- **Organization . . . 4194304 by 16 Bits**
- **Single 3.3-V Power Supply (± 0.3 V Tolerance)**
- **Performance Ranges:**

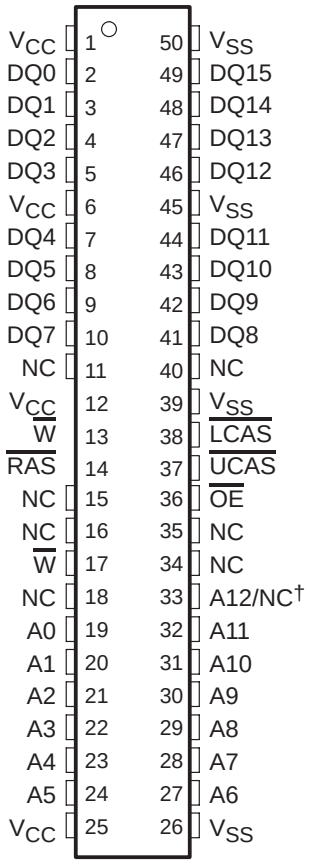
	ACCESS TIME t_{RAC} MAX	ACCESS TIME t_{CAC} MAX	ACCESS TIME t_{AA} MAX	EDO CYCLE t_{HPC} MIN
'46x169/P-50	50 ns	13 ns	25 ns	20 ns
'46x169/P-60	60 ns	15 ns	30 ns	25 ns

- **Extended-Data-Out (EDO) Operation**
- **$\overline{\text{xCAS}}$-Before-$\overline{\text{RAS}}$ (xCBR) Refresh**
- **Long Refresh Period and Self-Refresh Option (TMS46x169P)**
- **3-State Unlatched Output**
- **Low Power Dissipation**
- **High-Reliability Plastic 50-Lead 400-Mil-Wide Surface-Mount Thin Small-Outline Package (TSOP) (DGE Suffix)**
- **Operating Free-Air Temperature Range 0°C to 70°C**

AVAILABLE OPTIONS

DEVICE	POWER SUPPLY	SELF-REFRESH, BATTERY BACKUP	REFRESH CYCLES
TMS465169	3.3 V	—	4096 in 64 ms
TMS465169P	3.3 V	Yes	4096 in 128 ms

DGE PACKAGE
(TOP VIEW)



description

The and TMS465169 is a high-speed, 67108864-bit dynamic random-access memory (DRAM) device organized as 4194304 words of 16 bits. The TMS465169P is similar DRAM but includes a long refresh period and a self-refresh option. Both employ state-of-the-art technology for high performance, reliability, and low power at low cost.

PIN NOMENCLATURE

A0−A12†	Address Inputs
DQ0−DQ15	Data In/Data Out
$\overline{\text{LCAS}}$	Lower Column-Address Strobe
$\overline{\text{UCAS}}$	Upper Column-Address Strobe
NC	No Internal Connection
$\overline{\text{OE}}$	Output Enable
$\overline{\text{RAS}}$	Row-Address Strobe
V_{CC}	3.3-V Supply
V_{SS}	Ground
$\overline{\text{W}}$	Write Enable

† A12 is NC for TMS465169 and TMS465169P.

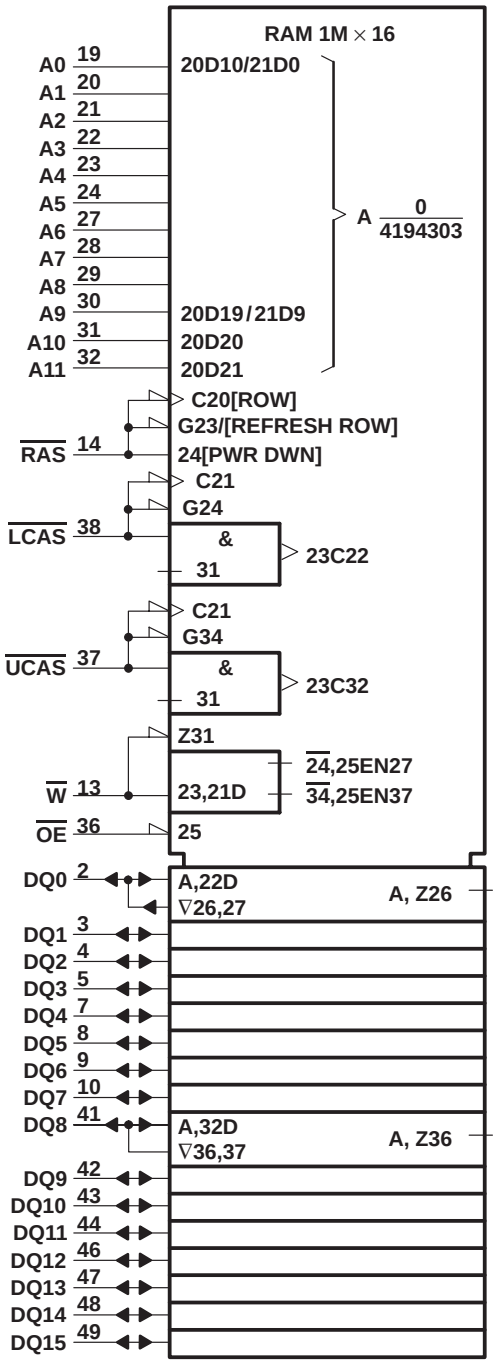
Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

description (continued)

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

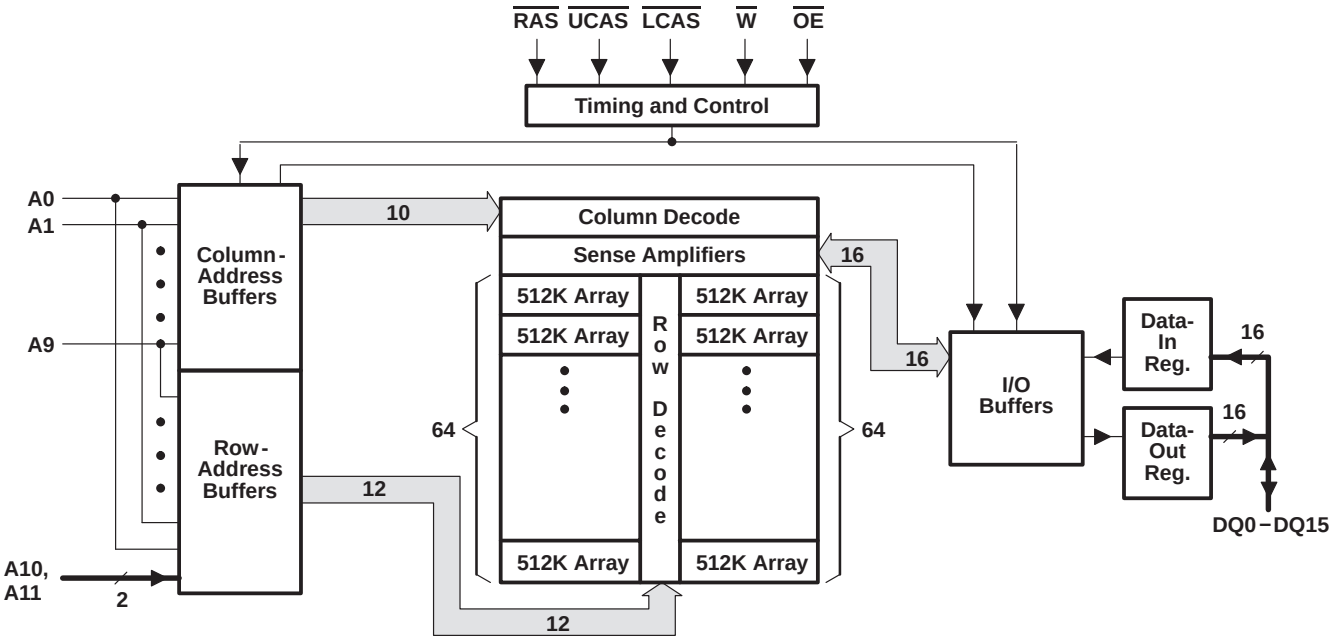
The TMS465169/P is offered in a 50-lead plastic surface-mount TSOP (DGE suffix). This package is designed for operation from 0°C to 70°C.

logic symbol (TMS465169 and TMS465169P)†



† This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.

functional block diagram (TMS465169 and TMS465169P)



operation

dual $\overline{\text{xCAS}}$

Two $\overline{\text{xCAS}}$ pins ($\overline{\text{LCAS}}$ and $\overline{\text{UCAS}}$) are provided to give independent byte control of the 16 data I/O pins (DQ0−DQ15), with $\overline{\text{LCAS}}$ corresponding to DQ0−DQ7 and $\overline{\text{UCAS}}$ corresponding to DQ8−DQ15. Each $\overline{\text{xCAS}}$ going low enables its corresponding DQx pins.

In write cycles, data-in setup and hold times (t_{DS} and t_{DH}), and write-command setup and hold times (t_{WCS}, t_{CWL}, and t_{WCH}) must be satisfied for each individual $\overline{\text{xCAS}}$ to ensure writing into the storage cells of the corresponding DQ pins.

extended data out

Extended data out (EDO) allows for 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 address multiplex is eliminated. The maximum number of columns that can be accessed is determined by t_{RASP}, the maximum $\overline{\text{RAS}}$ low time.

EDO does not enter the DQs into the high-impedance state with the rising edge of $\overline{\text{xCAS}}$. The output remains valid for the system to latch the data. After $\overline{\text{xCAS}}$ goes high, the DRAM decodes the next address. $\overline{\text{OE}}$ and $\overline{\text{W}}$ can be used to control the output impedance. Descriptions of $\overline{\text{OE}}$ and $\overline{\text{W}}$ further explain the benefit of EDO operation.

address: A0−A11 (TMS465169, TMS465169P)

Twenty-two address bits are required to decode each of the 4194304 storage cell locations. For the TMS465169 and TMS465169P, 12 row-address bits are set up on A0−A11 and latched on the chip by $\overline{\text{RAS}}$. Ten column-address bits are set up on A0−A9 and latched on the chip by the first $\overline{\text{xCAS}}$. All addresses must be stable on or before the falling edge of $\overline{\text{RAS}}$ and $\overline{\text{xCAS}}$. $\overline{\text{RAS}}$ is similar to a chip-enable in that it activates the sense amplifiers as well as the row decoder. $\overline{\text{xCAS}}$ is used as a chip-select, activating its corresponding output buffer and latching the address bits into the column-address buffers.

To latch in a new column address, both $\overline{\text{xCAS}}$ pins must be brought high. The column-precharge time (see parameter t_{CP}) is measured from the last $\overline{\text{xCAS}}$ rising edge to the first $\overline{\text{xCAS}}$ falling edge of the new cycle.

write enable ($\overline{\text{W}}$)

The read or write mode is selected through $\overline{\text{W}}$. A logic high on $\overline{\text{W}}$ selects the read mode and a logic low selects the write mode. The data input is disabled when the read mode is selected. When $\overline{\text{W}}$ goes low prior to $\overline{\text{xCAS}}$ (early write), data out remains in the high-impedance state for the entire cycle, permitting a write operation independent of the state of $\overline{\text{OE}}$. This permits early-write operations to be completed with $\overline{\text{OE}}$ grounded. If $\overline{\text{W}}$ goes low in an EDO read cycle, the DQ pins go into the high-impedance state as long as $\overline{\text{xCAS}}$ is high.

data in (DQ0−DQ15)

Data is written during a write or read-modify-write cycle. Depending on the mode of operation, the falling edge of $\overline{\text{xCAS}}$ or $\overline{\text{W}}$ strobes data into the on-chip data latch. In an early-write cycle, $\overline{\text{W}}$ is brought low prior to an $\overline{\text{xCAS}}$ falling edge, and data is strobed into the on-chip data latch for the corresponding DQ pins with setup and hold times referenced to this $\overline{\text{xCAS}}$ signal.

