

## NMOS 65,536-BIT DYNAMIC RANDOM ACCESS MEMORY

### DESCRIPTION

The Fujitsu MB8264 is a fully decoded, dynamic NMOS random access memory organized as 65536 one-bit words. The design is optimized for high-speed, high performance applications such as mainframe memory, buffer memory, peripheral storage and environments where low power dissipation and compact layout are required.

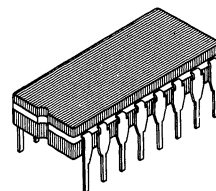
Multiplexed row and column address inputs permit the MB8264 to be housed in a standard 16-pin DIP. Pin-outs conform to the JEDEC approved pin out.

### FEATURES

- 65,536 x 1 RAM, 16-pin package
- Silicon-gate, Double Poly NMOS, single transistor cell
- Row access time:  
150ns Max (MB8264-15)  
200ns Max (MB8264-20)
- Cycle time:  
270ns Min (MB8264-15)  
330ns Min (MB8264-20)
- Low power:  
22 mW Max Standby  
275 mW Max Active (MB8264-15)  
248 mW Max Active (MB8264-20)
- $\pm 10\%$  tolerance on +5V Supply
- On-chip substrate bias generator
- All inputs TTL compatible, low capacitive load
- Three-state TTL compatible output
- "Gated" CAS
- 128 refresh cycles
- Common I/O capability using "Early Write" operation
- Output unlatched at cycle end allows extended page boundary and two-dimensional chip select
- Read-Modify-Write, RAS-only refresh, and Page-Mode capability
- On-chip latches for Addresses and Data-in
- Hidden Refresh Capability
- Pin compatible with HM4864, MK4164, TMS4164, MCM6665,  $\mu$ PD4164 and IMS2600

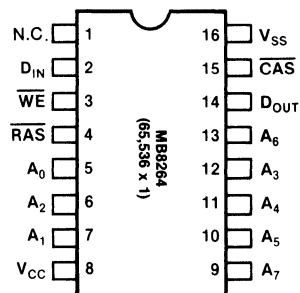
The MB8264 is fabricated using silicon-gate NMOS and Fujitsu's advanced Double-Layer Polysilicon process. This process, coupled with single-transistor memory storage cells, permits maximum circuit density and minimal chip size. Dynamic circuitry is employed in the design, including the sense amplifiers.

Clock timing requirements are non-critical, and power supply tolerance is  $\pm 10\%$ . All inputs/outputs are TTL compatible.

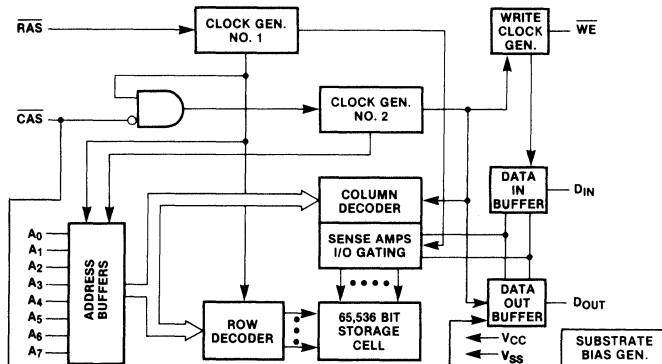


**CERDIP PACKAGE  
DIP-16C-C04**

### PIN ASSIGNMENT



### MB8264 BLOCK DIAGRAM



**MB8264-15/MB8264-20**
**ABSOLUTE MAXIMUM RATINGS** (See NOTE)

Rating	Symbol	Value	Unit
Voltage on any Pin Relative to $V_{SS}$	$V_{IN}, V_{OUT}$	-1 to +7.0	V
Voltage on $V_{CC}$ Supply relative to $V_{SS}$	$V_{CC}$	-1 to +7.0	V
Operating Temperature	$T_{OP}$	0 to +70	°C
Storage Temperature	$T_{STG}$	-55 to +150	°C
Power Dissipation	$P_D$	1.0	W
Short Circuit Output Current	$I_{OS}$	50	mA

NOTE: 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. This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields. However, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high impedance circuit.

**RECOMMENDED OPERATING CONDITIONS**

 (Referenced to  $V_{SS}$ )

Parameter	Symbol	Value			Unit	Temperature
		Min	Typ	Max		
Supply Voltage	$V_{CC}$	4.5	5.0	5.5	V	0°C to +70°C
	$V_{SS}$	0	0	0	V	
Input High Voltage, all inputs	$V_{IH}$	2.4	—	6.5	V	
Input Low Voltage, all inputs	$V_{IL}$	-1.0	—	0.8	V	

**CAPACITANCE** ( $T_A = 25^\circ\text{C}$ )

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Input Capacitance $A_0 \sim A_7, D_{IN}$	$C_{IN1}$	—	—	5	pF
Input Capacitance $RAS, CAS, WE$	$C_{IN2}$	—	—	8	pF
Output Capacitance $D_{OUT}$	$C_{OUT}$	—	—	7	pF

**STATIC CHARACTERISTICS**

(Recommended operating conditions unless otherwise noted.)

