DRAM

MT4LC4M4B1, MT4C4M4B1
MT4LC4M4A1, MT4C4M4A1

FEATURES

- Industry-standard x4 pinout, timing, functions and packages
- State-of-the-art, high-performance, low power CMOS silicon-gate process
- Single power supply (+3.3V ±0.3V or +5V ±10%)
- All inputs, outputs and clocks are TTL-compatible
- Refresh modes: RAS#-ONLY, HIDDEN, and CAS#-BEFORE-RAS# (CBR)
- Optional Self Refresh (S) for low power data retention
- 11 row, 11 column addresses (2K refresh) or 12 row, 10 column addresses (4K refresh)
- FAST-PAGE-MODE (FPM) PAGE access cycle
- 5V tolerant inputs and I/Os on 3.3V devices

OPTIONS — MARKING

- Voltage
  - 3.3V — LC
  - 5V — C
- Refresh Addressing
  - 2,048 (i.e. 2K) rows — B1
  - 4,096 (i.e. 4K) rows — A1
- Packages
  - Plastic SOJ (300 mil) — DJ
  - Plastic TSOP (300 mil) — TG
- Timing
  - 60ns access — -6
- Refresh Rate
  - Standard Refresh — None
  - Self Refresh (128ms period) — S
- Part Number Example: MT4LC4M4B1DJ-6

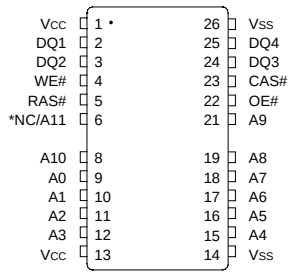
Note: The 4 Meg x 4 FPM DRAM base number differentiates the offerings in two places - MT4LC4M4B1*. The third field distinguishes the low voltage offering: LC designates Vcc = 3.3V and C designates Vcc = 5V. The fifth field distinguishes various options: B1 designates a 2K refresh and an A1 designates a 4K refresh for FPM DRAMs.*

KEY TIMING PARAMETERS

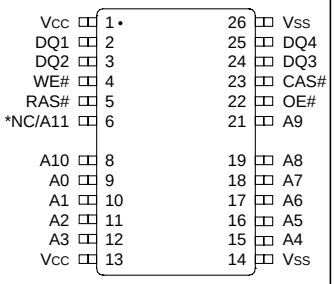
SPEED	^tRC	^tRAC	^tPC	^tAA	^tCAC	^tRP
-6	110ns	60ns	35ns	30ns	15ns	40ns

PIN ASSIGNMENT (Top View)

24/26-Pin SOJ (DA-2)



24/26-Pin TSOP (DB-2)



Note: NC on 2K refresh and A11 on 4K refresh options. The # symbol indicates signal is active LOW.

4 MEG x 4 FPM DRAM PART NUMBERS

PART NUMBER	Vcc	REFRESH	PACKAGE	REFRESH
MT4LC4M4B1DJ	3.3V	2K	SOJ	Standard
MT4LC4M4B1DJS	3.3V	2K	SOJ	Self
MT4LC4M4B1TG	3.3V	2K	TSOP	Standard
MT4LC4M4B1TGS	3.3V	2K	TSOP	Self
MT4LC4M4A1DJ	3.3V	4K	SOJ	Standard
MT4LC4M4A1DJS	3.3V	4K	SOJ	Self
MT4LC4M4A1TG	3.3V	4K	TSOP	Standard
MT4LC4M4A1TGS	3.3V	4K	TSOP	Self
MT4C4M4B1DJ	5V	2K	SOJ	Standard
MT4C4M4B1DJS	5V	2K	SOJ	Self
MT4C4M4B1TG	5V	2K	TSOP	Standard
MT4C4M4B1TGS	5V	2K	TSOP	Self
MT4C4M4A1DJ	5V	4K	SOJ	Standard
MT4C4M4A1DJS	5V	4K	SOJ	Self
MT4C4M4A1TG	5V	4K	TSOP	Standard
MT4C4M4A1TGS	5V	4K	TSOP	Self

GENERAL DESCRIPTION

The 4 Meg x 4 DRAM is a randomly accessed, solid-state memory containing 16,777,216 bits organized in a x4 configuration. RAS# is used to latch the row address (first 11 bits for 2K and first 12 bits for 4K). Once the page has been opened by RAS#, CAS# is used to latch the column address (the latter 11 bits for 2K and later 10 bits for 4K, address pins A10 and A11 are "don't care"). READ and WRITE cycles are selected with the WE# input. A logic HIGH on WE# dictates READ mode while a logic LOW on WE# dictates WRITE mode. During a WRITE cycle, data-in (D) is latched by the falling edge of WE# or CAS#, whichever occurs last. If WE# goes LOW prior to CAS# going LOW, the output pins remain open (High- Z) until the next CAS# cycle, regardless of OE#.

A logic HIGH on WE# dictates READ mode while a logic LOW on WE# dictates WRITE mode. During a WRITE cycle, data-in (D) is latched by the falling edge of WE# or CAS#, whichever occurs last. An EARLY WRITE occurs when WE# is taken LOW prior to CAS# falling. A LATE WRITE or READ-MODIFY-WRITE occurs when WE# falls after CAS# was taken LOW. During EARLY WRITE cycles, the data outputs (Q) will remain High-Z regardless of the state of OE#. During LATE WRITE or READ-MODIFY-WRITE cycles, OE# must be taken HIGH to disable the data outputs prior to applying input data. If a LATE WRITE or READ-MODIFY-WRITE is attempted while keeping OE# LOW, no write will occur, and the data outputs will drive read data from the accessed location.

The four data inputs and the four data outputs are routed through four pins using common I/O, and pin direction is controlled by WE# and OE#.

PAGE ACCESS

PAGE operations allow faster data operations (READ, WRITE or READ-MODIFY-WRITE) within a row-address-defined page boundary. The PAGE cycle is always initiated with a row address strobed-in by RAS# followed by a column address strobed-in by CAS#. CAS# may be toggled-in by holding RAS# LOW and strobing-in different column addresses, thus executing faster memory cycles. Returning RAS# HIGH terminates the PAGE MODE of operation, i.e. closes the page.

REFRESH

Preserve correct memory cell data by maintaining power and executing any RAS# cycle (READ, WRITE) or RAS# refresh cycle (RAS#-ONLY, CBR, or HIDDEN) so that all combinations of RAS# addresses (2,048 for 2K and 4,096 for 4K) are executed within ^{t}REF (MAX), regardless of sequence. The CBR and SELF REFRESH cycles will invoke the internal refresh counter for automatic RAS# addressing.

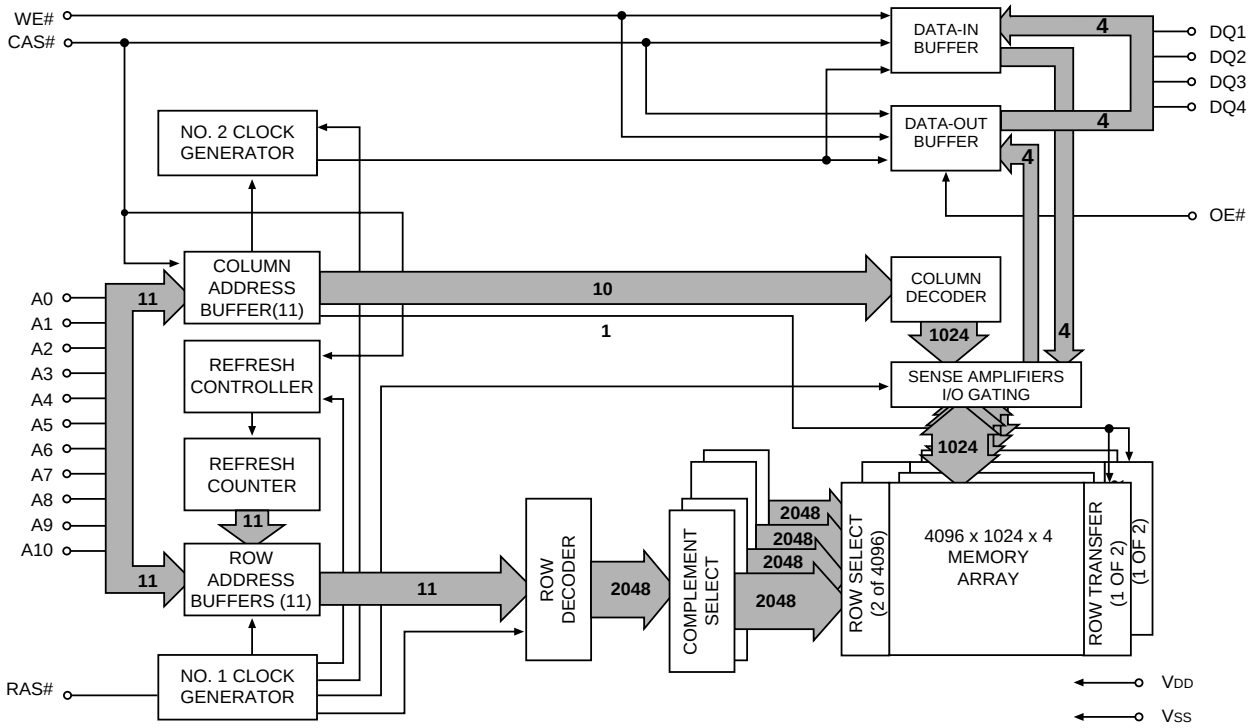
An optional SELF REFRESH mode is also available the S version. The "S" option allows the user the choice of a fully static low-power data retention mode, or a dynamic refresh mode at the extended refresh period of 128ms. The optional SELF REFRESH feature is initiated by performing a CBR REFRESH cycle and holding RAS# LOW for the specified ^{t}RASS. Additionally, the "S" option allows for an extended refresh period of 128ms, or 31.25µs per row for a 4K refresh and 62.5µs per row for a 2K refresh if using distributed CBR REFRESH. This refresh rate can be applied during normal operation, as well as during a standby or BATTERY BACKUP mode.

