

4M x 16bit CMOS Dynamic RAM with Extended Data Out

DESCRIPTION

This is a family of 4,194,304 x 16 bit Extended Data Out Mode CMOS DRAMs. Extended Data Out Mode offers high speed random access of memory cells within the same row. Refresh cycle(4K Ref. or 8K Ref.), access time (-45, -50 or -60), power consumption(Normal or Low power) are optional features of this family. All of this family have $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh, $\overline{\text{RAS}}$ -only refresh and Hidden refresh capabilities. Furthermore, Self-refresh operation is available in L-version. This 4Mx16 EDO Mode DRAM family is fabricated using Samsung's advanced CMOS process to realize high band-width, low power consumption and high reliability.

FEATURES

• **Part Identification**

- K4E661612E-TC/L(3.3V, 8K Ref.)
- K4E641612E-TC/L(3.3V, 4K Ref.)

• **Active Power Dissipation**

Unit : mW

| Speed | 8K | 4K |
|-------|-----|-----|
| -45 | 324 | 468 |
| -50 | 288 | 432 |
| -60 | 252 | 396 |

- Extended Data Out Mode operation
- 2 $\overline{\text{CAS}}$ Byte/Word Read/Write operation
- $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh capability
- $\overline{\text{RAS}}$ -only and Hidden refresh capability
- Fast parallel test mode capability
- Self-refresh capability (L-ver only)
- LVTTTL(3.3V) compatible inputs and outputs
- Early Write or output enable controlled write
- JEDEC Standard pinout
- Available in Plastic TSOP(II) packages
- +3.3V \pm 0.3V power supply

• **Refresh Cycles**

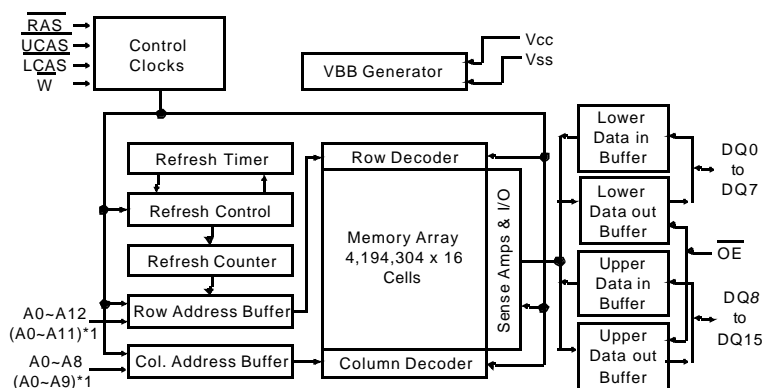
| Part NO. | Refresh cycle | Refresh time | |
|-------------|---------------|--------------|-------|
| | | Normal | L-ver |
| K4E661612E* | 8K | 64ms | 128ms |
| K4E641612E | 4K | | |

* Access mode & $\overline{\text{RAS}}$ only refresh mode : 8K cycle/64ms(Normal), 8K cycle/128ms(L-ver.)
 $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ & Hidden refresh mode : 4K cycle/64ms(Normal), 4K cycle/128ms(L-ver.)

• **Performance Range**

| Speed | t _{rac} | t _{cac} | t _{rc} | t _{hpc} |
|-------|------------------|------------------|-----------------|------------------|
| -45 | 45ns | 12ns | 74ns | 17ns |
| -50 | 50ns | 13ns | 84ns | 20ns |
| -60 | 60ns | 15ns | 104ns | 25ns |

FUNCTIONAL BLOCK DIAGRAM

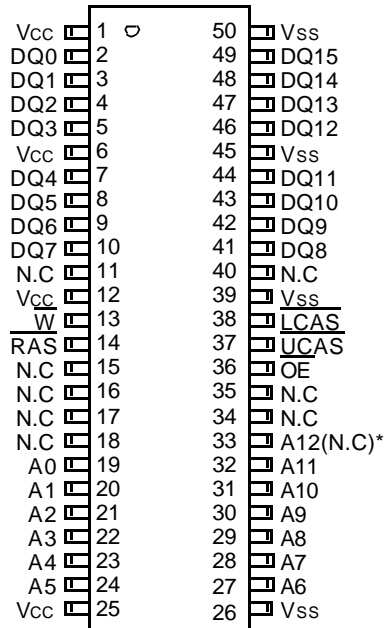


Note) *1 : 4K Refresh

SAMSUNG ELECTRONICS CO., LTD. reserves the right to change products and specifications without notice.

PIN CONFIGURATION (Top Views)

- K4E661612E-T
- K4E641612E-T



(400mil TSOP(II))

*(N.C) : N.C for 4K Refresh Product

| Pin Name | Pin function |
|-------------------|-----------------------------|
| A0 - A12 | Address Inputs(8K Product) |
| A0 - A11 | Address Inputs(4K Product) |
| DQ0 - 15 | Data In/Out |
| Vss | Ground |
| \overline{RAS} | Row Address Strobe |
| \overline{UCAS} | Upper Column Address Strobe |
| \overline{LCAS} | Lower Column Address Strobe |
| \overline{W} | Read/Write Input |
| \overline{OE} | Data Output Enable |
| Vcc | Power(+3.3V) |
| N.C | No Connection |

ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Rating | Units |
|---|------------------------------------|--------------|-------|
| Voltage on any pin relative to V _{SS} | V _{IN} , V _{OUT} | -0.5 to +4.6 | V |
| Voltage on V _{CC} supply relative to V _{SS} | V _{CC} | -0.5 to +4.6 | V |
| Storage Temperature | T _{stg} | -55 to +150 | °C |
| Power Dissipation | P _D | 1 | W |
| Short Circuit Output Current | I _{OS} Address | 50 | mA |

* Permanent device damage may occur if "ABSOLUTE MAXIMUM RATINGS" are exceeded. Functional operation should be restricted to the conditions as detailed in the operational sections of this data sheet. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS (Voltage referenced to V_{SS}, T_A= 0 to 70°C)

| Parameter | Symbol | Min | Typ | Max | Units |
|--------------------|-----------------|--------------------|-----|------------------------------------|-------|
| Supply Voltage | V _{CC} | 3.0 | 3.3 | 3.6 | V |
| Ground | V _{SS} | 0 | 0 | 0 | V |
| Input High Voltage | V _{IH} | 2.0 | - | V _{CC} +0.3 ^{*1} | V |
| Input Low Voltage | V _{IL} | -0.3 ^{*2} | - | 0.8 | V |

*1 : V_{CC}+1.3V at pulse width ≤15ns which is measured at V_{CC}

*2 : -1.3 at pulse width ≤15ns which is measured at V_{SS}

DC AND OPERATING CHARACTERISTICS (Recommended operating conditions unless otherwise noted.)

| Parameter | Symbol | Min | Max | Units |
|---|-------------------|-----|-----|-------|
| Input Leakage Current (Any input 0 ≤ V _{IN} ≤ V _{CC} +0.3V, all other pins not under test=0 Volt) | I _{I(L)} | -5 | 5 | μA |
| Output Leakage Current (Data out is disabled, 0V ≤ V _{OUT} ≤ V _{CC}) | I _{O(L)} | -5 | 5 | μA |
| Output High Voltage Level(I _{OH} =-2mA) | V _{OH} | 2.4 | - | V |
| Output Low Voltage Level(I _{OL} =2mA) | V _{OL} | - | 0.4 | V |

DC AND OPERATING CHARACTERISTICS (Continued)

| Symbol | Power | Speed | Max | | Units |
|------------------|-------------|------------|------------|------------|-------|
| | | | K4E661612E | K4E641612E | |
| I _{CC1} | Don't care | -45 | 90 | 130 | mA |
| | | -50 | 80 | 120 | mA |
| | | -60 | 70 | 110 | mA |
| I _{CC2} | Normal L | Don't care | 1 | 1 | mA |
| | | | 1 | 1 | mA |
| I _{CC3} | Don't care | -45 | 90 | 130 | mA |
| | | -50 | 80 | 120 | mA |
| | | -60 | 70 | 110 | mA |
| I _{CC4} | Don't care | -45 | 100 | 100 | mA |
| | | -50 | 90 | 90 | mA |
| | | -60 | 80 | 80 | mA |
| I _{CC5} | Normal L | Don't care | 0.5 | 0.5 | mA |
| | | | 200 | 200 | uA |
| I _{CC6} | Don't care | -45 | 130 | 130 | mA |
| | | -50 | 120 | 120 | mA |
| | | -60 | 110 | 110 | mA |
| I _{CC7} | L | Don't care | 350 | 350 | uA |
| I _{CC8} | L | Don't care | 350 | 350 | uA |

I_{CC1}* : Operating Current ($\overline{\text{RAS}}$ and $\overline{\text{UCAS}}$, $\overline{\text{LCAS}}$, Address cycling @ $t_{\text{RC}}=\text{min.}$)

I_{CC2} : Standby Current ($\overline{\text{RAS}}=\overline{\text{UCAS}}=\overline{\text{LCAS}}=\overline{\text{W}}=V_{\text{IH}}$)

I_{CC3}* : $\overline{\text{RAS}}$ -only Refresh Current ($\overline{\text{UCAS}}=\overline{\text{LCAS}}=V_{\text{IH}}$, $\overline{\text{RAS}}$, Address cycling @ $t_{\text{RC}}=\text{min.}$)

I_{CC4}* : Extended Data Out Mode Current ($\overline{\text{RAS}}=V_{\text{IL}}$, $\overline{\text{UCAS}}$ or $\overline{\text{LCAS}}$, Address cycling @ $t_{\text{HPC}}=\text{min.}$)

I_{CC5} : Standby Current ($\overline{\text{RAS}}=\overline{\text{UCAS}}=\overline{\text{LCAS}}=\overline{\text{W}}=V_{\text{CC}}-0.2\text{V}$)

I_{CC6}* : $\overline{\text{CAS}}$ -Before- $\overline{\text{RAS}}$ Refresh Current ($\overline{\text{RAS}}$ and $\overline{\text{UCAS}}$ or $\overline{\text{LCAS}}$ cycling @ $t_{\text{RC}}=\text{min.}$)

I_{CC7} : Battery back-up current, Average power supply current, Battery back-up mode

Input high voltage(V_{IH})= $V_{\text{CC}}-0.2\text{V}$, Input low voltage(V_{IL})= 0.2V , $\overline{\text{UCAS}}$, $\overline{\text{LCAS}}=\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ cycling or 0.2V

$\overline{\text{W}}$, $\overline{\text{OE}}=V_{\text{IH}}$, Address=Don't care, DQ=Open, $T_{\text{RC}}=31.25\mu\text{s}$

I_{CC8} : Self Refresh Current

$\overline{\text{RAS}}=\overline{\text{UCAS}}=\overline{\text{LCAS}}=0.2\text{V}$, $\overline{\text{W}}=\overline{\text{OE}}=A0 \sim A12(A11)=V_{\text{CC}}-0.2\text{V}$ or 0.2V , DQ0 ~ DQ15= $V_{\text{CC}}-0.2\text{V}$, 0.2V or Open

***Note :** I_{CC1}, I_{CC3}, I_{CC4} and I_{CC6} are dependent on output loading and cycle rates. Specified values are obtained with the output open. I_{CC} is specified as an average current. In I_{CC1}, I_{CC3} and I_{CC6}, address can be changed maximum once while $\overline{\text{RAS}}=V_{\text{IL}}$. In I_{CC4}, address can be changed maximum once within one EDO mode cycle time, t_{HPC} .

K4E661612E, K4E641612E

CMOS DRAM

CAPACITANCE (T_A=25°C, V_{CC}=3.3V, f=1MHz)

| Parameter | Symbol | Min | Max | Units |
|--|------------------|-----|-----|-------|
| Input capacitance [A0 ~ A12] | C _{IN1} | - | 5 | pF |
| Input capacitance [$\overline{\text{RAS}}$, $\overline{\text{UCAS}}$, $\overline{\text{LCAS}}$, $\overline{\text{W}}$, $\overline{\text{OE}}$] | C _{IN2} | - | 7 | pF |
| Output capacitance [DQ0 - DQ15] | C _{DQ} | - | 7 | pF |

AC CHARACTERISTICS (0°C ≤ T_A ≤ 70°C, See note 2)

Test condition : V_{CC}=3.3V±0.3V, V_{IH}/V_{IL}=2.2/0.7V, V_{OH}/V_{OL}=2.0/0.8V

| Parameter | Symbol | -45 | | -50 | | -60 | | Units | Note |
|---|------------------|-----|-----|-----|-----|-----|-----|-------|--------|
| | | Min | Max | Min | Max | Min | Max | | |
| Random read or write cycle time | t _{RC} | 74 | | 84 | | 104 | | ns | |
| Read-modify-write cycle time | t _{RWC} | 101 | | 113 | | 138 | | ns | |
| Access time from $\overline{\text{RAS}}$ | t _{RAC} | | 45 | | 50 | | 60 | ns | 3,4,10 |
| Access time from $\overline{\text{CAS}}$ | t _{CAC} | | 12 | | 13 | | 15 | ns | 3,4,5 |
| Access time from column address | t _{AA} | | 23 | | 25 | | 30 | ns | 3,10 |
| $\overline{\text{CAS}}$ to output in Low-Z | t _{CLZ} | 3 | | 3 | | 3 | | ns | 3 |
| Output buffer turn-off delay from $\overline{\text{CAS}}$ | t _{CEZ} | 3 | 13 | 3 | 13 | 3 | 13 | ns | 6,20 |
| $\overline{\text{OE}}$ to output in Low-Z | t _{OLZ} | 3 | | 3 | | 3 | | ns | 3 |
| Transition time (rise and fall) | t _T | 1 | 50 | 1 | 50 | 1 | 50 | ns | 2 |
| $\overline{\text{RAS}}$ precharge time | t _{RP} | 25 | | 30 | | 40 | | ns | |
| $\overline{\text{RAS}}$ pulse width | t _{RAS} | 45 | 10K | 50 | 10K | 60 | 10K | ns | |
| $\overline{\text{RAS}}$ hold time | t _{RSH} | 8 | | 8 | | 10 | | ns | |
| $\overline{\text{CAS}}$ hold time | t _{CSH} | 35 | | 38 | | 40 | | ns | |
| $\overline{\text{CAS}}$ pulse width | t _{CAS} | 7 | 5K | 8 | 10K | 10 | 10K | ns | |
| $\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ delay time | t _{RCD} | 11 | 33 | 11 | 37 | 14 | 45 | ns | 4 |
| $\overline{\text{RAS}}$ to column address delay time | t _{RAD} | 9 | 22 | 9 | 25 | 12 | 30 | ns | 10 |
| $\overline{\text{CAS}}$ to $\overline{\text{RAS}}$ precharge time | t _{CRP} | 5 | | 5 | | 5 | | ns | |
| Row address set-up time | t _{ASR} | 0 | | 0 | | 0 | | ns | |
| Row address hold time | t _{RAH} | 7 | | 7 | | 10 | | ns | |
| Column address set-up time | t _{ASC} | 0 | | 0 | | 0 | | ns | 13 |
| Column address hold time | t _{CAH} | 7 | | 7 | | 10 | | ns | 13 |
| Column address to $\overline{\text{RAS}}$ lead time | t _{RAL} | 23 | | 25 | | 30 | | ns | |
| Read command set-up time | t _{RCS} | 0 | | 0 | | 0 | | ns | |
| Read command hold time referenced to $\overline{\text{CAS}}$ | t _{RCH} | 0 | | 0 | | 0 | | ns | 8 |
| Read command hold time referenced to $\overline{\text{RAS}}$ | t _{RRH} | 0 | | 0 | | 0 | | ns | 8 |
| Write command hold time | t _{WCH} | 7 | | 7 | | 10 | | ns | |
| Write command pulse width | t _{WP} | 6 | | 7 | | 10 | | ns | |
| Write command to $\overline{\text{RAS}}$ lead time | t _{RWL} | 8 | | 8 | | 10 | | ns | |
| Write command to $\overline{\text{CAS}}$ lead time | t _{CWL} | 7 | | 7 | | 10 | | ns | 16 |
| Data set-up time | t _{DS} | 0 | | 0 | | 0 | | ns | 9,19 |