Parameter	Symbol	Min	Max	Units
OPERATING CURRENT*				
Average power supply current (MB8264-20)	$I_{CC1}$		45	mA
Average power supply current ( $\overline{RAS}, \overline{CAS}$ cycling; $t_{RC} = \text{min}$ ) (MB8264-15)		—	50	mA
STANDBY CURRENT				
Power supply current ( $\overline{RAS} = \overline{CAS} = V_{IH}$ )	$I_{CC2}$	—	4	mA
REFRESH CURRENT*				
Average power supply current (MB8264-20)	$I_{CC3}$		36	mA
Average power supply current ( $\overline{RAS}$ cycling, $\overline{CAS} = V_{IH}$ ; $t_{RC} = \text{min}$ ) (MB8264-15)		—	42	mA
PAGE MODE CURRENT*				
Average power supply current ( $\overline{RAS} = V_{IL}, \overline{CAS}$ cycling, $t_{PC} = \text{min}$ )	$I_{CC4}$	—	34	mA
INPUT LEAKAGE CURRENT				
Input leakage current, any input ( $0V \leq V_{IN} \leq 5.5V$ )	$I_{IL}$	-10	10	$\mu\text{A}$
Input pins not under test = $0V, V_{CC} = 5.5V, V_{SS} = 0V$				
OUTPUT LEAKAGE CURRENT				
(Data out is disabled, $0V \leq V_{OUT} \leq 5.5V$ )	$I_{OL}$	-10	10	$\mu\text{A}$
OUTPUT LEVEL				
Output low voltage ( $I_{OL} = 4.2\text{mA}$ )	$V_{OL}$	—	0.4	V
OUTPUT LEVEL				
Output high voltage ( $I_{OH} = -5\text{mA}$ )	$V_{OH}$	2.4	—	V

Note\*:  $I_{CC}$  is dependent on output loading and cycle rates. Specified values are obtained with the output open.

**DYNAMIC CHARACTERISTICS** Notes 1,2,3

(Recommended operating conditions unless otherwise noted.)

Parameter	Notes	Symbol	MB8264-20			MB8264-15			Unit
			Min	Typ	Max	Min	Typ	Max	
Time between Refresh		t <sub>REF</sub>	—	—	2	—	—	2	ms
Random Read/Write Cycle Time		t <sub>RC</sub>	330	—	—	270	—	—	ns
Read-Write Cycle Time		t <sub>RWC</sub>	375	—	—	300	—	—	ns
Page Mode Cycle Time		t <sub>PC</sub>	225	—	—	170	—	—	ns
Access Time from $\overline{\text{RAS}}$	4 6	t <sub>RAC</sub>	—	—	200	—	—	150	ns
Access Time from $\overline{\text{CAS}}$	5 6	t <sub>CAC</sub>	—	—	135	—	—	100	ns
Output Buffer Turn Off Delay		t <sub>OFF</sub>	0	—	50	0	—	40	ns
Transition Time		t <sub>T</sub>	3	—	50	3	—	35	ns
$\overline{\text{RAS}}$ Precharge Time		t <sub>RP</sub>	120	—	—	100	—	—	ns
$\overline{\text{RAS}}$ Pulse Width		t <sub>RAS</sub>	200	—	10000	150	—	10000	ns
$\overline{\text{RAS}}$ Hold Time		t <sub>RSH</sub>	135	—	—	100	—	—	ns
$\overline{\text{CAS}}$ Precharge Time (Page Mode Only)		t <sub>CP</sub>	80	—	—	60	—	—	ns
$\overline{\text{CAS}}$ Precharge Time (All Cycles Except Page Mode)		t <sub>CPN</sub>	30	—	—	25	—	—	ns
$\overline{\text{CAS}}$ Pulse Width		t <sub>CAS</sub>	135	—	10000	100	—	10000	ns
$\overline{\text{CAS}}$ Hold Time		t <sub>CSH</sub>	200	—	—	150	—	—	ns
$\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ Delay Time	7 8	t <sub>RCD</sub>	30	—	65	25	—	50	ns
$\overline{\text{CAS}}$ to $\overline{\text{RAS}}$ Precharge Time		t <sub>CRP</sub>	0	—	—	0	—	—	ns
Row Address Set Up Time		t <sub>ASR</sub>	0	—	—	0	—	—	ns
Row Address Hold Time		t <sub>RAH</sub>	20	—	—	15	—	—	ns
Column Address Set Up Time		t <sub>ASC</sub>	0	—	—	0	—	—	ns
Column Address Hold Time		t <sub>CAH</sub>	55	—	—	45	—	—	ns
Column Address Hold Time Referenced to $\overline{\text{RAS}}$		t <sub>AR</sub>	120	—	—	95	—	—	ns
Read Command Set Up Time		t <sub>RCS</sub>	0	—	—	0	—	—	ns
Read Command Hold Time	10	t <sub>RCH</sub>	0	—	—	0	—	—	ns
Write Command Set Up Time	9	t <sub>WCS</sub>	-10	—	—	-10	—	—	ns
Write Command Hold Time		t <sub>WCH</sub>	55	—	—	45	—	—	ns
Write Command Hold Time Reference to $\overline{\text{RAS}}$		t <sub>WCR</sub>	120	—	—	95	—	—	ns
Write Command Pulse Width		t <sub>WP</sub>	55	—	—	45	—	—	ns
Write Command to $\overline{\text{RAS}}$ Lead Time		t <sub>RWL</sub>	80	—	—	60	—	—	ns
Write Command to $\overline{\text{CAS}}$ Lead Time		t <sub>CWL</sub>	80	—	—	60	—	—	ns
Data In Set Up Time		t <sub>DS</sub>	0	—	—	0	—	—	ns
Data In Hold Time		t <sub>DH</sub>	55	—	—	45	—	—	ns
Data In Hold Time Referenced to $\overline{\text{RAS}}$		t <sub>DHR</sub>	120	—	—	95	—	—	ns
$\overline{\text{CAS}}$ to $\overline{\text{WE}}$ Delay	9	t <sub>CWD</sub>	95	—	—	70	—	—	ns
$\overline{\text{RAS}}$ to $\overline{\text{WE}}$ Delay	9	t <sub>RWD</sub>	160	—	—	120	—	—	ns
Read Command Hold Time Referenced to $\overline{\text{RAS}}$	10	t <sub>RRH</sub>	25	—	—	20	—	—	ns

