

**Document Title**

64K x16 bit Dynamic RAM with Fast Page Mode

**Revision History**

<u>Revision No</u>	<u>History</u>	<u>Draft Date</u>	<u>Remark</u>
0A	Initial Draft	October 17,2001	

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# 64K x 16 (1-MBIT) DYNAMIC RAM WITH FAST PAGE MODE

## FEATURES

- Fast access and cycle time
- TTL compatible inputs and outputs
- Refresh Interval: 256 cycles/4 ms
- Refresh Mode:  $\overline{\text{RAS}}$ -Only,  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  (CBR), Hidden
- JEDEC standard pinout
- Single power supply:
  - $5V \pm 10\%$  (IC41C1665)
  - $3.3V \pm 10\%$  (IC41LV1665)
- Byte Write and Byte Read operation via two  $\overline{\text{CAS}}$
- Available in 40-pin SOJ and TSOP-2

## DESCRIPTION

The ICSI IC41C1665 and the IC41LV1665 are 65,536 x 16-bit high-performance CMOS Dynamic Random Access Memory. Fast Page Mode allows 256 random accesses within a single row with access cycle time as short as 12 ns per 16-bit word. The Byte Write control, of upper and lower byte, makes these devices ideal for use in 16-, 32-bit wide data bus systems.

These features make the IC41C1665 and the IC41LV1665 ideally suited for high band-width graphics, digital signal processing, high-performance computing systems, and peripheral applications.

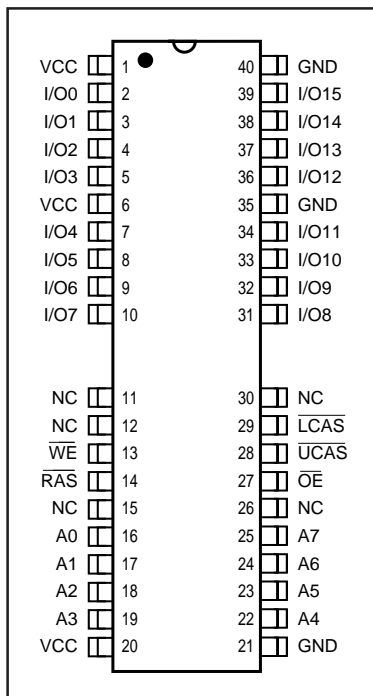
The IC41C1665 and the IC41LV1665 are packaged in a 40-pin, 400mil SOJ and TSOP-2.

## KEY TIMING PARAMETERS

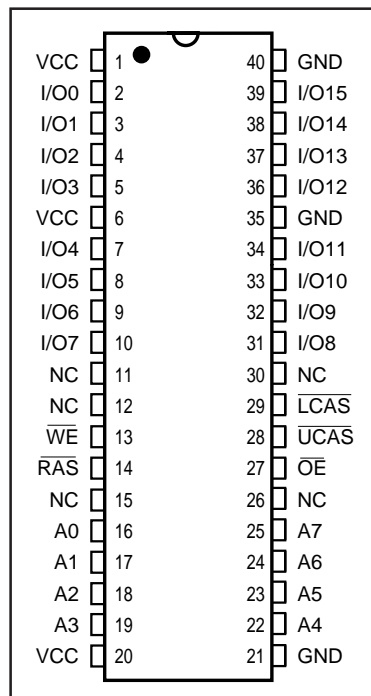
Parameter	-25	-30	-35	-40	Unit
Max. $\overline{\text{RAS}}$ Access Time ( $t_{\text{RAC}}$ )	25	30	35	40	ns
Max. CAS Access Time ( $t_{\text{CAC}}$ )	8	9	10	11	ns
Max. Column Address Access Time ( $t_{\text{AA}}$ )	12	16	18	20	ns
Min. Fast Page Mode Cycle Time ( $t_{\text{PC}}$ )	15	20	23	25	ns
Min. Read/Write Cycle Time ( $t_{\text{RC}}$ )	43	55	65	75	ns

## PIN CONFIGURATIONS

### 40-Pin TSOP-2



### 40-Pin SOJ

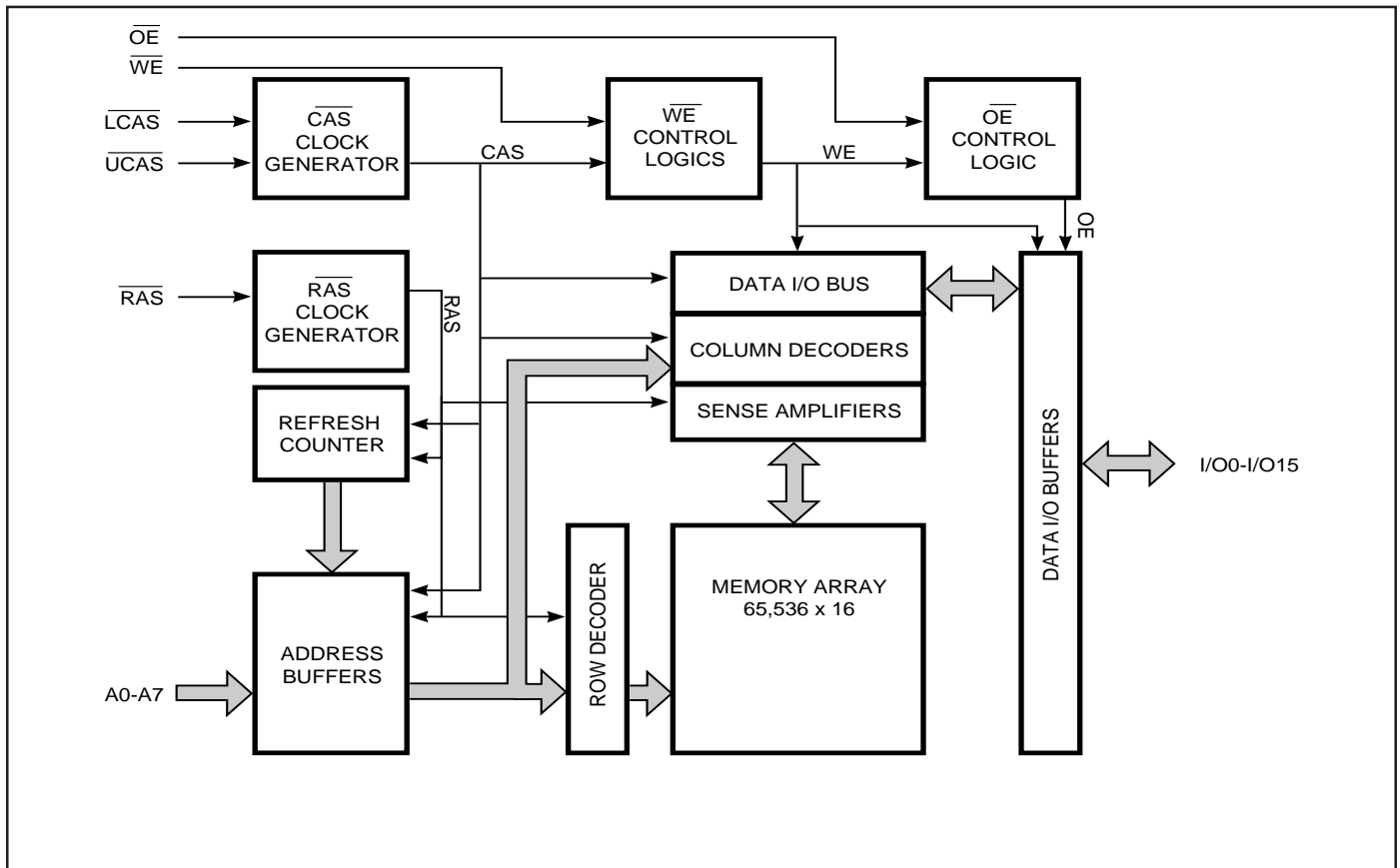


## PIN DESCRIPTIONS

A0-A7	Address Inputs
I/O0-I/O15	Data Inputs/Outputs
$\overline{\text{WE}}$	Write Enable
$\overline{\text{OE}}$	Output Enable
$\overline{\text{RAS}}$	Row Address Strobe
$\overline{\text{UCAS}}$	Upper Column Address Strobe
$\overline{\text{LCAS}}$	Lower Column Address Strobe
Vcc	Power
GND	Ground
NC	No Connection

