M5M416400CJ,TP-5,-6,-7, -5S,-6S,-7S

FAST PAGE MODE 16777216-BIT (4194304-WORD BY 4-BIT) DYNAMIC RAM

DESCRIPTION

This is a family of 4194304-word by 4-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 metal process combined with twin-well CMOS 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.

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 dissipa-tion (typ.mW)
M5M416400CXX-5,-5S	50	13	25	13	90	495
M5M416400CXX-6,-6S	60	15	30	15	110	405
M5M416400CXX-7,-7S	70	20	35	20	130	340

XX=J, TP

- Standard 26 pin SOJ, 26 pin TSOP
- Single 5V ± 10% supply
- Low stand-by power dissipation
  5.5mW (Max).....CMOS Input level
  2.2mW (Max).....CMOS Input level
- Low operating power dissipation
  M5M416400Cxx-5,-5S..... 605.0mW (Max)
  M5M416400Cxx-6,-6S..... 495.0mW (Max)
  M5M416400Cxx-7,-7S..... 415.0mW (Max)
- Self refresh capability *
  self refresh current..... 200.0 μA (Max)
- Fast-page mode, Read-modify-write, $\overline{RAS}$-only refresh
- $\overline{CAS}$ before $\overline{RAS}$ refresh, Hidden refresh capabilities
  Early-write mode and $\overline{OE}$ to control output buffer impedance
- All inputs, output TTL compatible and low capacitance
- 4096 refresh cycles every 64ms (A_0 ~ A_{11})

  * Applicable to self refresh version (M5M416400CJ,TP-5S,-6S, -7S:option) only

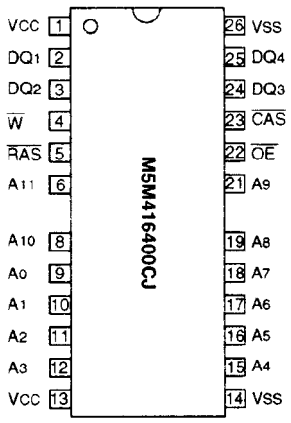
APPLICATION

Main memory unit for computers, Microcomputer memory, Refresh memory for CRT

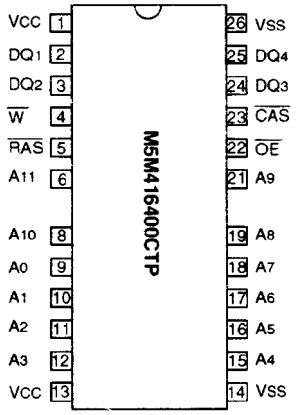
PIN DESCRIPTION

Pin name	Function
A_0 ~ A_{11}	Address inputs
DQ_1 ~ DQ_4	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
V_{CC}	Power supply (+5V)
V_{SS}	Ground (0V)

PIN CONFIGURATION (TOP VIEW)



Outline 26POD-B (300mil SOJ)



Outline 26P3D-E (300mil TSOP)

FUNCTION

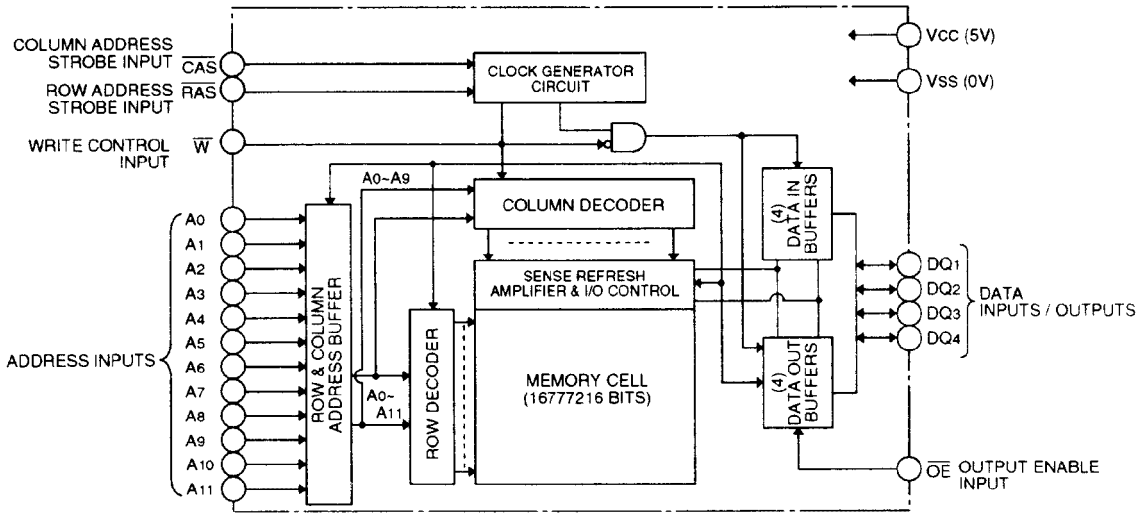
The M5M416400CJ,TP provide, in addition to normal read, write, and read-modify-write operations, a number of other functions, e.g., fast page mode, $\overline{RAS}$-only refresh, and delayed-write. The input conditions for each are shown in Table 1.

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	NAC	ACT	APD	DNC	OPN	VLD	YES	
Self refresh	ACT	ACT	NAC	DNC	DNC	DNC	DNC	OPN	YES	
$\overline{CAS}$ before $\overline{RAS}$ refresh	ACT	ACT	NAC	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



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	5.5	V
V_{SS}	Supply voltage	0	0	0	V
V_{IH}	High-level input voltage, all inputs	2.4		5.5	V
V_{IL}	Low-level input voltage, all inputs	-1.0**		0.8	V

Note 1: All voltage values are with respect to V_{SS}

**: V_{IL}(min.) is -2.0V when undershoot width is less than 25ns. (Undershoot 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} = -5.0mA	2.4		V_{CC}	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} ≤5.5V, Other inputs pins = 0V	-10		10	μA
$I_{CC1(AV)}$	Average supply current from V_{CC}, operating (Note 3,4)	M5M416400C-5,-5S	$\overline{RAS}$, $\overline{CAS}$ cycling t_{RC} = t_{WC} = min. output open			110	mA
		M5M416400C-6,-6S				90	
		M5M416400C-7,-7S				75	
I_{CC2}	Supply current from V_{CC}, stand-by (Note 5)		$\overline{RAS}$ = $\overline{CAS}$ = V_{IH}, output open			2	mA
			$\overline{RAS}$ = $\overline{CAS}$ ≥ V_{CC} -0.2V			0.5	
$I_{CC3\ (AV)}$	Average supply current from V_{CC}, refreshing (Note 3)	M5M416400C-5,-5S	$\overline{RAS}$ cycling, $\overline{CAS}$ = V_{IH} t_{RC} = min. output open			110	mA
		M5M416400C-6,-6S				90	
		M5M416400C-7,-7S				75	
$I_{CC4\ (AV)}$	Average supply current from V_{CC}, Fast-Page-Mode (Note 3,4)	M5M416400C-5,-5S	$\overline{RAS}$ = V_{IL}, $\overline{CAS}$ cycling t_{PC} = min. output open			80	mA
		M5M416400C-6,-6S				70	
		M5M416400C-7,-7S				60	
$I_{CC6\ (AV)}$	Average supply current from V_{CC}, $\overline{CAS}$ before $\overline{RAS}$ refresh mode (Note 3)	M5M416400C-5,-5S	$\overline{CAS}$ before $\overline{RAS}$ refresh cycling t_{RC} = min. output open			110	mA
		M5M416100B-6,-6S				90	
		M5M416100B-7,-7S				75	

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.

CAPACITANCE

(Ta = 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	$V_I = V_{SS}$ f = 1MHz V_I = 25mVrms			5	pF
$C_{I(\overline{OE})}$	Input capacitance, $\overline{OE}$ input				7	pF
$C_{I(\overline{W})}$	Input capacitance, write control input				7	pF
$C_{I(\overline{RAS})}$	Input capacitance, $\overline{RAS}$ input				7	pF
$C_{I(\overline{CAS})}$	Input capacitance, $\overline{CAS}$ input				7	pF
$C_{I/O}$	Input/Output capacitance, data ports				8	pF

SWITCHING CHARACTERISTICS

(Ta = 0 ~ 70°C, V_{CC} = 5V ± 10%, V_{SS} = 0V, unless otherwise noted, see notes 5, 12, 13)

Symbol	Parameter		Limits						Unit
			M5M416400C-5,-5S		M5M416400C-6,-6S		M5M416400C-7,-7S		
			Min	Max	Min	Max	Min	Max	
t_{CAC}	Access time from $\overline{CAS}$	(Note 6, 7)		13		15		20	ns
t_{RAC}	Access time from $\overline{RAS}$	(Note 6, 8)		50		60		70	ns
t_{AA}	Column address access time	(Note 6, 9)		25		30		35	ns
t_{CPA}	Access time from $\overline{CAS}$ precharge	(Note 6, 10)		30		35		40	ns
t_{OEA}	Access time from $\overline{OE}$	(Note 6)		13		15		20	ns
t_{CLZ}	Output low impedance time from $\overline{CAS}$ low	(Note 6)	5		5		5		ns
t_{OFF}	Output disable time after $\overline{CAS}$ high	(Note 11)	0	13	0	15	0	15	ns
t_{OEZ}	Output disable time after $\overline{OE}$ high	(Note 11)	0	13	0	15	0	15	ns

Note 5: An initial pause of 500 μs is required after power-up followed by a minimum of eight initialization $\overline{RAS}$ cycles. The initialization cycles should be done either by $\overline{RAS}$-only refresh cycles or by $\overline{CAS}$ before $\overline{RAS}$ refresh cycles only.
Note the $\overline{RAS}$ may be cycled during the initial pause. And any 8 $\overline{RAS}$ or $\overline{RAS}/\overline{CAS}$ cycles are required after prolonged periods (greater than 64ms) of $\overline{RAS}$ inactivity before proper device operation is achieved.
After the initialization cycles, $\overline{RAS}$ should be kept either higher than V_{IH}(min) or lower than V_{IL}(max) except $\overline{RAS}$ transition time.