**Notes:**

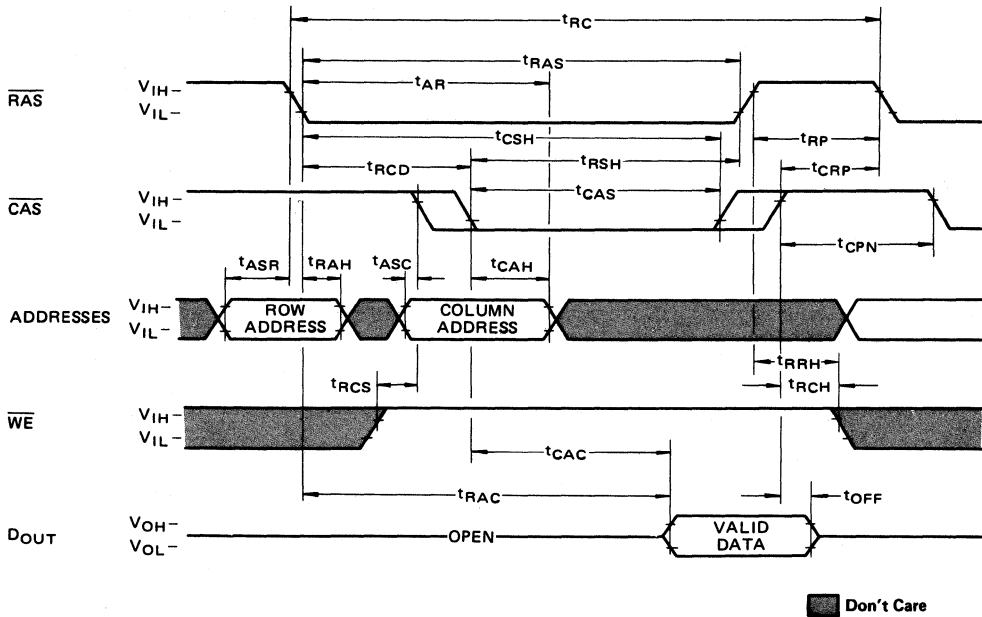
1. An initial pause of 200µs is required after power-up followed by any 8 RAS cycles before proper device operation is achieved.
2. Dynamic measurements assume  $t_T = 5ns$ .
3.  $V_{IH}(min)$  and  $V_{IL}(max)$  are reference levels for measuring timing of input signals. Also, transition times are measured between  $V_{IH}(min)$  and  $V_{IL}(max)$ .
4. Assumes that  $t_{RCD} \leq t_{RCD}(max)$ . 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.
5. Assumes that  $t_{RCD} \geq t_{RCD}(max)$ .
6. Measured with a load equivalent to 2 TTL loads and 100 pF.
7. Operation within the  $t_{RCD}(max)$  limit insures 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  $t_{CAC}$ .