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### FUNCTIONAL BLOCK DIAGRAM



**TRUTH TABLE**

Function	$\overline{\text{RAS}}$	$\overline{\text{LCAS}}$	$\overline{\text{UCAS}}$	$\overline{\text{WE}}$	$\overline{\text{OE}}$	Address $t_{\text{R}}/t_{\text{C}}$	I/O	
Standby	H	H	H	X	X	X	High-Z	
Read: Word	L	L	L	H	L	ROW/COL	DOUT	
Read: Lower Byte	L	L	H	H	L	ROW/COL	Lower Byte, DOUT Upper Byte, High-Z	
Read: Upper Byte	L	H	L	H	L	ROW/COL	Lower Byte, High-Z Upper Byte, DOUT	
Write: Word (Early Write)	L	L	L	L	X	ROW/COL	DIN	
Write: Lower Byte (Early Write)	L	L	H	L	X	ROW/COL	Lower Byte, DIN Upper Byte, High-Z	
Write: Upper Byte (Early Write)	L	H	L	L	X	ROW/COL	Lower Byte, High-Z Upper Byte, DIN	
Read-Write <sup>(1,2)</sup>	L	L	L	H→L	L→H	ROW/COL	DOUT, DIN	
Hidden Refresh <sup>2)</sup>	Read	L→H→L	L	L	H	L	ROW/COL	DOUT
	Write	L→H→L	L	L	L	X	ROW/COL	DIN
RAS-Only Refresh	L	H	H	X	X	ROW/NA	High-Z	
CBR Refresh <sup>(3)</sup>	H→L	L	L	X	X	X	High-Z	

**Notes:**

1. These WRITE cycles may also be BYTE WRITE cycles (either  $\overline{\text{LCAS}}$  or  $\overline{\text{UCAS}}$  active).
2. These READ cycles may also be BYTE READ cycles (either  $\overline{\text{LCAS}}$  or  $\overline{\text{UCAS}}$  active).
3. At least one of the two CAS signals must be active ( $\overline{\text{LCAS}}$  or  $\overline{\text{UCAS}}$ ).

## FUNCTIONAL DESCRIPTION

The IC41C1665 and the IC41LV1665 are CMOS DRAMs optimized for high-speed bandwidth, low-power applications. During READ or WRITE cycles, each bit is uniquely addressed through the 16 address bits. These are entered nine bits (A0-A7) at a time. The row address is latched by the Row Address Strobe ( $\overline{\text{RAS}}$ ). The column address is latched by the Column Address Strobe ( $\overline{\text{CAS}}$ ).  $\overline{\text{RAS}}$  is used to latch the first eight bits and  $\overline{\text{CAS}}$  is used to latch the latter eight bits.

The IC41C1665 and the IC41LV1665 have two  $\overline{\text{CAS}}$  controls,  $\overline{\text{LCAS}}$  and  $\overline{\text{UCAS}}$ . The  $\overline{\text{LCAS}}$  and  $\overline{\text{UCAS}}$  inputs internally generate a  $\overline{\text{CAS}}$  signal functioning in an identical manner to the single  $\overline{\text{CAS}}$  input on the other 64K x 16 DRAMs. The key difference is that each  $\overline{\text{CAS}}$  controls its corresponding I/O tristate logic (in conjunction with  $\overline{\text{OE}}$  and  $\overline{\text{WE}}$  and  $\overline{\text{RAS}}$ ).  $\overline{\text{LCAS}}$  controls I/O0 - I/O7 and  $\overline{\text{UCAS}}$  controls I/O8 - I/O15.

The IC41C1665/IC41LV1665  $\overline{\text{CAS}}$  function is determined by the first  $\overline{\text{CAS}}$  ( $\overline{\text{LCAS}}$  or  $\overline{\text{UCAS}}$ ) transitioning LOW and the last transitioning back HIGH. The two  $\overline{\text{CAS}}$  controls give the IC41C1665 both BYTE READ and BYTE WRITE cycle capabilities.

### Memory Cycle

A memory cycle is initiated by bringing  $\overline{\text{RAS}}$  LOW and it is terminated by returning both  $\overline{\text{RAS}}$  and  $\overline{\text{CAS}}$  HIGH. To ensure proper device operation and data integrity any memory cycle, once initiated, must not be ended or aborted before the minimum  $t_{\text{RAS}}$  time has expired. A new cycle must not be initiated until the minimum precharge time  $t_{\text{RP}}$ ,  $t_{\text{CP}}$  has elapsed.

### Read Cycle

A read cycle is initiated by the falling edge of  $\overline{\text{CAS}}$  or  $\overline{\text{OE}}$ , whichever occurs last, while holding  $\overline{\text{WE}}$  HIGH. The column address must be held for a minimum time specified by  $t_{\text{AR}}$ . Data Out becomes valid only when  $t_{\text{RAC}}$ ,  $t_{\text{AA}}$ ,  $t_{\text{CAC}}$  and  $t_{\text{OE}}$  are all satisfied. As a result, the access time is dependent on the timing relationships between these parameters.

### Write Cycle

A write cycle is initiated by the falling edge of  $\overline{\text{CAS}}$  and  $\overline{\text{WE}}$ , whichever occurs last. The input data must be valid at or before the falling edge of  $\overline{\text{CAS}}$  or  $\overline{\text{WE}}$ , whichever occurs last.

### Refresh Cycle

To retain data, 256 refresh cycles are required in each 4 ms period. There are two ways to refresh the memory:

1. By clocking each of the 256 row addresses (A0 through A7) with  $\overline{\text{RAS}}$  at least once every 4 ms. Any read, write, read-modify-write or  $\overline{\text{RAS}}$ -only cycle refreshes the addressed row.
2. Using a  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh cycle.  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh is activated by the falling edge of  $\overline{\text{RAS}}$ , while holding  $\overline{\text{CAS}}$  LOW. In  $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  refresh cycle, an internal 8-bit counter provides the row addresses and the external address inputs are ignored.

$\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$  is a refresh-only mode and no data access or device selection is allowed. Thus, the output remains in the High-Z state during the cycle.

### Power-On

After application of the  $V_{\text{CC}}$  supply, an initial pause of 200  $\mu\text{s}$  is required followed by a minimum of eight initialization cycles (any combination of cycles containing a  $\overline{\text{RAS}}$  signal).

During power-on, it is recommended that  $\overline{\text{RAS}}$  track with  $V_{\text{CC}}$  or be held at a valid  $V_{\text{IH}}$  to avoid current surges.

