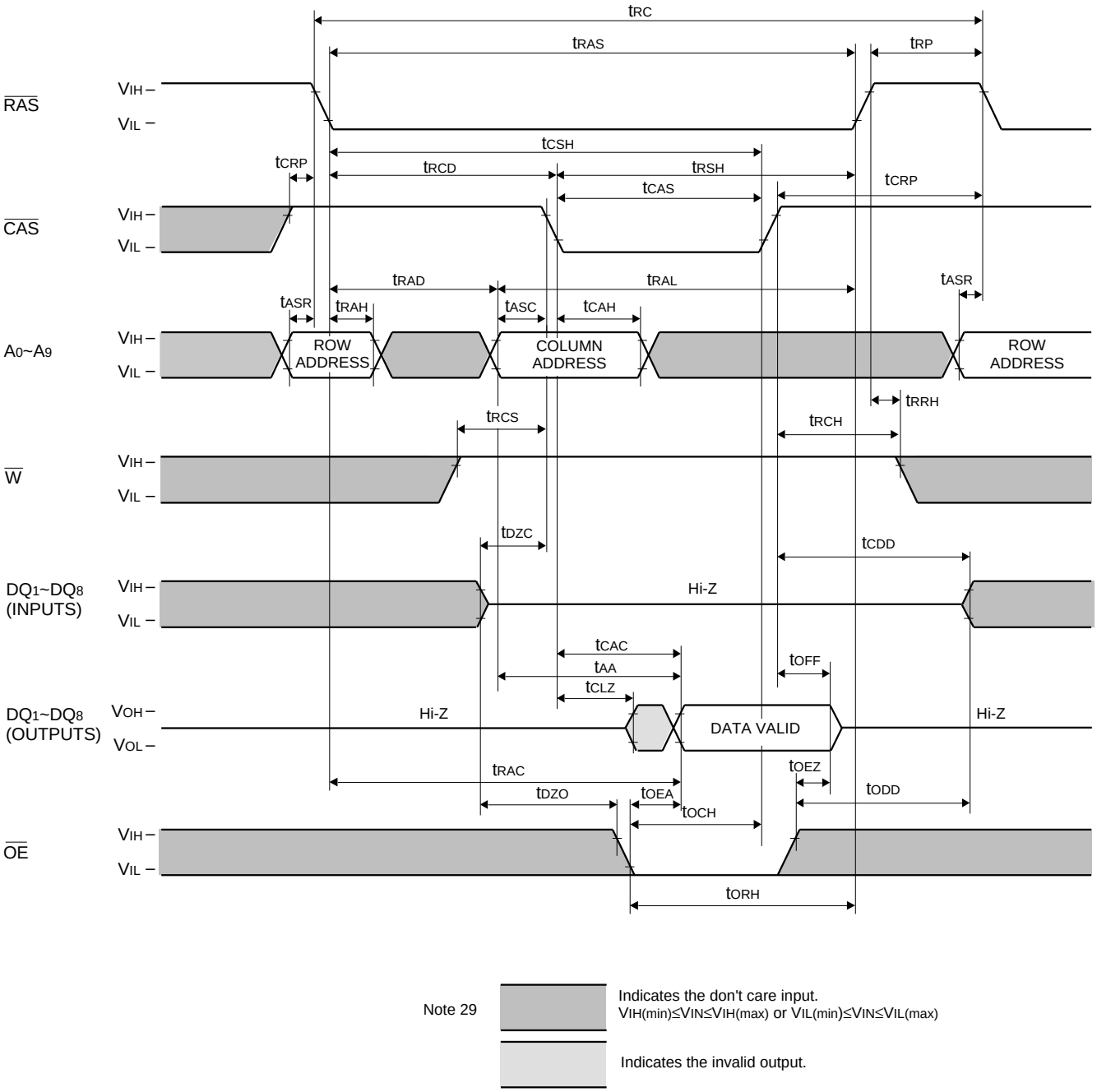
Symbol	Parameter	Limits						Unit
		M5M44800C-5,-5S		M5M44800C-6,-6S		M5M44800C-7,-7S		
		Min	Max	Min	Max	Min	Max	
t_{CSR}	$\overline{CAS}$ setup time before $\overline{RAS}$ low	5		5		5		ns
t_{CHR}	$\overline{CAS}$ hold time after $\overline{RAS}$ low	10		10		15		ns
t_{CAS}	$\overline{CAS}$ low pulse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

Note 27: Eight or more $\overline{CAS}$ before $\overline{RAS}$ cycles instead of eight $\overline{RAS}$ cycles are necessary for proper operation of $\overline{CAS}$ before $\overline{RAS}$ 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	
t_{RASS}	CBR self refresh $\overline{RAS}$ low pulse width	100		100		100		µs
t_{RPS}	CBR self refresh $\overline{RAS}$ high precharge time	90		110		130		ns
t_{CHS}	CBR self refresh $\overline{CAS}$ hold time	-50		-50		-50		ns