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

7: Assumes that $t_{RCD} \geq t_{RCD(max)}$ and $t_{ASC} \geq t_{ASC(max)}$.

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

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

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

11: $t_{OFF(max)}$ and t_{OEZ} defines the time at which the output achieves the high impedance state ($|_{OUT} \leq | \pm 10 \mu A |$) 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)

(Ta = 0 ~ 70°C, V_{CC} = 5V ± 10%, V_{SS} = 0V, unless otherwise noted, see notes 12, 13)

Symbol	Parameter		Limits						Unit
			M5M416400C-5,-5S		M5M416400C-6,-6S		M5M416400C-7,-7S		
			Min	Max	Min	Max	Min	Max	
t_{REF}	Refresh cycle time			64		64		64	ms
t_{RP}	$\overline{RAS}$ high pulse width		30		40		50		ns
t_{RCD}	Delay time, $\overline{RAS}$ low to $\overline{CAS}$ low	(Note 14)	18	37	20	45	20	50	ns
t_{CRP}	Delay time, $\overline{CAS}$ high to $\overline{RAS}$ low		10		10		10		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 15)	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 16)	0	10	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 17)	0		0		0		ns
t_{DZO}	Delay time, data to $\overline{OE}$ low	(Note 17)	0		0		0		ns
t_{CDD}	Delay time, $\overline{CAS}$ high to data	(Note 18)	13		15		15		ns
t_{ODD}	Delay time, $\overline{OE}$ high to data	(Note 18)	13		15		15		ns
t_T	Transition time	(Note 19)	1	50	1	50	1	50	ns

Note 12: The timing requirements are assumed t_T = 5ns.
13: $V_{IH(min)}$ and $V_{IL(max)}$ are reference levels for measuring timing of input signals.
14: $t_{RCD(max)}$ 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}. $t_{RCD(min)}$ is specified as $t_{RCD(min)} = t_{RAH(min)} + 2t_H + t_{ASC(min)}$.
15: $t_{RAD(max)}$ 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}.
16: $t_{ASC(max)}$ 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 to t_{CAC}.
17: Either t_{DZC} or t_{DZO} must be satisfied.
18: Either t_{CDD} or t_{ODD} must be satisfied.
19: t_T is measured between $V_{IH(min)}$ and $V_{IL(max)}$.

Read and Refresh Cycles

Symbol	Parameter		Limits						Unit
			M5M416400C-5,-5S		M5M416400C-6,-6S		M5M416400C-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 after $\overline{CAS}$ high		0		0		0		ns
t_{RCH}	Read hold time after $\overline{CAS}$ low	(Note 20)	0		0		0		ns
t_{RRH}	Read hold time after $\overline{RAS}$ low	(Note 20)	10		10		10		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 20: Either t_{RCH} or t_{RRH} must be satisfied for a read cycle.

Write Cycle (Early Write and Delayed Write)

Symbol	Parameter	Limits						Unit
		M5M416400C-5,-5S		M5M416400C-6,-6S		M5M416400C-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 22)	0		0		0		ns
t_{WCH}	Write hold time after $\overline{CAS}$ low	8		10		10		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		10		ns
t_{DS}	Data setup time before $\overline{CAS}$ low or $\overline{W}$ low	0		0		0		ns
t_{DH}	Date 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
		M5M416400C-5,-5S		M5M416400C-6,-6S		M5M416400C-7,-7S		
		Min	Max	Min	Max	Min	Max	
t_{RWC}	Read write/read modify write cycle time (Note 21)	131		155		180		ns
t_{RAS}	$\overline{RAS}$ low pulse width	91	10000	105	10000	120	10000	ns
t_{CAS}	$\overline{CAS}$ low pulse width	54	10000	60	10000	70	10000	ns
t_{CSH}	$\overline{CAS}$ hold time after $\overline{RAS}$ low	91		105		120		ns
t_{RSH}	$\overline{RAS}$ hold time after $\overline{CAS}$ low	54		60		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 22)	36		40		45		ns
t_{RWD}	Delay time, $\overline{RAS}$ low to $\overline{W}$ low (Note 22)	73		85		95		ns
t_{AWD}	Delay time, address to $\overline{W}$ low (Note 22)	48		55		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		10		ns
t_{DS}	Data setup time before $\overline{W}$ low	0		0		0		ns
t_{DH}	Data hold time after $\overline{W}$ low	8		10		15		ns
t_{OEH}	$\overline{OE}$ hold time after $\overline{W}$ low	13		15		15		ns

Note 21: t_{RWC} is specified as $t_{RWC(min)} = t_{RAC(max)} + t_{ODD(min)} + t_{RWL(min)} + t_{RP(min)} + 5t_T$.

Note 22: 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 23)

Symbol	Parameter	Limits						Unit
		M5M416400C-5,-5S		M5M416400C-6,-6S		M5M416400C-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	76		85		95		ns
t_{RAS}	$\overline{RAS}$ low pulse width for read write cycle (Note 24)	85	125000	100	125000	115	125000	ns
t_{CP}	$\overline{CAS}$ high pulse width (Note 25)	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 22)	53		60		65		ns

Note 23: All previously specified timing requirements and switching characteristics are applicable to their respective fast page mode cycle.
24: $t_{RAS(min)}$ is specified as two cycles of $\overline{CAS}$ input are performed.
25: $t_{CP(max)}$ is specified as a reference point only.

$\overline{CAS}$ before $\overline{RAS}$ Refresh Cycle

(Note 26)

Symbol	Parameter	Limits						Unit
		M5M416400C-5,-5S		M5M416400C-6,-6S		M5M416400C-7,-7S		
		Min	Max	Min	Max	Min	Max	
t_{CSR}	$\overline{CAS}$ setup time before $\overline{RAS}$ low	10		10		10		ns
t_{CHR}	$\overline{CAS}$ hold time after $\overline{RAS}$ low	10		10		15		ns
t_{RSR}	Read setup time before $\overline{RAS}$ low	10		10		10		ns
t_{RHR}	Read hold time after $\overline{RAS}$ low	10		10		15		ns

Note 26: 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 SPECIFICATIONS

Self refresh devices are denoted by “S” after speed item, like -5S/-6S/-7S. The other characteristics and requirements than the below are same as normal devices.

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	
$I_{CC8(AV)}$	Average supply current from VCC Slow-Refresh cycle (Note 5)	M5M416400C (S)	$\overline{CAS}$ before $\overline{RAS}$ refresh cycling or $\overline{RAS}$ cycling & $\overline{CAS} \leq 0.2V$ $\overline{OE}$ & $\overline{WE} \leq 0.2V$ or $\overline{OE}$ & $\overline{WE} \geq V_{CC}$ - 0.2V A_0 ~ $A_{11} \leq 0.2V$ or A_0 ~ $A_{11} \geq V_{CC}$ - 0.2V t_{REF} = 128ms (4096 cycles) output = OPEN $t_{RAS} = t_{RASmin.}$ ~ 500ns			500	μA
$I_{CC9(AV)}$	Average supply current from VCC Slow-Refresh cycle (Note 5)	M5M416400C (S)	$\overline{RAS}$ = $\overline{CAS} \leq 0.2V$ output = OPEN			200	μA

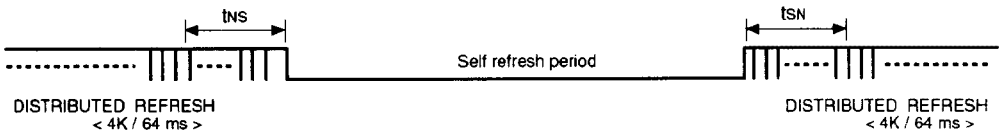
TIMING REQUIREMENTS

(Ta = 0 ~ 70°C, V_{CC} = 5V ± 10%, V_{SS} = 0V, unless otherwise noted, see notes 12, 13)

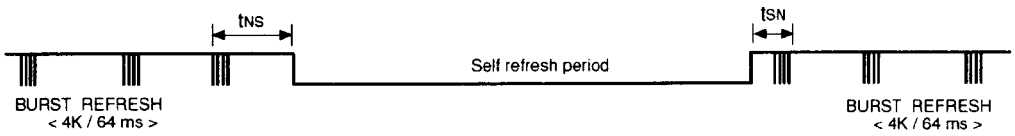
Symbol	Parameter	Limits						Unit
		M5M416400C-5S		M5M416400C-6S		M5M416400C-7S		
		Min	Max	Min	Max	Min	Max	
t_{RASS}	Self Refresh $\overline{RAS}$ low pulse width	100		100		100		µs
t_{RPS}	Self Refresh $\overline{RAS}$ high precharge time	90		110		130		ns
t_{CHS}	Self Refresh $\overline{RAS}$ hold time	-50		-50		-50		ns
t_{RSR}	Read setup time before $\overline{RAS}$ low	10		10		10		ns
t_{RHR}	Read hold time after $\overline{RAS}$ low	10		10		15		ns

SELF REFRESH ENTRY & EXIT CONDITIONS

1. In case of distributed refresh
   The last / first full refresh cycles (4K) must be made within t_{NS} / t_{SN} before / after self refresh, on the condition of $t_{NS} \leq 64$ms and $t_{SN} \leq 64$ms.