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

Symbol	Parameters		Rating	Unit
V <sub>T</sub>	Voltage on Any Pin Relative to GND	5V	-1.0 to +7.0	V
		3.3V	-0.5 to +4.6	V
V <sub>CC</sub>	Supply Voltage	5V	-1.0 to +7.0	V
		3.3V	-0.5 to +4.6	V
I <sub>OUT</sub>	Output Current		50	mA
P <sub>D</sub>	Power Dissipation		1	W
T <sub>A</sub>	Operation Temperature	Com.	0 to +70	°C
		Ind.	-40 to +85	°C
T <sub>STG</sub>	Storage Temperature		-55 to +125	°C

**Note:**

1. Stress greater than those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

## RECOMMENDED OPERATING CONDITIONS (Voltages are referenced to GND)

Symbol	Parameter		Min.	Typ.	Max.	Unit
V <sub>CC</sub>	Supply Voltage	5V	4.5	5.0	5.5	V
		3.3V	3.0	3.3	3.6	V
V <sub>IH</sub>	Input High Voltage	5V	2.4	—	V <sub>CC</sub> + 1.0	V
		3.3V	2.0	—	V <sub>CC</sub> + 0.3	V
V <sub>IL</sub>	Input Low Voltage	5V	-1.0	—	0.8	V
		3.3V	-0.3	—	0.8	V
T <sub>A</sub>	Ambient Temperature	Com.	0	—	70	°C
		Ind.	-40	—	85	°C

## CAPACITANCE<sup>(1,2)</sup>

Symbol	Parameter	Max.	Unit
C <sub>IN1</sub>	Input Capacitance: A0-A7	5	pF
C <sub>IN2</sub>	Input Capacitance: RAS, UCAS, LCAS, WE, OE	7	pF
C <sub>IO</sub>	Data Input/Output Capacitance: I/O0-I/O15	7	pF

**Notes:**

1. Tested initially and after any design or process changes that may affect these parameters.
2. Test conditions: T<sub>A</sub> = 25°C, f = 1 MHz, V<sub>CC</sub> = 5.0V + 10%, or V<sub>CC</sub> = 3.3V + 10%.

**ELECTRICAL CHARACTERISTICS<sup>(1)</sup>** (Recommended Operation Conditions unless otherwise noted.)

Symbol	Parameter	Test Condition	Speed	Min.	Max.	Unit
I <sub>IL</sub>	Input Leakage Current	Any input $0V \leq V_{IN} \leq V_{CC}$ Other inputs not under test = 0V		-10	10	μA
I <sub>IO</sub>	Output Leakage Current	Output is disabled (Hi-Z) $0V \leq V_{OUT} \leq V_{CC}$		-10	10	μA
V <sub>OH</sub>	Output High Voltage Level	I <sub>OH</sub> = -5 mA		2.4	—	V
V <sub>OL</sub>	Output Low Voltage Level	I <sub>OL</sub> = +4.2 mA		—	0.4	V
I <sub>CC1</sub>	Stand-by Current: TTL	$\overline{RAS}, \overline{LCAS}, \overline{UCAS} \geq V_{IH}$	5V	—	2	mA
I <sub>CC1</sub>	Stand-by Current: TTL	$\overline{RAS}, \overline{LCAS}, \overline{UCAS} \geq V_{IH}$	3.3V	—	1	mA
I <sub>CC2</sub>	Stand-by Current: CMOS	$\overline{RAS}, \overline{LCAS}, \overline{UCAS} \geq V_{CC} - 0.2V$	5V	—	1	mA
I <sub>CC2</sub>	Stand-by Current: CMOS	$\overline{RAS}, \overline{LCAS}, \overline{UCAS} \geq V_{CC} - 0.2V$	3.3V	—	0.5	mA
I <sub>CC3</sub>	Operating Current: Random Read/Write <sup>(2,3,4)</sup> Average Power Supply Current	$\overline{RAS}, \overline{LCAS}, \overline{UCAS}$ , Address Cycling, t <sub>RC</sub> = t <sub>RC</sub> (min.)	-25 -30 -35 -40	— — — —	170 150 130 120	mA
I <sub>CC4</sub>	Operating Current: Fast Page Mode <sup>(2,3,4)</sup> Average Power Supply Current	$\overline{RAS} = V_{IL}, \overline{LCAS}, \overline{UCAS}$ , Cycling t <sub>PC</sub> = t <sub>PC</sub> (min.)	-25 -30 -35 -40	— — — —	170 150 130 120	mA
I <sub>CC5</sub>	Refresh Current: RAS-Only <sup>(2,3)</sup> Average Power Supply Current	$\overline{RAS}$ Cycling, $\overline{LCAS}, \overline{UCAS} \geq V_{IH}$ t <sub>RC</sub> = t <sub>RC</sub> (min.)	-25 -30 -35 -40	— — — —	170 150 130 120	mA
I <sub>CC6</sub>	Refresh Current: CBR <sup>(2,3,5)</sup> Average Power Supply Current	$\overline{RAS}, \overline{LCAS}, \overline{UCAS}$ Cycling t <sub>RC</sub> = t <sub>RC</sub> (min.)	-25 -30 -35 -40	— — — —	170 150 130 120	mA

**Notes:**

1. An initial pause of 200 μs is required after power-up followed by eight  $\overline{RAS}$  refresh cycles ( $\overline{RAS}$ -Only or CBR) before proper device operation is assured. The eight RAS cycles wake-up should be repeated any time the t<sub>REF</sub> refresh requirement is exceeded.
2. Dependent on cycle rates.
3. Specified values are obtained with minimum cycle time and the output open.
4. Column-address is changed once each fast page cycle.
5. Enables on-chip refresh and address counters.

**AC CHARACTERISTICS**<sup>(1,2,3,4,5,6)</sup>

(Recommended Operating Conditions unless otherwise noted.)

Symbol	Parameter	-25		-30		-35		-40		Units
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
t <sub>RC</sub>	Random READ or WRITE Cycle Time	43	—	55	—	65	—	75	—	ns
t <sub>RAC</sub>	Access Time from $\overline{\text{RAS}}$ <sup>(6, 7)</sup>	—	25	—	30	—	35	—	40	ns
t <sub>CAC</sub>	Access Time from $\overline{\text{CAS}}$ <sup>(6, 8, 15)</sup>	—	8	—	9	—	10	—	11	ns
t <sub>AA</sub>	Access Time from Column-Address <sup>(6)</sup>	—	12	—	16	—	18	—	20	ns
t <sub>RAS</sub>	$\overline{\text{RAS}}$ Pulse Width	25	10k	30	10K	35	10K	40	10K	ns
t <sub>RP</sub>	$\overline{\text{RAS}}$ Precharge Time	15	—	20	—	23	—	25	—	ns
t <sub>CAS</sub>	$\overline{\text{CAS}}$ Pulse Width <sup>(26)</sup>	4	10k	9	10K	10	10K	11	10K	ns
t <sub>CP</sub>	$\overline{\text{CAS}}$ Precharge Time <sup>(9, 25)</sup>	4	—	5	—	6	—	7	—	ns
t <sub>CSH</sub>	$\overline{\text{CAS}}$ Hold Time <sup>(21)</sup>	21	—	30	—	35	—	40	—	ns
t <sub>RCD</sub>	$\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ Delay Time <sup>(10, 20)</sup>	10	17	10	21	10	25	10	29	ns
t <sub>ASR</sub>	Row-Address Setup Time	0	—	0	—	0	—	0	—	ns
t <sub>RAH</sub>	Row-Address Hold Time	5	—	5	—	5	—	5	—	ns
t <sub>ASC</sub>	Column-Address Setup Time <sup>(20)</sup>	0	—	0	—	0	—	0	—	ns
t <sub>CAH</sub>	Column-Address Hold Time <sup>(20)</sup>	5	—	5	—	5	—	5	—	ns
t <sub>AR</sub>	Column-Address Hold Time (referenced to $\overline{\text{RAS}}$ )	22	—	26	—	30	—	34	—	ns
t <sub>RAD</sub>	$\overline{\text{RAS}}$ to Column-Address Delay Time <sup>(11)</sup>	8	13	8	14	8	17	8	20	ns
t <sub>RAL</sub>	Column-Address to $\overline{\text{RAS}}$ Lead Time	12	—	16	—	18	—	20	—	ns
t <sub>RPC</sub>	$\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ Precharge Time	10	—	10	—	10	—	10	—	ns
t <sub>RSH</sub>	$\overline{\text{RAS}}$ Hold Time <sup>(27)</sup>	8	—	9	—	10	—	11	—	ns
t <sub>CLZ</sub>	$\overline{\text{CAS}}$ to Output in Low-Z <sup>(15, 29)</sup>	3	—	3	—	3	—	3	—	ns
t <sub>CRP</sub>	$\overline{\text{CAS}}$ to $\overline{\text{RAS}}$ Precharge Time <sup>(21)</sup>	5	—	5	—	5	—	5	—	ns
t <sub>OD</sub>	Output Disable Time <sup>(19, 28, 29)</sup>	—	6	—	8	—	8	—	8	ns
t <sub>OE</sub>	Output Enable Time <sup>(15, 16)</sup>	—	8	—	9	—	10	—	11	ns
t <sub>OES</sub>	$\overline{\text{OE}}$ LOW to $\overline{\text{CAS}}$ HIGH Setup Time	5	—	5	—	5	—	5	—	ns
t <sub>RCS</sub>	Read Command Setup Time <sup>(17, 20)</sup>	0	—	0	—	0	—	0	—	ns
t <sub>RRH</sub>	Read Command Hold Time (referenced to $\overline{\text{RAS}}$ ) <sup>(12)</sup>	0	—	0	—	0	—	0	—	ns
t <sub>RCH</sub>	Read Command Hold Time (referenced to $\overline{\text{CAS}}$ ) <sup>(12, 17, 21)</sup>	0	—	0	—	0	—	0	—	ns
t <sub>WCH</sub>	Write Command Hold Time <sup>(17, 27)</sup>	5	—	5	—	5	—	5	—	ns
t <sub>WCR</sub>	Write Command Hold Time (referenced to $\overline{\text{RAS}}$ ) <sup>(17)</sup>	22	—	26	—	30	—	34	—	ns
t <sub>WP</sub>	Write Command Pulse Width <sup>(17)</sup>	5	—	5	—	5	—	5	—	ns
t <sub>RWL</sub>	Write Command to $\overline{\text{RAS}}$ Lead Time <sup>(17)</sup>	7	—	8	—	9	—	10	—	ns
t <sub>CWL</sub>	Write Command to $\overline{\text{CAS}}$ Lead Time <sup>(17, 21)</sup>	5	—	6	—	7	—	8	—	ns
t <sub>WCS</sub>	Write Command Setup Time <sup>(14, 17, 20)</sup>	0	—	0	—	0	—	0	—	ns
t <sub>DHR</sub>	Data-in Hold Time (referenced to $\overline{\text{RAS}}$ )	22	—	26	—	30	—	34	—	ns

