MICRON TECHNOLOGY, INC.

MT4C4001J
1 MEG x 4 DRAM

T-46-23-18

DRAM

1 MEG x 4 DRAM

FAST PAGE MODE

FEATURES

- Industry standard x4 pinout, timing, functions and packages
- High-performance, CMOS silicon-gate process
- Single +5V ±10% power supply
- Low power, 3mW standby; 225mW active, typical
- All inputs, outputs and clocks are fully TTL compatible
- 1,024-cycle refresh distributed across 16ms
- Refresh modes: $\overline{RAS}$-ONLY, $\overline{CAS}$-BEFORE-$\overline{RAS}$ (CBR) and HIDDEN
- FAST PAGE MODE access cycle

OPTIONS

	MARKING
• Timing	
60ns access	-6
70ns access	-7
80ns access	-8
• Packages	
Plastic SOJ (300 mil)	DJ
Plastic TSOP (300 mil)*	TG
Plastic ZIP (350 mil)	Z

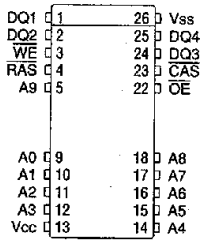
NOTE: Available in die form (commercial or military) or military ceramic packages. Please consult factory for die data sheets or refer to Micron's *Military Data Book*.

• Operating Temperature, T_A	
Commercial (0°C to +70°C)	None
Industrial (-40°C to +85°C)	IT

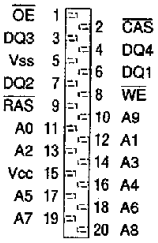
- Part Number Example: MT4C4001JDJ-6

PIN ASSIGNMENT (Top View)

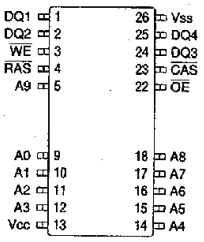
20-Pin SOJ (N-2)



20-Pin ZIP (O-1)



20-Pin TSOP (R-1)



*Consult factory on availability of reverse pinout TSOP packages

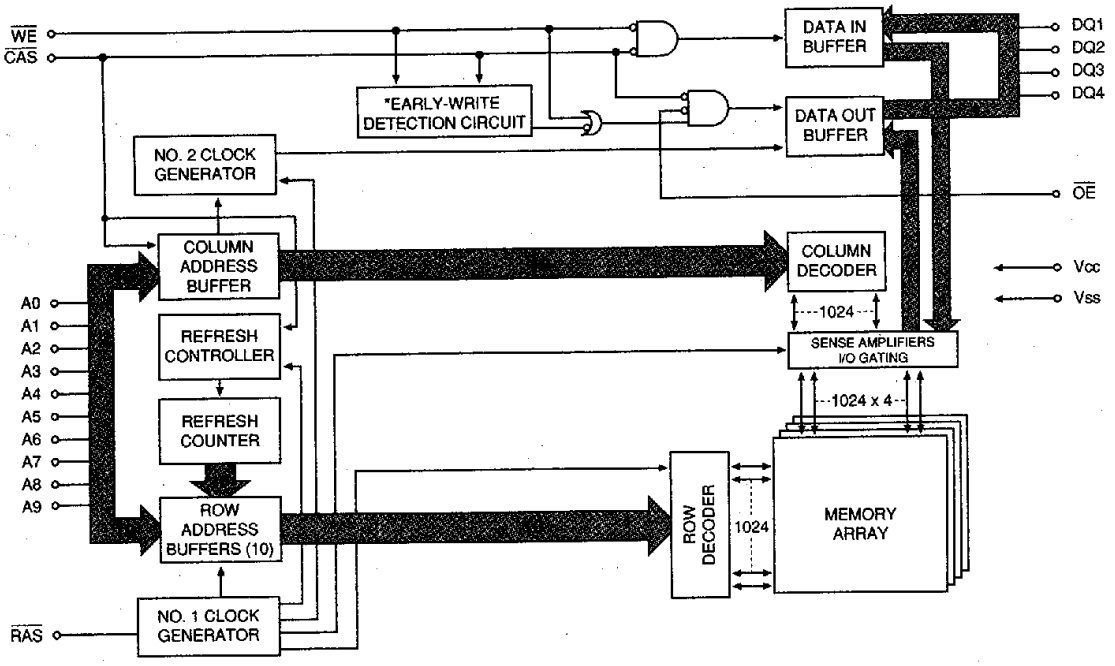
GENERAL DESCRIPTION

The MT4C4001J is a randomly accessed solid-state memory containing 4,194,304 bits organized in a x4 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. READ and WRITE cycles are 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. If $\overline{WE}$ goes LOW prior to $\overline{CAS}$ going LOW, the output pin(s) remain open (High-Z) until the next $\overline{CAS}$ cycle. If $\overline{WE}$ goes LOW after data reaches the output pin(s), The Qs are activated and retain the selected cell data as long as $\overline{CAS}$ remains low (regardless of $\overline{WE}$ or $\overline{RAS}$). This late $\overline{WE}$ pulse results in a READ-WRITE cycle. The four data inputs and four data outputs are routed through four pins using common I/O, and pin direction is controlled by $\overline{WE}$ and $\overline{OE}$.

FAST PAGE MODE operations allow faster data operations (READ, WRITE or READ-MODIFY-WRITE) within a row address (A0-A9) defined 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.