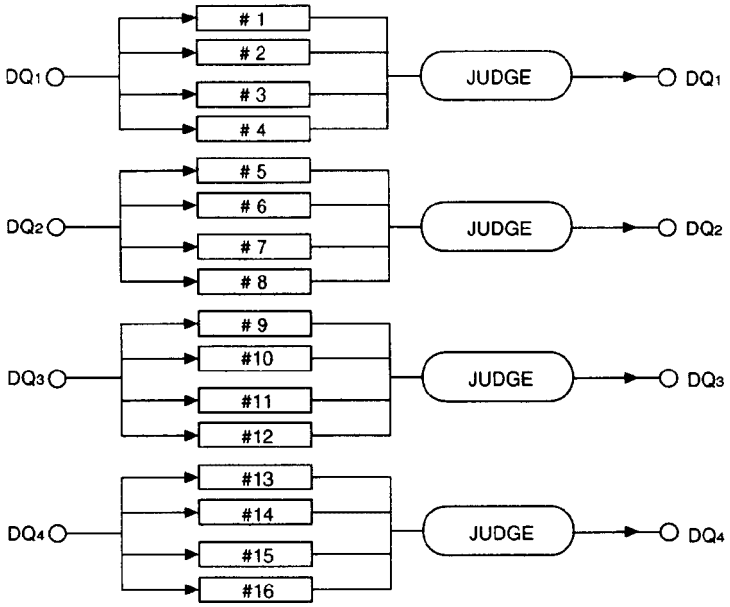
2. In case of burst refresh
   The last / first full refresh cycles (4K) must be made within t_{NS} / t_{SN} before / after self refresh, on the condition of $t_{NS} + t_{SN} \leq 64$ms.



TEST Mode SET Cycle

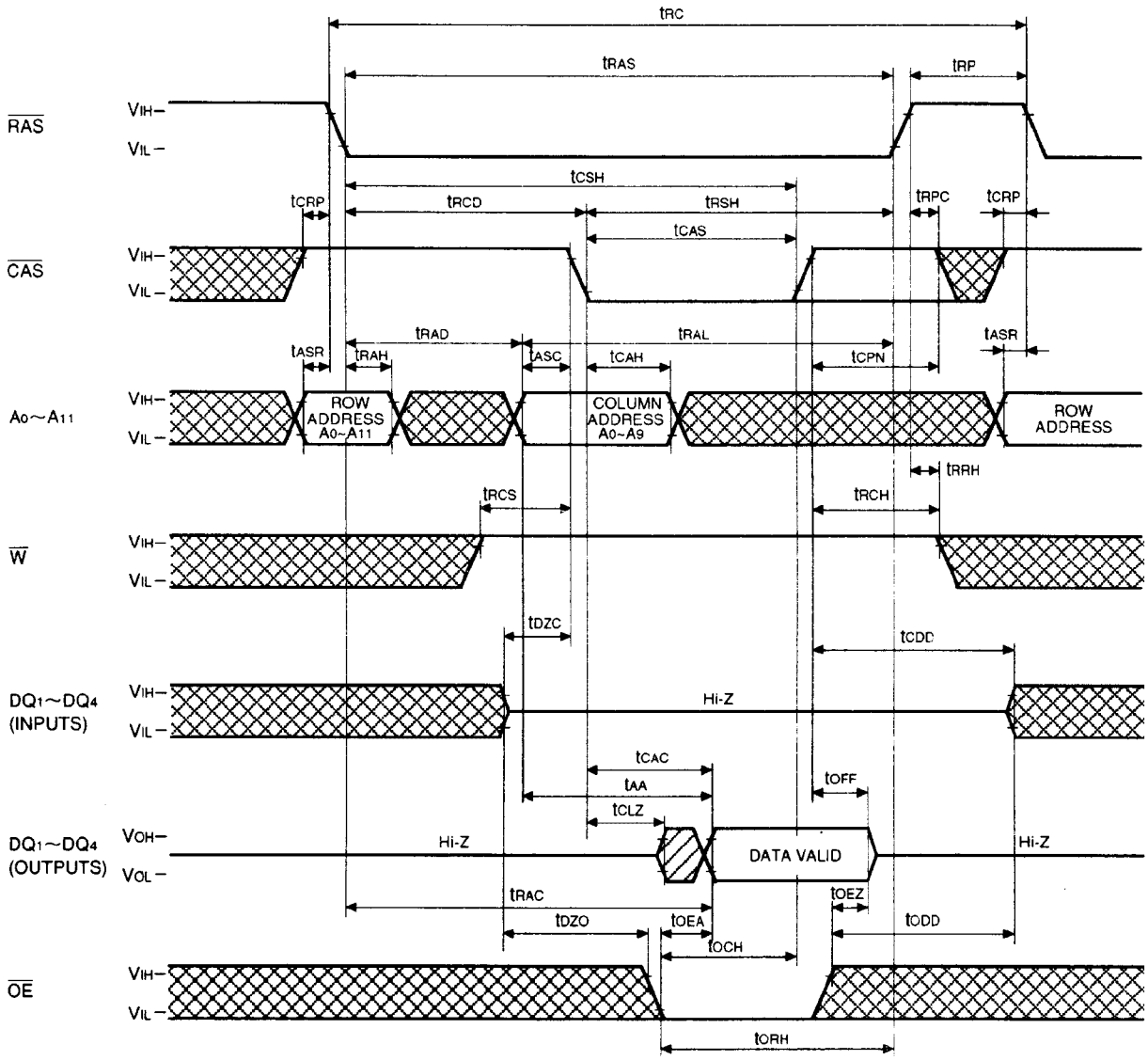
Symbol	Parameter	Limits						Unit
		M5M416400C-5,-5S		M5M416400C-6,-6S		M5M416400C-7,-7S		
		Min	Max	Min	Max	Min	Max	
t_{WSR}	$\overline{W}$ setup time before $\overline{RAS}$ low	10		10		10		ns
t_{WHR}	$\overline{W}$ hold time after $\overline{RAS}$ low	10		10		15		ns

Note 27: The test mode function is initiated by a $\overline{W}$ and $\overline{CAS}$ before $\overline{RAS}$ cycle (WCBR cycle) as specified in timing diagram.
The test mode function is terminated by either a $\overline{CAS}$ before $\overline{RAS}$ refresh cycle (CBR refresh cycle) or a $\overline{RAS}$ only refresh cycle.
During the test mode, the device is internally organized as 16-bits wide (1M bytes depth). No addressing or CA_0, CA_1 is required.
During a write cycle, data must be applied to all DQ (input) pins. The data can be different between DQ pins. The data on each DQ pin is written into 4-bits memory cells, respectively. During a read cycle, each DQ (output) pin shows the test result of the 4-bits, respectively. High state indicates that they are same. Low state indicates that they are not same.
During the test mode operation, only WCBR cycle can be used to perform refresh.



Timing Diagrams Read Cycle

(Note 28)