The SELF REFRESH mode is terminated by driving RAS# HIGH for a minimum time of ^{t}RPS. This delay allows for the completion of any internal refresh cycles that may be in process at the time of the RAS# LOW-to-HIGH transition. If the DRAM controller uses a distributed refresh sequence, a burst refresh is not required upon exiting SELF REFRESH. However, if the DRAM controller utilizes RAS#-ONLY or burst refresh sequence, all rows must be refreshed within the average internal refresh rate prior to the resumption of normal operation.

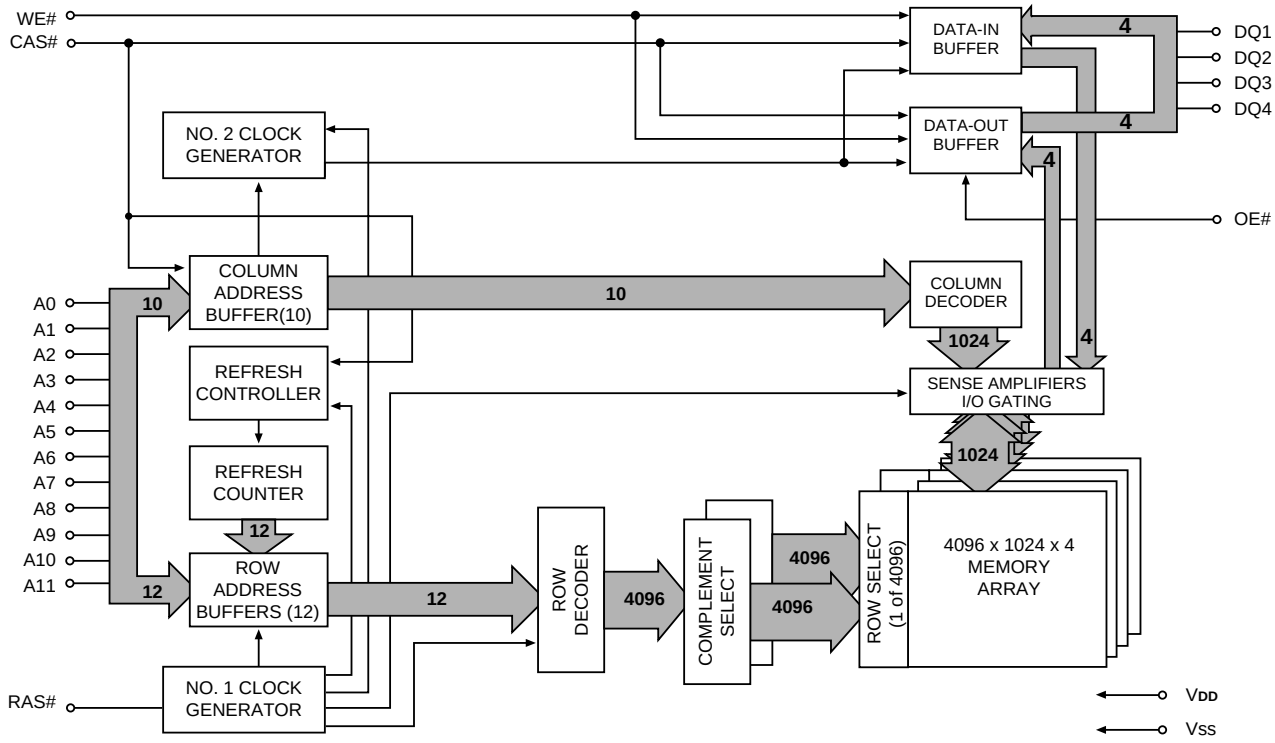
STANDBY

Returning RAS# and CAS# HIGH terminates a memory cycle and decreases chip current to a reduced standby level. The chip is preconditioned for the next cycle during the RAS# HIGH time.

FUNCTIONAL BLOCK DIAGRAM - 2K REFRESH



FUNCTIONAL BLOCK DIAGRAM - 4K REFRESH



TRUTH TABLE

FUNCTION		RAS#	CAS#	WE#	OE#	ADDRESSES		DATA-IN/OUT
						^tR	^tC	DQ1-DQ4
Standby		H	H→X	X	X	X	X	High-Z
READ		L	L	H	L	ROW	COL	Data-Out
EARLY WRITE		L	L	L	X	ROW	COL	Data-In
READ WRITE		L	L	H→L	L→H	ROW	COL	Data-Out, Data-In
FAST-PAGE-MODE	1st Cycle	L	H→L	H	L	ROW	COL	Data-Out
READ	2nd Cycle	L	H→L	H	L	n/a	COL	Data-Out
FAST-PAGE-MODE	1st Cycle	L	H→L	L	X	ROW	COL	Data-In
EARLY-WRITE	2nd Cycle	L	H→L	L	X	n/a	COL	Data-In
FAST-PAGE-MODE	1st Cycle	L	H→L	H→L	L→H	ROW	COL	Data-Out, Data-In
READ-WRITE	2nd Cycle	L	H→L	H→L	L→H	n/a	COL	Data-Out, Data-In
RAS#-ONLY REFRESH		L	H	X	X	ROW	n/a	High-Z
HIDDEN	READ	L→H→L	L	H	L	ROW	COL	Data-Out
REFRESH	WRITE	L→H→L	L	L	X	ROW	COL	Data-In
CBR REFRESH		H→L	L	H	X	X	X	High-Z
SELF REFRESH		H→L	L	H	X	X	X	High-Z

ABSOLUTE MAXIMUM RATINGS*

Voltage on V_{CC} pin Relative to V_{SS}:
- 3.3V ..... -1V to +4.6V
- 5V ..... -1V to +7V

Voltage on NC, Inputs or I/O pins Relative to V_{SS}:
- 3.3V ..... -1V to +5.5V
- 5V ..... -1V to +7V

Operating Temperature, T_A (ambient) ..... 0°C to +70°C
Storage Temperature (plastic)..... -55°C to +150°C
Power Dissipation 1W
Short Circuit Output Current 50mA

*Stresses 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.

DC ELECTRICAL CHARACTERISTICS AND OPERATING CONDITIONS

(Notes: 1, 2, 3)

PARAMETER/CONDITION	SYMBOL	3.3V		5V		UNITS	NOTES
		MIN	MAX	MIN	MAX		
Supply Voltage	V_{CC}	3.0	3.6	4.5	5.5	V	
Input High Voltage: Valid Logic 1; all inputs, I/Os and any NC	V_{IH}	2.0	5.5	2.4	V_{CC} +1	V	
Input Low Voltage: Valid Logic 0; all inputs, I/Os and any NC	V_{IL}	-1.0	0.8	-1.0	0.8	V	
Input Leakage Current: Any input at V_{IN} ($0V \le V_{IN} \le V_{IH_{MAX}}$); all other pins not under test = 0V	I_I	-2	2	-2	2	µA	4
Output High Voltage: I_{OUT} = -2mA (3.3V), -5mA (5V)	V_{OH}	2.4	-	2.4	-	V	
Output Low Voltage: I_{OUT} = 2mA (3.3V), 4.2mA (5V)	V_{OL}	-	0.4	-	0.4	V	
Output Leakage Current: Any output at V_{OUT} ($0V \le V_{OUT} \le 5.5V$); DQ is disabled and in High-Z state	I_{OZ}	-5	5	-5	5	µA	

I_{CC} OPERATING CONDITIONS AND MAXIMUM LIMITS

(Notes: 1, 2, 3) ($V_{CC_{MIN}} \le V_{CC} \le V_{CC_{MAX}}$)

PARAMETER/CONDITION	SYM	SPEED	3.3V 2K Refresh	3.3V 4K Refresh	5V 2K Refresh	5V 4K Refresh	UNITS	NOTES
STANDBY CURRENT: TTL (RAS# = CAS# = V_{IH})	I_{CC1}	-6	1	1	2	2	mA	
STANDBY CURRENT: CMOS (non-S version only) (RAS# = CAS# = other inputs = V_{CC} -0.2V)	I_{CC2}	-6	500	500	500	500	µA	
STANDBY CURRENT: CMOS (S version only) (RAS# = CAS# = other inputs = V_{CC} -0.2V)	I_{CC2}	-6	150	150	150	150	µA	
OPERATING CURRENT: Random READ/WRITE Average power supply current (RAS#, CAS#, address cycling: $^tRC = ^tRC$ [MIN])	I_{CC3}	-6	100	80	130	110	mA	5, 6
OPERATING CURRENT: FPM PAGE MODE Average power supply current (RAS# = V_{IL}, CAS#, address cycling: $^tPC = ^tPC$ [MIN])	I_{CC4}	-6	80	70	100	90	mA	5, 6
REFRESH CURRENT: RAS#-ONLY Average power supply current (RAS# cycling, CAS# = V_{IH}: $^tRC = ^tRC$ [MIN])	I_{CC5}	-6	100	80	130	110	mA	5, 6
REFRESH CURRENT: CBR Average power supply current (RAS#, CAS#, address cycling: $^tRC = ^tRC$ [MIN])	I_{CC6}	-6	100	80	130	110	mA	5, 7
REFRESH CURRENT: Extended (S version only) Average power supply current: CAS# = 0.2V or CBR cycling; RAS# = ^tRAS (MIN); WE# = V_{CC} -0.2V; A0-A11, OE# and D_{IN} = V_{CC} -0.2V or 0.2V (D_{IN} may be left open)	I_{CC7}	-6	300	300	300	300	µA	5, 7
		^tRC	62.5	31.25	62.5	31.25	µs	23
REFRESH CURRENT: Self (S version only) Average power supply current: CBR with RAS# ≥ ^tRASS (MIN) and CAS# held LOW; WE# = V_{CC} -0.2V; A0-A11, OE# and D_{IN} = V_{CC} -0.2V or 0.2V (D_{IN} may be left open)	I_{CC8}	-6	300	300	300	300	µA	5, 7

