

4M x 4Bit CMOS Dynamic RAM with Fast Page Mode

DESCRIPTION

This is a family of 4,194,304 x 4 bit Fast Page Mode CMOS DRAMs. Fast Page Mode offers high speed random access of memory cells within the same row. Power supply voltage (+5.0V or +3.3V), refresh cycle (2K Ref. or 4K Ref.), access time (-50 or -60), power consumption(Normal or Low power) and package type(SOJ or TSOP-II) 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 4Mx4 Fast Page Mode DRAM family is fabricated using Samsung's advanced CMOS process to realize high band-width, low power consumption and high reliability. It may be used as main memory for high level computer, microcomputer and personal computer.

FEATURES

• Part Identification

- K4F170411D-B(F) (5V, 4K Ref.)
- K4F160411D-B(F) (5V, 2K Ref.)
- K4F170412D-B(F) (3.3V, 4K Ref.)
- K4F160412D-B(F) (3.3V, 2K Ref.)

• Active Power Dissipation

Unit : mW

| Speed | 3.3V | | 5V | |
|-------|------|-----|-----|-----|
| | 4K | 2K | 4K | 2K |
| -50 | 324 | 396 | 495 | 605 |
| -60 | 288 | 360 | 440 | 550 |

• Refresh Cycles

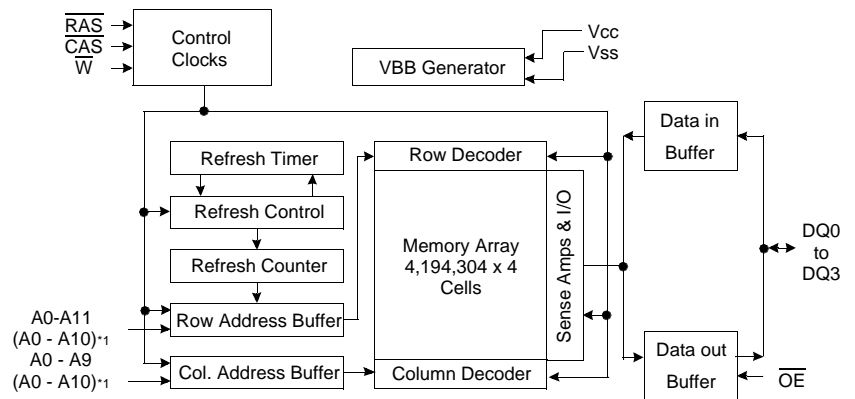
| Part NO. | Vcc | Refresh cycle | Refresh period | |
|------------|------|---------------|----------------|-------|
| | | | Normal | L-ver |
| K4F170411D | 5V | 4K | 64ms | 128ms |
| K4F170412D | 3.3V | | 64ms | |
| K4F160411D | 5V | 2K | 32ms | |
| K4F160412D | 3.3V | | 32ms | |

• Performance Range

| Speed | t _{RAC} | t _{CAC} | t _{RC} | t _{PC} | Remark |
|-------|------------------|------------------|-----------------|-----------------|---------|
| -50 | 50ns | 13ns | 90ns | 35ns | 5V/3.3V |
| -60 | 60ns | 15ns | 110ns | 40ns | 5V/3.3V |

- Fast Page Mode operation
- $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh capability
- $\overline{\text{RAS}}$ -only and Hidden refresh capability
- Self-refresh capability (L-ver only)
- Fast parallel test mode capability
- TTL(5V)/LVTTTL(3.3V) compatible inputs and outputs
- Early Write or output enable controlled write
- JEDEC Standard pinout
- Available in Plastic SOJ and TSOP(II) packages
- Single +5V±10% power supply (5V product)
- Single +3.3V±0.3V power supply (3.3V product)

FUNCTIONAL BLOCK DIAGRAM

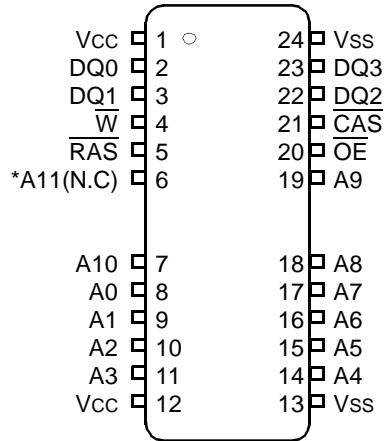


Note) *1: 2K Refresh

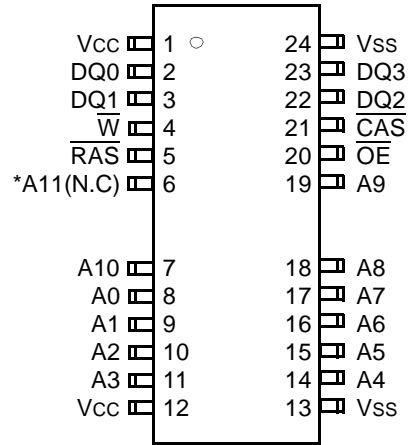
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PIN CONFIGURATION (Top Views)

• K4F17(6)0411(2)D-B



• K4F17(6)0411(2)D-F



*A11 is N.C for K4F160411(2)D(5V/3.3V, 2K Ref. product)

B : 300mil 26(24) SOJ

F : 300mil 26(24) TSOP II

| Pin Name | Pin Function |
|------------------|---------------------------------|
| A0 - A11 | Address Inputs (4K Product) |
| A0 - A10 | Address Inputs (2K Product) |
| DQ0 - 3 | Data In/Out |
| Vss | Ground |
| \overline{RAS} | Row Address Strobe |
| \overline{CAS} | Column Address Strobe |
| \overline{W} | Read/Write Input |
| \overline{OE} | Data Output Enable |
| Vcc | Power(+5V) |
| | Power(+3.3V) |
| N.C | No Connection (2K Ref. product) |

ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Rating | | Units |
|---------------------------------------|------------|--------------|--------------|-------|
| | | 3.3V | 5V | |
| Voltage on any pin relative to Vss | VIN,VOUT | -0.5 to +4.6 | -1.0 to +7.0 | V |
| Voltage on Vcc supply relative to Vss | Vcc | -0.5 to +4.6 | -1.0 to +7.0 | V |
| Storage Temperature | Tstg | -55 to +150 | -55 to +150 | °C |
| Power Dissipation | PD | 1 | 1 | W |
| Short Circuit Output Current | IosAddress | 50 | 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 Vss, TA= 0 to 70°C)

| Parameter | Symbol | 3.3V | | | 5V | | | Units |
|--------------------|--------|--------|-----|-----------|--------|-----|-----------|-------|
| | | Min | Typ | Max | Min | Typ | Max | |
| Supply Voltage | Vcc | 3.0 | 3.3 | 3.6 | 4.5 | 5.0 | 5.5 | V |
| Ground | Vss | 0 | 0 | 0 | 0 | 0 | 0 | V |
| Input High Voltage | VIH | 2.0 | - | Vcc+0.3*1 | 2.4 | - | Vcc+1.0*1 | V |
| Input Low Voltage | VIL | -0.3*2 | - | 0.8 | -1.0*2 | - | 0.8 | V |

*1 : Vcc+1.3V/15ns(3.3V), Vcc+2.0V/20ns(5V), Pulse width is measured at Vcc

*2 : -1.3V/15ns(3.3V), -2.0V/20ns(5V), Pulse width is measured at Vss

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

| Max | Parameter | Symbol | Min | Max | Units |
|------|---|--------|-----|-----|-------|
| 3.3V | Input Leakage Current (Any input $0 \leq V_{IN} \leq V_{IN} + 0.3V$, all other input pins not under test=0 Volt) | II(L) | -5 | 5 | uA |
| | Output Leakage Current (Data out is disabled, $0V \leq V_{OUT} \leq V_{CC}$) | IO(L) | -5 | 5 | uA |
| | Output High Voltage Level($I_{OH} = -2mA$) | VOH | 2.4 | - | V |
| | Output Low Voltage Level($I_{OL} = 2mA$) | VOL | - | 0.4 | V |
| 5V | Input Leakage Current (Any input $0 \leq V_{IN} \leq V_{IN} + 0.5V$, all other input pins not under test=0 Volt) | II(L) | -5 | 5 | uA |
| | Output Leakage Current (Data out is disabled, $0V \leq V_{OUT} \leq V_{CC}$) | IO(L) | -5 | 5 | uA |
| | Output High Voltage Level($I_{OH} = -5mA$) | VOH | 2.4 | - | V |
| | Output Low Voltage Level($I_{OL} = 4.2mA$) | VOL | - | 0.4 | V |