In a delayed-write or read-modify-write cycle, $\overline{\text{xCAS}}$ is already low and data is strobed in by $\overline{\text{W}}$ with setup and hold times referenced to this signal. In this cycle, $\overline{\text{OE}}$ must be high to bring the output buffers to the high-impedance state prior to impressing data on the I/O lines (see parameter t_{OED}).

data out (DQ0−DQ15)

Data out is the same polarity as data in. The output is in the high-impedance (floating) state until $\overline{\text{xCAS}}$ and $\overline{\text{OE}}$ are brought low. In a read cycle, the output becomes valid after the access time interval t_{CAC} (which begins with the negative transition of $\overline{\text{xCAS}}$) as long as t_{RAC} and t_{AA} are satisfied. The delay time from $\overline{\text{xCAS}}$ low to valid data out is measured from each individual $\overline{\text{xCAS}}$ to its corresponding DQx pin.

output enable ($\overline{\text{OE}}$)

$\overline{\text{OE}}$ controls the impedance of the output buffers. While $\overline{\text{xCAS}}$ and $\overline{\text{RAS}}$ are low and $\overline{\text{W}}$ is high, $\overline{\text{OE}}$ can be brought low or high and the DQs transition between valid data and high impedance. There are two methods for placing the DQs into the high-impedance state and keeping them in that state during $\overline{\text{xCAS}}$ high time by using $\overline{\text{OE}}$. The first method is to transition $\overline{\text{OE}}$ high before $\overline{\text{xCAS}}$ transitions high and to keep $\overline{\text{OE}}$ high for t_{CHO} past the $\overline{\text{xCAS}}$ transition (see Figure 7). This disables the DQs and they remain in the high-impedance state, regardless of $\overline{\text{OE}}$, until $\overline{\text{xCAS}}$ falls again. The second method is to have $\overline{\text{OE}}$ low as $\overline{\text{xCAS}}$ transitions high. Then $\overline{\text{OE}}$ can pulse high for a minimum of t_{OEP} anytime during $\overline{\text{xCAS}}$ high time, disabling the DQs regardless of further transitions on $\overline{\text{OE}}$ until $\overline{\text{xCAS}}$ falls again (see Figure 7).

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

A refresh operation must be performed at least once every 64 ms (128 ms for TMS465169P) to retain data. This is achieved by strobing each of the 4096 rows for TMS465169/P. 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 both $\overline{\text{xCAS}}$ 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

Hidden refresh can be performed while maintaining valid data at the output pins. This is accomplished by holding $\overline{\text{xCAS}}$ 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.

$\overline{\text{xCAS}}$-before-$\overline{\text{RAS}}$ (xCBR) refresh

An xCBR refresh is achieved by bringing at least one $\overline{\text{xCAS}}$ 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 xCBR refresh cycles, $\overline{\text{xCAS}}$ can remain low while cycling $\overline{\text{RAS}}$. The external address is ignored and the refresh address is generated internally.

battery-backup refresh (TMS465169P)

A low-power battery-backup refresh mode that requires less than 250 μA of refresh current is available on the TMS465169P. Data integrity is maintained using xCBR 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).

self-refresh (TMS465169P)

The self-refresh mode is entered by dropping $\overline{\text{xCAS}}$ low prior to $\overline{\text{RAS}}$ going low. Then $\overline{\text{xCAS}}$ 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 xCBR counter is used to keep track of the address. To exit the self-refresh mode, both $\overline{\text{RAS}}$ and $\overline{\text{xCAS}}$ are brought high to satisfy t_{CHS}. Upon exiting self-refresh mode, a burst refresh (refresh of a full set of row addresses) must be executed before continuing with normal operation. The burst refresh ensures that the DRAM is completely 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 xCBR) cycle.

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

Supply voltage range, V_{CC} . . . . . − 0.5 V to 4.6 V
Voltage range on any pin (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

		’465169/P			UNIT
		MIN	NOM	MAX	
V_{CC}	Supply voltage	3	3.3	3.6	V
V_{SS}	Supply voltage		0		V
V_{IH}	High-level input voltage	2		V_{CC} + 0.3	V
V_{IL}	Low-level input voltage (see Note 2)	− 0.3		0.8	V
T_A	Operating free-air temperature	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.

TMS465169/P

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

PARAMETER		TEST CONDITIONS†		’465169/P-50		’465169/P-60		UNIT
				MIN	MAX	MIN	MAX	
V_{OH}	High-level output voltage	I_{OH} = − 2 mA	LVTTL	2.4		2.4		V
		I_{OH} = − 100 µA	LVCMOS	V_{CC} − 0.2		V_{CC} − 0.2		
V_{OL}	Low-level output voltage	I_{OL} = 2 mA	LVTTL		0.4		0.4	V
		I_{OL} = 100 µA	LVCMOS		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	µA
I_O	Output current (leakage)	V_{CC} = 3.6 V, V_O = 0 V to V_{CC}, $\overline{xCAS}$ high			± 10		± 10	µA
I_{CC1}‡§	Average read- or write-cycle current	V_{CC} = 3.6 V, Minimum cycle			130		110	mA
I_{CC2}	Average standby current	V_{IH} = 2 V (LVTTL), After one memory cycle, $\overline{RAS}$ and $\overline{xCAS}$ high	’465169		1.5		1.5	mA
		V_{IH} = 2 V (LVTTL), After one memory cycle, $\overline{RAS}$ and $\overline{xCAS}$ high	’465169P		1		1	mA
		V_{IH} = V_{CC} − 0.2 V (LVCMOS), After one memory cycle, $\overline{RAS}$ and $\overline{xCAS}$ high	’465169		500		500	µA
			’465169P		300		300	
I_{CC3}§	$\overline{RAS}$-only refresh, average refresh current	V_{CC} = 3.6 V, $\overline{RAS}$ cycling, Minimum cycle, $\overline{xCAS}$ high			130		110	mA
I_{CC4}‡¶	Average EDO current	V_{CC} = 3.6 V, $\overline{RAS}$ low, t_{HPC} = MIN, $\overline{xCAS}$ cycling			120		100	mA
I_{CC5}	Average CBR refresh current	V_{CC} = 3.6 V, Minimum cycle, $\overline{RAS}$ low after $\overline{CAS}$ low			130		110	mA
I_{CC6}#	Average self-refresh current	$\overline{xCAS}$ < 0.2 V, $\overline{RAS}$ < 0.2 V, Measured after t_{RASS} min			400		400	µA
I_{CC10}#	Average battery back-up operating current, xCBR 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			550		550	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 TMS465169P only

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−A12†		5	pF
$C_{i(OE)}$	Input capacitance, $\overline{OE}$		7	pF
$C_{i(RC)}$	Input capacitance, $\overline{xCAS}$ and $\overline{RAS}$		7	pF
$C_{i(W)}$	Input capacitance, $\overline{W}$		7	pF
C_O	Output capacitance‡		7	pF

† A12 is NC for TMS465169 and TMS465169P.
‡ $\overline{xCAS}$ and $\overline{OE}$ = V_{IH} to disable outputs
NOTE 3: V_{CC} = 3.3 V ± 0.3 V, 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		’465169/P-50		’465169/P-60		UNIT
		MIN	MAX	MIN	MAX	
t_{AA}	Access time from column address (see Note 5)		25		30	ns
t_{CAC}	Access time from $\overline{xCAS}$ (see Note 5)		13		15	ns
t_{CPA}	Access time from $\overline{xCAS}$ precharge (see Note 5)		28		35	ns
t_{RAC}	Access time from $\overline{RAS}$ (see Note 5)		50		60	ns
t_{OEA}	Access time from $\overline{OE}$ (see Note 5)		13		15	ns
t_{CLZ}	Delay time, $\overline{xCAS}$ to output in the low-impedance state	0		0		ns
t_{OEZ}	Output buffer turnoff delay from $\overline{OE}$ (see Note 6)	3	13	3	15	ns
t_{REZ}	Output buffer turnoff delay from $\overline{RAS}$ (see Note 6)	3	13	3	15	ns
t_{CEZ}	Output buffer turnoff delay from $\overline{xCAS}$ (see Note 6)	3	13	3	15	ns
t_{WEZ}	Output buffer turnoff delay from $\overline{W}$ (see Note 6)	3	13	3	15	ns

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

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

		’465169/P-50		’465169/P-60		UNIT
		MIN	MAX	MIN	MAX	
t_{HPC}	Cycle time, EDO page-mode read or write	20		25		ns
t_{PRWC}	Cycle time, EDO read-write	57		68		ns
t_{CSH}	Delay time, $\overline{RAS}$ active to $\overline{xCAS}$ precharge	40		48		ns
t_{CHO}	Hold time, $\overline{OE}$ from $\overline{xCAS}$	5		5		ns
t_{DOH}	Hold time, output from $\overline{xCAS}$ active	5		5		ns
t_{CAS}	Pulse duration, $\overline{xCAS}$ active (see Note 7)	8	10000	10	10000	ns
t_{WPE}	Pulse duration, $\overline{W}$ (output disable only)	5		5		ns
t_{CP}	Pulse duration, $\overline{xCAS}$ precharge	8		10		ns
t_{OCH}	Setup time, $\overline{OE}$ before $\overline{xCAS}$	5		5		ns
t_{OEP}	Precharge time, $\overline{OE}$ (output disable only)	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)

		'465169/P-50		'465169/P-60		UNIT
		MIN	MAX	MIN	MAX	
t_{RC}	Cycle time, read	84		104		ns
t_{RWC}	Cycle time, read-write	111		135		ns
t_{RASP}	Pulse duration, $\overline{RAS}$ active, page mode (see Note 8)	50	100 000	60	100 000	ns
t_{RAS}	Pulse duration, $\overline{RAS}$ active, nonpage mode (see Note 8)	50	10 000	60	10 000	ns
t_{RP}	Pulse duration, $\overline{RAS}$ precharge	30		40		ns
t_{WP}	Pulse duration, write command	8		10		ns
t_{ASC}	Setup time, column address	0		0		ns
t_{ASR}	Setup time, row address	0		0		ns
t_{DS}	Setup time, data in (see Note 9)	0		0		ns
t_{RCS}	Setup time, read command	0		0		ns
t_{CWL}	Setup time, write command before $\overline{xCAS}$ precharge	8		10		ns
t_{RWL}	Setup time, write command before $\overline{RAS}$ precharge	8		10		ns
t_{WCS}	Setup time, write command before $\overline{xCAS}$ active (early-write only)	0		0		ns
t_{WRP}	Setup time, write before $\overline{RAS}$ active (xCBR refresh only)	5		5		ns
t_{CSR}	Setup time, $\overline{xCAS}$ referenced to $\overline{RAS}$ (xCBR refresh only)	5		5		ns
t_{CAH}	Hold time, column address	8		10		ns
t_{DH}	Hold time, data in (see Note 9)	8		10		ns
t_{RAH}	Hold time, row address	8		10		ns
t_{RCH}	Hold time, read command referenced to $\overline{xCAS}$ (see Note 10)	0		0		ns
t_{RRH}	Hold time, read command referenced to $\overline{RAS}$ (see Note 10)	0		0		ns
t_{WCH}	Hold time, write command during $\overline{xCAS}$ active (early-write only)	8		10		ns
t_{RHCP}	Hold time, $\overline{RAS}$ active from $\overline{xCAS}$ precharge	28		35		ns
t_{OEH}	Hold time, $\overline{OE}$ command	13		15		ns
t_{ROH}	Hold time, $\overline{RAS}$ referenced to $\overline{OE}$	8		10		ns
t_{WRH}	Hold time, write after $\overline{RAS}$ active (xCBR refresh only)	8		10		ns
t_{CHS}	Hold time, $\overline{CAS}$ active after $\overline{RAS}$ precharge (self-refresh)	− 50		− 50		ns
t_{AWD}	Delay time, column address to write command (read-write only)	42		49		ns
t_{CHR}	Delay time, $\overline{xCAS}$ referenced to $\overline{RAS}$ (xCBR refresh only)	8		10		ns
t_{CRP}	Delay time, $\overline{xCAS}$ precharge to $\overline{RAS}$	5		5		ns
t_{CWD}	Delay time, $\overline{xCAS}$ to write command (read-write operation only)	30		34		ns

