

*2M x 8Bit CMOS Dynamic RAM with Fast Page Mode*

**DESCRIPTION**

This is a family of 2,097,152 x 8 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 2Mx8 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 graphic memory unit for microcomputer, personal computer and portable machines.

**FEATURES**

• **Part Identification**

- K4F170811D-B(F) (5V, 4K Ref.)
- K4F160811D-B(F) (5V, 2K Ref.)
- K4F170812D-B(F) (3.3V, 4K Ref.)
- K4F160812D-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**

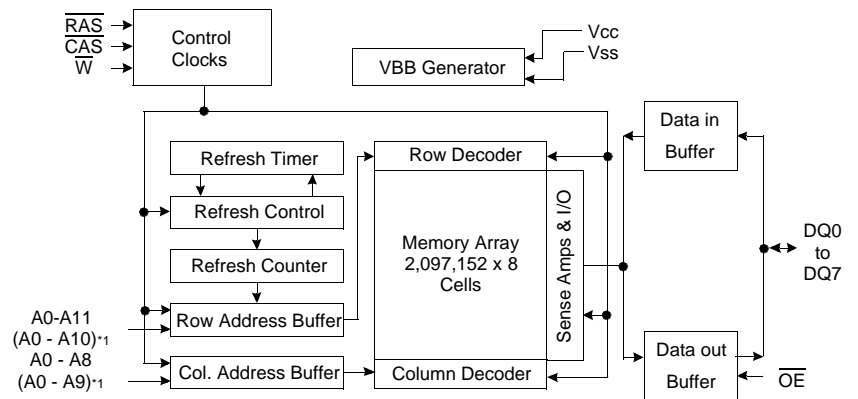
Part NO.	VCC	Refresh cycle	Refresh period	
			Normal	L-ver
K4F170811D	5V	4K	64ms	128ms
K4F170812D	3.3V			
K4F160811D	5V	2K	32ms	
K4F160812D	3.3V			

• **Performance Range**

Speed	t <sub>RAC</sub>	t <sub>CAC</sub>	t <sub>RC</sub>	t <sub>PC</sub>	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**

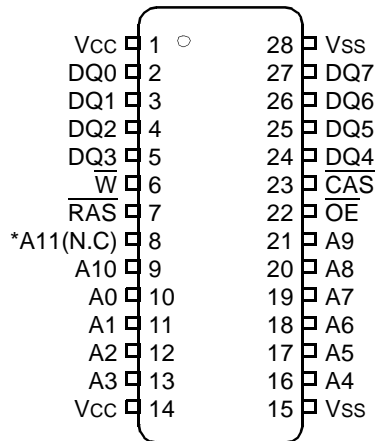


Note) \*1: 2K Refresh

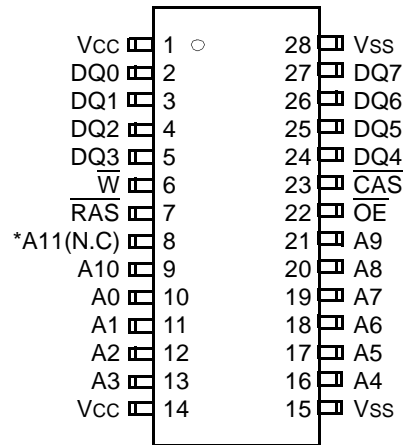
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PIN CONFIGURATION (Top Views)

• K4F17(6)0811(2)D-B



• K4F17(6)0811(2)D-F



\*A11 is N.C for K160811(2)D(5V/3.3V, 2K Ref. product)

B : 300mil 28 SOJ  
F : 300mil 28 TSOP II

Pin Name	Pin Function
A0 - A11	Address Inputs (4K Product)
A0 - A10	Address Inputs (2K Product)
DQ0 - 7	Data In/Out
Vss	Ground
$\overline{\text{RAS}}$	Row Address Strobe
$\overline{\text{CAS}}$	Column Address Strobe
$\overline{\text{W}}$	Read/Write Input
$\overline{\text{OE}}$	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	V <sub>IN</sub> ,V <sub>OUT</sub>	-0.5 to +4.6	-1.0 to +7.0	V
Voltage on Vcc supply relative to Vss	V <sub>CC</sub>	-0.5 to +4.6	-1.0 to +7.0	V
Storage Temperature	T <sub>stg</sub>	-55 to +150	-55 to +150	°C
Power Dissipation	P <sub>D</sub>	1	1	W
Short Circuit Output Current	I <sub>osAddress</sub>	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, T<sub>A</sub>= 0 to 70°C)

Parameter	Symbol	3.3V			5V			Units
		Min	Typ	Max	Min	Typ	Max	
Supply Voltage	V <sub>CC</sub>	3.0	3.3	3.6	4.5	5.0	5.5	V
Ground	V <sub>SS</sub>	0	0	0	0	0	0	V
Input High Voltage	V <sub>IH</sub>	2.0	-	V <sub>CC</sub> +0.3 <sup>*1</sup>	2.4	-	V <sub>CC</sub> +1.0 <sup>*1</sup>	V
Input Low Voltage	V <sub>IL</sub>	-0.3 <sup>*2</sup>	-	0.8	-1.0 <sup>*2</sup>	-	0.8	V

\*1 : V<sub>CC</sub>+1.3V/15ns(3.3V), V<sub>CC</sub>+2.0V/20ns(5V), Pulse width is measured at V<sub>CC</sub>

\*2 : -1.3V/15ns(3.3V), -2.0V/20ns(5V), Pulse width is measured at V<sub>SS</sub>

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

Max	Parameter	Symbol	Min	Max	Units
3.3V	Input Leakage Current (Any input 0≤V <sub>IN</sub> ≤V <sub>IN</sub> +0.3V, all other input pins not under test=0 Volt)	I <sub>I(L)</sub>	-5	5	uA
	Output Leakage Current (Data out is disabled, 0V≤V <sub>OUT</sub> ≤V <sub>CC</sub> )	I <sub>O(L)</sub>	-5	5	uA
	Output High Voltage Level(I <sub>OH</sub> =-2mA)	V <sub>OH</sub>	2.4	-	V
	Output Low Voltage Level(I <sub>OL</sub> =2mA)	V <sub>OL</sub>	-	0.4	V
5V	Input Leakage Current (Any input 0≤V <sub>IN</sub> ≤V <sub>IN</sub> +0.5V, all other input pins not under test=0 Volt)	I <sub>I(L)</sub>	-5	5	uA
	Output Leakage Current (Data out is disabled, 0V≤V <sub>OUT</sub> ≤V <sub>CC</sub> )	I <sub>O(L)</sub>	-5	5	uA
	Output High Voltage Level(I <sub>OH</sub> =-5mA)	V <sub>OH</sub>	2.4	-	V
	Output Low Voltage Level(I <sub>OL</sub> =4.2mA)	V <sub>OL</sub>	-	0.4	V



**DC AND OPERATING CHARACTERISTICS (Continued)**

Symbol	Power	Speed	Max				Units
			K4F170812D	K4F160812D	K4F170811D	K4F160811D	
I <sub>CC1</sub>	Don't care	-50	90	110	90	110	mA
		-60	80	100	80	100	mA
I <sub>CC2</sub>	Normal L	Don't care	1	1	2	2	mA
			1	1	1	1	mA
I <sub>CC3</sub>	Don't care	-50	90	110	90	110	mA
		-60	80	100	80	100	mA
I <sub>CC4</sub>	Don't care	-50	80	90	80	90	mA
		-60	70	80	70	80	mA
I <sub>CC5</sub>	Normal L	Don't care	0.5	0.5	1	1	mA
			200	200	250	250	uA
I <sub>CC6</sub>	Don't care	-50	90	110	90	110	mA
		-60	80	100	80	100	mA
I <sub>CC7</sub>	L	Don't care	250	250	300	300	uA
I <sub>CCS</sub>	L	Don't care	200	200	250	250	uA

I<sub>CC1</sub>\* : Operating Current ( $\overline{RAS}$  and  $\overline{CAS}$  cycling @trc=min.)

