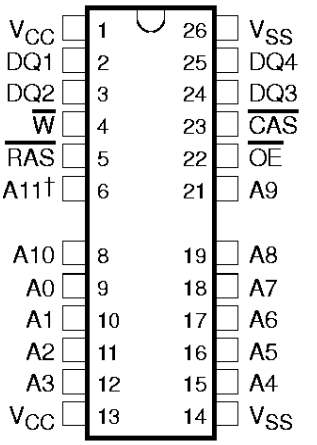
This data sheet is applicable to all TMS41x409As and TMS42x409A/Ps symbolized by Revision "B", Revision "E" and subsequent revisions as described in the device symbolization section.

- **Organization . . . 4194304 × 4**
- **Single Power Supply (5 V or 3.3 V)**
- **Performance Ranges:**

	ACCESS TIME t_{RAC} MAX	ACCESS TIME t_{CAC} MAX	ACCESS TIME t_{AA} MAX	EDO CYCLE t_{HPC} MIN
'41x409A-50	50 ns	13 ns	25 ns	20 ns
'41x409A-60	60 ns	15 ns	30 ns	25 ns
'41x409A-70	70 ns	18 ns	35 ns	30 ns
'42x409A/P-50	50 ns	13 ns	25 ns	20 ns
'42x409A/P-60	60 ns	15 ns	30 ns	25 ns
'42x409A/P-70	70 ns	18 ns	35 ns	30 ns

- **Extended Data Out (EDO) Operation**
- **$\overline{\text{CAS}}$-Before-$\overline{\text{RAS}}$ ($\overline{\text{CBR}}$) Refresh**
- **Long Refresh Period and Self-Refresh Option (TMS42x409AP)**
- **Low Power Dissipation**
- **3-State Unlatched Output**
- **High-Reliability Plastic 24/26-Lead 300-Mil-Wide Surface-Mount Small-Outline J-Lead (SOJ) Package (DJ Suffix) and 24/26-Lead 300-Mil-Wide Surface-Mount Thin Small-Outline Package (TSOP) (DGA Suffix)**

DJ/DGA PACKAGES
(TOP VIEW)



PIN NOMENCLATURE	
A0–A11†	Address Inputs
DQ1–DQ4	Data In/Data Out
$\overline{\text{CAS}}$	Column-Address Strobe
NC	No Internal Connection
$\overline{\text{OE}}$	Output Enable
$\overline{\text{RAS}}$	Row-Address Strobe
V_{CC}	5-V or 3.3-V Supply‡
V_{SS}	Ground
$\overline{\text{W}}$	Write Enable

† A11 is NC for TMS417409A and TMS427409A/P.
‡ See Available Options Table

- **Operating Free-Air Temperature Range 0°C to 70°C**
- **Fabricated Using Enhanced Performance Implanted CMOS (EPIC™) Technology by Texas Instruments (TI™)**

description

The TMS41x409A and TMS42x409A series are high-speed, 16777216-bit dynamic random-access memories (DRAMs) organized as 4194304 words of four bits each. The TMS42x409AP series are high-speed, low-power, self-refresh, 16777216-bit DRAMs organized as 4194304 words of four bits each.

These devices feature maximum $\overline{\text{RAS}}$ access times of 50 ns, 60 ns, and 70 ns. All address and data-in lines are latched on chip to simplify system design. Data out is unlatched to allow greater system flexibility.

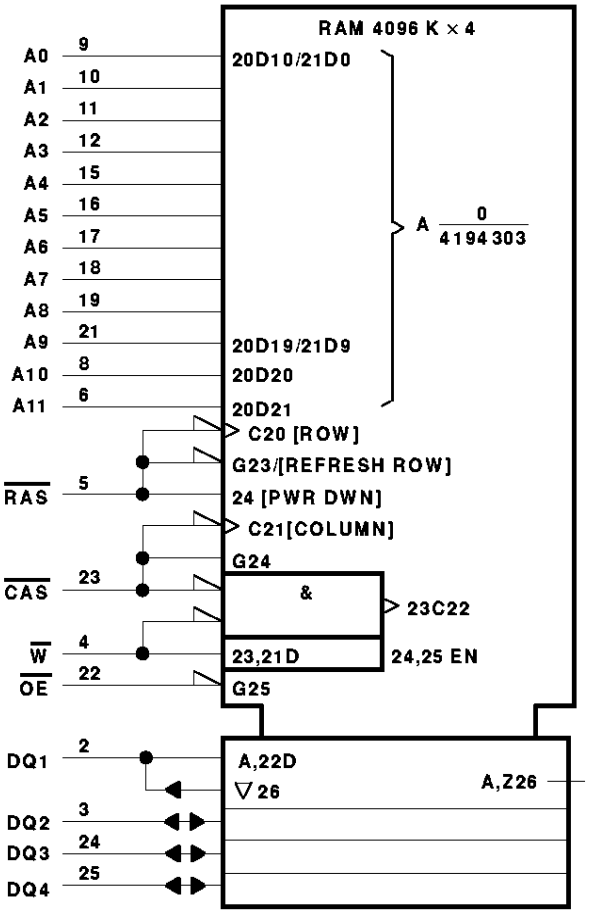
AVAILABLE OPTIONS

DEVICE	POWER SUPPLY	SELF REFRESH, BATTERY BACKUP	REFRESH CYCLES
TMS416409A	5 V	–	4096 in 64 ms
TMS417409A	5 V	–	2048 in 32 ms
TMS426409A	3.3 V	–	4096 in 64 ms
TMS426409AP	3.3 V	Yes	4096 in 128 ms
TMS427409A	3.3 V	–	2048 in 32 ms
TMS427409AP	3.3 V	Yes	2048 in 128 ms

description (continued)

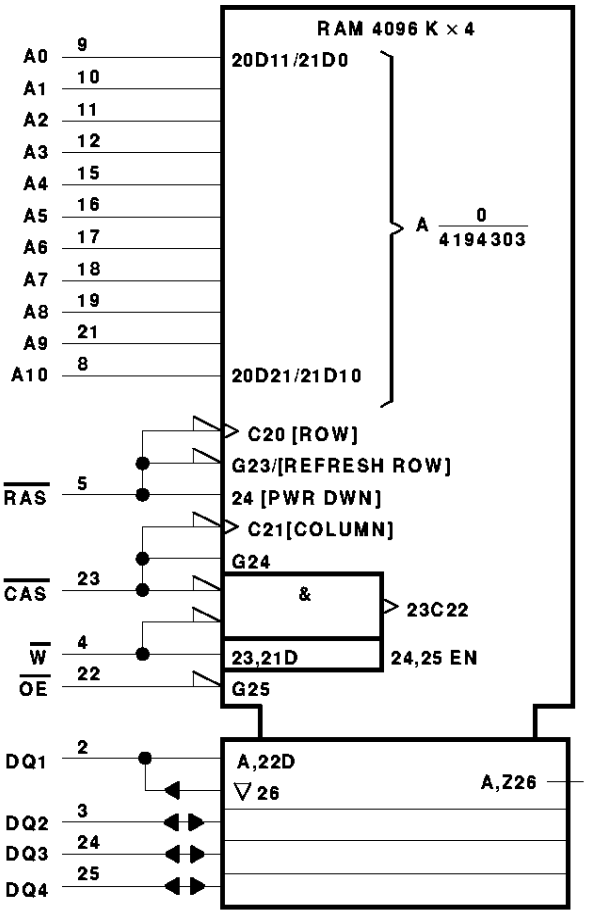
The TMS416409A and TMS417409A are offered in a 24/26-lead plastic surface-mount SOJ package (DJ suffix). The TMS426409A/P and TMS427409A/P are offered in a 24/26-lead plastic surface-mount SOJ package (DJ suffix) and a 24/26-lead plastic surface-mount TSOP (DGA suffix). These packages are designed for operation from 0°C to 70°C.

logic symbol (TMS416409A and TMS426409A/P)†



† This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 647-12.

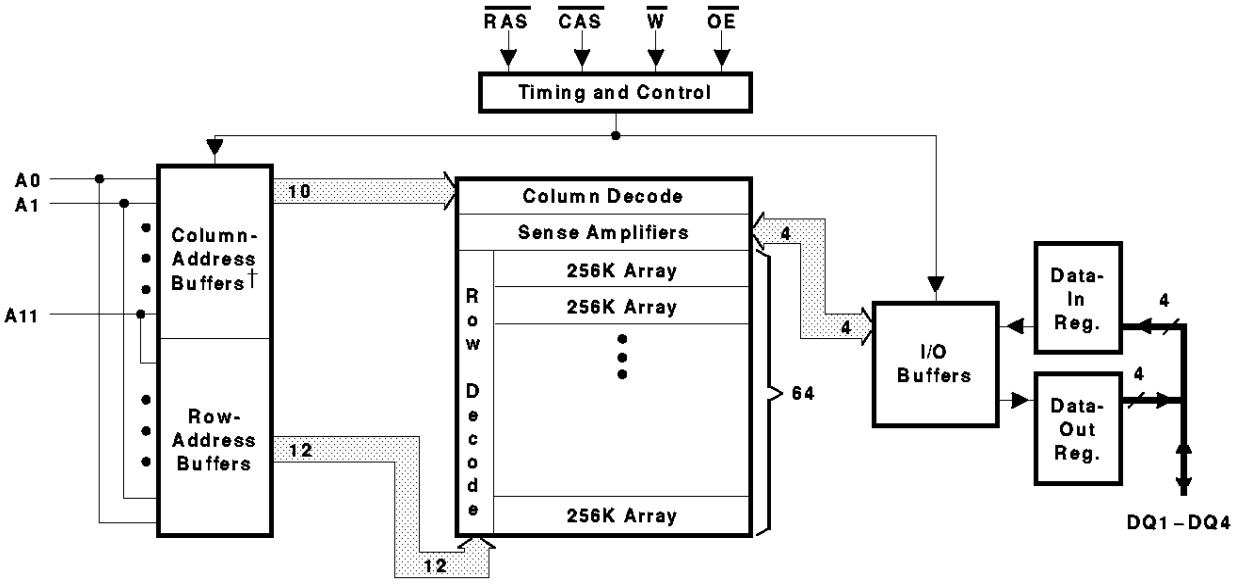
logic symbol (TMS417409A and TMS427409A/P)†



† This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 647-12.

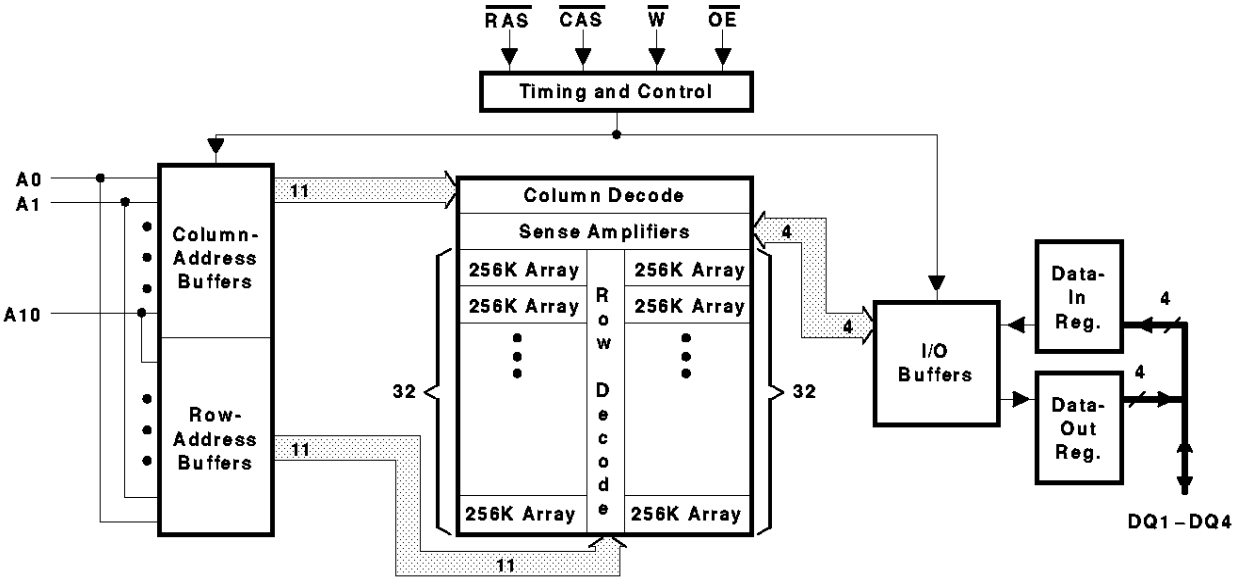
functional block diagram

TMS416409A, TMS426409A/P



† Column addresses A10 and A11 are not used.

TMS417409A, TMS427409A/P



operation

extended data out

Extended data out (EDO) allows data output rates of up to 50 MHz for 50-ns devices. When keeping the same row address while selecting random column addresses, the time for row-address setup and hold and for address multiplex is eliminated. The maximum number of columns that can be accessed is determined by t_{RASP}, the maximum $\overline{RAS}$ low time.

Extended data out does not place the data in/data out pins (DQ pins) into the high-impedance state with the rising edge of $\overline{CAS}$. The output remains valid for the system to latch the data. After $\overline{CAS}$ goes high, the DRAM decodes the next address. $\overline{OE}$ and $\overline{W}$ can control the output impedance. Descriptions of $\overline{OE}$ and $\overline{W}$ further explain EDO operation benefit.

address: A0–A11 (TMS416409A and TMS426409A/P) and A0–A10 (TMS417409A and TMS427409A/P)

Twenty-two address bits are required to decode each of the 4194304 storage cell locations. For the TMS416409A and TMS426409A/P,12 row-address bits are set up on A0 through A11 and latched onto the chip by the row-address strobe ($\overline{RAS}$). Ten column-address bits are set up on A0 through A9. For the TMS417409A and TMS427409A/P, 11 row-address bits are set up on inputs A0 through A10 and latched onto the chip by $\overline{RAS}$. Eleven column-address bits are set up on A0 through A10. All addresses must be stable on or before the falling edge of $\overline{RAS}$ and $\overline{CAS}$. $\overline{RAS}$ is similar to a chip enable because it activates the sense amplifiers as well as the row decoder. $\overline{CAS}$ is used as a chip select, activating the output buffers and latching the address bits into the column-address buffers.

output enable ($\overline{OE}$)

$\overline{OE}$ controls the impedance of the output buffers. While $\overline{CAS}$ and $\overline{RAS}$ are low and $\overline{W}$ is high, $\overline{OE}$ can be brought low or high and the DQs transition between valid data and high impedance (see Figure 8). There are two methods for placing the DQs into the high-impedance state and maintaining that state during $\overline{CAS}$ high time. The first method is to transition $\overline{OE}$ high before $\overline{CAS}$ transitions high and keep $\overline{OE}$ high for t_{CHO} (hold time, $\overline{OE}$ from $\overline{CAS}$) past the $\overline{CAS}$ transition. This disables the DQs and they remain disabled, regardless of $\overline{OE}$, until $\overline{CAS}$ falls again. The second method is to have $\overline{OE}$ low as $\overline{CAS}$ transitions high. Then $\overline{OE}$ can pulse high for a minimum of t_{OEP} (precharge time, $\overline{OE}$) anytime during $\overline{CAS}$ high time, disabling the DQs regardless of further transitions on $\overline{OE}$ until $\overline{CAS}$ falls again (see Figure 8).

write enable ($\overline{W}$)

The read or write mode is selected through $\overline{W}$. A logic high on $\overline{W}$ selects the read mode, and a logic low selects the write mode. The data inputs are disabled when the read mode is selected. When $\overline{W}$ goes low prior to $\overline{CAS}$ (early write), data out remains in the high-impedance state for the entire cycle, permitting a write operation with $\overline{OE}$ grounded. If $\overline{W}$ goes low in an extended-data-out read cycle, the DQs are disabled so long as $\overline{CAS}$ is high (see Figure 9).

data in/data out (DQ1–DQ4)

Data is written during a write or read-modify-write cycle. Depending on the mode of operation, the later falling edge of $\overline{CAS}$ or $\overline{W}$ strobes data into the on-chip data latch with setup and hold times referenced to the later edge. The DQs drive valid data after all access times are met and remain valid except in cases described in the $\overline{W}$ and $\overline{OE}$ sections.