CAPACITANCE

PARAMETER	SYMBOL	MAX	UNITS	NOTES
Input Capacitance: Address pins	C_{I1}	5	pF	2
Input Capacitance: RAS#, CAS#, WE#, OE#	C_{I2}	7	pF	2
Input/Output Capacitance: DQ	C_{IO}	7	pF	2

AC ELECTRICAL CHARACTERISTICS

(Notes: 5, 6, 7, 8, 9, 10, 11, 12, 20) ($V_{CC_{MIN}} \le V_{CC} \le V_{CC_{MAX}}$)

AC CHARACTERISTICS		-6			
PARAMETER	SYM	MIN	MAX	UNITS	NOTES
Access time from column address	^tAA		30	ns	
Column-address hold time (referenced to RAS#)	^tAR	45		ns	
Column-address setup time	^tASC	0		ns	
Row-address setup time	^tASR	0		ns	
Column-address to WE# delay time	^tAWD	55		ns	18
Access time from CAS#	^tCAC		15	ns	
Column-address hold time	^tCAH	10		ns	
CAS# pulse width	^tCAS	15	10,000	ns	
CAS# LOW to “don’t care” during SELF REFRESH	^tCHD	15		ns	
CAS# hold time (CBR REFRESH)	^tCHR	10		ns	4
CAS# to output in Low-Z	^tCLZ	3		ns	22
CAS# precharge time	^tCP	10		ns	13
Access time from CAS# precharge	^tCPA		35	ns	
CAS# to RAS# precharge time	^tCRP	5		ns	
CAS# hold time	^tCSH	60		ns	
CAS# setup time (CBR REFRESH)	^tCSR	5		ns	4
CAS# to WE# delay time	^tCWD	40		ns	18
Write command to CAS# lead time	^tCWL	15		ns	
Data-in hold time	^tDH	10		ns	19
Data-in setup time	^tDS	0		ns	19
Output disable	^tOD	3	15	ns	22
Output enable	^tOE		15	ns	20
OE# hold time from WE# during READ-MODIFY-WRITE cycle	^tOEH	15		ns	
Output buffer turn-off delay	^tOFF	3	15	ns	17, 22
OE# setup prior to RAS# during HIDDEN REFRESH cycle	^tORD	0		ns	
FAST-PAGE-MODE READ or WRITE cycle time	^tPC	35		ns	
FAST-PAGE-MODE READ-WRITE cycle time	^tPRWC	85		ns	
Access time from RAS#	^tRAC		60	ns	
RAS# to column-address delay time	^tRAD	15		ns	15
Row-address hold time	^tRAH	10		ns	
RAS# pulse width	^tRAS	60	10,000	ns	
RAS# pulse width (FAST PAGE MODE)	^tRASP	60	125,000	ns	
RAS# pulse width during SELF REFRESH	^tRASS	100		µs	
Random READ or WRITE cycle time	^tRC	110		ns	
RAS# to CAS# delay time	^tRCD	20		ns	14

AC ELECTRICAL CHARACTERISTICS

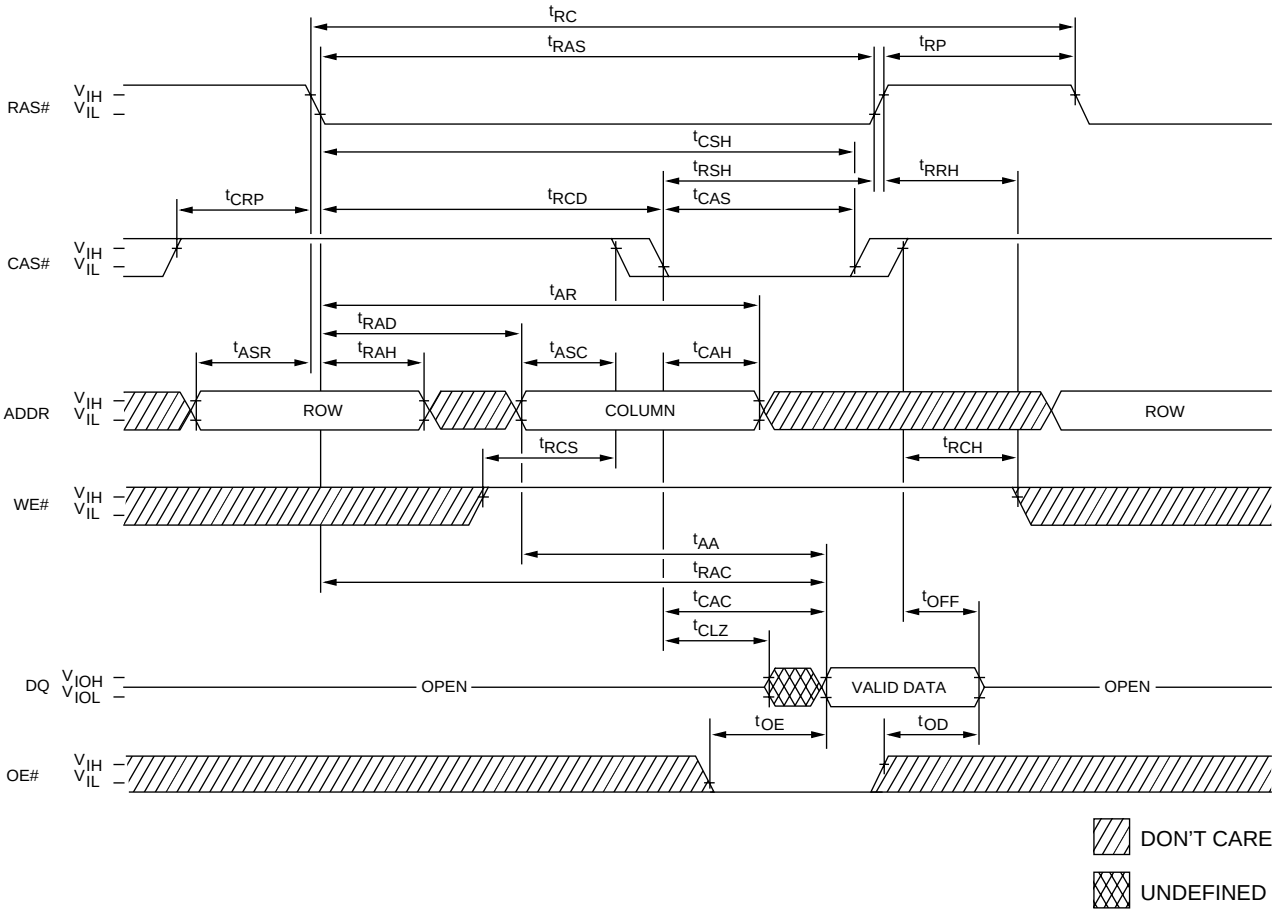
(Notes: 5, 6, 7, 8, 9, 10, 11, 12, 20) ($V_{CC_{MIN}} \leq V_{CC} \leq V_{CC_{MAX}}$)

AC CHARACTERISTICS		-6			
PARAMETER	**SYM**	**MIN**	**MAX**	**UNITS**	**NOTES**
Read command hold time (referenced to CAS#)	^{t}RCH	0		ns	16
Read command setup time	^{t}RCS	0		ns	
Refresh period (2,048 cycles)	^{t}REF		32	ms	
Refresh period (4,096 cycles)	^{t}REF		64	ms	
Refresh period S version	^{t}REF		128	ms	
RAS# precharge time	^{t}RP	40		ns	
RAS# to CAS# precharge time	^{t}RPC	0		ns	
RAS# precharge time exiting SELF REFRESH	^{t}RPS	110		ns	
Read command hold time (referenced to RAS#)	^{t}RRH	0		ns	16
RAS# hold time	^{t}RSH	15		ns	
READ WRITE cycle time	^{t}RWC	155		ns	
RAS# to WE# delay time	^{t}RWD	85		ns	18
Write command to RAS# lead time	^{t}RWL	15		ns	
Transition time (rise or fall)	^{t}T	2	50	ns	
Write command hold time	^{t}WCH	10		ns	
Write command hold time (referenced to RAS#)	^{t}WCR	45		ns	
WE# command setup time	^{t}WCS	0		ns	18
Write command pulse width	^{t}WP	10		ns	
WE# hold time (CBR REFRESH)	^{t}WRH	10		ns	
WE# setup time (CBR REFRESH)	^{t}WRP	10		ns	