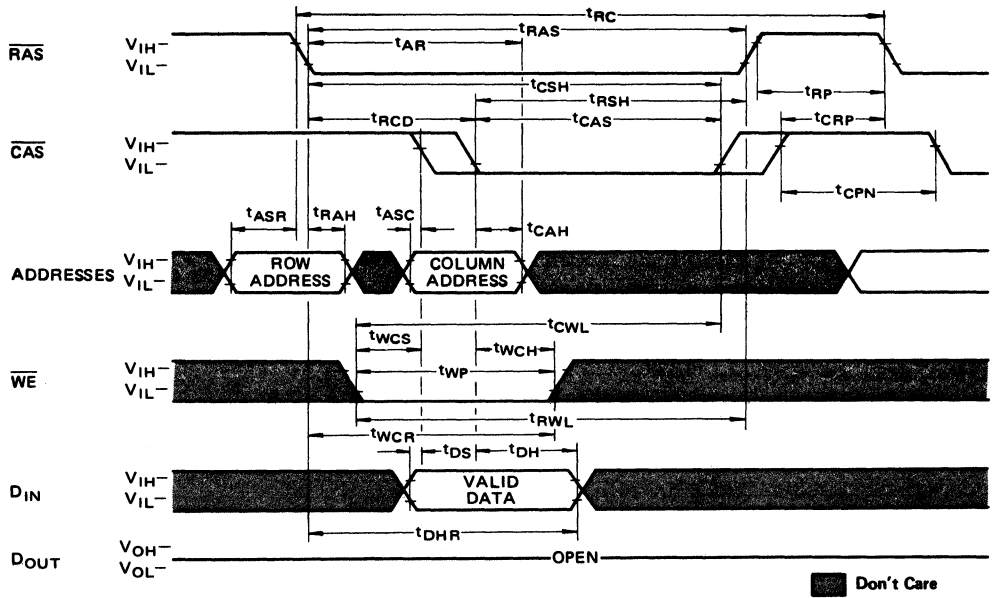
8.  $t_{RCD}(min) = t_{RAH}(min) + 2t_T(t_T = 5ns) + t_{ASC}(min)$ .
9.  $t_{WCS}$ ,  $t_{CWD}$  and  $t_{RWD}$  are not restrictive operating parameters. They are included in the data sheet as electrical characteristics only. If  $t_{WCS} \geq t_{WCS}(min)$ , the cycle is an early write cycle and the data out pin will remain open circuit (high impedance) throughout the entire cycle.  
  
If  $t_{CWD} \geq t_{CWD}(min)$  and  $t_{RWD} \geq t_{RWD}(min)$ , the cycle is a read-write cycle and data out will contain data read from the selected cell. If neither of the above sets of conditions is satisfied the condition of the data out is indeterminate.
10. Either  $t_{RRH}$  or  $t_{RCH}$  must be satisfied for a read cycle.