I<sub>CC2</sub> : Standby Current ( $RAS=CAS=W=V_{IH}$ )

I<sub>CC3</sub>\* :  $\overline{RAS}$ -only Refresh Current ( $\overline{CAS}=V_{IH}$ ,  $\overline{RAS}$  cycling @trc=min.)

I<sub>CC4</sub>\* : Fast Page Mode Current ( $\overline{RAS}=V_{IL}$ ,  $\overline{CAS}$ , Address cycling @tPC=min.)

I<sub>CC5</sub> : Standby Current ( $RAS=CAS=W=V_{CC}-0.2V$ )

I<sub>CC6</sub>\* :  $\overline{CAS}$ -Before- $\overline{RAS}$  Refresh Current ( $\overline{RAS}$  and  $\overline{CAS}$  cycling @trc=min.)

I<sub>CC7</sub> : 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

I<sub>CCS</sub> : Self Refresh Current

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

DQ0 ~ DQ7= $V_{CC}-0.2V$ ,  $0.2V$  or Open

**\*Note** : I<sub>CC1</sub>, I<sub>CC3</sub>, I<sub>CC4</sub> and I<sub>CC6</sub> are dependent on output loading and cycle rates. Specified values are obtained with the output open. I<sub>CC</sub> is specified as an average current. In I<sub>CC1</sub>, I<sub>CC3</sub> and I<sub>CC6</sub> address can be changed maximum once while  $\overline{RAS}=V_{IL}$ . In I<sub>CC4</sub>, 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  $3.3\text{V}$ ,  $f=1\text{MHz}$ )

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 - DQ7]	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 <sub>RC</sub>	90		110		ns	
Read-modify-write cycle time	t <sub>RWC</sub>	133		155		ns	
Access time from $\overline{\text{RAS}}$	t <sub>RAC</sub>		50		60	ns	3,4,10
Access time from $\overline{\text{CAS}}$	t <sub>CAC</sub>		13		15	ns	3,4,5
Access time from column address	t <sub>AA</sub>		25		30	ns	3,10
$\overline{\text{CAS}}$ to output in Low-Z	t <sub>CLZ</sub>	0		0		ns	3
Output buffer turn-off delay	t <sub>OFF</sub>	0	13	0	15	ns	6
Transition time (rise and fall)	t <sub>T</sub>	3	50	3	50	ns	2
$\overline{\text{RAS}}$ precharge time	t <sub>RP</sub>	30		40		ns	
$\overline{\text{RAS}}$ pulse width	t <sub>RAS</sub>	50	10K	60	10K	ns	
$\overline{\text{RAS}}$ hold time	t <sub>RSH</sub>	13		15		ns	
$\overline{\text{CAS}}$ hold time	t <sub>CSH</sub>	50		60		ns	
$\overline{\text{CAS}}$ pulse width	t <sub>CAS</sub>	13	10K	15	10K	ns	
$\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ delay time	t <sub>RCD</sub>	20	37	20	45	ns	4
$\overline{\text{RAS}}$ to column address delay time	t <sub>RAD</sub>	15	25	15	30	ns	10
$\overline{\text{CAS}}$ to $\overline{\text{RAS}}$ precharge time	t <sub>CRP</sub>	5		5		ns	
Row address set-up time	t <sub>ASR</sub>	0		0		ns	
Row address hold time	t <sub>RAH</sub>	10		10		ns	
Column address set-up time	t <sub>ASC</sub>	0		0		ns	
Column address hold time	t <sub>CAH</sub>	10		10		ns	
Column address to $\overline{\text{RAS}}$ lead time	t <sub>RAL</sub>	25		30		ns	
Read command set-up time	t <sub>RCS</sub>	0		0		ns	
Read command hold time referenced to $\overline{\text{CAS}}$	t <sub>RCH</sub>	0		0		ns	8
Read command hold time referenced to $\overline{\text{RAS}}$	t <sub>RRH</sub>	0		0		ns	8
Write command hold time	t <sub>WCH</sub>	10		10		ns	
Write command pulse width	t <sub>WP</sub>	10		10		ns	
Write command to $\overline{\text{RAS}}$ lead time	t <sub>RWL</sub>	13		15		ns	
Write command to $\overline{\text{CAS}}$ lead time	t <sub>CWL</sub>	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 )