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, $\overline{RAS}$-ONLY, $\overline{CAS}$-BEFORE-$\overline{RAS}$ (CBR) or HIDDEN refresh) so that all 1,024 combinations of $\overline{RAS}$ addresses (A0-A9) are executed at least every 16ms, regardless of sequence. The CBR refresh cycle will invoke the internal refresh counter for automatic $\overline{RAS}$ addressing.

FUNCTIONAL BLOCK DIAGRAM
FAST PAGE MODE



*NOTE: $\overline{WE}$ LOW prior to $\overline{CAS}$ LOW, EW detection circuit output is a HIGH (EARLY-WRITE)
$\overline{CAS}$ LOW prior to $\overline{WE}$ LOW, EW detection circuit output is a LOW (LATE-WRITE)

TRUTH TABLE

FUNCTION		$\overline{RAS}$	$\overline{CAS}$	$\overline{WE}$	$\overline{OE}$	ADDRESSES t_R	ADDRESSES t_C	DATA IN/OUT 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 READ	1st Cycle	L	H→L	H	L	ROW	COL	Data Out
	2nd Cycle	L	H→L	H	L	n/a	COL	Data Out
FAST-PAGE-MODE EARLY-WRITE	1st Cycle	L	H→L	L	X	ROW	COL	Data In
	2nd Cycle	L	H→L	L	X	n/a	COL	Data In
FAST-PAGE-MODE READ-WRITE	1st Cycle	L	H→L	H→L	L→H	ROW	COL	Data Out, Data In
	2nd Cycle	L	H→L	H→L	L→H	n/a	COL	Data Out, Data In
$\overline{RAS}$-ONLY REFRESH		L	H	X	X	ROW	n/a	High-Z
HIDDEN REFRESH	READ	L→H→L	L	H	L	ROW	COL	Data Out
	WRITE	L→H→L	L	L	X	ROW	COL	Data In
$\overline{CAS}$-BEFORE-$\overline{RAS}$ REFRESH		H→L	L	H	X	X	X	High-Z

ABSOLUTE MAXIMUM RATINGS*

Voltage on Any Pin Relative to V_{SS} ..... -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.

ELECTRICAL CHARACTERISTICS AND RECOMMENDED DC OPERATING CONDITIONS

(Notes: 1, 3, 4, 6, 7) (V_{CC} = 5V ±10%)

PARAMETER/CONDITION	SYMBOL	MIN	MAX	UNITS	NOTES
Supply Voltage	V_{CC}	4.5	5.5	V	1
Input High (Logic 1) Voltage, All Inputs	V_{IH}	2.4	V_{CC}+1	V	1
Input Low (Logic 0) Voltage, All Inputs	V_{IL}	-1.0	0.8	V	1
INPUT LEAKAGE CURRENT Any Input 0V ≤ V_{IN} ≤ 6.5V (All other pins not under test = 0V)	I_I	-2	2	µA	
OUTPUT LEAKAGE CURRENT (Q is disabled, 0V ≤ V_{OUT} ≤ 5.5V)	I_{OZ}	-10	10	µA	
OUTPUT LEVELS Output High Voltage (I_{OUT} = -5mA)	V_{OH}	2.4		V	
Output Low Voltage (I_{OUT} = 4.2mA)	V_{OL}		0.4	V	

PARAMETER/CONDITION	SYMBOL	MAX -6	MAX -7	MAX -8	UNITS	NOTES
STANDBY CURRENT: (TTL) ($\overline{RAS}$ = $\overline{CAS}$ = V_{IH})	I_{CC1}	2	2	2	mA	
STANDBY CURRENT: (CMOS) ($\overline{RAS}$ = $\overline{CAS}$ = Other Inputs = V_{CC} -0.2V)	I_{CC2}	1	1	1	mA	
OPERATING CURRENT: Random READ/WRITE Average power supply current ($\overline{RAS}$, $\overline{CAS}$, Address Cycling: ^tRC = ^tRC (MIN))	I_{CC3}	110	100	90	mA	3, 4
OPERATING CURRENT: FAST PAGE MODE Average power supply current ($\overline{RAS}$ = V_{IL}, $\overline{CAS}$, Address Cycling: ^tPC = ^tPC (MIN))	I_{CC4}	80	70	60	mA	3, 4
REFRESH CURRENT: $\overline{RAS}$-ONLY Average power supply current ($\overline{RAS}$ Cycling, $\overline{CAS}$ = V_{IH}: ^tRC = ^tRC (MIN))	I_{CC5}	110	100	90	mA	3
REFRESH CURRENT: $\overline{CAS}$-BEFORE-$\overline{RAS}$ Average power supply current ($\overline{RAS}$, $\overline{CAS}$, Address Cycling: ^tRC = ^tRC (MIN))	I_{CC6}	110	100	90	mA	3, 5

CAPACITANCE

PARAMETER	SYMBOL	MIN	MAX	UNITS	NOTES
Input Capacitance: A0-A9	C_{I1}		5	pF	2
Input Capacitance: $\overline{RAS}$, $\overline{CAS}$, $\overline{WE}$, $\overline{OE}$	C_{I2}		7	pF	2
Input/Output Capacitance: DQ	C_{IO}		7	pF	2

ELECTRICAL CHARACTERISTICS AND RECOMMENDED AC OPERATING CONDITIONS

(Notes: 6, 7, 8, 9, 10, 11, 12, 13, 23) (V_{CC} = 5V ±10%)

