



MT8D132(X), MT16D232(X)
1 MEG, 2 MEG x 32 DRAM MODULES

DRAM MODULE

1 MEG, 2 MEG x 32

4, 8 MEGABYTE, 5V, FAST PAGE OR EDO PAGE MODE

FEATURES

- JEDEC- and industry-standard pinout in a 72-pin, single-in-line memory module (SIMM)
- High-performance CMOS silicon-gate process.
- Single +5V ±10% power supply
- All device pins are TTL-compatible
- Low power, 48mW standby; 1,824mW active, typical (8MB)
- Refresh modes: \overline{RAS} ONLY, \overline{CAS} -BEFORE- \overline{RAS} (CBR) and HIDDEN
- Multiple RAS lines allow x16 or x32 width
- 1,024-cycle refresh distributed across 16ms
- FAST PAGE MODE (FPM) operating mode or Extended Data-Out (EDO) PAGE MODE operating mode

OPTIONS

- Timing
 - 60ns access
 - 70ns access (FAST PAGE MODE only)
- Packages
 - 72-pin SIMM
 - 72-pin SIMM (gold)
- Operating Modes
 - FAST PAGE MODE
 - EDO PAGE MODE

MARKING

-6
-7

M
G

Blank
X

KEY TIMING PARAMETERS

EDO Operating Mode

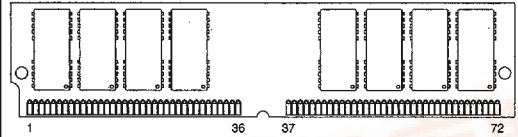
SPEED	t _{RC}	t _{RAC}	t _{PC}	t _{AA}	t _{CAC}	t _{CAS}
-6	110ns	60ns	26ns	30ns	17ns	13ns

FPM Operating Mode

SPEED	t _{RC}	t _{RAC}	t _{PC}	t _{AA}	t _{CAC}	t _{RP}
-6	110ns	60ns	35ns	30ns	15ns	40ns
-7	130ns	70ns	40ns	35ns	20ns	50ns

PIN ASSIGNMENT (Front View)

72-Pin SIMM
(DD-3) 1 Meg x 32
(DD-4) 2 Meg x 32



PIN #	SYMBOL	PIN #	SYMBOL	PIN #	SYMBOL	PIN #	SYMBOL
1	V _{ss}	19	NC	37	NC	55	DQ12
2	DQ1	20	DQ5	38	NC	56	DQ28
3	DQ17	21	DQ21	39	V _{ss}	57	DQ13
4	DQ2	22	DQ6	40	CAS ₀	58	DQ29
5	DQ18	23	DQ22	41	CAS ₂	59	V _{cc}
6	DQ3	24	DQ7	42	CAS ₃	60	DQ30
7	DQ19	25	DQ23	43	CAS ₁	61	DQ14
8	DQ4	26	DQ8	44	RAS ₀	62	DQ31
9	DQ20	27	DQ24	45	NC*/RAS ₁	63	DQ15
10	V _{cc}	28	A7	46	NC	64	DQ32
11	NC	29	NC	47	WE	65	DQ16
12	A0	30	V _{cc}	48	NC	66	NC
13	A1	31	A8	49	DQ9	67	PRD1
14	A2	32	A9	50	DQ25	68	PRD2
15	A3	33	NC*/RAS ₃	51	DQ10	69	PRD3
16	A4	34	RAS ₂	52	DQ26	70	PRD4
17	A5	35	NC	53	DQ11	71	NC
18	A6	36	NC	54	DQ27	72	V _{ss}

*4MB version only

DRAM SIMM



PART NUMBERS

EDO Operating Mode

PART NUMBER	DESCRIPTION
MT8D132G-xx X	1 Meg x 32, EDO, Gold
MT8D132M-xx X	1 Meg x 32, EDO, Tin/Lead
MT16D232G-xx X	2 Meg x 32, EDO, Gold
MT16D232M-xx X	2 Meg x 32, EDO, Tin/Lead

xx = speed

FPM Operating Mode

PART NUMBER	DESCRIPTION
MT8D132G-xx	1 Meg x 32, Gold
MT8D132M-xx	1 Meg x 32, Tin/Lead
MT16D232G-xx	2 Meg x 32, Gold
MT16D232M-xx	2 Meg x 32, Tin/Lead

xx = speed

GENERAL DESCRIPTION

The MT8D132(X) and MT16D232(X) are randomly accessed 4MB and 8MB solid-state memories organized in a x32 configuration. During READ or WRITE cycles each bit is uniquely addressed through the 20 address bits, which are entered 10 bits (A0-A9) at a time. \overline{RAS} is used to latch the first 10 bits and \overline{CAS} the latter 10 bits. A READ or WRITE cycle is selected with the \overline{WE} input. A logic HIGH on \overline{WE} dictates READ mode while a logic LOW on \overline{WE} dictates WRITE mode. During a WRITE cycle, data-in (D) is latched by the falling edge of \overline{WE} or \overline{CAS} , whichever occurs last. EARLY WRITE occurs when \overline{WE} goes LOW prior to \overline{CAS} going LOW, the output pin(s) remain open (High-Z) until the next \overline{CAS} cycle.

FAST PAGE MODE

FAST PAGE MODE operations allow faster data operations (READ or WRITE) within a row-address-defined (A0-A9) page boundary. The FAST PAGE MODE cycle is always initiated with a row-address strobed-in by \overline{RAS}

followed by a column-address strobed-in by \overline{CAS} . \overline{CAS} may be toggled-in by holding \overline{RAS} LOW and strobing-in different column-addresses, thus executing faster memory cycles. Returning \overline{RAS} HIGH terminates the FAST PAGE MODE operation.

EDO PAGE MODE

EDO PAGE MODE, designated by the "X" version, is an accelerated FAST PAGE MODE cycle. The primary advantage of EDO is the availability of data-out even after \overline{CAS} goes back HIGH. EDO provides for \overline{CAS} precharge time (t_{CP}) to occur without the output data going invalid. This elimination of \overline{CAS} output control provides for pipeline READS.

FAST PAGE MODE modules have traditionally turned the output buffers off (High-Z) with the rising edge of \overline{CAS} . EDO operates as any DRAM READ or FAST-PAGE-MODE READ, except data will be held valid after \overline{CAS} goes HIGH, as long as \overline{RAS} and \overline{OE} are held LOW and \overline{WE} is held HIGH (reference MT4C4007J DRAM data sheet for additional information on EDO functionality).