DC AND OPERATING CHARACTERISTICS (Continued)

| Symbol | Power | Speed | Max | | | | Units |
|--------|-------------|------------|------------|------------|------------|------------|-------|
| | | | K4F170412D | K4F160412D | K4F170411D | K4F160411D | |
| Icc1 | Don't care | -50 | 90 | 110 | 90 | 110 | mA |
| | | -60 | 80 | 100 | 80 | 100 | mA |
| Icc2 | Normal L | Don't care | 1 | 1 | 2 | 2 | mA |
| | | | 1 | 1 | 1 | 1 | mA |
| Icc3 | Don't care | -50 | 90 | 110 | 90 | 110 | mA |
| | | -60 | 80 | 100 | 80 | 100 | mA |
| Icc4 | Don't care | -50 | 80 | 90 | 80 | 90 | mA |
| | | -60 | 70 | 80 | 70 | 80 | mA |
| Icc5 | Normal L | Don't care | 0.5 | 0.5 | 1 | 1 | mA |
| | | | 200 | 200 | 250 | 250 | uA |
| Icc6 | Don't care | -50 | 90 | 110 | 90 | 110 | mA |
| | | -60 | 80 | 100 | 80 | 100 | mA |
| Icc7 | L | Don't care | 250 | 250 | 300 | 300 | uA |
| Iccs | L | Don't care | 200 | 200 | 250 | 250 | uA |

Icc1* : Operating Current (\overline{RAS} and \overline{CAS} , Address cycling @trc=min.)

Icc2 : Standby Current ($RAS=CAS=W=V_{IH}$)

Icc3* : \overline{RAS} -only Refresh Current ($\overline{CAS}=V_{IH}$, \overline{RAS} , Address cycling @trc=min.)

Icc4* : Fast Page Mode Current ($\overline{RAS}=V_{IL}$, \overline{CAS} , Address cycling @tPC=min.)

Icc5 : Standby Current ($RAS=CAS=W=V_{CC}-0.2V$)

Icc6* : \overline{CAS} -Before- \overline{RAS} Refresh Current (\overline{RAS} and \overline{CAS} cycling @trc=min.)

Icc7 : Battery back-up current, Average power supply current, Battery back-up mode

Input high voltage(V_{IH})= $V_{CC}-0.2V$, Input low voltage(V_{IL})= $0.2V$, $\overline{CAS}=0.2V$,

DQ=Don't care, Trc=31.25us(4K/L-ver), 62.5us(2K/L-ver), TRAS=TRASmin~300ns

Iccs : Self Refresh Current

$RAS=CAS=0.2V$, $\overline{W}=OE=A0 \sim A11=V_{CC}-0.2V$ or $0.2V$,

DQ0 ~ DQ3= $V_{CC}-0.2V$, $0.2V$ or Open

***Note** : Icc1, Icc3, Icc4 and Icc6 are dependent on output loading and cycle rates. Specified values are obtained with the output open. Icc is specified as an average current. In Icc1, Icc3 and Icc6 address can be changed maximum once while $\overline{RAS}=V_{IL}$. In Icc4, address can be changed maximum once within one fast page mode cycle time, tPC.

CAPACITANCE ($T_A=25^{\circ}\text{C}$, $V_{CC}=5\text{V}$ or 3.3V , $f=1\text{MHz}$)

| Parameter | Symbol | Min | Max | Units |
|--|--------|-----|-----|-------|
| Input capacitance [A0 ~ A11] | CIN1 | - | 5 | pF |
| Input capacitance [$\overline{\text{RAS}}$, $\overline{\text{CAS}}$, $\overline{\text{W}}$, $\overline{\text{OE}}$] | CIN2 | - | 7 | pF |
| Output capacitance [DQ0 - DQ3] | CDQ | - | 7 | pF |

AC CHARACTERISTICS ($0^{\circ}\text{C} \leq T_A \leq 70^{\circ}\text{C}$, See note 1,2)

Test condition (5V device) : $V_{CC}=5.0\text{V} \pm 10\%$, $V_{ih}/V_{il}=2.4/0.8\text{V}$, $V_{oh}/V_{ol}=2.4/0.4\text{V}$

Test condition (3.3V device) : $V_{CC}=3.3\text{V} \pm 0.3\text{V}$, $V_{ih}/V_{il}=2.0/0.8\text{V}$, $V_{oh}/V_{ol}=2.0/0.8\text{V}$

| Parameter | Symbol | -50 | | -60 | | Units | Notes |
|---|------------------|-----|-----|-----|-----|-------|--------|
| | | Min | Max | Min | Max | | |
| Random read or write cycle time | t _{RC} | 90 | | 110 | | ns | |
| Read-modify-write cycle time | t _{RWC} | 133 | | 155 | | ns | |
| Access time from $\overline{\text{RAS}}$ | t _{RAC} | | 50 | | 60 | ns | 3,4,10 |
| Access time from $\overline{\text{CAS}}$ | t _{CAC} | | 13 | | 15 | ns | 3,4,5 |
| Access time from column address | t _{AA} | | 25 | | 30 | ns | 3,10 |
| $\overline{\text{CAS}}$ to output in Low-Z | t _{CLZ} | 0 | | 0 | | ns | 3 |
| Output buffer turn-off delay | t _{OFF} | 0 | 13 | 0 | 15 | ns | 6 |
| Transition time (rise and fall) | t _T | 3 | 50 | 3 | 50 | ns | 2 |
| $\overline{\text{RAS}}$ precharge time | t _{RP} | 30 | | 40 | | ns | |
| $\overline{\text{RAS}}$ pulse width | t _{RAS} | 50 | 10K | 60 | 10K | ns | |
| $\overline{\text{RAS}}$ hold time | t _{RSH} | 13 | | 15 | | ns | |
| $\overline{\text{CAS}}$ hold time | t _{CSH} | 50 | | 60 | | ns | |
| $\overline{\text{CAS}}$ pulse width | t _{CAS} | 13 | 10K | 15 | 10K | ns | |
| $\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ delay time | t _{RCD} | 20 | 37 | 20 | 45 | ns | 4 |
| $\overline{\text{RAS}}$ to column address delay time | t _{RAD} | 15 | 25 | 15 | 30 | ns | 10 |
| $\overline{\text{CAS}}$ to $\overline{\text{RAS}}$ precharge time | t _{CRP} | 5 | | 5 | | ns | |
| Row address set-up time | t _{ASR} | 0 | | 0 | | ns | |
| Row address hold time | t _{RAH} | 10 | | 10 | | ns | |
| Column address set-up time | t _{ASC} | 0 | | 0 | | ns | |
| Column address hold time | t _{CAH} | 10 | | 10 | | ns | |
| Column address to $\overline{\text{RAS}}$ lead time | t _{RAL} | 25 | | 30 | | ns | |
| Read command set-up time | t _{RCS} | 0 | | 0 | | ns | |
| Read command hold time referenced to $\overline{\text{CAS}}$ | t _{RCH} | 0 | | 0 | | ns | 8 |
| Read command hold time referenced to $\overline{\text{RAS}}$ | t _{RRH} | 0 | | 0 | | ns | 8 |
| Write command hold time | t _{WCH} | 10 | | 10 | | ns | |
| Write command pulse width | t _{WP} | 10 | | 10 | | ns | |
| Write command to $\overline{\text{RAS}}$ lead time | t _{RWL} | 13 | | 15 | | ns | |
| Write command to $\overline{\text{CAS}}$ lead time | t _{CWL} | 13 | | 15 | | ns | |