AC CHARACTERISTICS		-6		-7		-8			
PARAMETER	SYM	MIN	MAX	MIN	MAX	MIN	MAX	UNITS	NOTES
Random READ or WRITE cycle time	tRC	110		130		150		ns	
READ-WRITE cycle time	tRWC	145		185		205		ns	
FAST-PAGE-MODE READ or WRITE cycle time	tPC	40		40		45		ns	
FAST-PAGE-MODE READ-WRITE cycle time	tPRWC	90		95		100		ns	
Access time from $\overline{RAS}$	tRAC		60		70		80	ns	14
Access time from $\overline{CAS}$	tCAC		15		20		20	ns	15
Output Enable	tOE		15		20		20	ns	23
Access time from column address	tAA		30		35		40	ns	
Access time from $\overline{CAS}$ precharge	tCPA		35		40		45	ns	
$\overline{RAS}$ pulse width	tRAS	60	100,000	70	100,000	80	100,000	ns	
$\overline{RAS}$ pulse width (FAST PAGE MODE)	tRASP	60	100,000	70	100,000	80	100,000	ns	
$\overline{RAS}$ hold time	tRSH	15		20		20		ns	
$\overline{RAS}$ precharge time	tRP	40		50		60		ns	
$\overline{CAS}$ pulse width	tCAS	15	100,000	20	100,000	20	100,000	ns	
$\overline{CAS}$ hold time	tCSH	60		70		80		ns	
$\overline{CAS}$ precharge time	tCPN	10		10		10		ns	16
$\overline{CAS}$ precharge time (FAST PAGE MODE)	tCP	10		10		10		ns	
$\overline{RAS}$ to $\overline{CAS}$ delay time	tRCD	20	45	20	50	20	60	ns	17
$\overline{CAS}$ to $\overline{RAS}$ precharge time	tCRP	10		10		10		ns	
Row address setup time	tASR	0		0		0		ns	
Row address hold time	tRAH	10		10		10		ns	
$\overline{RAS}$ to column address delay time	tRAD	15	30	15	35	15	40	ns	18
Column address setup time	tASC	0		0		0		ns	
Column address hold time	tCAH	10		15		15		ns	
Column address hold time (referenced to $\overline{RAS}$)	tAR	50		55		60		ns	
Column address to $\overline{RAS}$ lead time	tRAL	30		35		40		ns	
Read command setup time	tRCS	0		0		0		ns	
Read command hold time (referenced to $\overline{CAS}$)	tRCH	0		0		0		ns	19
Read command hold time (referenced to $\overline{RAS}$)	tRRH	0		0		0		ns	19
$\overline{CAS}$ to output in Low-Z	tCLZ	0		0		0		ns	
Output buffer turn-off delay	tOFF	0	15	0	20	0	20	ns	20

ELECTRICAL CHARACTERISTICS AND RECOMMENDED AC OPERATING CONDITIONS

(Notes: 6, 7, 8, 9, 10, 11, 12, 13, 23) (Vcc = 5V ±10%)

AC CHARACTERISTICS		-6		-7		-8			
PARAMETER	SYM	MIN	MAX	MIN	MAX	MIN	MAX	UNITS	NOTES
$\overline{WE}$ command setup time	t_{WCS}	0		0		0		ns	21, 27
Write command hold time	t_{WCH}	10		15		15		ns	
Write command hold time (referenced to $\overline{RAS}$)	t_{WCR}	45		55		60		ns	
Write command pulse width	t_{WP}	10		15		15		ns	
Write command to $\overline{RAS}$ lead time	t_{RWL}	15		20		20		ns	
Write command to $\overline{CAS}$ lead time	t_{CWL}	15		20		20		ns	
Data-in setup time	t_{DS}	0		0		0		ns	22
Data-in hold time	t_{DH}	10		15		15		ns	22
Data-in hold time (referenced to $\overline{RAS}$)	t_{DHR}	45		55		60		ns	
$\overline{RAS}$ to $\overline{WE}$ delay time	t_{RWD}	85		100		110		ns	21
Column address to $\overline{WE}$ delay time	t_{AWD}	60		65		70		ns	21
$\overline{CAS}$ to $\overline{WE}$ delay time	t_{CWD}	45		50		50		ns	21
Transition time (rise or fall)	t_T	3	50	3	50	3	50	ns	9, 10
Refresh period (1,024 cycles)	t_{REF}		16		16		16	ms	
$\overline{RAS}$ to $\overline{CAS}$ precharge time	t_{RPC}	0		0		0		ns	
$\overline{CAS}$ setup time ($\overline{CAS}$-BEFORE-$\overline{RAS}$ refresh)	t_{CSR}	10		10		10		ns	5
$\overline{CAS}$ hold time ($\overline{CAS}$-BEFORE-$\overline{RAS}$ refresh)	t_{CHR}	15		15		15		ns	5
$\overline{WE}$ hold time ($\overline{CAS}$-BEFORE-$\overline{RAS}$ refresh)	t_{WRH}	10		10		10		ns	25, 28
$\overline{WE}$ setup time ($\overline{CAS}$-BEFORE-$\overline{RAS}$ refresh)	t_{WRP}	10		10		10		ns	25, 28
$\overline{WE}$ hold time (WCBR test cycle)	t_{WTH}	10		10		10		ns	25, 28
$\overline{WE}$ setup time (WCBR test cycle)	t_{WTS}	10		10		10		ns	25, 28
$\overline{OE}$ setup prior to RAS during HIDDEN REFRESH cycle	t_{ORD}	0		0		0		ns	
Output disable	t_{OD}		15		20		20	ns	27
$\overline{OE}$ hold time from $\overline{WE}$ during READ-MODIFY-WRITE cycle	t_{OEH}	15		20		20		ns	26