REFRESH

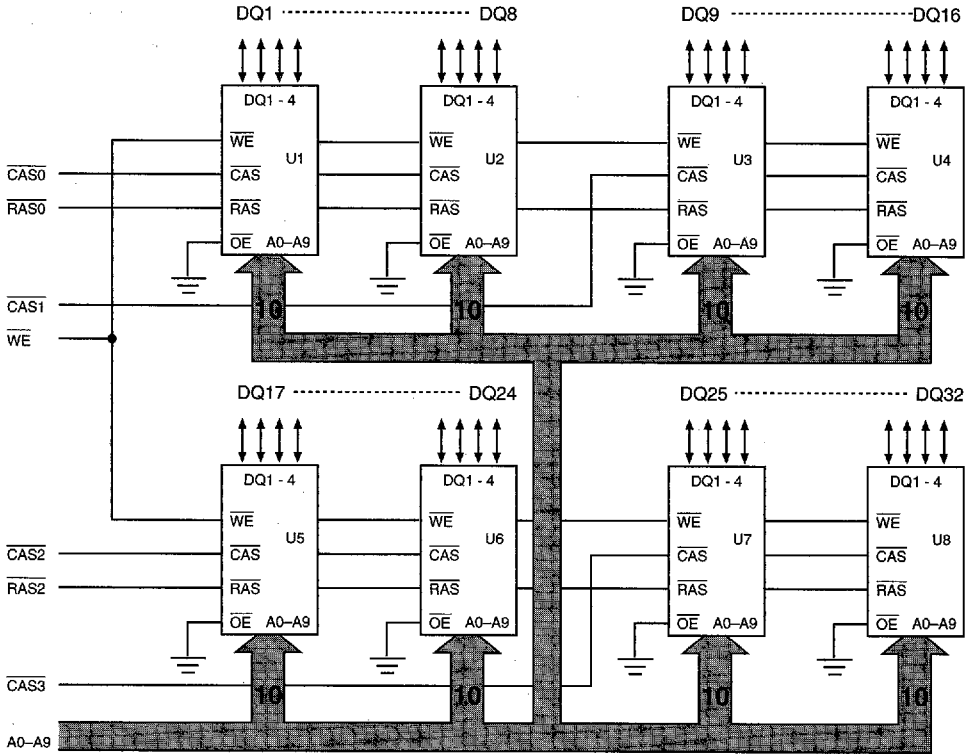
Returning \overline{RAS} and \overline{CAS} HIGH terminates a memory cycle and decreases chip current to a reduced standby level. Also, the chip is preconditioned for the next cycle during the \overline{RAS} HIGH time. Memory cell data is retained in its correct state by maintaining power and executing any \overline{RAS} cycle (READ, WRITE) or \overline{RAS} refresh cycle (\overline{RAS} ONLY, CBR or HIDDEN) so that all 1,024 combination of \overline{RAS} addresses (A0-A9) are executed at least every 16ms, regardless of sequence.

x16 CONFIGURATION

For x16 applications, the corresponding DQ and \overline{CAS} pins must be connected together (DQ1 to DQ17, DQ2 to DQ18 and so forth, and $\overline{CAS0}$ to $\overline{CAS2}$ and $\overline{CAS1}$ to $\overline{CAS3}$). Each \overline{RAS} is then a bank select for the x16 memory organization.

DRAM SIMM

**FUNCTIONAL BLOCK DIAGRAM
MT8D132(X) (4MB)**



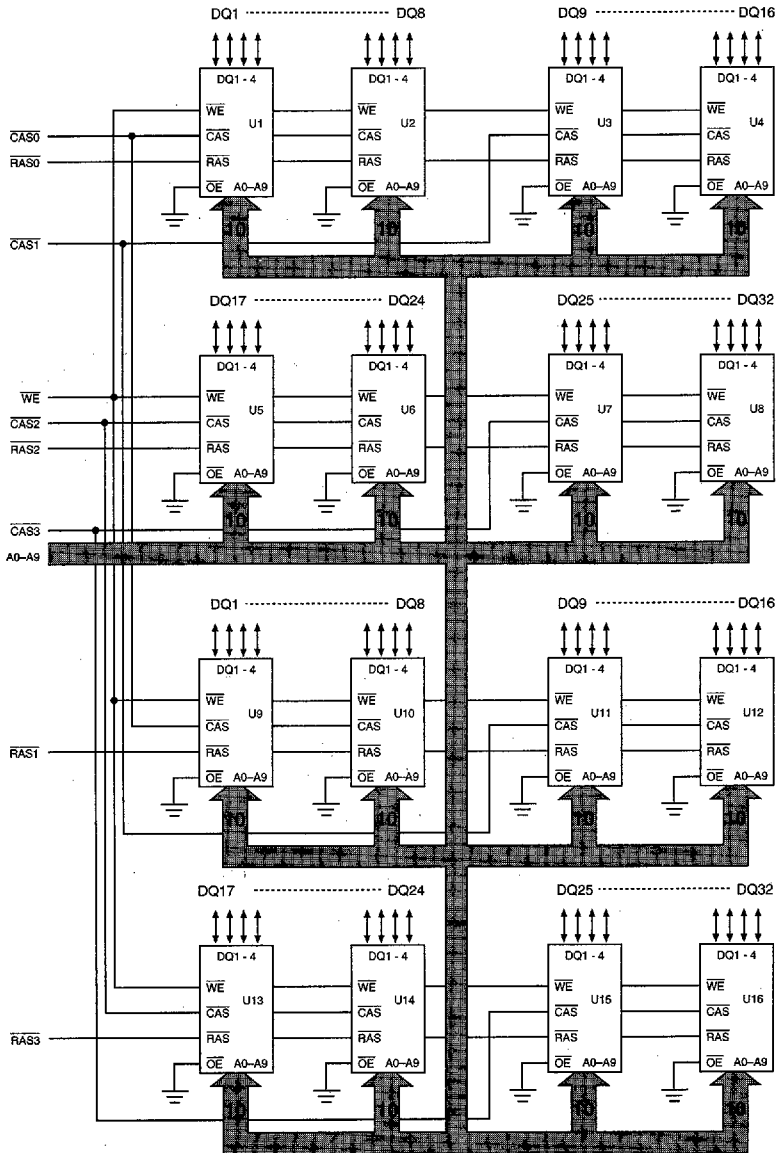
DRAM SIMM

**FAST PAGE MODE
U1-U8 = MT4C4001JDJ**

**EDO PAGE MODE
U1-U8 = MT4C4007JDJ**

FUNCTIONAL BLOCK DIAGRAM
MT16D232(X) (8MB)

DRAM SIMM



FAST PAGE MODE
U1-U16 = MT4C4001J

EDO PAGE MODE
U1-U16 = MT4C4007JDJ

TRUTH TABLE

FUNCTION		RAS	CAS	ADDRESSES			DATA-IN/OUT
				WE	!R	!C	DQ1-DQ32
Standby		H	H→X	X	X	X	High-Z
READ		L	L	H	ROW	COL	Data-Out
EARLY WRITE		L	L	L	ROW	COL	Data-In
EDO/FAST-PAGE-MODE READ	1st Cycle	L	H→L	H	ROW	COL	Data-Out
	2nd Cycle	L	H→L	H	n/a	COL	Data-Out
	Any Cycle (X version)	L	L→H	H	n/a	n/a	Data-Out
EDO/FAST-PAGE-MODE EARLY WRITE	1st Cycle	L	H→L	L	ROW	COL	Data-In
	2nd Cycle	L	H→L	L	n/a	COL	Data-In
RAS-ONLY REFRESH		L	H	X	ROW	n/a	High-Z
HIDDEN REFRESH	READ	L→H→L	L	H	ROW	COL	Data-Out
	WRITE	L→H→L	L	L	ROW	COL	Data-In
CBR REFRESH		H→L	L	H	X	X	High-Z

DRAM SIMM

JEDEC DEFINED PRESENCE-DETECT - MT8D132(X) (4MB)

SYMBOL	PIN #	-6	-7
PRD1	67	V _{ss}	V _{ss}
PRD2	68	V _{ss}	V _{ss}
PRD3	69	NC	V _{ss}
PRD4	70	NC	NC

JEDEC DEFINED PRESENCE-DETECT - MT16D232(X) (8MB)

SYMBOL	PIN #	-6	-7
PRD1	67	NC	NC
PRD2	68	NC	NC
PRD3	69	NC	V _{ss}
PRD4	70	NC	NC

ABSOLUTE MAXIMUM RATINGS*

Voltage on Vcc Supply Relative to Vss -1V to +7V
 Operating Temperature, T_A (ambient) 0°C to +70°C
 Storage Temperature (plastic) -55°C to +125°C
 Power Dissipation 8W
 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.