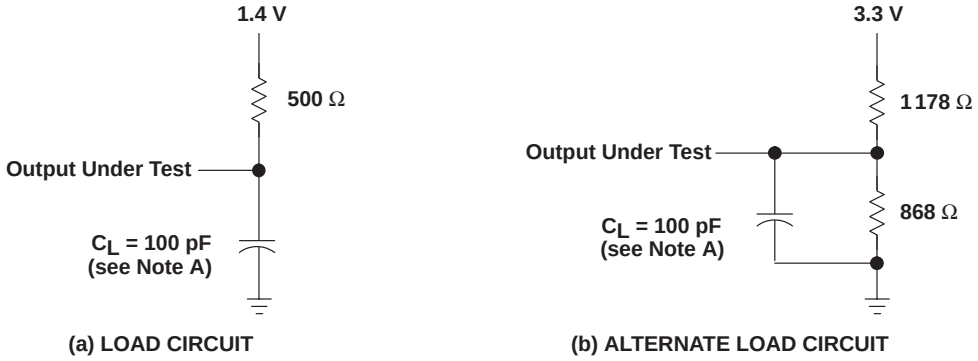
NOTES: 4. With ac parameters, it is assumed that t_T = 2 ns.
8. In a read-write cycle, t_{RWD} and t_{RWL} must be observed.
9. Referenced to the later of $\overline{xCAS}$ or $\overline{W}$ in write operations
10. Either t_{RRH} or t_{RCH} must be satisfied for a read cycle.

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

			’465169/P-50		’465169/P-60		UNIT
			MIN	MAX	MIN	MAX	
t_{OED}	Delay time, $\overline{OE}$ to data in		13		15		ns
t_{RAD}	Delay time, $\overline{RAS}$ to column address (see Note 11)		10	25	12	30	ns
t_{RAL}	Delay time, column address to $\overline{RAS}$ precharge		25		30		ns
t_{CAL}	Delay time, column address to $\overline{xCAS}$ precharge		15		18		ns
t_{RCD}	Delay time, $\overline{RAS}$ to $\overline{xCAS}$ (see Note 11)		12	37	14	45	ns
t_{RPC}	Delay time, $\overline{RAS}$ precharge to $\overline{xCAS}$		5		5		ns
t_{RSH}	Delay time, $\overline{xCAS}$ active to $\overline{RAS}$ precharge		8		10		ns
t_{RWD}	Delay time, $\overline{RAS}$ active to write command (read-write only)		67		79		ns
t_{CPW}	Delay time, $\overline{xCAS}$ precharge to write command (read-write only)		45		54		ns
t_{RASS}	Pulse duration, $\overline{RAS}$ active, self-refresh (see Note 12)		100		100		µs
t_{RPS}	Pulse duration, $\overline{RAS}$ precharge after self refresh		90		110		ns
t_{REF}	Refresh time interval	’465169		64		64	ms
		’465169P		128		128	ms
t_T	Transition time		1	50	1	50	ns

NOTES: 4. With ac parameters, it is assumed that t_T = 2 ns.
11. The maximum value is specified only to assure access time.
12. During the period of 10 µs ≤ t_{RASS} ≤ 100 µs, the device is in transition state from normal operational mode to self-refresh mode.

PARAMETER MEASUREMENT INFORMATION

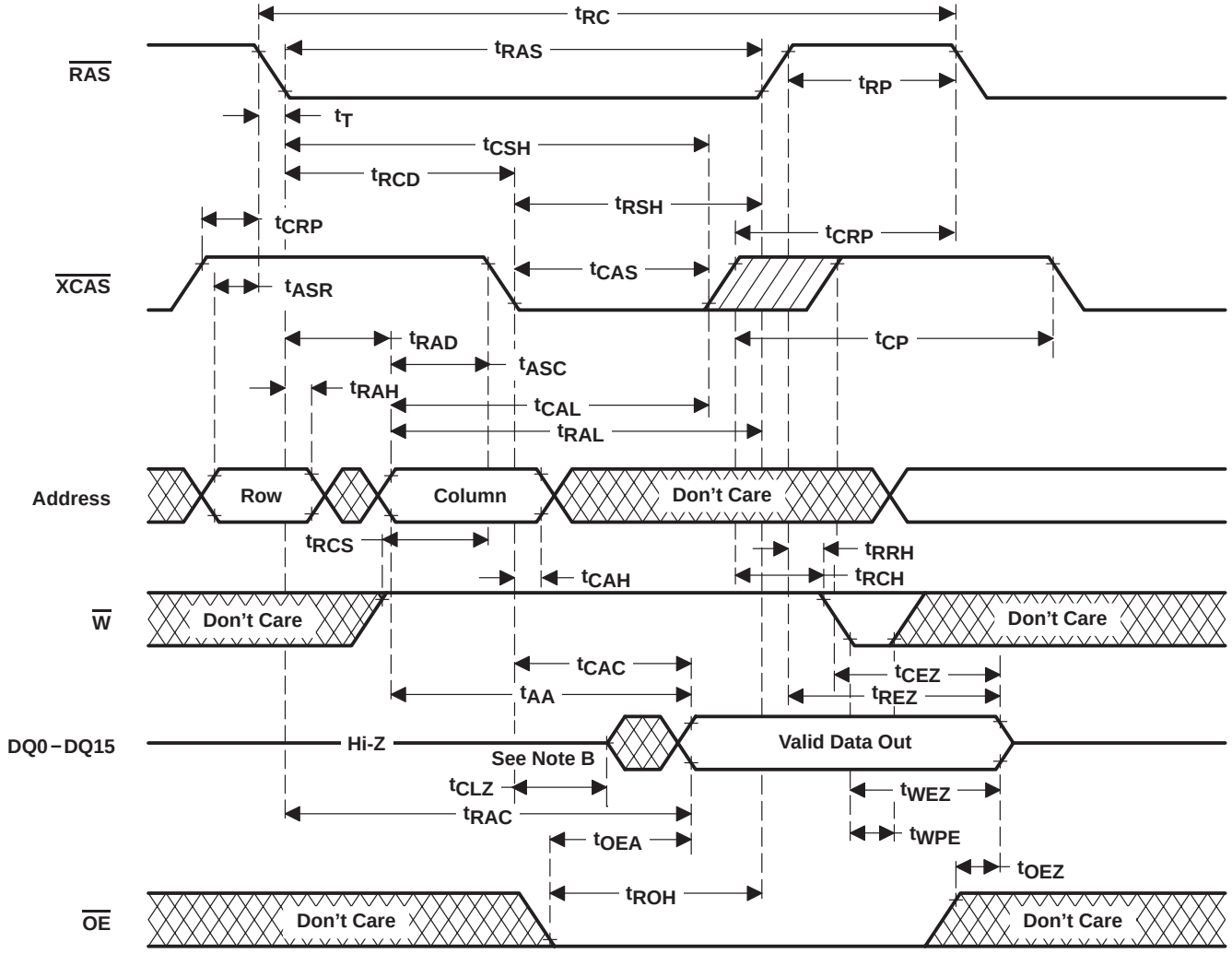


(a) LOAD CIRCUIT (b) ALTERNATE LOAD CIRCUIT

NOTE A: C_L includes probe and fixture capacitance.

Figure 1. Load Circuits for Timing Parameters

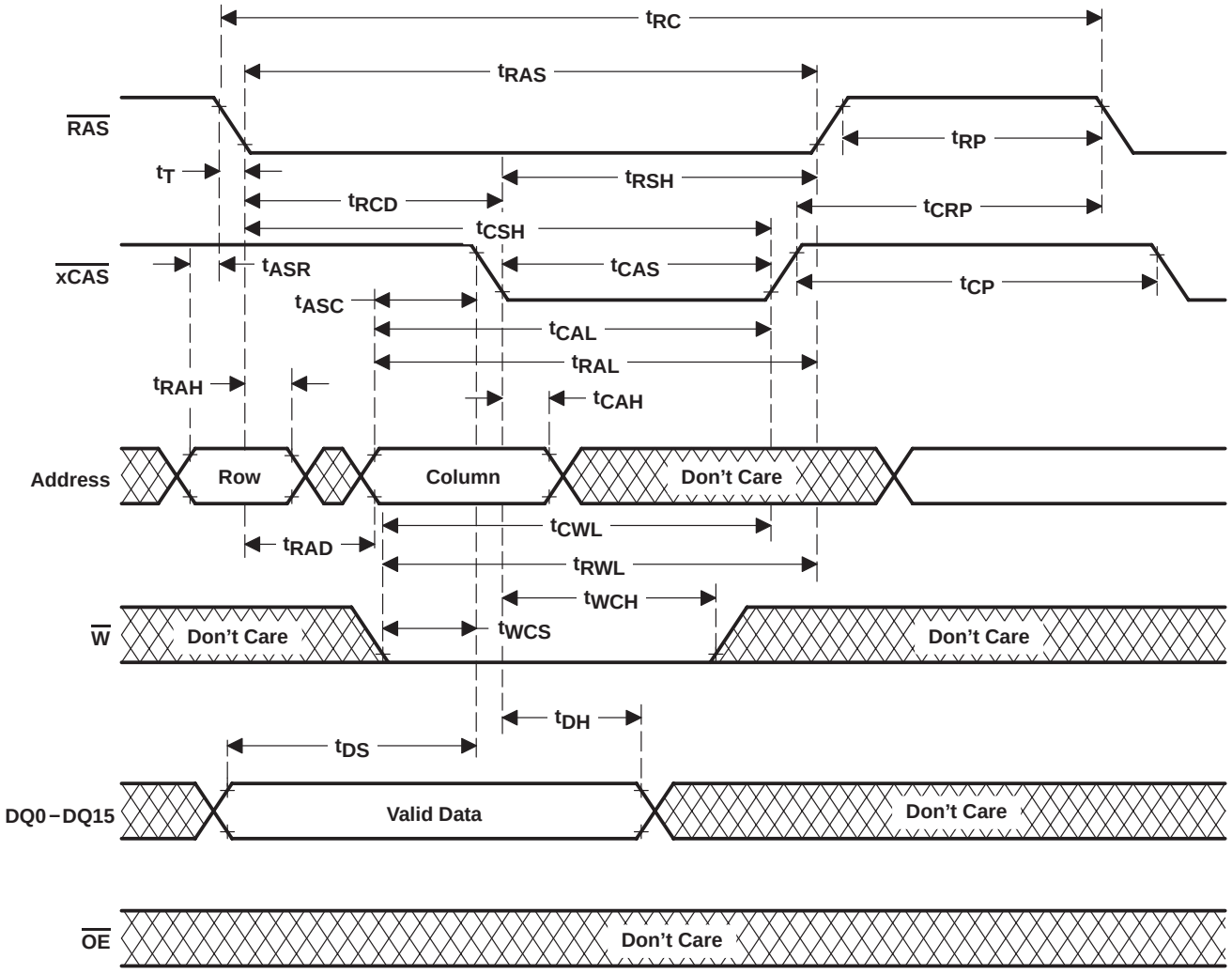
PARAMETER MEASUREMENT INFORMATION



NOTES: A. When $\overline{\text{LCAS}}$ corresponds to DQ0−DQ7 and $\overline{\text{UCAS}}$ corresponds to DQ8−DQ15, byte-reading can be achieved by holding $\overline{\text{xCAS}}$ high for the other byte.
B. Data out can go from the high-impedance state to an invalid-data state prior to the specified access time.