Timing Diagrams (Note 29)
Read Cycle

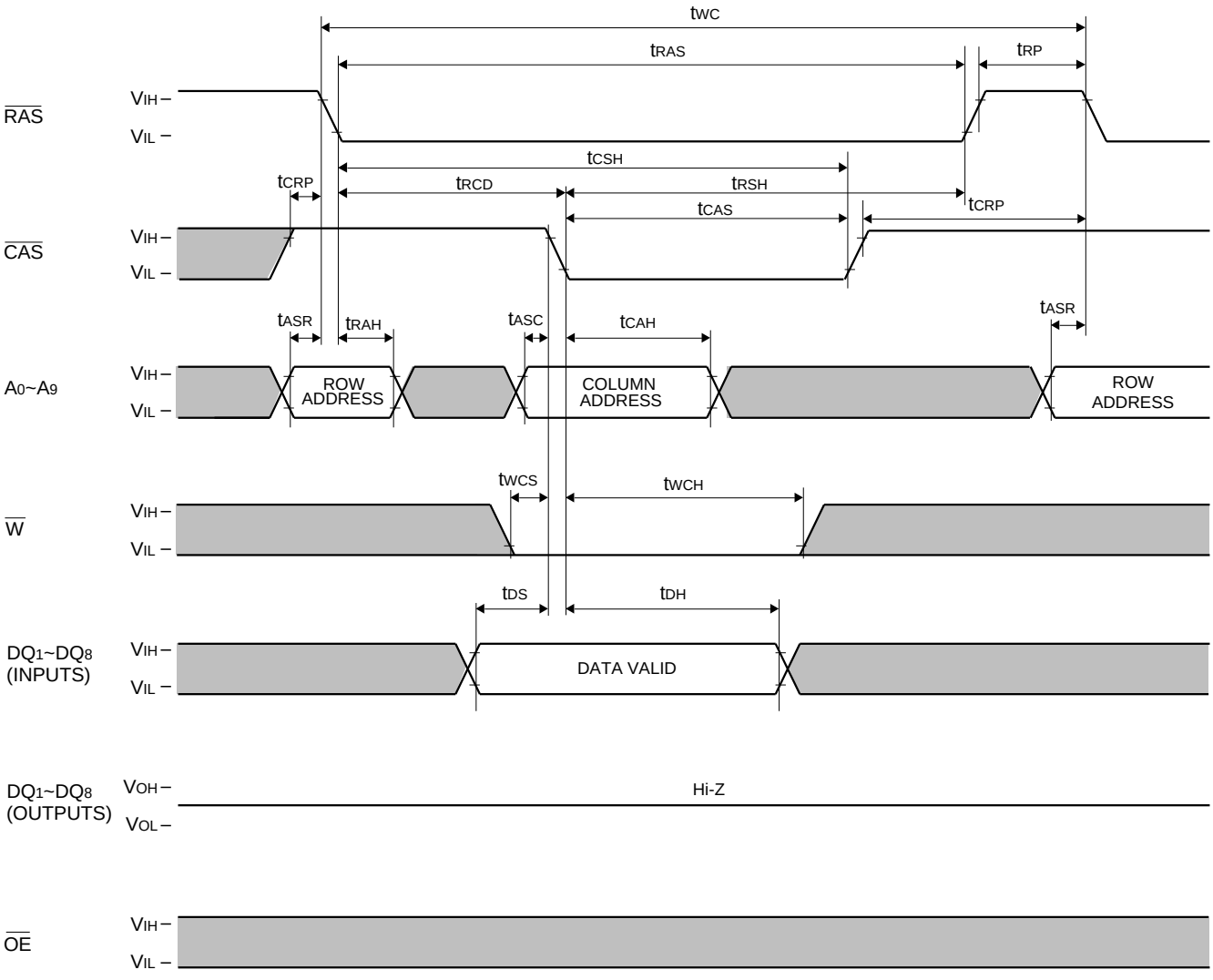


Note 29

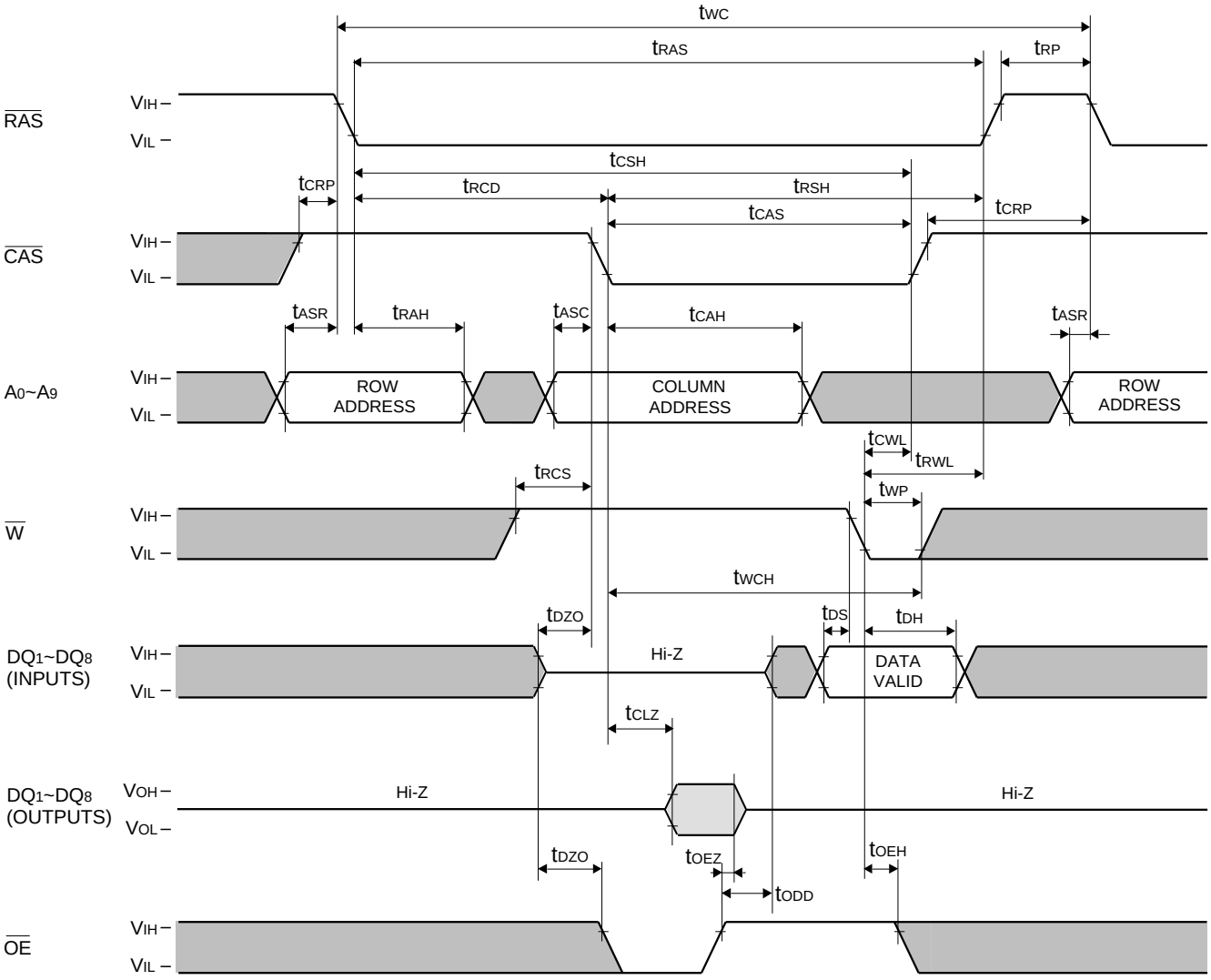
Indicates the don't care input.
$V_{IH(min)} \leq V_{IN} \leq V_{IH(max)}$ or $V_{IL(min)} \leq V_{IN} \leq V_{IL(max)}$

Indicates the invalid output.