ELECTRICAL CHARACTERISTICS AND RECOMMENDED DC OPERATING CONDITIONS

(Notes: 1, 3, 6) (Vcc = +5V ±10%)

PARAMETER/CONDITION	SYMBOL	MIN	MAX	UNITS	NOTES	
Supply Voltage	Vcc	4.5	5.5	V		
Input High (Logic 1) Voltage, all inputs	V _{IH}	2.4	Vcc+1	V		
Input Low (Logic 0) Voltage, all inputs	V _{IL}	-1.0	0.8	V		
INPUT LEAKAGE CURRENT Any input 0V ≤ V _{IN} ≤ Vcc + 1.0V (All other pins not under test = 0V)	CAS0-CAS3	I _{I1}	-8	8	μA	
	A0-A9, WE	I _{I2}	-32	32	μA	25
	RAS0-RAS3	I _{I3}	-8	8	μA	25
OUTPUT LEAKAGE CURRENT (Q is disabled; 0V ≤ V _{out} ≤ 5.5V)	DQ1-DQ32	I _{OZ}	-20	20	μA	25
OUTPUT LEVELS High Voltage (I _{out} = -5mA) Low Voltage (I _{out} = 4.2mA)	V _{OH}	2.4		V		
	V _{OL}		0.4	V		

DRAM SIMM

PARAMETER/CONDITION	SYMBOL	SIZE	MAX		UNITS	NOTES
			-6	-7		
STANDBY CURRENT: (TTL) (RAS = CAS = V _{IH})	I _{CC1}	4MB 8MB	16 32	16 32	mA	
STANDBY CURRENT: (CMOS) (RAS = CAS = other inputs = Vcc - 0.2V)	I _{CC2}	4MB 8MB	8 16	8 16	mA	
OPERATING CURRENT: Random READ/WRITE Average power supply current (RAS, CAS, address cycling: ^t RC = ^t RC [MIN])	I _{CC3}	4MB 8MB	880 896	800 816	mA	2, 24
OPERATING CURRENT: FAST PAGE MODE Average power supply current (RAS = V _{IL} , CAS, address cycling: ^t PC = ^t PC [MIN])	I _{CC4}	4MB 8MB	640 656	560 576	mA	2, 24
OPERATING CURRENT: EDO PAGE MODE Average power supply current (RAS = V _{IL} , CAS, address cycling: ^t PC = ^t PC [MIN])	I _{CC5} (X only)	4MB 8MB	640 656	— —	mA	2
REFRESH CURRENT: RAS ONLY Average power supply current (RAS cycling, CAS = V _{IH} : ^t RC = ^t RC [MIN])	I _{CC6}	4MB 8MB	880 896	800 816	mA	2, 24
REFRESH CURRENT: CBR Average power supply current (RAS, CAS, address cycling: ^t RC = ^t RC [MIN])	I _{CC7}	4MB 8MB	880 896	800 816	mA	2, 19

CAPACITANCE

PARAMETER	SYMBOL	MAX		UNITS	NOTES
		4MB	8MB		
Input Capacitance: A0-A9	C ₁₁	48	95	pF	17
Input Capacitance: WE	C ₁₂	64	127	pF	17
Input Capacitance: RAS0-RAS3	C ₁₄	32	32	pF	17
Input Capacitance: CAS0-CAS3	C ₁₅	16	32	pF	17
Input/Output Capacitance: DQ1-DQ32	C ₁₀	10	18	pF	17

FAST PAGE MODE
ELECTRICAL CHARACTERISTICS AND RECOMMENDED AC OPERATING CONDITIONS

 (Notes: 3, 4, 5, 6, 7, 10, 11, 16) (V_{cc} = +5V ±10%)

AC CHARACTERISTICS - FAST PAGE MODE OPTION	SYM	-6		-7		UNITS	NOTES
		MIN	MAX	MIN	MAX		
Access time from column-address	¹ AA		30		35	ns	
Column-address hold time (referenced to RAS)	¹ AR	45		50		ns	
Column-address setup time	¹ ASC	0		0		ns	
Row-address setup time	¹ ASR	0		0		ns	
Access time from CAS	¹ CAC		15		20	ns	9
Column-address hold time	¹ CAH	10		15		ns	
CAS pulse width	¹ CAS	15	10,000	20	10,000	ns	
CAS hold time (CBR REFRESH)	¹ CHR	10		10		ns	19
CAS to output in Low-Z	¹ CLZ	0		0		ns	
CAS precharge time	¹ CP	10		10		ns	18
Access time from CAS precharge	¹ CPA		35		40	ns	
CAS to RAS precharge time	¹ CRP	10		10		ns	
CAS hold time	¹ CSH	60		70		ns	
CAS setup time (CBR REFRESH)	¹ CSR	10		10		ns	19
Write command to CAS lead time	¹ CWL	15		20		ns	
Data-in hold time	¹ DH	10		15		ns	15
Data-in hold time (referenced to RAS)	¹ DHR	45		55		ns	
Data-in setup time	¹ DS	0		0		ns	15
Output buffer turn-off delay	¹ OFF	3	15	3	20	ns	12, 23, 26
FAST-PAGE-MODE READ or WRITE cycle time	¹ PC	35		40		ns	
Access time from RAS	¹ RAC		60		70	ns	8
RAS to column-address delay time	¹ RAD	15	30	15	35	ns	22
Row-address hold time	¹ RAH	10		10		ns	
Column-address to RAS lead time	¹ RAL	30		35		ns	
RAS pulse width	¹ RAS	60	10,000	70	10,000	ns	
RAS pulse width (FAST PAGE MODE)	¹ RASP	60	100,000	70	100,000	ns	
Random READ or WRITE cycle time	¹ RC	110		130		ns	
RAS to CAS delay time	¹ RCD	20	45	20	50	ns	13
Read command hold time (referenced to CAS)	¹ RCH	0		0		ns	14
Read command setup time	¹ RCS	0		0		ns	
Refresh period (1,024 cycles)	¹ REF		16		16	ms	

FAST PAGE MODE

ELECTRICAL CHARACTERISTICS AND RECOMMENDED AC OPERATING CONDITIONS

(Notes: 3, 4, 5, 6, 7, 10, 11, 16) ($V_{CC} = +5V \pm 10\%$)