AC CHARACTERISTICS (Continued)

| Parameter | Symbol | -45 | | -50 | | -60 | | Units | Note |
|---|--------------------|-----|------|-----|------|-----|------|-------|----------|
| | | Min | Max | Min | Max | Min | Max | | |
| Data hold time | t _{DH} | 7 | | 7 | | 10 | | ns | 9,19 |
| Refresh period (Normal) | t _{REF} | | 64 | | 64 | | 64 | ms | |
| Refresh period (L-ver) | t _{REF} | | 128 | | 128 | | 128 | ms | |
| Write command set-up time | t _{WCS} | 0 | | 0 | | 0 | | ns | 7 |
| $\overline{\text{CAS}}$ to $\overline{\text{W}}$ delay time | t _{CWD} | 24 | | 27 | | 32 | | ns | 7,15 |
| $\overline{\text{RAS}}$ to $\overline{\text{W}}$ delay time | t _{RWD} | 57 | | 64 | | 77 | | ns | 7 |
| Column address to $\overline{\text{W}}$ delay time | t _{AWD} | 35 | | 39 | | 47 | | ns | 7 |
| $\overline{\text{CAS}}$ set-up time ($\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh) | t _{CSR} | 5 | | 5 | | 5 | | ns | 17 |
| $\overline{\text{CAS}}$ hold time ($\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh) | t _{CHR} | 10 | | 10 | | 10 | | ns | 18 |
| $\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ precharge time | t _{RPC} | 5 | | 5 | | 5 | | ns | |
| Access time from $\overline{\text{CAS}}$ precharge | t _{CPA} | | 24 | | 28 | | 35 | ns | 3 |
| Hyper Page cycle time | t _{HPC} | 17 | | 20 | | 25 | | ns | 21 |
| Hyper Page read-modify-write cycle time | t _{HPRWC} | 47 | | 47 | | 56 | | ns | 21 |
| $\overline{\text{CAS}}$ precharge time (Hyper page cycle) | t _{CP} | 6.5 | | 7 | | 10 | | ns | 14 |
| $\overline{\text{RAS}}$ pulse width (Hyper page cycle) | t _{RASP} | 45 | 200K | 50 | 200K | 60 | 200K | ns | |
| $\overline{\text{RAS}}$ hold time from $\overline{\text{CAS}}$ precharge | t _{RHCP} | 24 | | 30 | | 35 | | ns | |
| $\overline{\text{OE}}$ access time | t _{OE A} | | 12 | | 13 | | 15 | ns | 3 |
| $\overline{\text{OE}}$ to data delay | t _{OE D} | 8 | | 10 | | 13 | | ns | |
| $\overline{\text{CAS}}$ precharge to $\overline{\text{W}}$ delay time | t _{CPWD} | 36 | | 41 | | 52 | | ns | |
| Output buffer turn off delay time from $\overline{\text{OE}}$ | t _{OE Z} | 3 | 11 | 3 | 13 | 3 | 13 | ns | 6 |
| $\overline{\text{OE}}$ command hold time | t _{OE H} | 5 | | 5 | | 5 | | ns | |
| Write command set-up time (Test mode in) | t _{WTS} | 10 | | 10 | | 10 | | ns | 11 |
| Write command hold time (Test mode in) | t _{WTH} | 10 | | 10 | | 10 | | ns | 11 |
| $\overline{\text{W}}$ to $\overline{\text{RAS}}$ precharge time (C-B-R refresh) | t _{WRP} | 10 | | 10 | | 10 | | ns | |
| $\overline{\text{W}}$ to $\overline{\text{RAS}}$ hold time (C-B-R refresh) | t _{WRH} | 10 | | 10 | | 10 | | ns | |
| Output data hold time | t _{DOH} | 4 | | 5 | | 5 | | ns | |
| Output buffer turn off delay from $\overline{\text{RAS}}$ | t _{REZ} | 3 | 13 | 3 | 13 | 3 | 13 | ns | 6,20 |
| Output buffer turn off delay from $\overline{\text{W}}$ | t _{WEZ} | 3 | 13 | 3 | 13 | 3 | 13 | ns | 6 |
| $\overline{\text{W}}$ to data delay | t _{WED} | 8 | | 15 | | 15 | | ns | |
| $\overline{\text{OE}}$ to $\overline{\text{CAS}}$ hold time | t _{OE H} | 5 | | 5 | | 5 | | ns | |
| $\overline{\text{CAS}}$ hold time to $\overline{\text{OE}}$ | t _{CHO} | 5 | | 5 | | 5 | | ns | |
| $\overline{\text{OE}}$ precharge time | t _{OE P} | 5 | | 5 | | 5 | | ns | |
| $\overline{\text{W}}$ pulse width (Hyper Page Cycle) | t _{WPE} | 5 | | 5 | | 5 | | ns | |
| $\overline{\text{RAS}}$ pulse width (C-B-R self refresh) | t _{RASS} | 100 | | 100 | | 100 | | us | 22,23,24 |
| $\overline{\text{RAS}}$ precharge time (C-B-R self refresh) | t _{RPS} | 74 | | 90 | | 110 | | ns | 22,23,24 |
| $\overline{\text{CAS}}$ hold time (C-B-R self refresh) | t _{CHS} | -50 | | -50 | | -50 | | ns | 22,23,24 |

TEST MODE CYCLE

(Note 11)

| Parameter | Symbol | -45 | | -50 | | -60 | | Units | Note |
|---|--------------------|-----|------|-----|------|-----|------|-------|-----------|
| | | Min | Max | Min | Max | Min | Max | | |
| Random read or write cycle time | t _{RC} | 79 | | 89 | | 109 | | ns | |
| Read-modify-write cycle time | t _{RWC} | 110 | | 121 | | 145 | | ns | |
| Access time from $\overline{\text{RAS}}$ | t _{RAC} | | 50 | | 55 | | 65 | ns | 3,4,10,12 |
| Access time from $\overline{\text{CAS}}$ | t _{CAC} | | 17 | | 18 | | 20 | ns | 3,4,5,12 |
| Access time from column address | t _{AA} | | 28 | | 30 | | 35 | ns | 3,10,12 |
| $\overline{\text{RAS}}$ pulse width | t _{RAS} | 50 | 10K | 55 | 10K | 65 | 10K | ns | |
| $\overline{\text{CAS}}$ pulse width | t _{CAS} | 12 | 10K | 13 | 10K | 15 | 10K | ns | |
| $\overline{\text{RAS}}$ hold time | t _{RSH} | 18 | | 18 | | 20 | | ns | |
| $\overline{\text{CAS}}$ hold time | t _{CSH} | 39 | | 43 | | 50 | | ns | |
| Column Address to $\overline{\text{RAS}}$ lead time | t _{RAL} | 28 | | 30 | | 35 | | ns | |
| $\overline{\text{CAS}}$ to $\overline{\text{W}}$ delay time | t _{CWD} | 29 | | 35 | | 39 | | ns | 7 |
| $\overline{\text{RAS}}$ to $\overline{\text{W}}$ delay time | t _{RWD} | 62 | | 72 | | 84 | | ns | 7 |
| Column Address to $\overline{\text{W}}$ delay time | t _{AWD} | 40 | | 47 | | 54 | | ns | 7 |
| Hyper Page cycle time | t _{HPC} | 22 | | 25 | | 30 | | ns | 21 |
| Hyper Page read-modify-write cycle time | t _{HPRWC} | 52 | | 53 | | 61 | | ns | 21 |
| $\overline{\text{RAS}}$ pulse width (Hyper page cycle) | t _{RASP} | 50 | 200K | 55 | 200K | 65 | 200K | ns | |
| Access time from $\overline{\text{CAS}}$ precharge | t _{CPA} | | 29 | | 33 | | 40 | ns | 3 |
| $\overline{\text{OE}}$ access time | t _{OE A} | | 17 | | 18 | | 20 | ns | 3 |
| $\overline{\text{OE}}$ to data delay | t _{OE D} | 13 | | 18 | | 20 | | ns | |
| $\overline{\text{OE}}$ command hold time | t _{OE H} | 13 | | 18 | | 20 | | ns | |

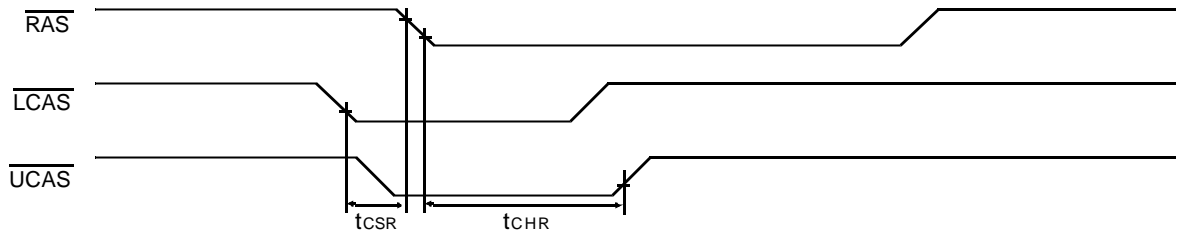
NOTES

1. An initial pause of 200us is required after power-up followed by any 8 $\overline{\text{RAS}}$ -only or $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh cycles before proper device operation is achieved.
2. Input voltage levels are V_{ih}/V_{il} . $V_{IH}(\text{min})$ and $V_{IL}(\text{max})$ are reference levels for measuring timing of input signals. Transition times are measured between $V_{IH}(\text{min})$ and $V_{IL}(\text{max})$ and are assumed to be 2ns for all inputs.
3. Measured with a load equivalent to 1 TTL load and 100pF.
4. Operation within the $t_{\text{RCD}}(\text{max})$ limit insures that $t_{\text{RAC}}(\text{max})$ can be met. $t_{\text{RCD}}(\text{max})$ is specified as a reference point only. If t_{RCD} is greater than the specified $t_{\text{RCD}}(\text{max})$ limit, then access time is controlled exclusively by t_{CAC} .
5. Assumes that $t_{\text{RCD}} \geq t_{\text{RCD}}(\text{max})$.
6. This parameter defines the time at which the output achieves the open circuit condition and is not referenced to V_{oh} or V_{ol} .
7. t_{WCS} , t_{RWD} , t_{CWD} and t_{AWD} are non restrictive operating parameters. They are included in the data sheet as electric characteristics only. If $t_{\text{WCS}} \geq t_{\text{WCS}}(\text{min})$, the cycles is an early write cycle and the data output will remain high impedance for the duration of the cycle. If $t_{\text{CWD}} \geq t_{\text{CWD}}(\text{min})$, $t_{\text{RWD}} \geq t_{\text{RWD}}(\text{min})$ and $t_{\text{AWD}} \geq t_{\text{AWD}}(\text{min})$, then the cycle is a read-modify-write cycle and the data output will contain the data read from the selected address. If neither of the above conditions is satisfied, the condition of the data out is indeterminate.
8. Either t_{RCH} or t_{RRH} must be satisfied for a read cycle.
9. This parameters are referenced to the $\overline{\text{CAS}}$ leading edge in early write cycles and to the $\overline{\text{W}}$ falling edge in $\overline{\text{OE}}$ controlled write cycle and read-modify-write cycles.
10. Operation within the $t_{\text{RAD}}(\text{max})$ limit insures that $t_{\text{RAC}}(\text{max})$ can be met. $t_{\text{RAD}}(\text{max})$ is specified as a reference point only. If t_{RAD} is greater than the specified $t_{\text{RAD}}(\text{max})$ limit, then access time is controlled by t_{AA} .
11. These specifications are applied in the test mode.
12. In test mode read cycle, the value of t_{RAC} , t_{AA} , t_{CAC} is delayed by 2ns to 5ns for the specified values. These parameters should be specified in test mode cycles by adding the above value to the specified value in this data sheet.
13. t_{ASC} , t_{CAH} are referenced to the earlier $\overline{\text{CAS}}$ falling edge.
14. t_{CP} is specified from the last $\overline{\text{CAS}}$ rising edge in the previous cycle to the first $\overline{\text{CAS}}$ falling edge in the next cycle.
15. t_{CWD} is referenced to the later $\overline{\text{CAS}}$ falling edge at word read-modify-write cycle.

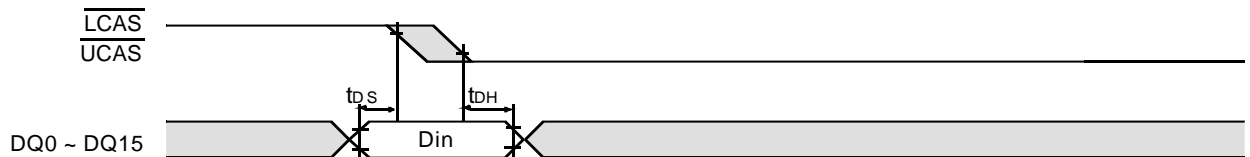
K4E64(6)1612E Truth Table

| $\overline{\text{RAS}}$ | $\overline{\text{LCAS}}$ | $\overline{\text{UCAS}}$ | $\overline{\text{W}}$ | $\overline{\text{OE}}$ | DQ0 - DQ7 | DQ8-DQ15 | STATE |
|-------------------------|--------------------------|--------------------------|-----------------------|------------------------|-----------|----------|------------|
| H | X | X | X | X | Hi-Z | Hi-Z | Standby |
| L | H | H | X | X | Hi-Z | Hi-Z | Refresh |
| L | L | H | H | L | DQ-OUT | Hi-Z | Byte Read |
| L | H | L | H | L | Hi-Z | DQ-OUT | Byte Read |
| L | L | L | H | L | DQ-OUT | DQ-OUT | Word Read |
| L | L | H | L | H | DQ-IN | - | Byte Write |
| L | H | L | L | H | - | DQ-IN | Byte Write |
| L | L | L | L | H | DQ-IN | DQ-IN | Word Write |
| L | L | L | H | H | Hi-Z | Hi-Z | - |

- 16. t_{CWL} is specified from \overline{W} falling edge to the earlier \overline{CAS} rising edge.
- 17. t_{CSR} is referenced to earlier \overline{CAS} falling before \overline{RAS} transition low.
- 18. t_{CHR} is referenced to the later \overline{CAS} rising high after \overline{RAS} transition low.