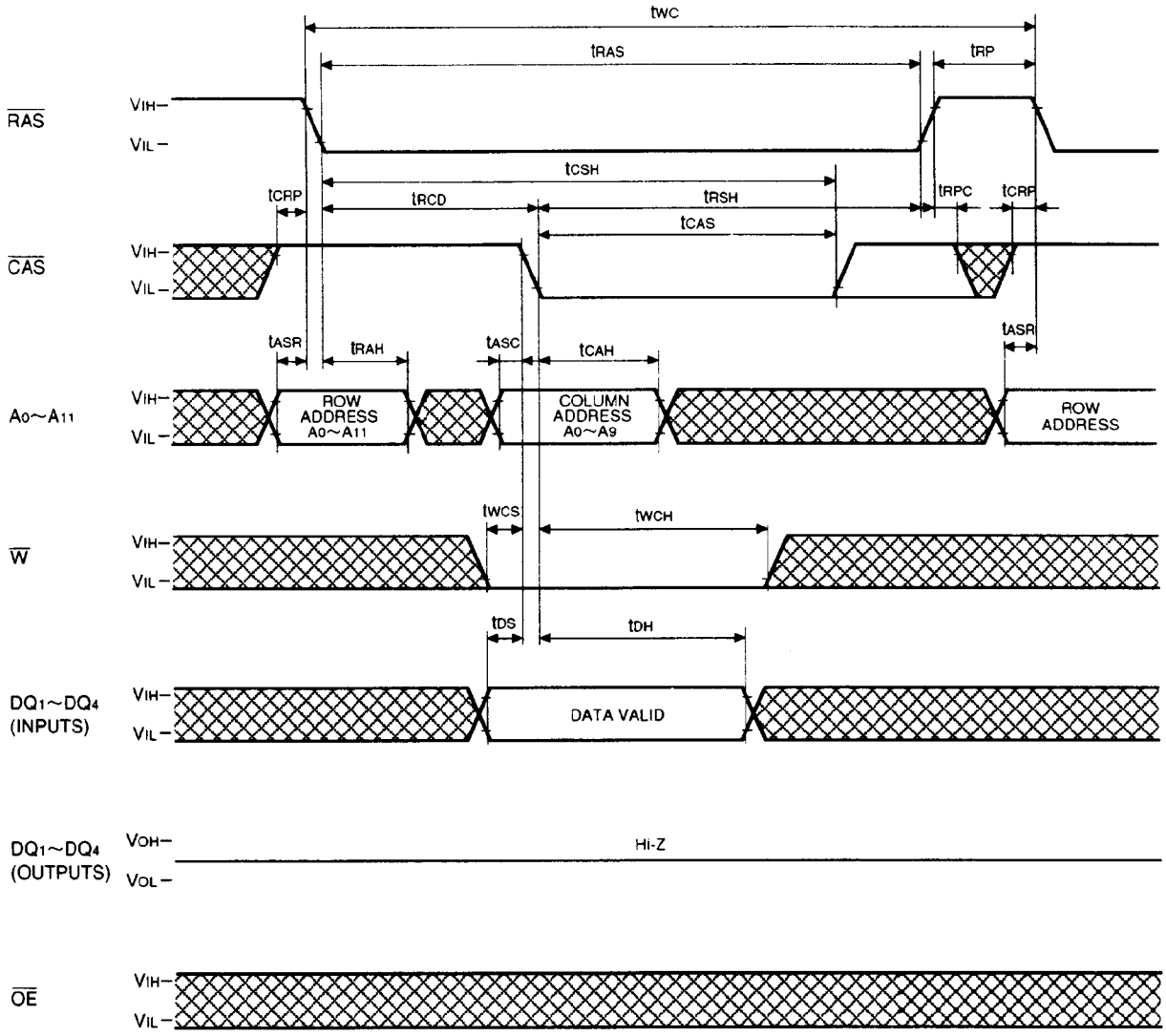


Note 28

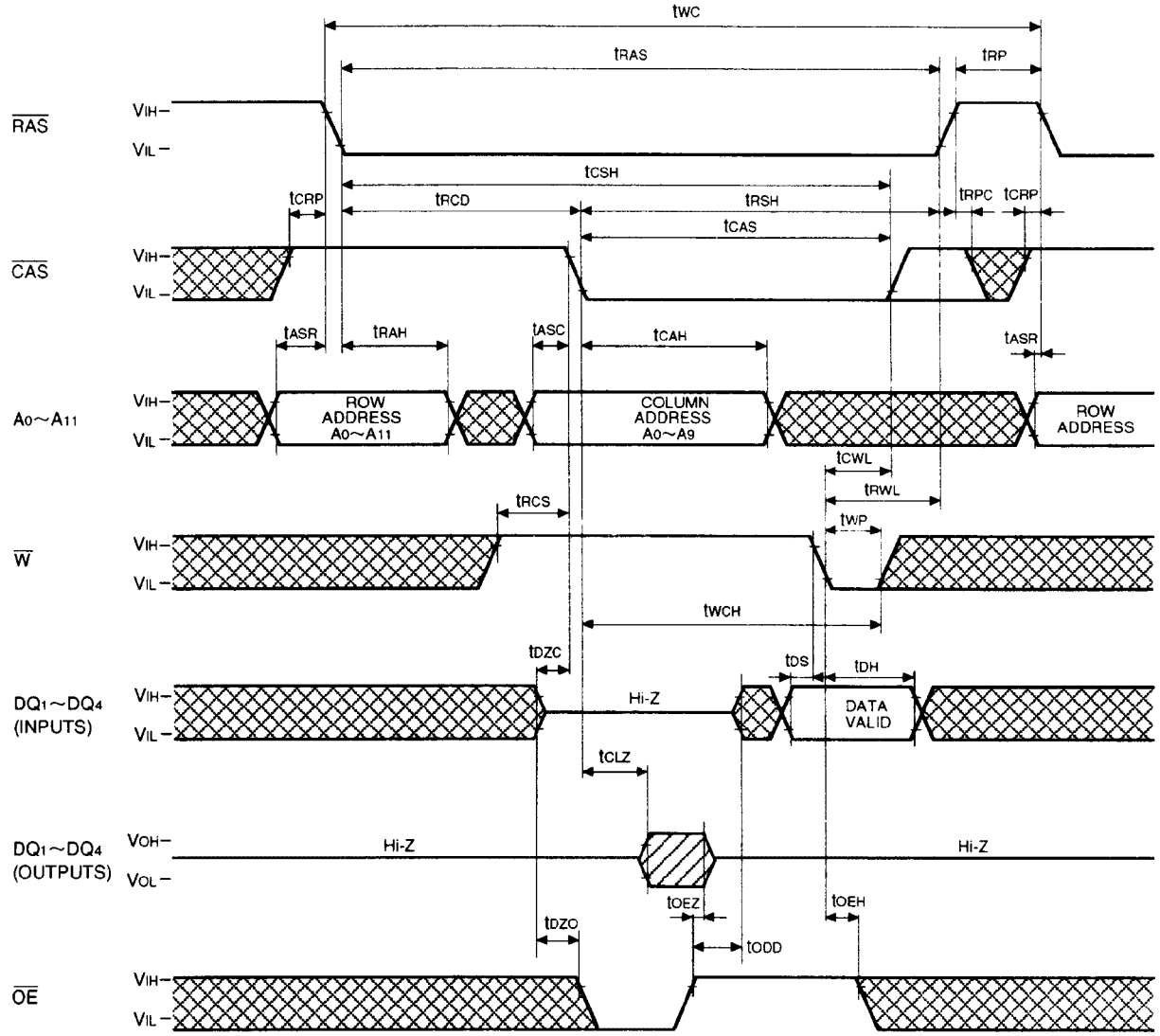
Indicates the don't care input.
VIH(min)≦VIN≦VIH(max) or VIL(min)≦VIN≦VIL(max)

Indicates the invalid output.

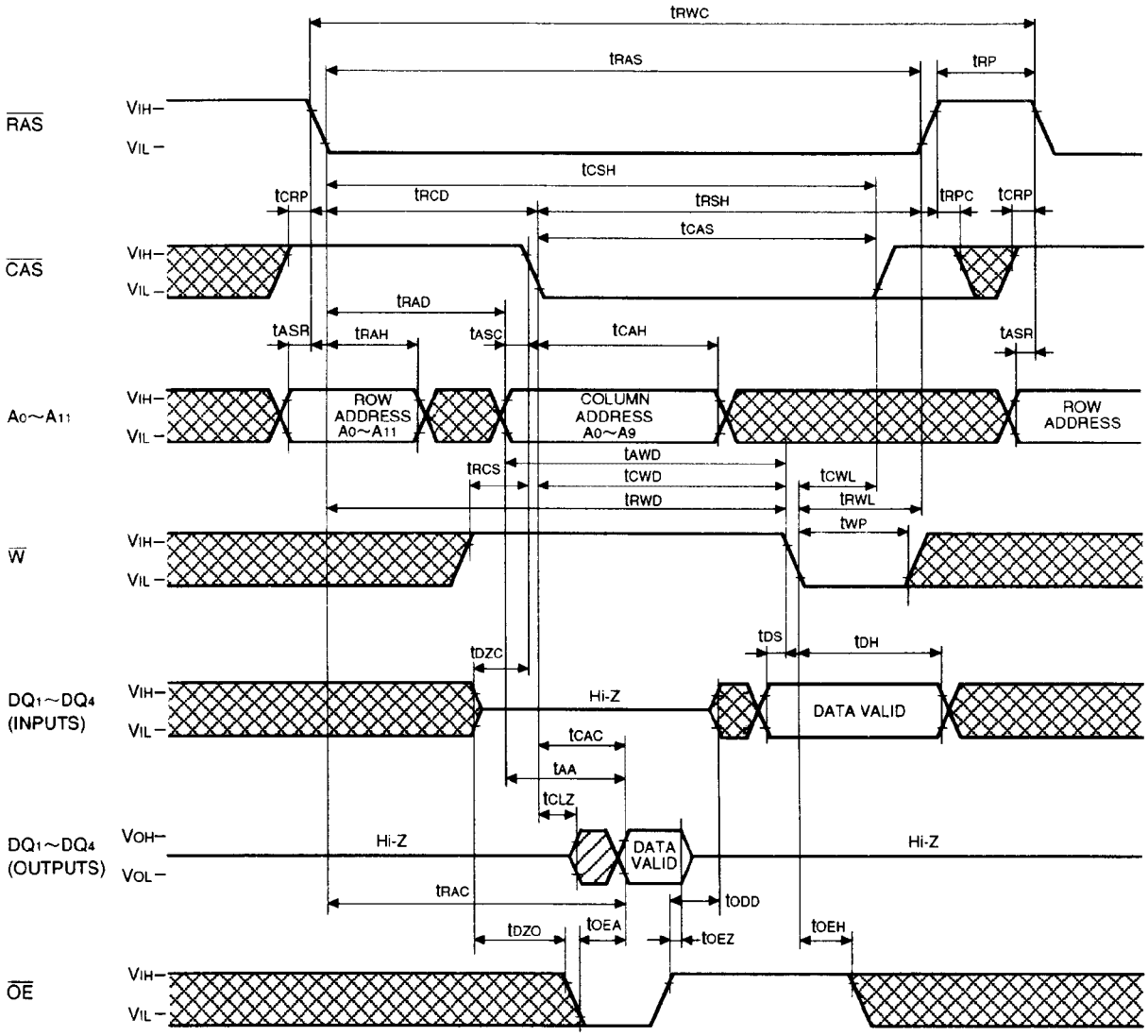
Write Cycle (Early Write)