**TIMING DIAGRAMS**

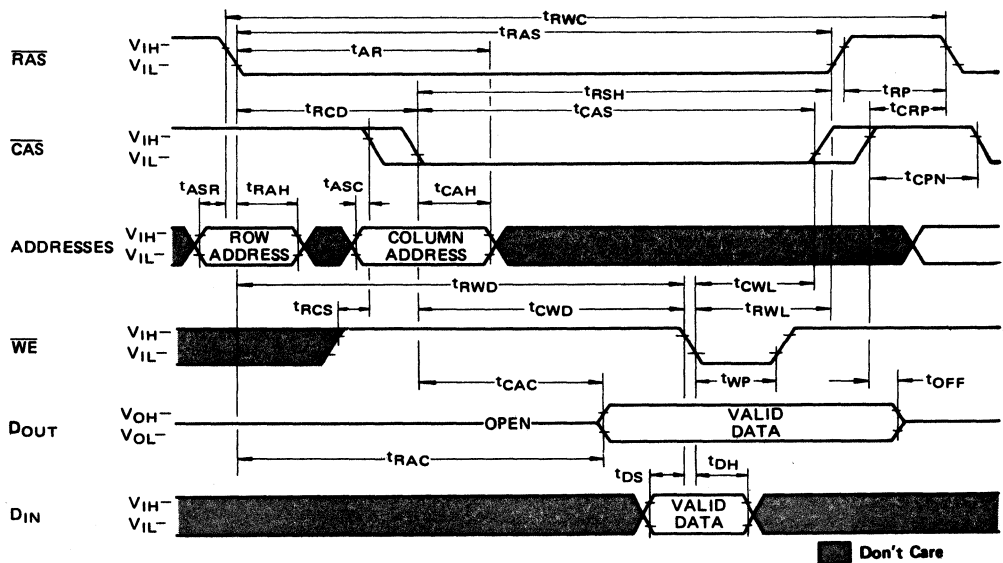
**READ CYCLE**



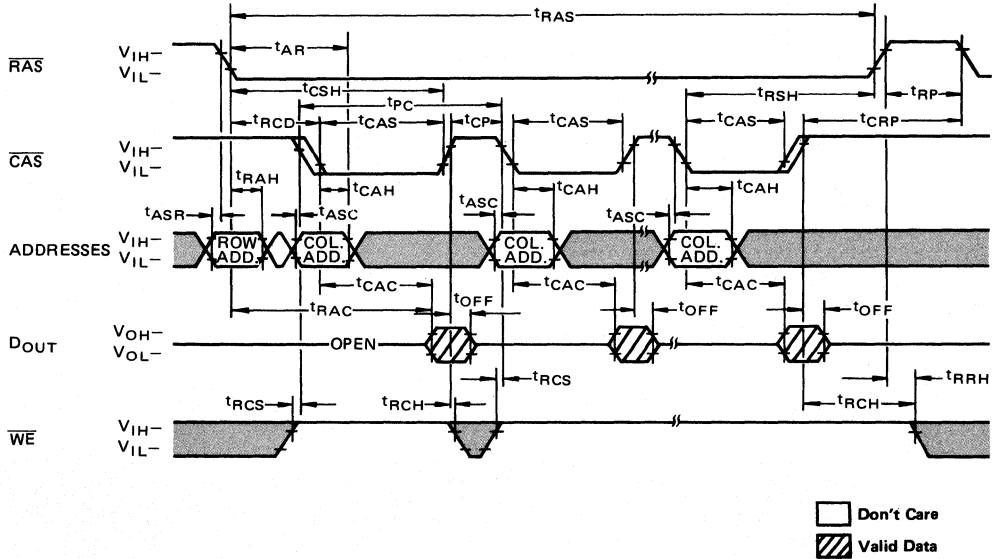
**WRITE CYCLE (EARLY WRITE)**



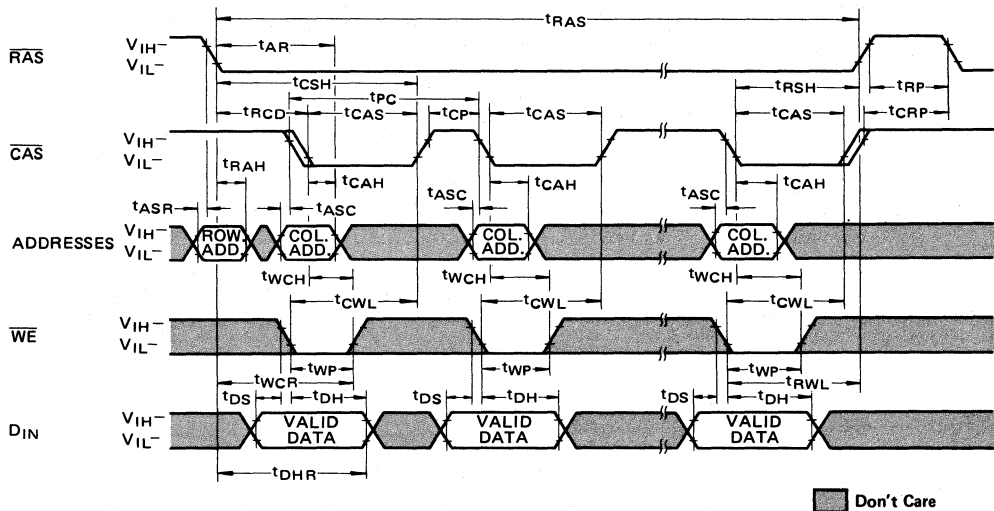
**READ-WRITE/READ-MODIFY-WRITE CYCLE**



PAGE-MODE READ CYCLE

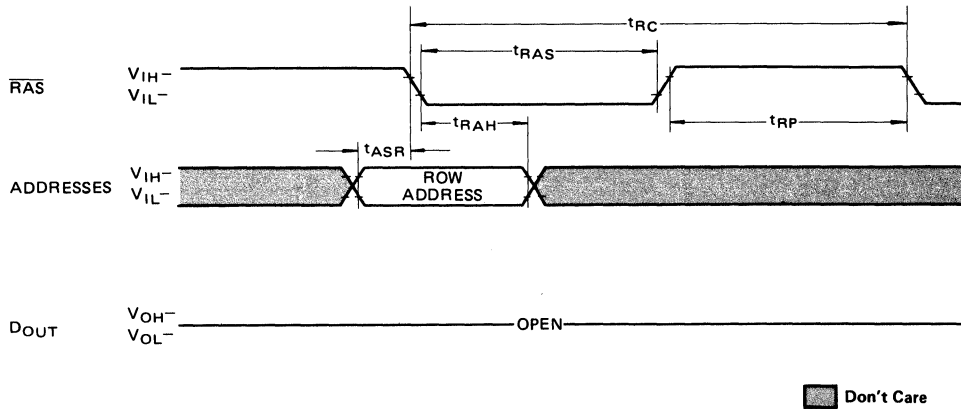


PAGE-MODE WRITE CYCLE

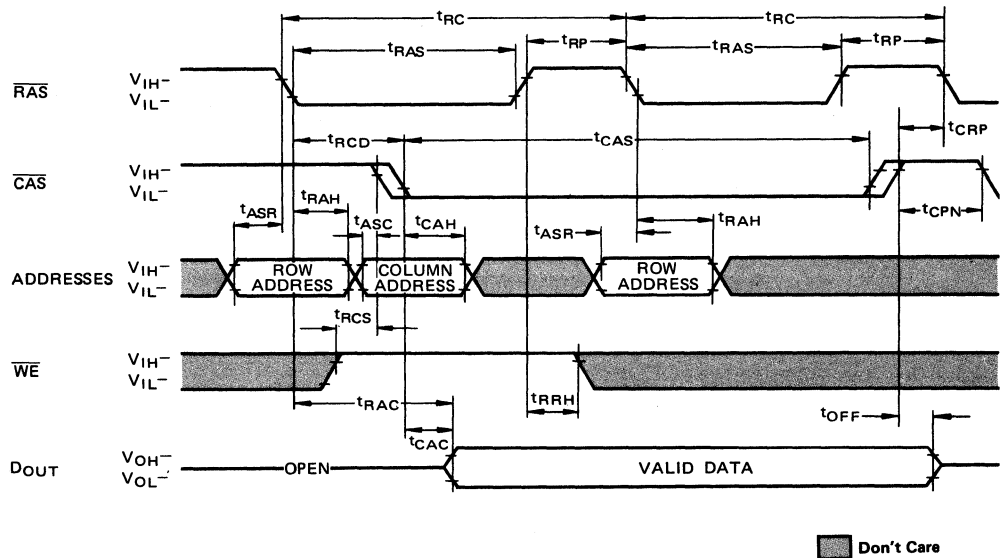


**"RAS-ONLY" REFRESH CYCLE**

NOTE:  $\overline{\text{CAS}} = V_{IH}$ ,  $\overline{\text{WE}} = \text{Don't care}$