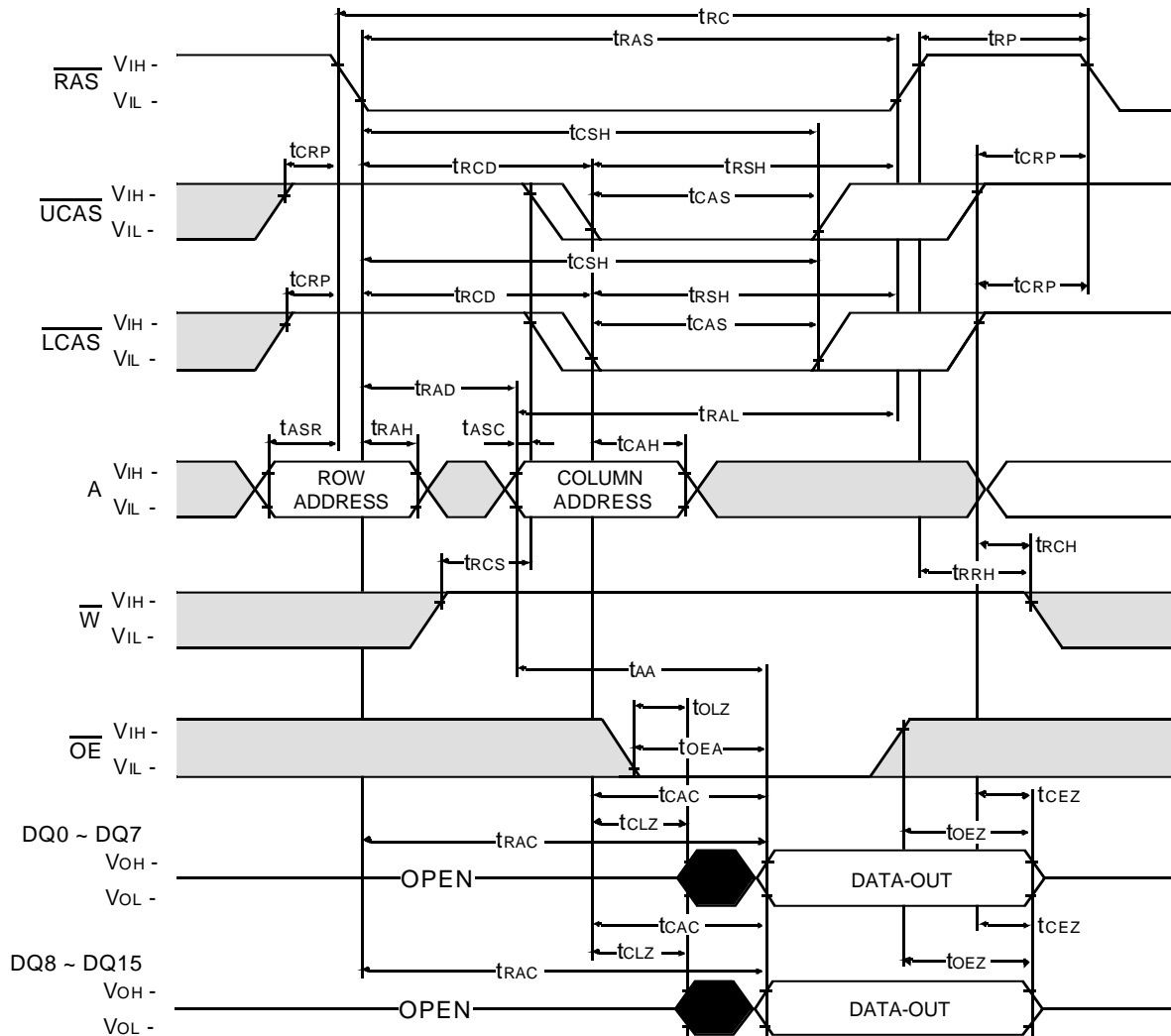


- 19. t_{DS} is specified for the earlier \overline{CAS} falling edge and t_{DH} is specified by the later \overline{CAS} falling edge in early write cycle.



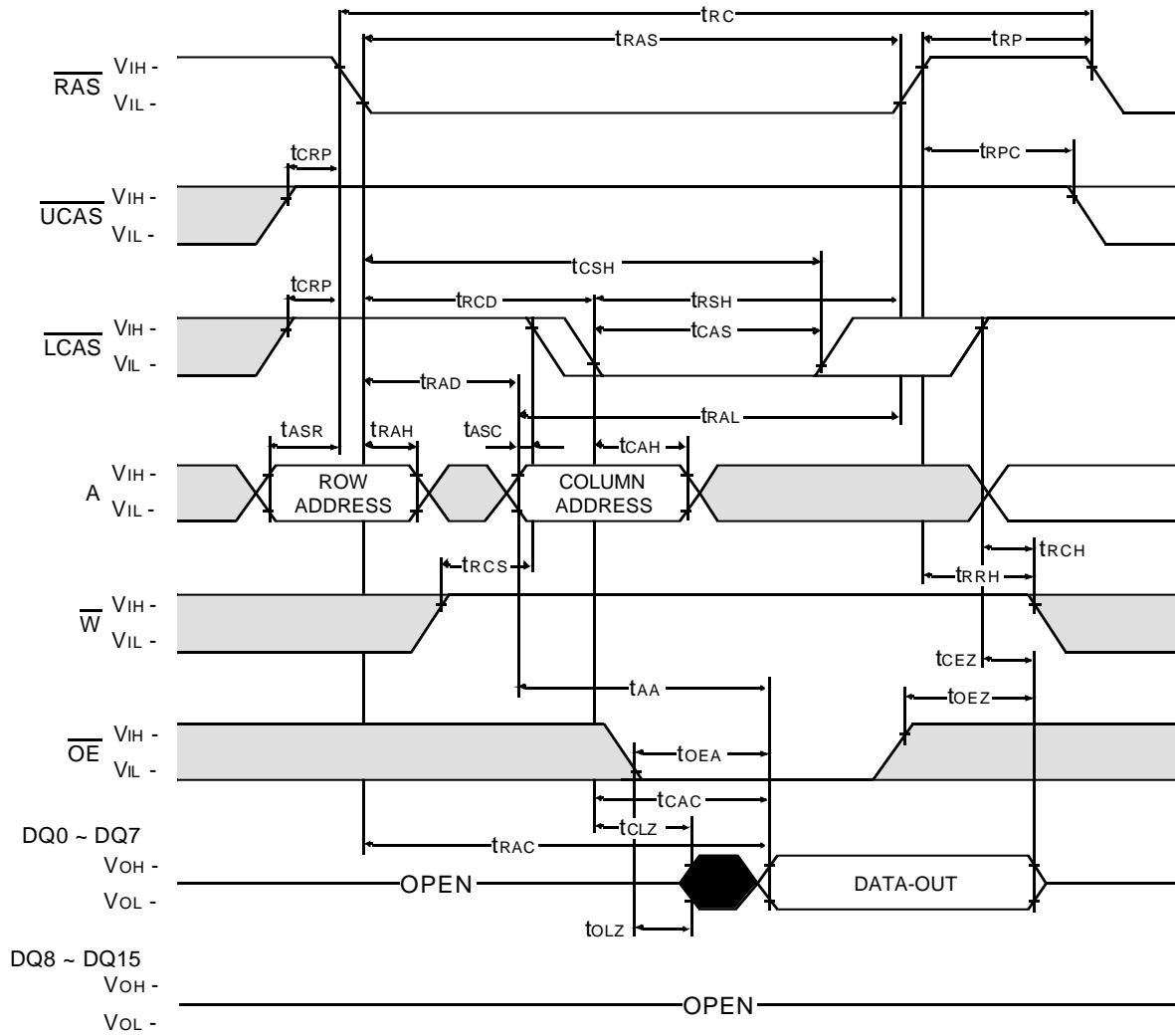
- 20. If \overline{RAS} goes high before \overline{CAS} high going, the open circuit condition of the output is achieved by \overline{CAS} high going.
- 21. $t_{ASC} \geq 6ns$, Assume $t_T = 2.0ns$, if $t_{ASC} \leq 6ns$, then $t_{HPC}(min)$ and $t_{CAS}(min)$ must be increased by the value of "6ns- t_{ASC} ".
- 22. If $t_{RASS} \geq 100us$, then \overline{RAS} precharge time must use t_{RPS} instead of t_{RP} .
- 23. For \overline{RAS} -only-Refresh and Burst \overline{CAS} -before- \overline{RAS} refresh mode, 4096 cycles(4K/8K) of burst refresh must be executed within 64ms before and after self refresh, in order to meet refresh specification.
- 24. For distributed \overline{CAS} -before- \overline{RAS} with 15.6us interval, CBR refresh should be executed with in 15.6us immediately before and after self refresh in order to meet refresh specification.

WORD READ CYCLE



LOWER BYTE READ CYCLE

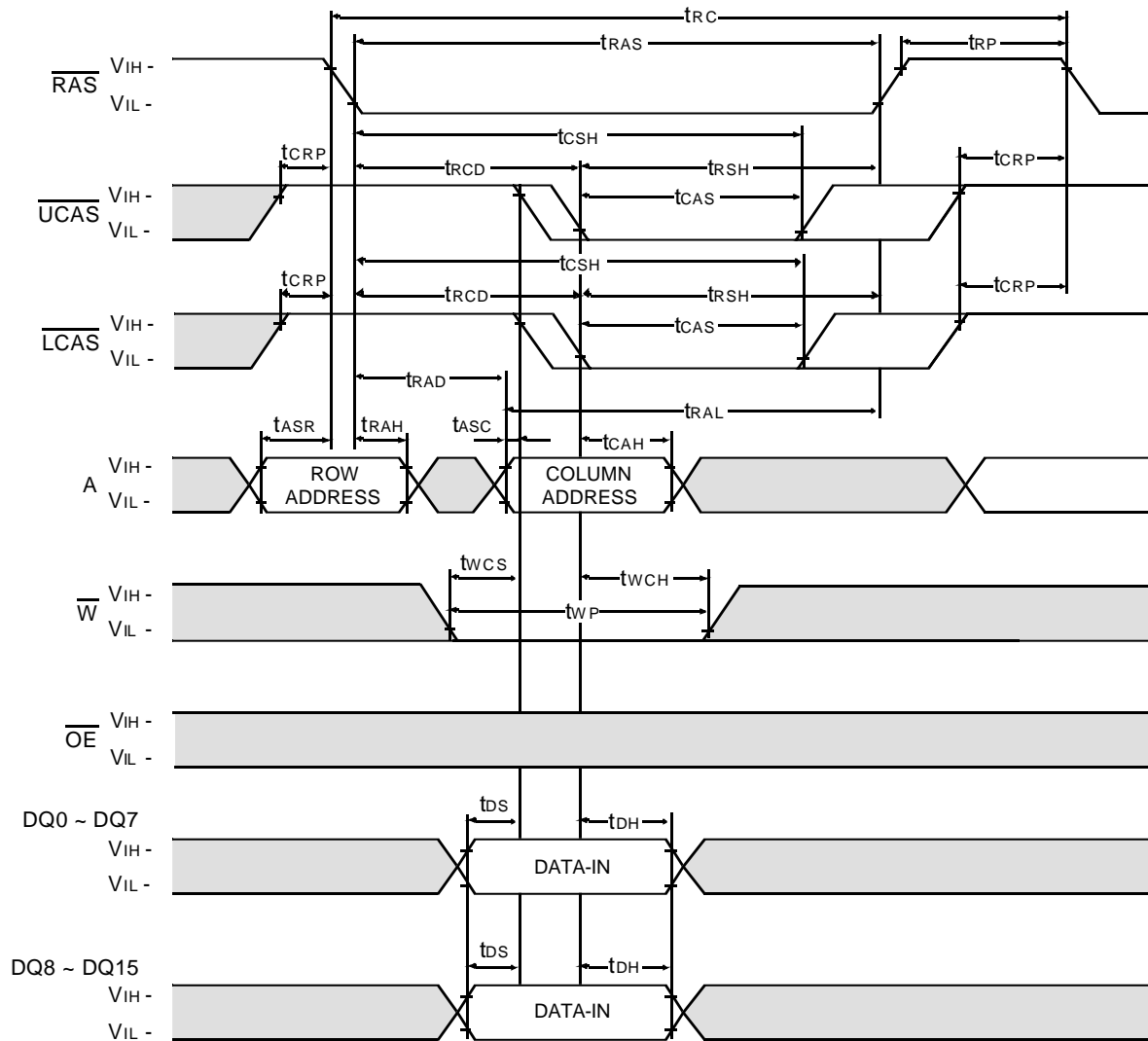
NOTE : D IN = OPEN



Don't care
 Undefined

WORD WRITE CYCLE (EARLY WRITE)

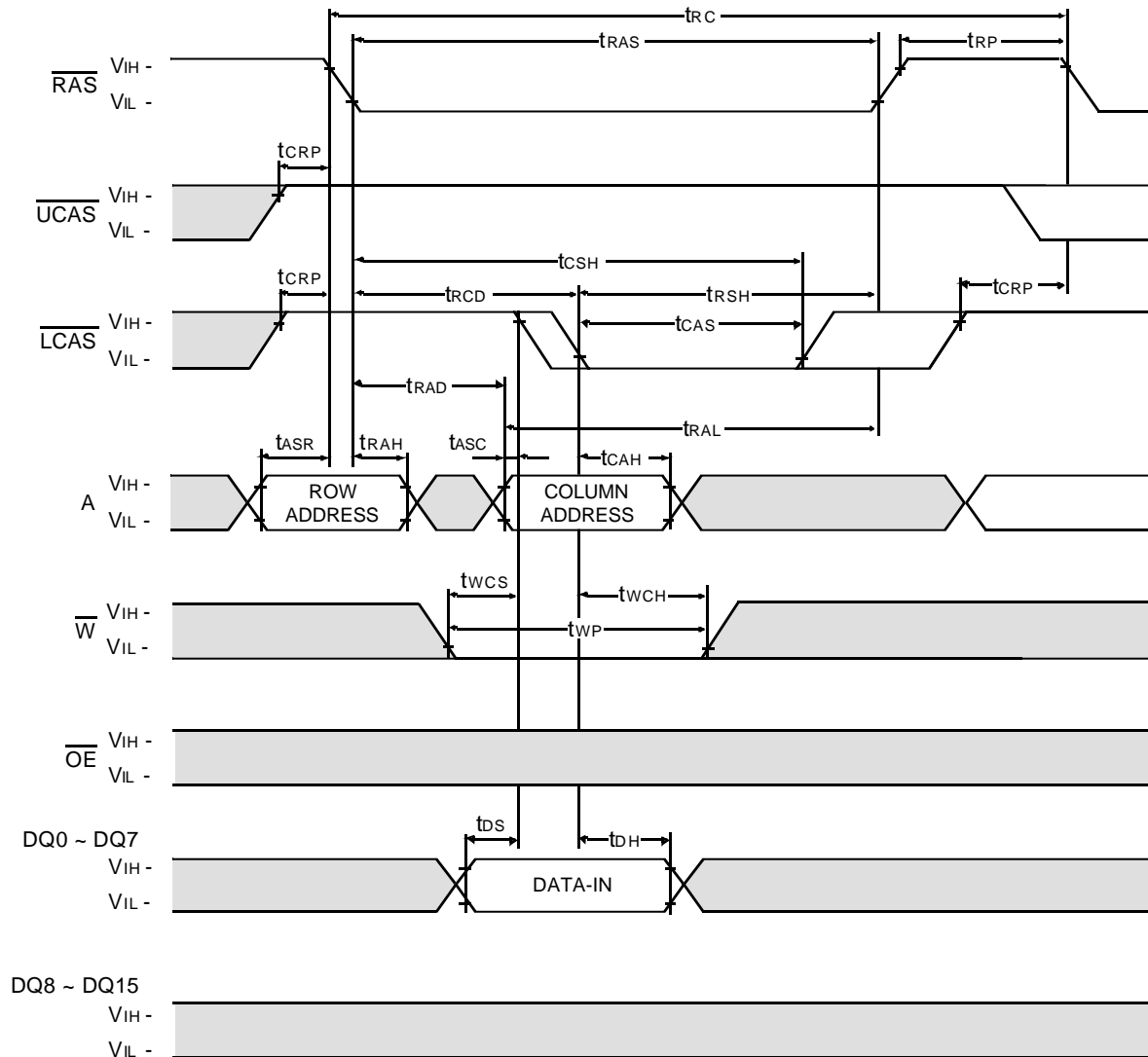
NOTE : DOUT = OPEN



Don't care
 Undefined

LOWER BYTE WRITE CYCLE (EARLY WRITE)