$\overline{\text{RAS}}$-only refresh

TMS416409A, TMS426409A/P

A refresh operation must be performed at least once every 64 ms (128 ms for TMS426409AP) to retain data. This can be achieved by strobing each of the 4096 rows (A0–A11). A normal read or write cycle refreshes all bits in each row that is selected. A $\overline{\text{RAS}}$-only operation can be used by holding $\overline{\text{CAS}}$ at the high (inactive) level, conserving power as the output buffers remain in the high-impedance state. Externally generated addresses must be used for a $\overline{\text{RAS}}$-only refresh.

TMS417409A, TMS427409A/P

A refresh operation must be performed at least once every 32 ms (128 ms for TMS427409AP) to retain data. This can be achieved by strobing each of the 2048 rows (A0–A10). A normal read or write cycle refreshes all bits in each row that is selected. A $\overline{\text{RAS}}$-only operation can be used by holding $\overline{\text{CAS}}$ at the high (inactive) level, conserving power as the output buffers remain in the high-impedance state. Externally generated addresses must be used for a $\overline{\text{RAS}}$-only refresh.

hidden refresh

A hidden refresh can be performed while maintaining valid data at the output pin. This is accomplished by holding $\overline{\text{CAS}}$ at V_{IL} after a read operation and cycling $\overline{\text{RAS}}$ after a specified precharge period, similar to a $\overline{\text{RAS}}$-only refresh cycle. The external address is ignored, and the refresh address is generated internally.

$\overline{\text{CAS}}$-before-$\overline{\text{RAS}}$ (CBR) refresh

CBR refresh is performed by bringing $\overline{\text{CAS}}$ low earlier than $\overline{\text{RAS}}$ (see parameter t_{CSR}) and holding it low after $\overline{\text{RAS}}$ falls (see parameter t_{CHR}). For successive CBR refresh cycles, $\overline{\text{CAS}}$ can remain low while cycling $\overline{\text{RAS}}$. The external address is ignored, and the refresh address is generated internally.

battery-backup refresh

TMS426409AP

A low-power battery-backup refresh mode that requires less than 350 µA of refresh current is available on the TMS426409AP. Data integrity is maintained using CBR refresh with a period of 31.25 µs while holding $\overline{\text{RAS}}$ low for less than 300 ns. To minimize current consumption, all input levels must be at CMOS levels ($V_{IL} < 0.2$ V, $V_{IH} > V_{CC} - 0.2$ V).

TMS427409AP

A low-power battery-backup refresh mode that requires less than 350 µA of refresh current is available on the TMS427409AP. Data integrity is maintained using CBR refresh with a period of 62.5 µs while holding $\overline{\text{RAS}}$ low for less than 300 ns. To minimize current consumption, all input levels must be at CMOS levels ($V_{IL} < 0.2$ V, $V_{IH} > V_{CC} - 0.2$ V).

self-refresh (TMS42x409AP)

The self-refresh mode is entered by dropping $\overline{\text{CAS}}$ low prior to $\overline{\text{RAS}}$ going low. Then $\overline{\text{CAS}}$ and $\overline{\text{RAS}}$ are both held low for a minimum of 100 µs. The chip is then refreshed internally by an on-board oscillator. No external address is required because the CBR counter is used to keep track of the address. To exit the self-refresh mode, both $\overline{\text{RAS}}$ and $\overline{\text{CAS}}$ are brought high to satisfy t_{CHS}. Upon exiting self-refresh mode, a burst refresh (refresh a full set of row addresses) must be executed before continuing with normal operation. The burst refresh ensures that the DRAM is fully refreshed.

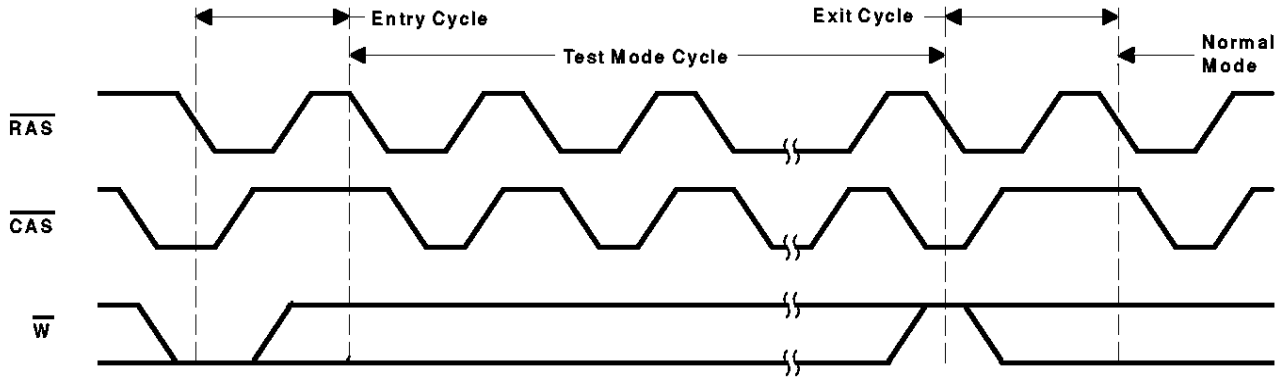
power up

To achieve proper device operation, an initial pause of 200 µs followed by a minimum of eight initialization cycles is required after power up to the full V_{CC} level. These eight initialization cycles must include at least one refresh ($\overline{\text{RAS}}$-only or CBR) cycle.

test mode

The test mode (see Figure 1) is initiated with a CBR-refresh cycle while simultaneously holding the $\overline{W}$ input low. The entry cycle performs an internal refresh cycle while internally setting the device to perform parallel read or write on subsequent cycles. While in the test mode, any data sequence can be performed. The device exits test mode if a CBR refresh cycle with $\overline{W}$ held high or a $\overline{RAS}$-only refresh cycle is performed.

In the test mode, the device is configured as 1024K bits × 4 bits for each DQ. Each DQ pin has a separate 4-bit parallel read and write data bus that ignores column addresses A0 and A1. During a read cycle, the four internal bits are compared for each DQ pin. If the four bits agree, DQ goes high; if not, DQ goes low. Test time is reduced by a factor of four for this series.



NOTE A: The states of $\overline{W}$, data in, and address are defined by the type of cycle used during test mode.

Figure 1. Test-Mode Cycle

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage range, V_{CC} (TMS41x409A) . . . . . – 1 V to 7 V
Supply voltage range, V_{CC} (TMS42x409A, TMS42x409AP) . . . . . – 0.5 V to 4.6 V
Voltage range on any pin (TMS41x409A) (see Note 1) . . . . . – 1 V to 7 V
Voltage range on any pin (TMS42x409A, TMS42x409AP) (see Note 1) . . . . . – 0.5 V to 4.6 V
Short-circuit output current . . . . . 50 mA
Power dissipation . . . . . 1 W
Operating free-air temperature range, T_A . . . . . 0°C to 70°C
Storage temperature range, T_{stg} . . . . . – 55°C to 125°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

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

recommended operating conditions

		TMS41x409A			TMS42x409A/P			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage	4.5	5	5.5	3	3.3	3.6	V
V_{SS}	Supply voltage		0			0		V
V_{IH}	High-level input voltage	2.4		6.5	2		V_{CC} + 0.3	V
V_{IL}	Low-level input voltage (see Note 2)	– 1		0.8	– 0.3		0.8	V
T_A	Operating free-air temperature	0		70	0		70	°C

NOTE 2: The algebraic convention, where the more negative (less positive) limit is designated as minimum, is used for logic-voltage levels only.

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

TMS416409A

PARAMETER		TEST CONDITIONS†	'416409A-50		'416409A-60		'416409A-70		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
V_{OH}	High-level output voltage	I_{OH} = – 5 mA	2.4		2.4		2.4		V
V_{OL}	Low-level output voltage	I_{OL} = 4.2 mA		0.4		0.4		0.4	V
I_I	Input current (leakage)	V_{CC} = 5.5 V, V_I = 0 V to 6.5 V, All others = 0 V to V_{CC}		± 10		± 10		± 10	µA
I_O	Output current (leakage)	V_{CC} = 5.5 V, V_O = 0 V to V_{CC}, $\overline{CAS}$ high		± 10		± 10		± 10	µA
I_{CC1}‡§	Average read- or write-cycle current	V_{CC} = 5.5 V, Minimum cycle		100		80		70	mA
I_{CC2}	Average standby current	V_{IH} = 2.4 V (TTL), After one memory cycle, $\overline{RAS}$ and $\overline{CAS}$ high		2		2		2	mA
		V_{IH} = V_{CC} – 0.2 V (CMOS), After one memory cycle, $\overline{RAS}$ and $\overline{CAS}$ high		1		1		1	mA
I_{CC3}‡§	Average refresh current ($\overline{RAS}$-only refresh or CBR)	V_{CC} = 5.5 V, Minimum cycle, $\overline{RAS}$ cycling, $\overline{CAS}$ high ($\overline{RAS}$ only), $\overline{RAS}$ low after $\overline{CAS}$ low (CBR)		100		80		70	mA
I_{CC4}‡¶	Average EDO current	V_{CC} = 5.5 V, t_{HPC} = MIN, $\overline{RAS}$ low, $\overline{CAS}$ cycling		100		90		80	mA

† For conditions shown as MIN/MAX, use the appropriate value specified in the timing requirements.
‡ Measured with outputs open
§ Measured with a maximum of one address change while $\overline{RAS}$ = V_{IL}
¶ Measured with a maximum of one address change during each EDO cycle, t_{HPC}

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (continued)

TMS417409A

PARAMETER		TEST CONDITIONS†	'417409A-50		'417409A-60		'417409A-70		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
V_{OH}	High-level output voltage	I_{OH} = – 5 mA	2.4		2.4		2.4		V
V_{OL}	Low-level output voltage	I_{OL} = 4.2 mA		0.4		0.4		0.4	V
I_I	Input current (leakage)	V_{CC} = 5.5 V, V_I = 0 V to 6.5 V, All others = 0 V to V_{CC}		± 10		± 10		± 10	µA
I_O	Output current (leakage)	$\overline{V_{CC}}$ = 5.5 V, V_O = 0 V to V_{CC}, $\overline{CAS}$ high		± 10		± 10		± 10	µA
I_{CC1}‡§	Average read- or write-cycle current	V_{CC} = 5.5 V, Minimum cycle		130		110		100	mA
I_{CC2}	Average standby current	V_{IH} = 2.4 V (TTL), After one memory cycle, $\overline{RAS}$ and $\overline{CAS}$ high		2		2		2	mA
		V_{IH} = V_{CC} – 0.2 V (CMOS), After one memory cycle, $\overline{RAS}$ and $\overline{CAS}$ high		1		1		1	mA
I_{CC3}‡§	Average refresh current ($\overline{RAS}$-only refresh or CBR)	$\overline{V_{CC}}$ = 5.5 V, Minimum cycle, $\overline{RAS}$ cycling, $\overline{CAS}$ high ($\overline{RAS}$ only), $\overline{RAS}$ low after $\overline{CAS}$ low (CBR)		130		110		100	mA
I_{CC4}‡¶	Average EDO current	$\overline{V_{CC}}$ = 5.5 V, t_{HPC} = MIN, $\overline{RAS}$ low, $\overline{CAS}$ cycling		110		90		80	mA

† For conditions shown as MIN/MAX, use the appropriate value specified in the timing requirements.
‡ Measured with outputs open
§ Measured with a maximum of one address change while $\overline{RAS}$ = V_{IL}
¶ Measured with a maximum of one address change during each EDO cycle, t_{HPC}

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (continued)

TMS426409A/P

PARAMETER		TEST CONDITIONS†		'426409A-50 '426409AP-50		'426409A-60 '426409AP-60		'426409A-70 '426409AP-70		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
V_{OH}	High-level output voltage	I_{OH} = – 2 mA	LVTTL	2.4		2.4		2.4		V
		I_{OH} = – 100 µA	LVCMOS	V_{CC}–0.2		V_{CC}–0.2		V_{CC}–0.2		
V_{OL}	Low-level output voltage	I_{OL} = 2 mA	LVTTL		0.4		0.4		0.4	V
		I_{OL} = 100 µA	LVCMOS		0.2		0.2		0.2	
I_I	Input current (leakage)	V_{CC} = 3.6 V, V_I = 0 V to 3.9 V, All others = 0 V to V_{CC}			± 10		± 10		± 10	µA
I_O	Output current (leakage)	$\overline{V_{CC}}$ = 3.6 V, V_O = 0 V to V_{CC}, $\overline{CAS}$ high			± 10		± 10		± 10	µA
I_{CC1}‡§	Average read- or write- cycle current	V_{CC} = 3.6 V, Minimum cycle			90		70		60	mA
I_{CC2}	Average standby current	V_{IH} = 2 V (LVTTL) After one memory cycle, $\overline{RAS}$ and $\overline{CAS}$ high	'426409A		2		2		2	mA
			'426409AP		1		1		1	mA
		V_{IH} = V_{CC} – 0.2 V (LVCMOS), After one memory cycle, $\overline{RAS}$ and $\overline{CAS}$ high	'426409A		1		1		1	mA
			'426409AP		150		150		150	µA
I_{CC3}‡§	Average refresh current ($\overline{RAS}$-only refresh or CBR)	$\overline{V_{CC}}$ = 3.6 V, Minimum cycle, $\overline{RAS}$ cycling, $\overline{CAS}$ high ($\overline{RAS}$-only refresh), $\overline{RAS}$ low after $\overline{CAS}$ low (CBR)			90		70		60	mA
I_{CC4}‡¶	Average EDO current	$\overline{V_{CC}}$ = 3.6 V, t_{HPC} = MIN, $\overline{RAS}$ low, $\overline{CAS}$ cycling			100		90		80	mA
I_{CC6}#	Average self-refresh current	$\overline{CAS}$ < 0.2 V, $\overline{RAS}$ < 0.2 V, Measured after t_{RASS} min			200		200		200	µA
I_{CC10}#	Average battery back-up operating current (equivalent refresh time is 128 ms), CBR only	t_{RC} = 31.25 µs, t_{RAS} ≤ 300 ns, V_{CC} – 0.2 V ≤ V_{IH} ≤ 3.9 V, 0 V ≤ V_{IL} ≤ 0.2 V, $\overline{W}$ and $\overline{OE}$ = V_{IH}, Address and data stable			350		350		350	µA

† For conditions shown as MIN/MAX, use the appropriate value specified in the timing requirements.
‡ Measured with outputs open
§ Measured with a maximum of one address change while $\overline{RAS}$ = V_{IL}
¶ Measured with a maximum of one address change during each EDO cycle, t_{HPC}
# For TMS426409AP only

ADVANCE INFORMATION

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (continued)