(Continued)



**AC CHARACTERISTICS<sup>(1,2,3,4,5,6)</sup>**

(Recommended Operating Conditions unless otherwise noted.)

Symbol	Parameter	-25		-30		-35		-40		Units
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
tACH	Column-Address Setup Time to CAS Precharge during WRITE Cycle	15	—	15	—	15	—	15	—	ns
toEH	OE Hold Time from WE during READ-MODIFY-WRITE cycle <sup>(18)</sup>	4	—	4	—	4	—	5	—	ns
tDS	Data-In Setup Time <sup>(15, 22)</sup>	0	—	0	—	0	—	0	—	ns
tDH	Data-In Hold Time <sup>(15, 22)</sup>	5	—	5	—	5	—	5	—	ns
trWC	READ-MODIFY-WRITE Cycle Time	65	—	85	—	95	—	105	—	ns
trWD	RAS to WE Delay Time during READ-MODIFY-WRITE Cycle <sup>(14)</sup>	34	—	46	—	51	—	56	—	ns
tcWD	CAS to WE Delay Time <sup>(14, 20)</sup>	17	—	25	—	26	—	27	—	ns
tAWD	Column-Address to WE Delay Time <sup>(14)</sup>	21	—	32	—	34	—	36	—	ns
tPC	Fast Page Mode READ or WRITE Cycle Time <sup>(24)</sup>	15	—	20	—	23	—	25	—	ns
trASP	Fast Page Mode RAS Pulse Width	25	10k	30	10K	35	10K	40	10K	ns
tCPA	Access Time from CAS Precharge <sup>(15)</sup>	—	14	—	18	—	20	—	22	ns
tPRWC	Fast Page Mode READ-WRITE Cycle Time <sup>(24)</sup>	37	—	42	—	49	—	52	—	ns
toFF	Output Buffer Turn-Off Delay from CAS or RAS <sup>(13, 15, 19, 29)</sup>	3	15	3	15	3	15	3	15	ns
tCLCH	Last CAS going LOW to First CAS returning HIGH <sup>(23)</sup>	4	—	9	—	10	—	11	—	ns
tCSR	CAS Setup Time (CBR REFRESH) <sup>(30, 20)</sup>	5	—	10	—	10	—	10	—	ns
tCHR	CAS Hold Time (CBR REFRESH) <sup>(30, 21)</sup>	7	—	10	—	10	—	10	—	ns
tORD	OE Setup Time prior to RAS during HIDDEN REFRESH Cycle	0	—	0	—	0	—	0	—	ns
tREF	Refresh Period (256 Cycles)	—	4	—	4	—	4	—	4	ms
tT	Transition Time (Rise or Fall) <sup>(2, 3)</sup>	1	50	1	50	1	50	1	50	ns

**AC TEST CONDITIONS**

Output load: Two TTL Loads and 50 pF (Vcc = 5.0V ±10%)  
One TTL Load and 50 pF (Vcc = 3.3V ±10%)

Input timing reference levels: V<sub>IH</sub> = 2.4V, V<sub>IL</sub> = 0.8V (Vcc = 5.0V ±10%);  
V<sub>IH</sub> = 2.0V, V<sub>IL</sub> = 0.8V (Vcc = 3.3V ±10%)

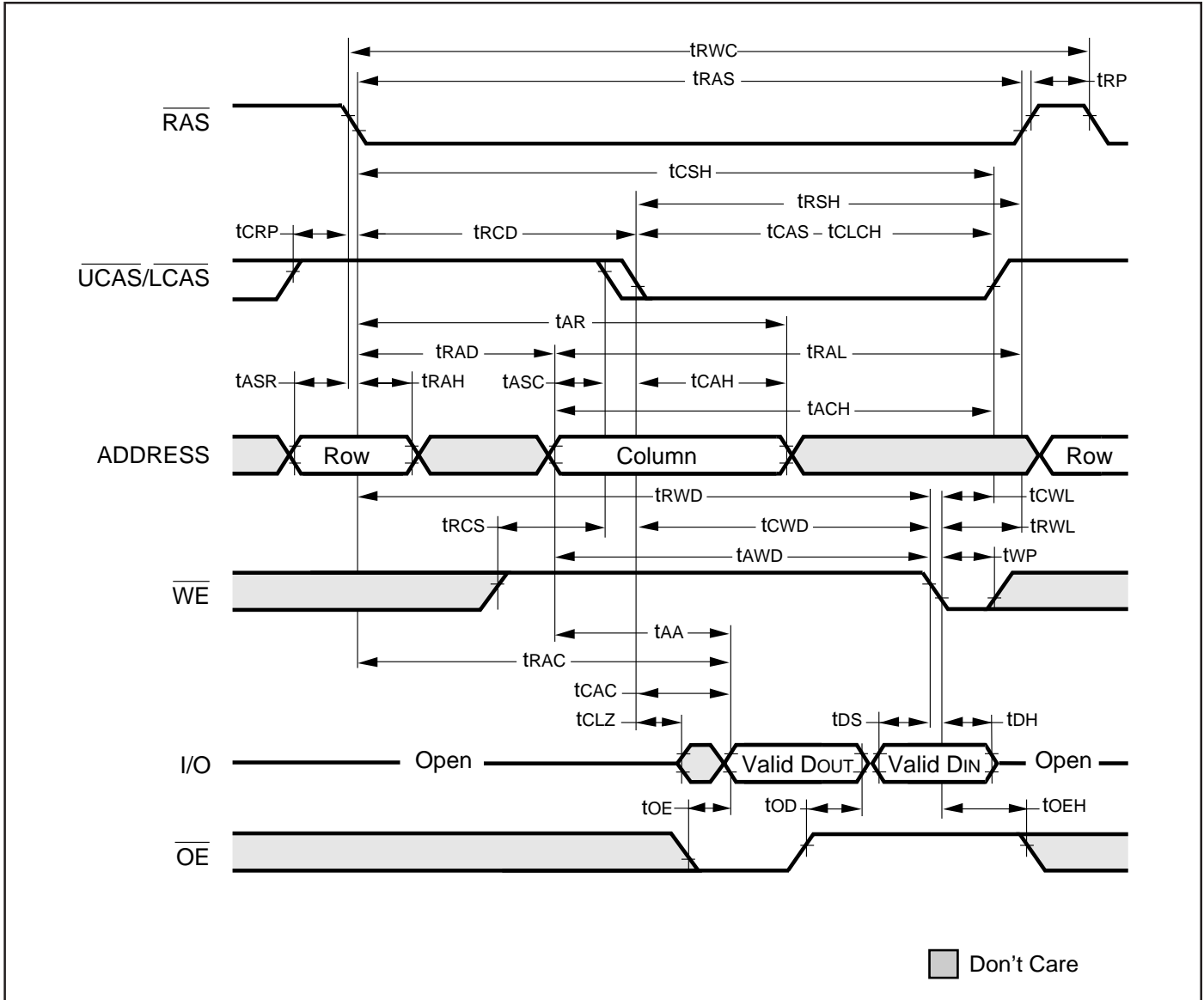
Output timing reference levels: V<sub>OH</sub> = 2.0V, V<sub>OL</sub> = 0.8V (Vcc = 5V ±10%, 3.3V ±10%)