AC CHARACTERISTICS (Continued)

| Parameter | Symbol | -50 | | -60 | | Units | Note |
|---|--------|-----|------|-----|------|-------|----------|
| | | Min | Max | Min | Max | | |
| Data set-up time | tDS | 0 | | 0 | | ns | 9 |
| Data hold time | tDH | 10 | | 10 | | ns | 9 |
| Refresh period (2K, Normal) | tREF | | 32 | | 32 | ms | |
| Refresh period (4K, Normal) | tREF | | 64 | | 64 | ms | |
| Refresh period (L-ver) | tREF | | 128 | | 128 | ms | |
| Write command set-up time | tWCS | 0 | | 0 | | ns | 7 |
| $\overline{\text{CAS}}$ to $\overline{\text{W}}$ delay time | tCWD | 36 | | 40 | | ns | 7 |
| $\overline{\text{RAS}}$ to $\overline{\text{W}}$ delay time | tRWD | 73 | | 85 | | ns | 7 |
| Column address to $\overline{\text{W}}$ delay time | tAWD | 48 | | 55 | | ns | 7 |
| $\overline{\text{CAS}}$ precharge to $\overline{\text{W}}$ delay time | tCPWD | 53 | | 60 | | ns | |
| $\overline{\text{CAS}}$ set-up time ($\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh) | tCSR | 5 | | 5 | | ns | |
| $\overline{\text{CAS}}$ hold time ($\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh) | tCHR | 10 | | 10 | | ns | |
| $\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ precharge time | tRPC | 5 | | 5 | | ns | |
| Access time from $\overline{\text{CAS}}$ precharge | tCPA | | 30 | | 35 | ns | 3 |
| Fast Page cycle time | tPC | 35 | | 40 | | ns | |
| Fast Page read-modify-write cycle time | tPRWC | 76 | | 85 | | ns | |
| $\overline{\text{CAS}}$ precharge time (Fast Page cycle) | tCP | 10 | | 10 | | ns | |
| $\overline{\text{RAS}}$ pulse width (Fast Page cycle) | tRASP | 50 | 200K | 60 | 200K | ns | |
| $\overline{\text{RAS}}$ hold time from $\overline{\text{CAS}}$ precharge | tRHCP | 30 | | 35 | | ns | |
| $\overline{\text{OE}}$ access time | tOEA | | 13 | | 15 | ns | |
| $\overline{\text{OE}}$ to data delay | tOED | 13 | | 15 | | ns | |
| Output buffer turn off delay time from $\overline{\text{OE}}$ | tOEZ | 0 | 13 | 0 | 15 | ns | 6 |
| $\overline{\text{OE}}$ command hold time | tOEH | 13 | | 15 | | ns | |
| Write command set-up time (Test mode in) | tWTS | 10 | | 10 | | ns | 11 |
| Write command hold time (Test mode in) | tWTH | 10 | | 10 | | ns | 11 |
| $\overline{\text{W}}$ to $\overline{\text{RAS}}$ precharge time($\overline{\text{C}}$ - $\overline{\text{B}}$ - $\overline{\text{R}}$ refresh) | tWRP | 10 | | 10 | | ns | |
| $\overline{\text{W}}$ to $\overline{\text{RAS}}$ hold time($\overline{\text{C}}$ - $\overline{\text{B}}$ - $\overline{\text{R}}$ refresh) | tWRH | 10 | | 10 | | ns | |
| $\overline{\text{RAS}}$ pulse width ($\overline{\text{C}}$ - $\overline{\text{B}}$ - $\overline{\text{R}}$ self refresh) | tRASS | 100 | | 100 | | us | 13,14,15 |
| $\overline{\text{RAS}}$ precharge time ($\overline{\text{C}}$ - $\overline{\text{B}}$ - $\overline{\text{R}}$ self refresh) | tRPS | 90 | | 110 | | ns | 13,14,15 |
| $\overline{\text{CAS}}$ hold time ($\overline{\text{C}}$ - $\overline{\text{B}}$ - $\overline{\text{R}}$ self refresh) | tCHS | -50 | | -50 | | ns | 13,14,15 |

TEST MODE CYCLE

(Note 11)

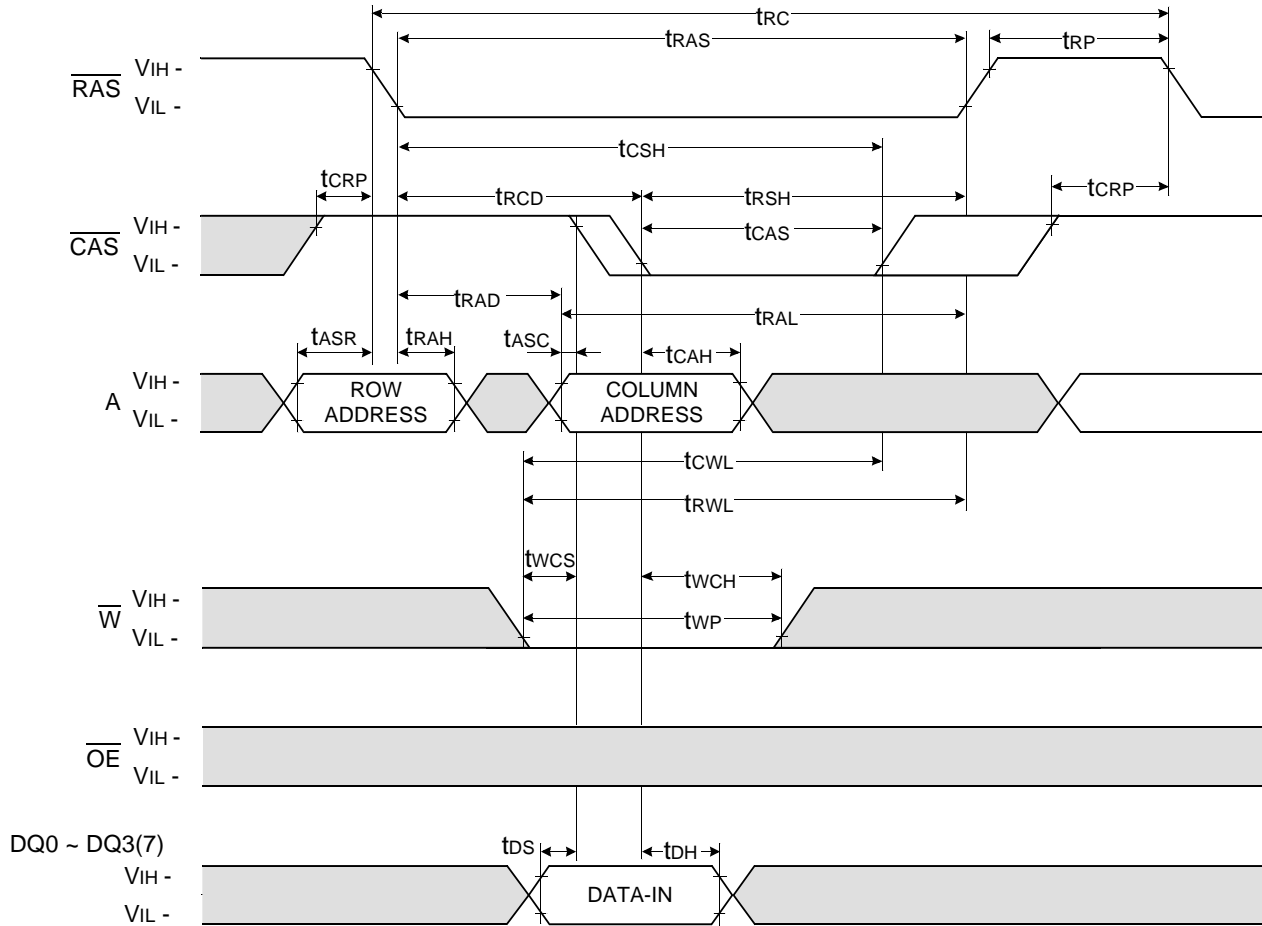
| Parameter | Symbol | -50 | | -60 | | Units | Notes |
|---|-------------------|-----|------|-----|------|-------|-----------|
| | | Min | Max | Min | Max | | |
| Random read or write cycle time | t _{RC} | 95 | | 115 | | ns | |
| Read-modify-write cycle time | t _{RWC} | 138 | | 160 | | ns | |
| Access time from $\overline{\text{RAS}}$ | t _{RAC} | | 55 | | 65 | ns | 3,4,10,12 |
| Access time from $\overline{\text{CAS}}$ | t _{CAC} | | 18 | | 20 | ns | 3,4,5,12 |
| Access time from column address | t _{AA} | | 30 | | 35 | ns | 3,10,12 |
| $\overline{\text{RAS}}$ pulse width | t _{RAS} | 55 | 10K | 65 | 10K | ns | |
| $\overline{\text{CAS}}$ pulse width | t _{CAS} | 18 | 10K | 20 | 10K | ns | |
| $\overline{\text{RAS}}$ hold time | t _{RSH} | 18 | | 20 | | ns | |
| $\overline{\text{CAS}}$ hold time | t _{CSH} | 55 | | 65 | | ns | |
| Column address to $\overline{\text{RAS}}$ lead time | t _{RAL} | 30 | | 35 | | ns | |
| $\overline{\text{CAS}}$ to $\overline{\text{W}}$ delay time | t _{CWD} | 41 | | 45 | | ns | 7 |
| $\overline{\text{RAS}}$ to $\overline{\text{W}}$ delay time | t _{RWD} | 78 | | 90 | | ns | 7 |
| Column address to $\overline{\text{W}}$ delay time | t _{AWD} | 53 | | 60 | | ns | 7 |
| $\overline{\text{CAS}}$ precharge to $\overline{\text{W}}$ delay time | t _{CPWD} | 58 | | 65 | | ns | |
| Fast Page cycle time | t _{PC} | 40 | | 45 | | ns | |
| Fast Page read-modify-write cycle time | t _{PRWC} | 81 | | 90 | | ns | |
| $\overline{\text{RAS}}$ pulse width (Fast Page cycle) | t _{RASP} | 55 | 200K | 65 | 200K | ns | |
| Access time from $\overline{\text{CAS}}$ precharge | t _{CPA} | | 35 | | 40 | ns | 3 |
| $\overline{\text{OE}}$ access time | t _{OEA} | | 18 | | 20 | ns | |
| $\overline{\text{OE}}$ to data delay | t _{OED} | 18 | | 20 | | ns | |
| $\overline{\text{OE}}$ command hold time | t _{OEH} | 18 | | 20 | | ns | |