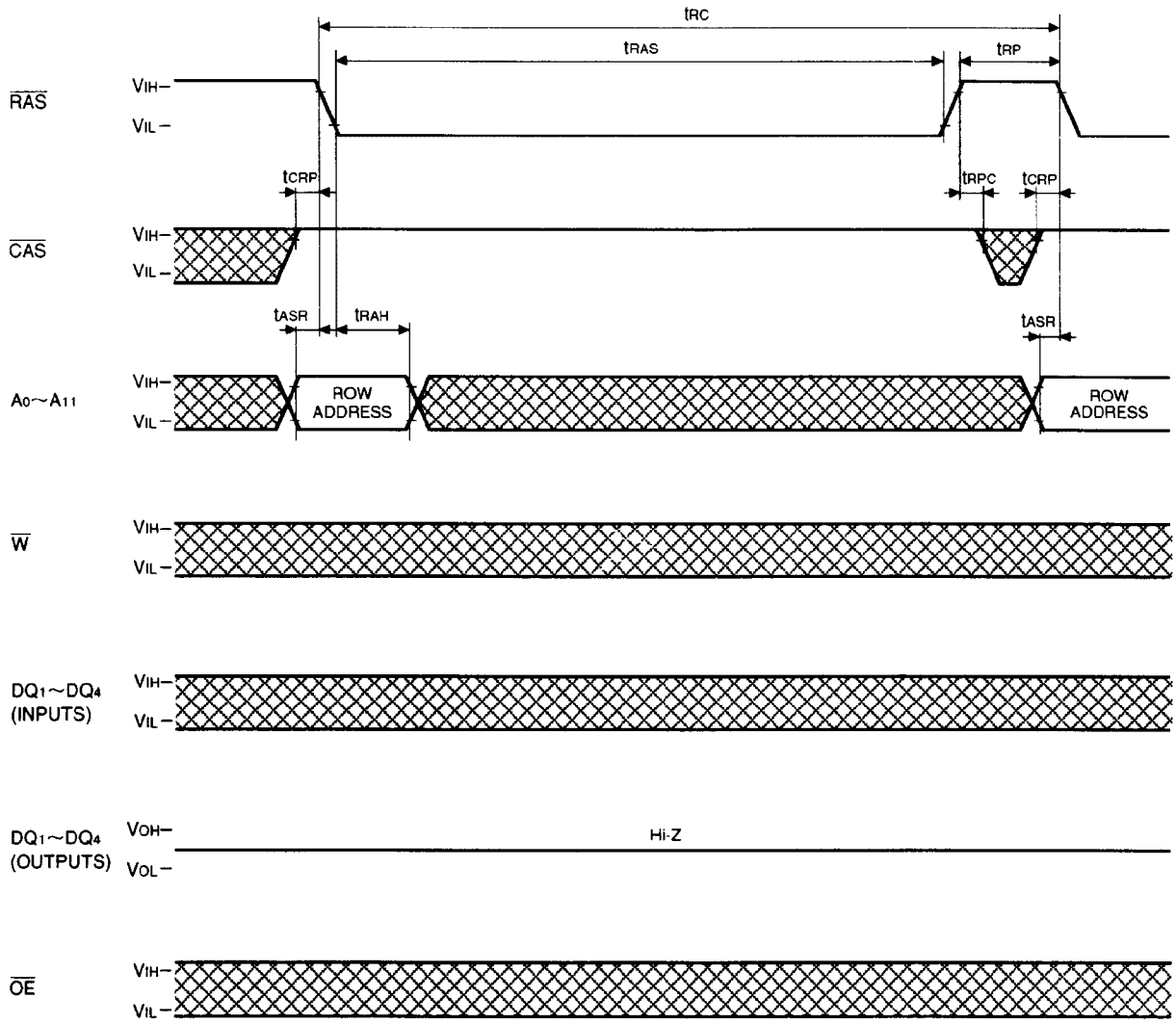
Write Cycle (Delayed Write)