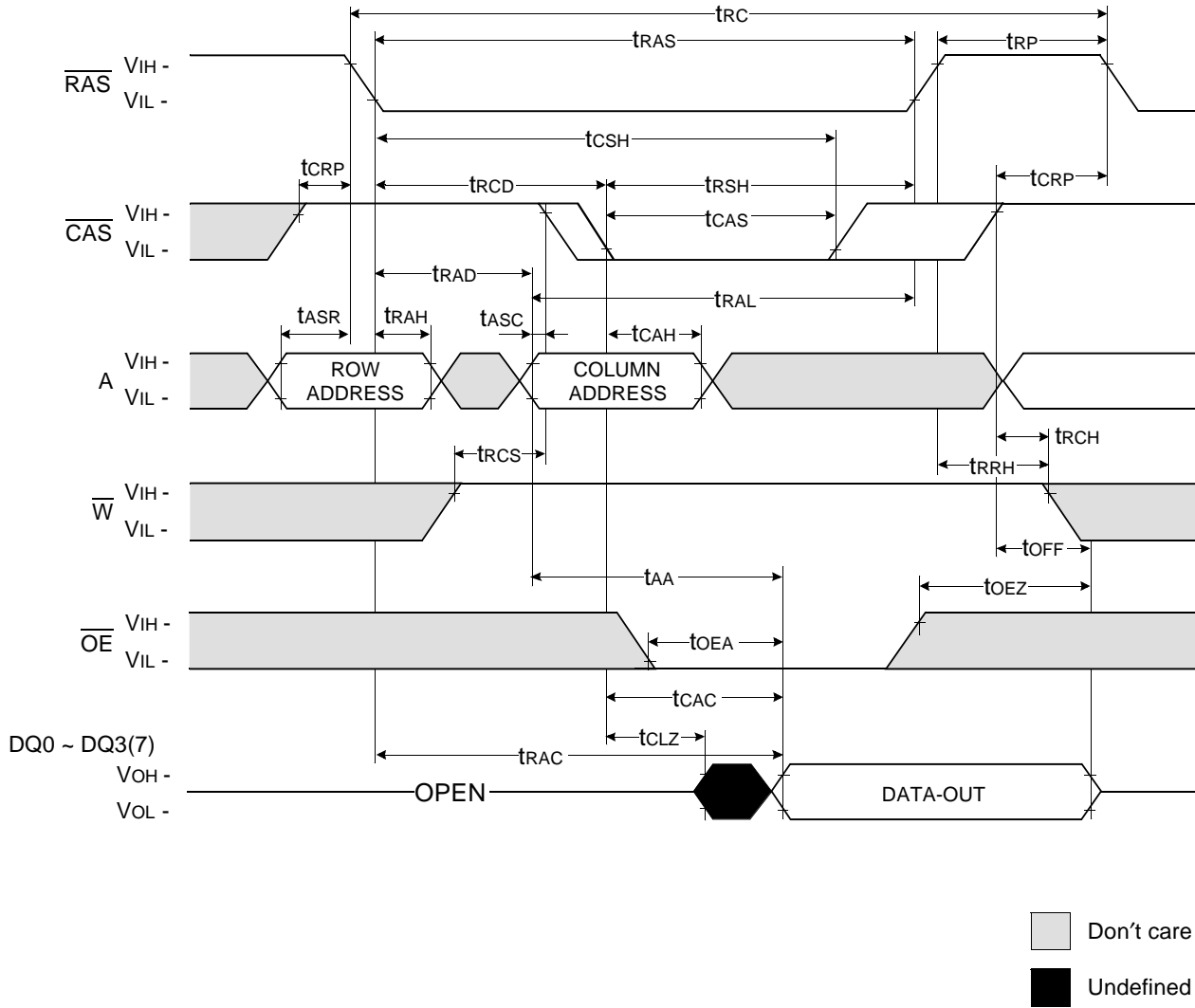
Parameter	Symbol	-50		-60		Units	Notes
		Min	Max	Min	Max		
Random read or write cycle time	tRC	95		115		ns	
Read-modify-write cycle time	tRWC	138		160		ns	
Access time from $\overline{\text{RAS}}$	tRAC		55		65	ns	3,4,10,12
Access time from $\overline{\text{CAS}}$	tCAC		18		20	ns	3,4,5,12
Access time from column address	tAA		30		35	ns	3,10,12
$\overline{\text{RAS}}$ pulse width	tRAS	55	10K	65	10K	ns	
$\overline{\text{CAS}}$ pulse width	tCAS	18	10K	20	10K	ns	
$\overline{\text{RAS}}$ hold time	tRSH	18		20		ns	
$\overline{\text{CAS}}$ hold time	tCSH	55		65		ns	
Column address to $\overline{\text{RAS}}$ lead time	tRAL	30		35		ns	
$\overline{\text{CAS}}$ to $\overline{\text{W}}$ delay time	tCWD	41		45		ns	7
$\overline{\text{RAS}}$ to $\overline{\text{W}}$ delay time	tRWD	78		90		ns	7
Column address to $\overline{\text{W}}$ delay time	tAWD	53		60		ns	7
$\overline{\text{CAS}}$ precharge to $\overline{\text{W}}$ delay time	tCPWD	58		65		ns	
Fast Page cycle time	tPC	40		45		ns	
Fast Page read-modify-write cycle time	tPRWC	81		90		ns	
$\overline{\text{RAS}}$ pulse width (Fast Page cycle)	tRASP	55	200K	65	200K	ns	
Access time from $\overline{\text{CAS}}$ precharge	tCPA		35		40	ns	3
$\overline{\text{OE}}$ access time	tOEA		18		20	ns	
$\overline{\text{OE}}$ to data delay	tOED	18		20		ns	
$\overline{\text{OE}}$ command hold time	tOEH	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  $t_{\text{RCD}}$  is greater than the specified  $t_{\text{RCD}}(\text{max})$  limit, then access time is controlled exclusively by  $t_{\text{CAC}}$ .
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.  $t_{\text{WCS}}$ ,  $t_{\text{RWD}}$ ,  $t_{\text{CWD}}$  and  $t_{\text{AWD}}$  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  $t_{\text{RCH}}$  or  $t_{\text{RRH}}$  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  $t_{\text{RAD}}$  is greater than the specified  $t_{\text{RAD}}(\text{max})$  limit, then access time is controlled by  $t_{\text{AA}}$ .
11. These specifications are applied in the test mode.
12. In test mode read cycle, the value of  $t_{\text{RAC}}$ ,  $t_{\text{AA}}$ ,  $t_{\text{CAC}}$  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  $t_{\text{RPS}}$  instead of  $t_{\text{RP}}$ .
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.