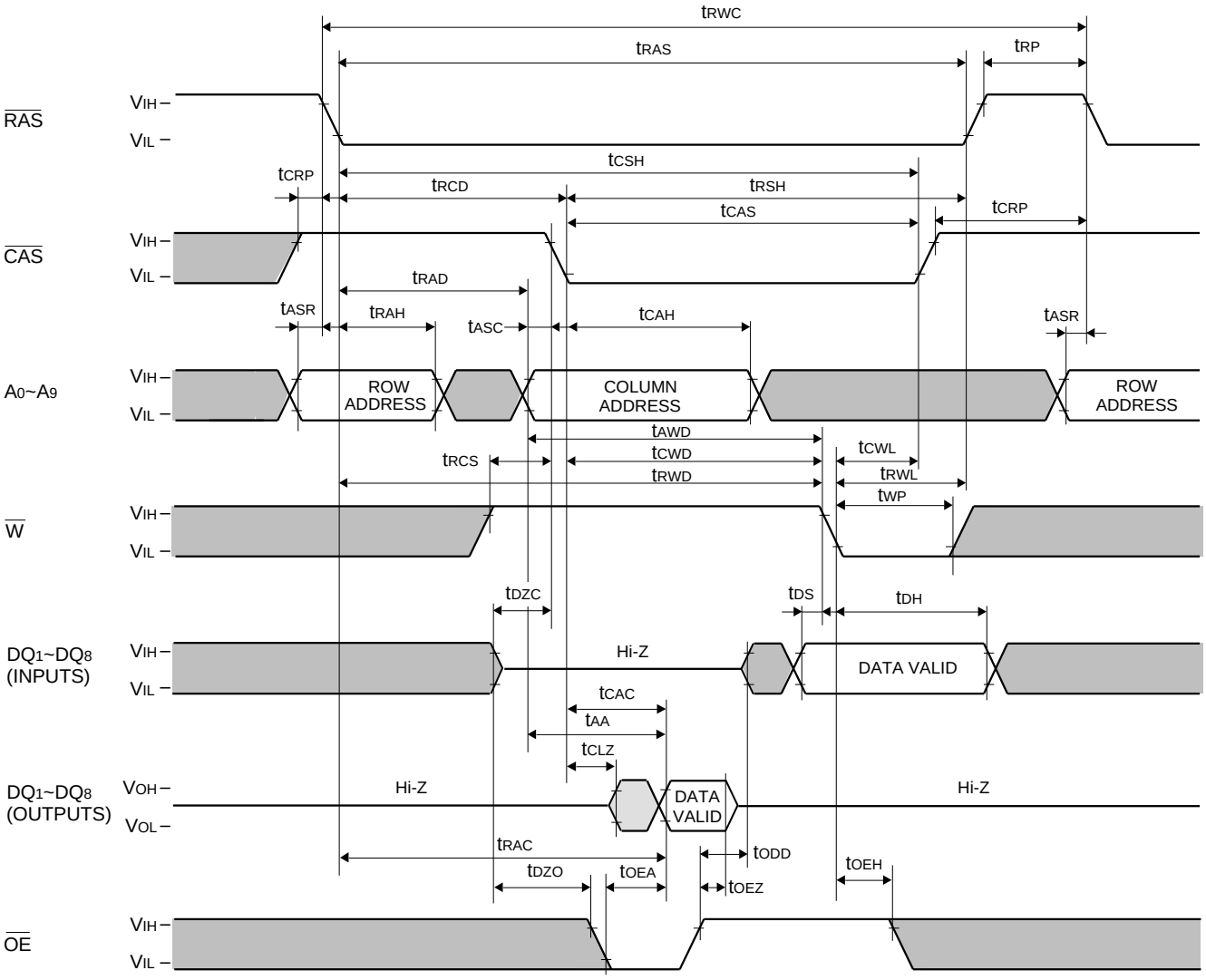
Write Cycle (Early write)



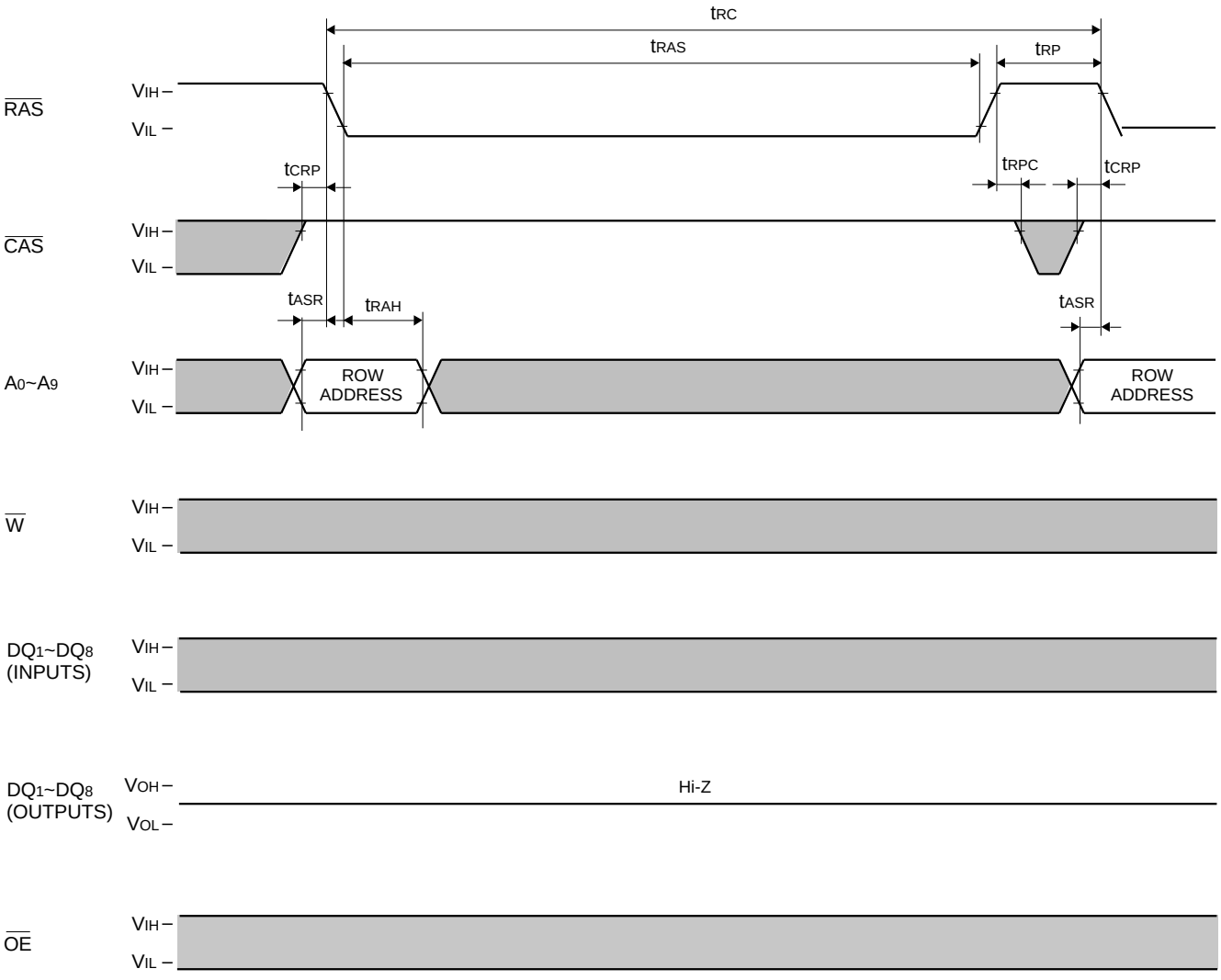
Write Cycle (Delayed write)