**Notes:**

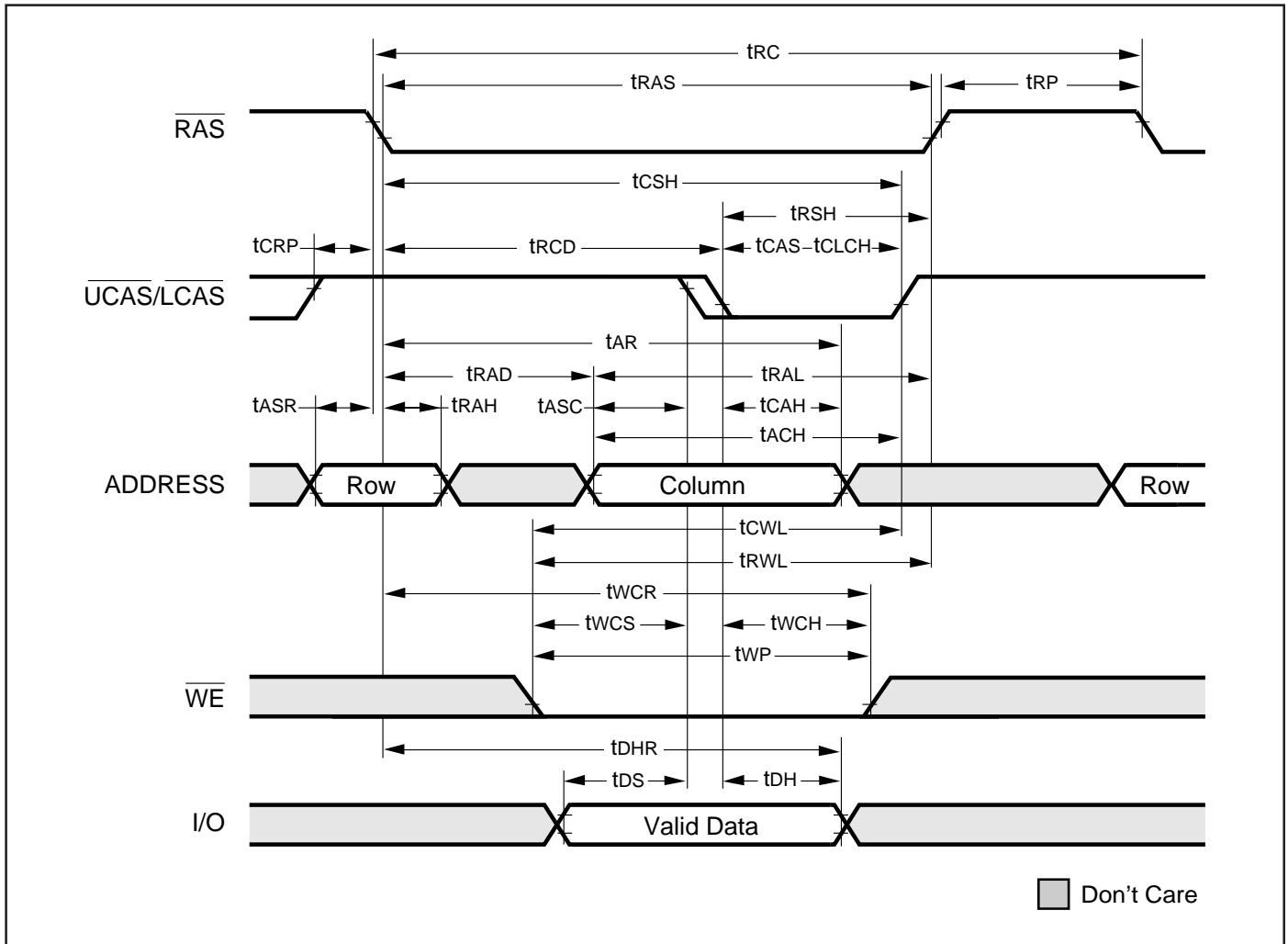
1. An initial pause of 200  $\mu$ s is required after power-up followed by eight  $\overline{\text{RAS}}$  refresh cycle ( $\overline{\text{RAS}}$ -Only or CBR) before proper device operation is assured. The eight RAS cycles wake-up should be repeated any time the  $t_{\text{REF}}$  refresh requirement is exceeded.
2.  $V_{\text{IH}}$  (MIN) and  $V_{\text{IL}}$  (MAX) are reference levels for measuring timing of input signals. Transition times, are measured between  $V_{\text{IH}}$  and  $V_{\text{IL}}$  (or between  $V_{\text{IL}}$  and  $V_{\text{IH}}$ ) and assume to be 1 ns for all inputs.
3. In addition to meeting the transition rate specification, all input signals must transit between  $V_{\text{IH}}$  and  $V_{\text{IL}}$  (or between  $V_{\text{IL}}$  and  $V_{\text{IH}}$ ) in a monotonic manner.
4. If  $\text{CAS}$  and  $\text{RAS} = V_{\text{IH}}$ , data output is High-Z.
5. If  $\text{CAS} = V_{\text{IL}}$ , data output may contain data from the last valid READ cycle.
6. Measured with a load equivalent to one TTL gate and 50 pF.
7. Assumes that  $t_{\text{RCD}} \leq t_{\text{RCD}} (\text{MAX})$ . If  $t_{\text{RCD}}$  is greater than the maximum recommended value shown in this table,  $t_{\text{RAC}}$  will increase by the amount that  $t_{\text{RCD}}$  exceeds the value shown.
8. Assumes that  $t_{\text{RCD}} \geq t_{\text{RCD}} (\text{MAX})$ .
9. If  $\text{CAS}$  is LOW at the falling edge of  $\text{RAS}$ , data out will be maintained from the previous cycle. To initiate a new cycle and clear the data output buffer,  $\overline{\text{CAS}}$  and  $\text{RAS}$  must be pulsed for  $t_{\text{CP}}$ .
10. Operation with the  $t_{\text{RCD}} (\text{MAX})$  limit ensures that  $t_{\text{RAC}} (\text{MAX})$  can be met.  $t_{\text{RCD}} (\text{MAX})$  is specified as a reference point only; if  $t_{\text{RCD}}$  is greater than the specified  $t_{\text{RCD}} (\text{MAX})$  limit, access time is controlled exclusively by  $t_{\text{CAC}}$ .
11. Operation within the  $t_{\text{RAD}} (\text{MAX})$  limit ensures that  $t_{\text{RCD}} (\text{MAX})$  can be met.  $t_{\text{RAD}} (\text{MAX})$  is specified as a reference point only; if  $t_{\text{RAD}}$  is greater than the specified  $t_{\text{RAD}} (\text{MAX})$  limit, access time is controlled exclusively by  $t_{\text{AA}}$ .
12. Either  $t_{\text{RCH}}$  or  $t_{\text{RRH}}$  must be satisfied for a READ cycle.
13.  $t_{\text{OFF}} (\text{MAX})$  defines the time at which the output achieves the open circuit condition; it is not a reference to  $V_{\text{OH}}$  or  $V_{\text{OL}}$ .
14.  $t_{\text{WCS}}$ ,  $t_{\text{RWD}}$ ,  $t_{\text{AWD}}$  and  $t_{\text{CWD}}$  are restrictive operating parameters in LATE WRITE and READ-MODIFY-WRITE cycle only. If  $t_{\text{WCS}} \geq t_{\text{WCS}} (\text{MIN})$ , the cycle is an EARLY WRITE cycle and the data output will remain open circuit throughout the entire cycle. If  $t_{\text{RWD}} \geq t_{\text{RWD}} (\text{MIN})$ ,  $t_{\text{AWD}} \geq t_{\text{AWD}} (\text{MIN})$  and  $t_{\text{CWD}} \geq t_{\text{CWD}} (\text{MIN})$ , the cycle is a READ-WRITE cycle and the data output will contain data read from the selected cell. If neither of the above conditions is met, the state of I/O (at access time and until  $\overline{\text{CAS}}$  and  $\overline{\text{RAS}}$  or  $\overline{\text{OE}}$  go back to  $V_{\text{IH}}$ ) is indeterminate.  $\overline{\text{OE}}$  held HIGH and  $\overline{\text{WE}}$  taken LOW after  $\overline{\text{CAS}}$  goes LOW result in a LATE WRITE ( $\overline{\text{OE}}$ -controlled) cycle.
15. Output parameter (I/O) is referenced to corresponding  $\overline{\text{CAS}}$  input, I/O0-I/O7 by  $\overline{\text{LCAS}}$  and I/O8-I/O15 by  $\overline{\text{UCAS}}$ .
16. During a READ cycle, if  $\text{OE}$  is LOW then taken HIGH before  $\text{CAS}$  goes HIGH, I/O goes open. If  $\text{OE}$  is tied permanently LOW, a LATE WRITE or READ-MODIFY-WRITE is not possible.
17. Write command is defined as  $\overline{\text{WE}}$  going low.
18. LATE WRITE and READ-MODIFY-WRITE cycles must have both  $t_{\text{OD}}$  and  $t_{\text{OEH}}$  met ( $\overline{\text{OE}}$  HIGH during WRITE cycle) in order to ensure that the output buffers will be open during the WRITE cycle. The I/Os will provide the previously written data if  $\overline{\text{CAS}}$  remains LOW and  $\overline{\text{OE}}$  is taken back to LOW after  $t_{\text{OEH}}$  is met.
19. The I/Os are in open during READ cycles once  $t_{\text{OD}}$  or  $t_{\text{OFF}}$  occur.
20. The first  $\chi\overline{\text{CAS}}$  edge to transition LOW.
21. The last  $\chi\overline{\text{CAS}}$  edge to transition HIGH.
22. These parameters are referenced to  $\overline{\text{CAS}}$  leading edge in EARLY WRITE cycles and  $\overline{\text{WE}}$  leading edge in LATE WRITE or READ-MODIFY-WRITE cycles.
23. Last falling  $\chi\overline{\text{CAS}}$  edge to first rising  $\chi\overline{\text{CAS}}$  edge.
24. Last rising  $\chi\overline{\text{CAS}}$  edge to next cycle's last rising  $\chi\overline{\text{CAS}}$  edge.
25. Last rising  $\chi\overline{\text{CAS}}$  edge to first falling  $\chi\overline{\text{CAS}}$  edge.
26. Each  $\chi\overline{\text{CAS}}$  must meet minimum pulse width.
27. Last  $\chi\overline{\text{CAS}}$  to go LOW.
28. I/Os controlled, regardless  $\overline{\text{UCAS}}$  and  $\overline{\text{LCAS}}$ .
29. The 3 ns minimum is a parameter guaranteed by design.
30. Enables on-chip refresh and address counters.