**HIDDEN "RAS-ONLY" REFRESH CYCLE**



## MB8264-15/MB8264-20

### DESCRIPTION

#### Address Inputs

A total of sixteen binary input address bits are required to decode any 1 of 65536 storage cell locations within the MB8264. Eight row-address bits are established on the input pins ( $A_0$  through  $A_7$ ) and latched with the Row Address Strobe ( $\overline{RAS}$ ). Then eight column-address bits are established on the input pins and latched with the Column Address Strobe ( $\overline{CAS}$ ). All input addresses must be stable on or before the falling edge of  $\overline{RAS}$ .  $\overline{CAS}$  is internally inhibited (or "gated") by  $\overline{RAS}$  to permit triggering of  $\overline{CAS}$  as soon as the Row Address Hold Time ( $t_{RAH}$ ) specification has been satisfied and the address inputs have been changed from row-addresses to column-addresses.

#### Write Enable

The read mode or write mode is selected with the  $\overline{WE}$  input. A logic high (1) on  $\overline{WE}$  dictates read mode; logic low (0) dictates write mode. Data input is disabled when read mode is selected.

#### Data Input

Data is written into the MB8264 during a write or read-write cycle. The last falling-edge of  $\overline{WE}$  or  $\overline{CAS}$  is a strobe for the Data In ( $D_{IN}$ ) register. In a write cycle, if  $\overline{WE}$  is brought low (write mode) before  $\overline{CAS}$ ,  $D_{IN}$  is strobed by  $\overline{CAS}$ , and the set-up and hold times are referenced to  $\overline{CAS}$ . In a read-write cycle,  $\overline{WE}$  will be delayed until  $\overline{CAS}$  has made its negative transition. Thus  $D_{IN}$  is strobed by  $\overline{WE}$ , and set-up and hold times are referenced to  $\overline{WE}$ .

#### Data Output

The output buffer is three-state TTL compatible with a fan-out of two standard TTL loads. Data-out is the same polarity as data-in. The output is in a high impedance

state until  $\overline{CAS}$  is brought low. In a read cycle, or a read-write cycle, the output is valid after  $t_{RAC}$  from transition of  $\overline{RAS}$  when  $t_{RCD}$  (max) is satisfied, or after  $t_{CAC}$  from transition of  $\overline{CAS}$  when the transition occurs after  $t_{RCD}$  (max). Data remains valid until  $\overline{CAS}$  is returned to a high level. In a write cycle the identical sequence occurs, but data is not valid.

#### Page-Mode

Page-mode operation permits strobing the row-address into the MB8264 while maintaining  $\overline{RAS}$  at a logic low (0) throughout all successive memory operations in which the row-address doesn't change. Thus the power dissipated by the negative going edge of  $\overline{RAS}$  is saved. Further, access and cycle times are decreased because the time normally required to strobe a new row-address is eliminated.

#### Refresh

Refresh of the dynamic memory cells is accomplished by performing a memory cycle at each of the 128 row-addresses ( $A_0 \sim A_6$ ) at least every two milliseconds. During refresh, either  $V_{IL}$  or  $V_{IH}$  is permitted for  $A_7$ .  $\overline{RAS}$ -only refresh avoids any output during refresh because the output buffer is in the high impedance state unless  $\overline{CAS}$  is brought low. Strobing each of 128 row-addresses with  $\overline{RAS}$  will cause all bits in each row to be refreshed. Further  $\overline{RAS}$ -only refresh results in a substantial reduction in power dissipation.

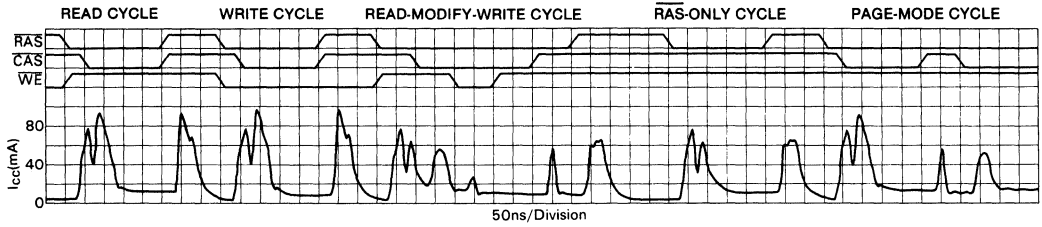
#### Hidden Refresh

$\overline{RAS}$ -ONLY REFRESH CYCLE may take place while maintaining valid output data. This feature is referred to as Hidden Refresh.