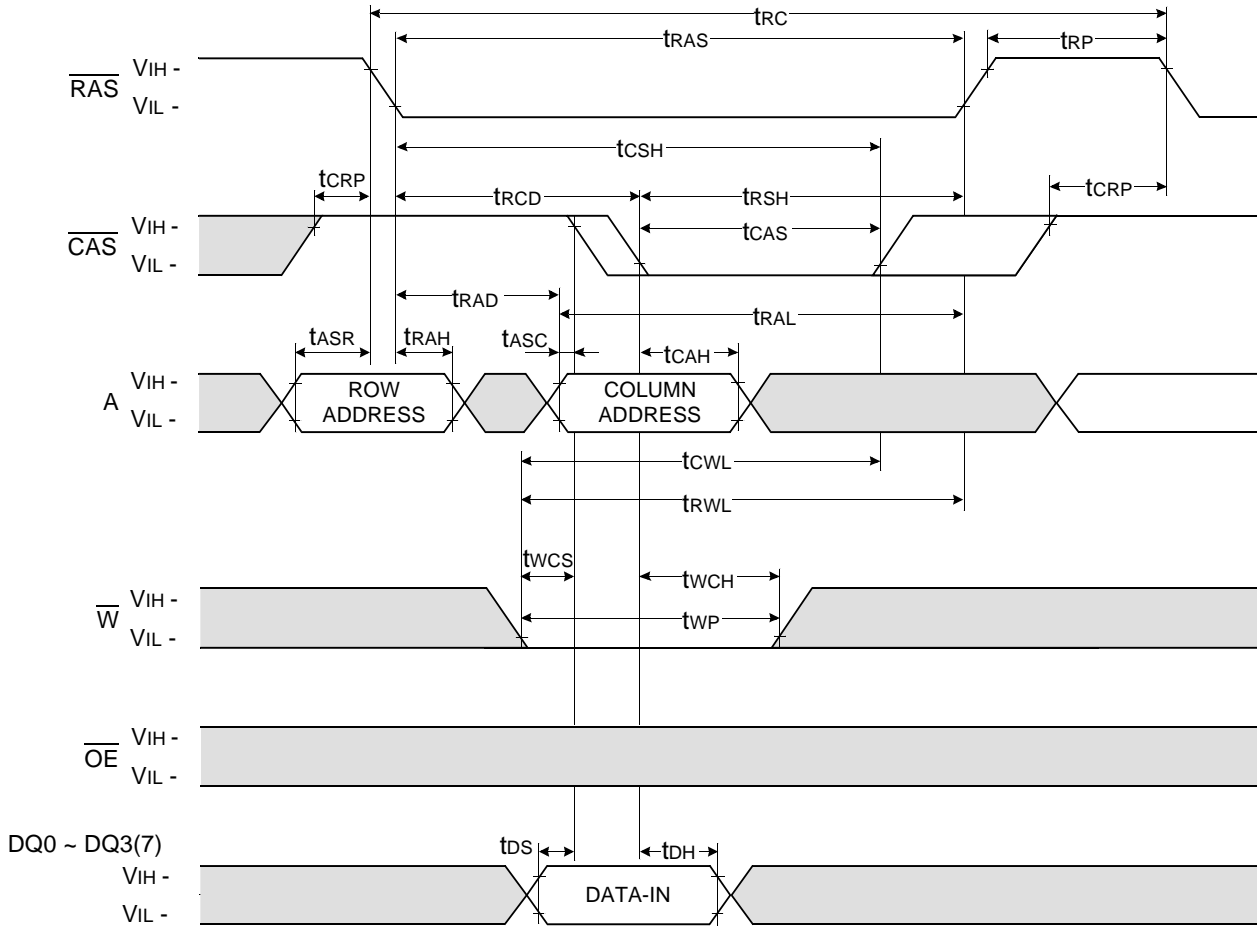


READ CYCLE



WRITE CYCLE ( EARLY WRITE )

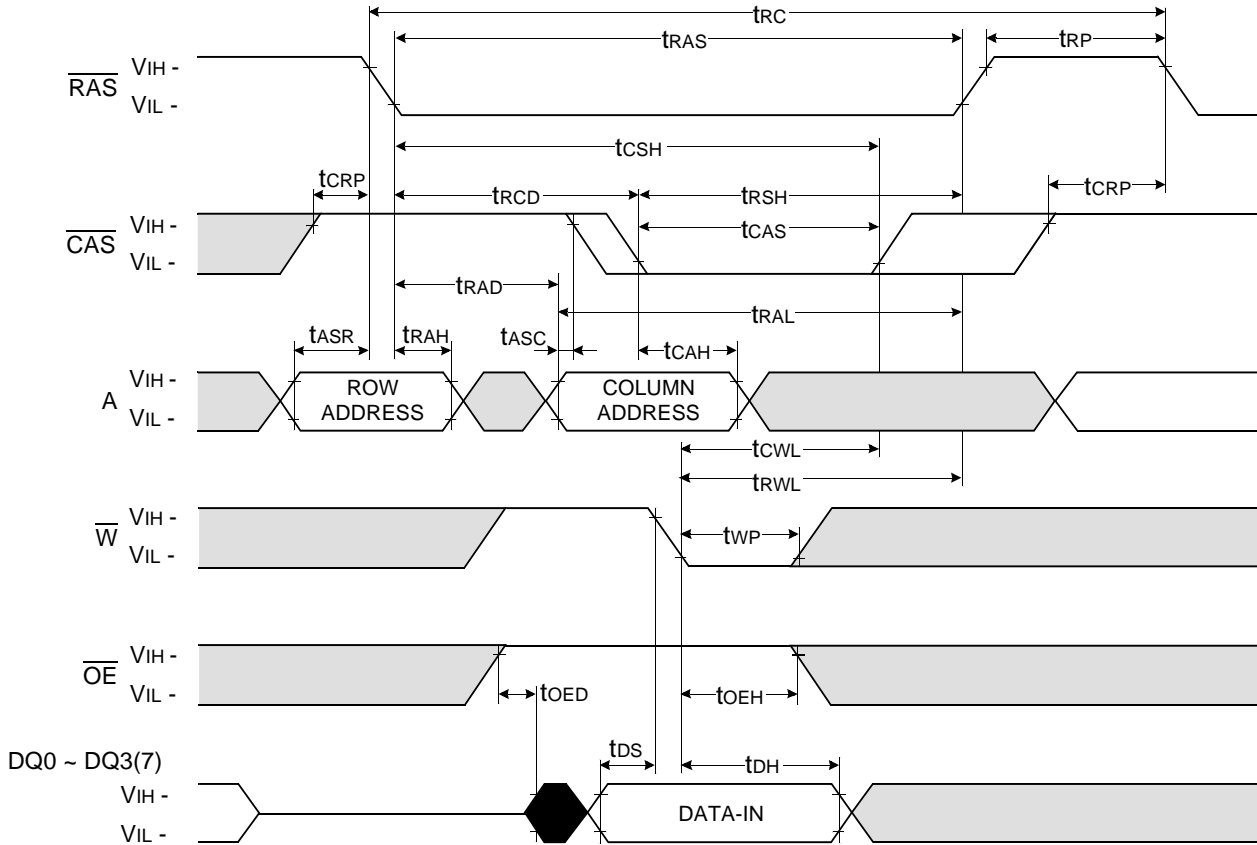
NOTE : DOUT = OPEN



□ Don't care  
 ■ Undefined

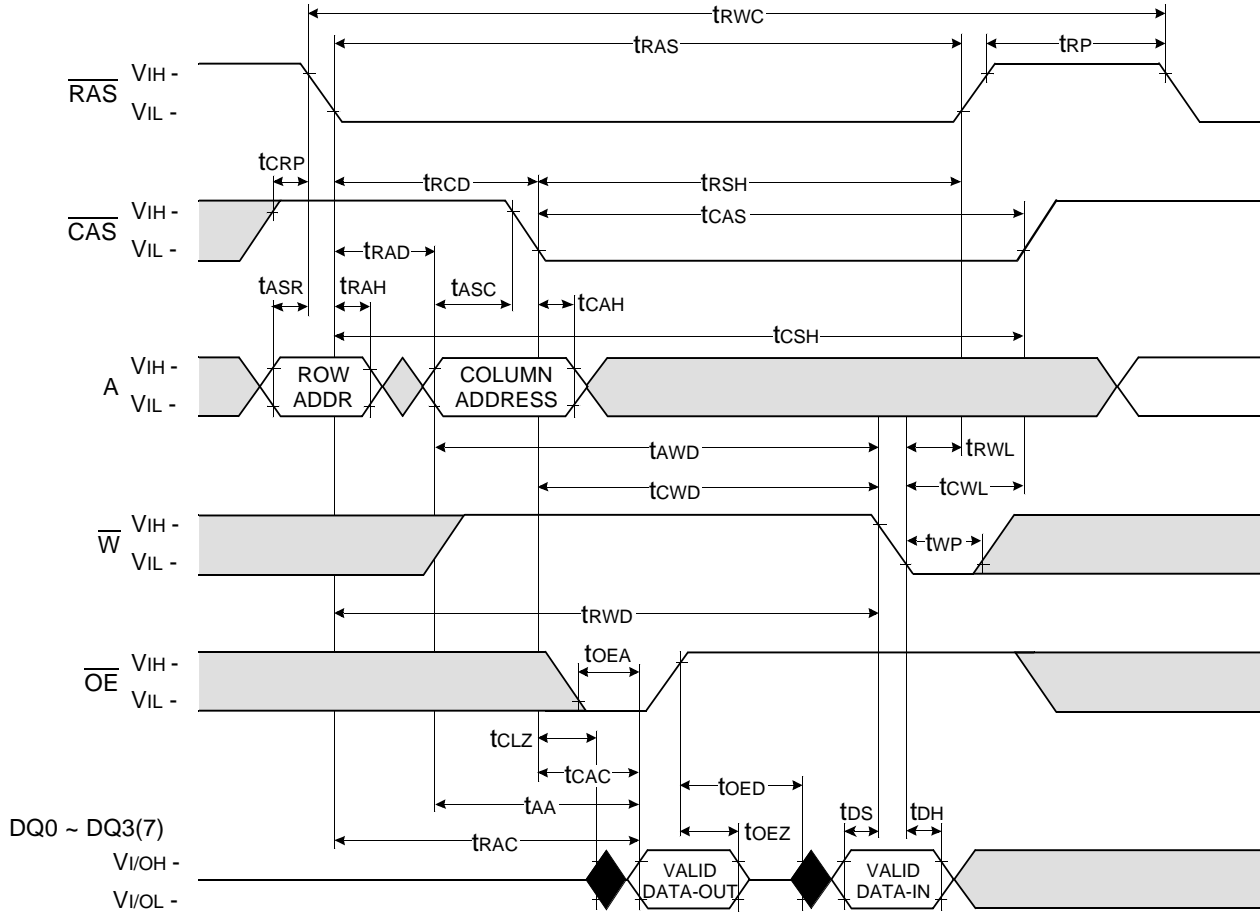
WRITE CYCLE (  $\overline{\text{OE}}$  CONTROLLED WRITE )