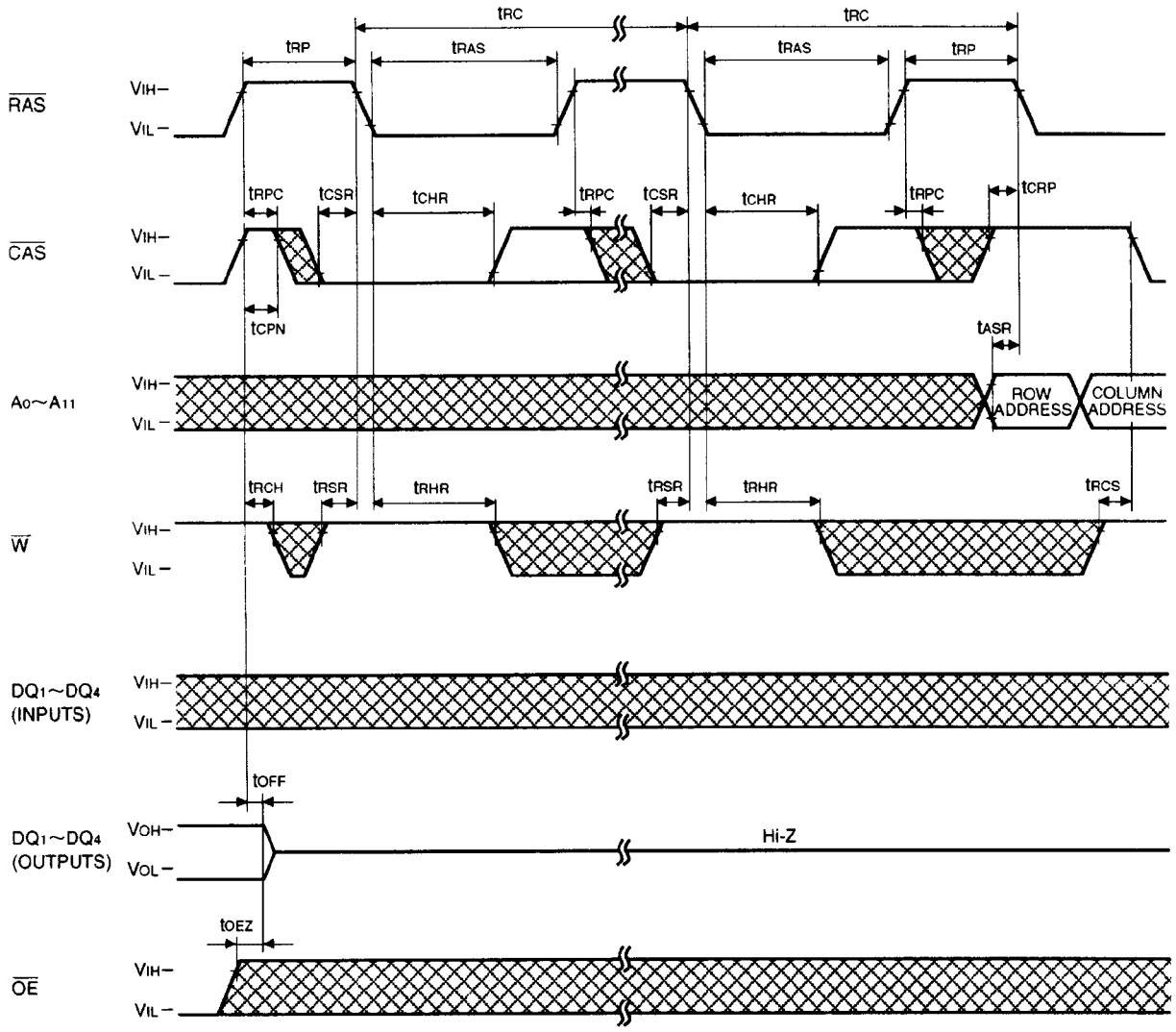
Read-Write, Read-Modify-Write Cycle



$\overline{RAS}$-only Refresh Cycle

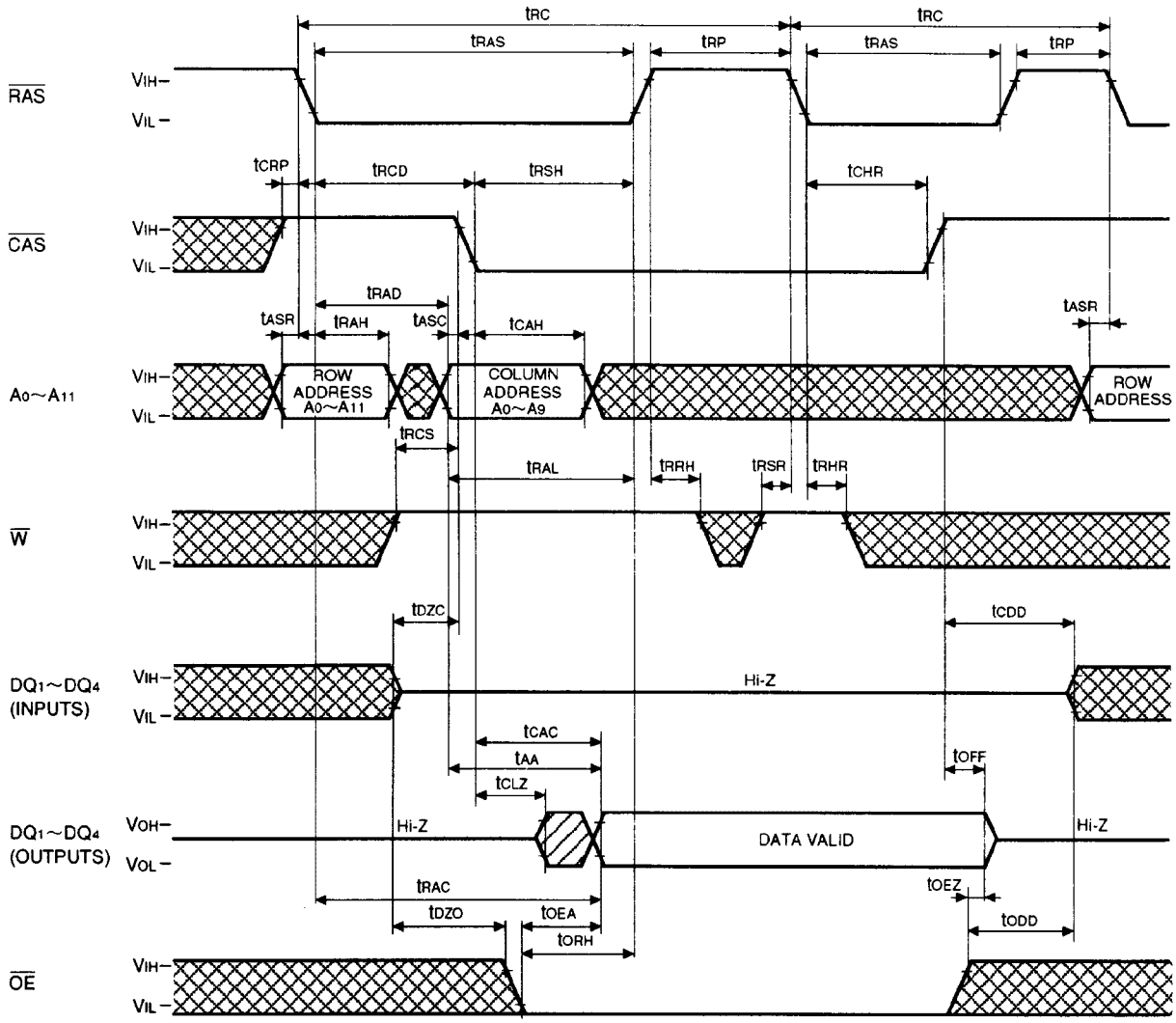


$\overline{CAS}$ before $\overline{RAS}$ Refresh Cycle, Slow Refresh Cycle



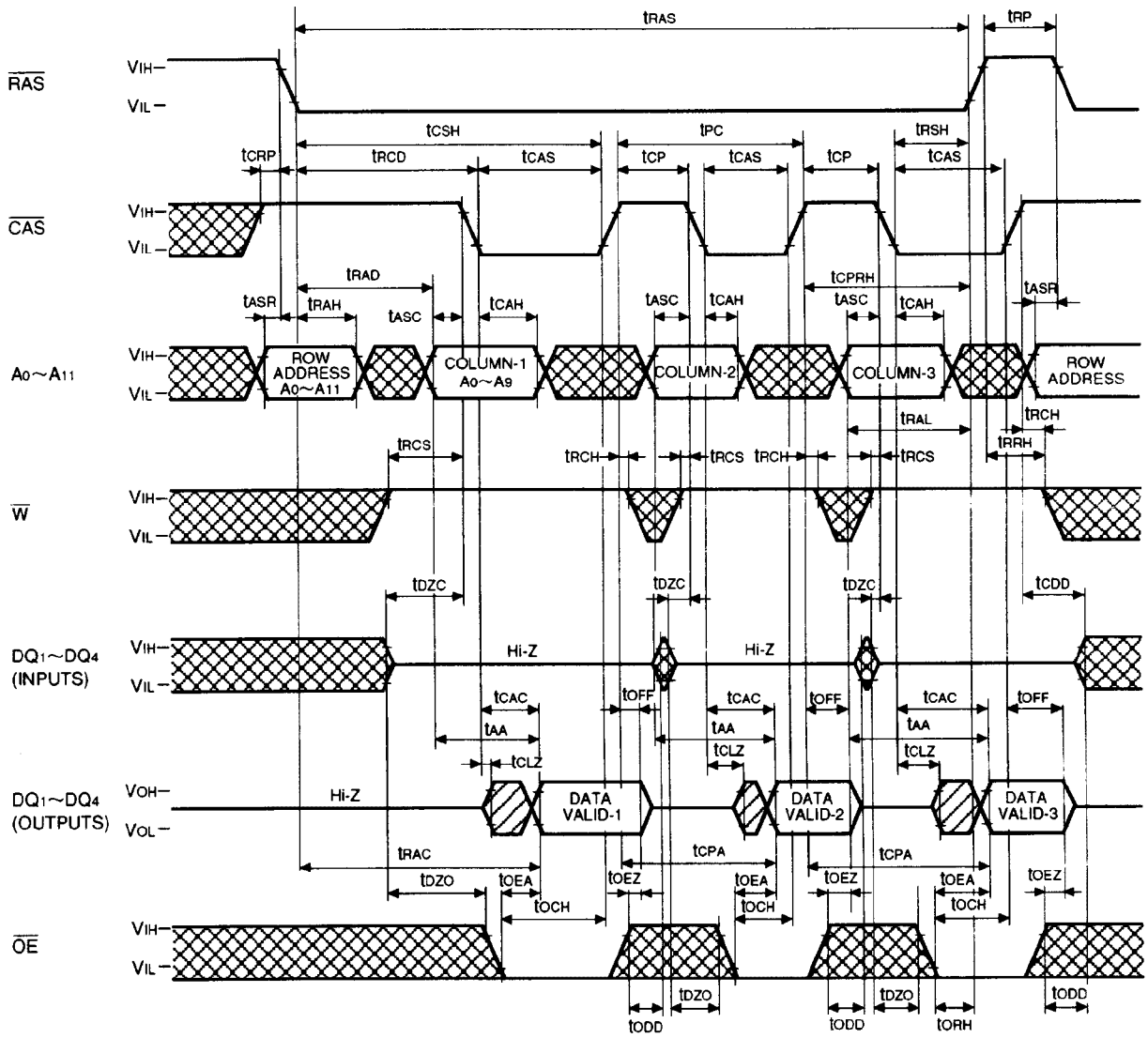
Hidden Refresh Cycle (Read)

(Note 29)