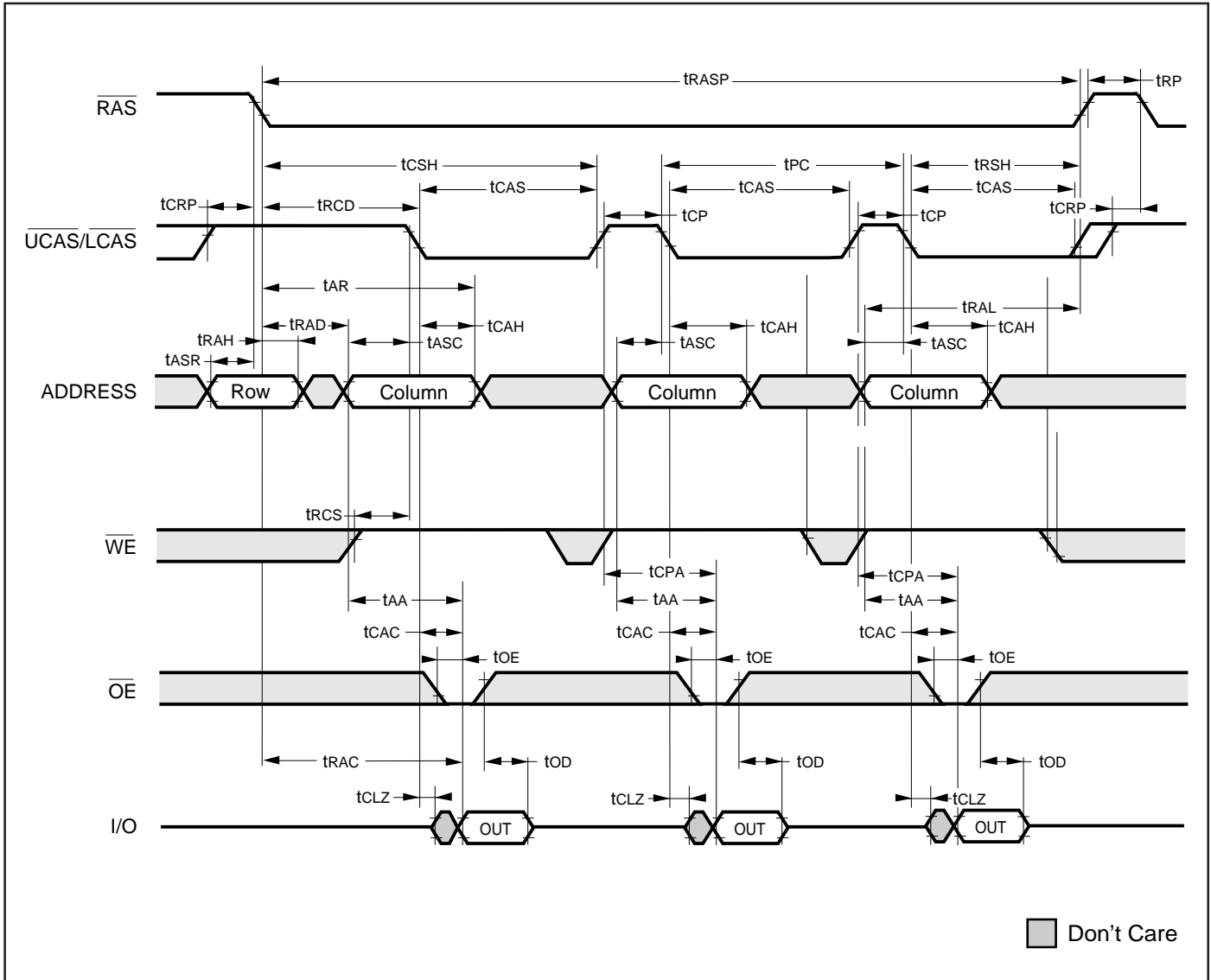
**READ WRITE CYCLE (LATE WRITE and READ-MODIFY-WRITE Cycles)**