Figure 2. Read-Cycle Timing (see Note A)

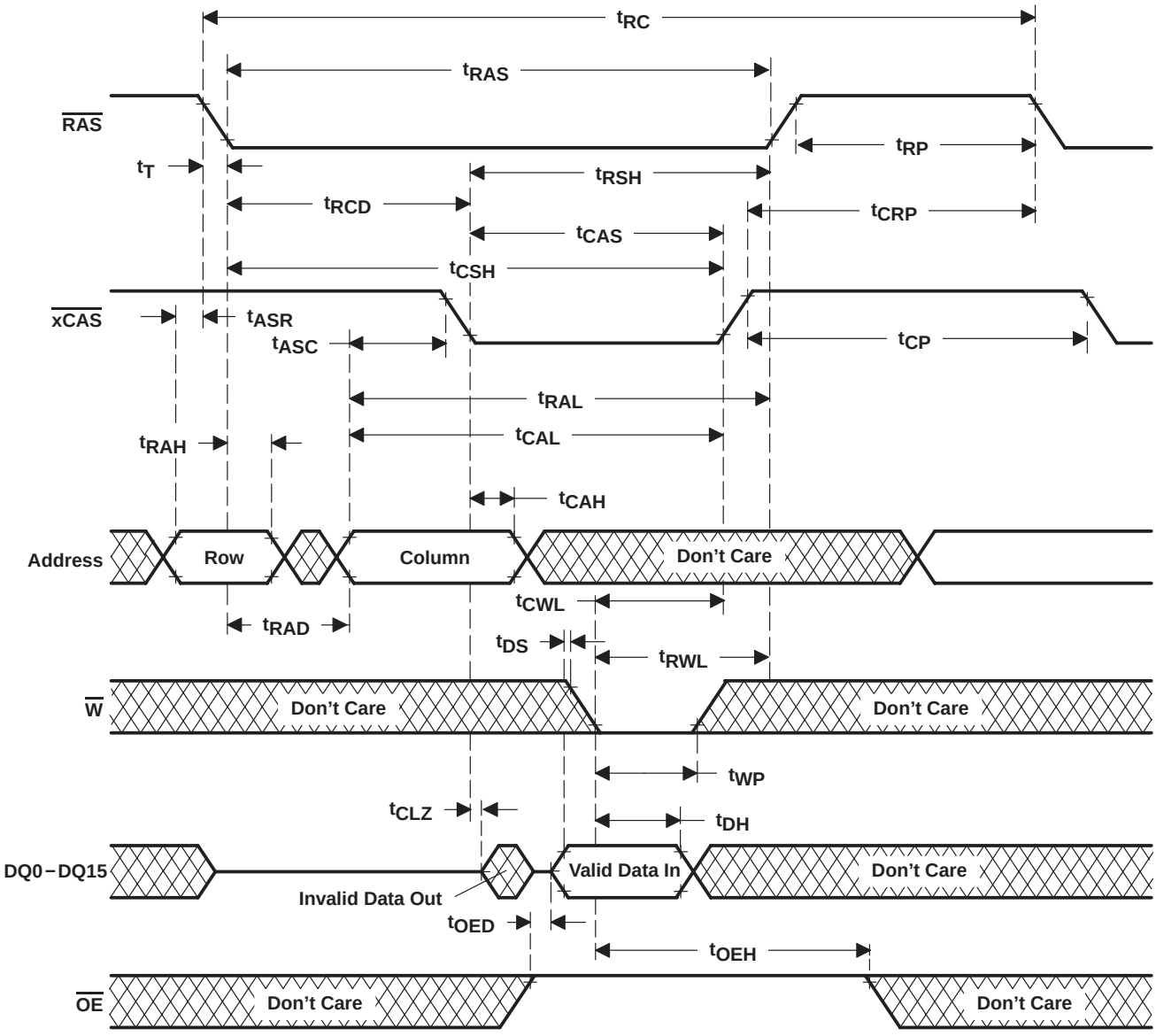
PARAMETER MEASUREMENT INFORMATION



NOTE A: When $\overline{\text{LCAS}}$ corresponds to DQ0−DQ7 and $\overline{\text{UCAS}}$ corresponds to DQ8−DQ15, byte writing can be achieved by holding $\overline{\text{xCAS}}$ high for the other byte.

Figure 3. Early-Write-Cycle Timing (see Note A)

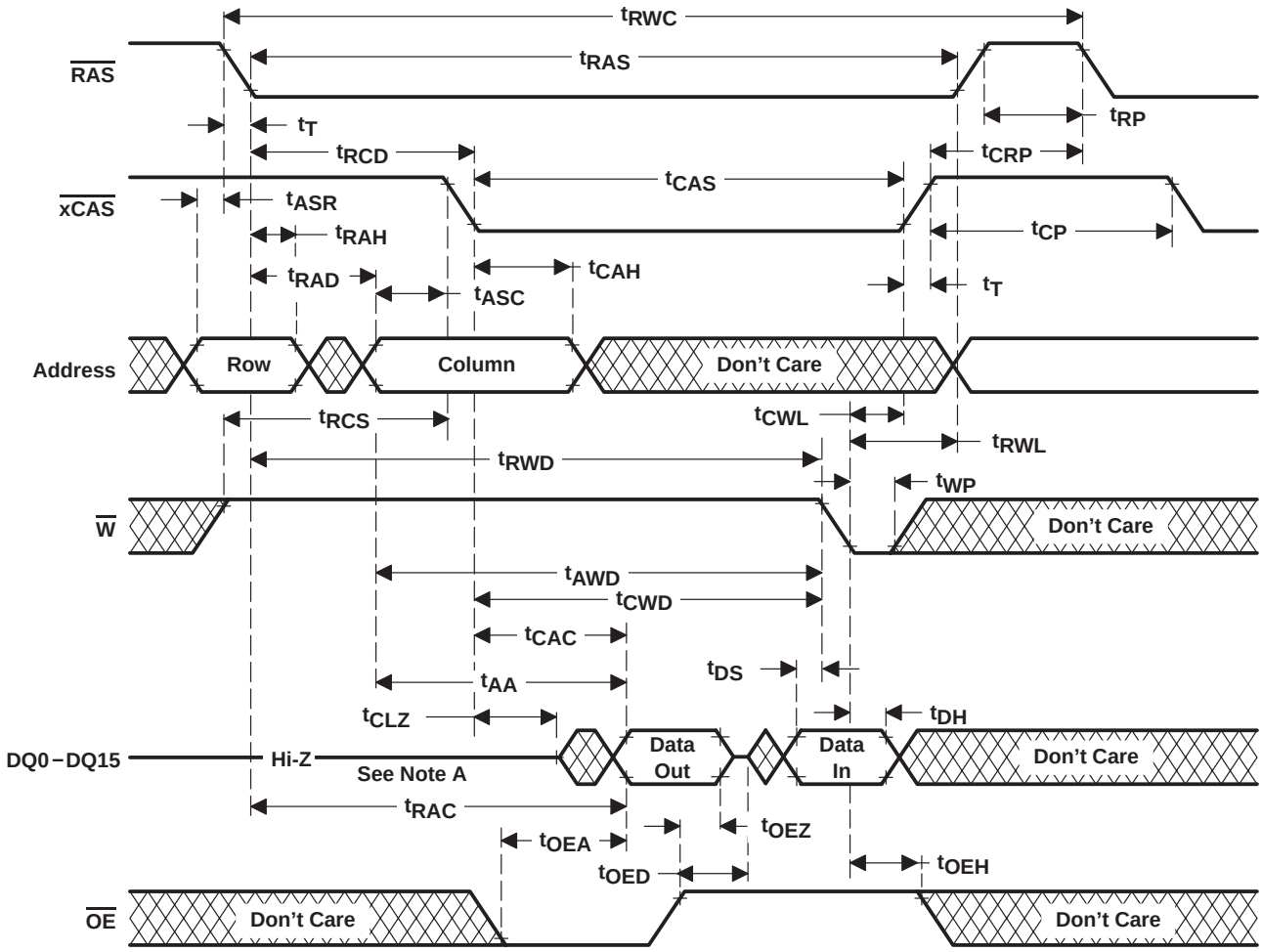
PARAMETER MEASUREMENT INFORMATION



NOTE A: When $\overline{\text{LCAS}}$ corresponds to DQ0−DQ7 and $\overline{\text{UCAS}}$ corresponds to DQ8−DQ15, byte writing can be achieved by holding $\overline{\text{xCAS}}$ high for the other byte.

Figure 4. Write-Cycle Timing (see Note A)