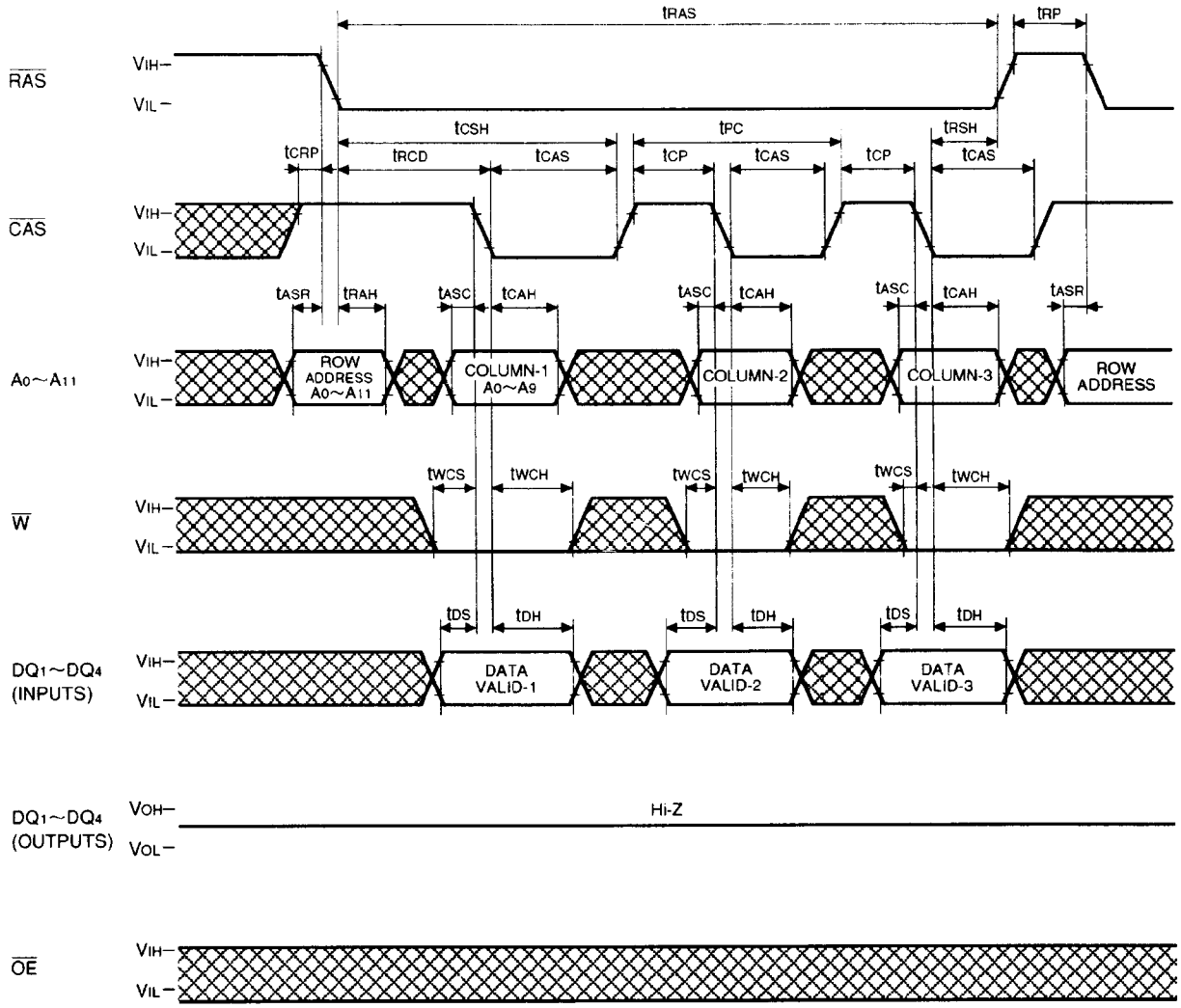


Note 29: Early write, delayed write, read write or read modify write cycle is applicable instead of read cycle.
Timing requirements and output state are the same as that of each cycle shown above.
Any in any cycle, t_{RSR} & t_{RHR} should be satisfied not to enter TEST MODE.

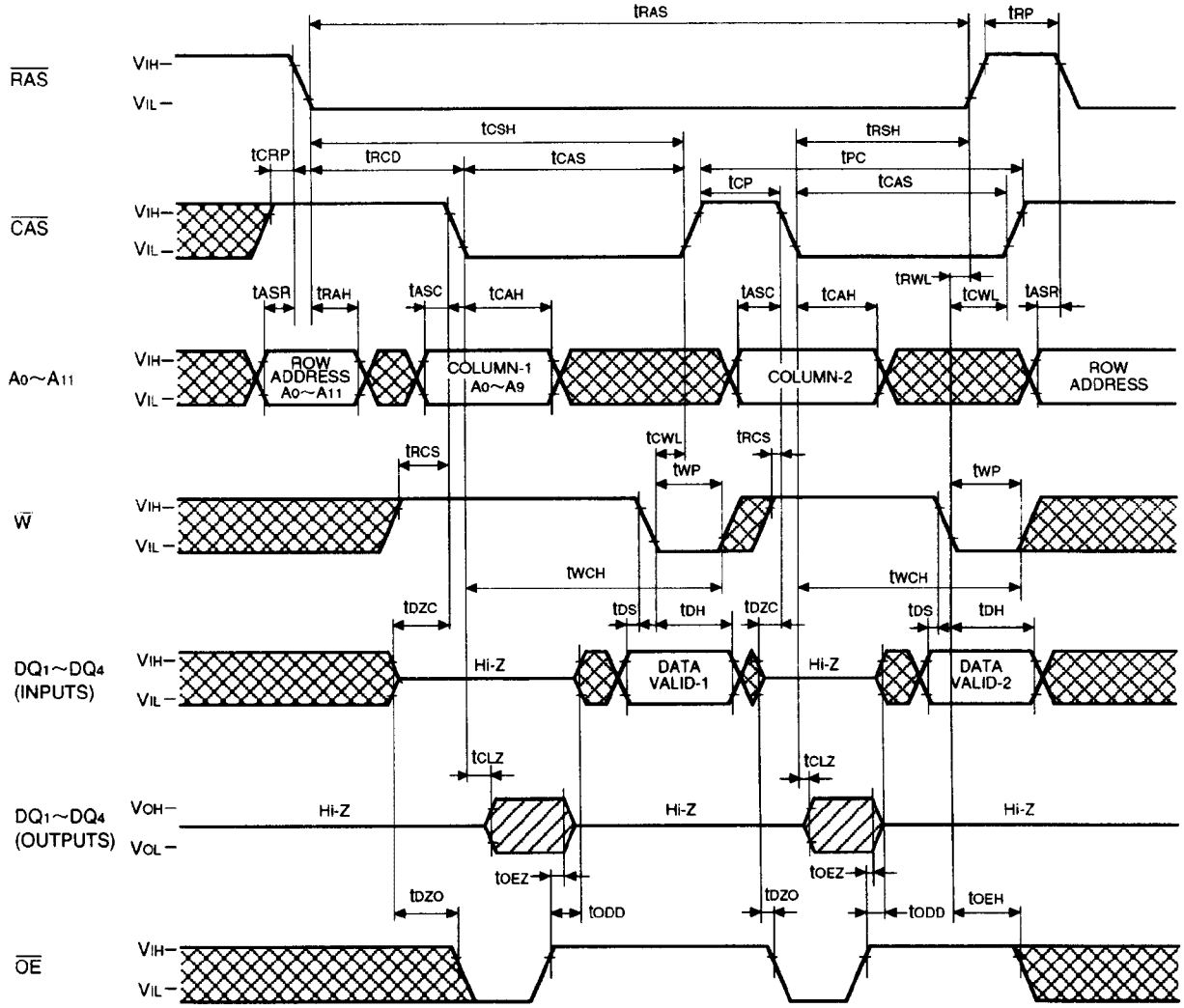
Fast Page Mode Read Cycle



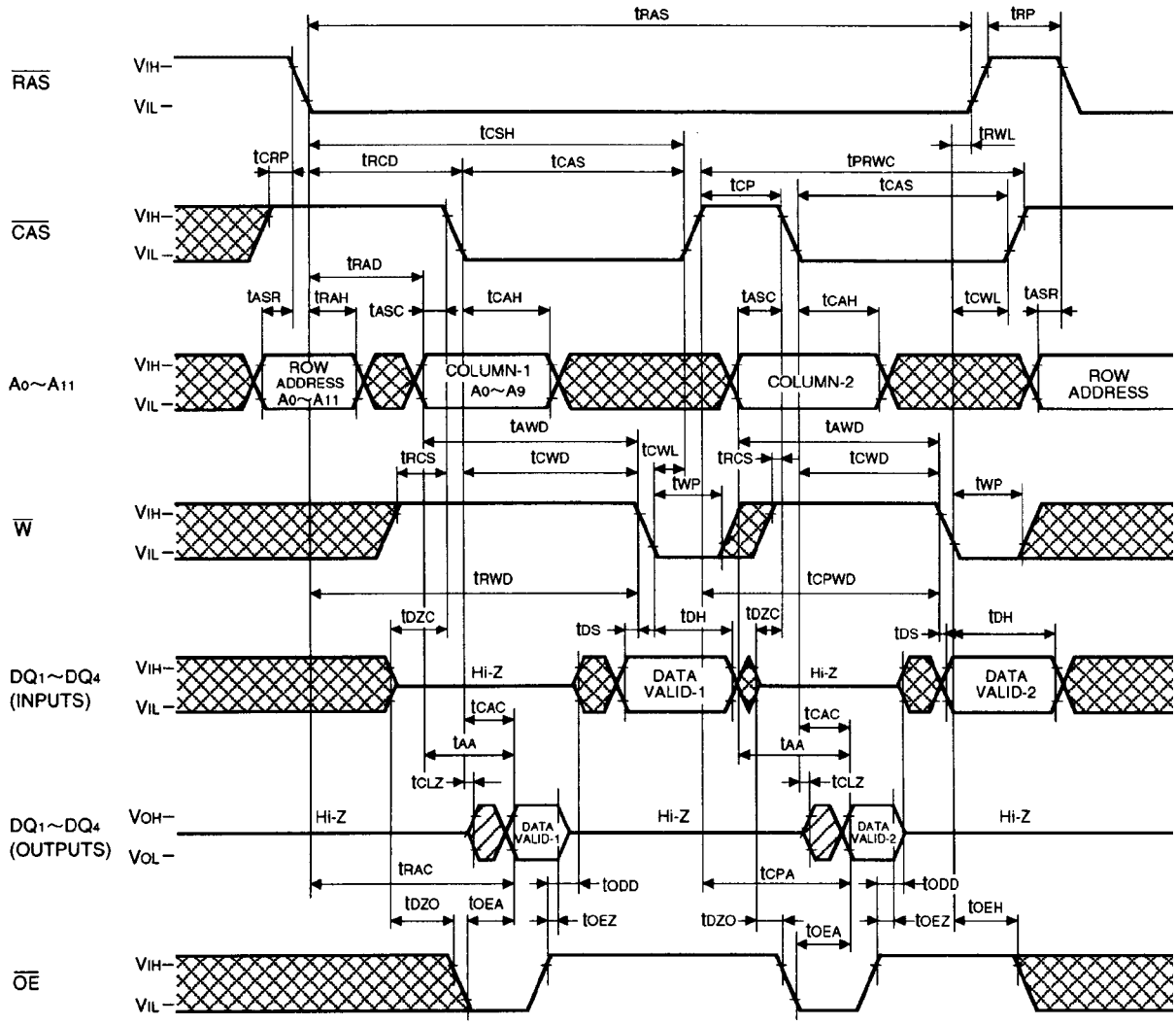
First Page Mode Write Cycle (Early Write)