AC CHARACTERISTICS - FAST PAGE MODE OPTION	SYM	-6		-7		UNITS	NOTES
		MIN	MAX	MIN	MAX		
RAS precharge time	t_{RP}	40		50		ns	
RAS to CAS precharge time	t_{RPC}	0		0		ns	
Read command hold time	t_{RRH}	0		0		ns	14
RAS hold time	t_{RSH}	15		20		ns	
Write command to RAS lead time	t_{RWL}	15		20		ns	
Transition time (rise or fall)	t_T	3	50	3	50	ns	
Write command hold time	t_{WCH}	10		15		ns	
Write command hold time (referenced to RAS)	t_{WCR}	45		55		ns	
WE command setup time	t_{WCS}	0		0		ns	
Write command pulse width	t_{WP}	10		15		ns	
WE hold time (CBR REFRESH)	t_{WRH}	10		10		ns	
WE setup time (CBR REFRESH)	t_{WRP}	10		10		ns	

DRAM SIMM

EDO PAGE MODE
ELECTRICAL CHARACTERISTICS AND RECOMMENDED AC OPERATING CONDITIONS

(Notes: 3, 4, 5, 6, 7, 10, 11, 16) (V_{cc} = +5V ±10%)

AC CHARACTERISTICS - EDO PAGE MODE OPTION		-6		UNITS	NOTES
PARAMETER	SYM	MIN	MAX		
Access time from column-address	^t AA		30	ns	
Column-address setup to $\overline{\text{CAS}}$ precharge during WRITE	^t ACH	15		ns	
Column-address hold time (referenced to $\overline{\text{RAS}}$)	^t AR	45		ns	
Column-address setup time	^t ASC	0		ns	
Row-address setup time	^t ASR	0		ns	
Access time from $\overline{\text{CAS}}$	^t CAC		17	ns	9
Column-address hold time	^t CAH	10		ns	
$\overline{\text{CAS}}$ pulse width	^t CAS	13	10,000	ns	
$\overline{\text{CAS}}$ hold time (CBR REFRESH)	^t CHR	10		ns	19
$\overline{\text{CAS}}$ to output in Low-Z	^t CLZ	3		ns	23
Data output hold after $\overline{\text{CAS}}$ LOW	^t COH	5		ns	
$\overline{\text{CAS}}$ precharge time	^t CP	10		ns	18
Access time from $\overline{\text{CAS}}$ precharge	^t CPA		35	ns	
$\overline{\text{CAS}}$ to $\overline{\text{RAS}}$ precharge time	^t CRP	10		ns	
$\overline{\text{CAS}}$ hold time	^t CSH	50		ns	
$\overline{\text{CAS}}$ setup time (CBR REFRESH)	^t CSR	10		ns	19
Write command to $\overline{\text{CAS}}$ lead time	^t CWL	15		ns	
Data-in hold time	^t DH	9		ns	15
Data-in hold time (referenced to $\overline{\text{RAS}}$)	^t DHR	45		ns	
Data-in setup time	^t DS	0		ns	15
Output buffer turn-off delay	^t OFF	3	15	ns	12, 23, 26
FAST-PAGE-MODE READ or WRITE cycle time	^t PC	26		ns	
Access time from $\overline{\text{RAS}}$	^t RAC		60	ns	8
$\overline{\text{RAS}}$ to column-address delay time	^t RAD	15	30	ns	22
Row-address hold time	^t RAH	10		ns	
Column-address to $\overline{\text{RAS}}$ lead time	^t RAL	30		ns	
$\overline{\text{RAS}}$ pulse width	^t RAS	60	10,000	ns	
$\overline{\text{RAS}}$ pulse width (FAST PAGE MODE)	^t RASP	60	100,000	ns	
Random READ or WRITE cycle time	^t RC	110		ns	
$\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ delay time	^t RCD	20	45	ns	13
Read command hold time (referenced to $\overline{\text{CAS}}$)	^t RCH	0		ns	14
Read command setup time	^t RCS	0		ns	
Refresh period (1,024 cycles)	^t REF		16	ms	

DRAM SIMM

EDO PAGE MODE

ELECTRICAL CHARACTERISTICS AND RECOMMENDED AC OPERATING CONDITIONS

(Notes: 3, 4, 5, 6, 7, 10, 11, 16) (V_{cc} = +5V ±10%)

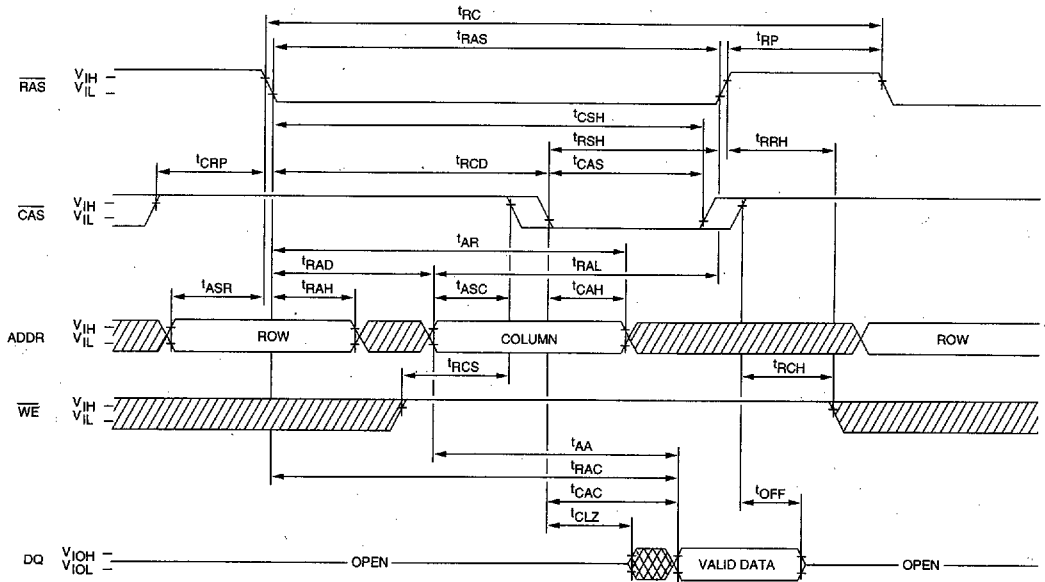
AC CHARACTERISTICS - EDO PAGE MODE OPTION		-6		UNITS	NOTES
PARAMETER	SYM	MIN	MAX		
RAS precharge time	¹ RP	40		ns	
RAS to CAS precharge time	¹ RPC	5		ns	
Read command hold time	¹ RRH	0		ns	14
RAS hold time	¹ RSH	15		ns	
Write command to $\overline{\text{RAS}}$ lead time	¹ RWL	15		ns	
Transition time (rise or fall)	¹ T	1.5	50	ns	4, 5
Write command hold time	¹ WCH	10		ns	
Write command hold time (referenced to $\overline{\text{RAS}}$)	¹ WCR	45		ns	
$\overline{\text{WE}}$ command setup time	¹ WCS	0		ns	
Output disable delay from $\overline{\text{WE}}$ (CAS HIGH)	¹ WHZ	3	15	ns	
Write command pulse width	¹ WP	10		ns	
$\overline{\text{WE}}$ pulse width for output disable when CAS HIGH	¹ WPZ	10		ns	
$\overline{\text{WE}}$ hold time (CBR REFRESH)	¹ WRH	10		ns	
$\overline{\text{WE}}$ setup time (CBR REFRESH)	¹ WRP	10		ns	