NOTES

1. All voltages referenced to V_{SS}.
2. This parameter is sampled. $V_{CC} = V_{CC_{MIN}}$; f = 1 MHz.
3. I_{CC} is dependent on output loading and cycle rates. Specified values are obtained with minimum cycle time and the outputs open.
4. Enables on-chip refresh and address counters.
5. The minimum specifications are used only to indicate cycle time at which proper operation over the full temperature range is ensured.
6. An initial pause of 100µs is required after power-up, followed by eight RAS# refresh cycles (RAS#-ONLY or CBR with WE# HIGH), before proper device operation is ensured. The eight RAS# cycle wake-ups should be repeated any time the ^{t}REF refresh requirement is exceeded.
7. AC characteristics assume ^{t}T = 5ns.
8. V_{IH} (MIN) and V_{IL} (MAX) are reference levels for measuring timing of input signals. Transition times are measured between V_{IH} and V_{IL} (or between V_{IL} and V_{IH}).
9. In addition to meeting the transition rate specification, all input signals must transit between V_{IH} and V_{IL} (or between V_{IL} and V_{IH}) in a monotonic manner.
10. If CAS# = V_{IH}, data output is High-Z.
11. If CAS# = V_{IL}, data output may contain data from the last valid READ cycle.
12. Measured with a load equivalent to two TTL gates, 100pF and V_{OL} = 0.8V and V_{OH} = 2V.
13. If CAS# is LOW at the falling edge of RAS#, Q will be maintained from the previous cycle. To initiate a new cycle and clear the data-out buffer, CAS# must be pulsed HIGH for ^{t}CP.
14. The ^{t}RCD (MAX) limit is no longer specified. ^{t}RCD (MAX) was specified as a reference point only. If ^{t}RCD was greater than the specified ^{t}RCD (MAX) limit, then access time was controlled exclusively by ^{t}CAC (^{t}RAC [MIN] no longer applied). With or without the ^{t}RCD limit, ^{t}AA and ^{t}CAC must always be met.
15. The ^{t}RAD (MAX) limit is no longer specified. ^{t}RAD (MAX) was specified as a reference point only. If ^{t}RAD was greater than the specified ^{t}RAD (MAX) limit, then access time was controlled exclusively by ^{t}AA (^{t}RAC and ^{t}CAC no longer applied). With or without the ^{t}RAD (MAX) limit, ^{t}AA, ^{t}RAC and ^{t}CAC must always be met.
16. Either ^{t}RCH or ^{t}RRH must be satisfied for a READ cycle.
17. ^{t}OFF (MAX) defines the time at which the output achieves the open circuit condition and is not referenced to V_{OH} or V_{OL}.
18. ^{t}WCS, ^{t}RWD, ^{t}AWD and ^{t}CWD are not restrictive operating parameters. ^{t}WCS applies to EARLY WRITE cycles. ^{t}RWD, ^{t}AWD and ^{t}CWD apply to READ-MODIFY-WRITE cycles. If ^{t}WCS ≥ ^{t}WCS (MIN), the cycle is an EARLY WRITE cycle and the data output will remain an open circuit throughout the entire cycle. If ^{t}RWD ≥ ^{t}RWD (MIN), ^{t}AWD ≥ ^{t}AWD (MIN) and ^{t}CWD ≥ ^{t}CWD (MIN), the cycle is a READ-MODIFY-WRITE and the data output will contain data read from the selected cell. If neither of the above conditions is met, the state of data-out is indeterminate. OE# held HIGH and WE# taken LOW after CAS# goes LOW result in a LATE WRITE (OE#-controlled) cycle. ^{t}WCS, ^{t}RWD, ^{t}CWD and ^{t}AWD are not applicable in a LATE WRITE cycle.
19. These parameters are referenced to CAS# leading edge in EARLY WRITE cycles and WE# leading edge in LATE WRITE or READ-MODIFY-WRITE cycles.
20. If OE# is tied permanently LOW, LATE WRITE or READ-MODIFY-WRITE operations are not permissible and should not be attempted.
21. A HIDDEN REFRESH may also be performed after a WRITE cycle. In this case, WE# = LOW and OE# = HIGH.
22. The 3ns minimum is a parameter guaranteed by design.
23. Column address changed once each cycle.

READ CYCLE

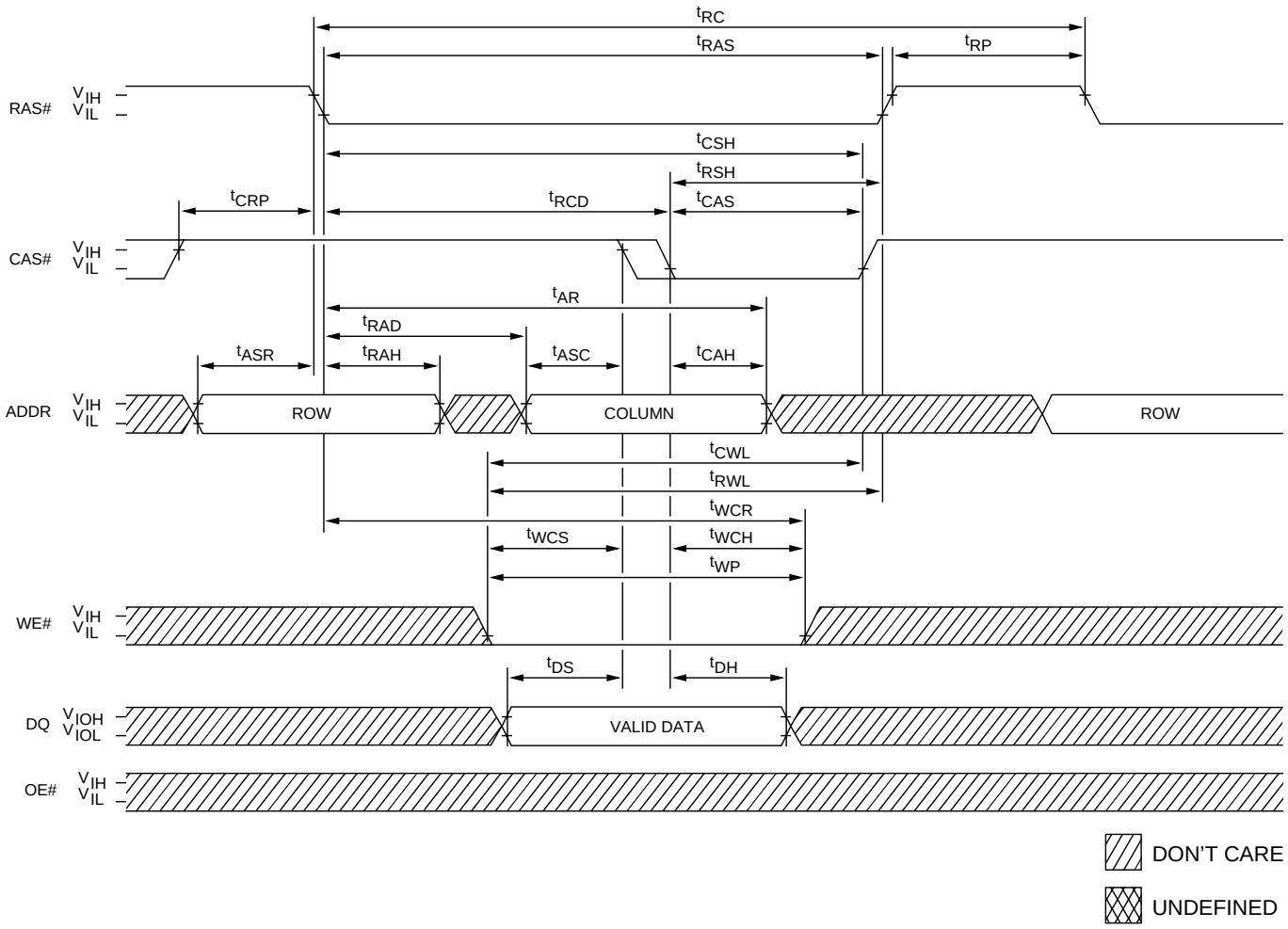


TIMING PARAMETERS

SYMBOL	-6 MIN	-6 MAX	UNITS
tAA		30	ns
tAR	45		ns
tASC	0		ns
tASR	0		ns
tCAC		15	ns
tCAH	10		ns
tCAS	15	10,000	ns
tCLZ	3		ns
tCRP	5		ns
tCSH	60		ns
tOD	3	15	ns
tOE		15	ns

SYMBOL	-6 MIN	-6 MAX	UNITS
tOFF	3	15	ns
tRAC		60	ns
tRAD	15		ns
tRAH	10		ns
tRAS	60	10,000	ns
tRC	110		ns
tRCD	20		ns
tRCH	0		ns
tRCS	0		ns
tRP	40		ns
tRRH	0		ns
tRSH	15		ns