TMS427409A/P

PARAMETER		TEST CONDITIONS†		'427409A-50 '427409AP-50		'427409A-60 '427409AP-60		'427409A-70 '427409AP-70		UNIT
				MIN	MAX	MIN	MAX	MIN	MAX	
V_{OH}	High-level output voltage	I_{OH} = – 2 mA	LVTTL	2.4		2.4		2.4		V
		I_{OH} = – 100 µA	LVCMOS	V_{CC}–0.2		V_{CC}–0.2		V_{CC}–0.2		
V_{OL}	Low-level output voltage	I_{OL} = 2 mA	LVTTL		0.4		0.4		0.4	V
		I_{OL} = 100 µA	LVCMOS		0.2		0.2		0.2	
I_I	Input current (leakage)	V_{CC} = 3.6 V, V_I = 0 V to 3.9 V, All others = 0 V to V_{CC}			± 10		± 10		± 10	µA
I_O	Output current (leakage)	V_{CC} = 3.6 V, V_O = 0 V to V_{CC}, $\overline{CAS}$ high			± 10		± 10		± 10	µA
I_{CC1}‡§	Average read- or write- cycle current	V_{CC} = 3.6 V, Minimum cycle			120		100		90	mA
I_{CC2}	Average standby current	V_{IH} = 2 V (LVTTL) After one memory cycle, $\overline{RAS}$ and $\overline{CAS}$ high	'427409A		2		2		2	mA
			'427409AP		1		1		1	
		V_{IH} = V_{CC} – 0.2 V (LVCMOS), After one memory cycle, $\overline{RAS}$ and $\overline{CAS}$ high	'427409A		1		1		1	mA
			'427409AP		150		150		150	µA
I_{CC3}‡§	Average refresh current ($\overline{RAS}$-only refresh or CBR)	V_{CC} = 3.6 V, Minimum cycle, $\overline{RAS}$ cycling, $\overline{CAS}$ high ($\overline{RAS}$-only refresh), $\overline{RAS}$ low after $\overline{CAS}$ low (CBR)			120		100		90	mA
I_{CC4}‡¶	Average EDO current	V_{CC} = 3.6 V, t_{HPC} = MIN, $\overline{RAS}$ low, $\overline{CAS}$ cycling			110		90		80	mA
I_{CC6}#	Average self-refresh current	$\overline{CAS}$ < 0.2 V, $\overline{RAS}$ < 0.2 V, Measured after t_{RASS} min			200		200		200	µA
I_{CC10}#	Average battery back-up operating current (equivalent refresh time is 128 ms), CBR only	t_{RC} = 62.5 µs, t_{RAS} ≤ 300 ns, V_{CC} – 0.2 V ≤ V_{IH} ≤ 3.9 V, 0 V ≤ V_{IL} ≤ 0.2 V, $\overline{W}$ and $\overline{OE}$ = V_{IH}, Address and data stable			350		350		350	µA

† For conditions shown as MIN/MAX, use the appropriate value specified in the timing requirements.
‡ Measured with outputs open
§ Measured with a maximum of one address change while $\overline{RAS}$ = V_{IL}
¶ Measured with a maximum of one address change during each EDO cycle, t_{HPC}
# For TMS427409AP only

ADVANCE INFORMATION

capacitance over recommended ranges of supply voltage and operating free-air temperature, f = 1 MHz (see Note 3)

PARAMETER		MIN	MAX	UNIT
$C_{i(A)}$	Input capacitance, A0–A11†		5	pF
$C_{i(OE)}$	Input capacitance, $\overline{OE}$		7	pF
$C_{i(RC)}$	Input capacitance, $\overline{CAS}$ and $\overline{RAS}$		7	pF
$C_{i(W)}$	Input capacitance, $\overline{W}$		7	pF
C_o	Output capacitance‡		7	pF

† A11 is NC (no internal connection) for TMS417409A and TMS427409A/P.
‡ $\overline{CAS}$ and $\overline{OE}$ = V_{IH} to disable outputs
NOTE 3: V_{CC} = NOM supply voltage ± 10%, and the bias on pins under test is 0 V.

switching characteristics over recommended ranges of supply voltage and operating free-air temperature (see Note 4)

PARAMETER		'41x409A-50		'41x409A-60		'41x409A-70		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t_{AA}	Access time from column address (see Note 5)		25		30		35	ns
t_{CAC}	Access time from $\overline{CAS}$ (see Note 5)		13		15		18	ns
t_{CPA}	Access time from $\overline{CAS}$ precharge (see Note 5)		28		35		40	ns
t_{RAC}	Access time from $\overline{RAS}$ (see Note 5)		50		60		70	ns
t_{OEA}	Access time from $\overline{OE}$ (see Note 5)		13		15		18	ns
t_{CLZ}	Delay time, $\overline{CAS}$ to output in low impedance	0		0		0		ns
t_{REZ}	Output buffer turn off delay from $\overline{RAS}$ (see Note 6)	3	13	3	15	3	18	ns
t_{CEZ}	Output buffer turn off delay from $\overline{CAS}$ (see Note 6)	3	13	3	15	3	18	ns
t_{OEZ}	Output buffer turn off delay from $\overline{OE}$ (see Note 6)	3	13	3	15	3	18	ns
t_{WEZ}	Output buffer turn off delay from $\overline{W}$ (see Note 6)	3	13	3	15	3	18	ns

switching characteristics over recommended ranges of supply voltage and operating free-air temperature (see Note 4)

PARAMETER		'42x409A/P-50		'42x409A/P-60		'42x409A/P-70		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t_{AA}	Access time from column address (see Note 5)		25		30		35	ns
t_{CAC}	Access time from $\overline{CAS}$ (see Note 5)		13		15		18	ns
t_{CPA}	Access time from $\overline{CAS}$ precharge (see Note 5)		28		35		40	ns
t_{RAC}	Access time from $\overline{RAS}$ (see Note 5)		50		60		70	ns
t_{OEA}	Access time from $\overline{OE}$ (see Note 5)		13		15		18	ns
t_{CLZ}	Delay time, $\overline{CAS}$ to output in low impedance	0		0		0		ns
t_{REZ}	Output buffer turn off delay from $\overline{RAS}$ (see Note 6)	3	13	3	15	3	18	ns
t_{CEZ}	Output buffer turn off delay from $\overline{CAS}$ (see Note 6)	3	13	3	15	3	18	ns
t_{OEZ}	Output buffer turn off delay from $\overline{OE}$ (see Note 6)	3	13	3	15	3	18	ns
t_{WEZ}	Output buffer turn off delay from $\overline{W}$ (see Note 6)	3	13	3	15	3	18	ns

NOTES: 4. With ac parameters, it is assumed that t_T = 2 ns.
5. For TMS42x409A/P, access times are measured with output reference levels of V_{OH} = 2 V and V_{OL} = 0.8 V.
6. The maximum values of t_{REZ}, t_{CEZ}, t_{OEZ}, and t_{WEZ} are specified when the output is no longer driven. Data in should not be driven until one of the applicable maximum specifications is satisfied.

EDO timing requirements over recommended ranges of supply voltage and operating free-air temperature (see Note 4)

		'41x409A-50		'41x409A-60		'41x409A-70		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t_{HPC}	Cycle time, EDO page mode, read-write	20		25		30		ns
t_{PRWC}	Cycle time, EDO read-write	57		68		78		ns
t_{CSH}	Delay time, $\overline{RAS}$ active to $\overline{CAS}$ precharge	40		48		58		ns
t_{CHO}	Hold time, $\overline{OE}$ from $\overline{CAS}$	7		10		10		ns
t_{DOH}	Hold time, output from $\overline{CAS}$	5		5		5		ns
t_{CAS}	Pulse duration, $\overline{CAS}$ active (see Note 7)	8	10000	10	10000	12	10000	ns
t_{WPE}	Pulse duration, $\overline{W}$ active (output disable only)	7		7		7		ns
t_{OCH}	Setup time, $\overline{OE}$ before $\overline{CAS}$	8		10		10		ns
t_{CP}	Pulse duration, $\overline{CAS}$ precharge	8		10		10		ns
t_{OEP}	Precharge time, $\overline{OE}$	5		5		5		ns

EDO timing requirements over recommended ranges of supply voltage and operating free-air temperature (see Note 4)

		'42x409A/P-50		'42x409A/P-60		'42x409A/P-70		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t_{HPC}	Cycle time, EDO page mode, read-write	20		25		30		ns
t_{PRWC}	Cycle time, EDO read-write	57		68		78		ns
t_{CSH}	Delay time, $\overline{RAS}$ active to $\overline{CAS}$ precharge	40		48		58		ns
t_{CHO}	Hold time, $\overline{OE}$ from $\overline{CAS}$	7		10		10		ns
t_{DOH}	Hold time, output from $\overline{CAS}$	5		5		5		ns
t_{CAS}	Pulse duration, $\overline{CAS}$ active (see Note 7)	8	10000	10	10000	12	10000	ns
t_{WPE}	Pulse duration, $\overline{W}$ active (output disable only)	7		7		7		ns
t_{OCH}	Setup time, $\overline{OE}$ before $\overline{CAS}$	8		10		10		ns
t_{CP}	Pulse duration, $\overline{CAS}$ precharge	8		10		10		ns
t_{OEP}	Precharge time, $\overline{OE}$	5		5		5		ns

NOTES: 4: With ac parameters, it is assumed that t_T = 2 ns.
7. In a read-write cycle, t_{CWD} and t_{CWL} must be observed.

timing requirements over recommended ranges of supply voltage and operating free-air temperature (see Note 4)

		'41x409A-50		'41x409A-60		'41x409A-70		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t_{RC}	Cycle time, random read or write	84		104		124		ns
t_{RWC}	Cycle time, read-write	111		135		160		ns
t_{RASP}	Pulse duration, $\overline{RAS}$ active, fast page mode (see Note 8)	50	100 000	60	100 000	70	100 000	ns
t_{RAS}	Pulse duration, $\overline{RAS}$ active, non-page mode (see Note 8)	50	10 000	60	10 000	70	10 000	ns
t_{RP}	Pulse duration, $\overline{RAS}$ precharge	30		40		50		ns
t_{WP}	Pulse duration, write command	8		10		10		ns
t_{RASS}	Pulse duration, $\overline{RAS}$ active, self-refresh (see Note 9)	100		100		100		µs
t_{RPS}	Pulse duration, $\overline{RAS}$ precharge after self-refresh	90		110		130		ns
t_{ASC}	Setup time, column address	0		0		0		ns
t_{ASR}	Setup time, row address	0		0		0		ns
t_{DS}	Setup time, data in (see Note 10)	0		0		0		ns
t_{RCS}	Setup time, read command	0		0		0		ns
t_{CWL}	Setup time, write command before $\overline{CAS}$ precharge	8		10		12		ns
t_{RWL}	Setup time, write command before $\overline{RAS}$ precharge	8		10		12		ns
t_{WCS}	Setup time, write command before $\overline{CAS}$ active (early-write only)	0		0		0		ns
t_{WRP}	Setup time, $\overline{W}$ high before $\overline{RAS}$ low (CBR refresh only)	10		10		10		ns
t_{WTS}	Setup time, $\overline{W}$ low before $\overline{RAS}$ low (test mode only)	10		10		10		ns
t_{CSR}	Setup time, $\overline{CAS}$ referenced to $\overline{RAS}$ (CBR refresh only)	5		5		5		ns
t_{CAH}	Hold time, column address	8		10		12		ns
t_{DH}	Hold time, data in (see Note 10)	8		10		12		ns
t_{RAH}	Hold time, row address	8		10		10		ns
t_{RCH}	Hold time, read command referenced to $\overline{CAS}$ (see Note 11)	0		0		0		ns
t_{RRH}	Hold time, read command referenced to $\overline{RAS}$ (see Note 11)	0		0		0		ns
t_{WCH}	Hold time, write command during $\overline{CAS}$ active (early-write only)	8		10		12		ns
t_{ROH}	Hold time, $\overline{RAS}$ referenced to $\overline{OE}$	8		10		10		ns
t_{WRH}	Hold time, $\overline{W}$ high after $\overline{RAS}$ low (CBR refresh)	10		10		10		ns
t_{WTH}	Hold time, $\overline{W}$ low after $\overline{RAS}$ low (test mode only)	10		10		10		ns
t_{CHR}	Hold time, $\overline{CAS}$ referenced to $\overline{RAS}$ (CBR refresh only)	10		10		10		ns
t_{OEH}	Hold time, $\overline{OE}$ command	13		15		18		ns
t_{CHS}	Hold time, $\overline{CAS}$ active after $\overline{RAS}$ precharge (self-refresh)	–50		–50		–50		ns
t_{RHCP}	Hold time, $\overline{RAS}$ active from $\overline{CAS}$ precharge	28		35		40		ns

NOTES: 4. With ac parameters, it is assumed that t_T = 2 ns.
8. In a read-write cycle, t_{RWD} and t_{RWL} must be observed.
9. During the period of 10 µs $\leq t_{RASS} \leq$ 100 µs, the device is in transition state from normal operation mode to self-refresh mode.
10. Referenced to the later of $\overline{CAS}$ or $\overline{W}$ in write operations
11. Either t_{RRH} or t_{RCH} must be satisfied for a read cycle.

timing requirements over recommended ranges of supply voltage and operating free-air temperature (see Note 4) (continued)

			'41x409A-50		'41x409A-60		'41x409A-70		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
t_{AWD}	Delay time, column address to write command (read-write only)		42		49		57		ns
t_{CPW}	Delay time, $\overline{W}$ low after $\overline{xCAS}$ precharge (read-write only)		45		54		62		ns
t_{CRP}	Delay time, $\overline{CAS}$ precharge to $\overline{RAS}$		5		5		5		ns
t_{CWD}	Delay time, $\overline{CAS}$ to write command (read-write only)		30		34		40		ns
t_{OED}	Delay time, $\overline{OE}$ to data in		13		15		18		ns
t_{RAD}	Delay time, $\overline{RAS}$ to column address (see Note 12)		10	25	12	30	12	35	ns
t_{RAL}	Delay time, column address to $\overline{RAS}$ precharge		25		30		35		ns
t_{CAL}	Delay time, column address to $\overline{CAS}$ precharge		18		20		25		ns
t_{RCD}	Delay time, $\overline{RAS}$ to $\overline{CAS}$ (see Note 12)		12	37	14	45	14	52	ns
t_{RPC}	Delay time, $\overline{RAS}$ precharge to $\overline{CAS}$		5		5		5		ns
t_{RSH}	Delay time, $\overline{CAS}$ active to $\overline{RAS}$ precharge		8		10		12		ns
t_{RWD}	Delay time, $\overline{RAS}$ to write command (read-write only)		67		79		92		ns
t_{TAA}	Access time from address (test mode)		30		35		40		ns
t_{TCPA}	Access time, from column precharge (test mode)		35		40		45		ns
t_{TRAC}	Access time, from $\overline{RAS}$ (test mode)		55		65		75		ns
t_T	Transition time		2	30	2	30	2	30	ns
t_{REF}	Refresh time interval	'4x6409A		64		64		64	ms
		'426409AP		128		128		128	ms
		'4x7409A		32		32		32	ms
		'427409AP		128		128		128	ms

NOTES: 4. With ac parameters, it is assumed that t_T = 2 ns.
12. The maximum value is specified only to ensure access time.

timing requirements over recommended ranges of supply voltage and operating free-air temperature (see Note 4)

		'42x409A/P-50		'42x409A/P-60		'42x409A/P-70		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
t_{RC}	Cycle time, random read or write	84		104		124		ns
t_{RWC}	Cycle time, read-write	111		135		160		ns
t_{RASP}	Pulse duration, $\overline{RAS}$ active, fast page mode (see Note 8)	50	100 000	60	100 000	70	100 000	ns
t_{RAS}	Pulse duration, $\overline{RAS}$ active, non-page mode (see Note 8)	50	10 000	60	10 000	70	10 000	ns
t_{RP}	Pulse duration, $\overline{RAS}$ precharge	30		40		50		ns
t_{WP}	Pulse duration, write command	8		10		10		ns
t_{RASS}	Pulse duration, $\overline{RAS}$ active, self-refresh (see Note 9)	100		100		100		µs
t_{RPS}	Pulse duration, $\overline{RAS}$ precharge after self-refresh	90		110		130		ns
t_{ASC}	Setup time, column address	0		0		0		ns
t_{ASR}	Setup time, row address	0		0		0		ns
t_{DS}	Setup time, data in (see Note 10)	0		0		0		ns
t_{RCS}	Setup time, read command	0		0		0		ns
t_{CWL}	Setup time, write command before $\overline{CAS}$ precharge	8		10		12		ns
t_{RWL}	Setup time, write command before $\overline{RAS}$ precharge	8		10		12		ns
t_{WCS}	Setup time, write command before $\overline{CAS}$ active (early-write only)	0		0		0		ns
t_{WRP}	Setup time, $\overline{W}$ high before $\overline{RAS}$ low (CBR refresh only)	10		10		10		ns
t_{WTS}	Setup time, $\overline{W}$ low before $\overline{RAS}$ low (test mode only)	10		10		10		ns
t_{CSR}	Setup time, $\overline{CAS}$ referenced to $\overline{RAS}$ (CBR refresh only)	5		5		5		ns
t_{CAH}	Hold time, column address	8		10		12		ns
t_{DH}	Hold time, data in (see Note 10)	8		10		12		ns
t_{RAH}	Hold time, row address	8		10		10		ns
t_{RCH}	Hold time, read command referenced to $\overline{CAS}$ (see Note 11)	0		0		0		ns
t_{RRH}	Hold time, read command referenced to $\overline{RAS}$ (see Note 11)	0		0		0		ns
t_{WCH}	Hold time, write command during $\overline{CAS}$ active (early-write only)	8		10		12		ns
t_{ROH}	Hold time, $\overline{RAS}$ referenced to $\overline{OE}$	8		10		10		ns
t_{WRH}	Hold time, $\overline{W}$ high after $\overline{RAS}$ low (CBR refresh)	10		10		10		ns
t_{WTH}	Hold time, $\overline{W}$ low after $\overline{RAS}$ low (test mode only)	10		10		10		ns
t_{CHR}	Hold time, $\overline{CAS}$ referenced to $\overline{RAS}$ (CBR refresh only)	10		10		10		ns
t_{OEH}	Hold time, $\overline{OE}$ command	13		15		18		ns
t_{CHS}	Hold time, $\overline{CAS}$ active after $\overline{RAS}$ precharge (self-refresh)	–50		–50		–50		ns
t_{RHCP}	Hold time, $\overline{RAS}$ active from $\overline{CAS}$ precharge	28		35		40		ns

NOTES: 4. With ac parameters, it is assumed that t_T = 2 ns.
8. In a read-write cycle, t_{RWD} and t_{RWL} must be observed.
9. During the period of 10 µs $\leq t_{RASS} \leq$ 100 µs, the device is in transition state from normal operation mode to self-refresh mode.
10. Referenced to the later of $\overline{CAS}$ or $\overline{W}$ in write operations
11. Either t_{RRH} or t_{RCH} must be satisfied for a read cycle.