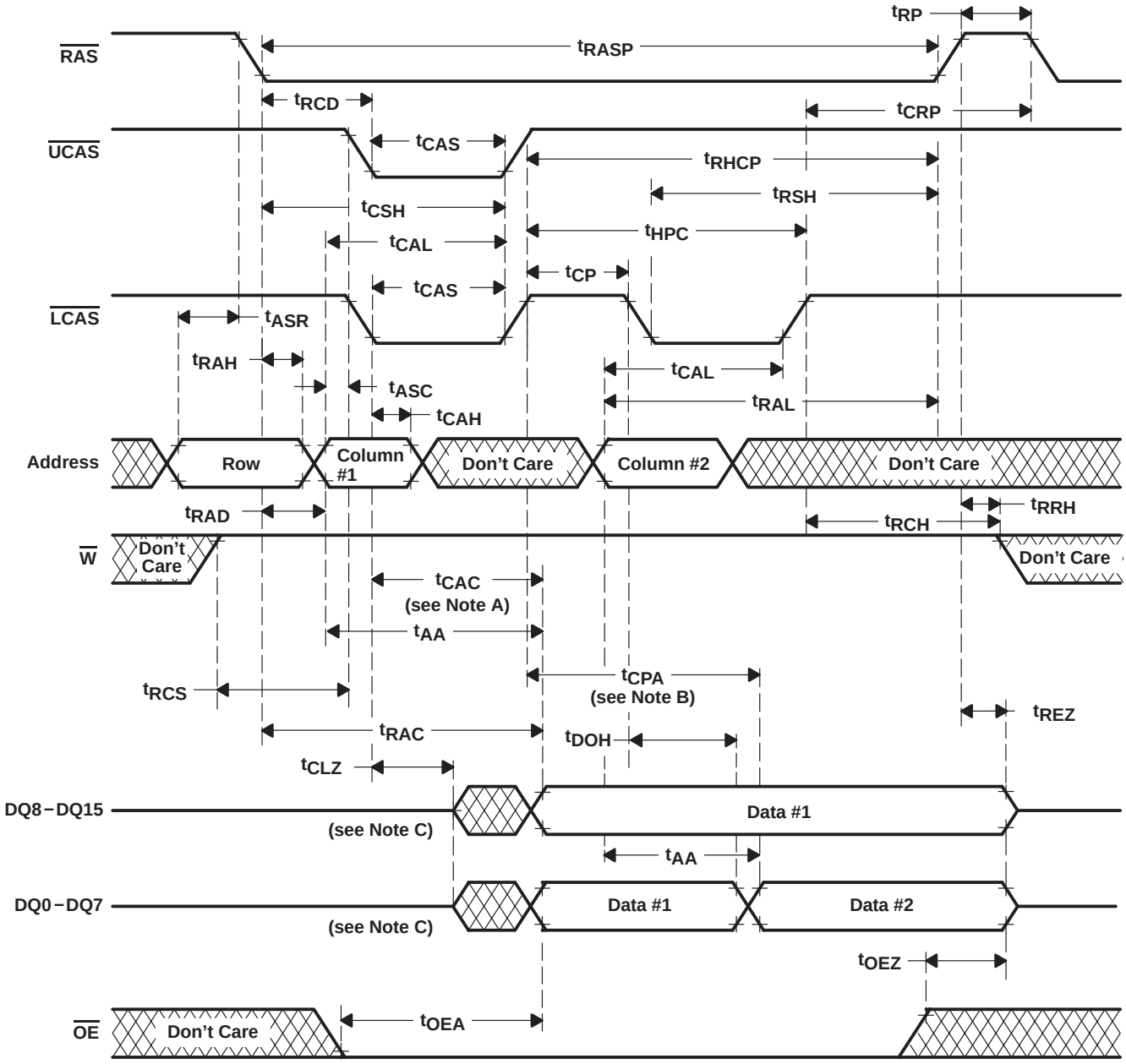
PARAMETER MEASUREMENT INFORMATION



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

Figure 5. Read-Write-Cycle Timing

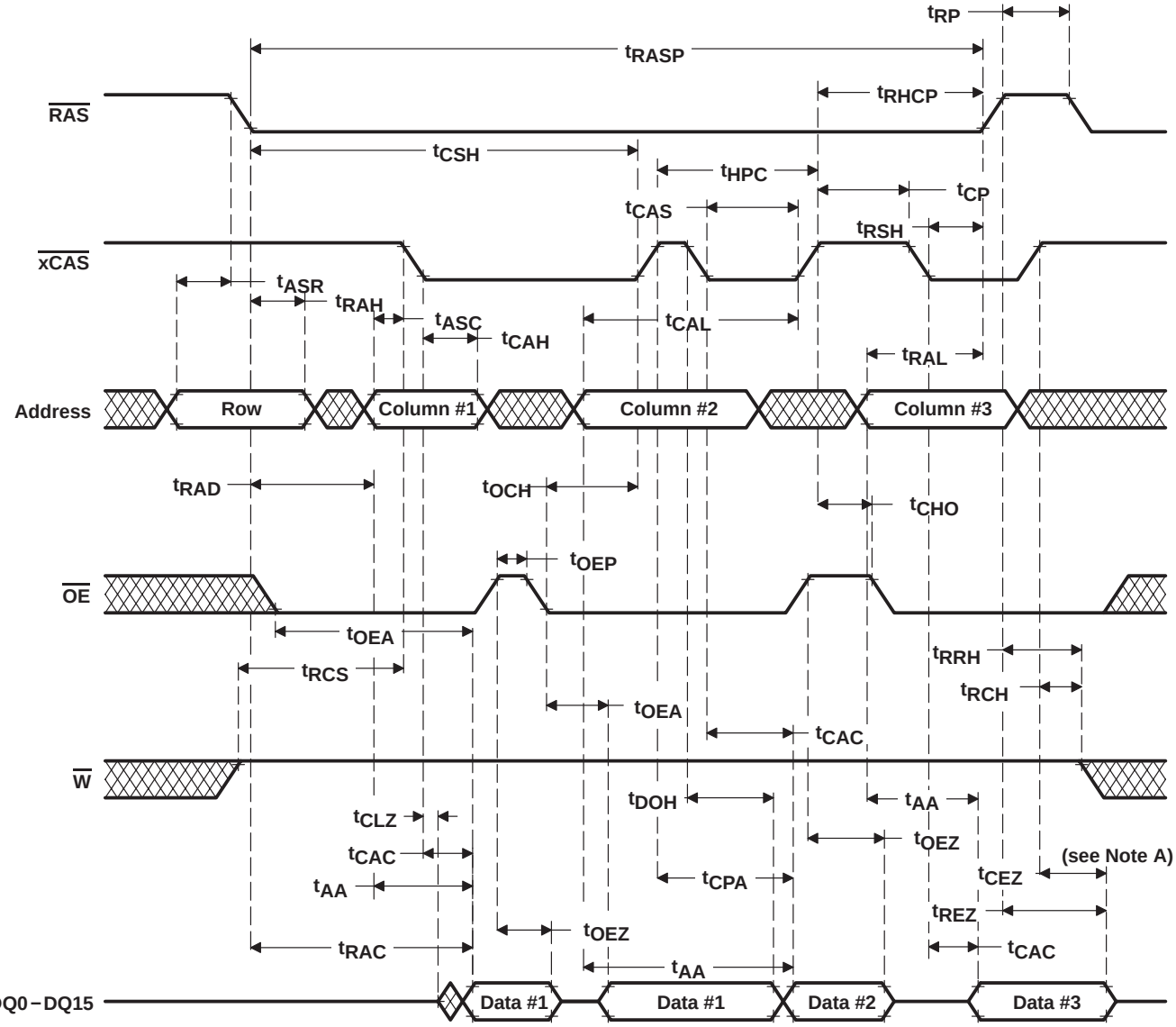
PARAMETER MEASUREMENT INFORMATION



NOTES: A. t_{CAC} is measured from $\overline{xCAS}$ to its corresponding DQx.
B. Access time is t_{CPA}-, t_{AA}-, or t_{CAC}-dependent.
C. Data out can go from the high-impedance state to an invalid-data state prior to the specified access time.
D. A write cycle or read-modify-write cycle can be mixed with the read cycles as long as the write- and read-modify-write timing specifications are not violated.

Figure 6. EDO Read-Cycle Timing (see Note D)