NOTES

1. An initial pause of 200us is required after power-up followed by any 8 $\overline{\text{RAS}}$ -only refresh or $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh cycles before proper device operation is achieved.
2. $V_{IH}(\text{min})$ 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 5ns for all inputs.
3. Measured with a load equivalent to 2 TTL(5V)/1 TTL(3.3V) loads 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. $t_{\text{OFF}}(\text{min})$ and $t_{\text{OEZ}}(\text{max})$ define the time at which the output achieves the open circuit condition and are not referenced 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 electrical characteristics only. If $t_{\text{WCS}} \geq t_{\text{WCS}}(\text{min})$, the cycle 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. These parameters are referenced to $\overline{\text{CAS}}$ falling edge in early write cycles and to $\overline{\text{W}}$ falling edge in 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. If $t_{\text{RASS}} \geq 100\text{us}$, then $\overline{\text{RAS}}$ precharge time must use t_{RPS} instead of t_{RP} .
14. For $\overline{\text{RAS}}$ -only refresh and burst $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh mode, 4096(4K)/2048(2K) cycles of burst refresh must be executed within 64ms/32ms before and after self refresh, in order to meet refresh specification.
15. For distributed $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ with 15.6us interval $\overline{\text{CAS}}$ -before- $\overline{\text{RAS}}$ refresh should be executed with in 15.6us immediately before and after self refresh in order to meet refresh specification.

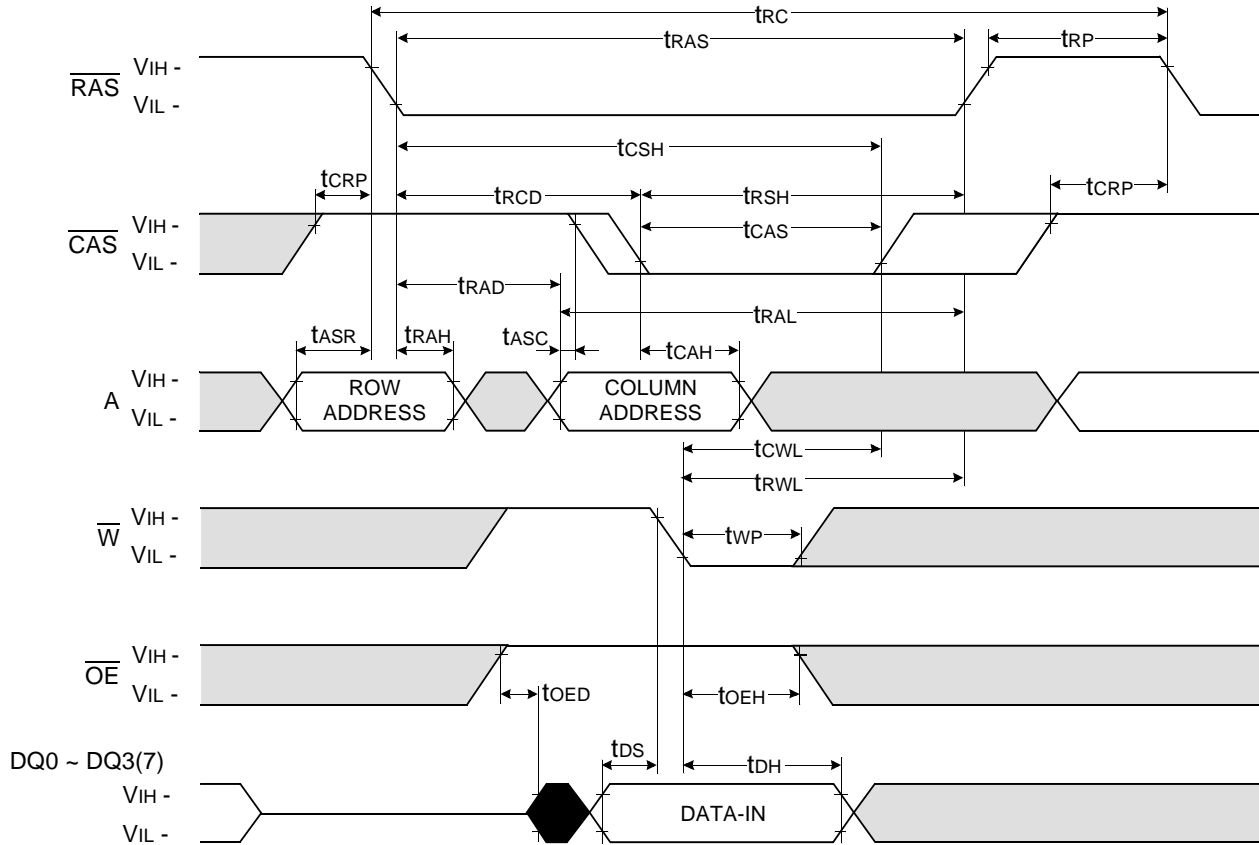
WRITE CYCLE (EARLY WRITE)