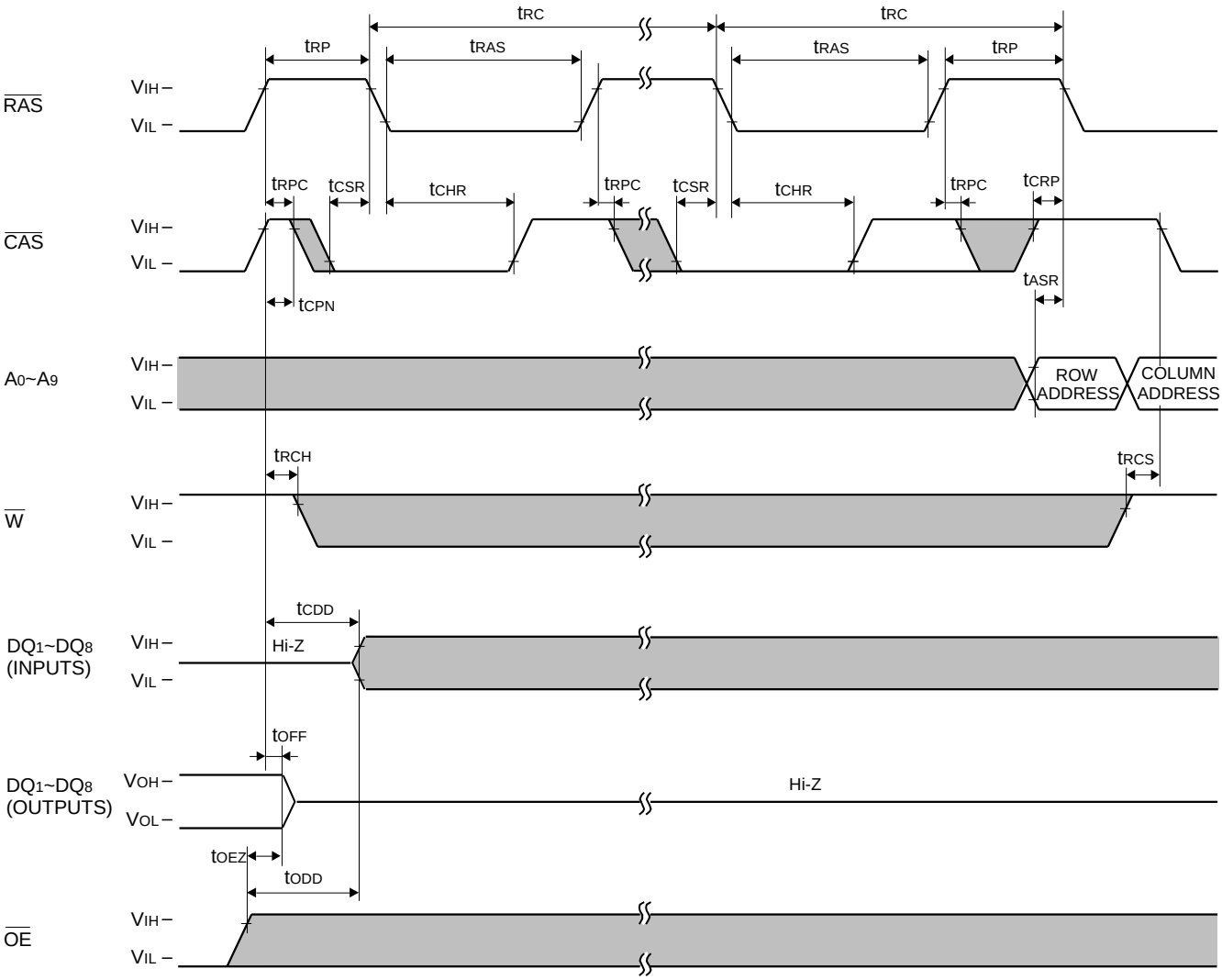
Read-Write, Read-Modify-Write Cycle



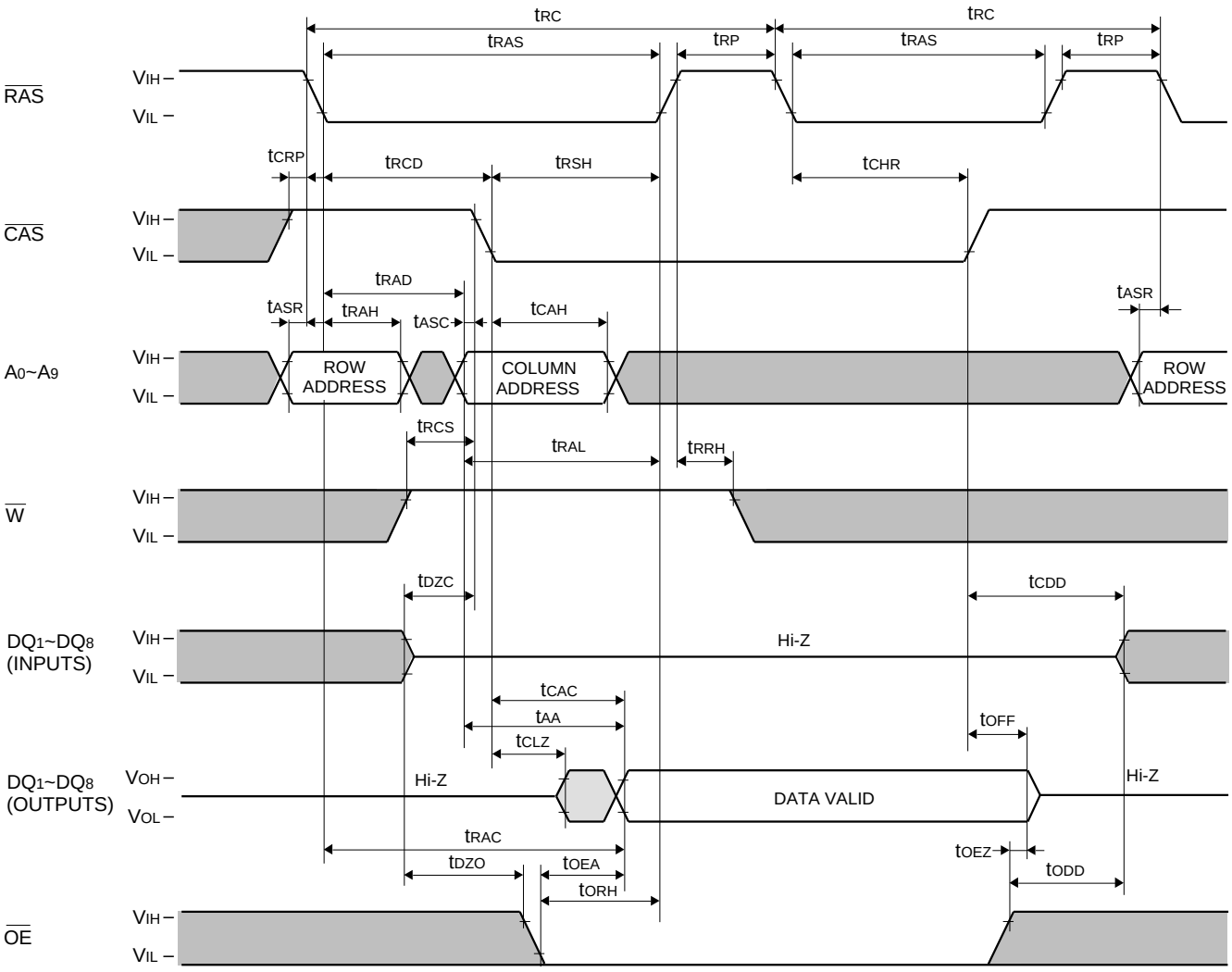
$\overline{RAS}$-only Refresh Cycle