EARLY WRITE CYCLE

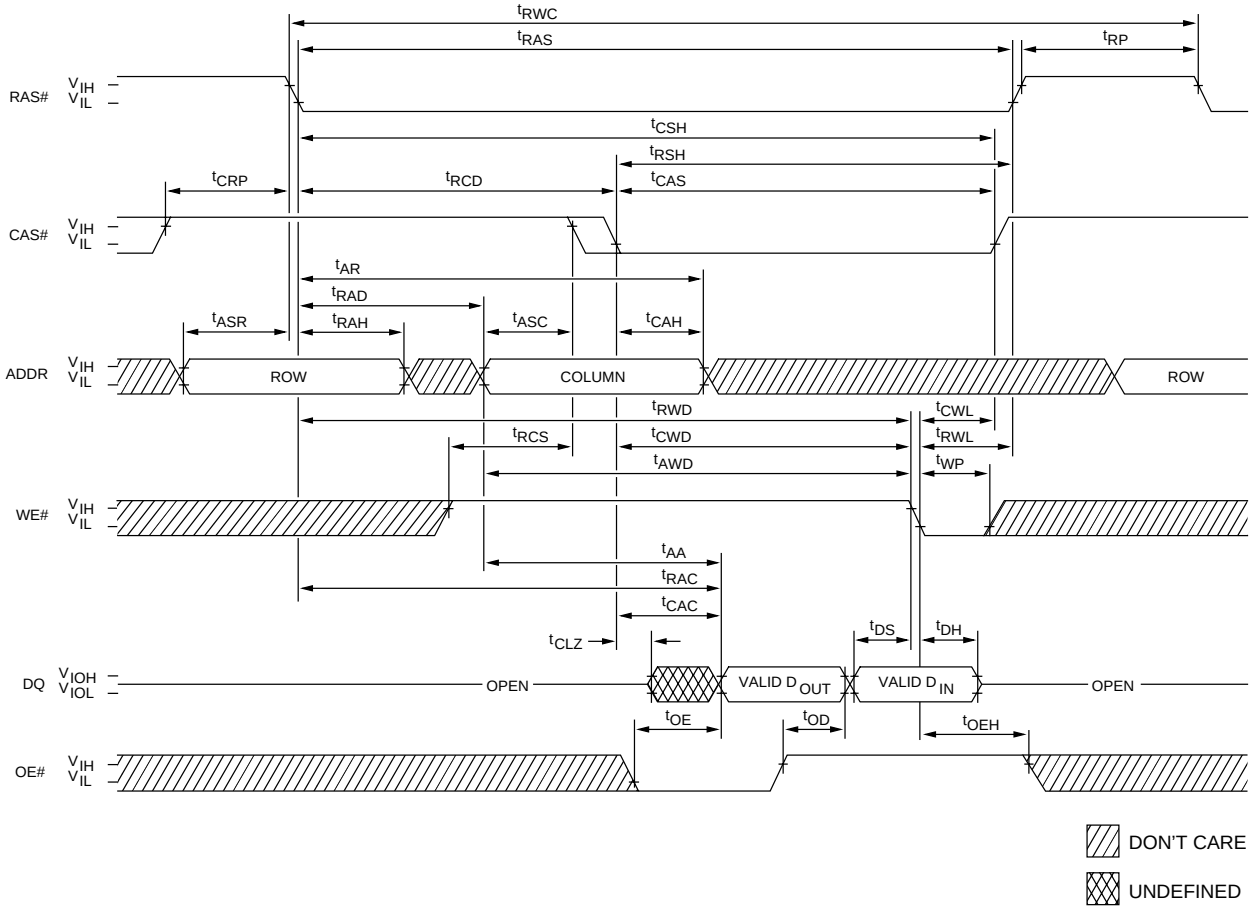


TIMING PARAMETERS

SYMBOL	-6 MIN	-6 MAX	UNITS
tAR	45		ns
tASC	0		ns
tASR	0		ns
tCAH	10		ns
tCAS	15	10,000	ns
tCRP	5		ns
tCSH	60		ns
tCWL	15		ns
tDH	10		ns
tDS	0		ns
tRAD	15		ns

SYMBOL	-6 MIN	-6 MAX	UNITS
tRAH	10		ns
tRAS	60	10,000	ns
tRC	110		ns
tRCD	20		ns
tRP	40		ns
tRSH	15		ns
tRWL	15		ns
tWCH	10		ns
tWCR	45		ns
tWCS	0		ns
tWP	10		ns

READ WRITE CYCLE
(LATE WRITE and READ-MODIFY-WRITE cycles)

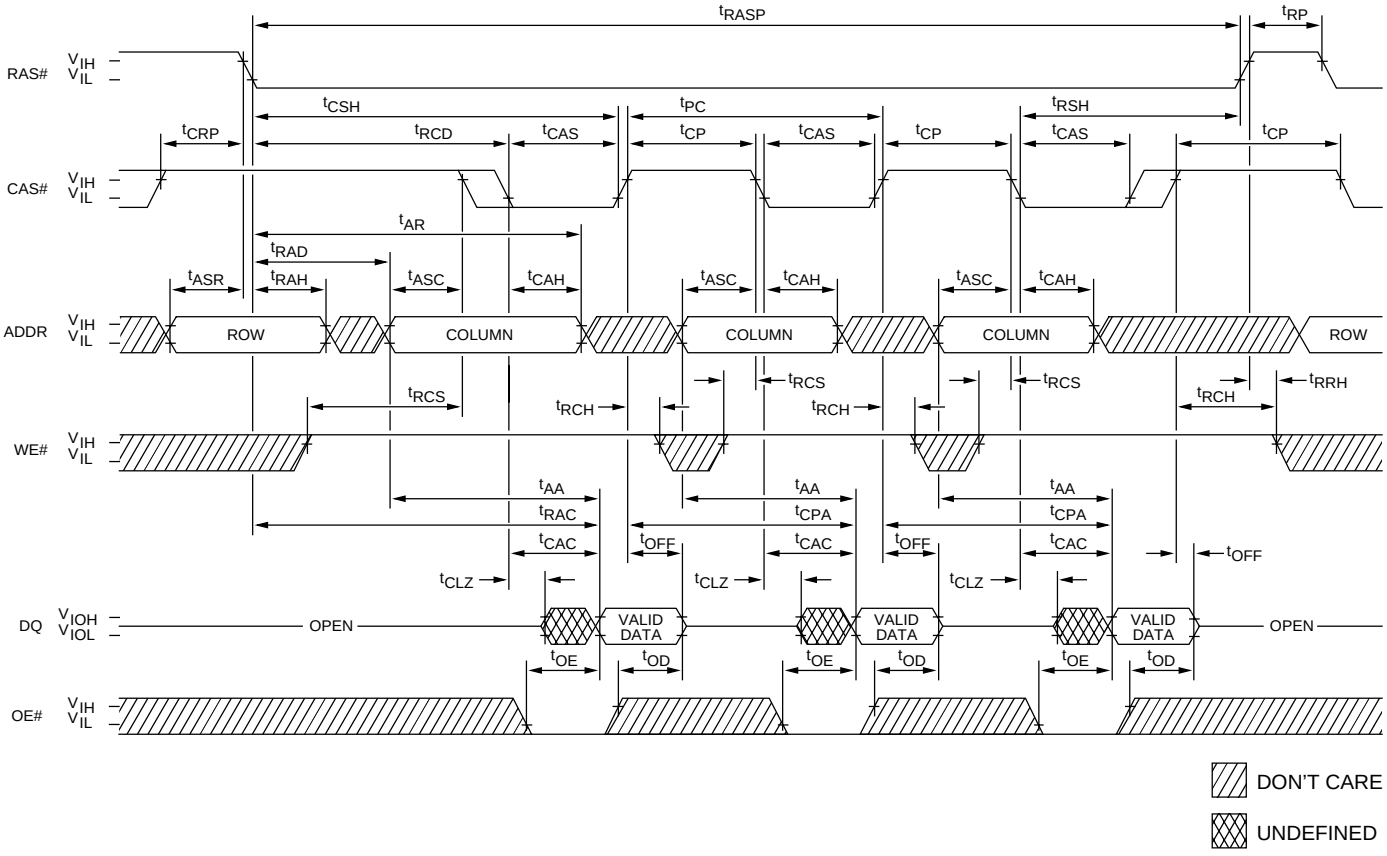


TIMING PARAMETERS

SYMBOL	-6 MIN	-6 MAX	UNITS
tAA		30	ns
tAR	45		ns
tASC	0		ns
tASR	0		ns
tAWD	55		ns
tCAC		15	ns
tCAH	10		ns
tCAS	15	10,000	ns
tCLZ	3		ns
tCRP	5		ns
tCSH	60		ns
tCWD	40		ns
tCWL	15		ns
tDH	10		ns
tDS	0		ns

SYMBOL	-6 MIN	-6 MAX	UNITS
tOD	3	15	ns
tOE		15	ns
tOEH	15		ns
tRAC		60	ns
tRAD	15		ns
tRAH	10		ns
tRAS	60	10,000	ns
tRCD	20		ns
tRCS	0		ns
tRP	40		ns
tRSH	15		ns
tRWC	155		ns
tRWD	85		ns
tRWL	15		ns
tWP	10		ns

FAST-PAGE-MODE READ CYCLE

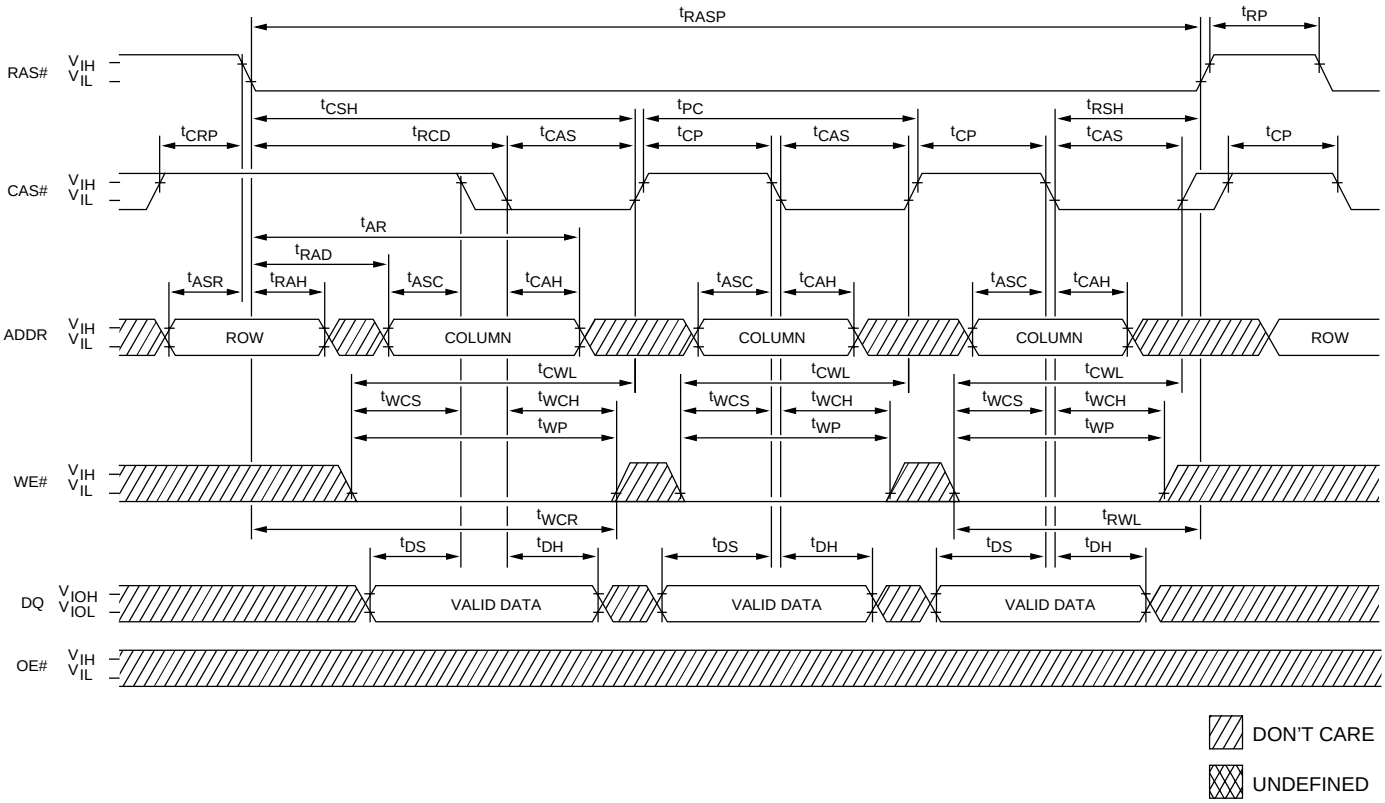


TIMING PARAMETERS

SYMBOL	-6 MIN	-6 MAX	UNITS
tAA		30	ns
tAR	45		ns
tASC	0		ns
tASR	0		ns
tCAC		15	ns
tCAH	10		ns
tCAS	15	10,000	ns
tCLZ	3		ns
tCP	10		ns
tCPA		35	ns
tCRP	5		ns
tCSH	60		ns
tOD	3	15	ns