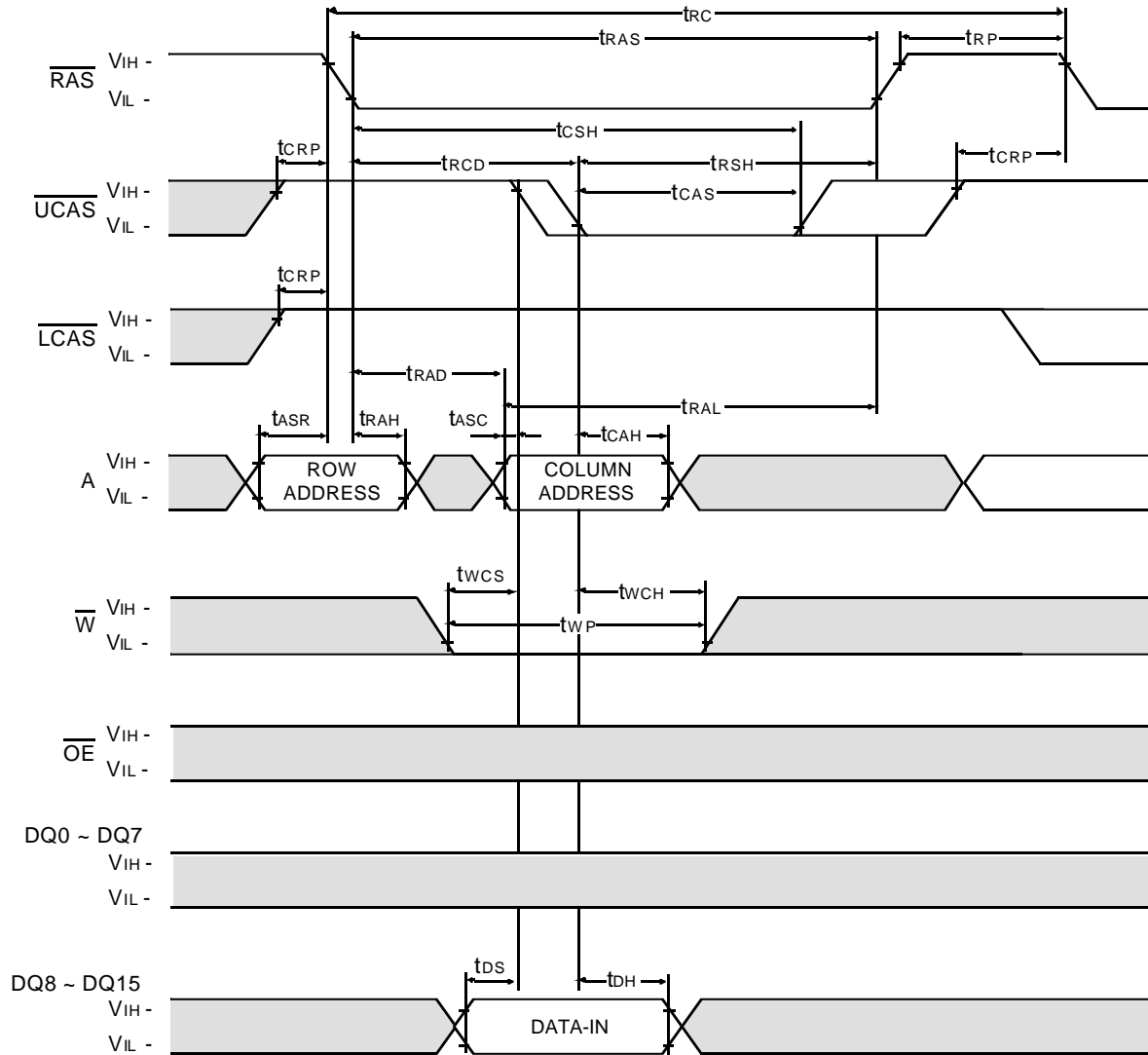
NOTE : DOUT = OPEN



Don't care
 Undefined

UPPER BYTE WRITE CYCLE (EARLY WRITE)

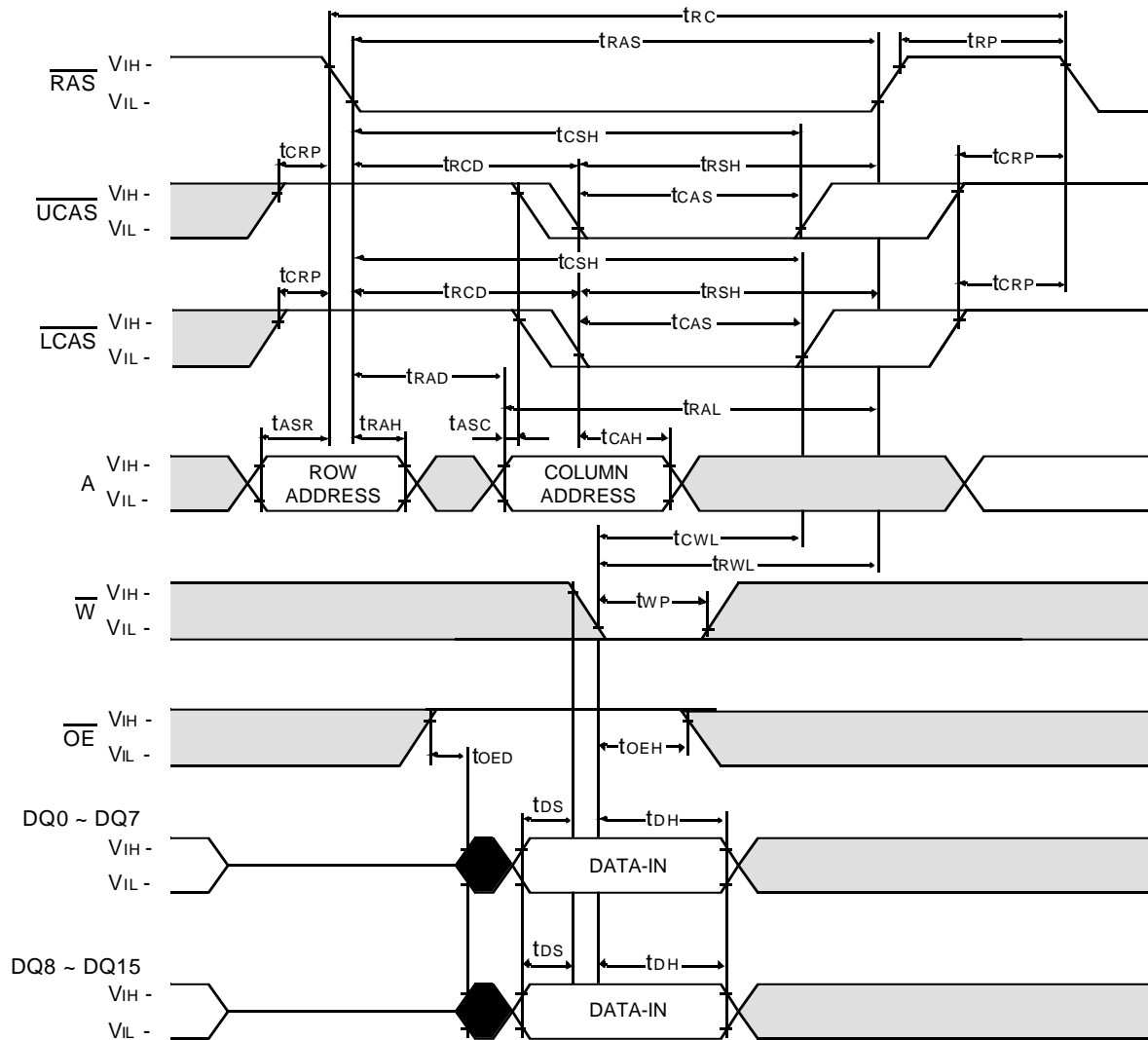
NOTE : DOUT = OPEN



Don't care
 Undefined

WORD WRITE CYCLE (\overline{OE} CONTROLLED WRITE)

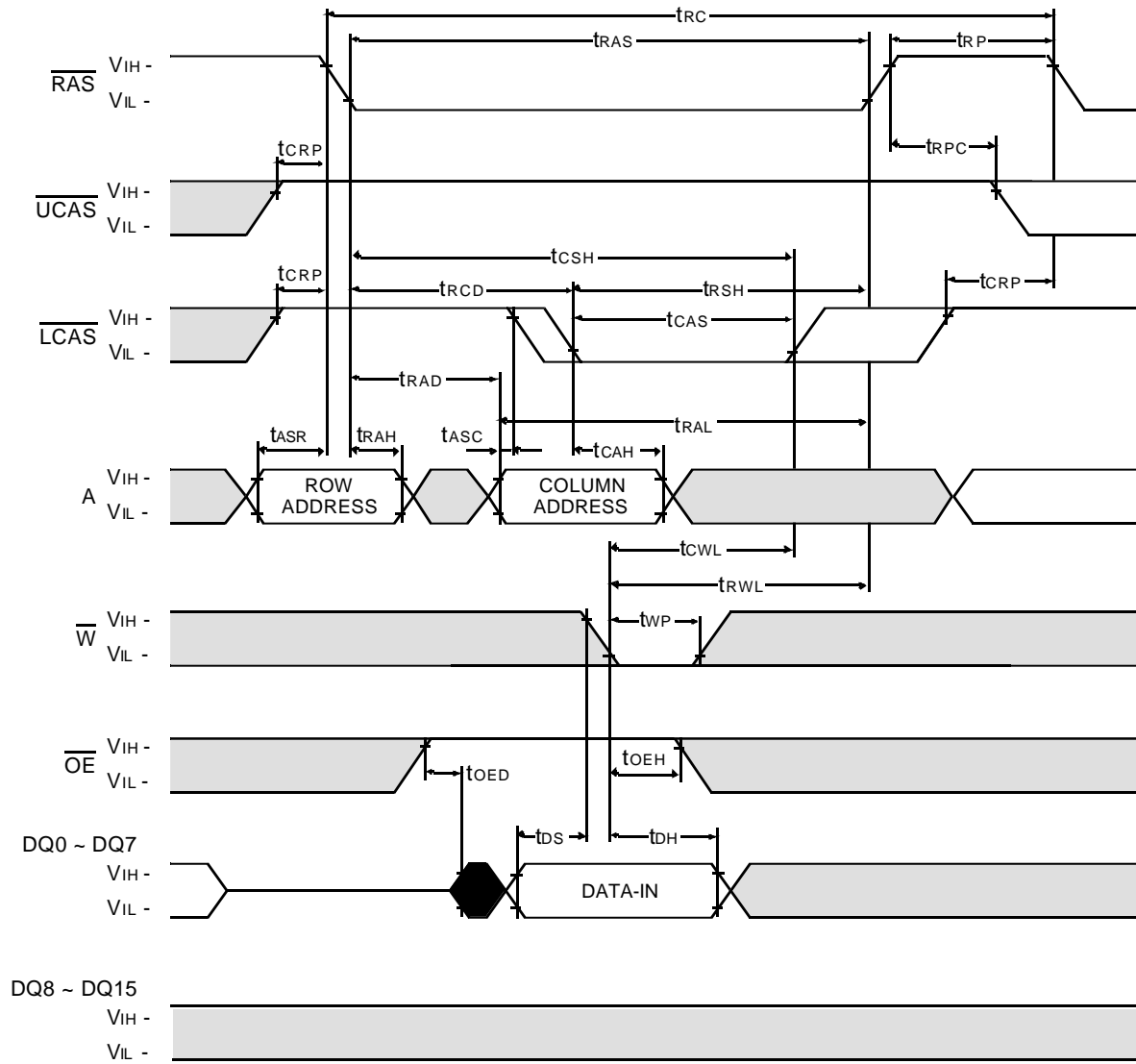
NOTE : DOUT = OPEN



Don't care
 Undefined

LOWER BYTE WRITE CYCLE (\overline{OE} CONTROLLED WRITE)