NOTE : DOUT = OPEN



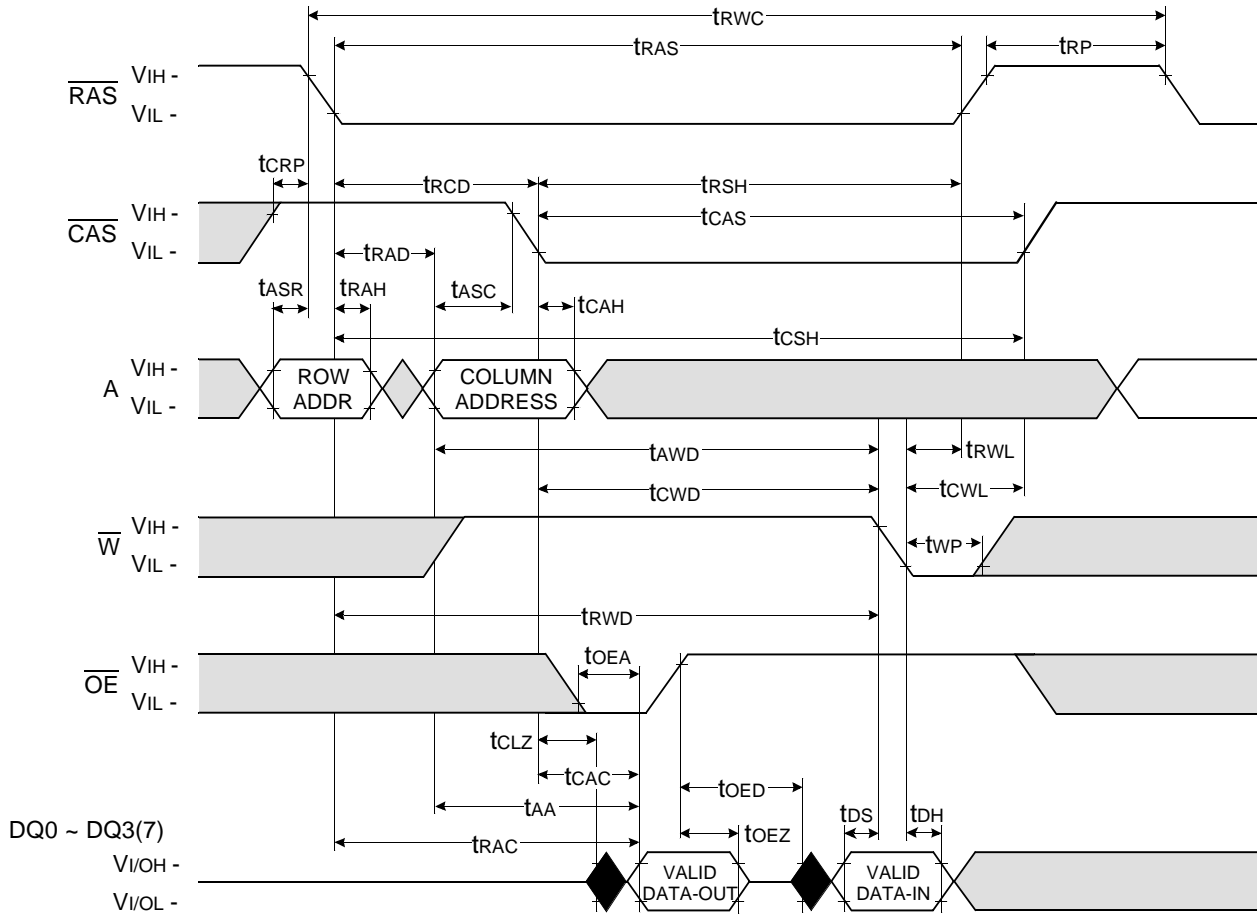
WRITE CYCLE ($\overline{\text{OE}}$ CONTROLLED WRITE)