$\overline{CAS}$ before $\overline{RAS}$ Refresh Cycle, Extended Refresh Cycle *

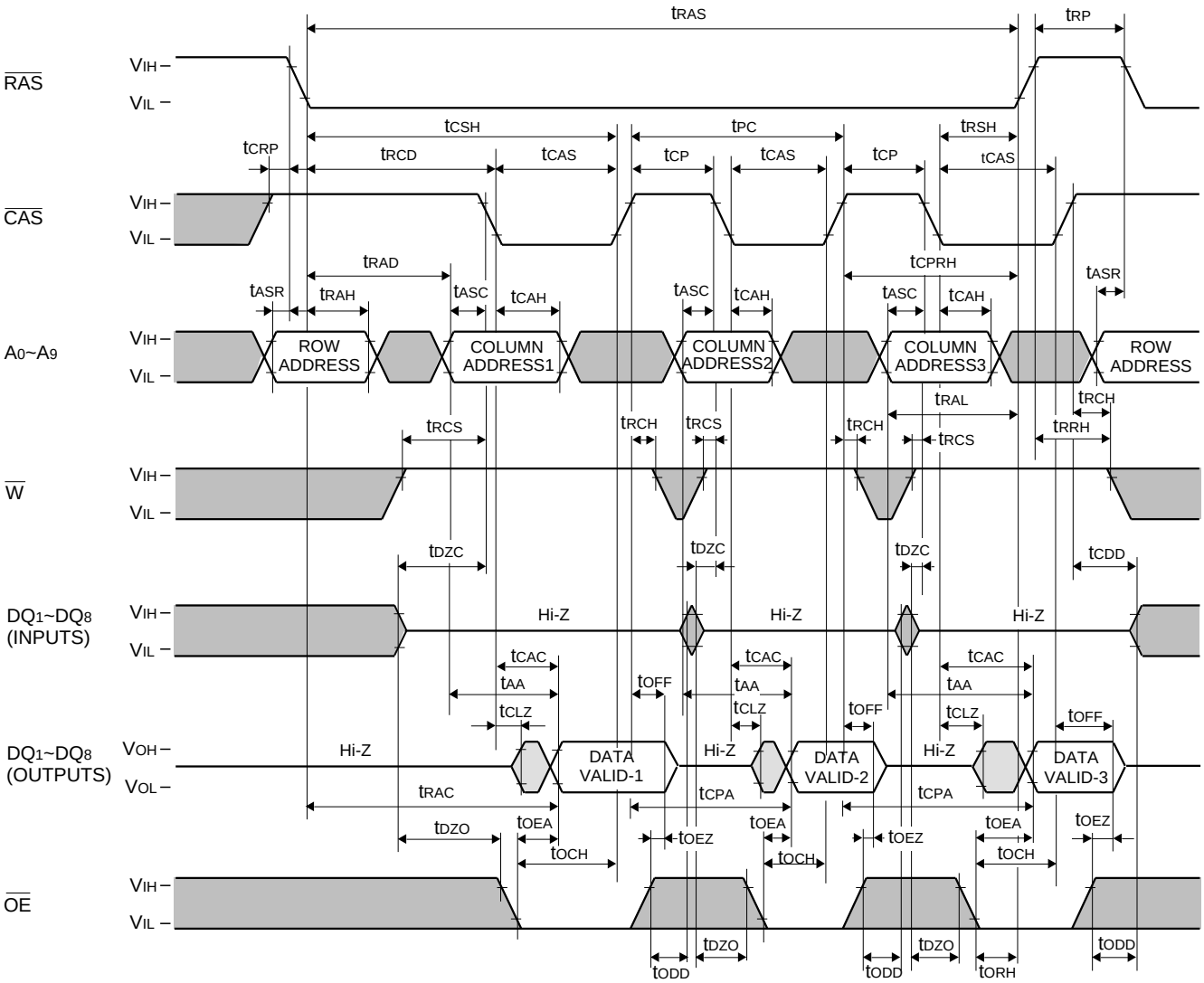


Hidden Refresh Cycle (Read) (Note 30)