NOTES

1. All voltages referenced to V_{SS}.
2. This parameter is sampled. V_{CC} = 5V ±10%, f = 1 MHz.
3. I_{CC} is dependent on cycle rates.
4. I_{CC} is dependent on output loading and cycle rates. Specified values are obtained with minimum cycle time and the outputs open.
5. Enables on-chip refresh and address counters.
6. The minimum specifications are used only to indicate cycle time at which proper operation over the full temperature range is assured.
7. An initial pause of 100µs is required after power-up followed by eight $\overline{RAS}$ refresh cycles ($\overline{RAS}$-ONLY or CBR with $\overline{WE}$ HIGH) before proper device operation is assured. The eight $\overline{RAS}$ cycle wake-up should be repeated any time the ^{t}REF refresh requirement is exceeded.
8. AC characteristics assume ^{t}T = 5ns.
9. 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}).
10. 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.
11. If $\overline{CAS}$ = V_{IH}, data output is High-Z.
12. If $\overline{CAS}$ = V_{IL}, data output may contain data from the last valid READ cycle.
13. Measured with a load equivalent to 2 TTL gates and 100pF.
14. Assumes that ^{t}RCD < ^{t}RCD (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.
15. Assumes that ^{t}RCD ≥ ^{t}RCD (MAX).
16. If $\overline{CAS}$ is LOW at the falling edge of $\overline{RAS}$, Q will be maintained from the previous cycle. To initiate a new cycle and clear the data out buffer, $\overline{CAS}$ must be pulsed HIGH for ^{t}CPN.
17. Operation within the ^{t}RCD (MAX) limit ensures that ^{t}RAC (MAX) can be met. ^{t}RCD (MAX) is specified as a reference point only; if ^{t}RCD is greater than the specified ^{t}RCD (MAX) limit, then access time is controlled exclusively by ^{t}CAC.
18. Operation within the ^{t}RAD (MAX) limit ensures that ^{t}RAC (MIN) and ^{t}CAC (MIN) can be met. ^{t}RAD (MAX) is specified as a reference point only; if ^{t}RAD is greater than the specified ^{t}RAD (MAX) limit, then access time is controlled exclusively by ^{t}AA.
19. Either ^{t}RCH or ^{t}RRH must be satisfied for a READ cycle.
20. ^{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}.
21. ^{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. $\overline{OE}$ held HIGH and $\overline{WE}$ taken LOW after $\overline{CAS}$ goes LOW results in a LATE-WRITE ($\overline{OE}$ controlled) cycle. ^{t}WCS, ^{t}RWD, ^{t}CWD and ^{t}AWD are not applicable in a LATE-WRITE cycle.
22. These parameters are referenced to $\overline{CAS}$ leading edge in EARLY-WRITE cycles and $\overline{WE}$ leading edge in LATE-WRITE or READ-MODIFY-WRITE cycles.
23. If $\overline{OE}$ is tied permanently LOW, LATE-WRITE or READ-MODIFY-WRITE operations are not possible.
24. A HIDDEN REFRESH may also be performed after a WRITE cycle. In this case, $\overline{WE}$ = LOW and $\overline{OE}$ = HIGH.
25. ^{t}WTS and ^{t}WTH are setup and hold specifications for the $\overline{WE}$ pin being held LOW to enable the JEDEC test mode (with CBR timing constraints). These two parameters are the inverts of ^{t}WRP and ^{t}WRH in the CBR refresh cycle.
26. LATE-WRITE and READ-MODIFY-WRITE cycles must have both ^{t}OD and ^{t}OEH met ($\overline{OE}$ HIGH during WRITE cycle) in order to ensure that the output buffers will be open during the WRITE cycle. The DQs will provide the previously read data if $\overline{CAS}$ remains LOW and $\overline{OE}$ is taken back LOW after ^{t}OEH is met. If $\overline{CAS}$ goes HIGH prior to $\overline{OE}$ going back LOW, the DQs will remain open.
27. The DQs open during READ cycles once ^{t}OD or ^{t}OFF occur. If $\overline{CAS}$ goes HIGH first, $\overline{OE}$ becomes a "don't care." If $\overline{OE}$ goes HIGH and $\overline{CAS}$ stays LOW, $\overline{OE}$ is not a "don't care;" and the DQs will provide the previously read data if $\overline{OE}$ is taken back LOW (while $\overline{CAS}$ remains LOW).
28. JEDEC test version only.