DRAM SIMM

NOTES

1. All voltages referenced to Vss.
2. Icc is dependent on output loading and cycle rates. Specified values are obtained with minimum cycle time and the output open.
3. An initial pause of 100 μ s is required after power-up followed by eight $\overline{\text{RAS}}$ refresh cycles ($\overline{\text{RAS}}$ ONLY or CBR with WE HIGH) before proper device operation is assured. The eight $\overline{\text{RAS}}$ cycle wake-ups should be repeated any time the $\overline{\text{REF}}$ refresh requirement is exceeded.
4. AC characteristics assume $t_T = 5\text{ns}$ for FAST PAGE MODE and $t_T = 1.5\text{ns}$ for EDO PAGE MODE.
5. 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} .
6. The minimum specifications are used only to indicate cycle time at which proper operation over the full temperature range ($0^\circ\text{C} \leq T_A \leq 70^\circ\text{C}$) is assured.
7. Measured with a load equivalent to two TTL gates and 100pF.
8. Assumes that $t_{\text{RCD}} < t_{\text{RCD}}(\text{MAX})$. If t_{RCD} is greater than the maximum recommended value shown in this table, t_{RAC} will increase by the amount that t_{RCD} exceeds the value shown.
9. Assumes that $t_{\text{RCD}} \geq t_{\text{RCD}}(\text{MAX})$.
10. If $\overline{\text{CAS}}$ and $\overline{\text{RAS}} = V_{IH}$, data output is High-Z.
11. If $\overline{\text{CAS}} = V_{IL}$, data output may contain data from the last valid READ cycle.
12. $t_{\text{OFF}}(\text{MAX})$ defines the time at which the output achieves the open circuit condition and is not referenced to V_{OH} or V_{OL} .
13. Operation within the $t_{\text{RCD}}(\text{MAX})$ limit ensures that $t_{\text{RAC}}(\text{MAX})$ can be met. $t_{\text{RCD}}(\text{MAX})$ is specified as a reference point only; if t_{RCD} is greater than the specified $t_{\text{RCD}}(\text{MAX})$ limit, then access time is controlled exclusively by t_{CAC} .
14. Either t_{RCH} or t_{RRH} must be satisfied for a READ cycle.
15. These parameters are referenced to $\overline{\text{CAS}}$ leading edge in EARLY WRITE cycles.
16. 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.
17. This parameter is sampled. Capacitance is measured using MIL-STD-883C, Method 3012.1 (1 MHz AC, $V_{CC} = 4.5\text{V}$, DC bias = 2.4V at 15mV RMS).
18. If $\overline{\text{CAS}}$ is LOW at the falling edge of $\overline{\text{RAS}}$, data-out (Q) will be maintained from the previous cycle. To initiate a new cycle and clear the data-out buffer, $\overline{\text{CAS}}$ must be pulsed HIGH for t_{CP} .
19. On-chip refresh and address counters are enabled.
20. A HIDDEN REFRESH may also be performed after a WRITE cycle. In this case, $\overline{\text{WE}} = \text{LOW}$.
21. LATE WRITE, READ WRITE or READ-MODIFY-WRITE cycles are not available due to $\overline{\text{OE}}$ being grounded on U1-U8/U16.
22. Operation within the $t_{\text{RAD}}(\text{MAX})$ limit ensures that $t_{\text{RCD}}(\text{MAX})$ can be met. $t_{\text{RAD}}(\text{MAX})$ is specified as a reference point only; if t_{RAD} is greater than the specified $t_{\text{RAD}}(\text{MAX})$ limit, then access time is controlled exclusively by t_{AA} .
23. The 3ns minimum is a parameter guaranteed by design.
24. Column-address changed once each cycle.
25. 4MB module values will be half of those shown.
26. For FAST PAGE MODE option, t_{OFF} is determined by the first $\overline{\text{RAS}}$ or $\overline{\text{CAS}}$ signal to transition HIGH. In comparison, t_{OFF} on an EDO option is determined by the latter of the $\overline{\text{RAS}}$ and $\overline{\text{CAS}}$ signal to transition HIGH.
27. Applies to both EDO and FAST PAGE MODES.

READ CYCLE
(FAST PAGE MODE Module)



DON'T CARE
 UNDEFINED

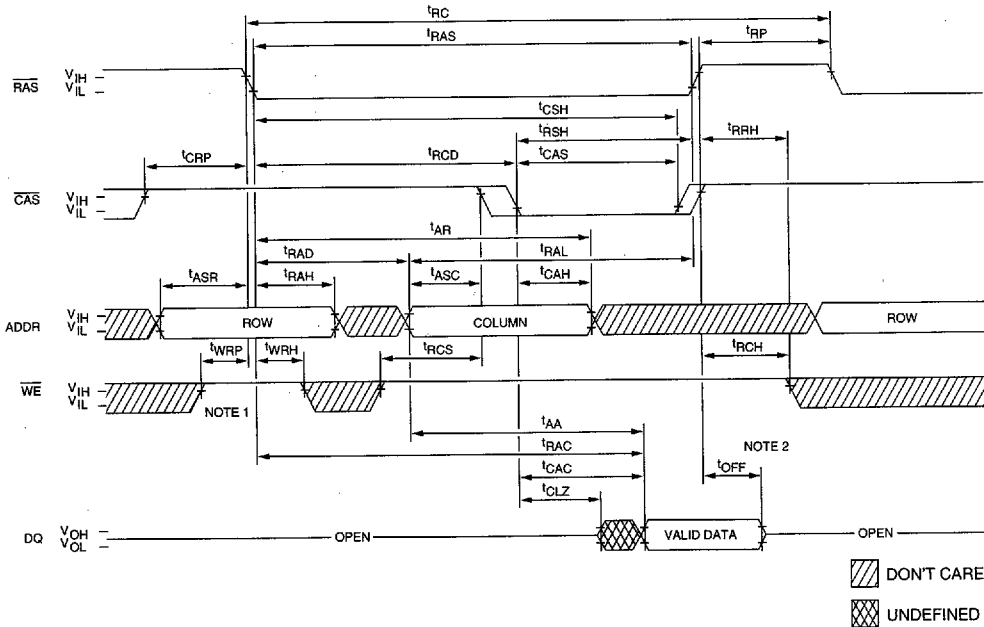
DRAM SIMM

FAST PAGE MODE
TIMING PARAMETERS

SYM	-6		-7		UNITS
	MIN	MAX	MIN	MAX	
t _{AA}		30		35	ns
t _{AR}	45		50		ns
t _{ASC}	0		0		ns
t _{ASR}	0		0		ns
t _{CAC}		15		20	ns
t _{CAH}	10		15		ns
t _{CAS}	15	10,000	20	10,000	ns
t _{CLZ}	0		0		ns
t _{CRP}	10		10		ns
t _{CSH}	60		70		ns
t _{OFF}	3	15	3	20	ns
t _{RAC}		60		70	ns