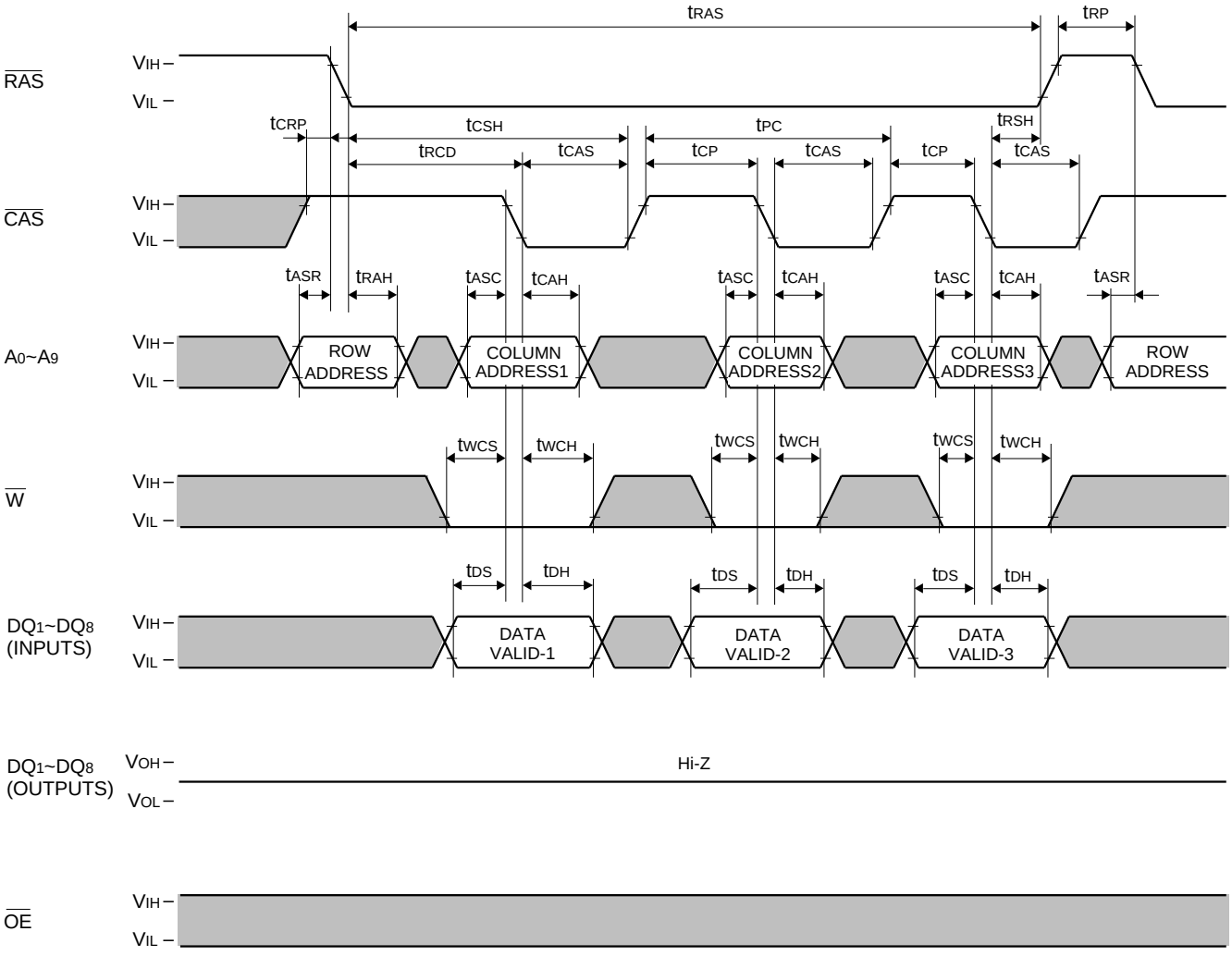


Note 30: Early write, delayed write, read write or read modify write cycle is applicable instead of read cycle.
Timing requirements and output state are the same as that of each cycle described above.