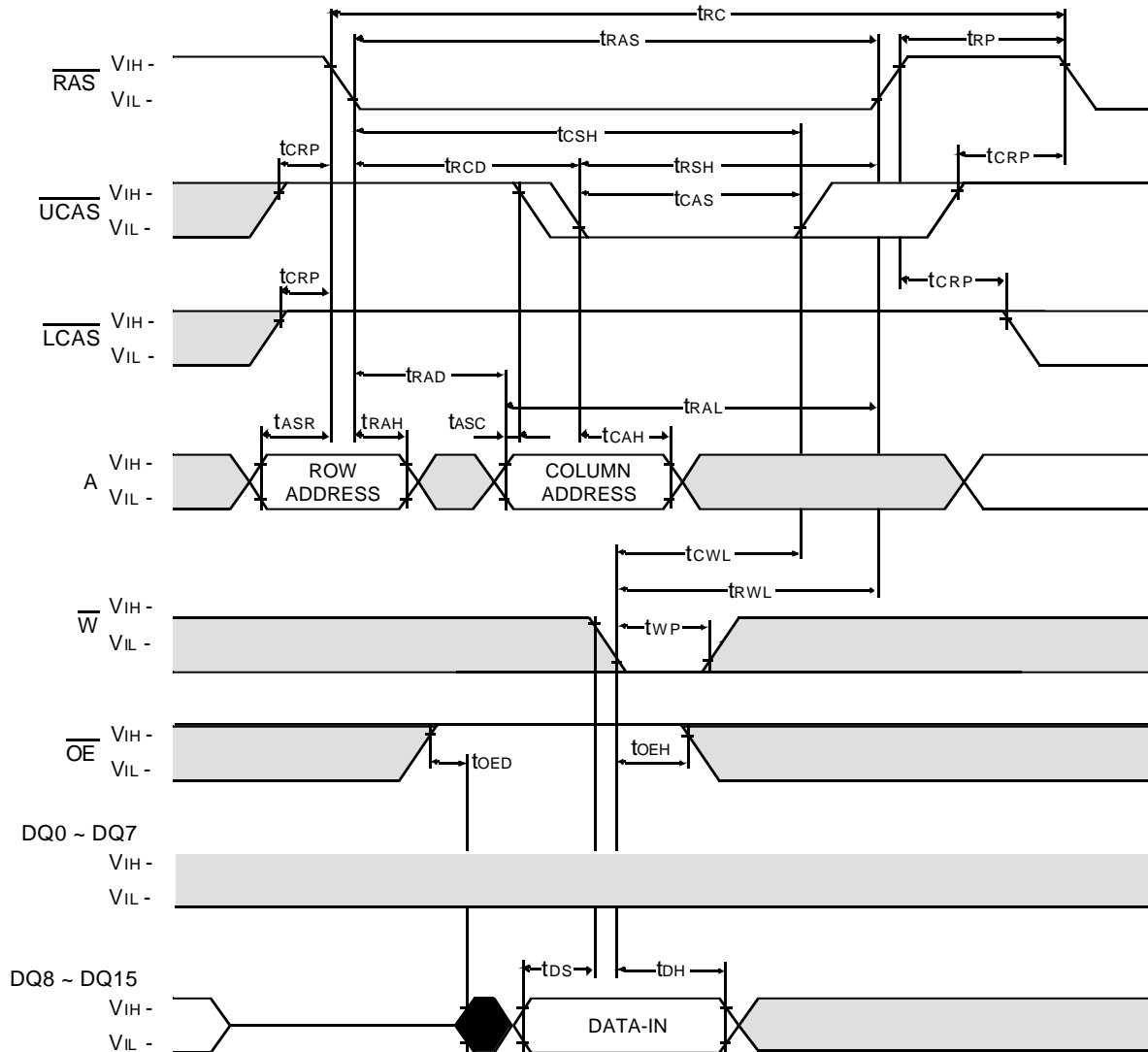
NOTE : DOUT = OPEN



Don't care
 Undefined

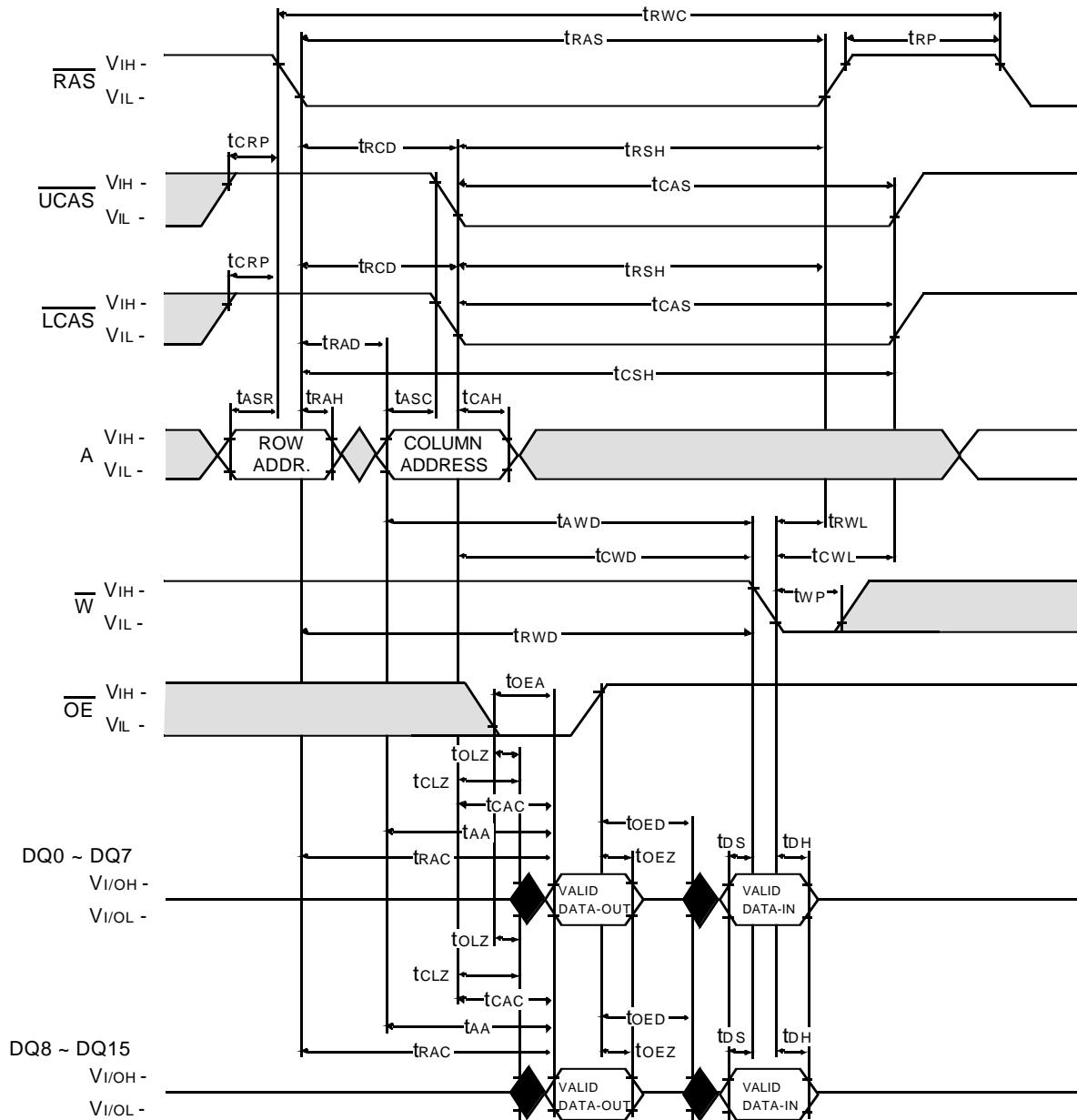
UPPER BYTE WRITE CYCLE (\overline{OE} CONTROLLED WRITE)