SYM	-6		-7		UNITS
	MIN	MAX	MIN	MAX	
t _{RAD}	15	30	15	35	ns
t _{RAH}	10		10		ns
t _{RAL}	30		35		ns
t _{RAS}	60	10,000	70	10,000	ns
t _{RC}	110		130		ns
t _{RCD}	20	45	20	50	ns
t _{RCH}	0		0		ns
t _{RCS}	0		0		ns
t _{RP}	40		50		ns
t _{RRH}	0		0		ns
t _{RSH}	15		20		ns

READ CYCLE
(EDO PAGE MODE Module)



DRAM SIMM

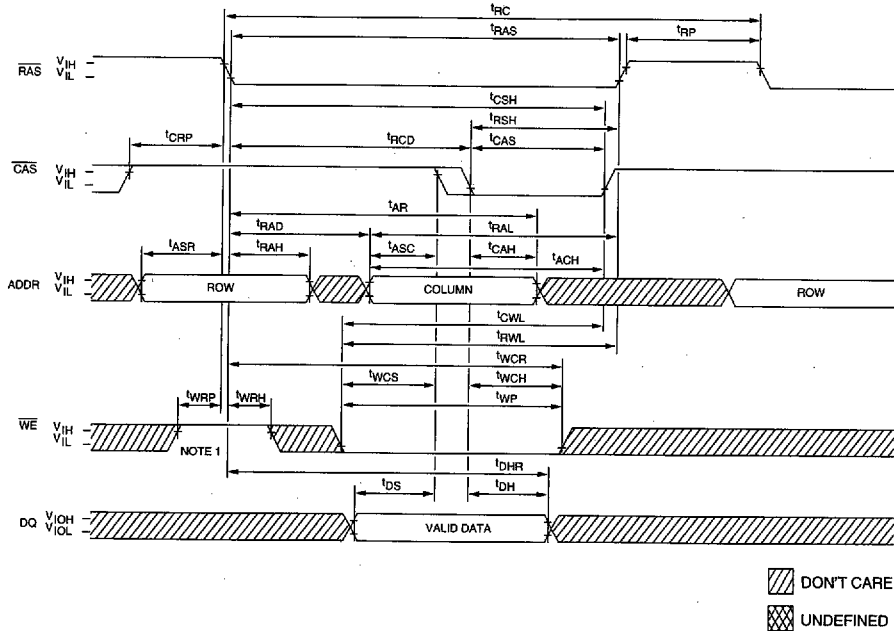
- NOTE:**
1. Although \overline{WE} is a "don't care" at \overline{RAS} time during an access cycle (READ or WRITE), the system designer should implement \overline{WE} HIGH for t_{WRP} and t_{WRH} . This design implementation will facilitate compatibility with future EDO DRAMs.
 2. t_{OFF} is referenced from rising edge of \overline{RAS} or \overline{CAS} , whichever occurs last.

EDO PAGE MODE
TIMING PARAMETERS

SYM	-6		UNITS
	MIN	MAX	
t_{AA}		30	ns
t_{AR}	45		ns
t_{ASC}	0		ns
t_{ASR}	0		ns
t_{CAC}		17	ns
t_{CAH}	10		ns
t_{CAS}	13	10,000	ns
t_{CLZ}	3		ns
t_{CRP}	10		ns
t_{CSH}	50		ns
t_{OFF}	3	15	ns
t_{RAC}		60	ns
t_{RAD}	15	30	ns

SYM	-6		UNITS
	MIN	MAX	
t_{RAH}	10		ns
t_{RAL}	30		ns
t_{RAS}	60	10,000	ns
t_{RC}	110		ns
t_{RCD}	20	45	ns
t_{RCH}	0		ns
t_{RCS}	0		ns
t_{RP}	40		ns
t_{RRH}	0		ns
t_{RSH}	15		ns
t_{WRH}	10		ns
t_{WRP}	10		ns

EARLY WRITE CYCLE 27



DRAM SIMM

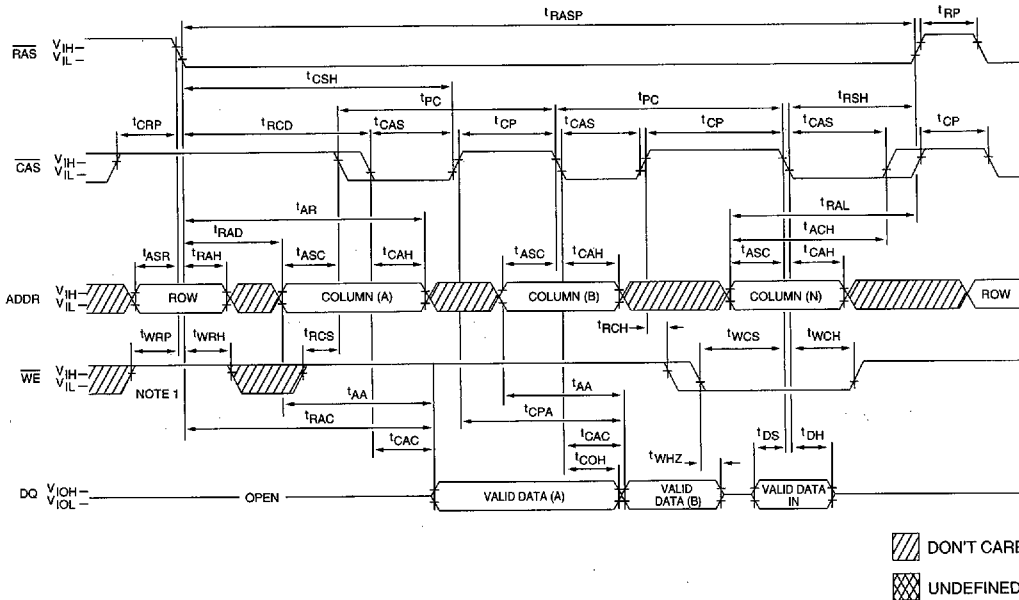
NOTE: 1. Although \overline{WE} is a "don't care" at RAS time during an access cycle (READ or WRITE), the system designer should implement \overline{WE} HIGH for t_{WRP} and t_{WRH} . This design implementation will facilitate compatibility with future EDO DRAMs.

**FAST PAGE MODE AND EDO PAGE MODE
TIMING PARAMETERS**

SYM	-6		-7		UNITS
	MIN	MAX	MIN	MAX	
t_{ACH} (EDO)	15		—		ns
t_{AR}	45		50		ns
t_{ASC}	0		0		ns
t_{ASR}	0		0		ns
t_{CAH}	10		15		ns
t_{CAS} (FPM)	15	10,000	20	10,000	ns
t_{CAS} (EDO)	13	10,000	—	—	ns
t_{CRP}	10		10		ns
t_{CSH} (FPM)	60		70		ns
t_{CSH} (EDO)	50		—		ns
t_{CWL}	15		20		ns
t_{DH} (FPM)	10		15		ns
t_{DH} (EDO)	9		—		ns
t_{DHR}	45		55		ns
t_{DS}	0		0		ns

SYM	-6		-7		UNITS
	MIN	MAX	MIN	MAX	
t_{RAD}	15	30	15	35	ns
t_{RAH}	10		10		ns
t_{RAL}	30		35		ns
t_{RAS}	60	10,000	70	10,000	ns
t_{RC}	110		130		ns
t_{RCD}	20	45	20	50	ns
t_{RP}	40		50		ns
t_{RSH}	15		20		ns
t_{RWL}	15		20		ns
t_{WCH}	10		15		ns
t_{WCR}	45		55		ns
t_{WCS}	0		0		ns
t_{WP}	10		15		ns
t_{WRH}	10		10		ns
t_{WRP}	10		10		ns

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



NOTE: 1. Although \overline{WE} is a "don't care" at \overline{RAS} time during an access cycle (READ or WRITE), the system designer should implement \overline{WE} HIGH for $tWRP$ and $tWRH$. This design implementation will facilitate compatibility with future EDO DRAMs.