ADVANCE INFORMATION

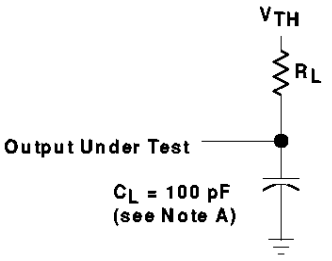
timing requirements over recommended ranges of supply voltage and operating free-air temperature (see Note 4) (continued)

			'42x409A/P-50		'42x409A/P-60		'42x409A/P-70		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	
t_{AWD}	Delay time, column address to write command (read-write only)		42		49		57		ns
t_{CPW}	Delay time, $\overline{W}$ low after $\overline{xCAS}$ precharge (read-write only)		45		54		62		ns
t_{CRP}	Delay time, $\overline{CAS}$ precharge to $\overline{RAS}$		5		5		5		ns
t_{CWD}	Delay time, $\overline{CAS}$ to write command (read-write only)		30		34		40		ns
t_{OED}	Delay time, $\overline{OE}$ to data in		13		15		18		ns
t_{RAD}	Delay time, $\overline{RAS}$ to column address (see Note 12)		10	25	12	30	12	35	ns
t_{RAL}	Delay time, column address to $\overline{RAS}$ precharge		25		30		35		ns
t_{CAL}	Delay time, column address to $\overline{CAS}$ precharge		18		20		25		ns
t_{RCD}	Delay time, $\overline{RAS}$ to $\overline{CAS}$ (see Note 12)		12	37	14	45	14	52	ns
t_{RPC}	Delay time, $\overline{RAS}$ precharge to $\overline{CAS}$		5		5		5		ns
t_{RSH}	Delay time, $\overline{CAS}$ active to $\overline{RAS}$ precharge		8		10		12		ns
t_{RWD}	Delay time, $\overline{RAS}$ to write command (read-write only)		67		79		92		ns
t_{TAA}	Access time from address (test mode)		30		35		40		ns
t_{TCPA}	Access time, from column precharge (test mode)		35		40		45		ns
t_{TRAC}	Access time, from $\overline{RAS}$ (test mode)		55		65		75		ns
t_T	Transition time		2	30	2	30	2	30	ns
t_{REF}	Refresh time interval	'4x6409A		64		64		64	ms
		'426409AP		128		128		128	ms
		'4x7409A		32		32		32	ms
		'427409AP		128		128		128	ms

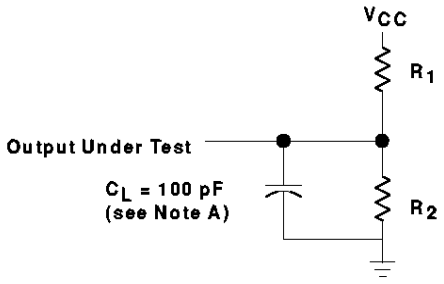
NOTES: 4. With ac parameters, it is assumed that t_T = 2 ns.
12. The maximum value is specified only to ensure access time.

ADVANCE INFORMATION

PARAMETER MEASUREMENT INFORMATION



(a) LOAD CIRCUIT



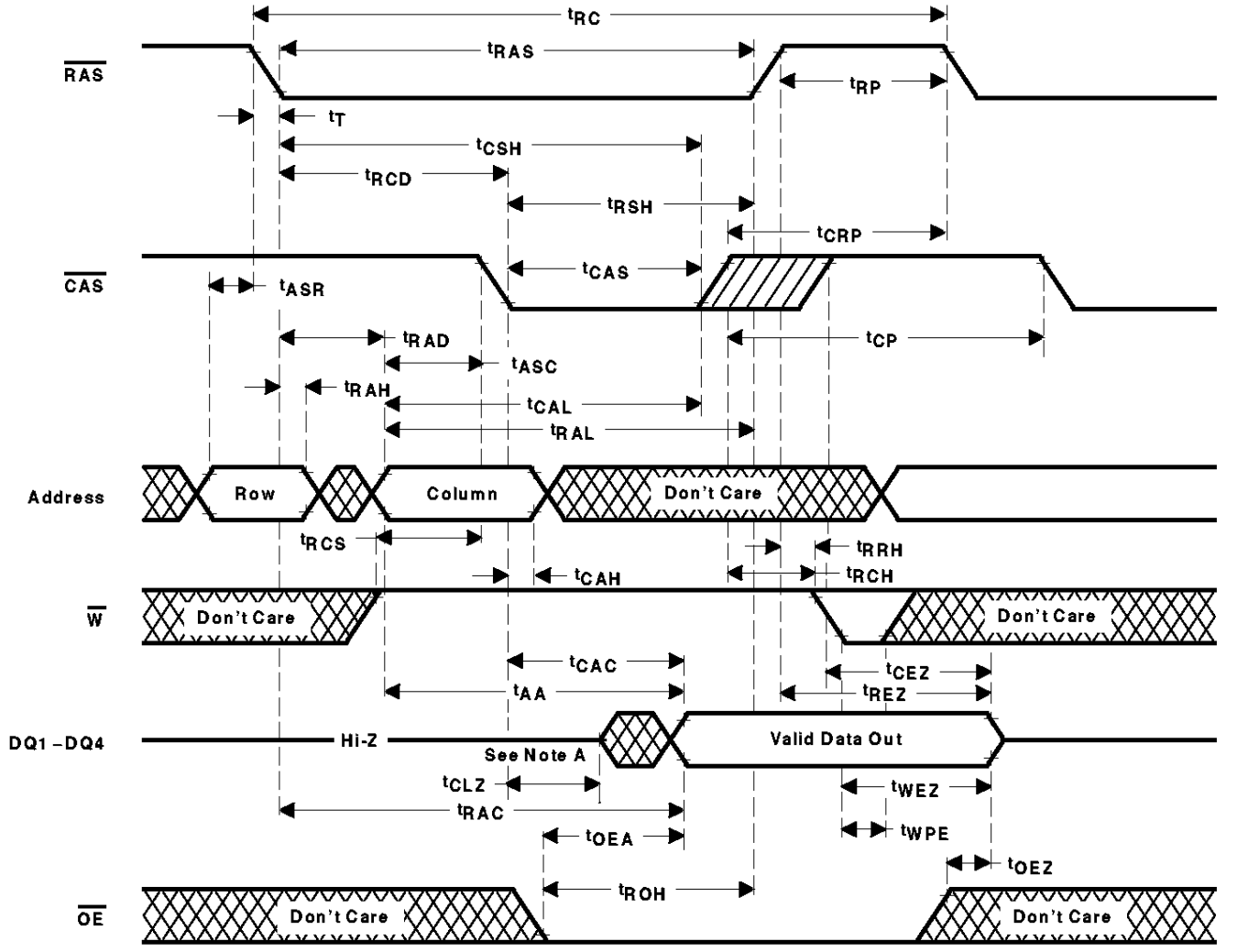
(b) ALTERNATE LOAD CIRCUIT

NOTE A: C_L includes probe and fixture capacitance.

DEVICE	V_{CC} (V)	R_1 (Ω)	R_2 (Ω)	V_{TH} (V)	R_L (Ω)
'41x409A	5	828	295	1.31	218
'42x409A/P	3.3	1178	868	1.4	500

Figure 2. Load Circuits for Timing Parameters

PARAMETER MEASUREMENT INFORMATION



NOTE A: Output can go from the high-impedance state to an invalid-data state prior to the specified access time.