SYMBOL	-6 MIN	-6 MAX	UNITS
tOE		15	ns
tOFF	3	15	ns
tPC	35		ns
tRAC		60	ns
tRAD	15		ns
tRAH	10		ns
tRASP	60	125,000	ns
tRCD	20		ns
tRCH	0		ns
tRCS	0		ns
tRP	40		ns
tRRH	0		ns
tRSH	15		ns

FAST-PAGE-MODE EARLY-WRITE CYCLE

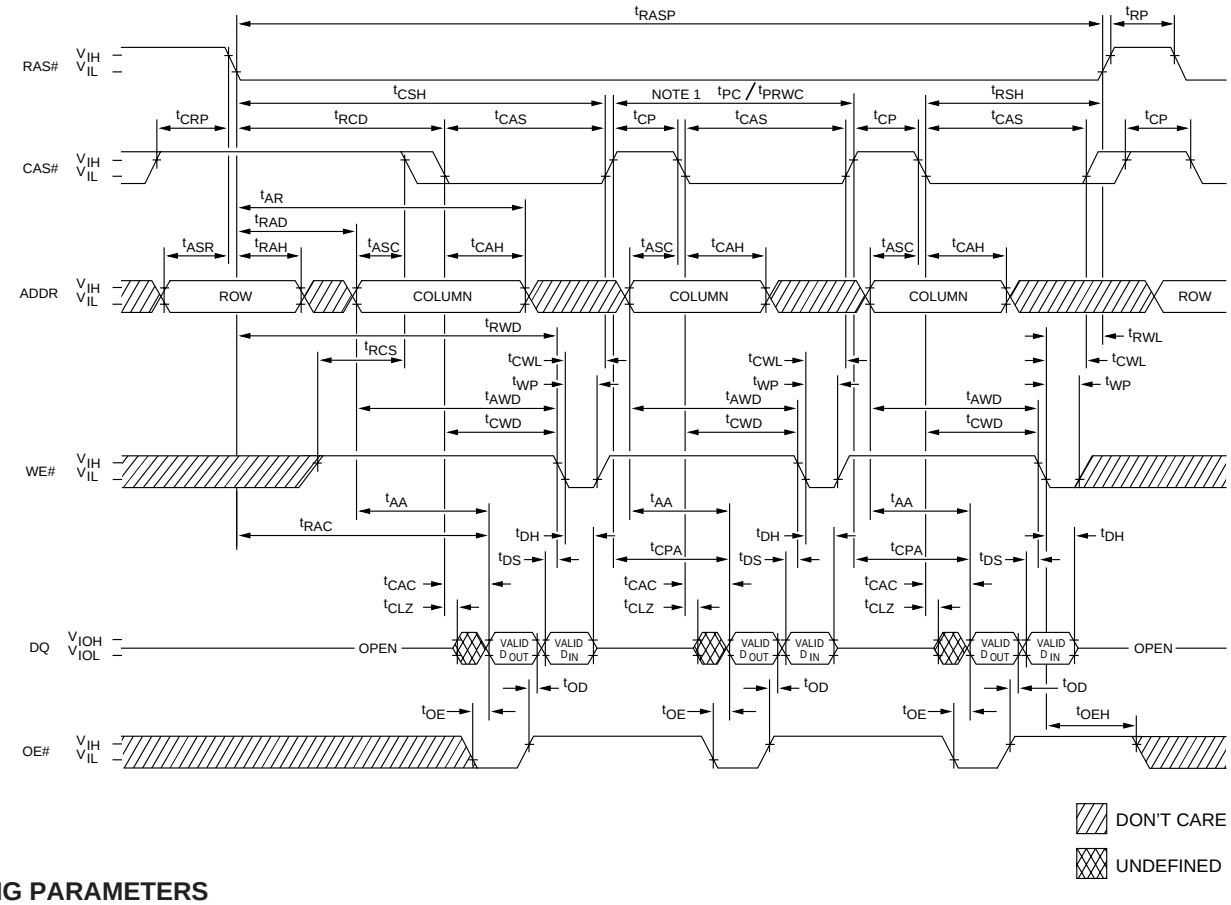


TIMING PARAMETERS

SYMBOL	-6 MIN	-6 MAX	UNITS
tAR	45		ns
tASC	0		ns
tASR	0		ns
tCAH	10		ns
tCAS	15	10,000	ns
tCP	10		ns
tCRP	5		ns
tCSH	60		ns
tCWL	15		ns
tDH	10		ns
tDS	0		ns
tPC	35		ns

SYMBOL	-6 MIN	-6 MAX	UNITS
tRAD	15		ns
tRAH	10		ns
tRASP	60	125,000	ns
tRCD	20		ns
tRP	40		ns
tRSH	15		ns
tRWL	15		ns
tWCH	10		ns
tWCR	45		ns
tWCS	0		ns
tWP	10		ns

FAST-PAGE-MODE READ-WRITE CYCLE
(LATE WRITE and READ-MODIFY-WRITE cycles)



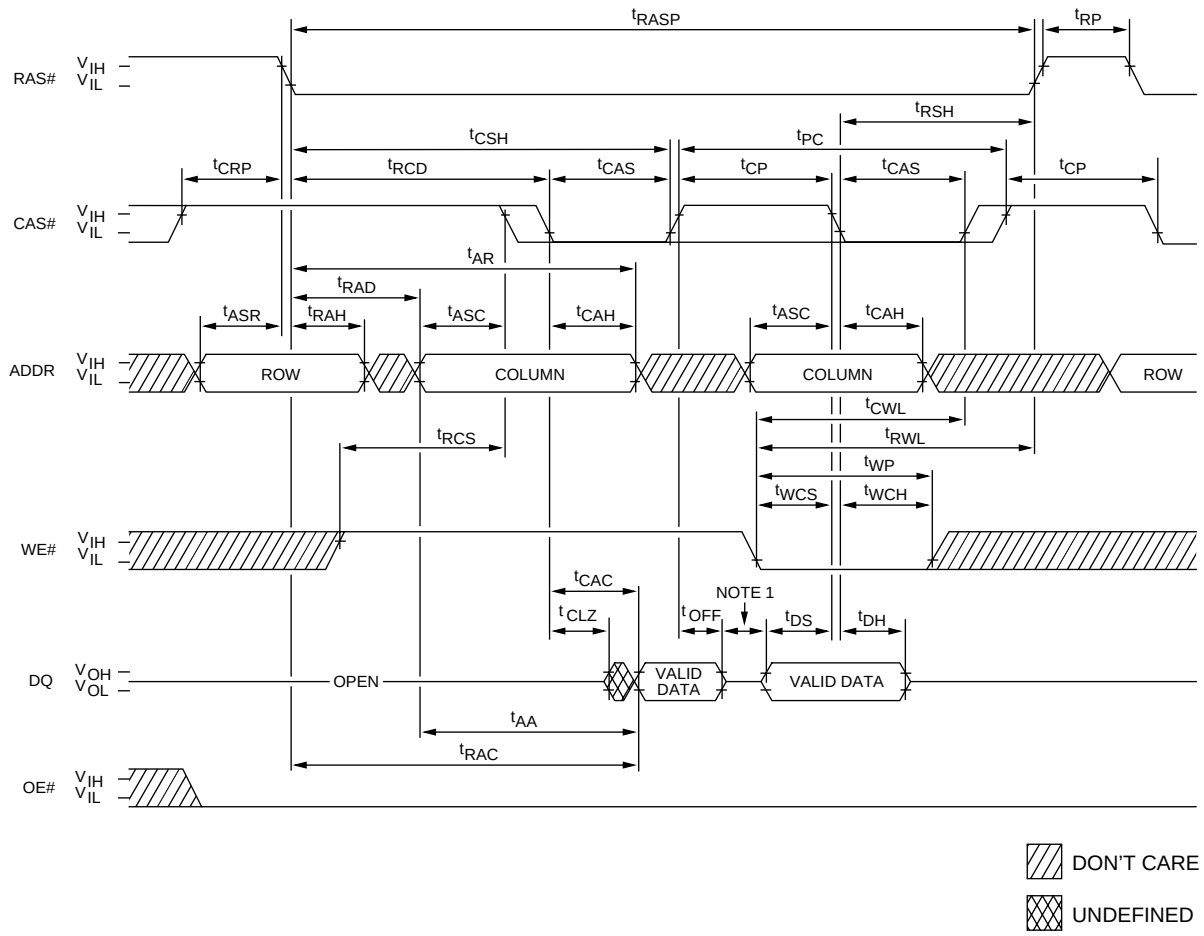
TIMING PARAMETERS

SYMBOL	-6 MIN	-6 MAX	UNITS
tAA		30	ns
tAR	45		ns
tASC	0		ns
tASR	0		ns
tAWD	55		ns
tCAC		15	ns
tCAH	10		ns
tCAS	15	10,000	ns
tCLZ	3		ns
tCP	10		ns
tCPA		35	ns
tCRP	5		ns
tCSH	60		ns
tCWD	40		ns
tCWL	15		ns
tDH	10		ns
tDS	0		ns

SYMBOL	-6 MIN	-6 MAX	UNITS
tOD	3	15	ns
tOE		15	ns
tOEH	15		ns
tPC	35		ns
tPRWC	85		ns
tRAC		60	ns
tRAD	15		ns
tRAH	10		ns
tRASP	60	125,000	ns
tRCD	20		ns
tRCS	0		ns
tRP	40		ns
tRSH	15		ns
tRWD	85		ns
tRWL	15		ns
tWP	10		ns

NOTE: 1. tPC is for LATE WRITE only.