NOTE : DOUT = OPEN



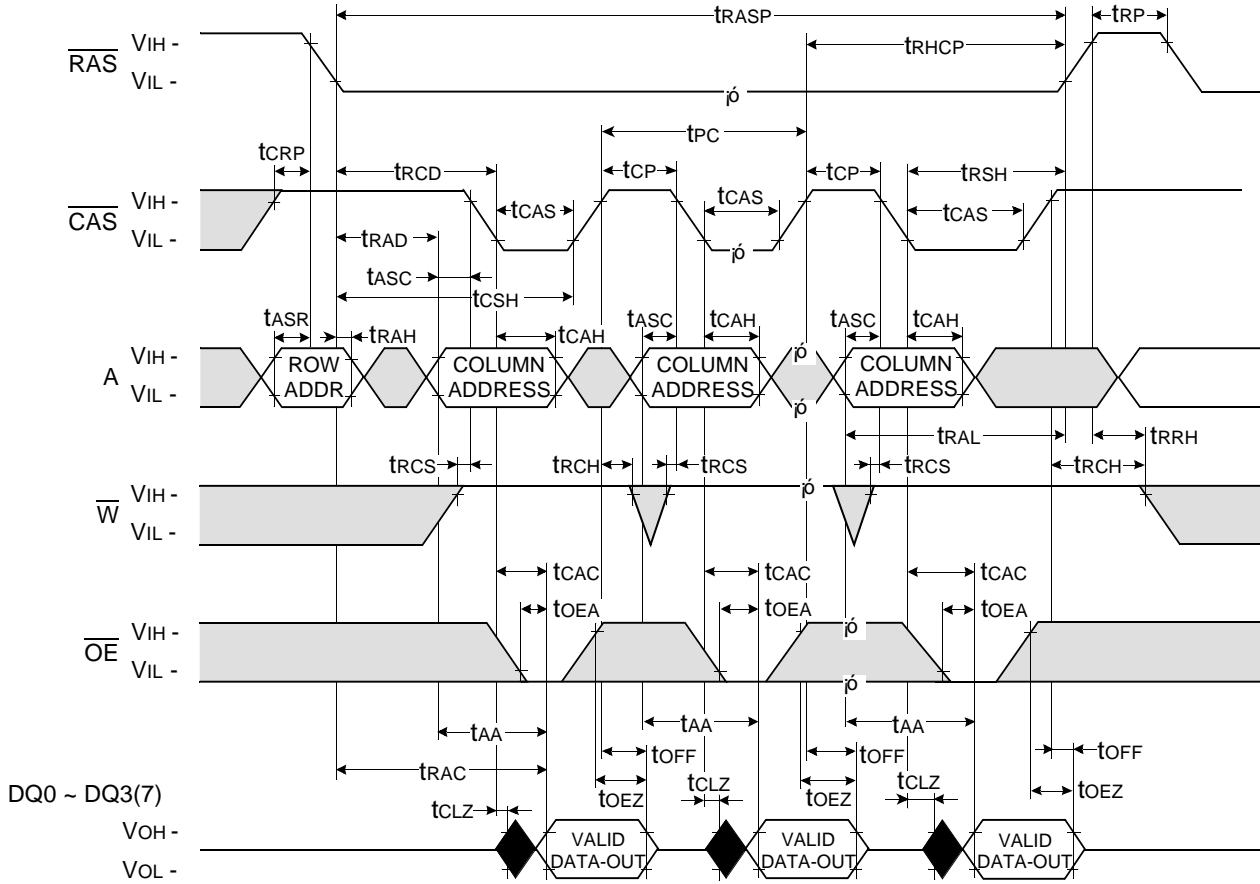
□ Don't care
 ■ Undefined

READ - MODIFY - WRITE CYCLE



Don't care
 Undefined

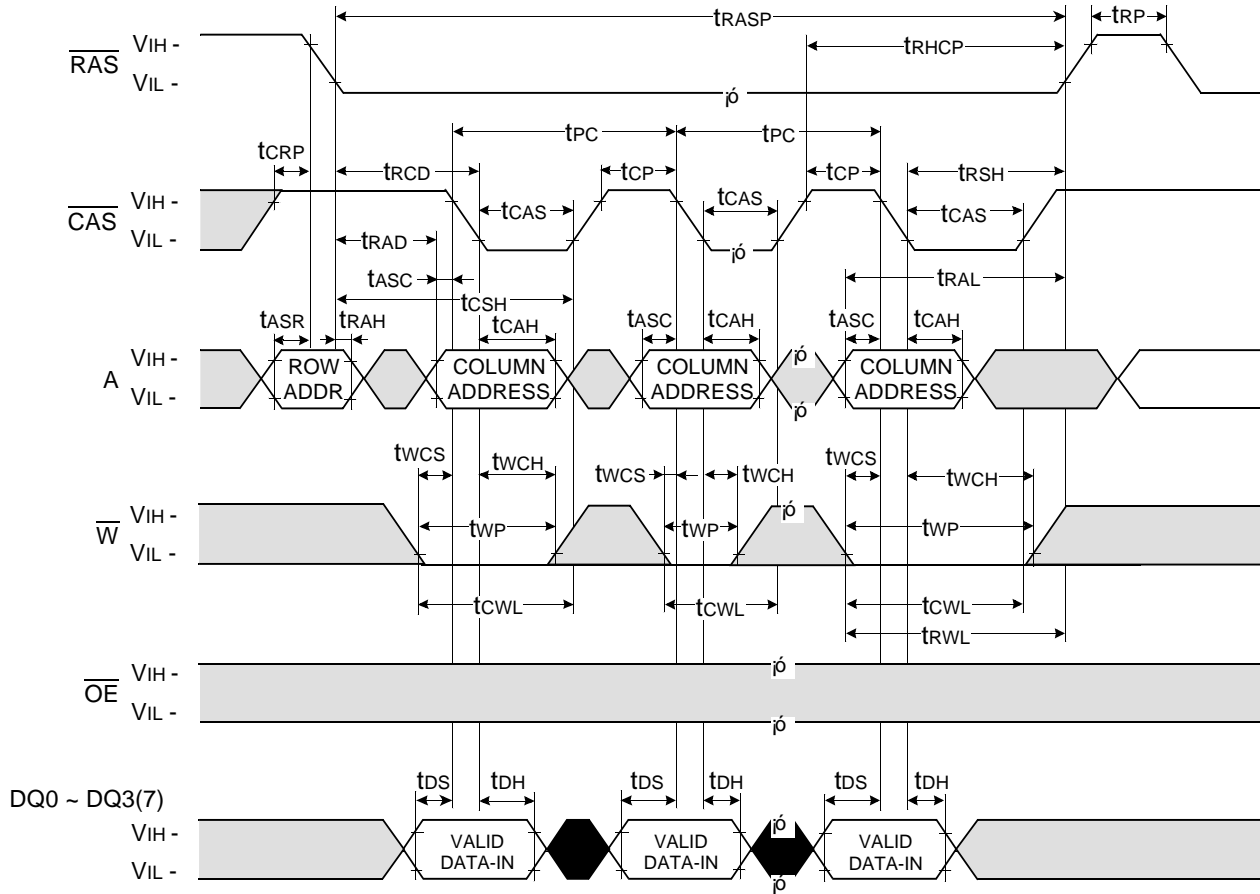
FAST PAGE READ CYCLE



□ Don't care
 ■ Undefined

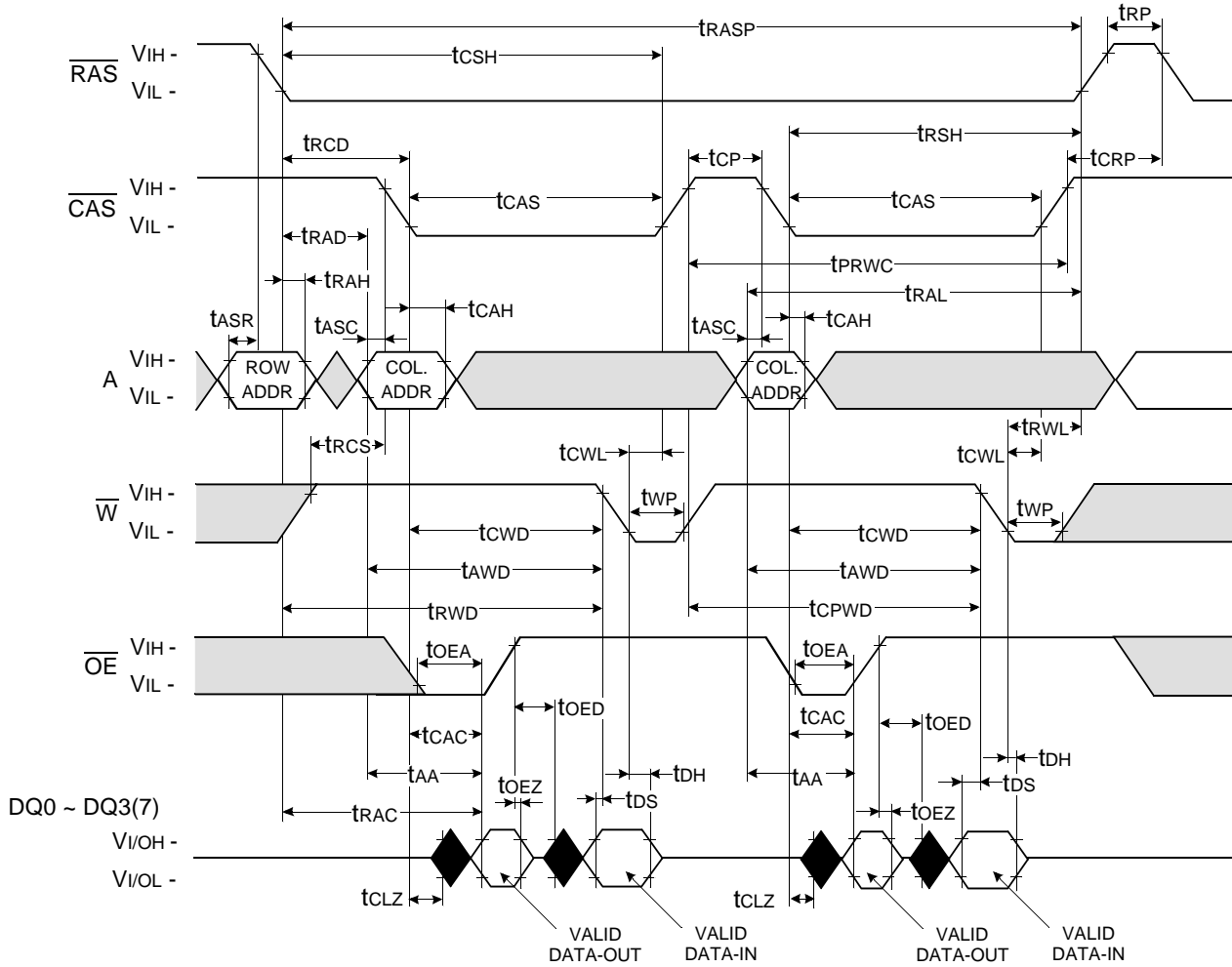
FAST PAGE WRITE CYCLE (EARLY WRITE)