Figure 3. Read-Cycle Timing

PARAMETER MEASUREMENT INFORMATION

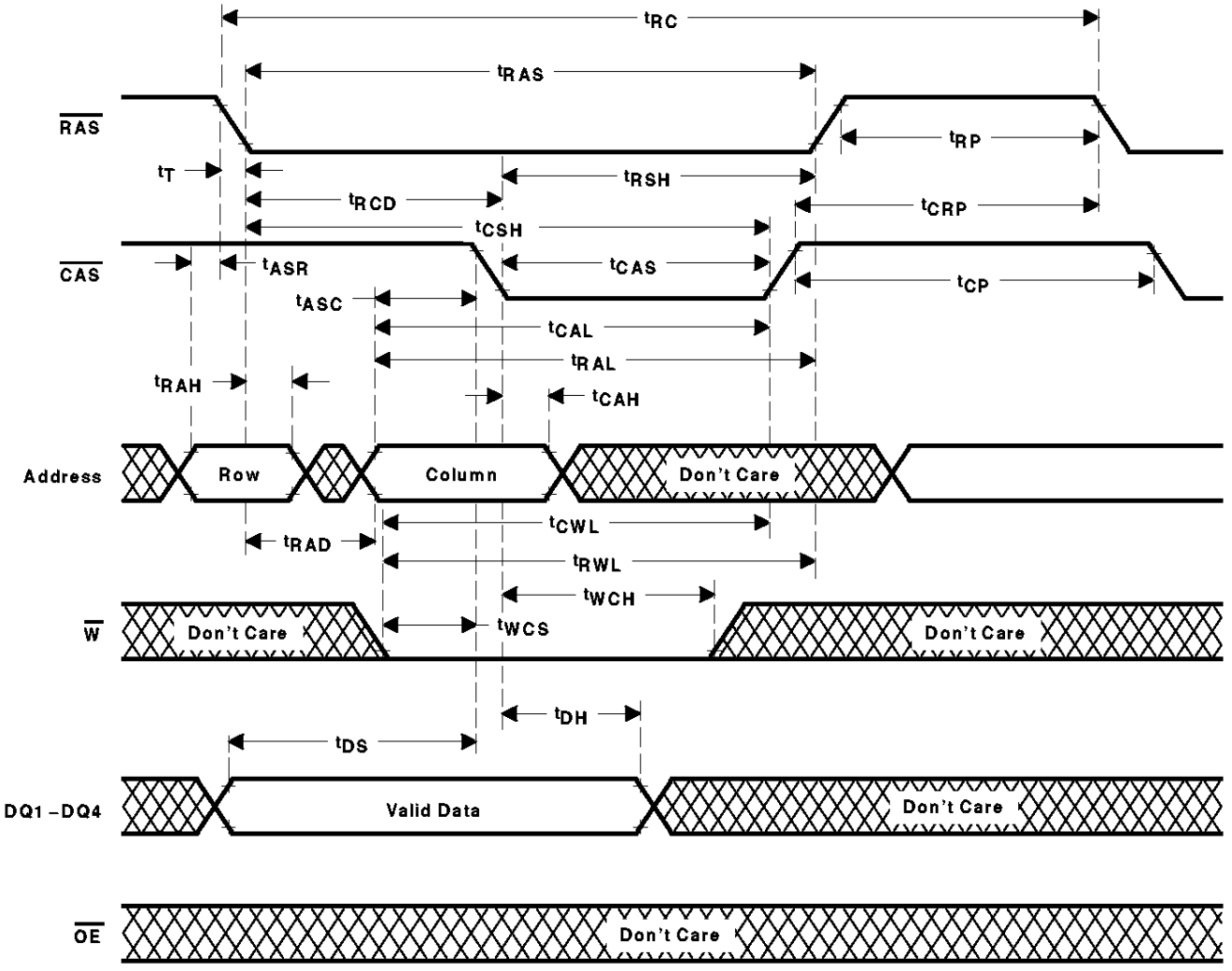


Figure 4. Early-Write-Cycle Timing

PARAMETER MEASUREMENT INFORMATION

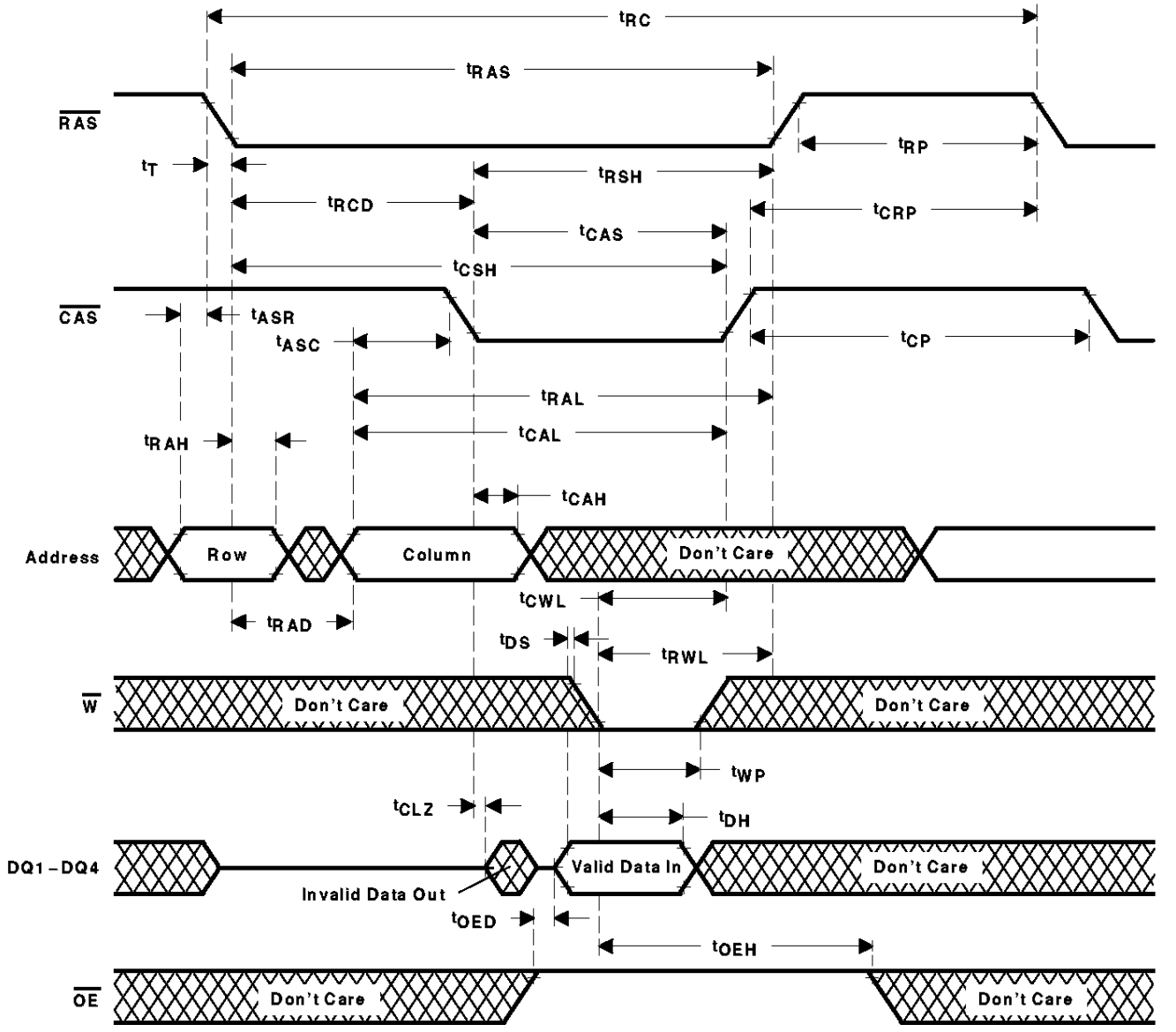
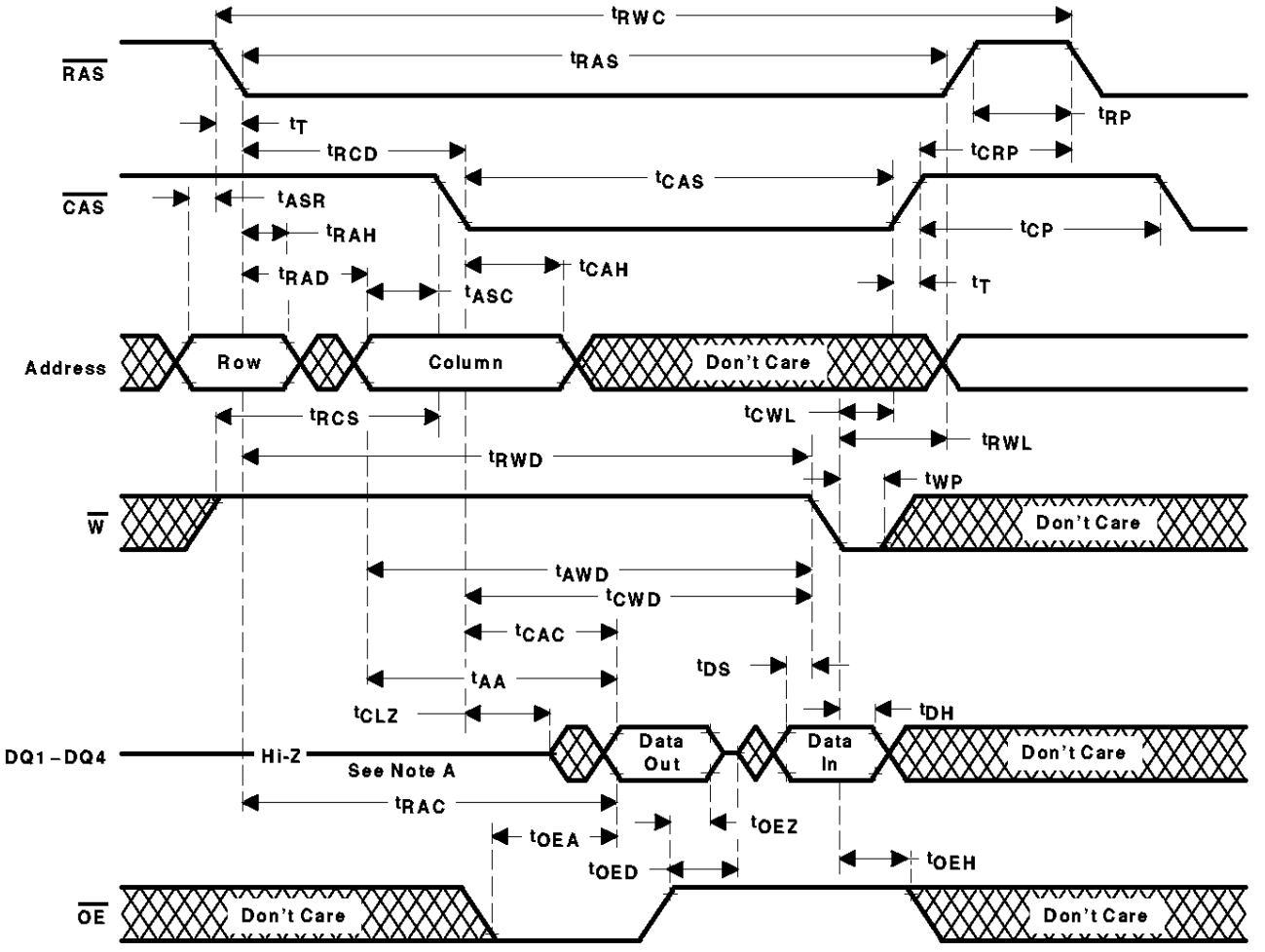


Figure 5. Write-Cycle Timing

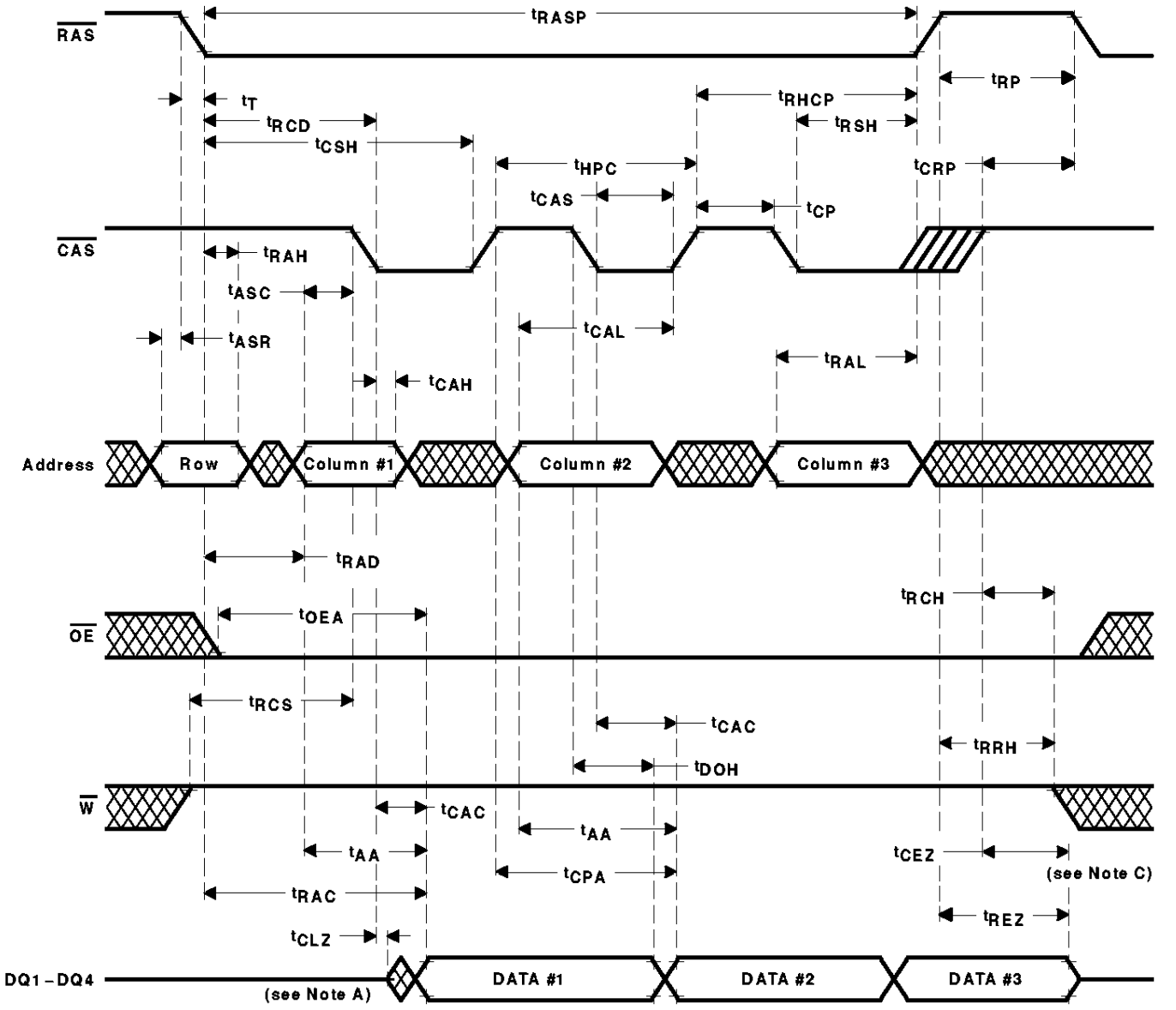
PARAMETER MEASUREMENT INFORMATION



NOTE A: Output can go from the high-impedance state to an invalid-data state prior to the specified access time.

Figure 6. Read-Write-Cycle Timing

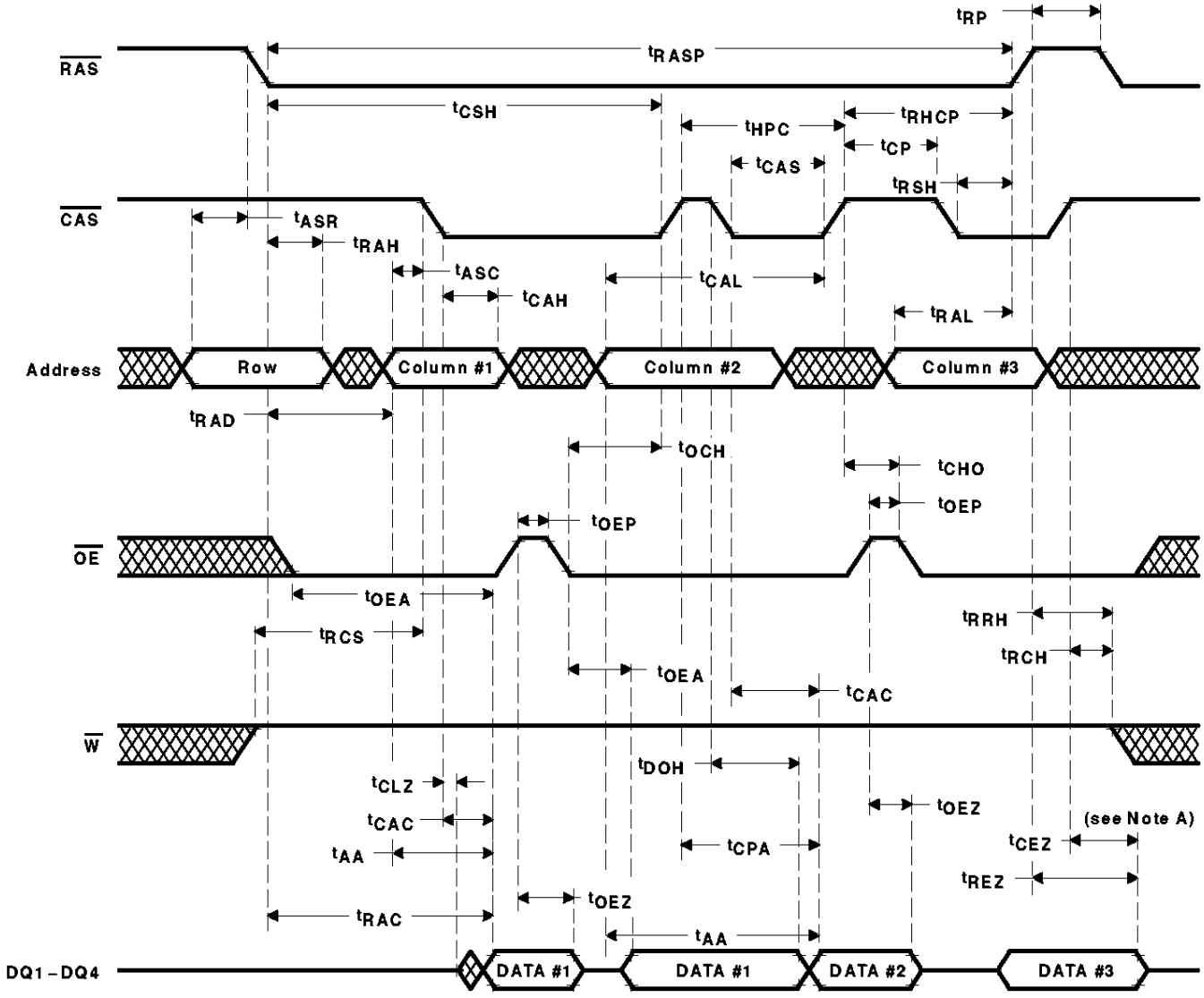
PARAMETER MEASUREMENT INFORMATION



NOTES: A. Output can go from the high-impedance state to an invalid-data state prior to the specified access time.
B. Access time is t_{CPA}-, t_{AA}-, or t_{CAC}-dependent.
C. Output is turned off by t_{CEZ} if $\overline{RAS}$ goes high during $\overline{CAS}$ low.

Figure 7. EDO Read Cycle

PARAMETER MEASUREMENT INFORMATION



NOTE A: Output is turned off by t_{CEZ} if $\overline{RAS}$ goes high during $\overline{CAS}$ low.