NOTE : DOUT = OPEN



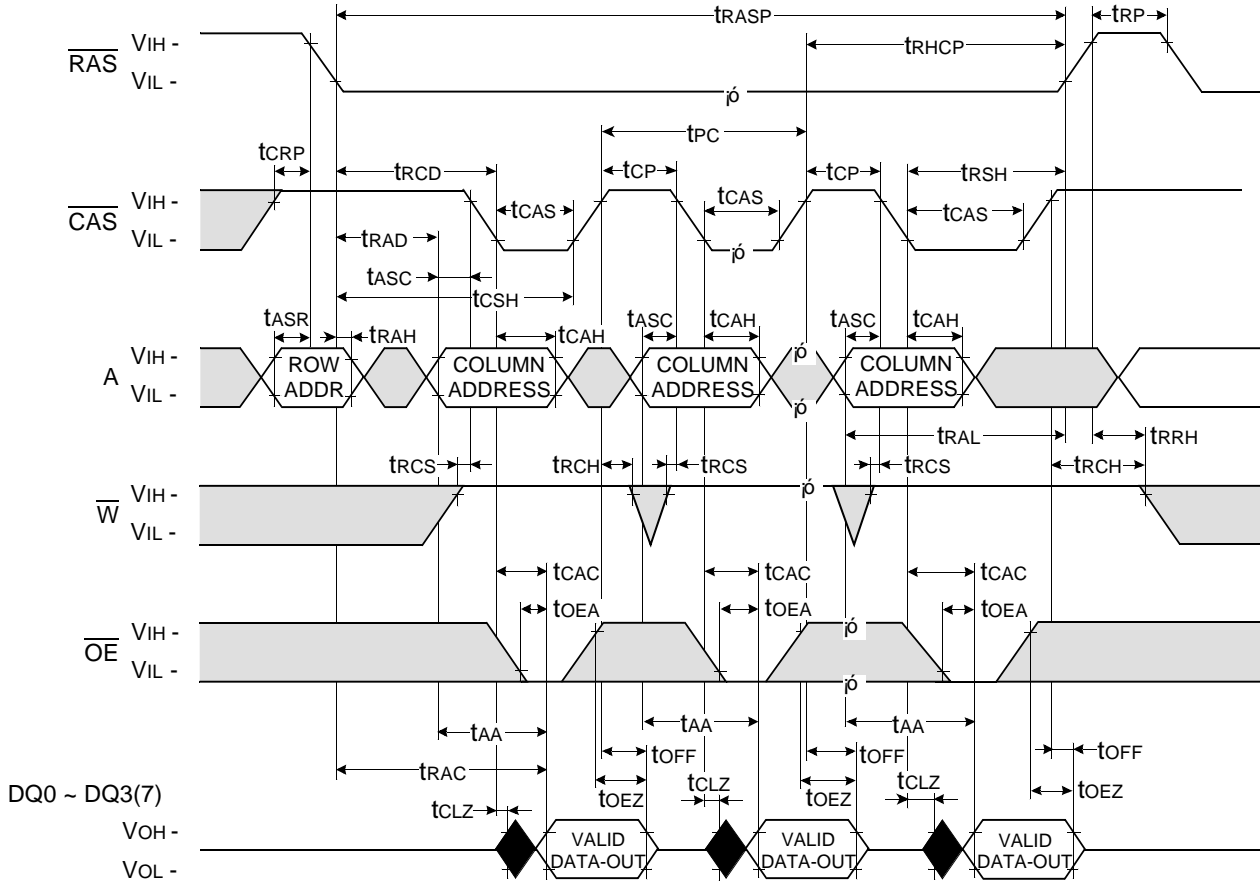
□ Don't care  
 ■ Undefined

READ - MODIFY - WRITE CYCLE



□ Don't care  
 ■ Undefined