FAST-PAGE-MODE READ-EARLY-WRITE CYCLE
(Pseudo READ-MODIFY-WRITE)



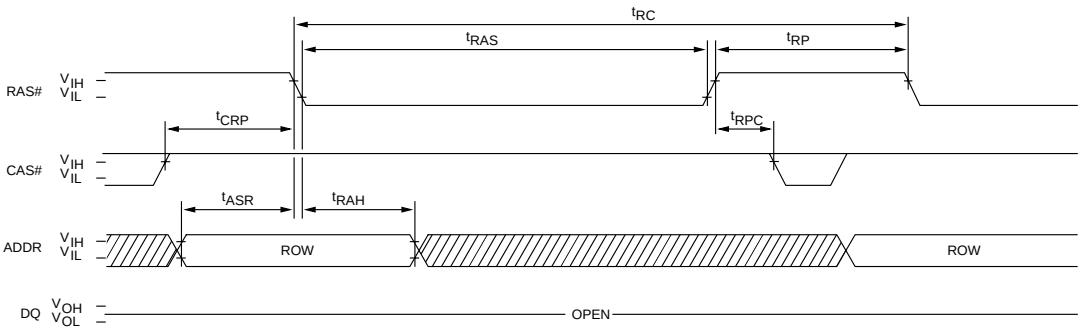
TIMING PARAMETERS

SYMBOL	-6 MIN	-6 MAX	UNITS
tAA		30	ns
tAR	45		ns
tASC	0		ns
tASR	0		ns
tCAC		15	ns
tCAH	10		ns
tCAS	15	10,000	ns
tCLZ	3		ns
tCP	10		ns
tCRP	5		ns
tCSH	60		ns
tCWL	15		ns
tDH	10		ns
tDS	0		ns

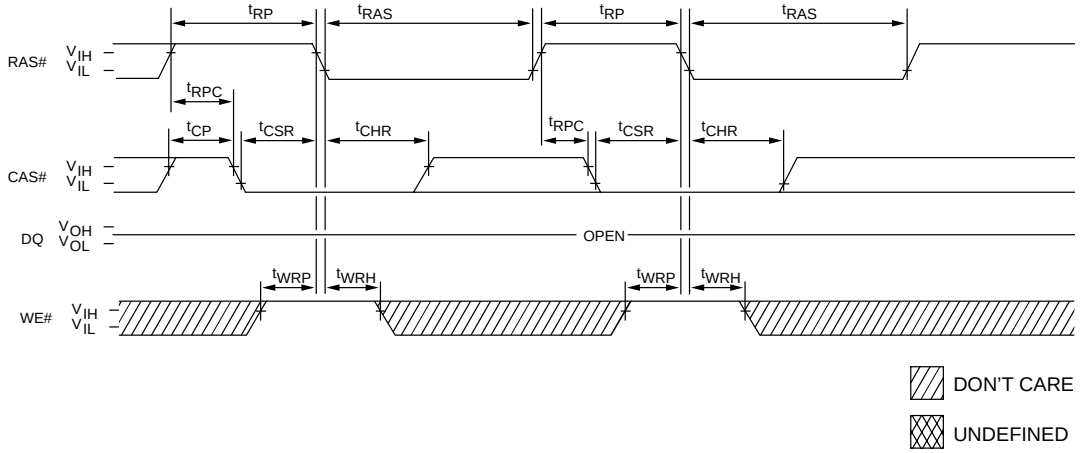
SYMBOL	-6 MIN	-6 MAX	UNITS
tOFF	3	15	ns
tPC	35		ns
tRAC		60	ns
tRAD	15		ns
tRAH	10		ns
tRASP	60	125,000	ns
tRCD	20		ns
tRCS	0		ns
tRP	40		ns
tRSH	15		ns
tRWL	15		ns
tWCH	10		ns
tWCS	0		ns
tWP	10		ns

NOTE: 1. Do not drive data prior to tristate.

RAS#-ONLY REFRESH CYCLE
(OE# and WE# = DON'T CARE)



CBR REFRESH CYCLE
(Addresses and OE# = DON'T CARE)

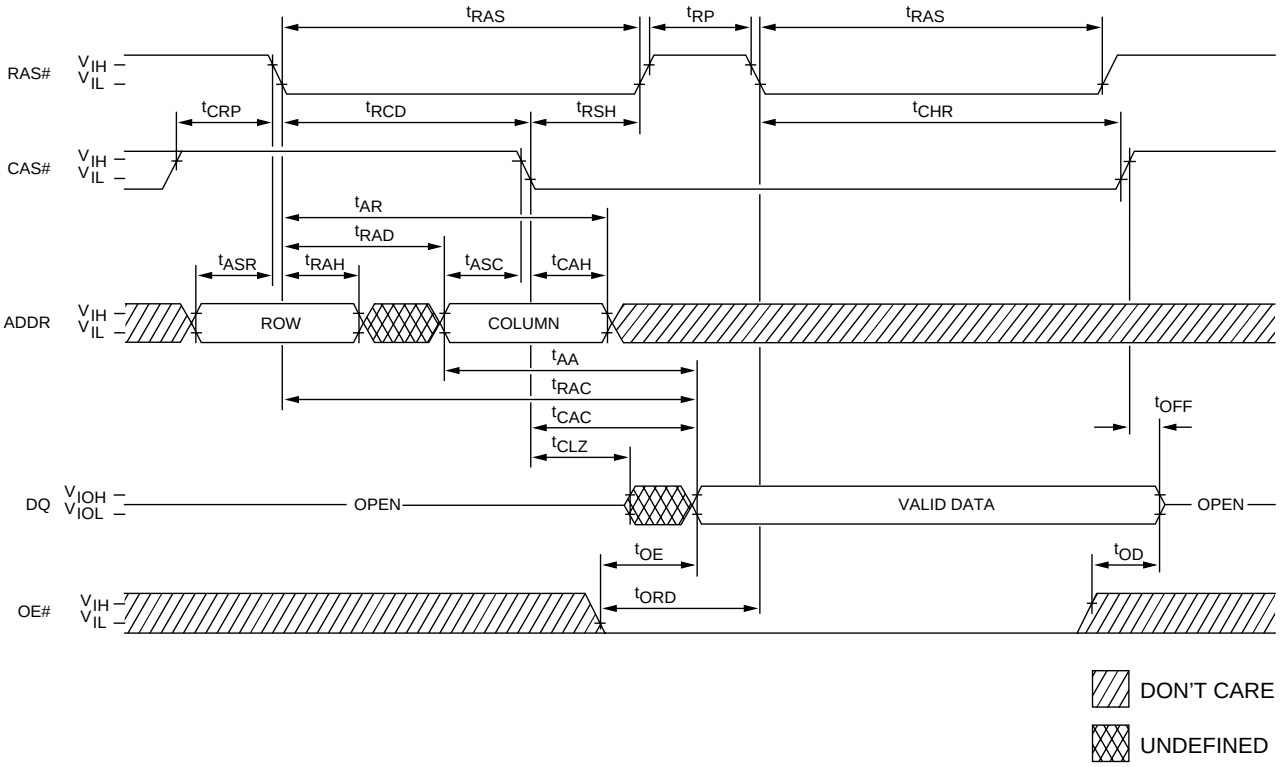


TIMING PARAMETERS

SYMBOL	-6 MIN	-6 MAX	UNITS
tASR	0		ns
tCHR	10		ns
tCP	10		ns
tCRP	5		ns
tCSR	5		ns
tRAH	10		ns

SYMBOL	-6 MIN	-6 MAX	UNITS
tRAS	60	10,000	ns
tRC	110		ns
tRP	40		ns
tRPC	0		ns
tWRH	10		ns
tWRP	10		ns

HIDDEN REFRESH CYCLE [21]
(WE# = HIGH; OE# = LOW)

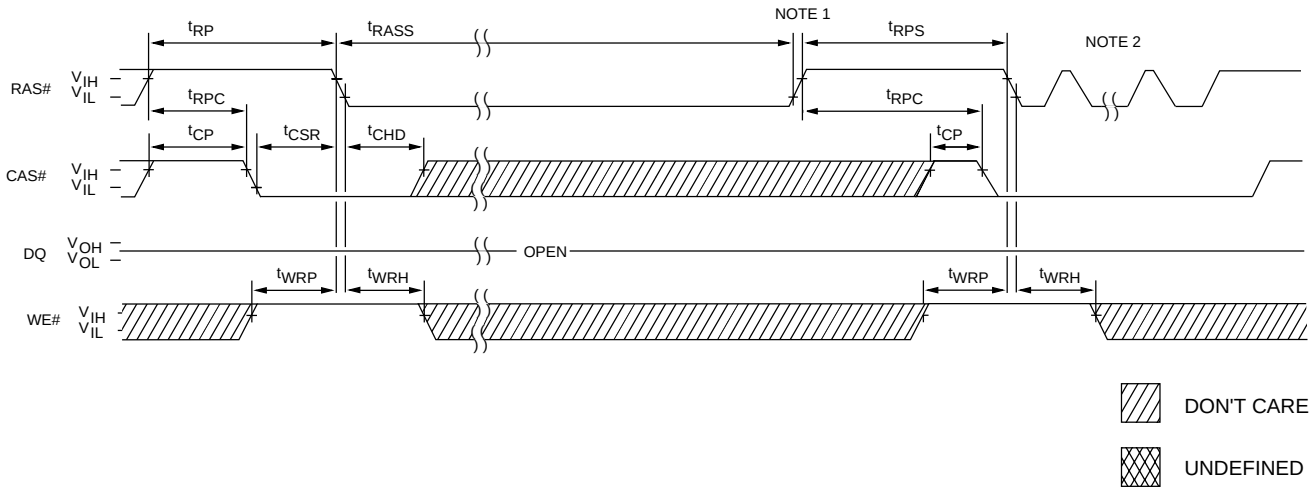


TIMING PARAMETERS

SYMBOL	-6 MIN	-6 MAX	UNITS
tAA		30	ns
tAR	45		ns
tASC	0		ns
tASR	0		ns
tCAC		15	ns
tCAH	10		ns
tCHR	10		ns
tCLZ	3		ns
tCRP	5		ns
tOD	3	15	ns