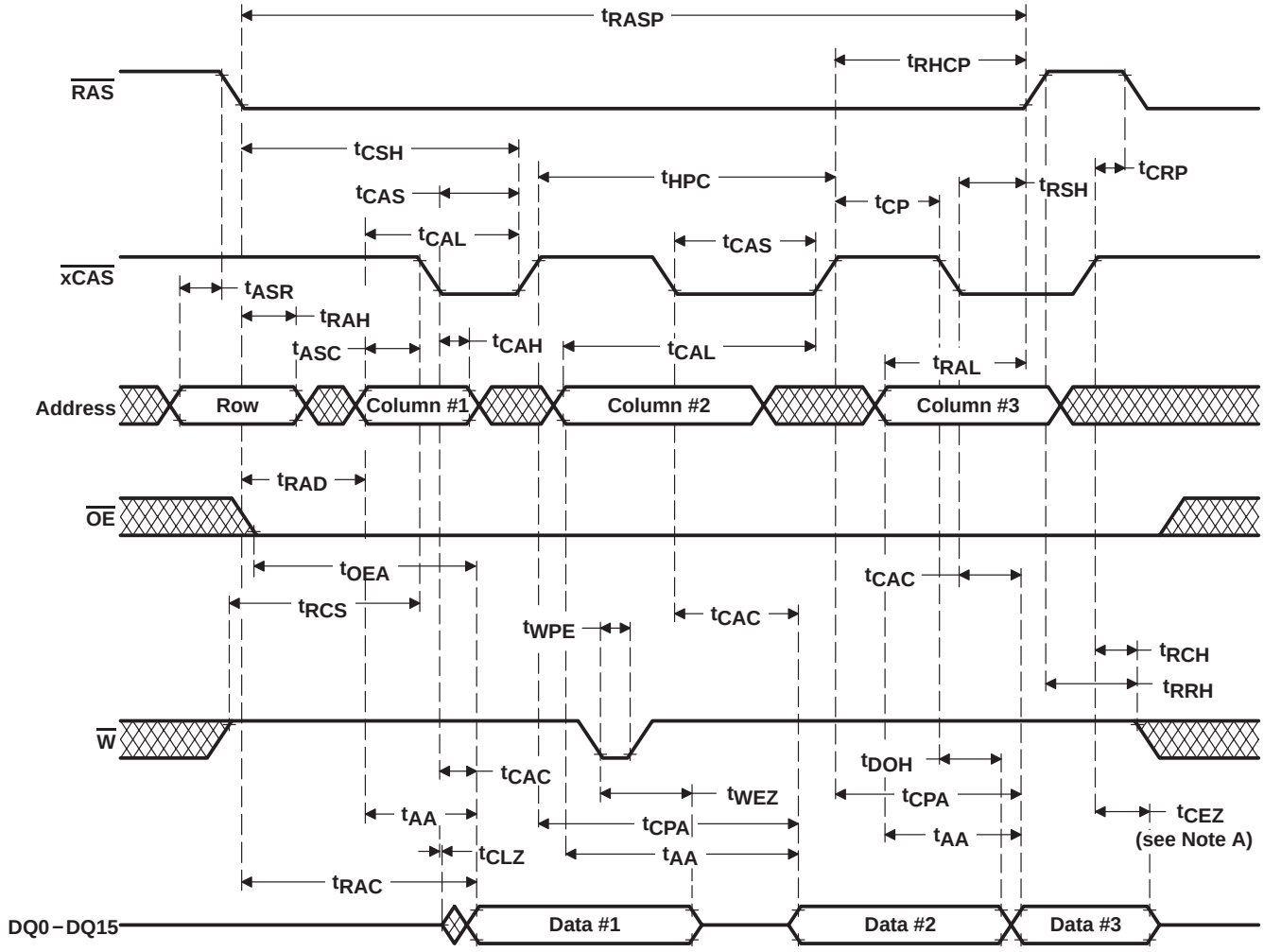
PARAMETER MEASUREMENT INFORMATION



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

Figure 7. EDO Read-Cycle Timing With $\overline{OE}$ Control

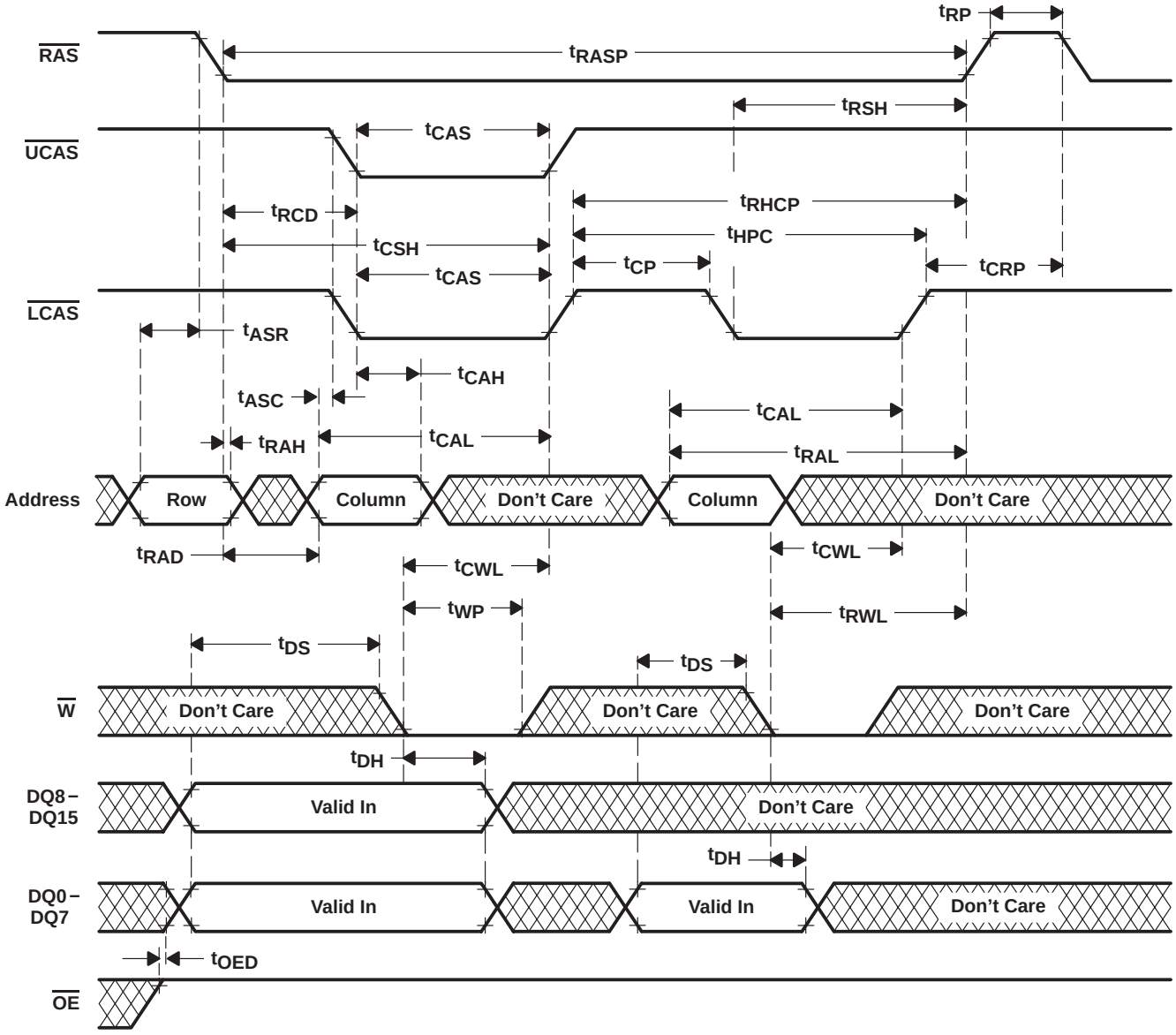
PARAMETER MEASUREMENT INFORMATION



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

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

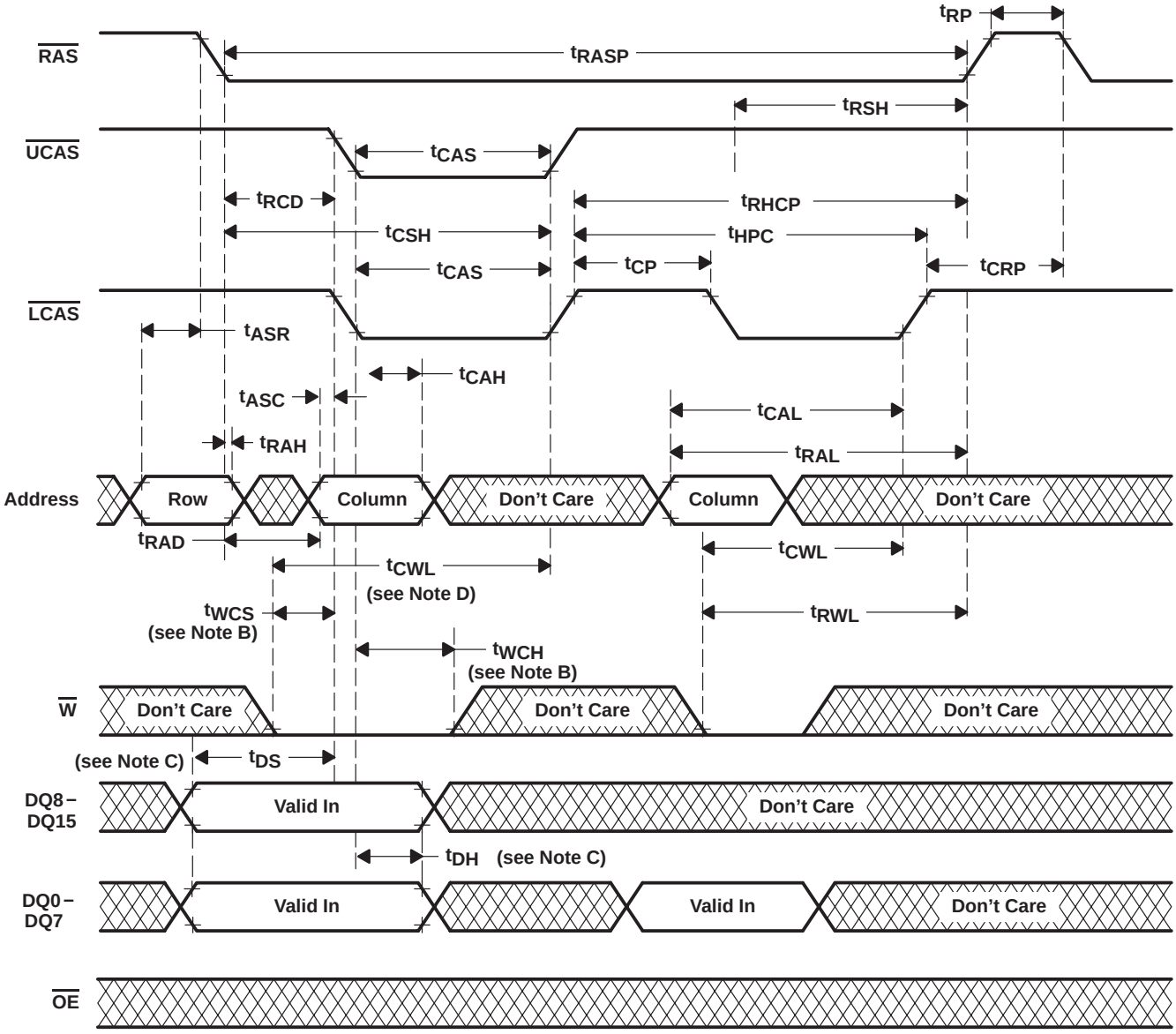
PARAMETER MEASUREMENT INFORMATION



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

Figure 9. EDO Write-Cycle Timing (see Note A)

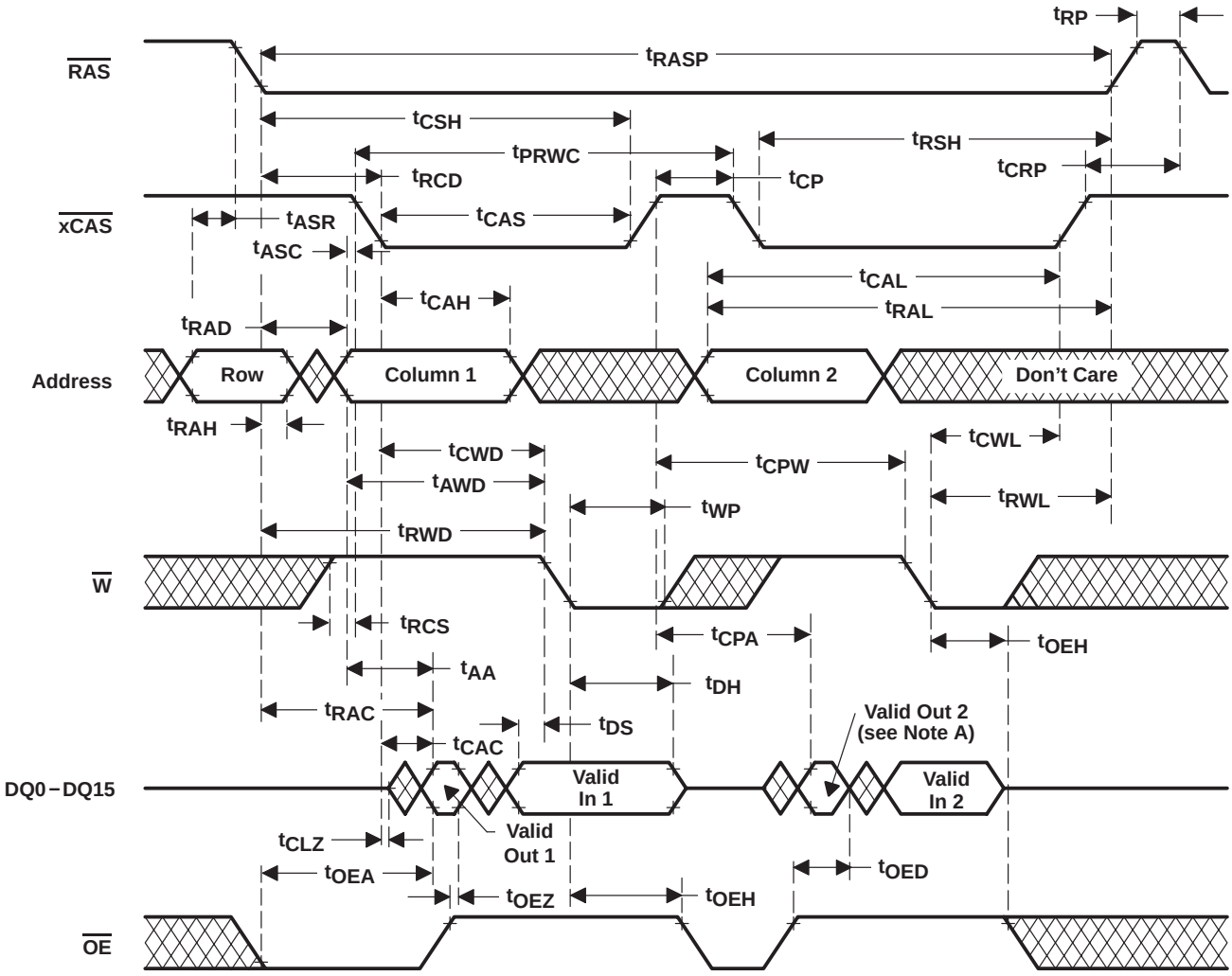
PARAMETER MEASUREMENT INFORMATION



NOTES: A. A read cycle or read-modify-write cycle can be mixed with the write cycles as long as the read- and read-modify-write timing specifications are not violated.
B. t_{WCS} and t_{WCH} must be satisfied for each $\overline{xCAS}$ in an early-write cycle.
C. t_{DS} and t_{DH} of a DQ input are referenced to the corresponding $\overline{xCAS}$.
D. t_{CWL} must be satisfied for each $\overline{xCAS}$ to ensure proper writing to each byte.