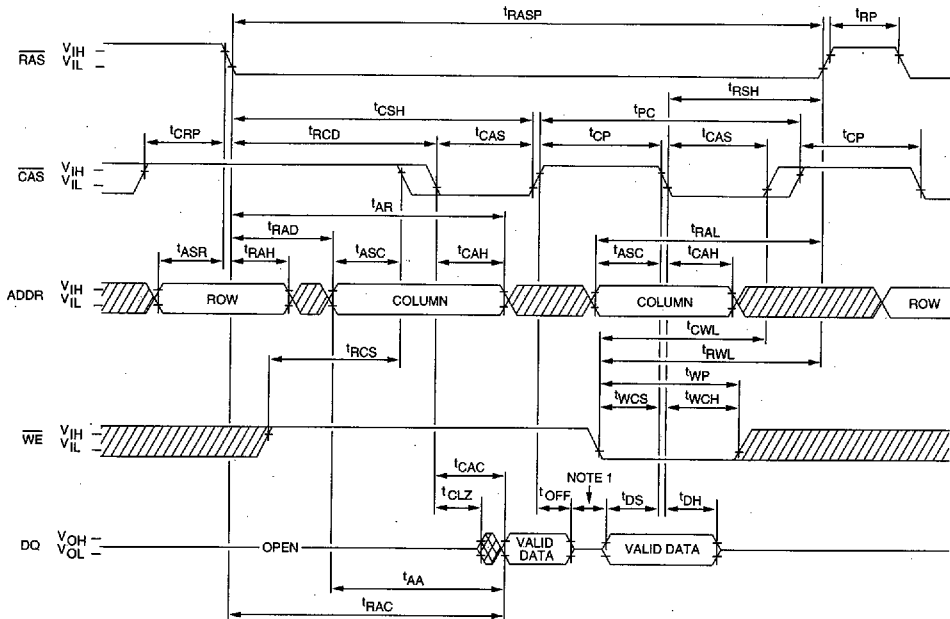
EDO PAGE MODE
TIMING PARAMETERS

SYM	-6		UNITS
	MIN	MAX	
t_{AA}		30	ns
t_{ACH}	15		ns
t_{AR}	45		ns
t_{ASC}	0		ns
t_{ASR}	0		ns
t_{CAC}		17	ns
t_{CAH}	10		ns
t_{CAS}	13	10,000	ns
t_{COH}	5		ns
t_{CP}	10		ns
t_{CPA}		35	ns
t_{CRP}	10		ns
t_{CSH}	50		ns
t_{DH}	9		ns
t_{DS}	0		ns
t_{PC}	26		ns

SYM	-6		UNITS
	MIN	MAX	
t_{RAC}		60	ns
t_{RAD}	15	30	ns
t_{RAH}	10		ns
t_{RAL}	30		ns
t_{RASP}	60	100,000	ns
t_{RCD}	20	45	ns
t_{RCH}	0		ns
t_{RCS}	0		ns
t_{RP}	40		ns
t_{RSH}	15		ns
t_{WCH}	10		ns
t_{WCS}	0		ns
t_{WHZ}	3	15	ns
t_{WRH}	10		ns
t_{WRP}	10		ns

DRAM SIMM

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



▨ DON'T CARE
▩ UNDEFINED

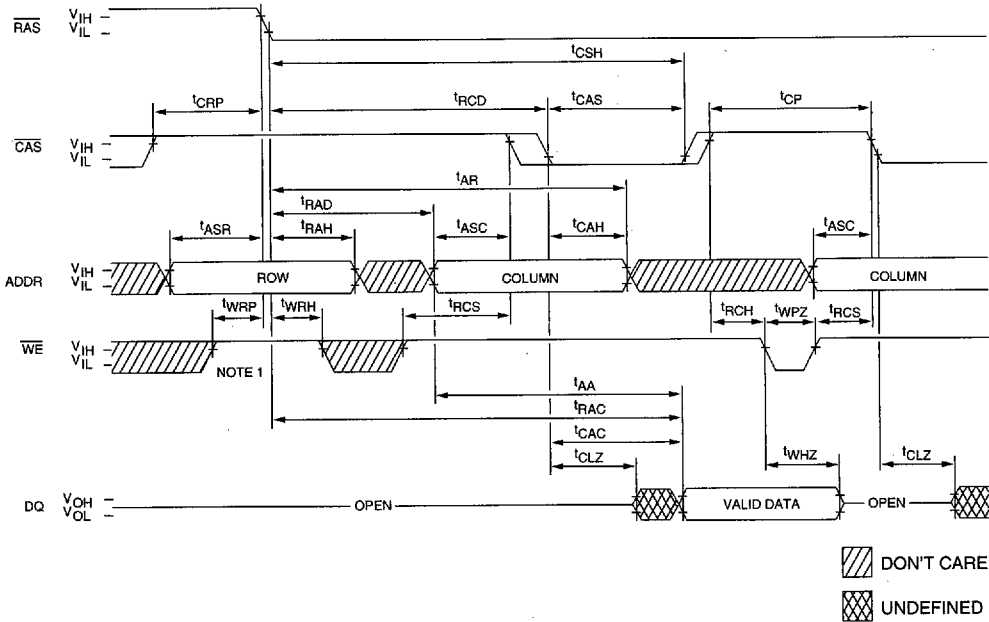
NOTE: 1. Do not drive data prior to tristate.

FAST PAGE MODE
TIMING PARAMETERS

SYM	-6		-7		UNITS
	MIN	MAX	MIN	MAX	
tAA		30		35	ns
tAR	45		50		ns
tASC	0		0		ns
tASR	0		0		ns
tCAC		15		20	ns
tCAH	10		15		ns
tCAS	15	10,000	20	10,000	ns
tCLZ	0		0		ns
tCP	10		10		ns
tCRP	10		10		ns
tCSH	60		70		ns
tCWL	15		20		ns
tDH	10		15		ns
tDS	0		0		ns
tOFF	3	15	3	20	ns

SYM	-6		-7		UNITS
	MIN	MAX	MIN	MAX	
tPC	35		40		ns
tRAC		60		70	ns
tRAD	15	30	15	35	ns
tRAH	10		10		ns
tRAL	30		35		ns
tRASP	60	100,000	70	100,000	ns
tRCD	20	45	20	50	ns
tRCS	0		0		ns
tRP	40		50		ns
tRSH	15		20		ns
tRWL	15		20		ns
tWCH	10		15		ns
tWCS	0		0		ns
tWP	10		15		ns

EDO READ CYCLE
(with WE-controlled disable)