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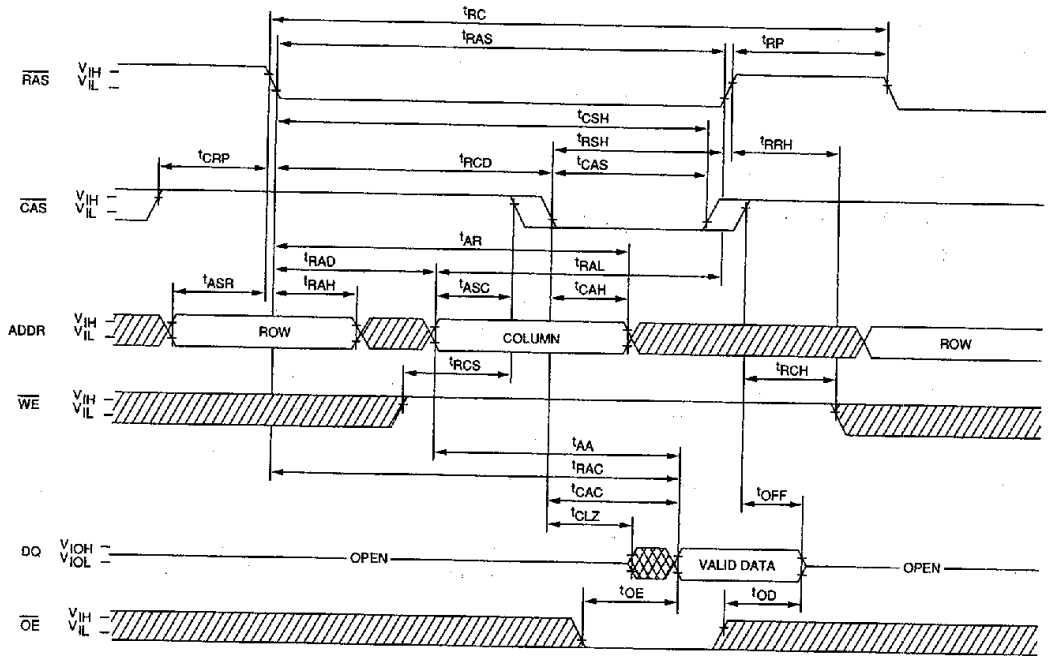
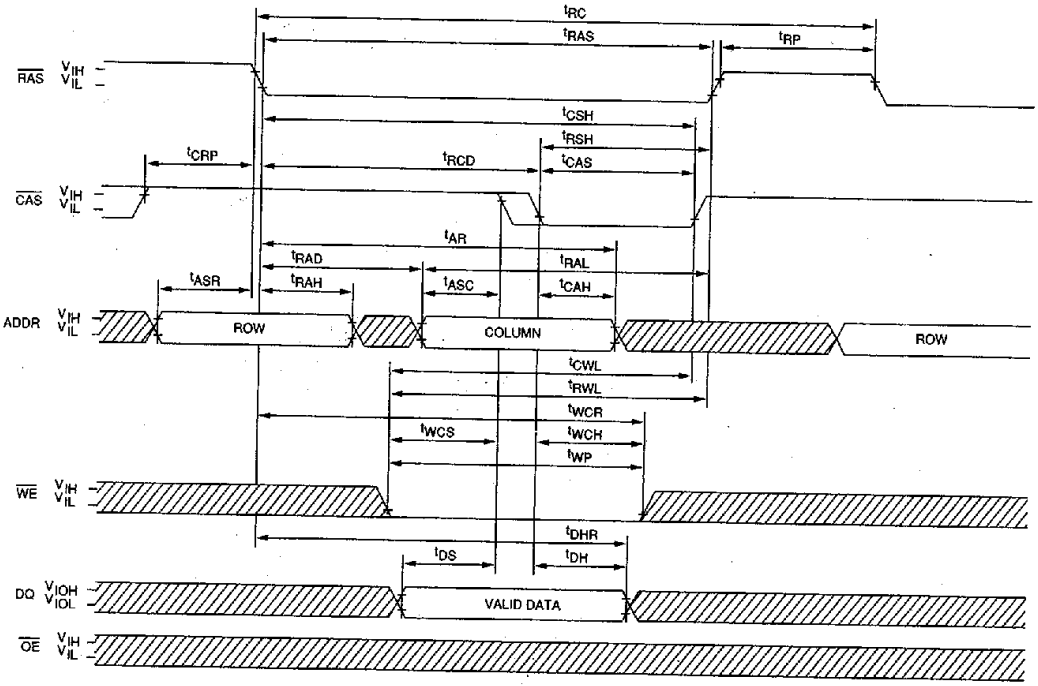
READ CYCLE