Figure 10. EDO Early Write-Cycle Timing (see Note A)

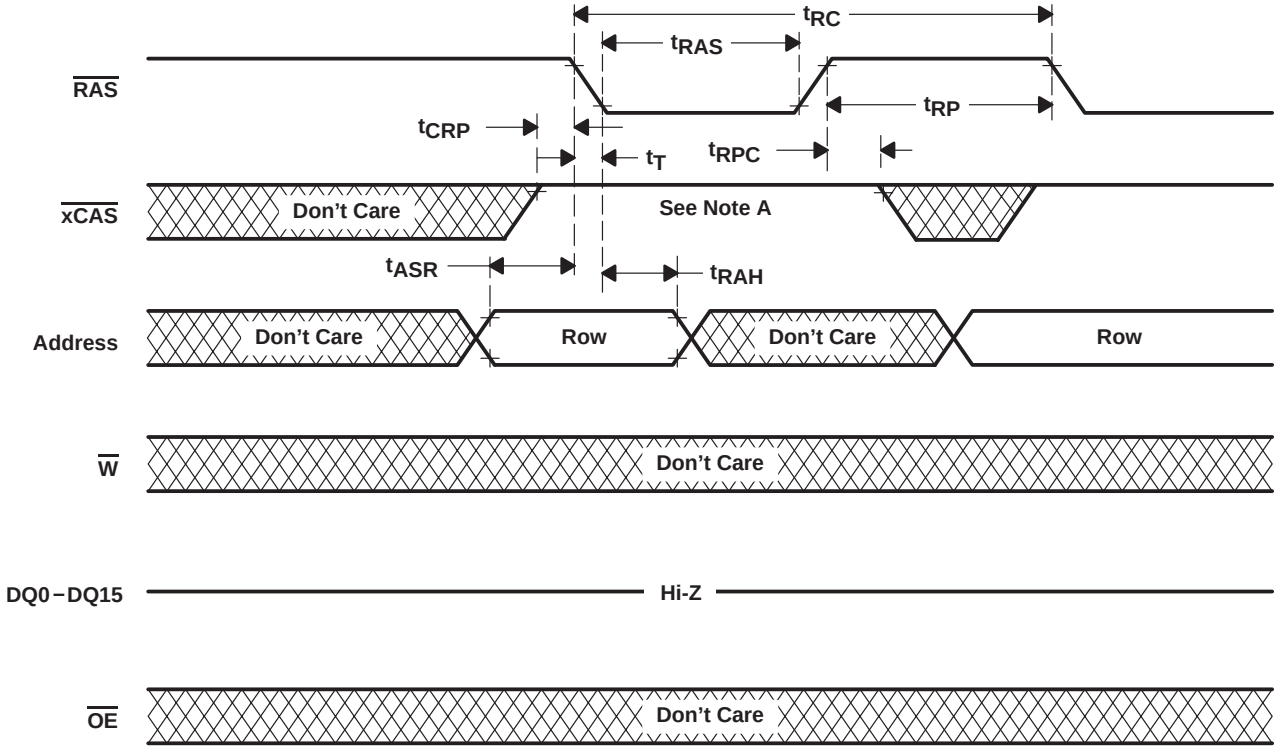
PARAMETER MEASUREMENT INFORMATION



NOTES: A. Data out 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 11. EDO Read-Write-Cycle Timing (see Note B)

PARAMETER MEASUREMENT INFORMATION



NOTE A: Both $\overline{\text{LCAS}}$ and $\overline{\text{UCAS}}$ must be high.

Figure 12. $\overline{\text{RAS}}$-Only Refresh-Cycle Timing

PARAMETER MEASUREMENT INFORMATION

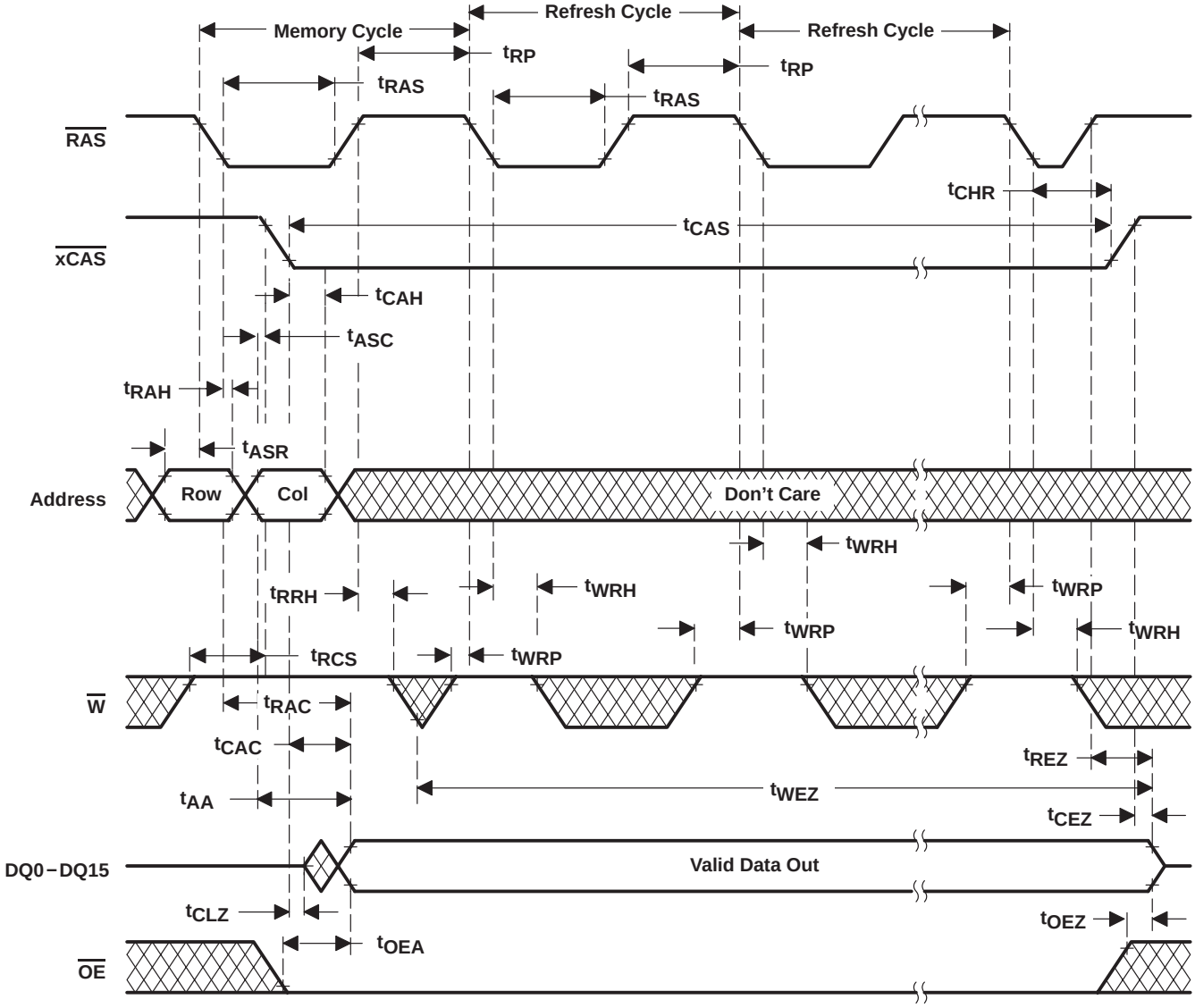


Figure 13. Hidden-Refresh-Cycle (Read) Timing

PARAMETER MEASUREMENT INFORMATION

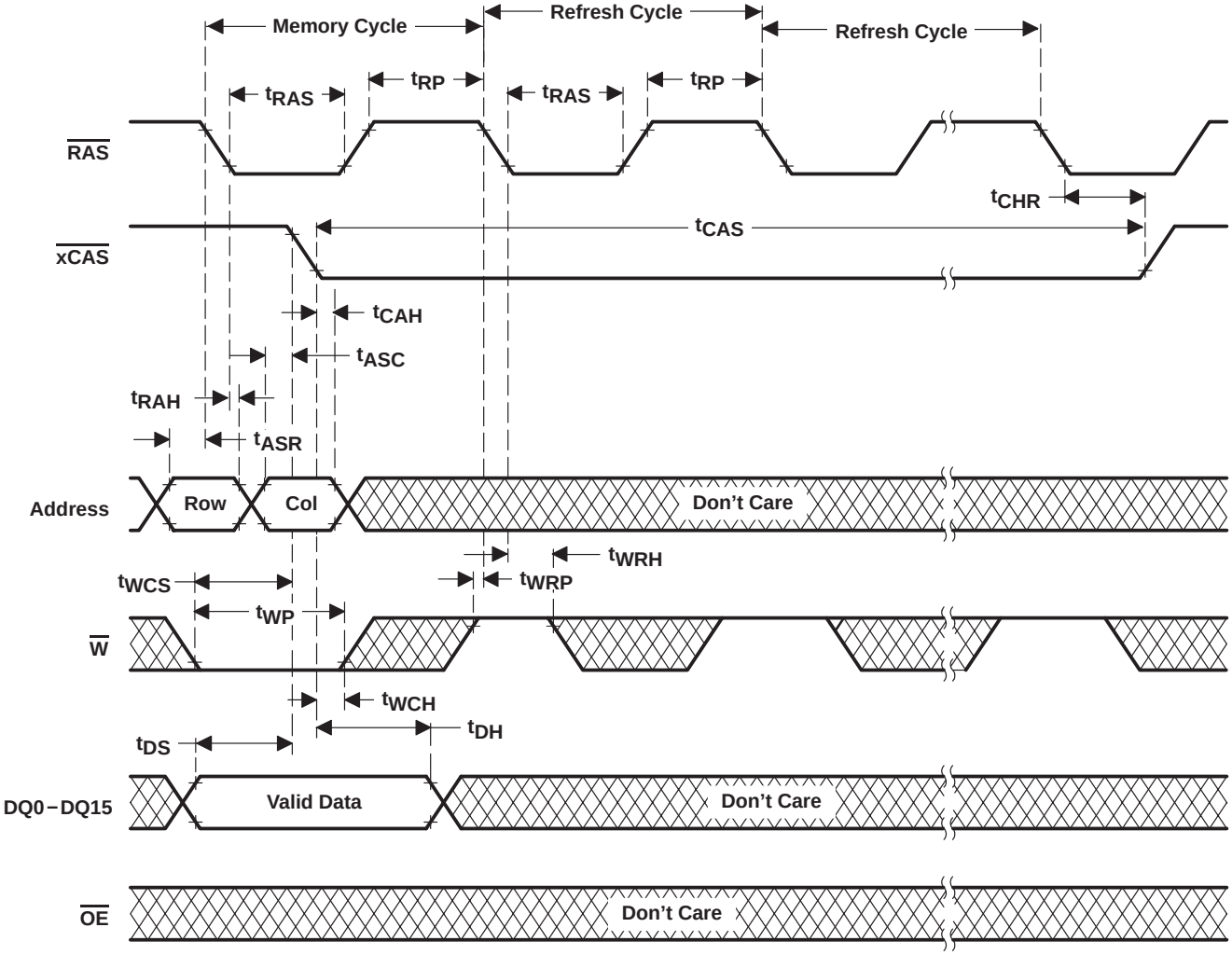
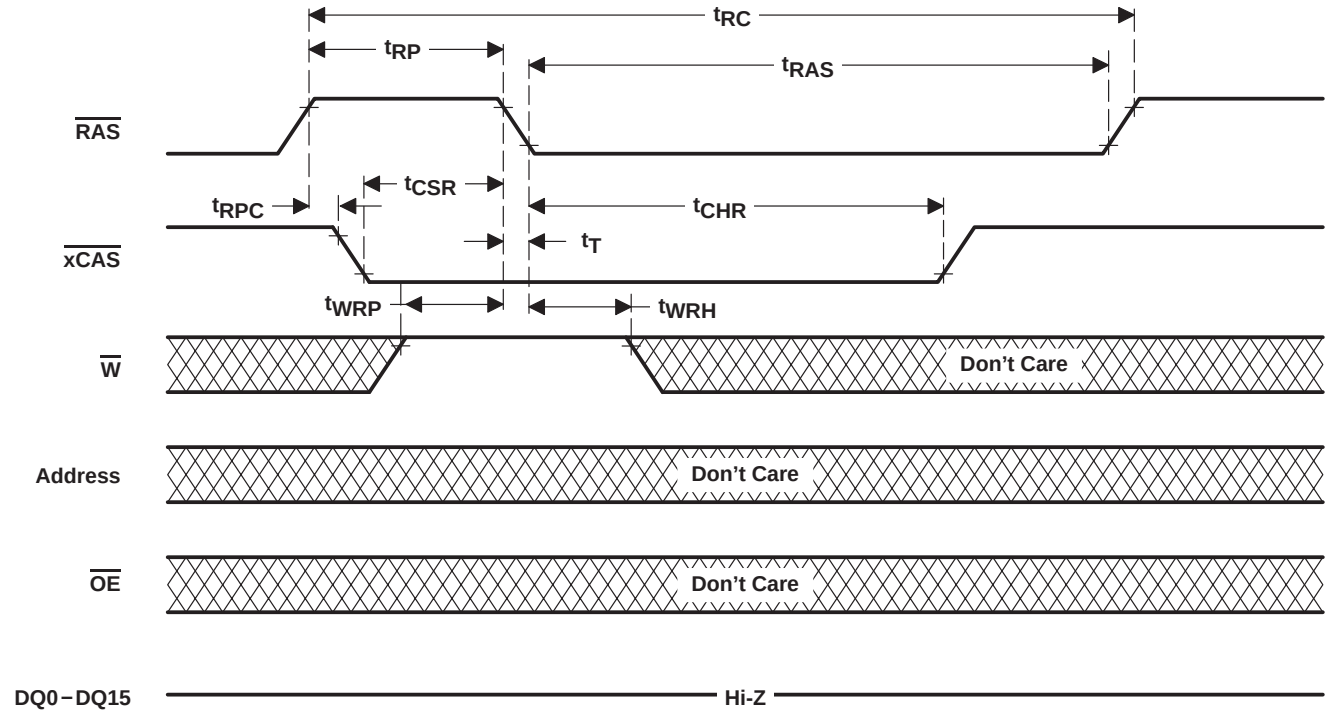