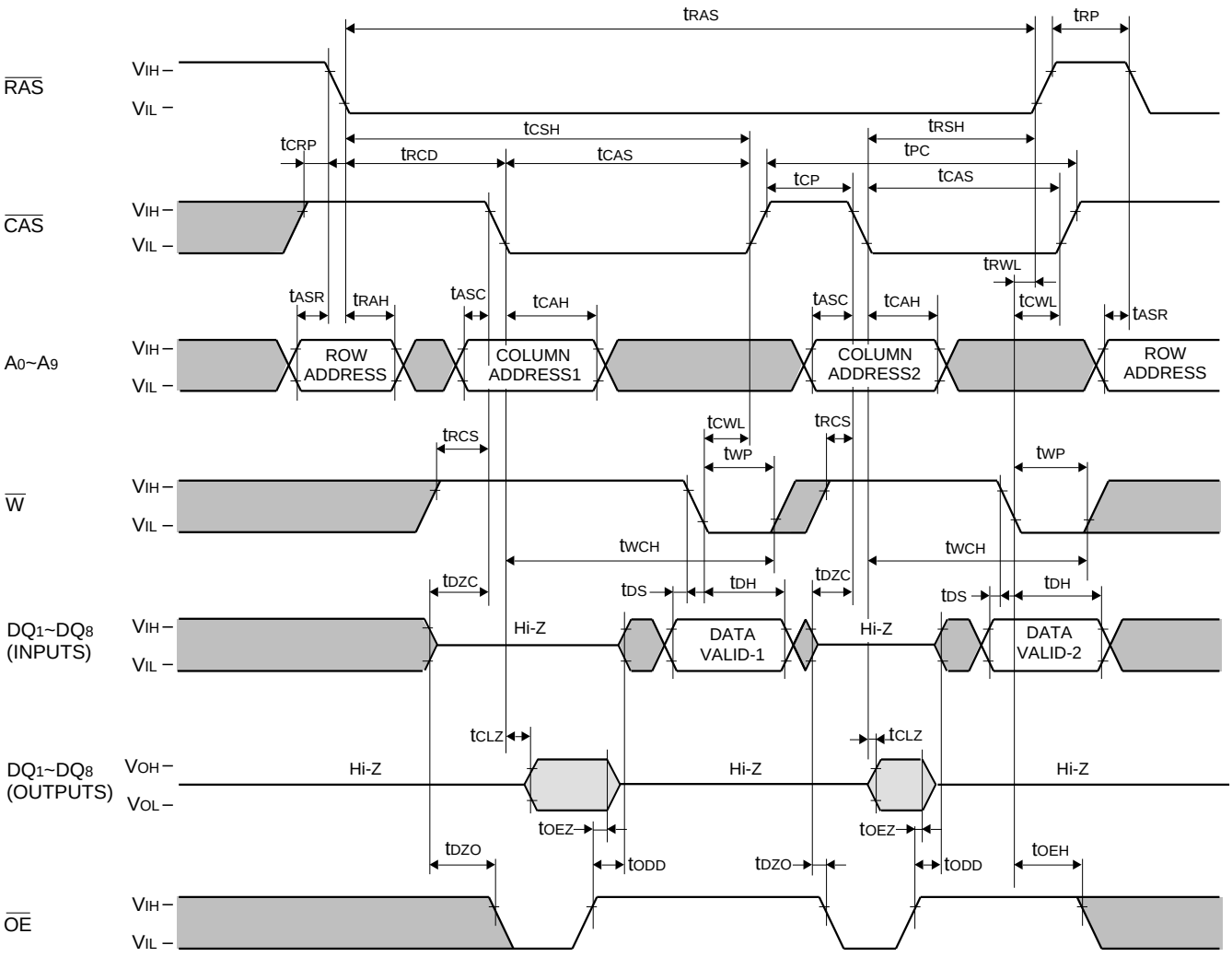
Fast Page Mode Read Cycle



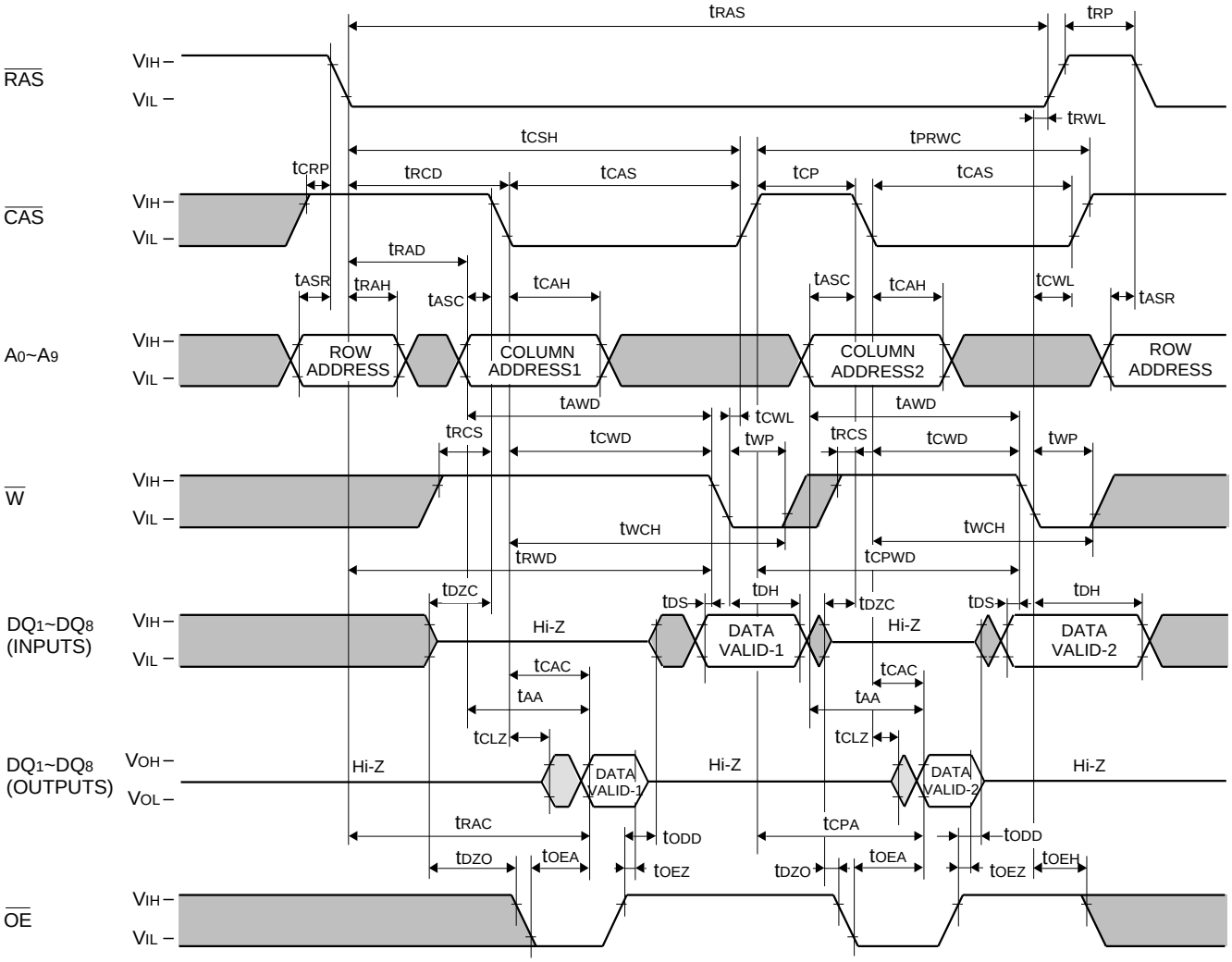
Fast Page Mode Write Cycle (Early Write)