NOTE : DOUT = OPEN



Don't care
 Undefined

FAST PAGE READ - MODIFY - WRITE CYCLE

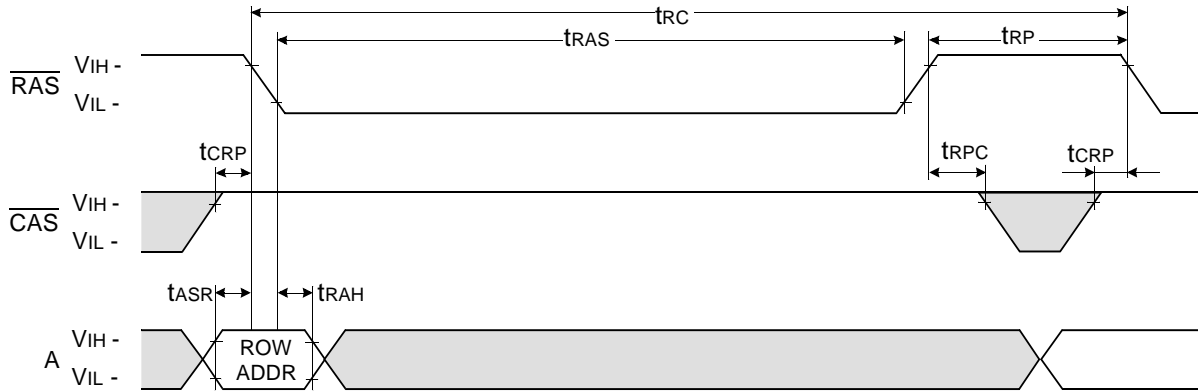


Don't care
 Undefined

$\overline{\text{RAS}}$ - ONLY REFRESH CYCLE

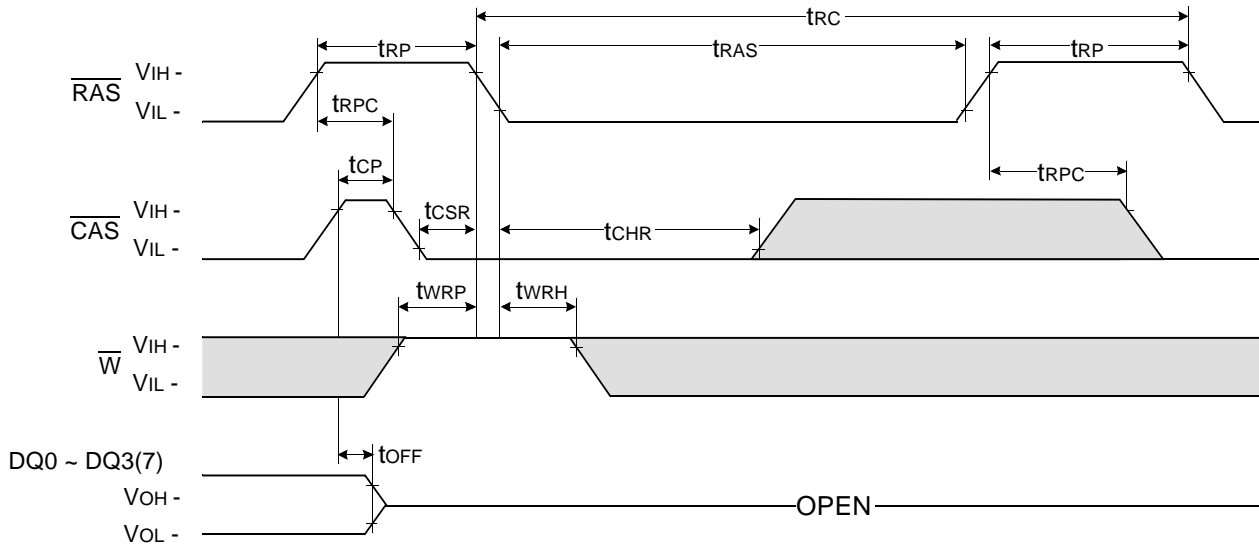
NOTE : $\overline{\text{W}}$, $\overline{\text{OE}}$, DIN = Don't care

DOUT = OPEN



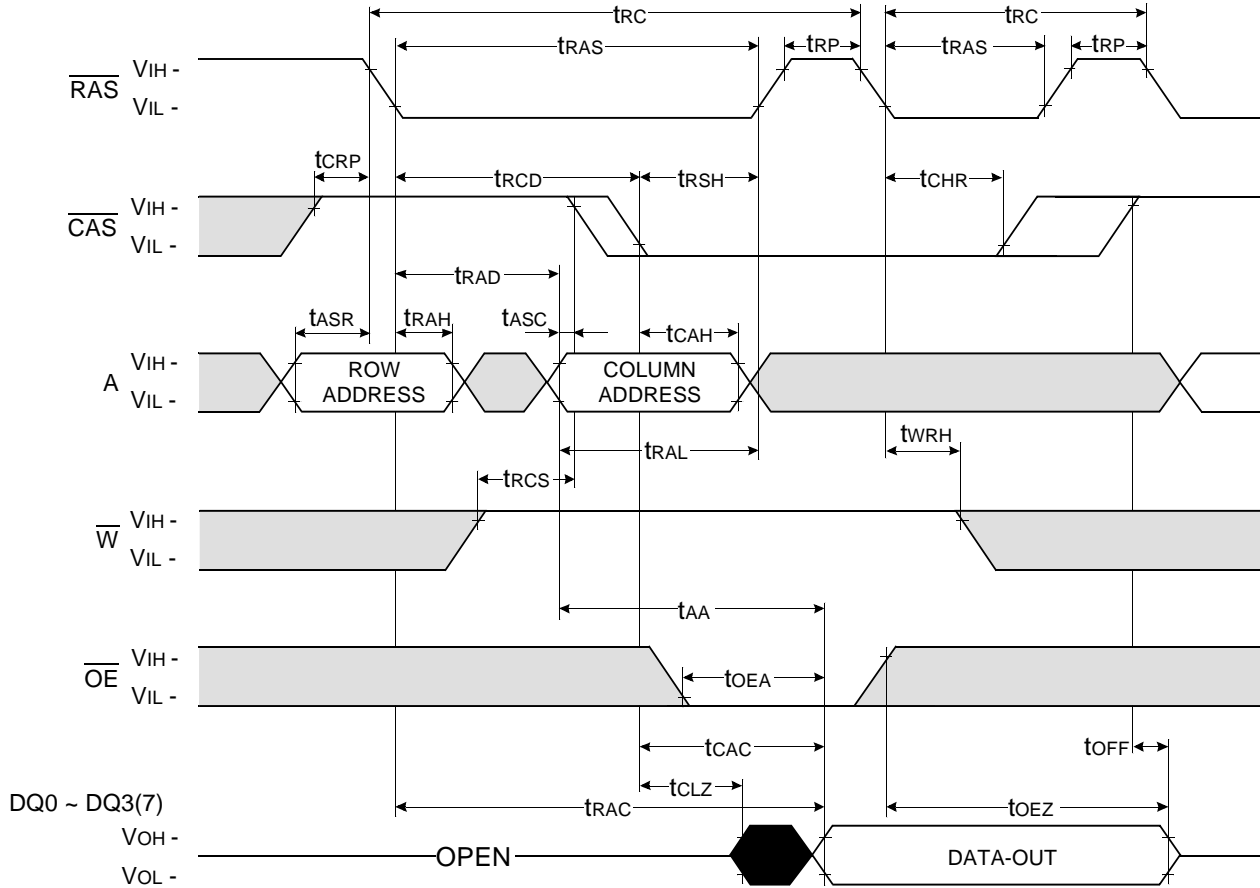
$\overline{\text{CAS}}$ - BEFORE - $\overline{\text{RAS}}$ REFRESH CYCLE