Figure 8. EDO Read-Cycle With $\overline{OE}$ Control

PARAMETER MEASUREMENT INFORMATION

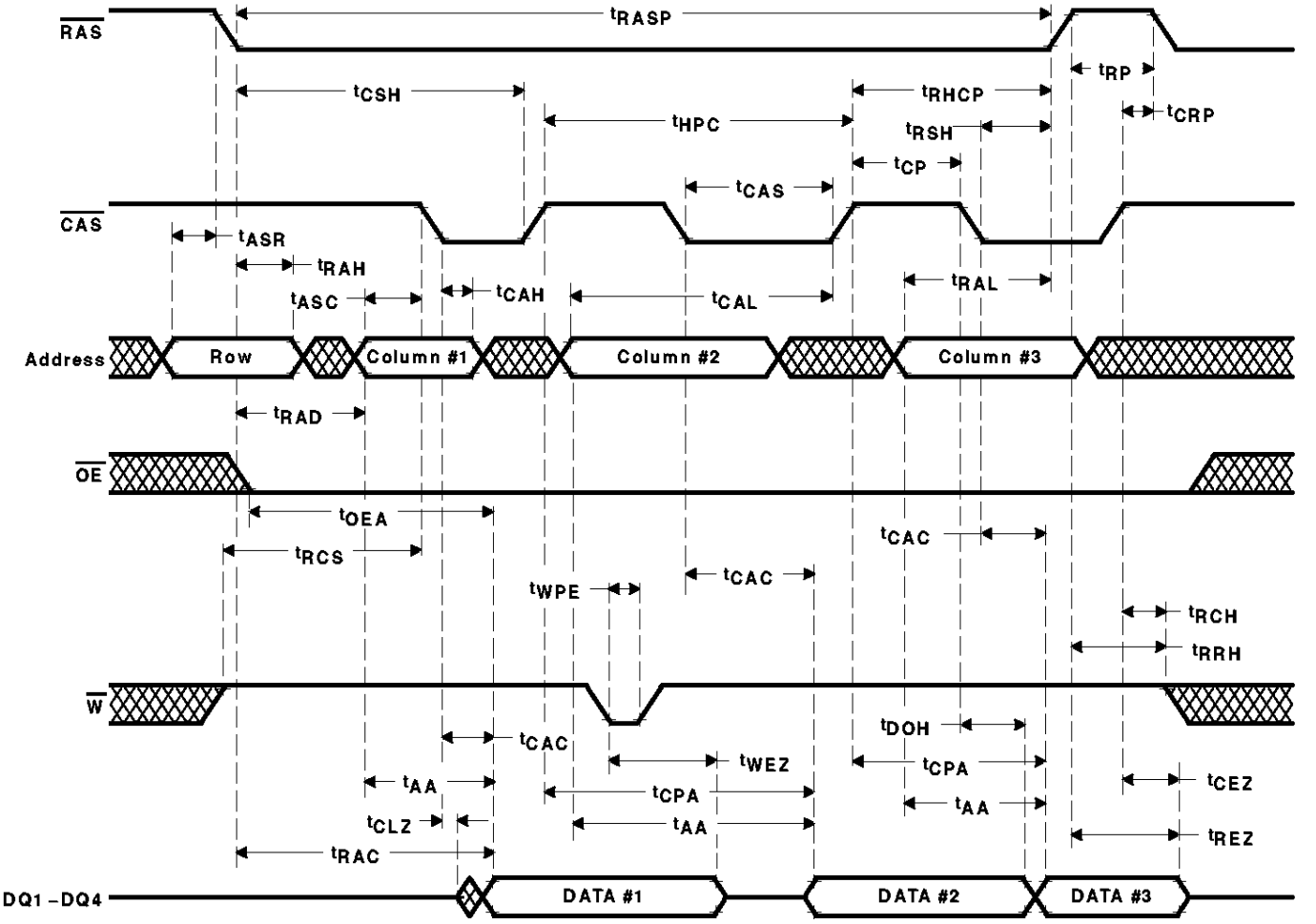
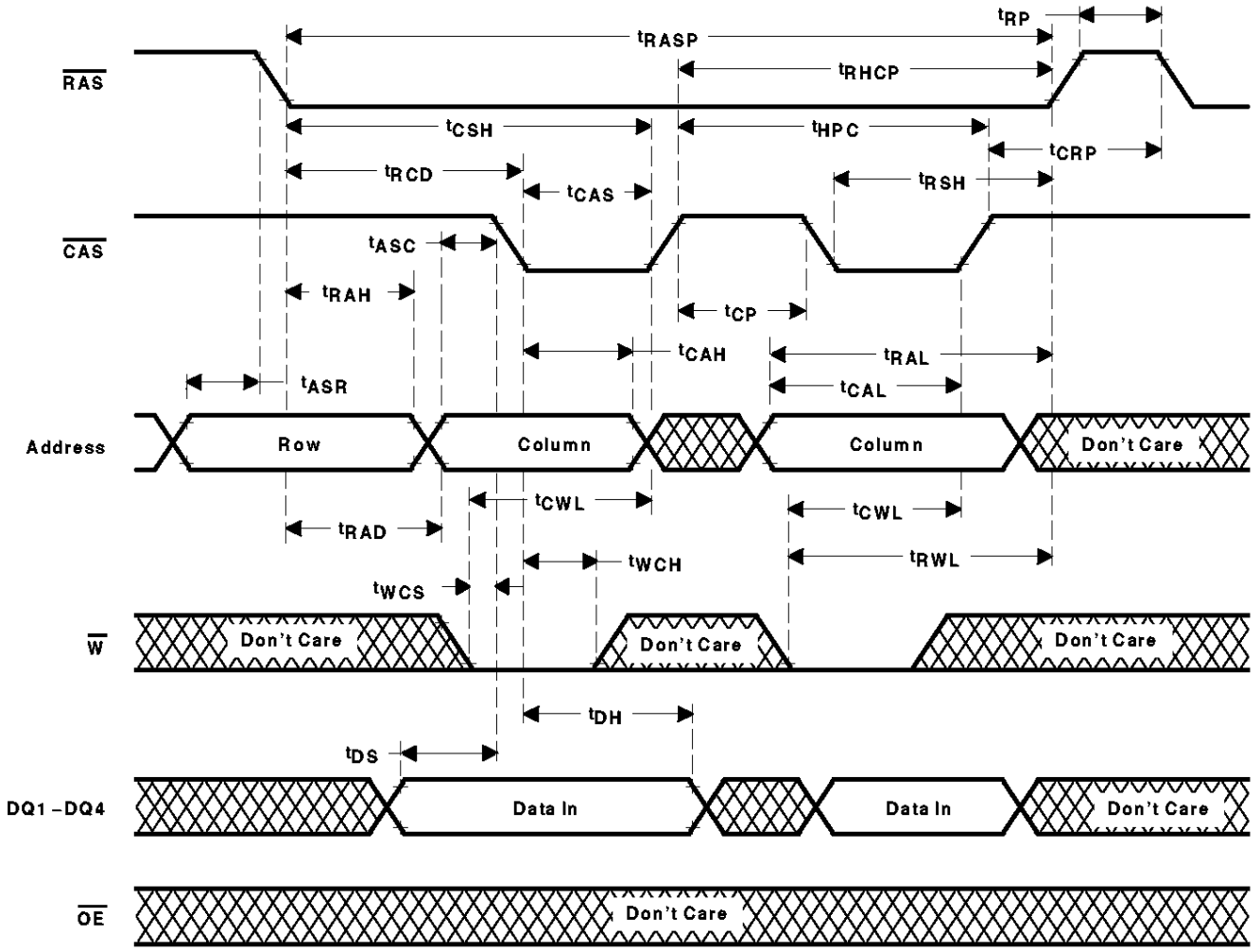


Figure 9. EDO Read-Cycle With $\overline{W}$ Control

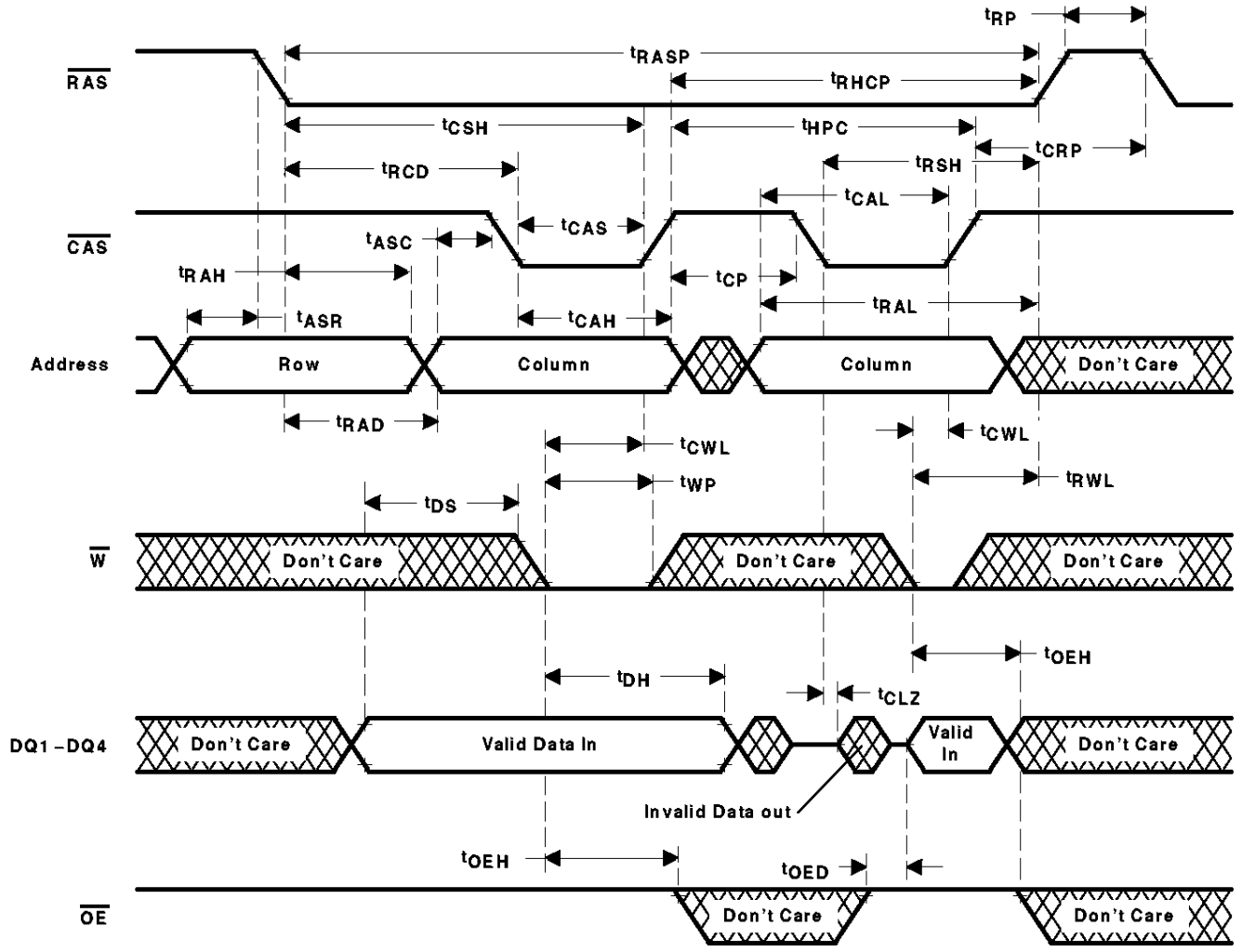
PARAMETER MEASUREMENT INFORMATION



NOTE A: A read cycle or a read-write cycle can be intermixed with write cycles as long as read and read-write timing specifications are not violated.

Figure 10. EDO Early-Write-Cycle Timing

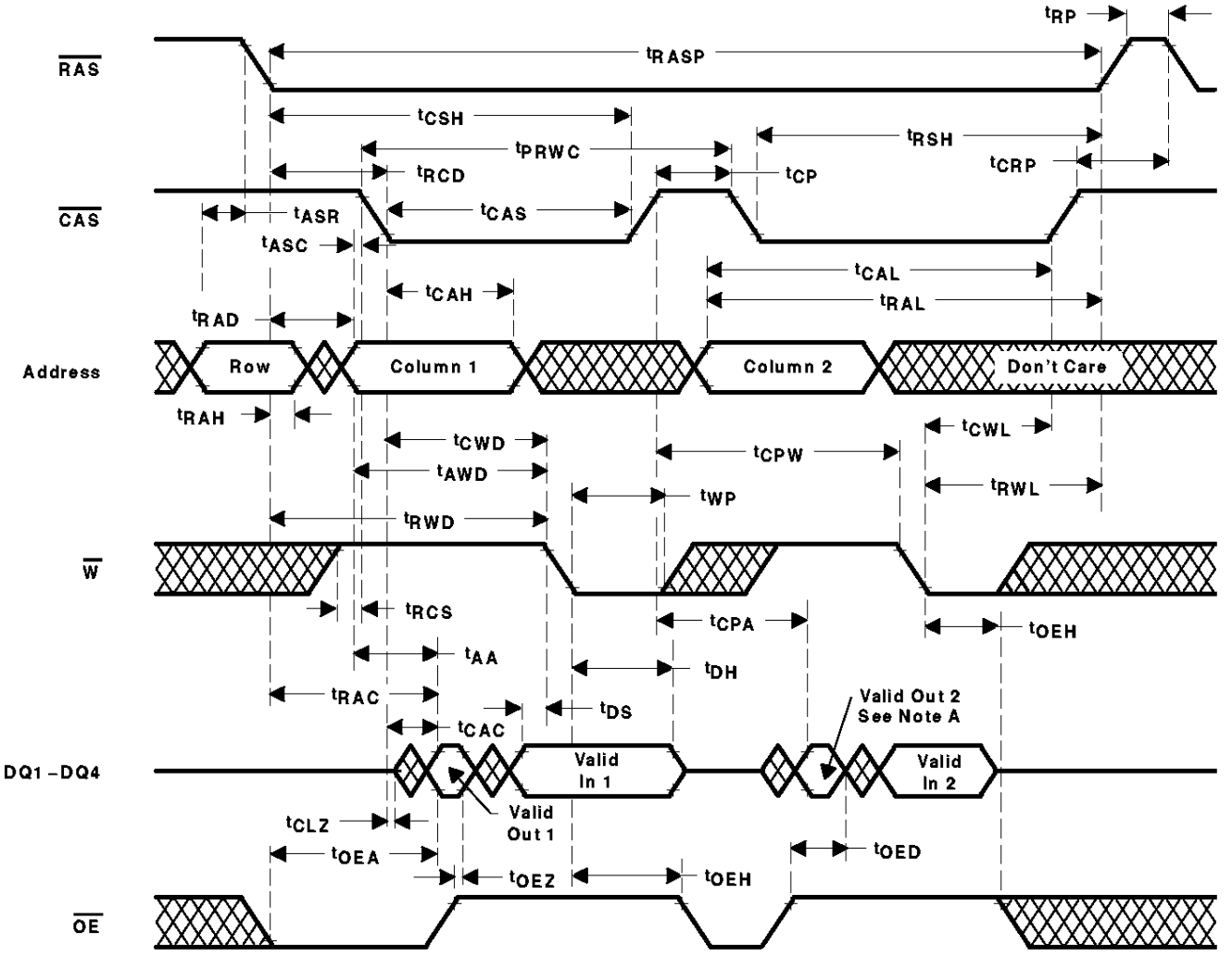
PARAMETER MEASUREMENT INFORMATION



NOTE A: A read cycle or a read-write cycle can be intermixed with write cycles as long as read and read-write timing specifications are not violated.

Figure 11. EDO Write-Cycle Timing

PARAMETER MEASUREMENT INFORMATION



NOTES: A. Output can go from the high-impedance state to an invalid-data state prior to the specified access time.
B. A read or write cycle can be intermixed with read-write cycles as long as the read- and write-timing specifications are not violated.