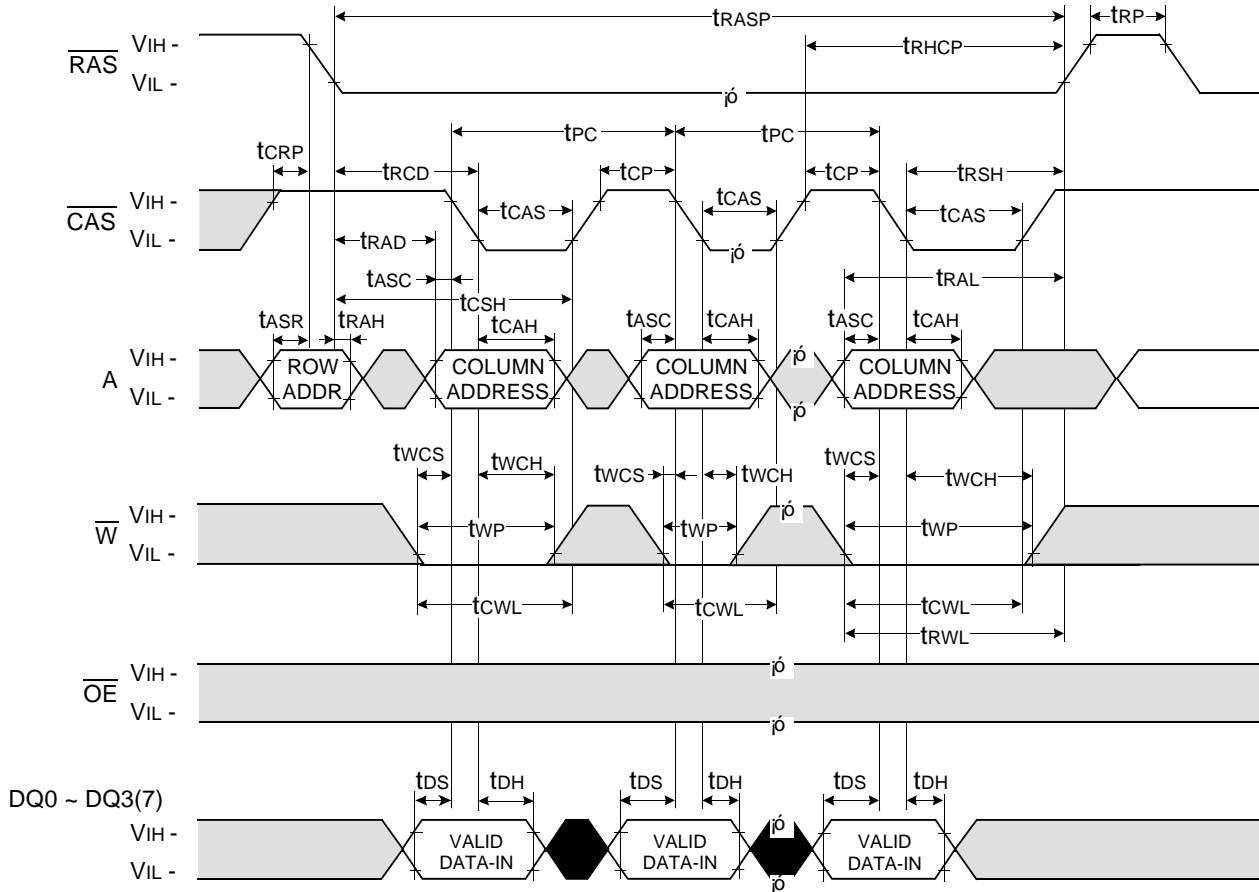
FAST PAGE READ CYCLE



□ Don't care  
 ■ Undefined

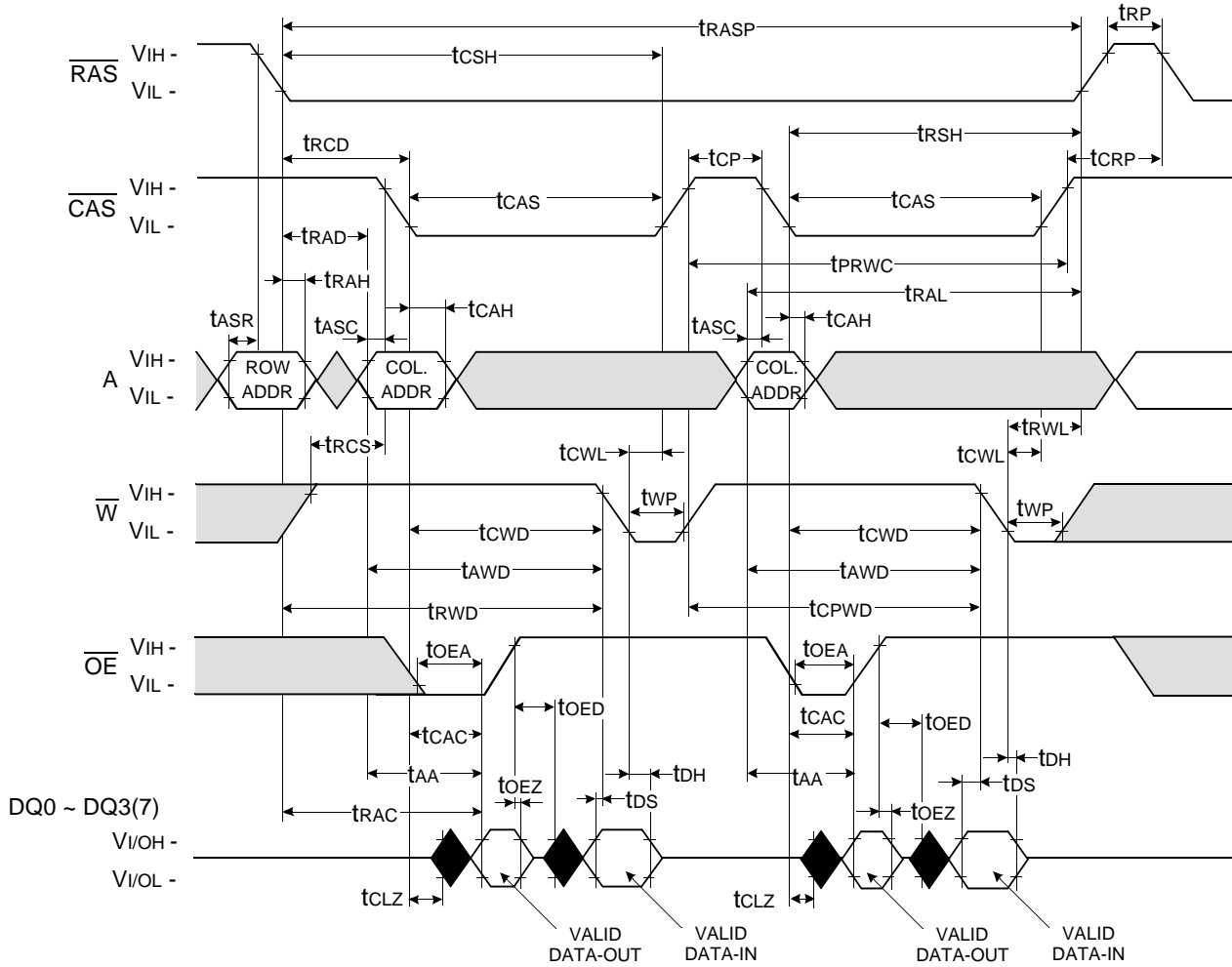
**FAST PAGE WRITE CYCLE ( EARLY WRITE )**