EARLY WRITE CYCLE ( $\overline{OE}$  = DON'T CARE)

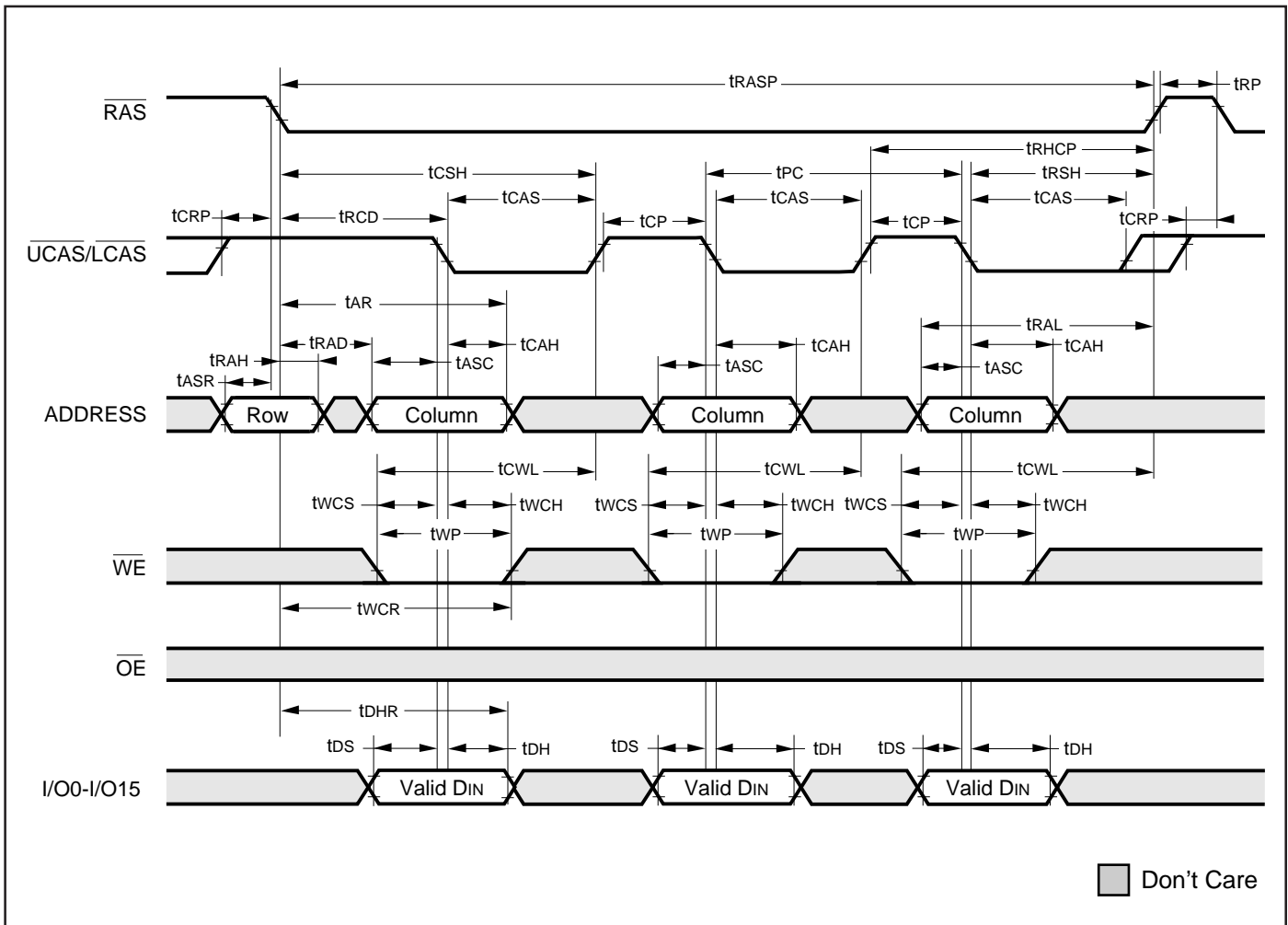


FAST PAGE MODE READ CYCLE



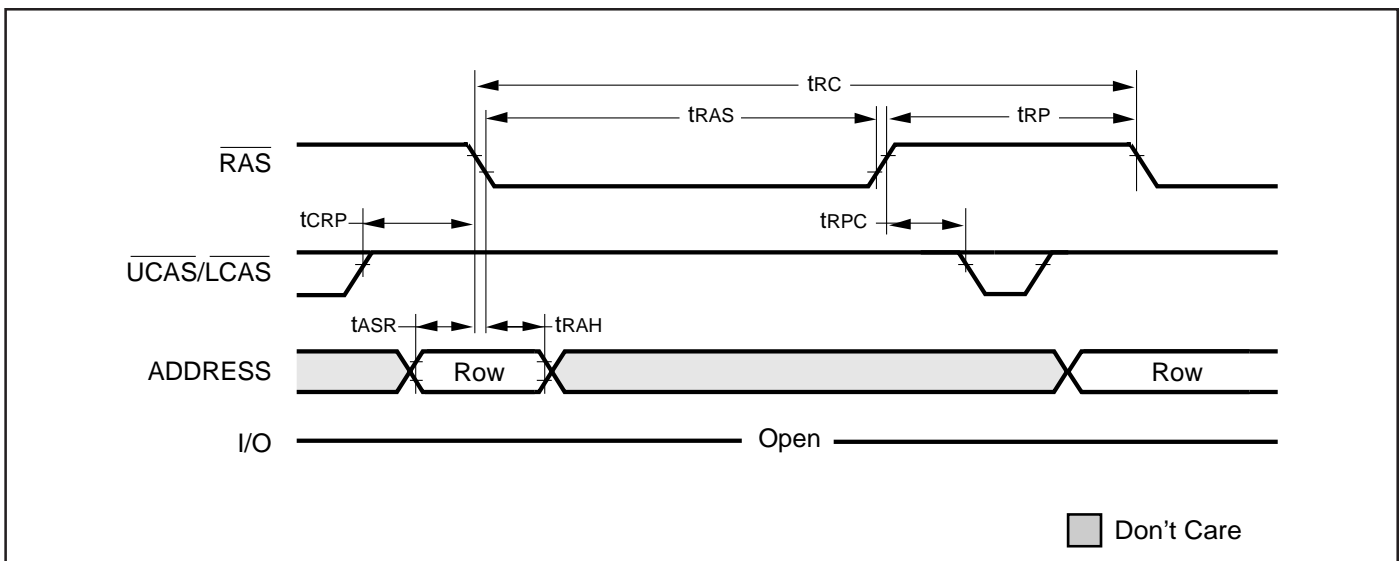


**FAST PAGE MODE EARLY WRITE CYCLE**



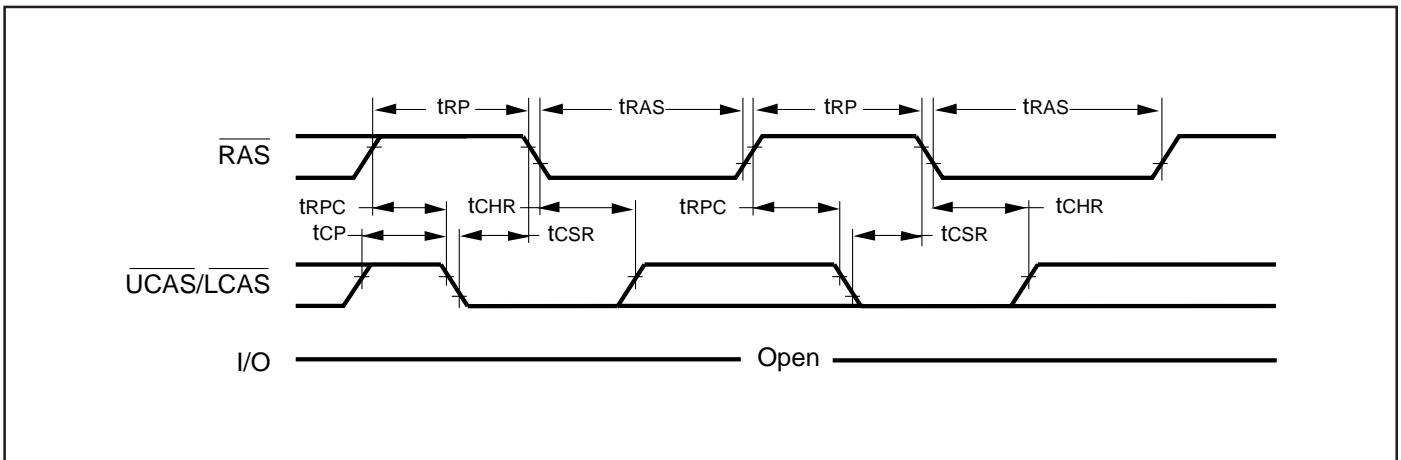
**AC WAVEFORMS**

**RAS-ONLY REFRESH CYCLE ( $\overline{OE}$ ,  $\overline{WE}$  = DON'T CARE)**

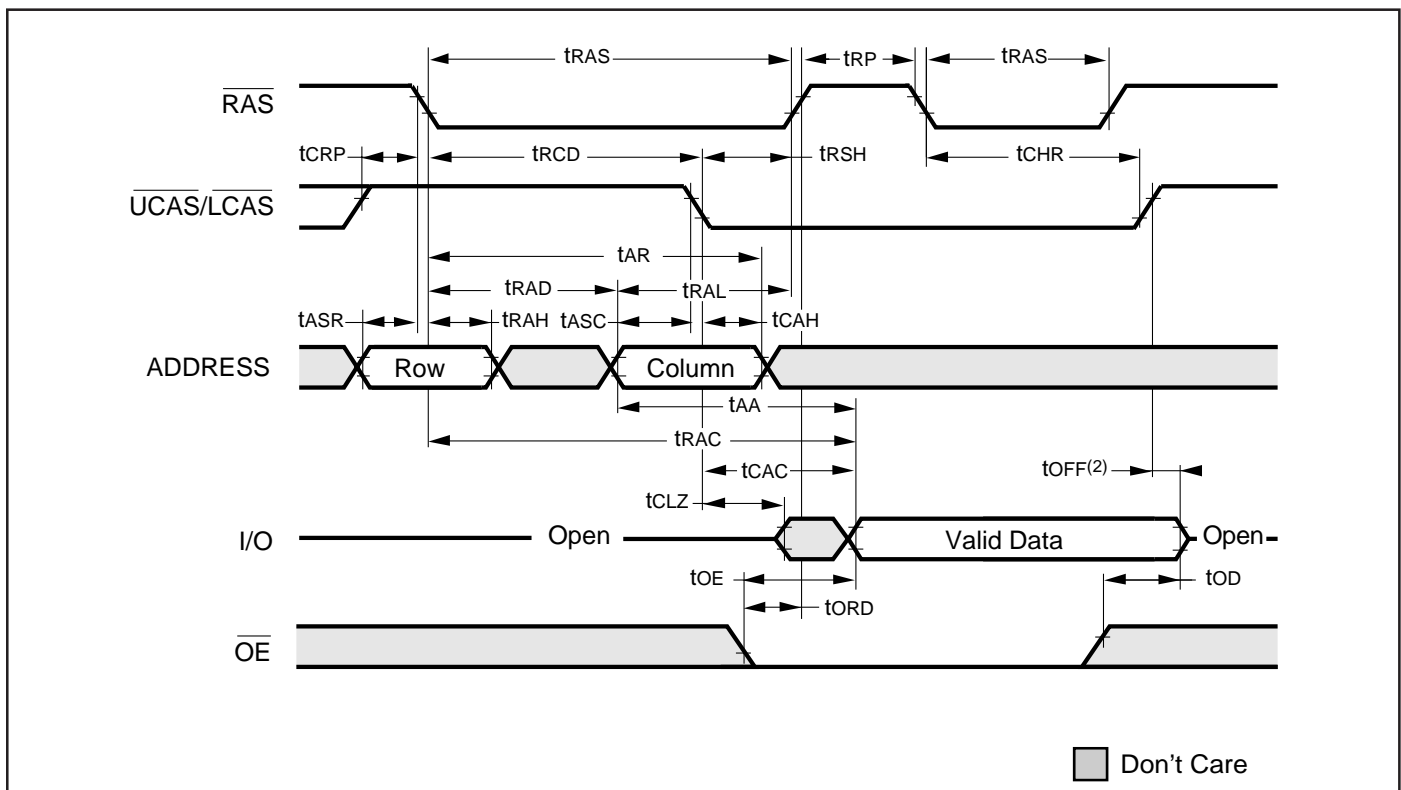




**CBR REFRESH CYCLE** (Addresses;  $\overline{WE}$ ,  $\overline{OE}$  = DON'T CARE)



**HIDDEN REFRESH CYCLE<sup>(1)</sup>** ( $\overline{WE}$  = HIGH;  $\overline{OE}$  = LOW)



**Notes:**

1. A Hidden Refresh may also be performed after a Write Cycle. In this case,  $\overline{WE}$  = LOW and  $\overline{OE}$  = HIGH.
2.  $t_{OFF}$  is referenced from rising edge of RAS or CAS, whichever occurs last.

**ORDERING INFORMATION**

**IC41C1665**

**Commercial Range: 0°C to 70°C**

Speed(ns)	OrderPartNo.	Package
25	IC41C1665-25K	400mil SOJ
	IC41C1665-25T	400mil TSOP-2
30	IC41C1665-30K	400mil SOJ
	IC41C1665-30T	400mil TSOP-2
35	IC41C1665-35K	400mil SOJ
	IC41C1665-35T	400mil TSOP-2