DRAM SIMM

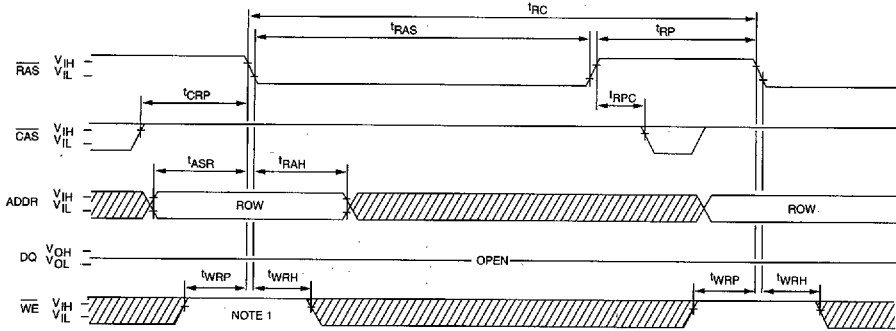
NOTE: 1. Although \overline{WE} is a "don't care" at \overline{RAS} time during an access cycle (READ or WRITE), the system designer should implement \overline{WE} HIGH for $tWRP$ and $tWRH$. This design implementation will facilitate compatibility with future EDO DRAMs.

EDO PAGE MODE
TIMING PARAMETERS

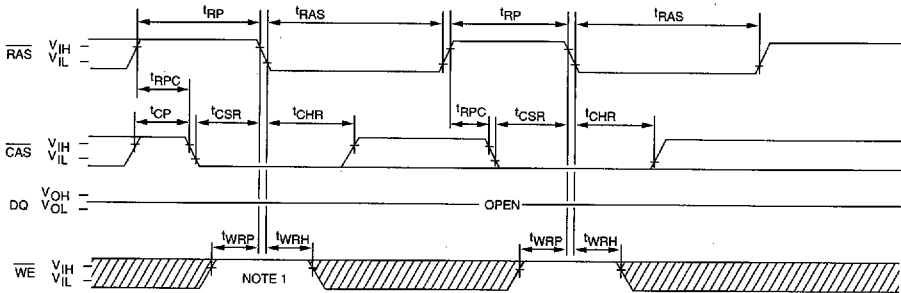
SYM	-6		UNITS
	MIN	MAX	
tAA		30	ns
tAR	45		ns
tASC	0		ns
tASR	0		ns
tCAC		17	ns
tCAH	10		ns
tCAS	13	10,000	ns
tCLZ	3		ns
tCP	10		ns
tCRP	10		ns
tCSH	50		ns

SYM	-6		UNITS
	MIN	MAX	
tRAC		60	ns
tRAD	15	30	ns
tRAH	10		ns
tRCD	20	45	ns
tRCH	0		ns
tRCS	0		ns
tWHZ	3	15	ns
tWPZ	10		ns
tWRH	10		ns
tWRP	10		ns

RAS-ONLY REFRESH CYCLE 27



CBR REFRESH CYCLE 29
(Addresses = DON'T CARE)



DON'T CARE
 UNDEFINED

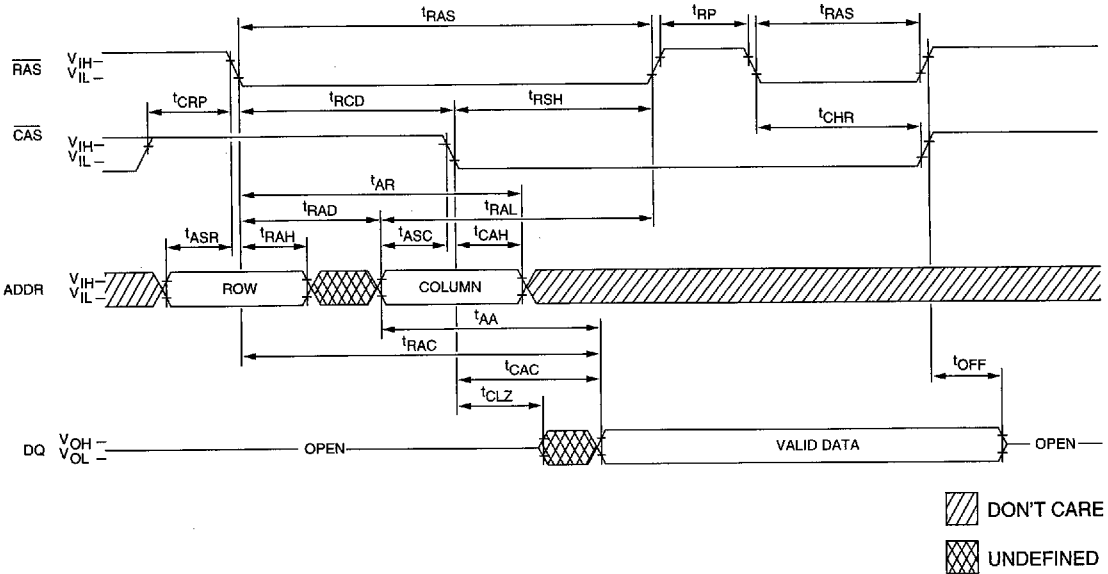
NOTE: 1. Although \overline{WE} is a "don't care" at \overline{RAS} time during an access cycle (READ or WRITE), the system designer should implement \overline{WE} HIGH for $tWRP$ and $tWRH$. This design implementation will facilitate compatibility with future EDO DRAMs.

FAST PAGE MODE AND EDO PAGE MODE
TIMING PARAMETERS

SYM	-6		-7		UNITS
	MIN	MAX	MIN	MAX	
t_{ASR}	0		0		ns
t_{CHR}	10		10		ns
t_{CP}	10		10		ns
t_{CRP}	10		10		ns
t_{CSR}	10		10		ns
t_{RAH}	10		10		ns
t_{RAS}	60	10,000	70	10,000	ns

SYM	-6		-7		UNITS
	MIN	MAX	MIN	MAX	
t_{RC}	110		130		ns
t_{RP}	40		50		ns
t_{RPC} (FPM)	0		0		ns
t_{RPC} (EDO)	5		—		ns
t_{WRH}	10		10		ns
t_{WRP}	10		10		ns

HIDDEN REFRESH CYCLE ^{20, 27}
(WE = HIGH)



DRAM SIMM

FAST PAGE MODE AND EDO PAGE MODE
TIMING PARAMETERS

SYM	-6		-7		UNITS
	MIN	MAX	MIN	MAX	
t _{AA}		30		35	ns
t _{AR}	45		50		ns
t _{ASC}	0		0		ns
t _{ASR}	0		0		ns
t _{CAC (FPM)}		15		20	ns
t _{CAC (EDO)}		17		—	ns
t _{CAH}	10		15		ns
t _{CHR}	10		10		ns
t _{CLZ}	3		3		ns
t _{CRP}	10		10		ns

SYM	-6		-7		UNITS
	MIN	MAX	MIN	MAX	
t _{OFF}	3	15	3	20	ns
t _{RAC}		60		70	ns
t _{RAD}	15	30	15	35	ns
t _{RAH}	10		10		ns
t _{RAL}	30		35		ns
t _{RAS}	60	10,000	70	10,000	ns
t _{RCD}	20	45	20	50	ns
t _{RP}	40		50		ns
t _{RSH}	15		20		ns