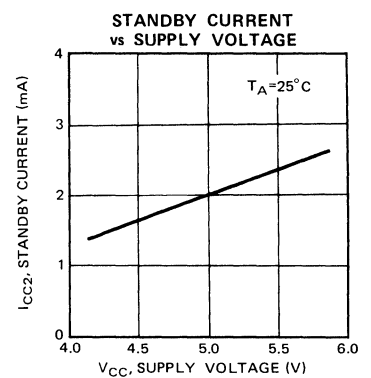
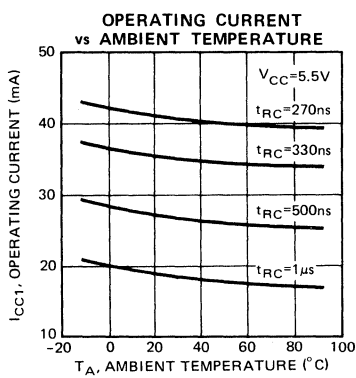
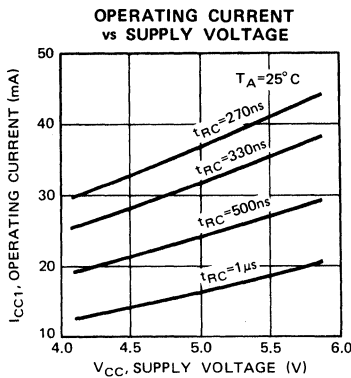
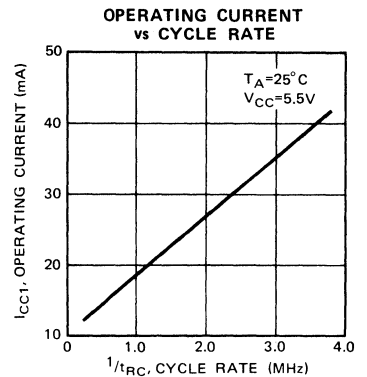
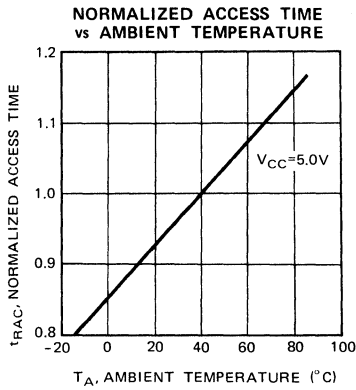
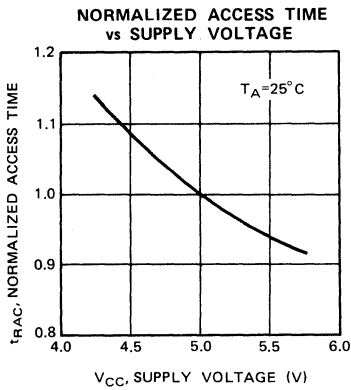
Hidden Refresh is performed by holding  $\overline{CAS}$  as  $V_{IL}$  from a previous memory read cycle.