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



□ Don't care
 ■ Undefined

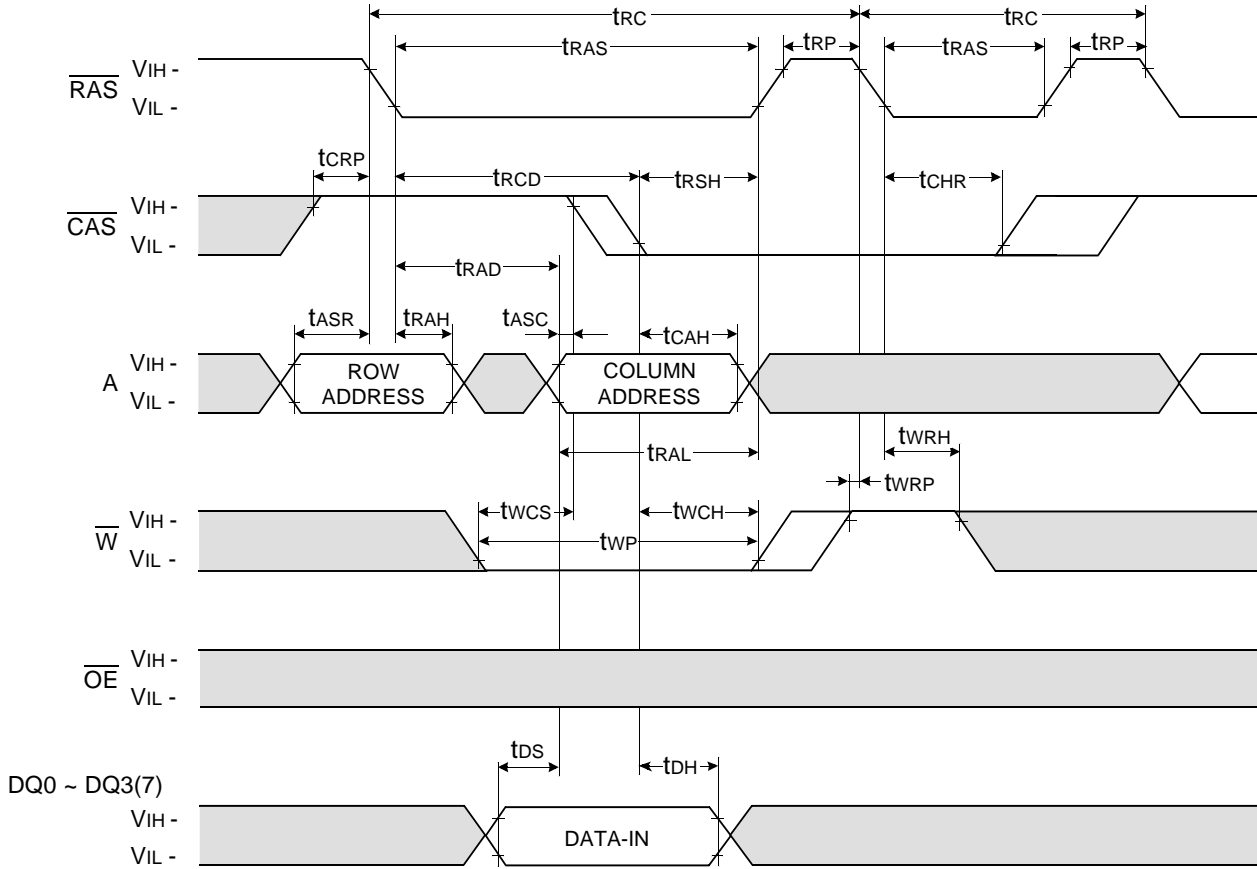
HIDDEN REFRESH CYCLE (READ)



□ Don't care
 ■ Undefined

HIDDEN REFRESH CYCLE (WRITE)

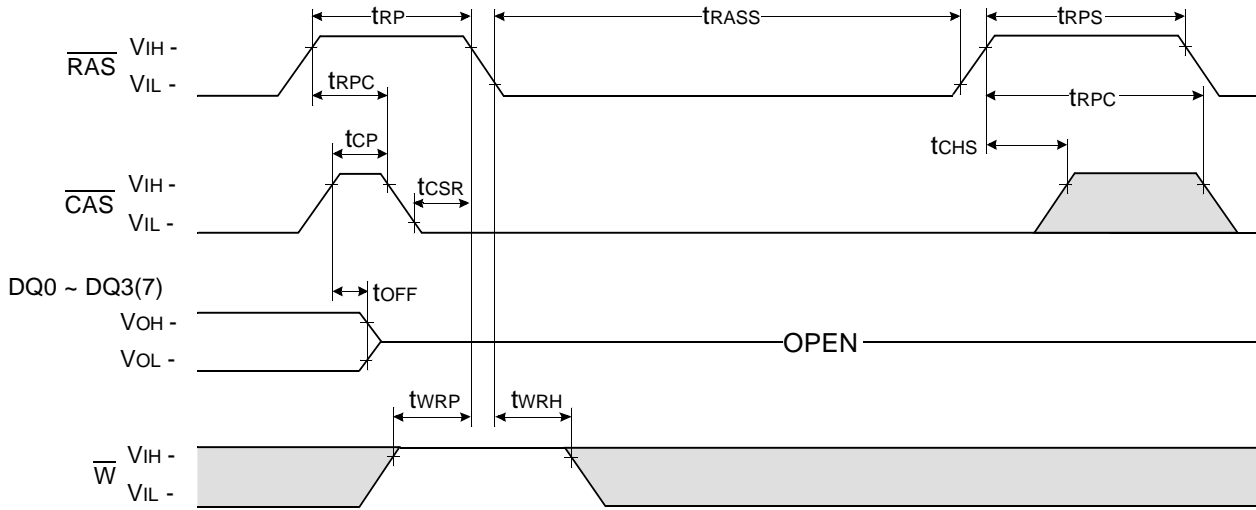
NOTE : DOUT = OPEN



□ Don't care
 ■ Undefined

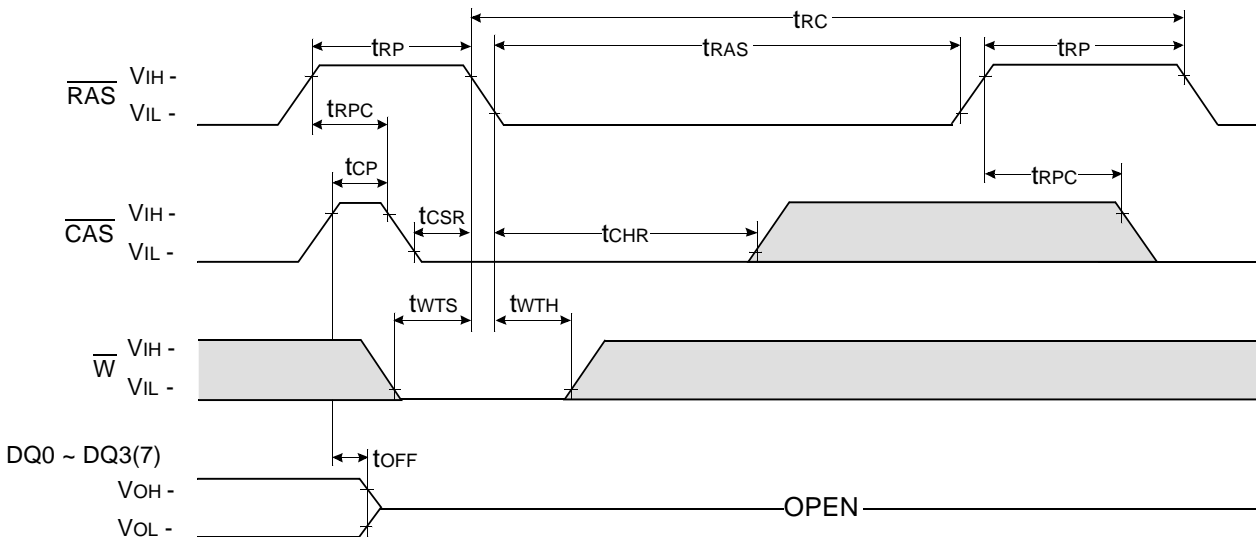
$\overline{\text{CAS}}$ - BEFORE - $\overline{\text{RAS}}$ SELF REFRESH CYCLE

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



TEST MODE IN CYCLE

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



□ Don't care
 ■ Undefined

PACKAGE DIMENSION