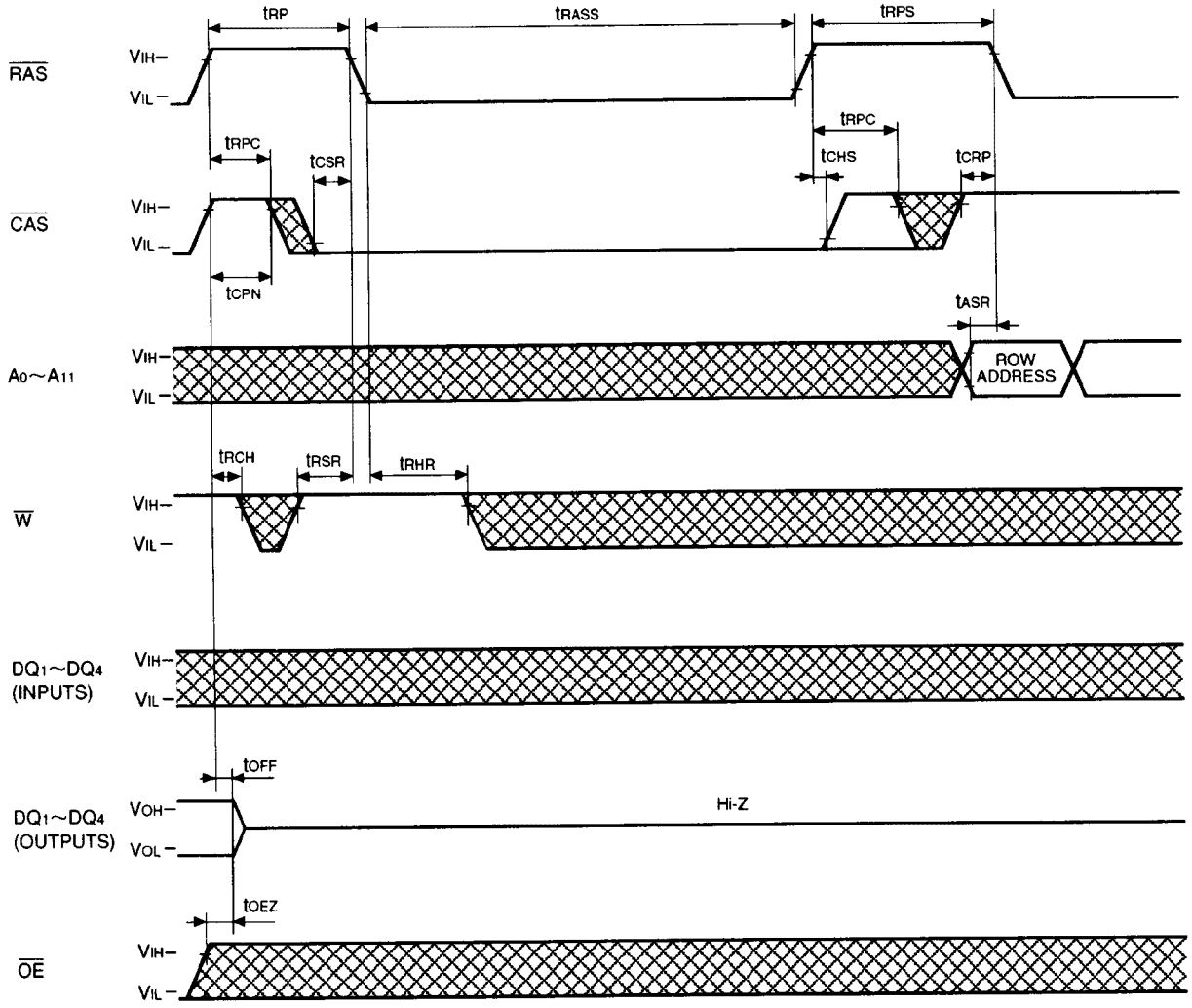
Fast-Page Mode Write Cycle (Delayed Write)



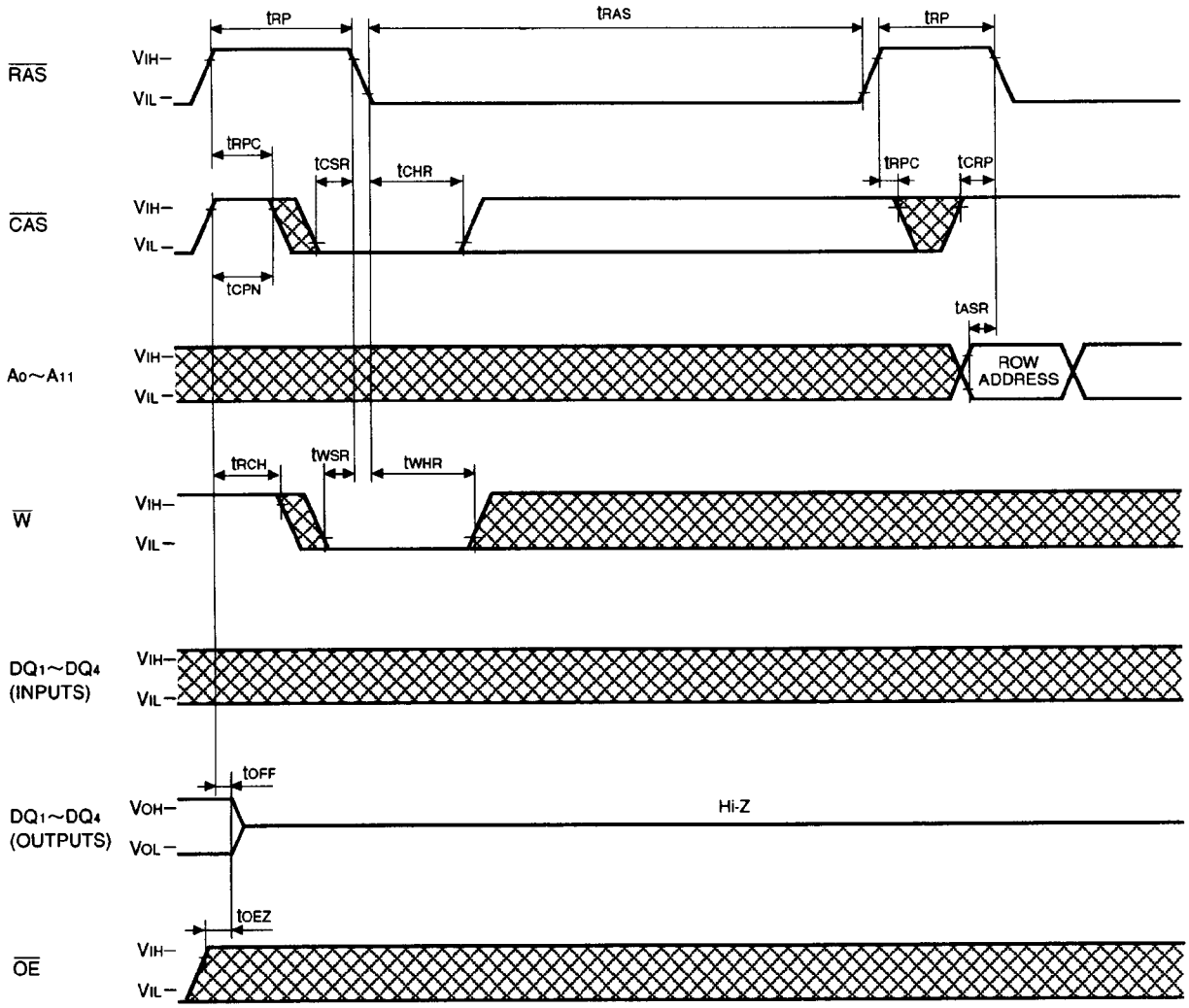
Fast Page Mode Read-Write, Read-Modify-Write Cycle



Self Refresh Cycle



TEST Mode SET Cycle



Note 30: This cycle can be used for initialized cycle after power-up, however entried into Test Mode.