NOTE : DOUT = OPEN



□ Don't care  
 ■ Undefined

FAST PAGE READ - MODIFY - WRITE CYCLE

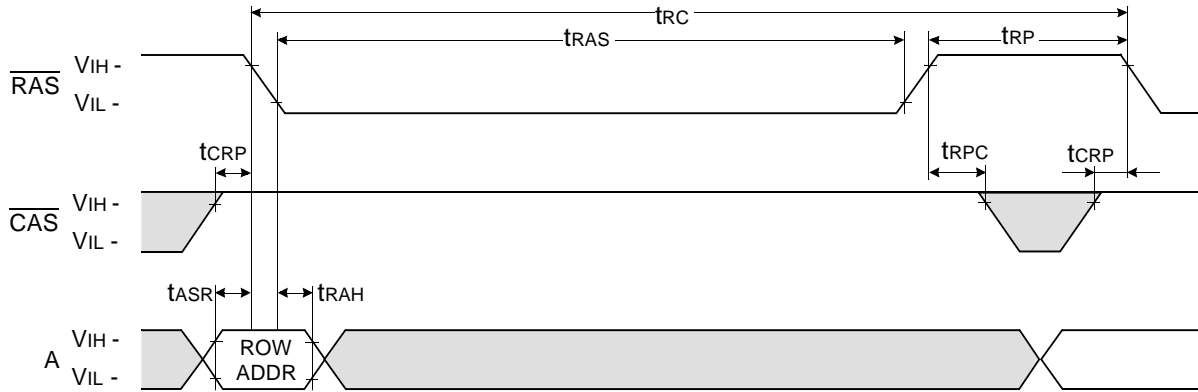


□ Don't care  
■ Undefined

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

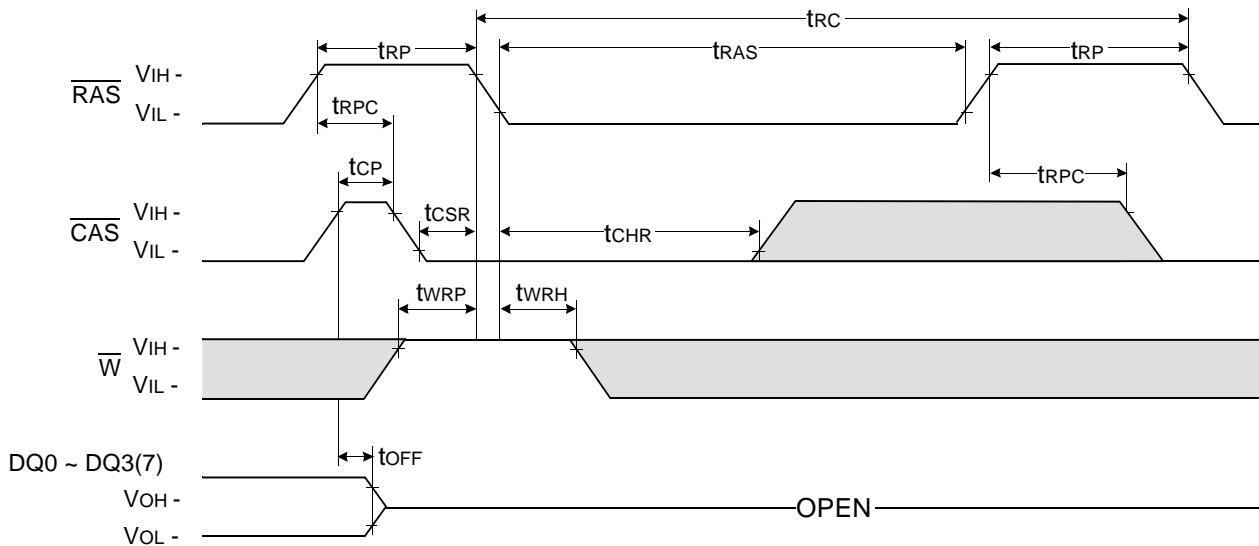
NOTE :  $\overline{\text{W}}$ ,  $\overline{\text{OE}}$ , DIN = Don't care

DOUT = OPEN



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

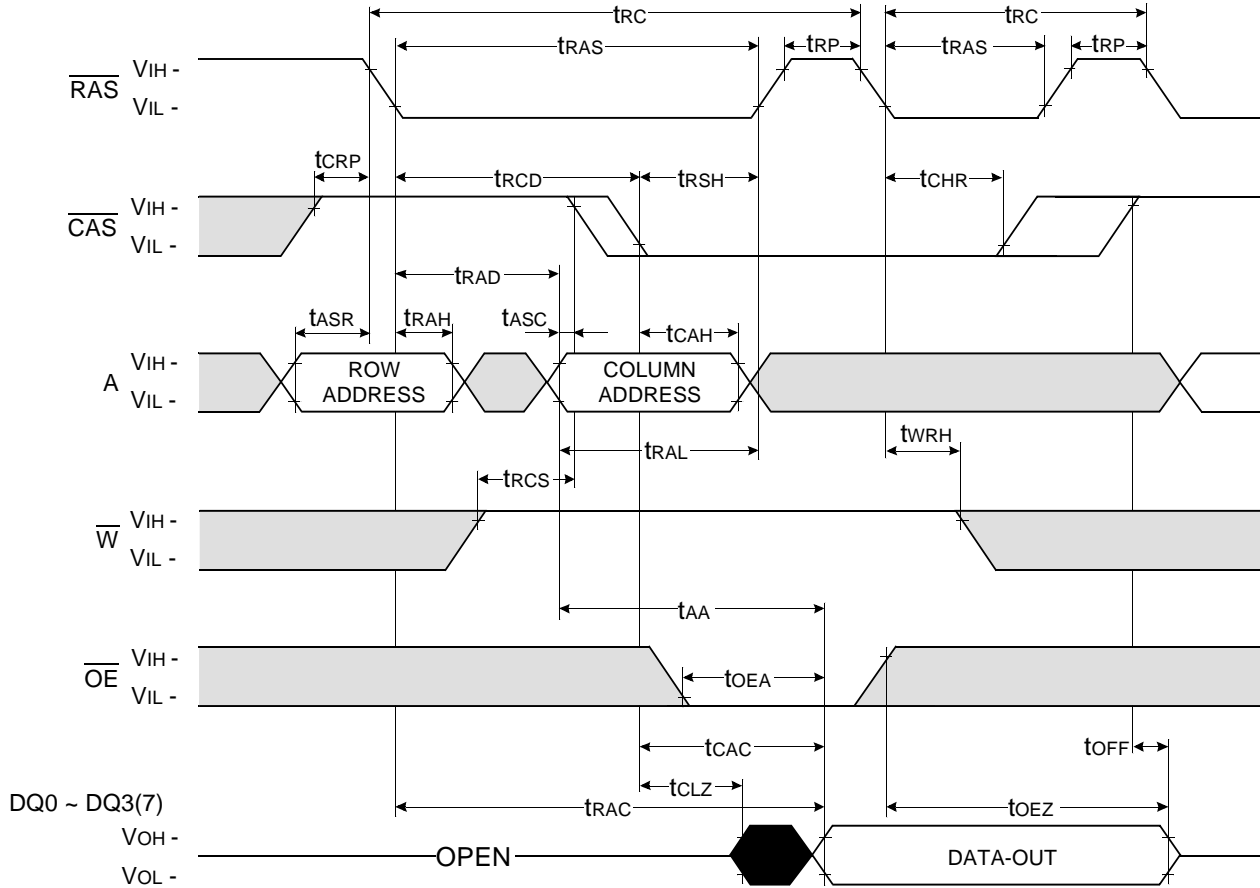
NOTE :  $\overline{\text{OE}}$ , A = Don't care