SYMBOL	-6 MIN	-6 MAX	UNITS
tOE		15	ns
tOFF	3	15	ns
tORD	0		ns
tRAC		60	ns
tRAD	15		ns
tRAH	10		ns
tRAS	60	10,000	ns
tRCD	20		ns
tRP	40		ns
tRSH	15		ns

SELF REFRESH CYCLE
(Addresses and OE# = DON'T CARE)



TIMING PARAMETERS

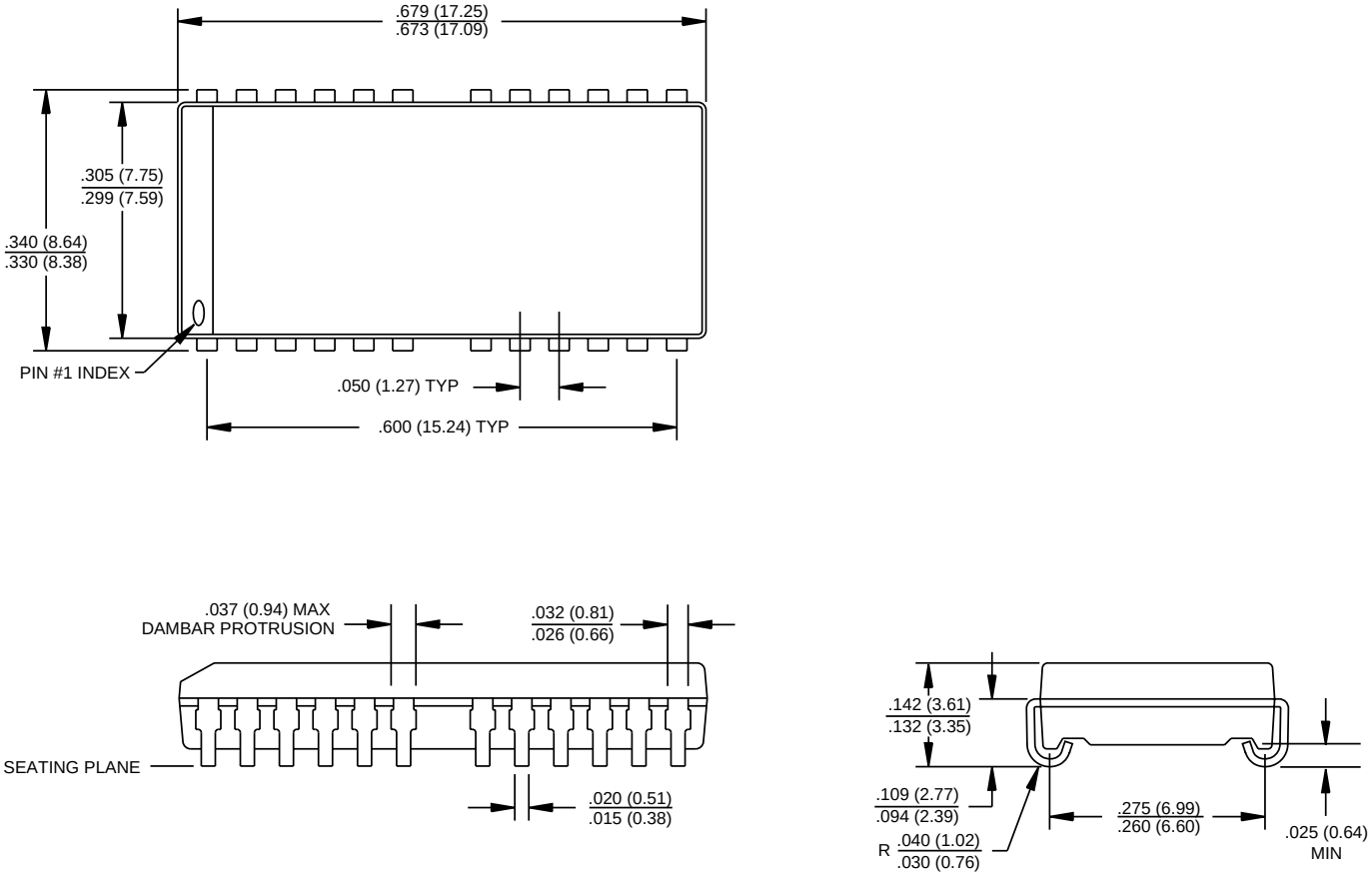
SYMBOL	-6 MIN	-6 MAX	UNITS
tCHD	15		ns
tCP	10		ns
tCSR	5		ns
tRASS	100		µs
tRP	40		ns

SYMBOL	-6 MIN	-6 MAX	UNITS
tRPC	0		ns
tRPS	110		ns
tWRH	10		ns
tWRP	10		ns

NOTE: 1. Once tRASS (MIN) is met and RAS# remains LOW, the DRAM will enter SELF REFRESH mode.
2. Once tRPS is satisfied, a complete burst of all rows should be executed.

24/26-PIN PLASTIC SOJ (300 mil)

DA-2

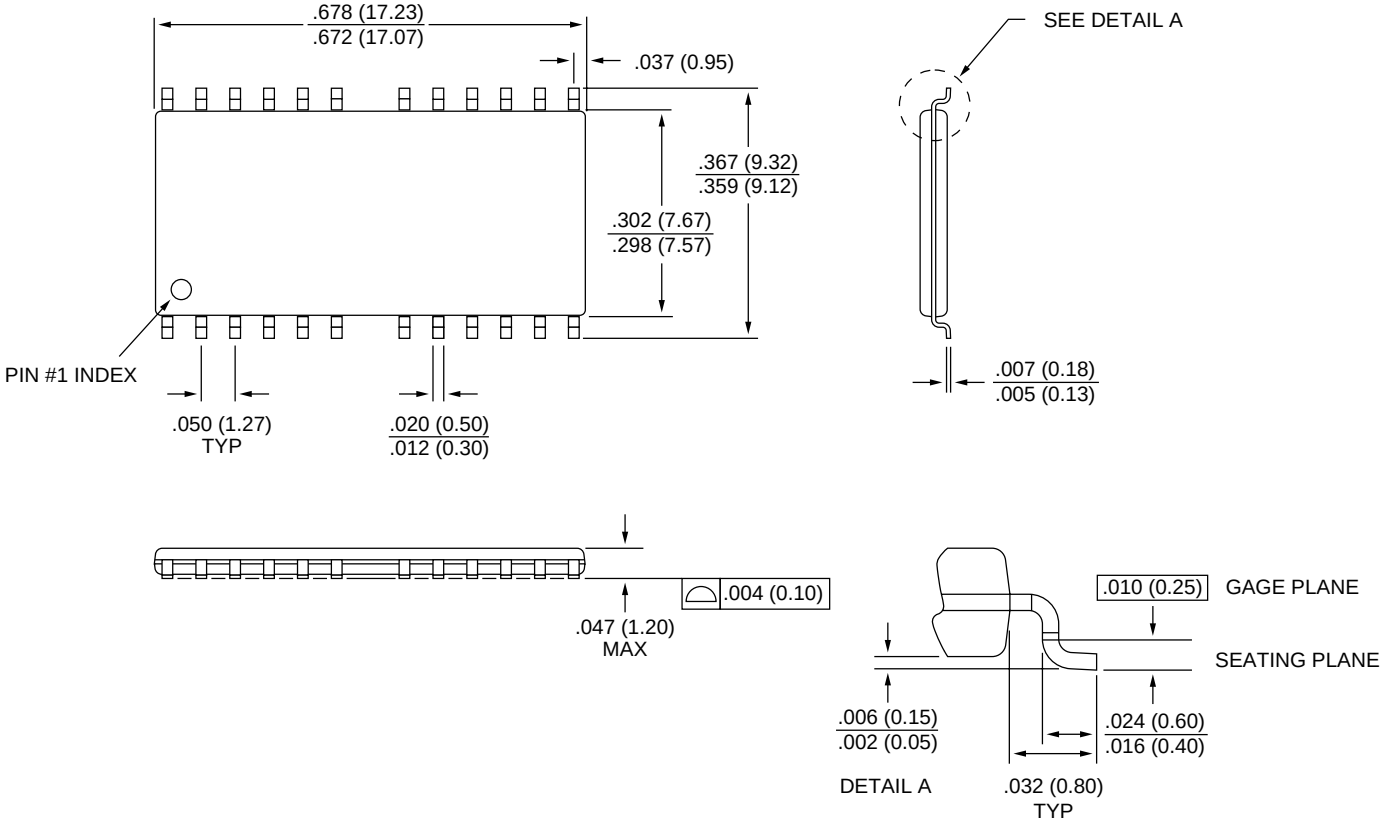


NOTE: 1. All dimensions in inches (millimeters) $\frac{\text{MAX}}{\text{MIN}}$ or typical where noted.

2. Package width and length do not include mold protrusion; allowable mold protrusion is .01" per side.

24/26-PIN PLASTIC TSOP (300 mil)

DB-2



NOTE: 1. All dimensions in inches (millimeters) $\frac{\text{MAX}}{\text{MIN}}$ or typical where noted.

2. Package width and length do not include mold protrusion; allowable mold protrusion is .01" per side.

Technology that works for you.

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