NOTE : DOUT = OPEN



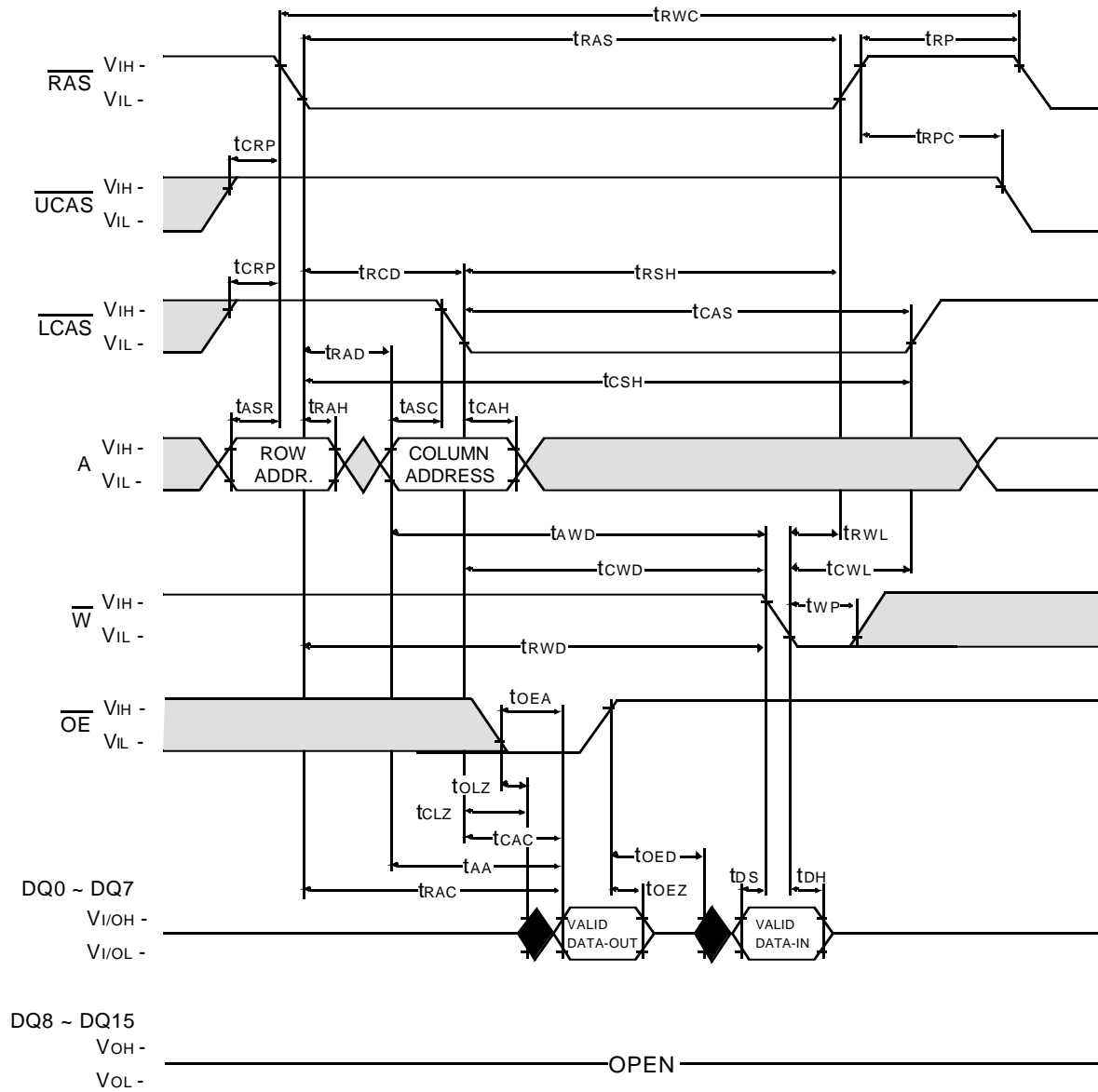
Don't care
 Undefined

WORD READ - MODIFY - WRITE CYCLE

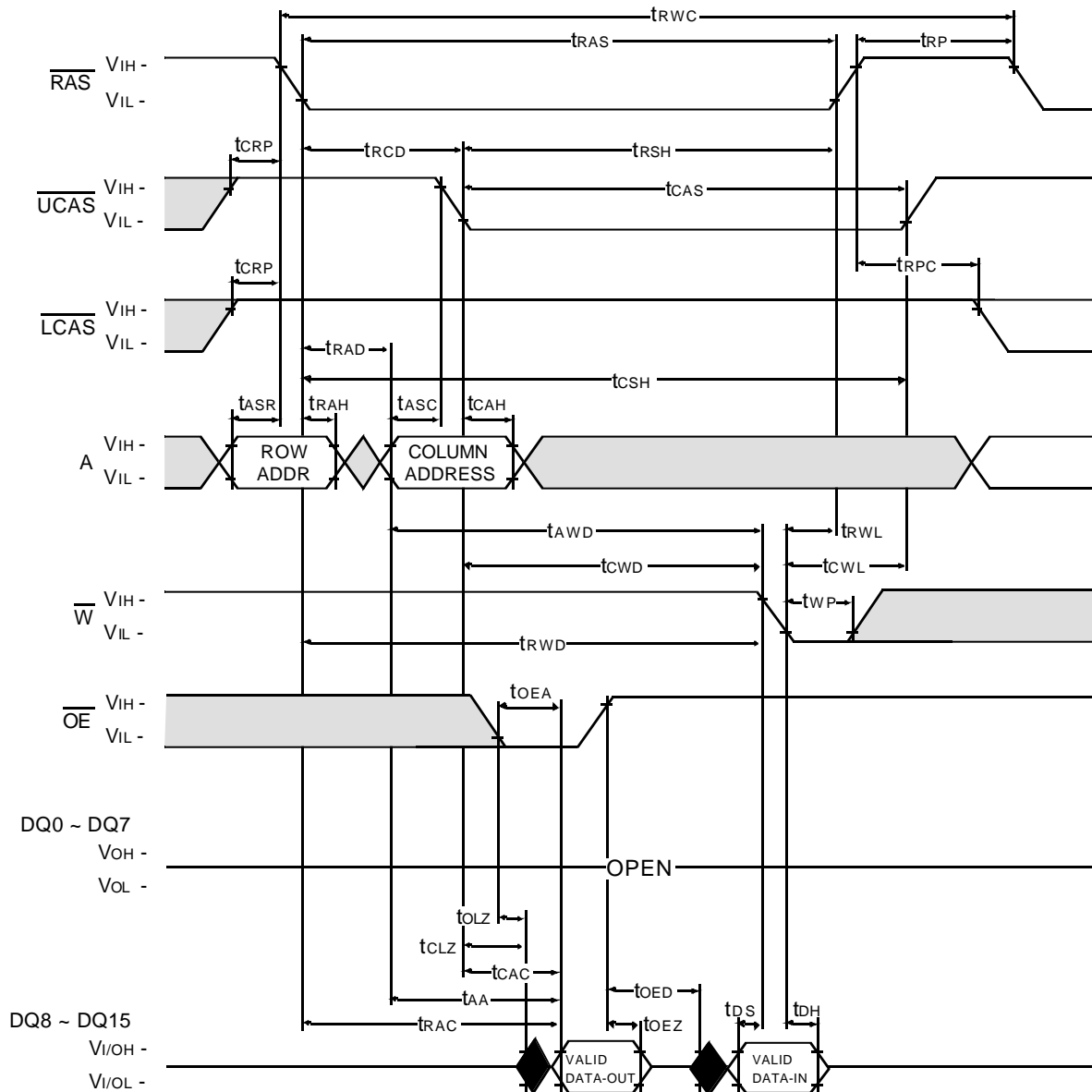


Don't care
 Undefined

LOWER-BYTE READ - MODIFY - WRITE CYCLE

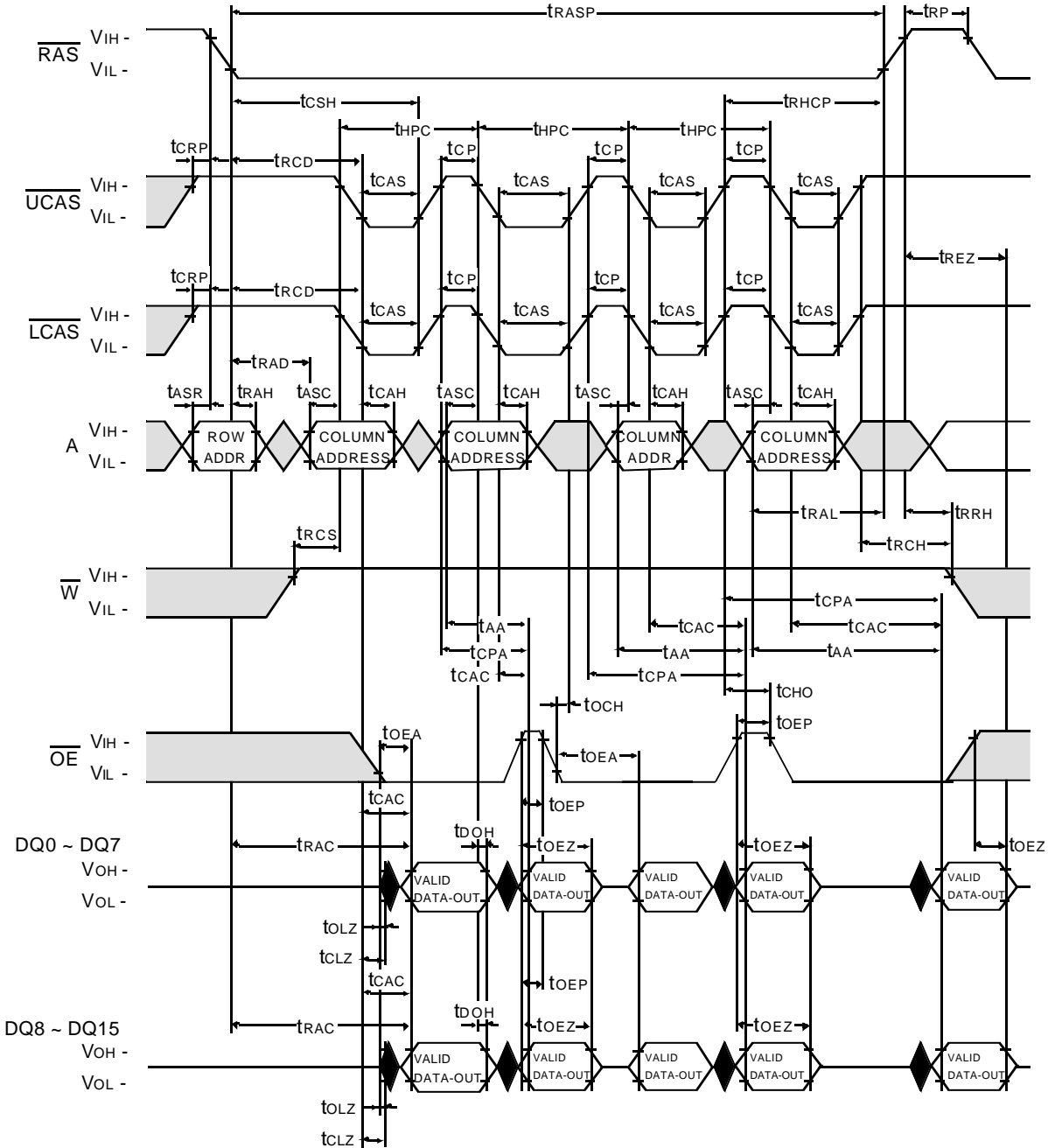




UPPER-BYTE READ - MODIFY - WRITE CYCLE



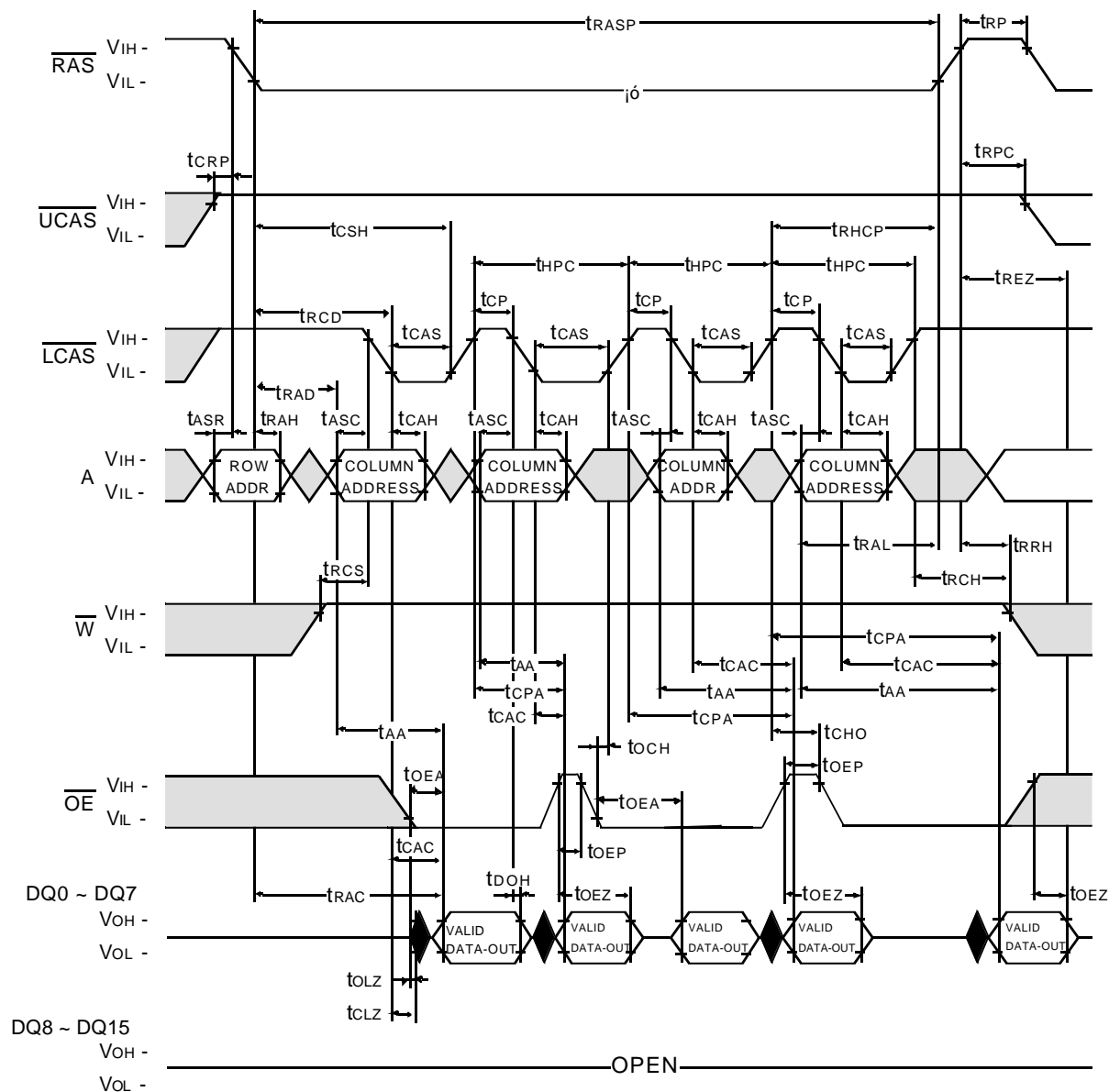
Don't care
 Undefined

HYPER PAGE MODE WORD READ CYCLE

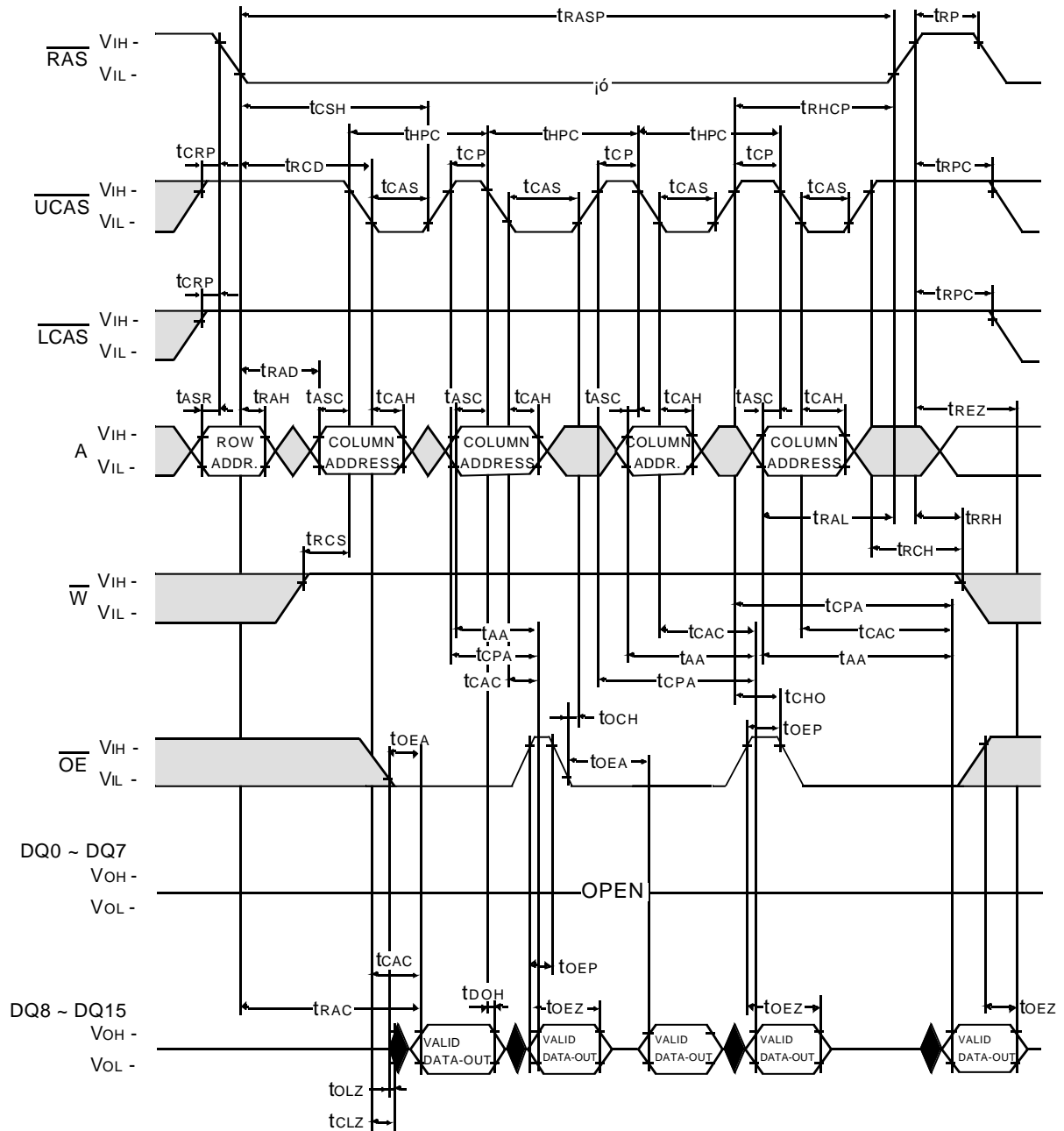


 Don't care
 Undefined

HYPER PAGE MODE LOWER BYTE READ CYCLE



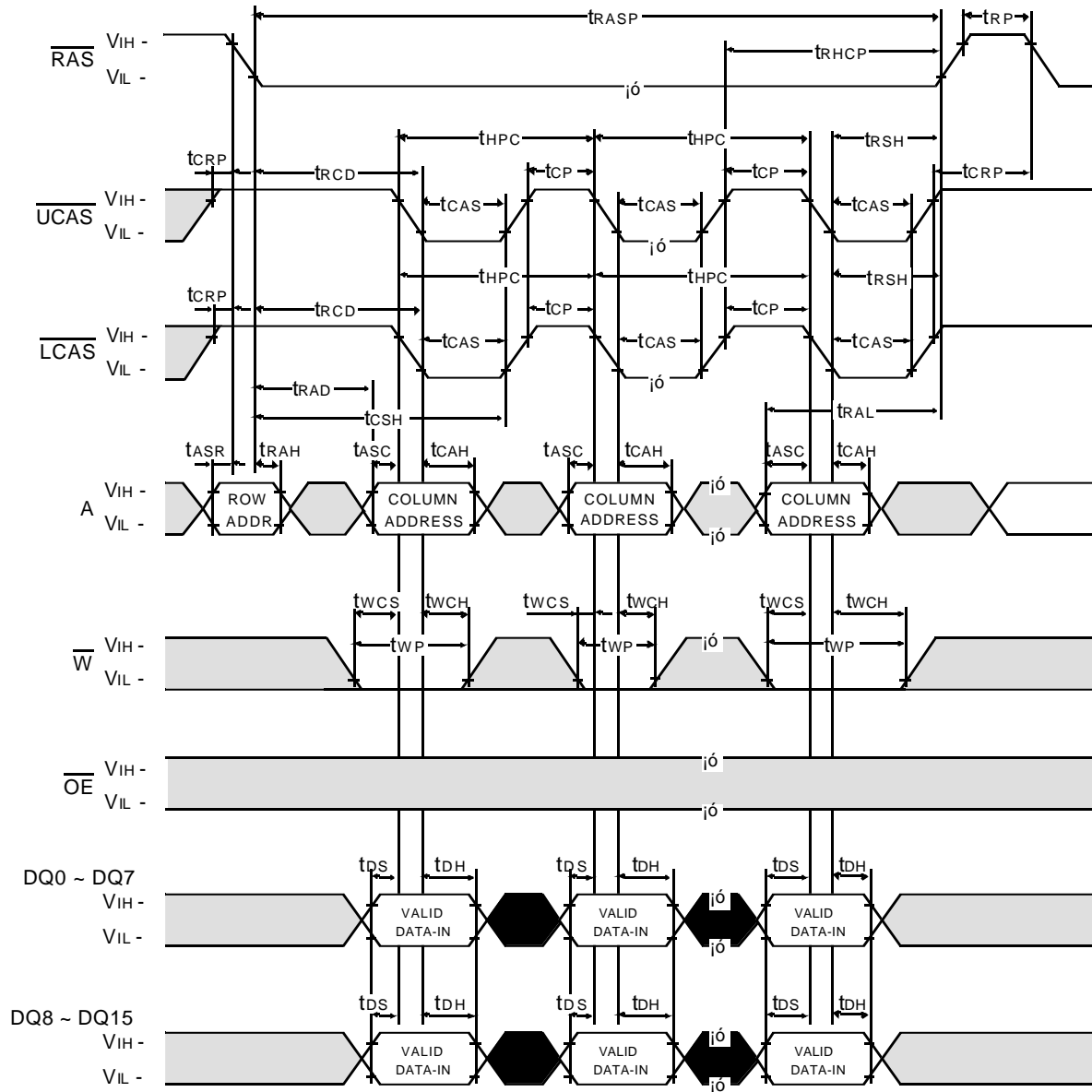
HYPER PAGE MODE UPPER BYTE READ CYCLE



□ Don't care
 ■ Undefined

HYPER PAGE MODE WORD WRITE CYCLE (EARLY WRITE)

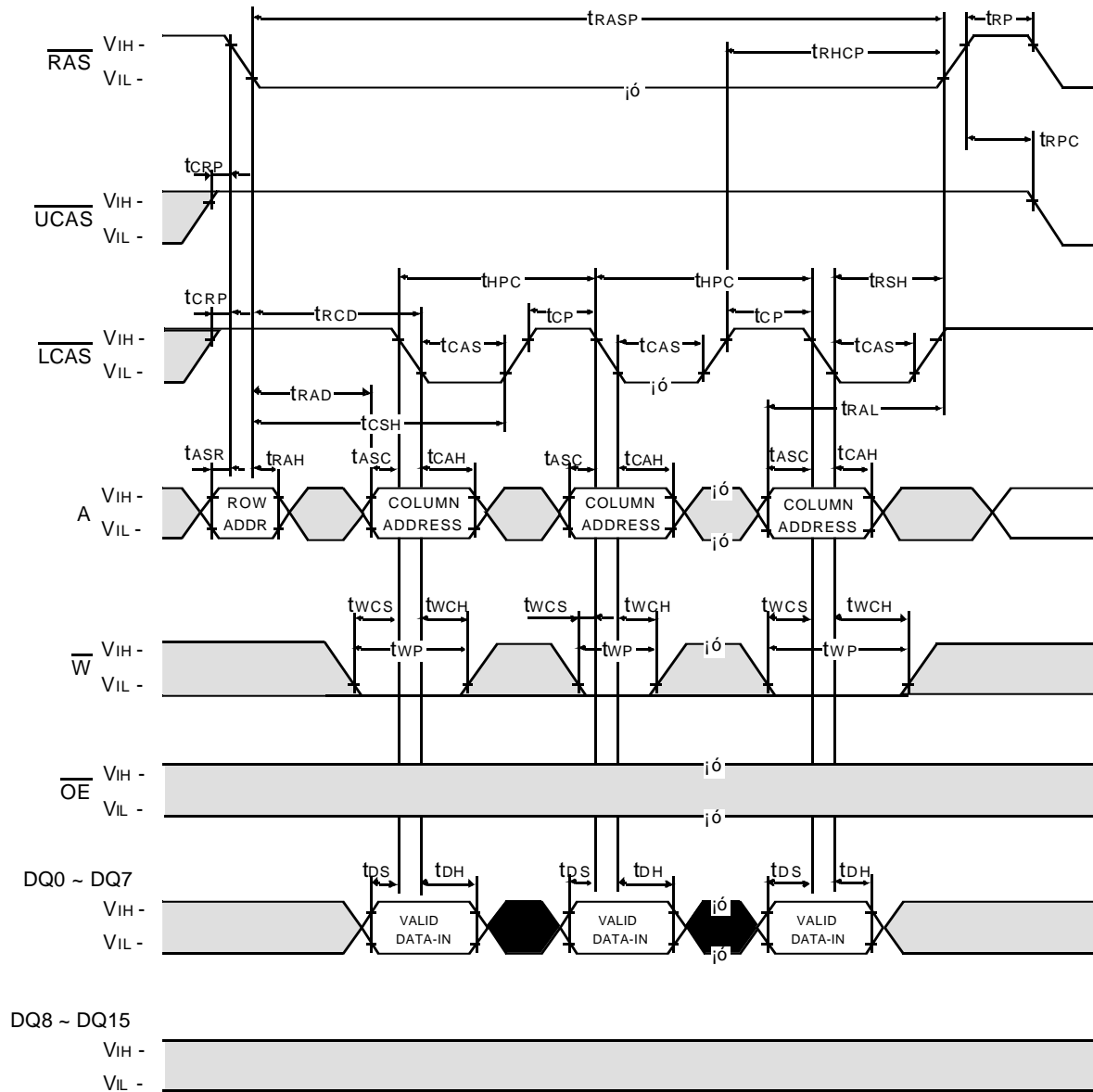
NOTE : DOUT = OPEN



Don't care
 Undefined

HYPER PAGE MODE LOWER BYTE WRITE CYCLE (EARLY WRITE)