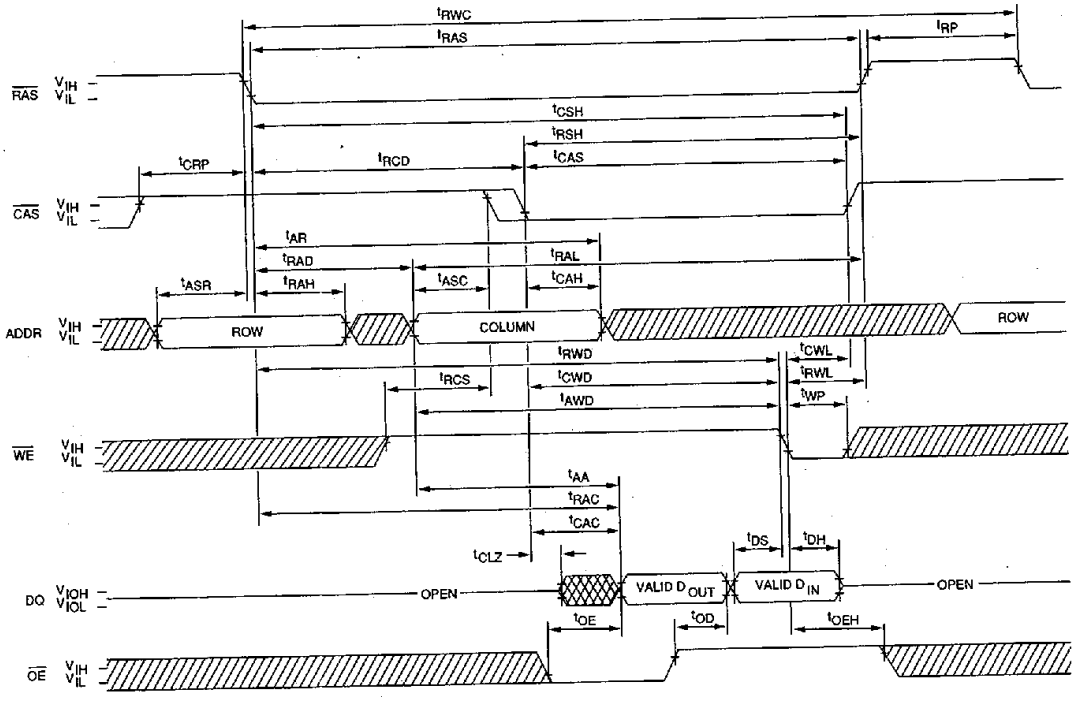
EARLY-WRITE CYCLE



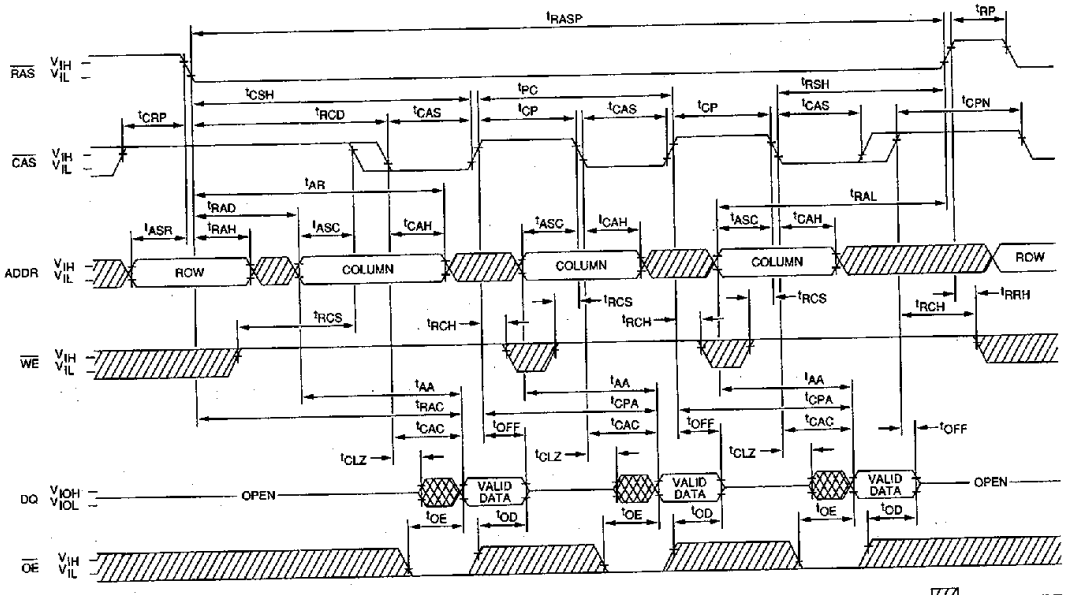
DON'T CARE

UNDEFINED

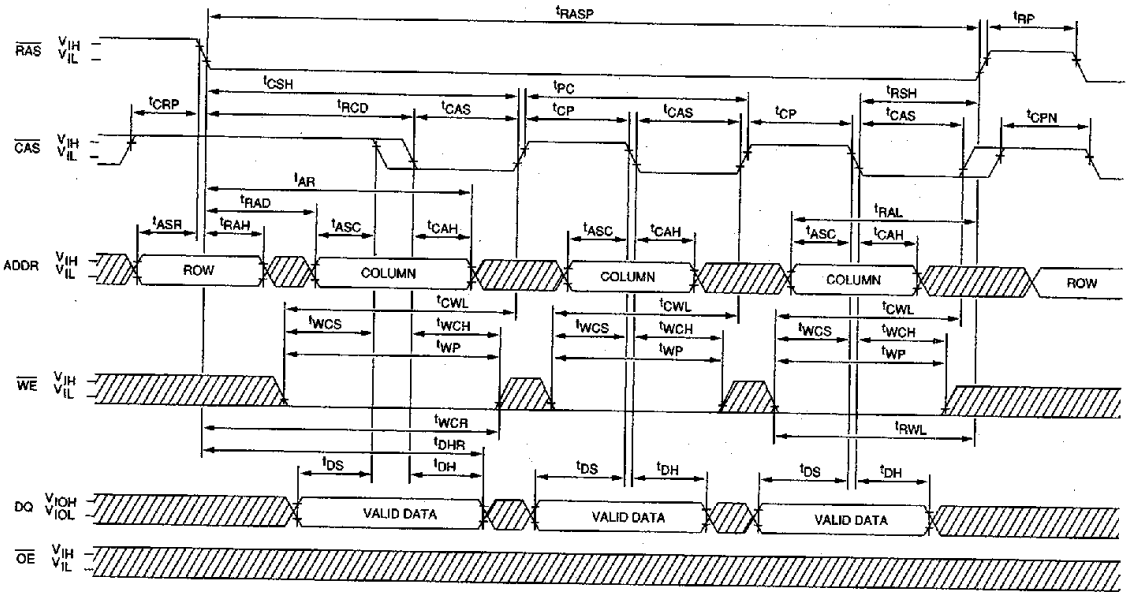
READ-WRITE CYCLE
(LATE-WRITE and READ-MODIFY-WRITE CYCLES)