40	IC41C1665-40K	400mil SOJ
	IC41C1665-40T	400mil TSOP-2

**Industrial Range: -40°C to 85°C**

Speed(ns)	OrderPartNo.	Package
25	IC41C1665-25KI	400mil SOJ
	IC41C1665-25TI	400mil TSOP-2
30	IC41C1665-30KI	400mil SOJ
	IC41C1665-30TI	400mil TSOP-2
35	IC41C1665-35KI	400mil SOJ
	IC41C1665-35TI	400mil TSOP-2
40	IC41C1665-40KI	400mil SOJ
	IC41C1665-40TI	400mil TSOP-2

**ORDERING INFORMATION**

**IC41LV1665**

**Commercial Range: 0°C to 70°C**

Speed(ns)	OrderPartNo.	Package
25	IC41LV1665-25K	400mil SOJ
	IC41LV1665-25T	400mil TSOP-2
30	IC41LV1665-30K	400mil SOJ
	IC41LV1665-30T	400mil TSOP-2
35	IC41LV1665-35K	400mil SOJ
	IC41LV1665-35T	400mil TSOP-2
40	IC41LV1665-40K	400mil SOJ
	IC41LV1665-40T	400mil TSOP-2

**Industrial Range: -40°C to 85°C**

Speed(ns)	OrderPartNo.	Package
25	IC41LV1665-25KI	400mil SOJ
	IC41LV1665-25TI	400mil TSOP-2
30	IC41LV1665-30KI	400mil SOJ
	IC41LV1665-30TI	400mil TSOP-2
35	IC41LV1665-35KI	400mil SOJ
	IC41LV1665-35TI	400mil TSOP-2
40	IC41LV1665-40KI	400mil SOJ
	IC41LV1665-40TI	400mil TSOP-2



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