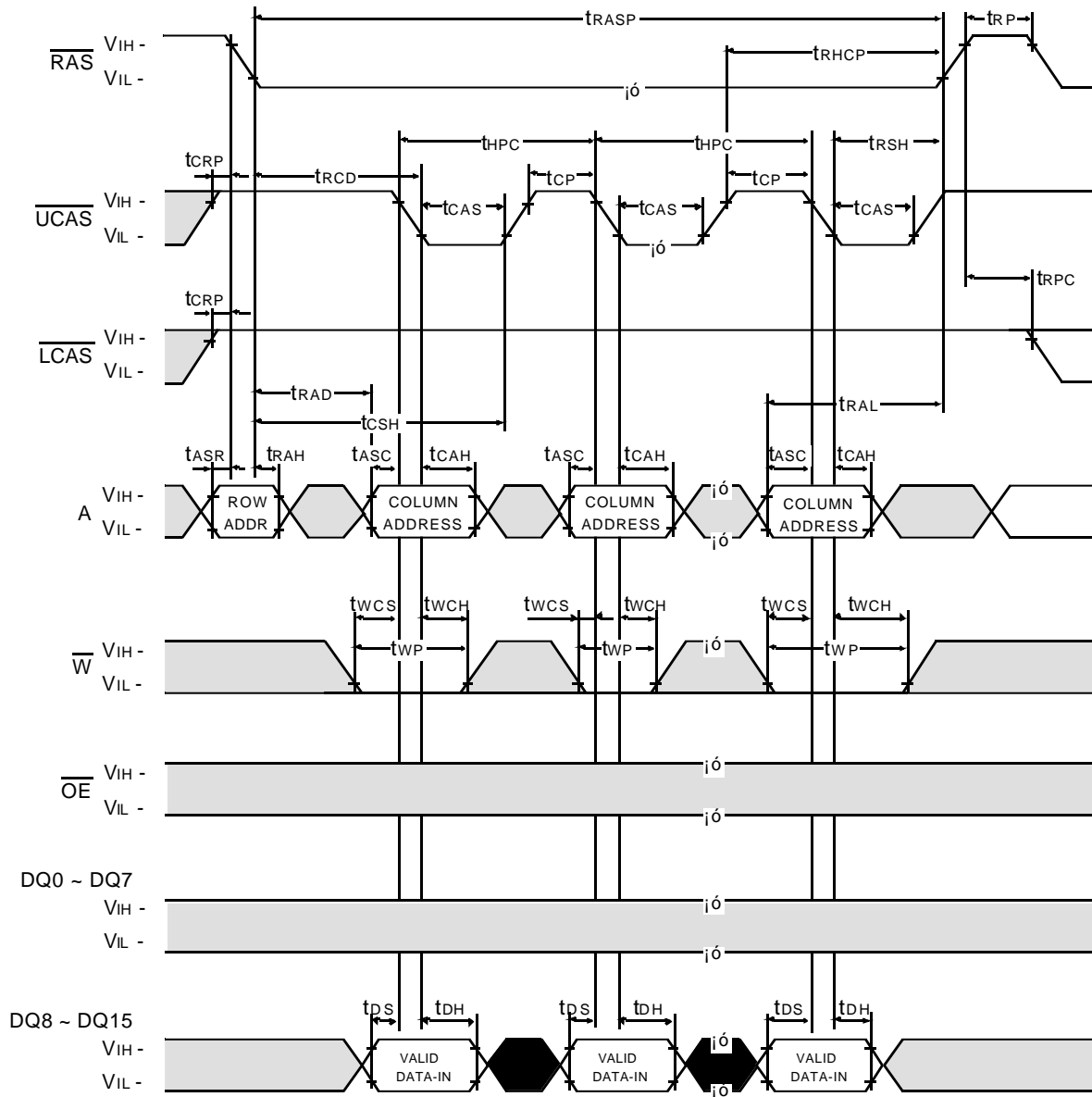
NOTE : DOUT = OPEN



Don't care
 Undefined

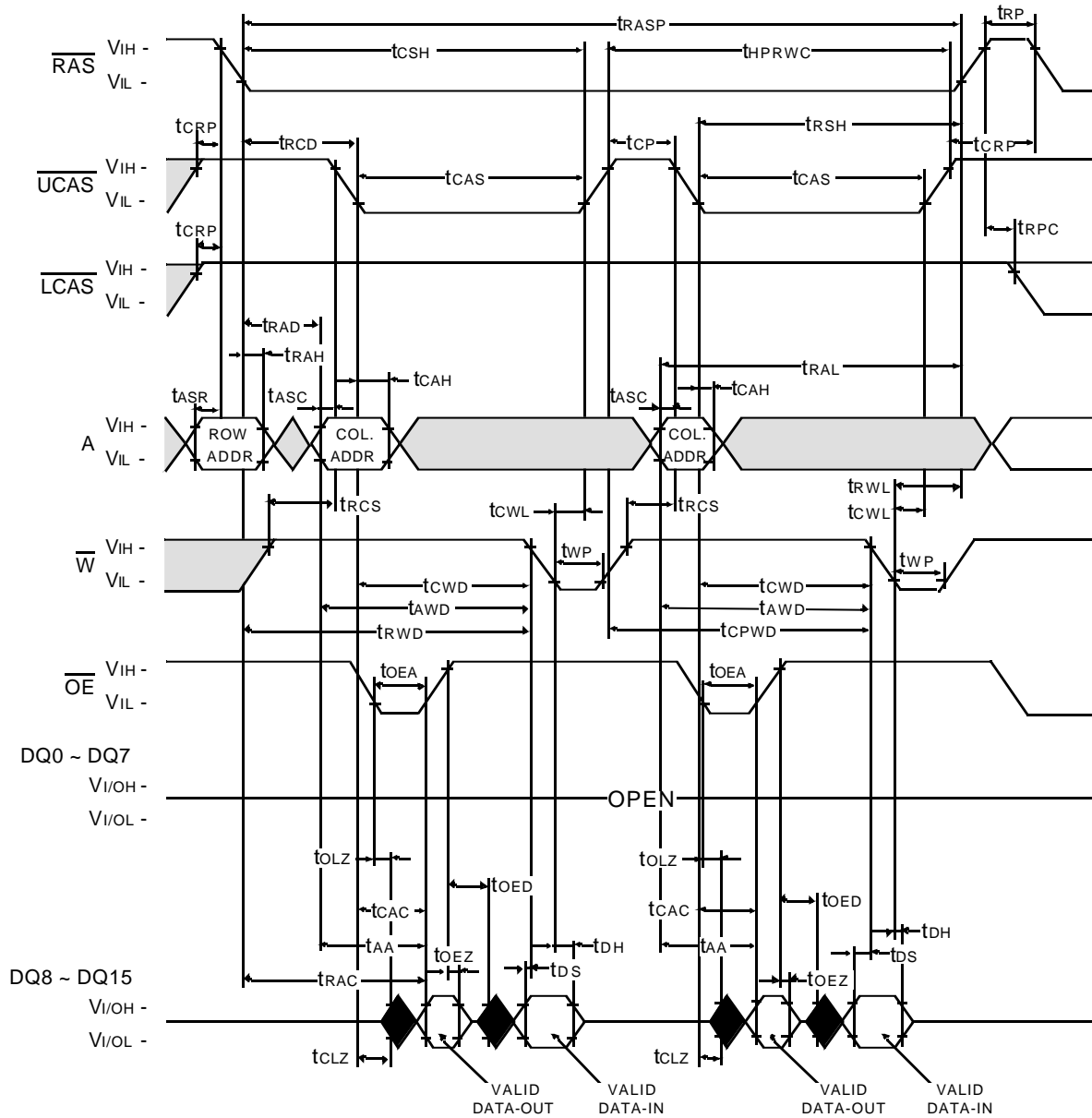
HYPER PAGE MODE UPPER BYTE WRITE CYCLE (EARLY WRITE)

NOTE : DOUT = OPEN



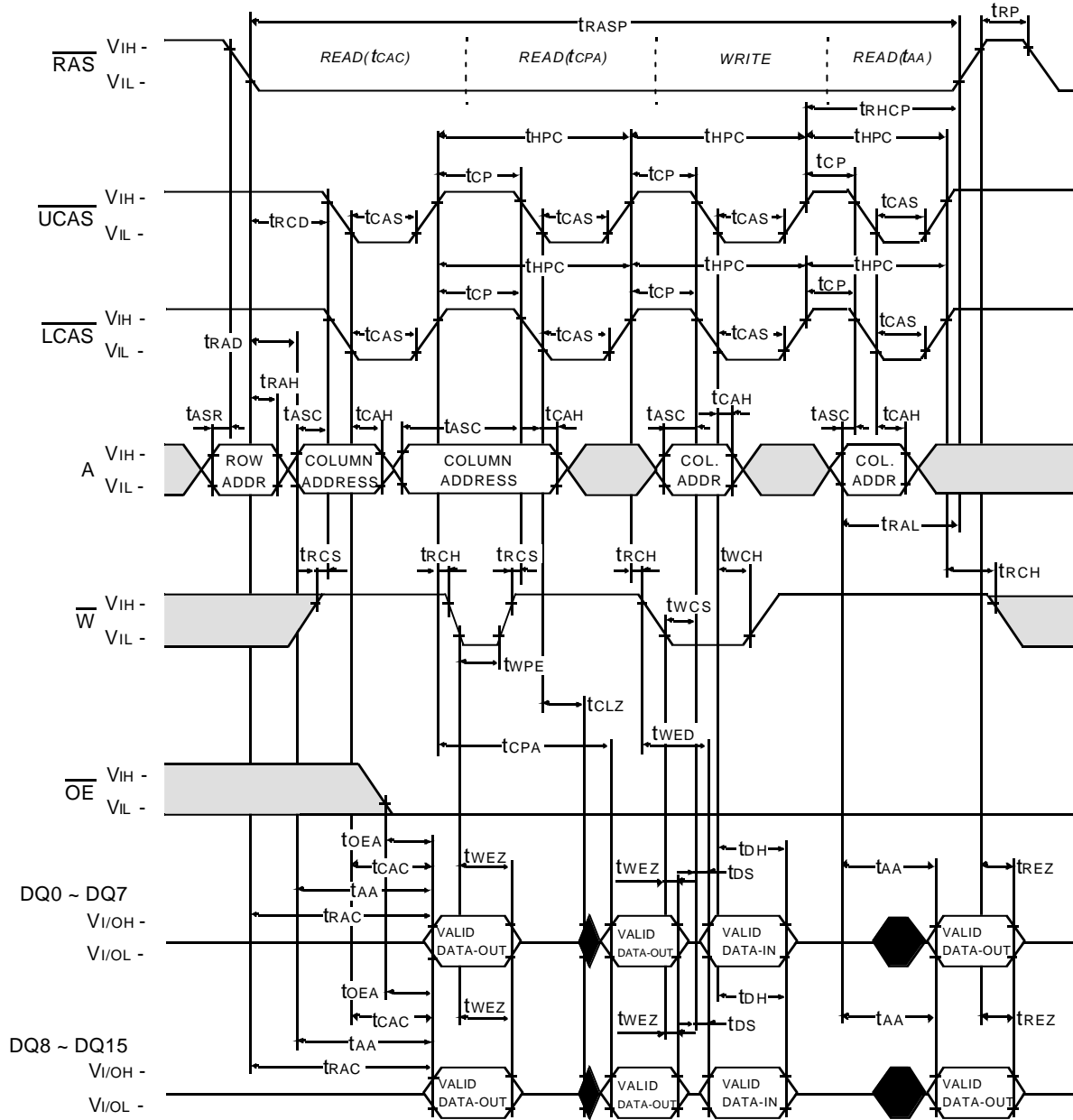
Don't care
 Undefined

HYPER PAGE MODE UPPER BYTE READ - MODIFY - WRITE CYCLE



Don't care
 Undefined

HYPER PAGE READ AND WRITE MIXED CYCLE

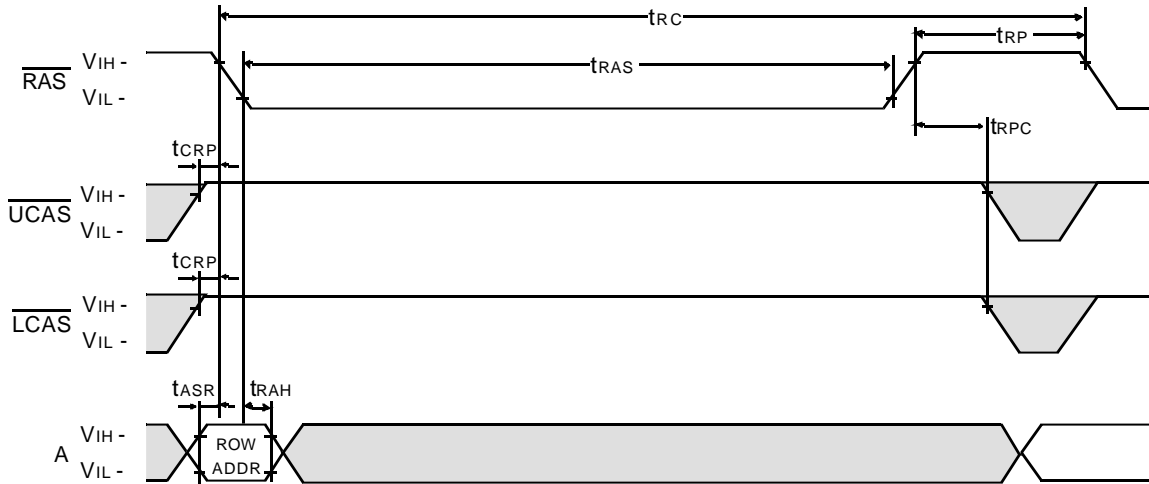


Don't care
 Undefined

RAS - ONLY REFRESH CYCLE

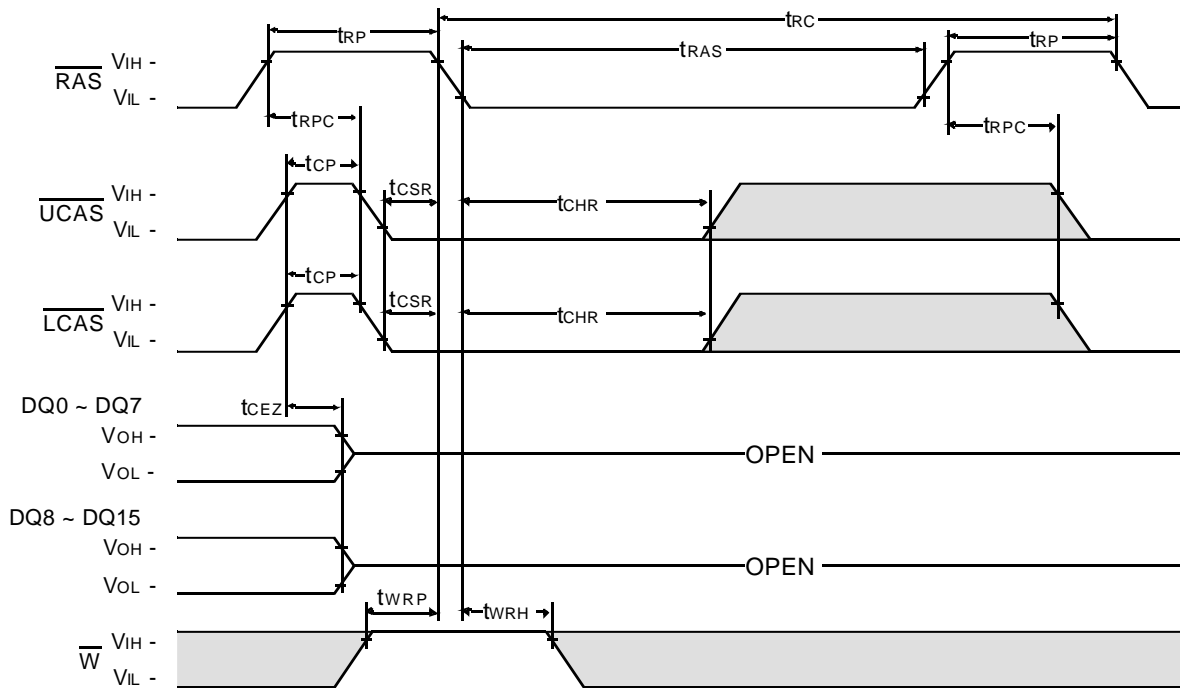
NOTE : \overline{W} , \overline{OE} , DIN = Don't care