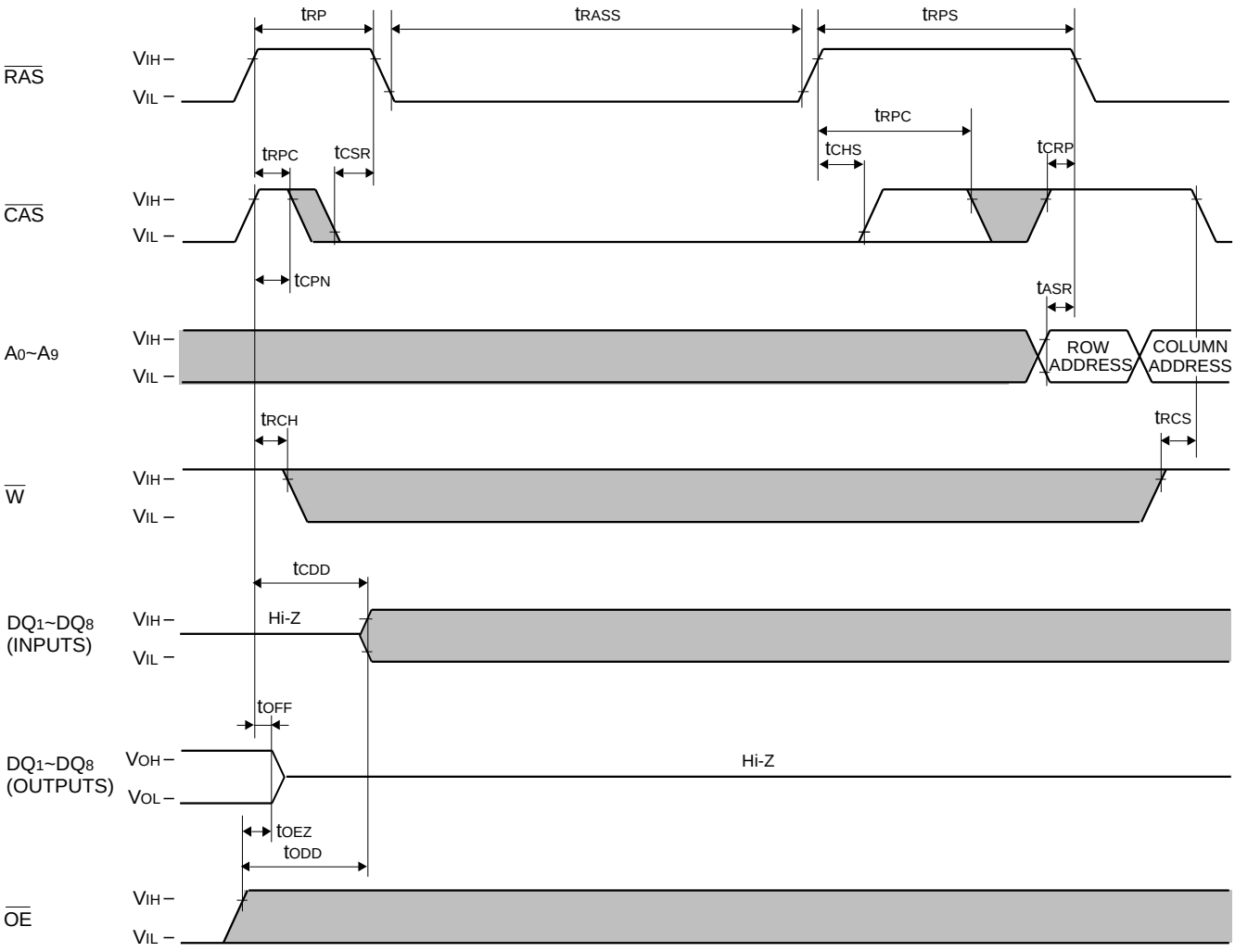
Fast-Page Mode Write Cycle (Delayed Write)



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



Self Refresh Cycle * (Note 28)



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

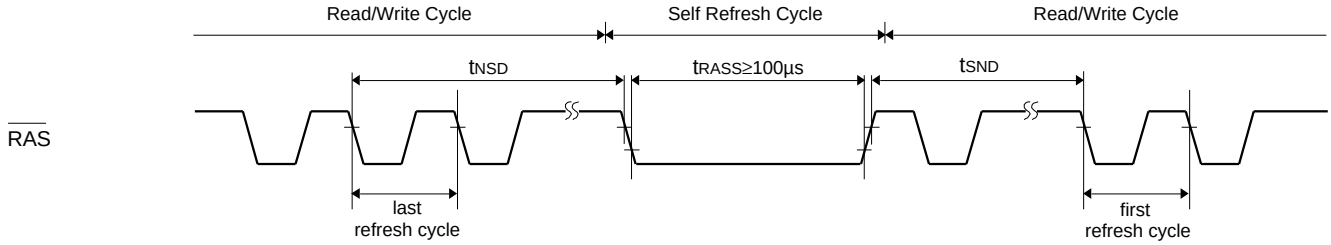
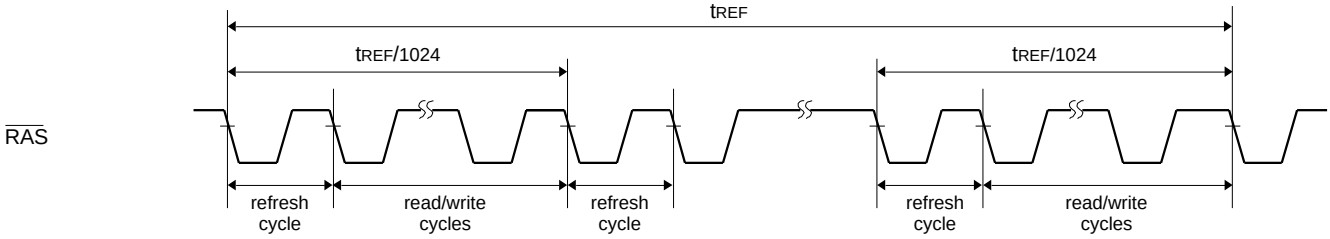


Table 2

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.

2. Burst refresh during Read/Write operation

(A) Timing diagram

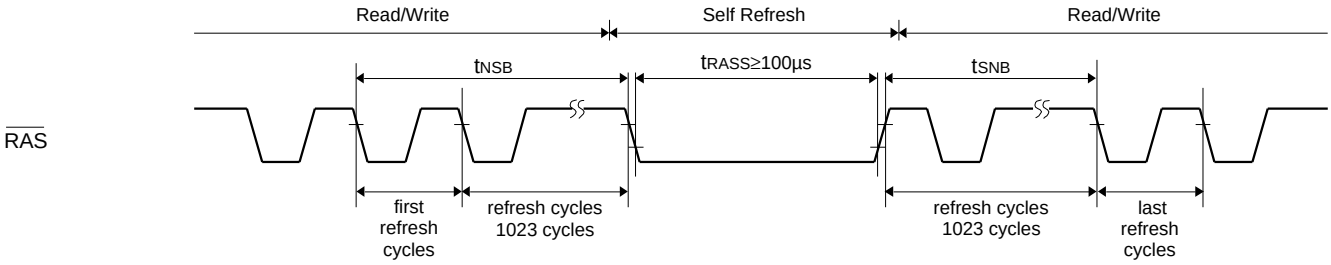
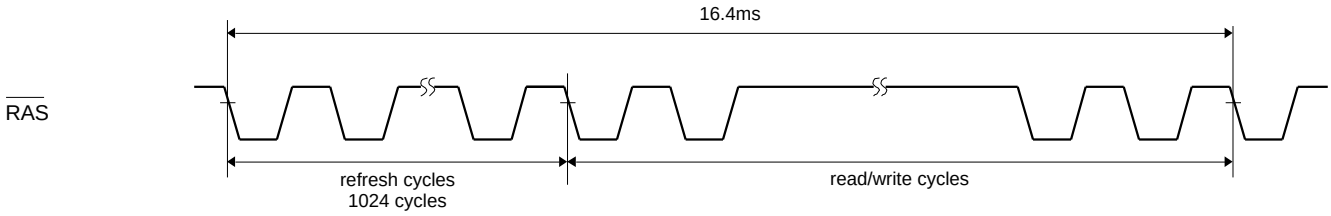


Table 3

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).