□ Don't care  
 ■ Undefined



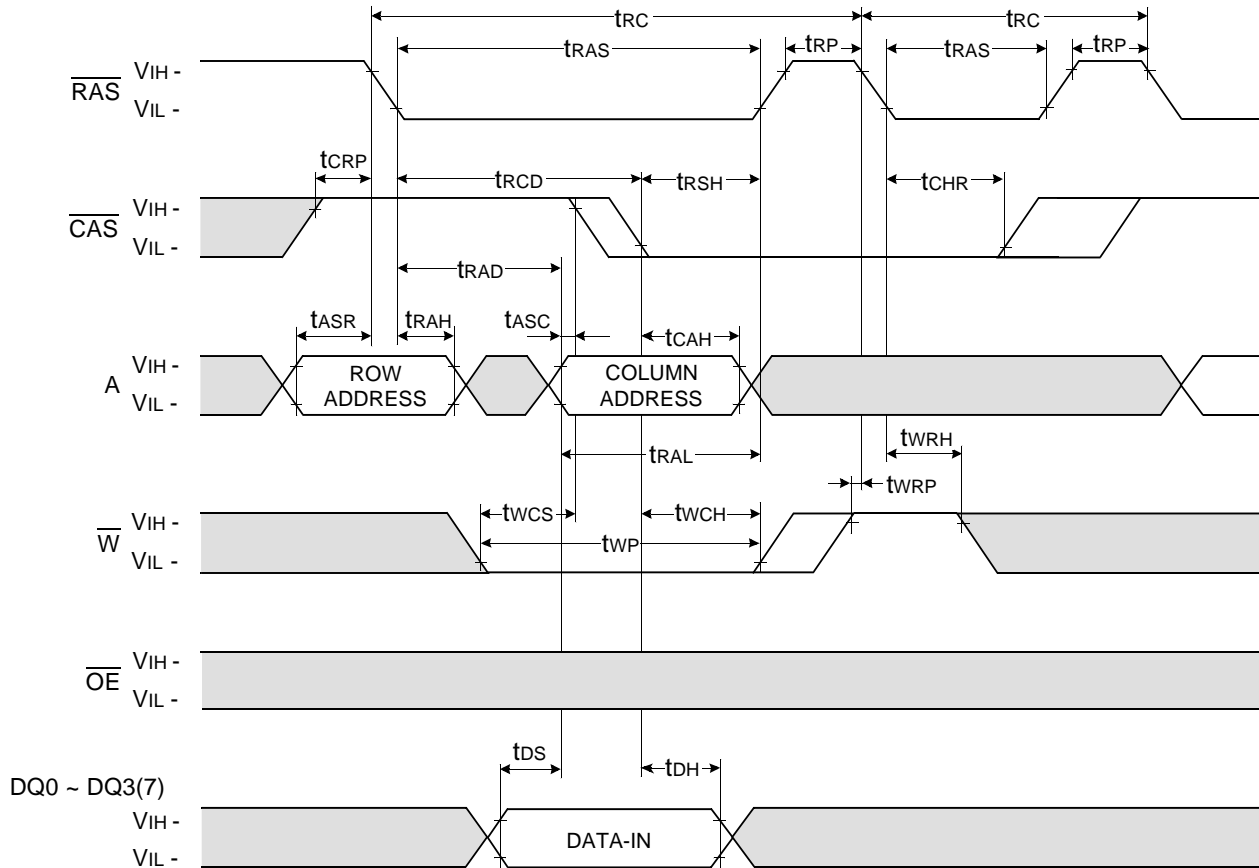
HIDDEN REFRESH CYCLE ( READ )



□ Don't care  
 ■ Undefined

**HIDDEN REFRESH CYCLE ( WRITE )**

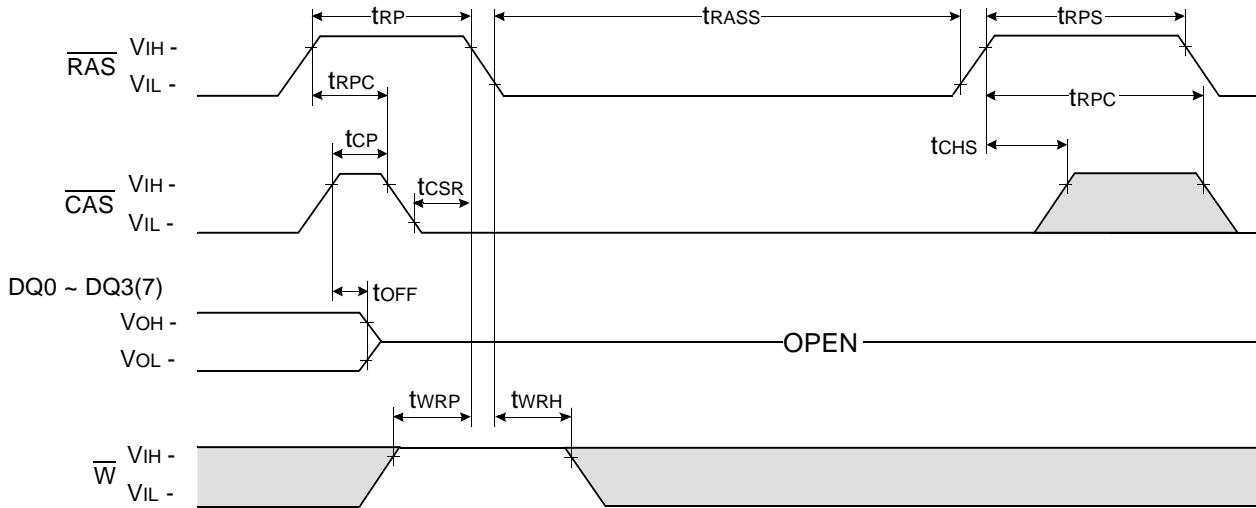
NOTE : DOUT = OPEN



□ Don't care  
 ■ Undefined

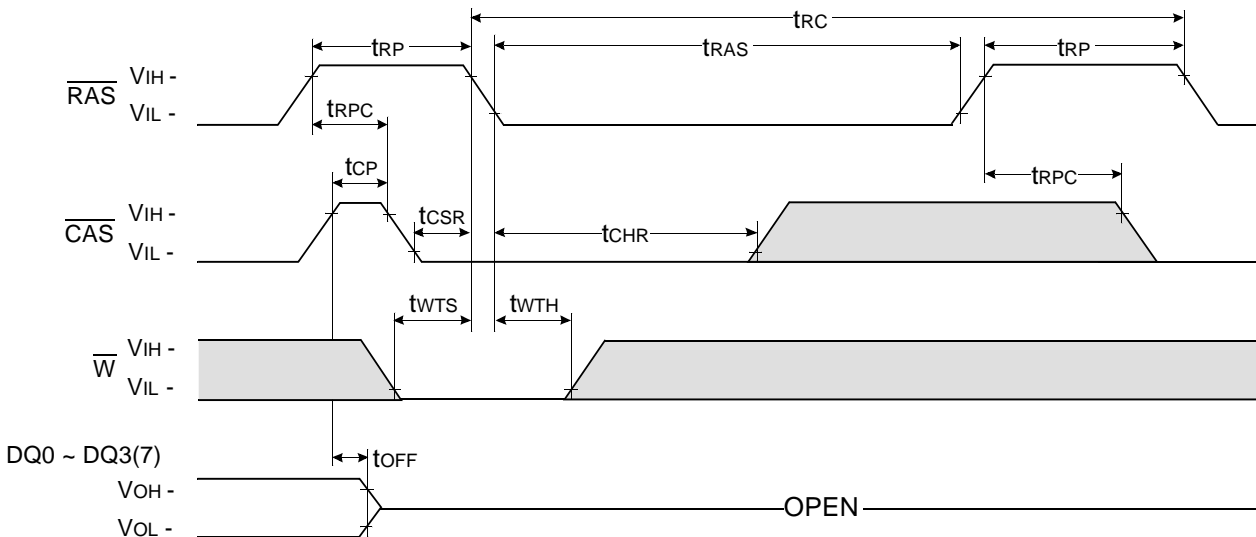
**$\overline{\text{CAS}}$  - BEFORE -  $\overline{\text{RAS}}$  SELF REFRESH CYCLE**

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