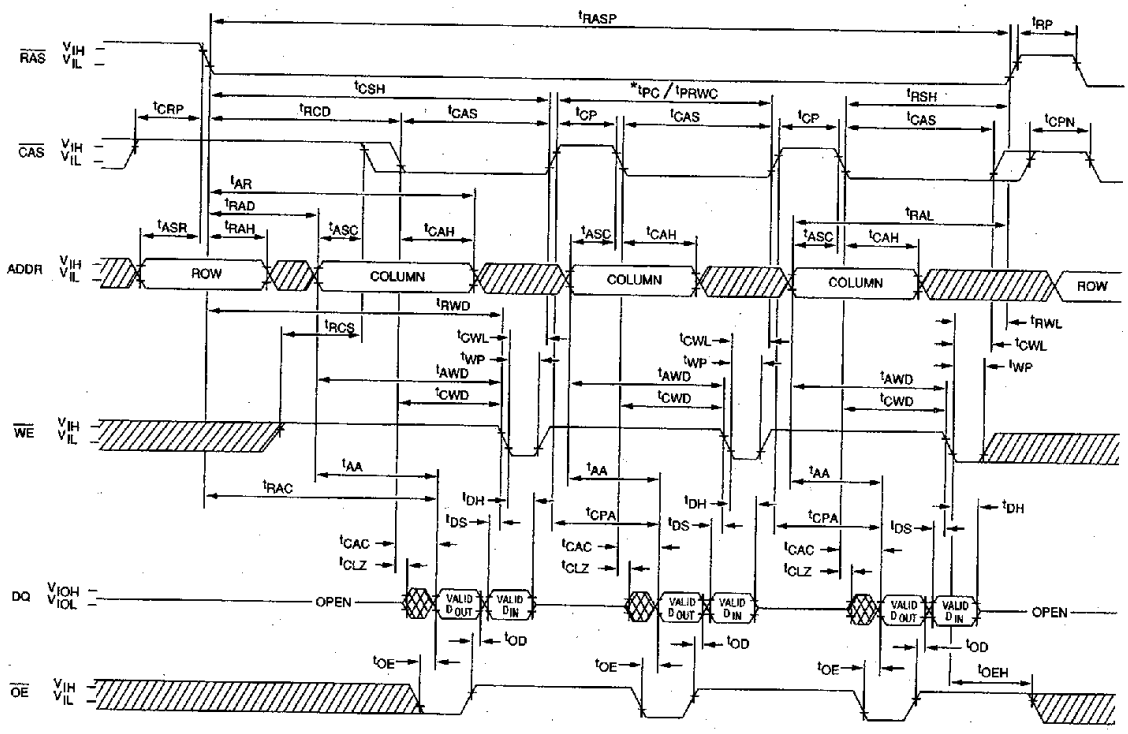
FAST-PAGE-MODE READ CYCLE



FAST-PAGE-MODE EARLY-WRITE CYCLE



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



*tPC is for LATE-WRITE only.

DON'T CARE

UNDEFINED

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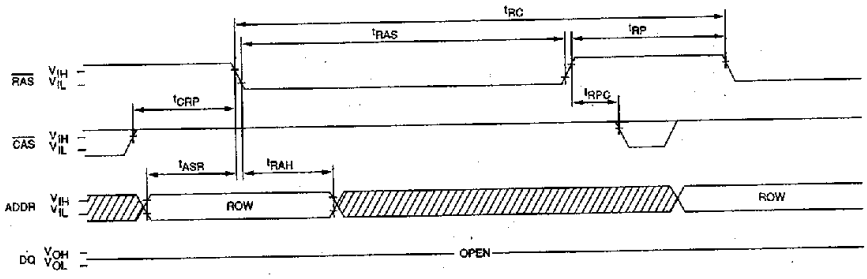
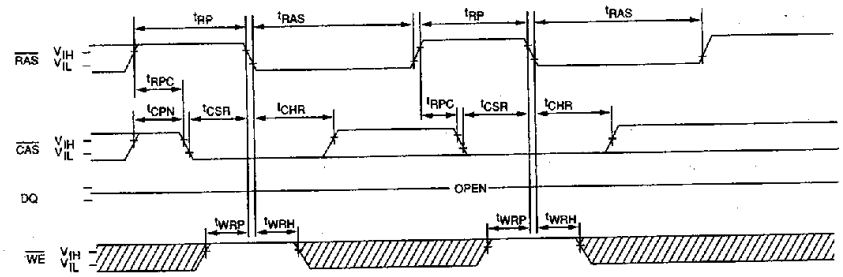
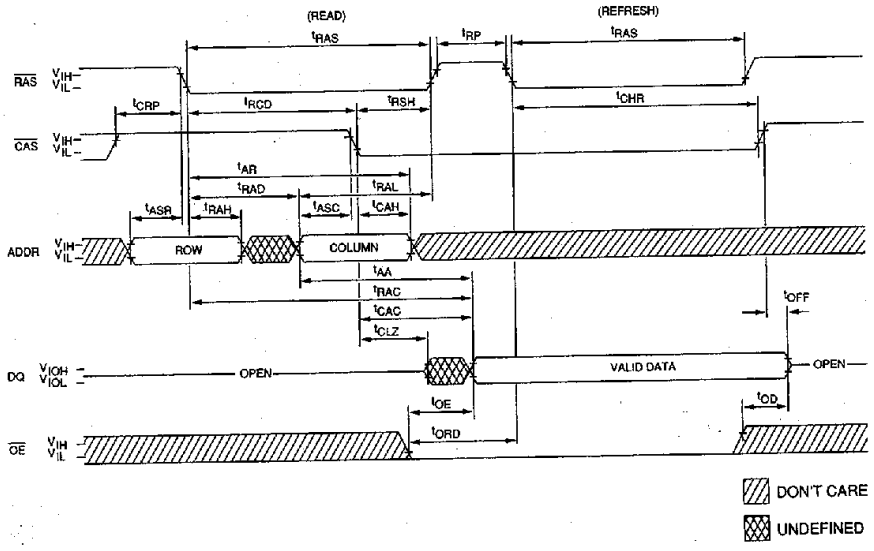
RAS-ONLY REFRESH CYCLE
(ADDR = A0-A9; WE = DON'T CARE)



CAS-BEFORE-RAS REFRESH CYCLE
(A0-A9, and OE = DON'T CARE)



HIDDEN REFRESH CYCLE [24]
(WE = HIGH; OE = LOW)



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DRAM

4 MEG POWER-UP AND REFRESH CONSTRAINTS

The EIA/JEDEC 4 Meg DRAM introduces two potential incompatibilities compared to the previous generation 1 Meg DRAM. The incompatibilities involve refresh and power-up. Understanding these incompatibilities and providing for them will offer the designer and system user greater compatibility between the 1 Meg and 4 Meg.