Figure 12. EDO Read-Write-Cycle Timing

PARAMETER MEASUREMENT INFORMATION

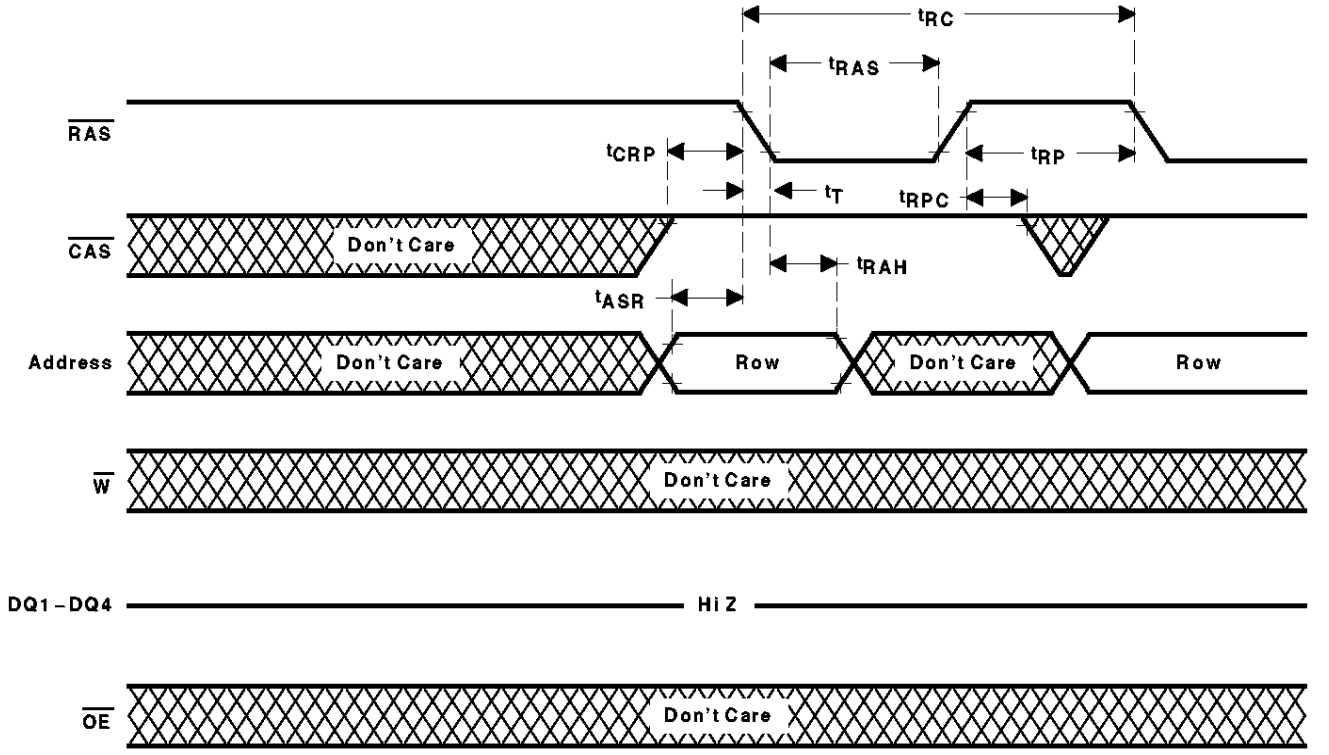


Figure 13. $\overline{\text{RAS}}$-Only Refresh-Cycle Timing

PARAMETER MEASUREMENT INFORMATION

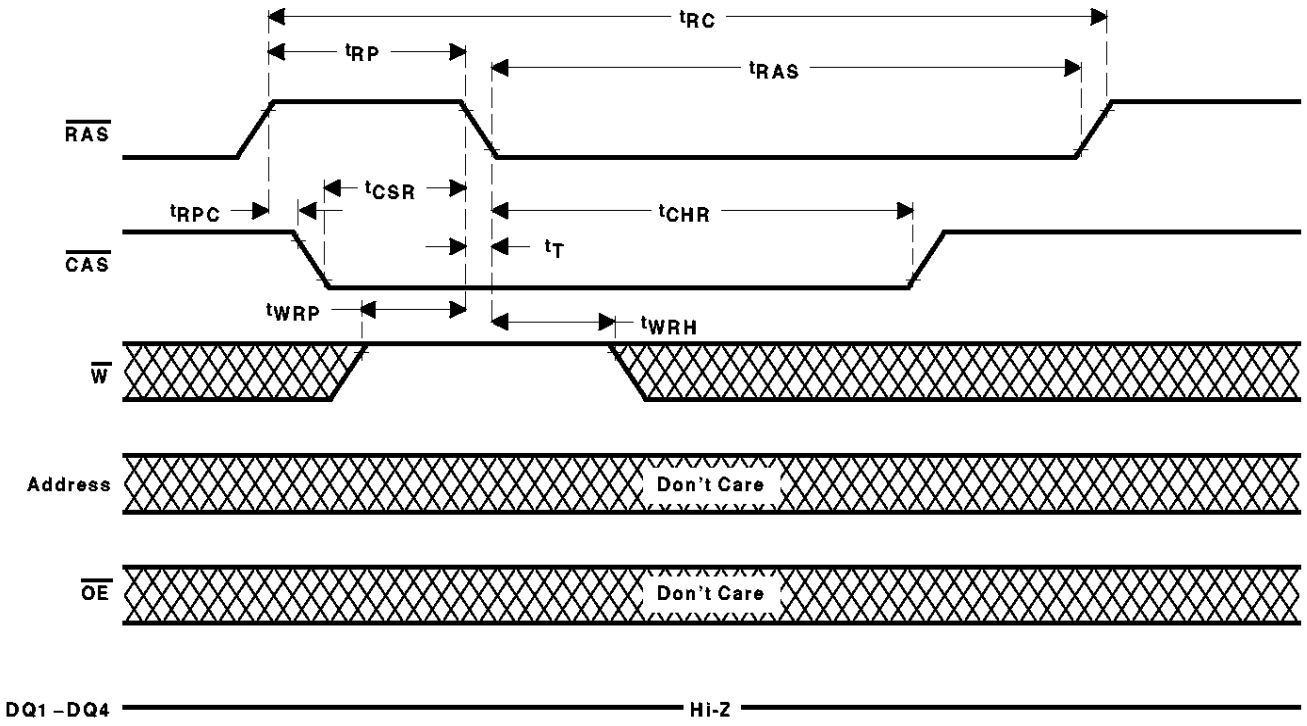


Figure 14. Automatic-CBR-Refresh-Cycle Timing

PARAMETER MEASUREMENT INFORMATION

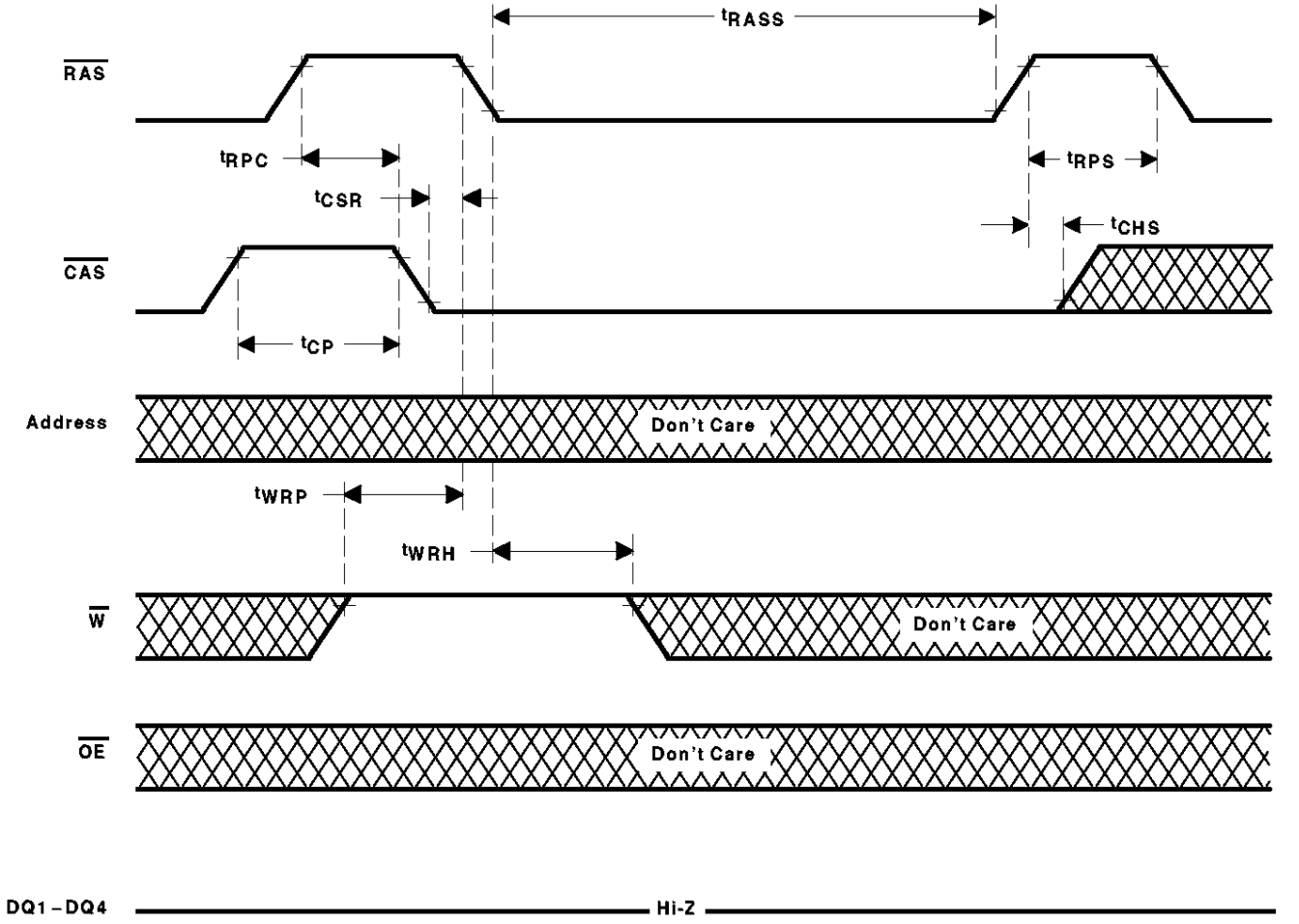


Figure 15. Self-Refresh-Cycle Timing

PARAMETER MEASUREMENT INFORMATION

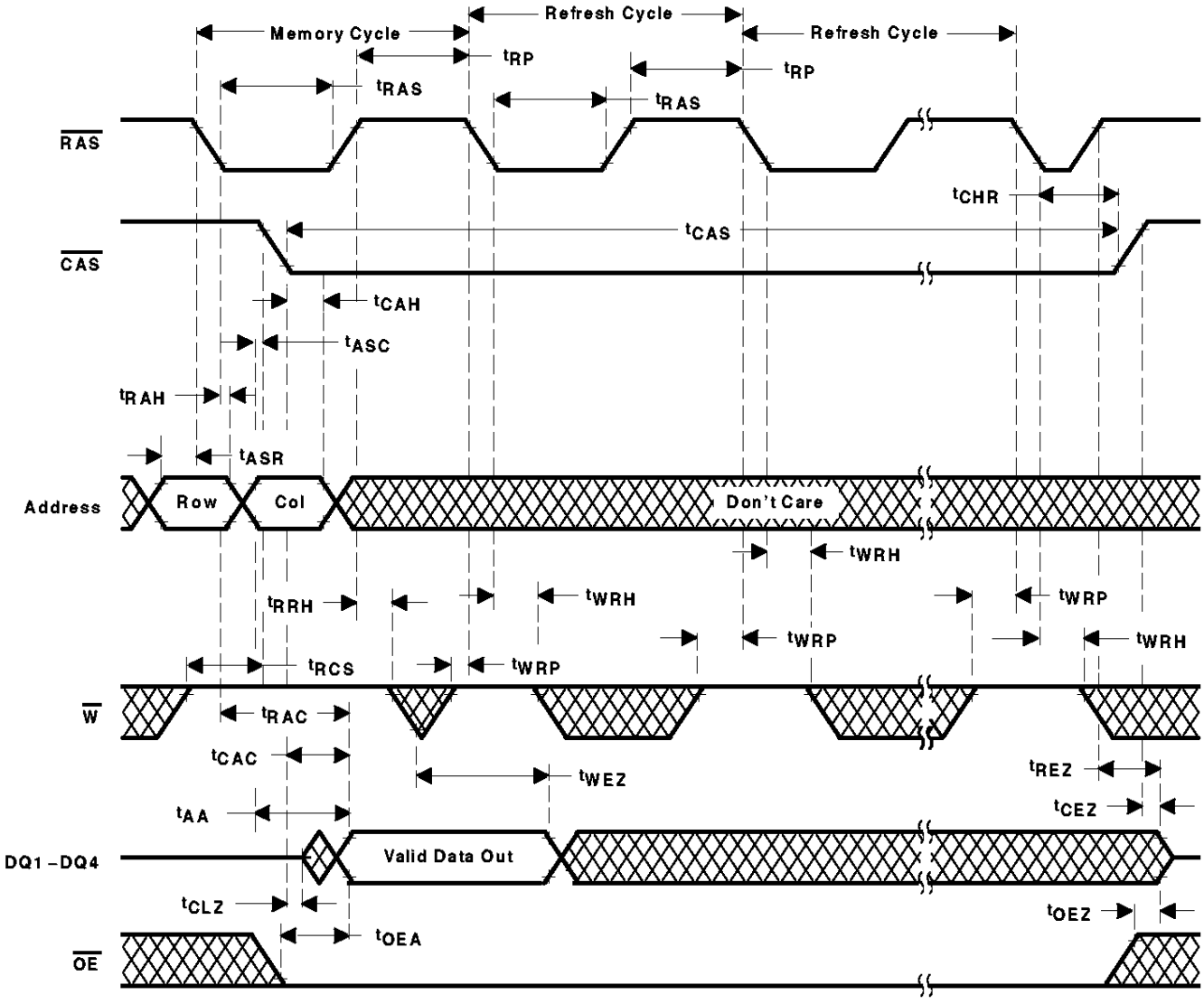


Figure 16. Hidden-Refresh-Cycle (Read) Timing

PARAMETER MEASUREMENT INFORMATION

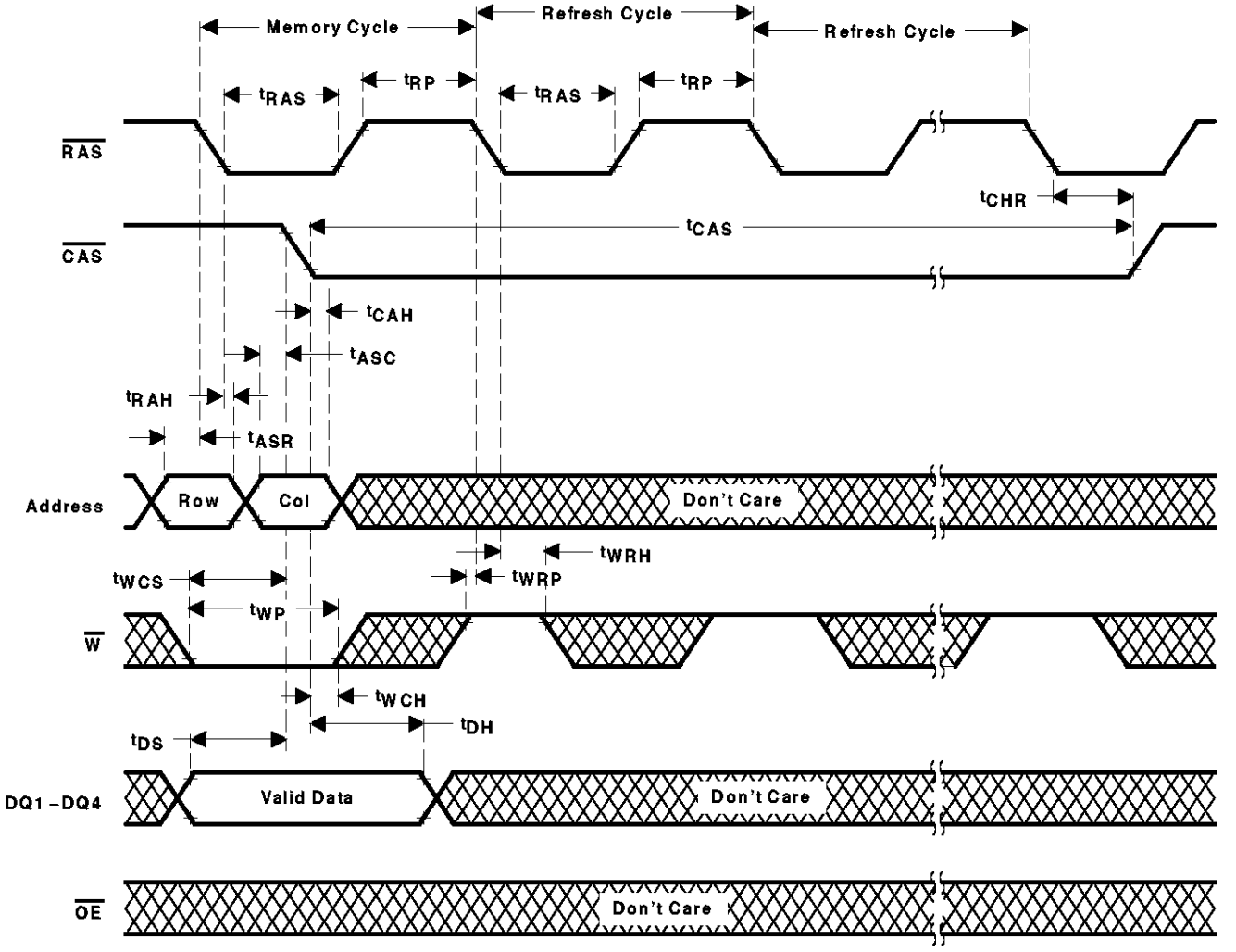


Figure 17. Hidden-Refresh-Cycle (Write) Timing

PARAMETER MEASUREMENT INFORMATION

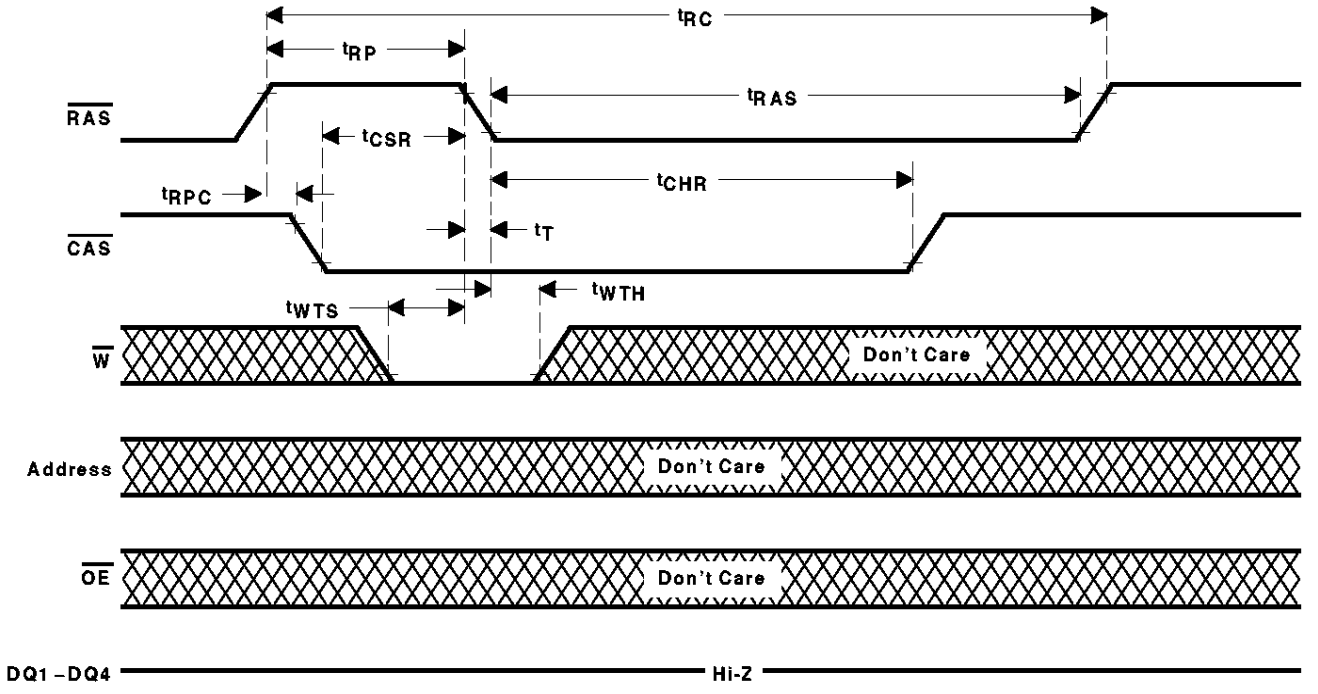