Figure 14. Hidden-Refresh Cycle (Write) Timing

PARAMETER MEASUREMENT INFORMATION



NOTE A: Any $\overline{\text{xCAS}}$ can be used. If both $\overline{\text{UCAS}}$ and $\overline{\text{LCAS}}$ are used, both must satisfy t_{CSR} and t_{CHR}.

Figure 15. Automatic (xCBR) Refresh-Cycle Timing

PARAMETER MEASUREMENT INFORMATION

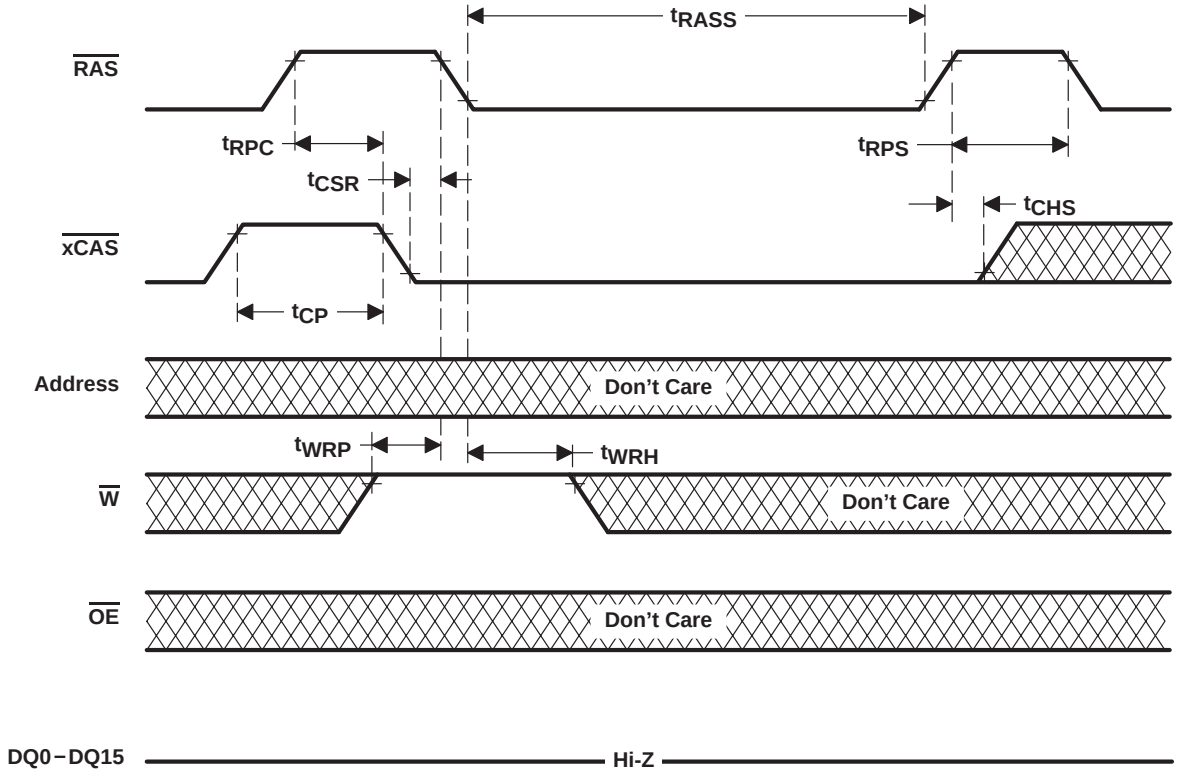
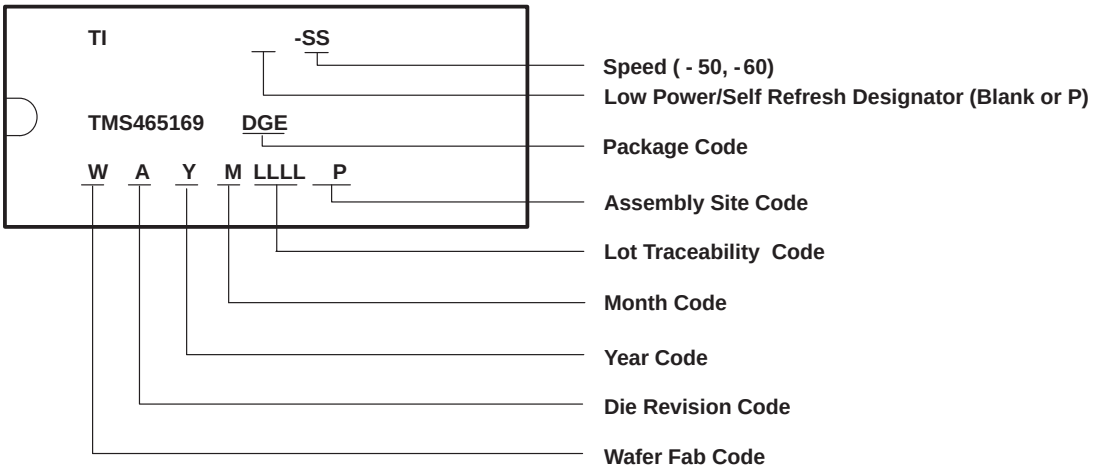


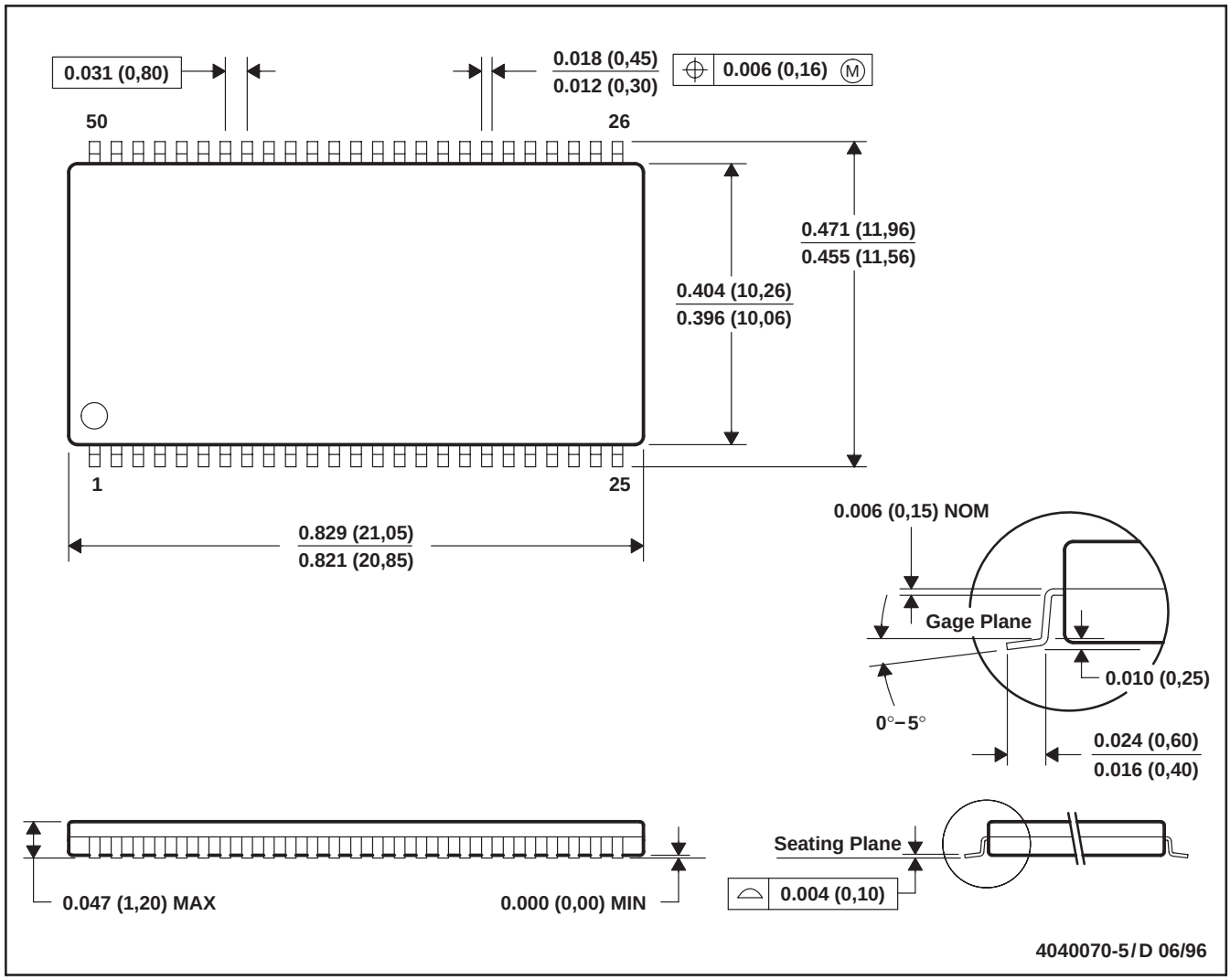
Figure 16. Self-Refresh-Cycle Timing

device symbolization (TMS465169 illustrated)



MECHANICAL DATA

DGE (R-PDSO-G50) **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.

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