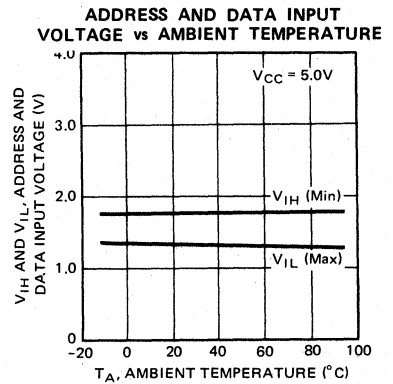
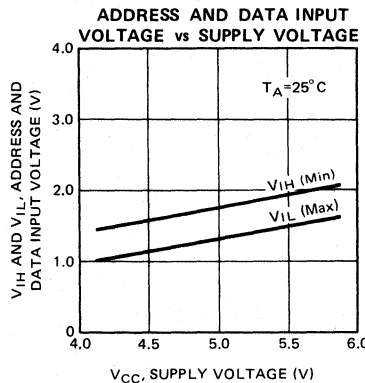
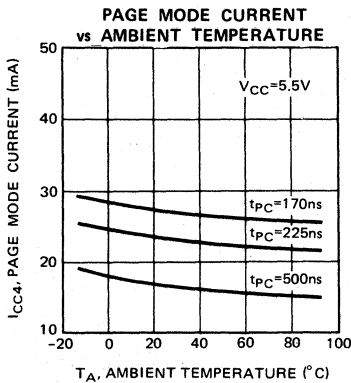
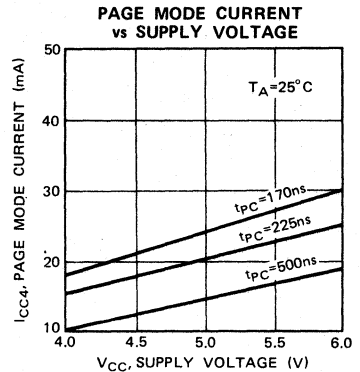
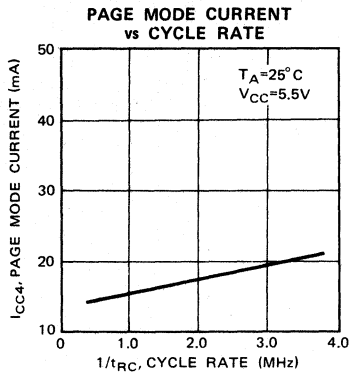
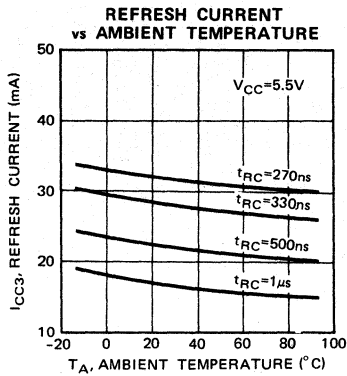
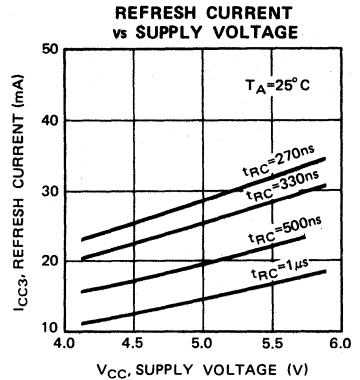
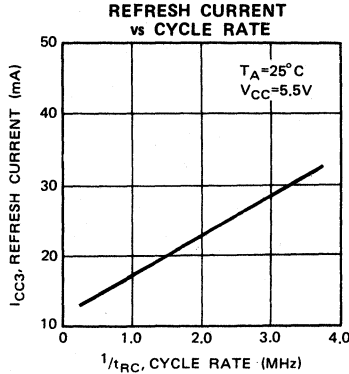
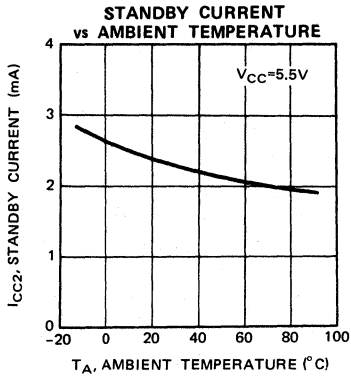
**CURRENT WAVEFORM** ( $V_{CC} = 5.5V$ ,  $T_A = 25^\circ C$ )



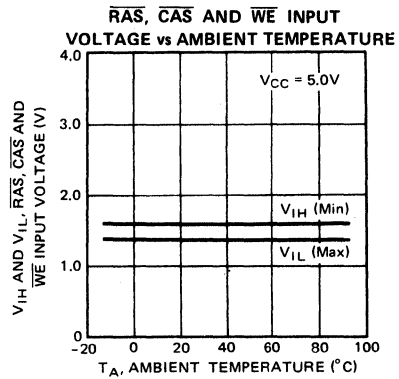
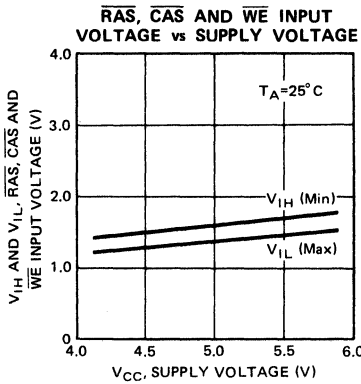
**TYPICAL CHARACTERISTICS CURVES**



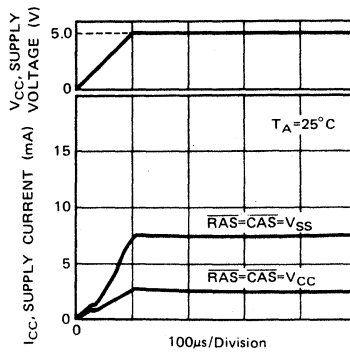
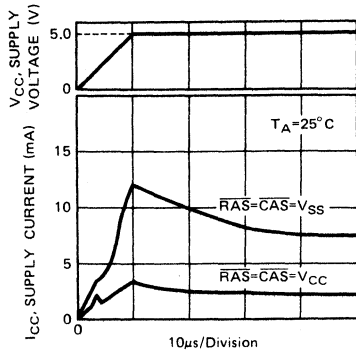
TYPICAL CHARACTERISTICS CURVES (Continued)



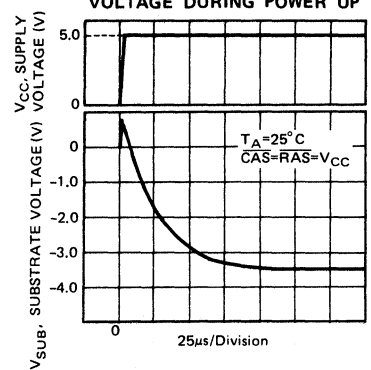
TYPICAL CHARACTERISTICS CURVES (Continued)



TYPICAL SUPPLY CURRENT vs SUPPLY VOLTAGE DURING POWER UP



SUBSTRATE VOLTAGE vs SUPPLY VOLTAGE DURING POWER UP



SUPPLY CURRENT vs SUPPLY VOLTAGE DURING POWER UP (ON MEMORY BOARD)