DOUT = OPEN



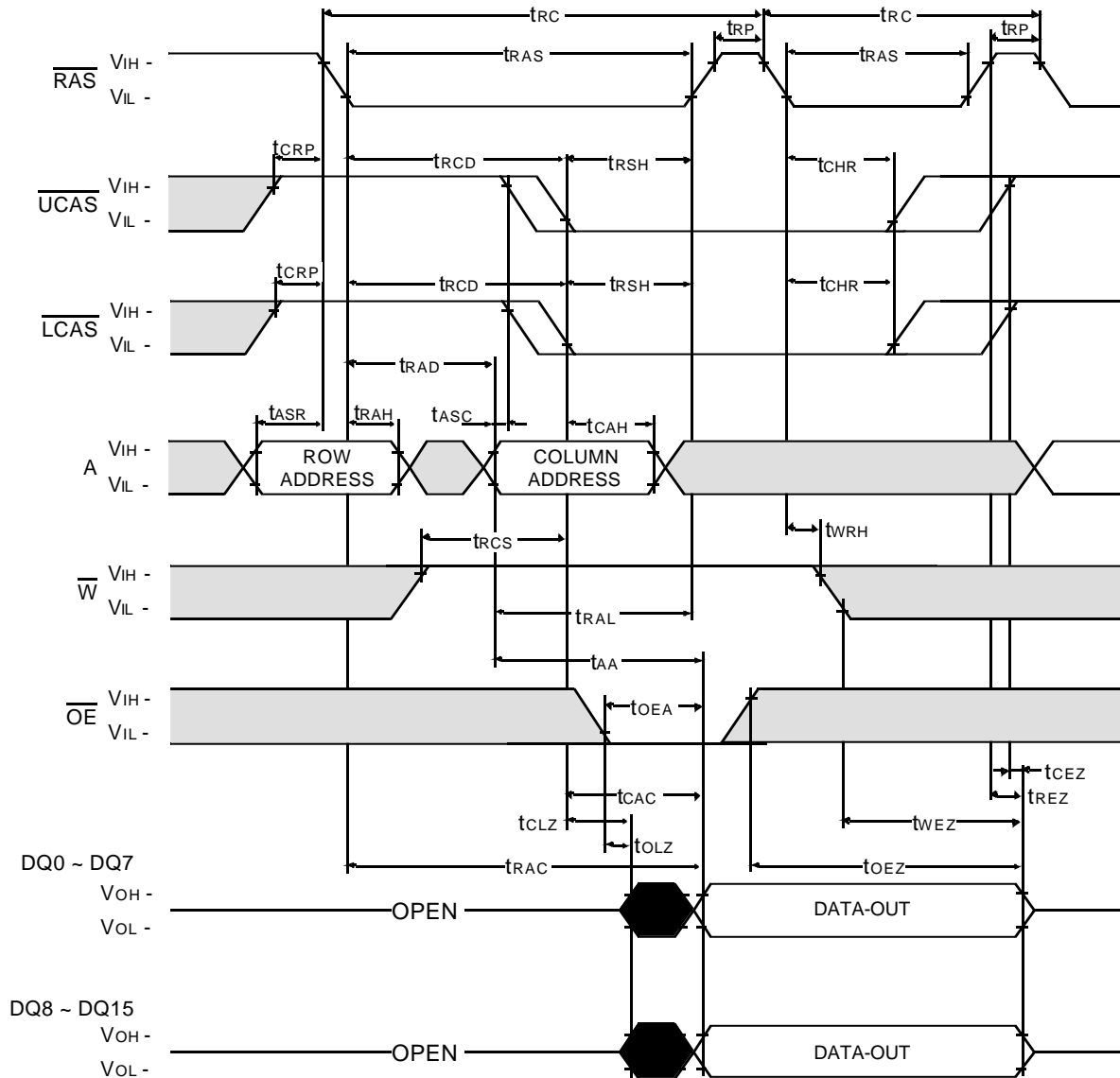
CAS - BEFORE - RAS REFRESH CYCLE

NOTE : \overline{OE} , A = Don't care



Don't care
 Undefined

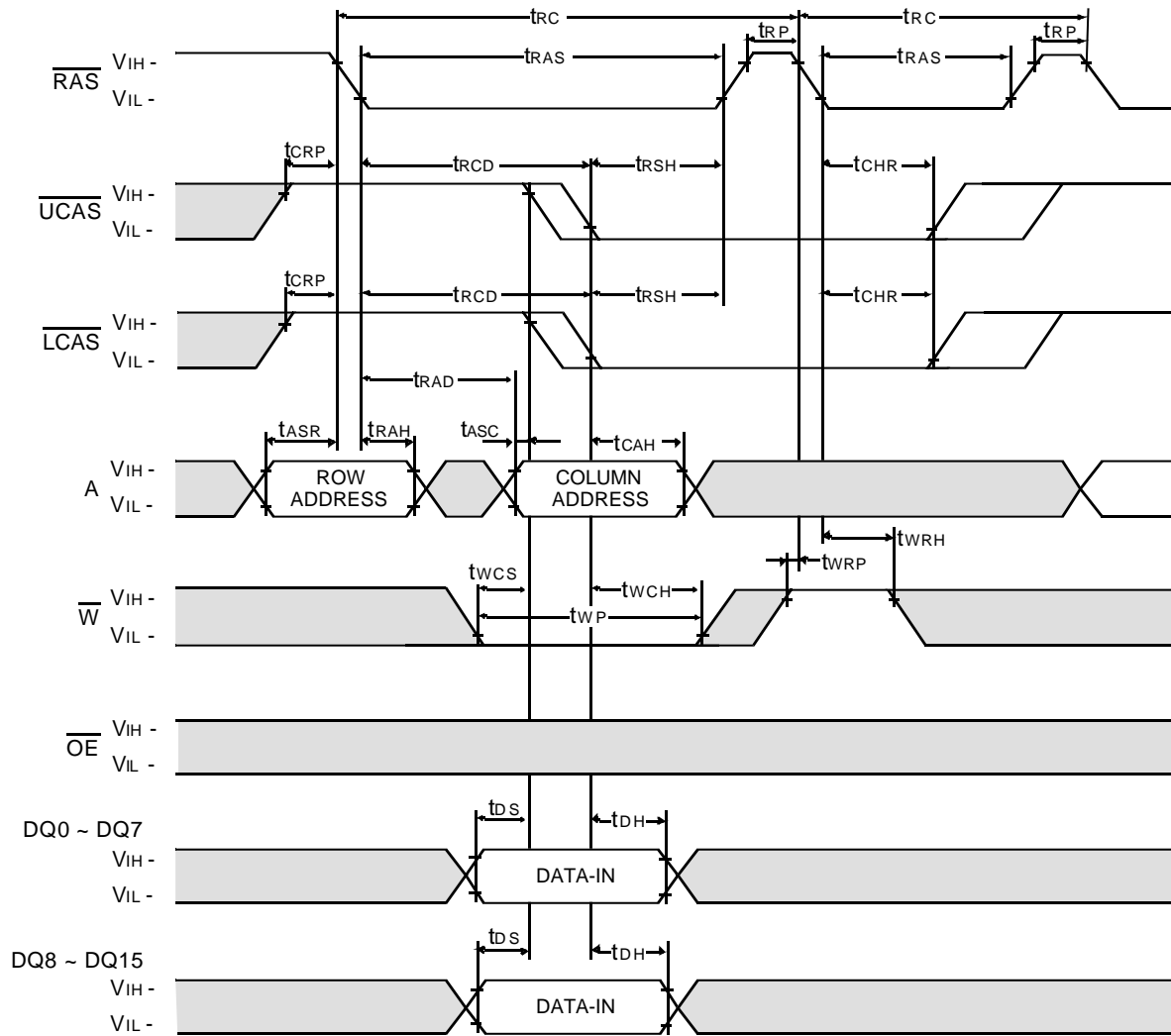
HIDDEN REFRESH CYCLE (READ)



Don't care
 Undefined

HIDDEN REFRESH CYCLE (WRITE)

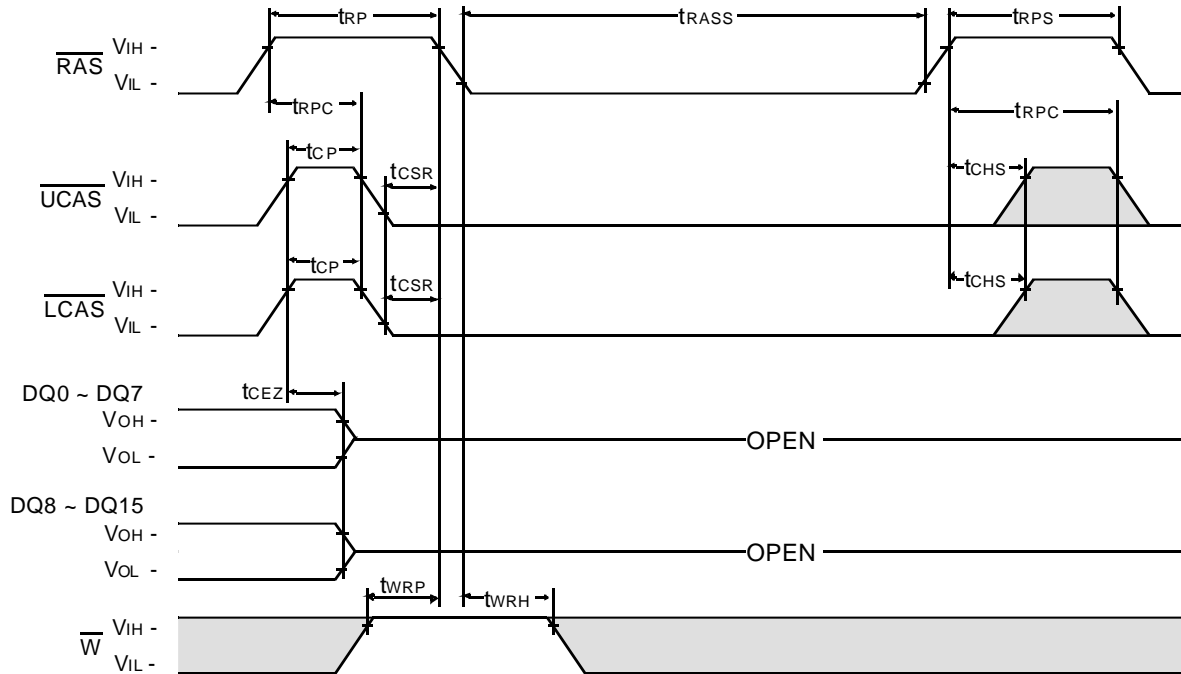
NOTE : DOUT = OPEN



□ Don't care
 ■ Undefined

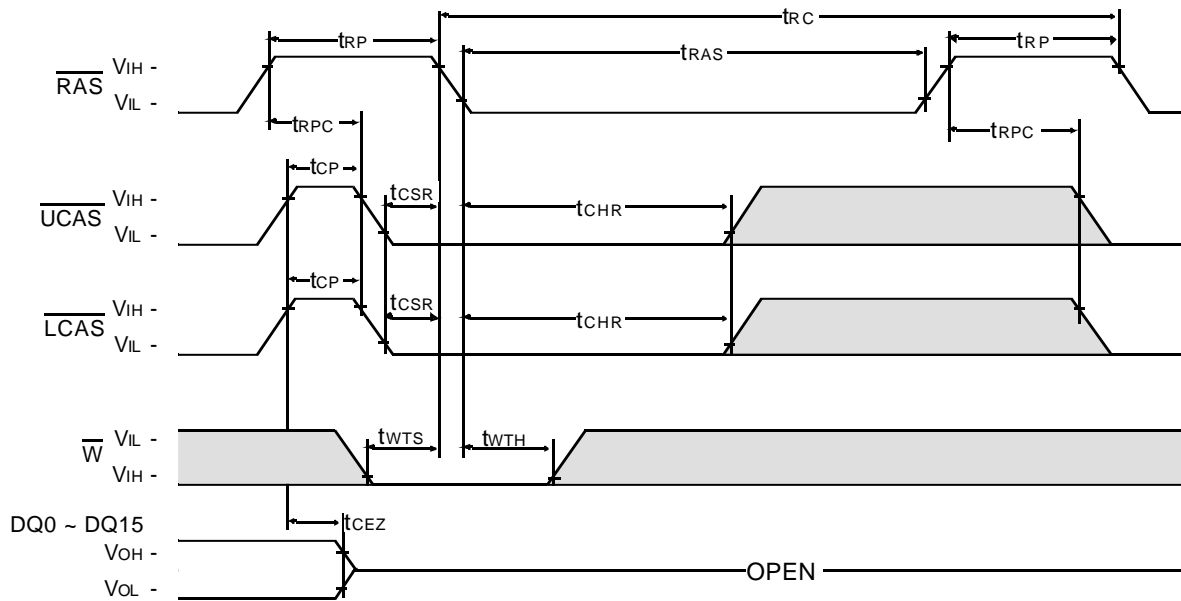
CAS - BEFORE - RAS SELF REFRESH CYCLE

NOTE : \overline{OE} , A = Don't care



TEST MODE IN CYCLE

NOTE : \overline{OE} , A = Don't care



Don't care
 Undefined

PACKAGE DIMENSION