Figure 18. Test-Mode-Entry-Cycle Timing

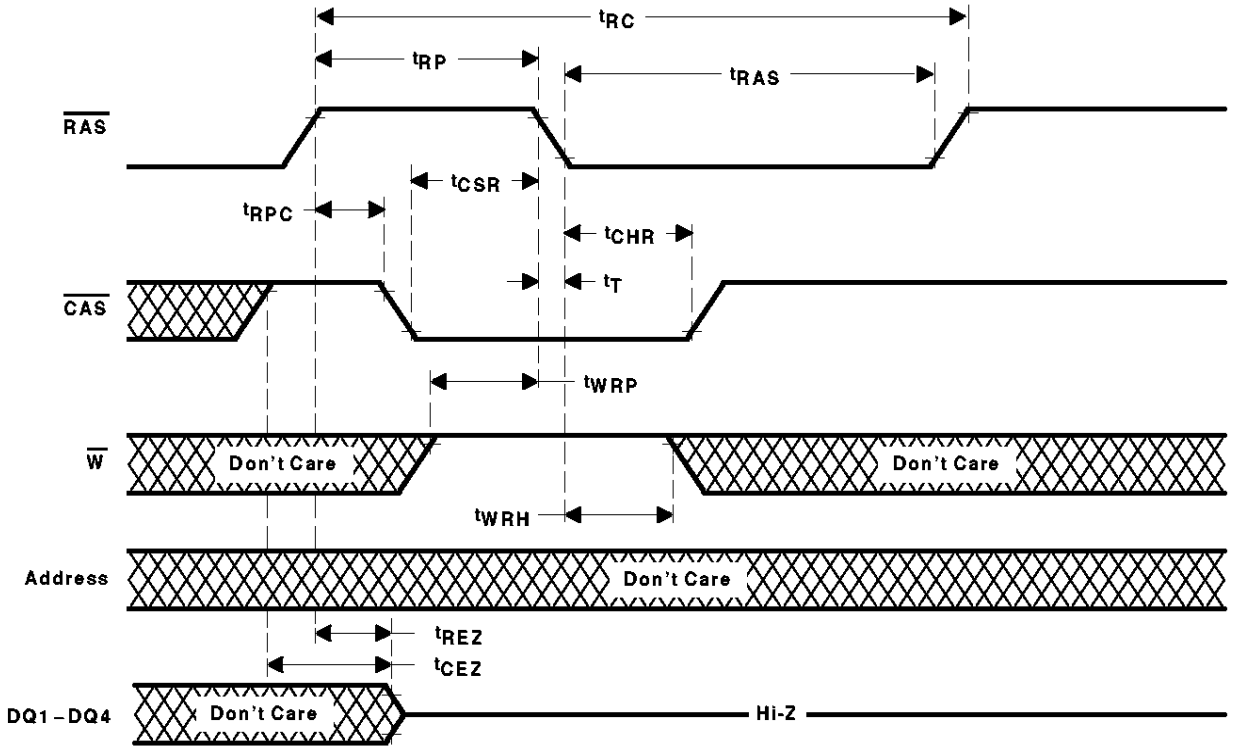
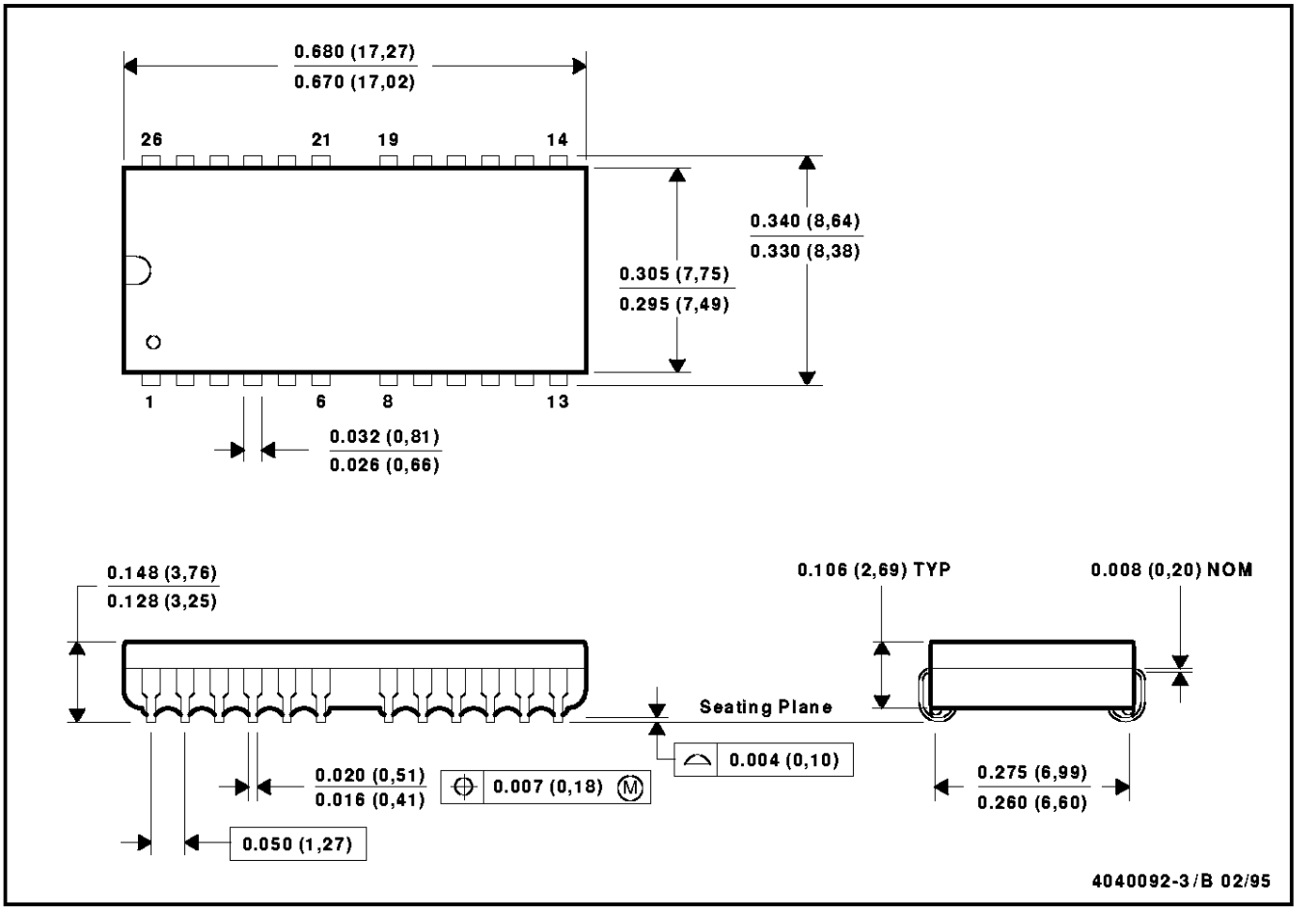


Figure 19. Test-Mode-Exit-Cycle CBR-Refresh-Cycle Timing

MECHANICAL DATA

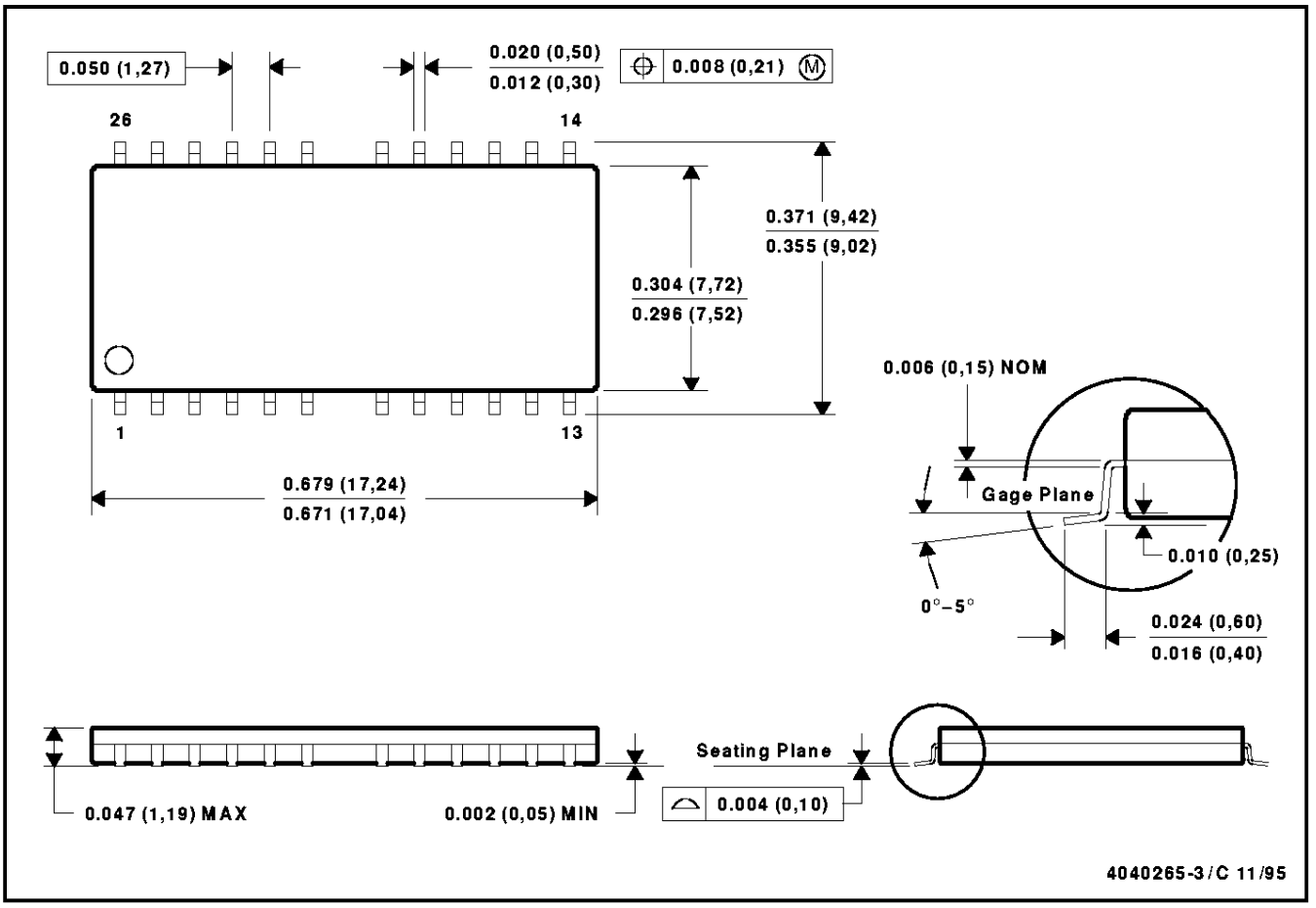
DJ (R-PDSO-J24/26) **PLASTIC SMALL-OUTLINE J-LEAD PACKAGE**



NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Plastic body dimensions do not include mold protrusion. Maximum mold protrusion is 0.005 (0,125).

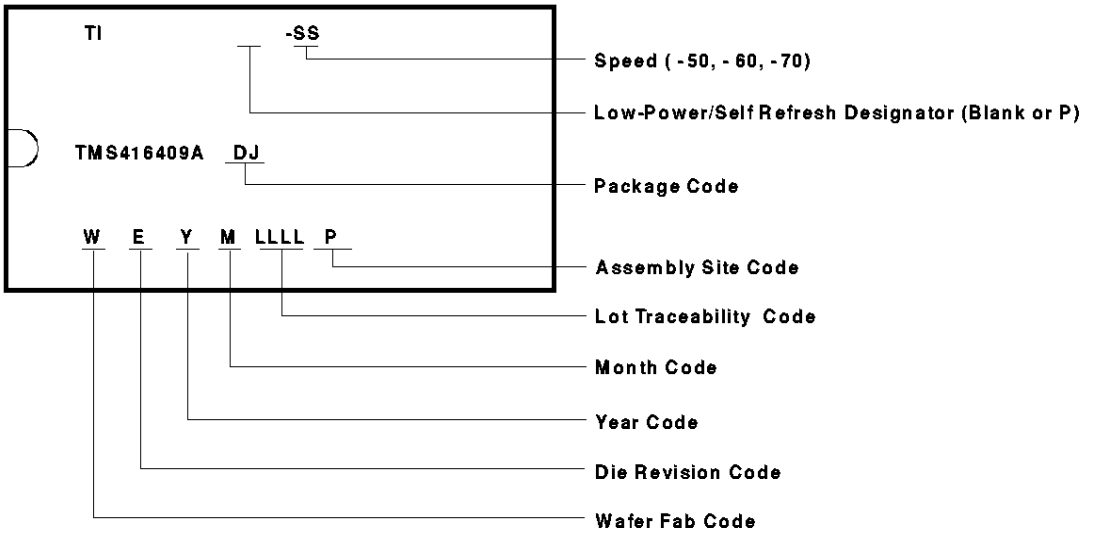
MECHANICAL DATA

DGA (R-PDSO-G24/26) **PLASTIC SMALL-OUTLINE PACKAGE**



NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion.

device symbolization (TMS416409A illustrated)



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