REFRESH

The most commonly used refresh mode of the 1 Meg is the CBR ($\overline{CAS}$-BEFORE-$\overline{RAS}$) REFRESH cycle. The CBR for the 1 Meg specifies the $\overline{WE}$ pin as a "don't care." The 4 Meg, on the other hand, specifies the CBR REFRESH mode with the $\overline{WE}$ pin held at a voltage HIGH level.

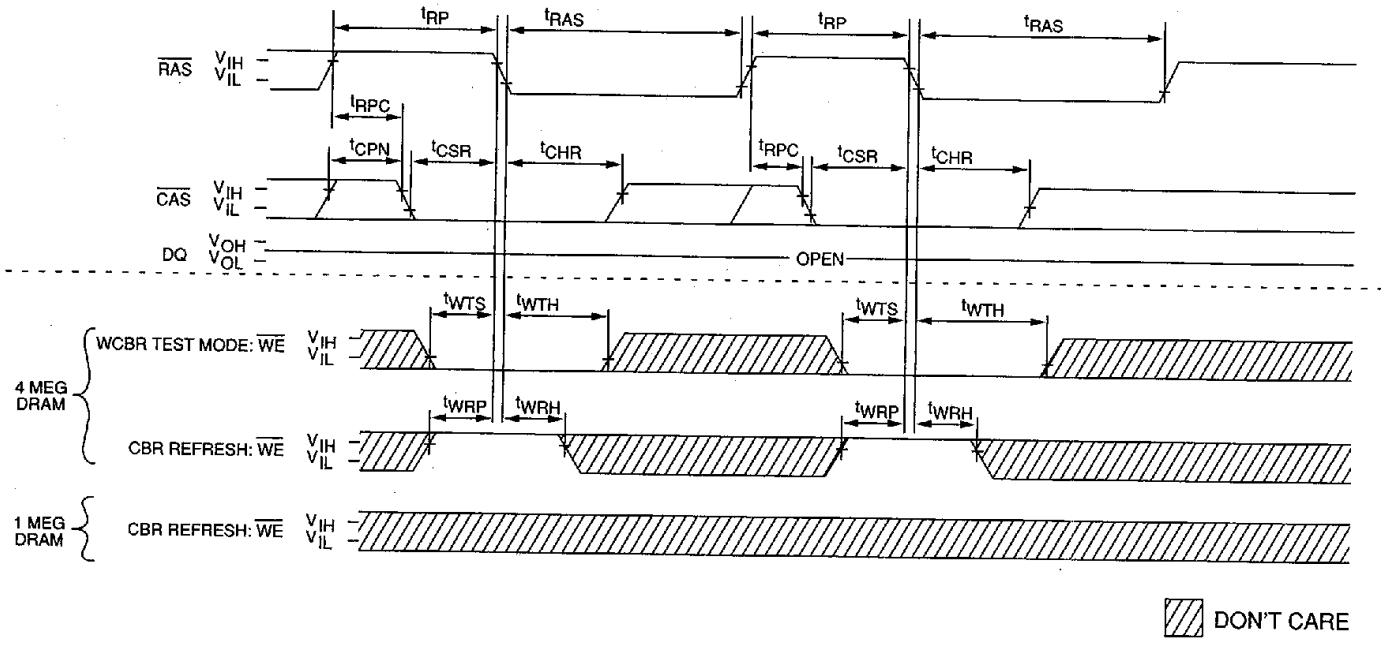
A CBR cycle with $\overline{WE}$ LOW will put the 4 Meg into the JEDEC specified test mode (WCBR).

POWER-UP

The 4 Meg JEDEC test mode constraint may introduce another problem. The 1 Meg POWER-UP cycle requires a 100µs delay followed by any eight $\overline{RAS}$ cycles. The 4 Meg POWER-UP is more restrictive in that eight $\overline{RAS}$-ONLY or CBR REFRESH ($\overline{WE}$ held HIGH) cycles must be used. The restriction is needed since the 4 Meg may power-up in the JEDEC specified test mode and must exit out of the test mode. The only way to exit the 4 Meg JEDEC test mode is with either a $\overline{RAS}$-ONLY or a CBR REFRESH cycle ($\overline{WE}$ held HIGH).

SUMMARY

1. The 1 Meg CBR REFRESH allows the $\overline{WE}$ pin to be "don't care" while the 4 Meg CBR requires $\overline{WE}$ to be HIGH.
2. The eight $\overline{RAS}$ wake-up cycles on the 1 Meg may be any valid $\overline{RAS}$ cycle while the 4 Meg may only use $\overline{RAS}$-ONLY or CBR REFRESH cycles ($\overline{WE}$ held HIGH).



COMPARISON OF 4 MEG TEST MODE AND WCBR TO 1 MEG CBR