PRELIMINARY

# MOSTEK®

## 131,072 x 1-BIT DYNAMIC RAM

# MK4528(D)-15/20/25

### FEATURES

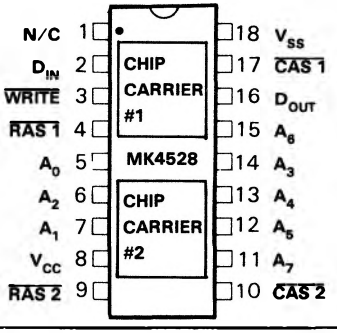
- Utilizes two standard MK4564 devices in an 18-pin package configuration
- Single +5V (± 10%) supply operation
- On chip substrate bias generator for optimum performance
- Active power 320mW (Single MK4564 active) Standby power 44mW
- 150ns access time, 260ns cycle time (MK4564-15) 200ns access time, 345ns cycle time (MK4564-20) 250ns access time, 425ns cycle time (MK4564-25)
- Common I/O capability using "early write"
- Separate $\overline{RAS}$, $\overline{CAS}$ Clocks
- Read, Write, Read-Write, Read-Modify-Write and Page-Mode capability
- All inputs TTL compatible, low capacitance, and are protected against static charge
- Scaled POLY 5 technology
- Pin compatible with the MK4332 (32K RAM)
- 128 refresh cycles (2 msec) for each MK4564 device in the dual density configuration (address $A_7$ is not used for refresh).
- Extended $D_{OUT}$ hold using CAS control (Hidden Refresh).

### DESCRIPTION

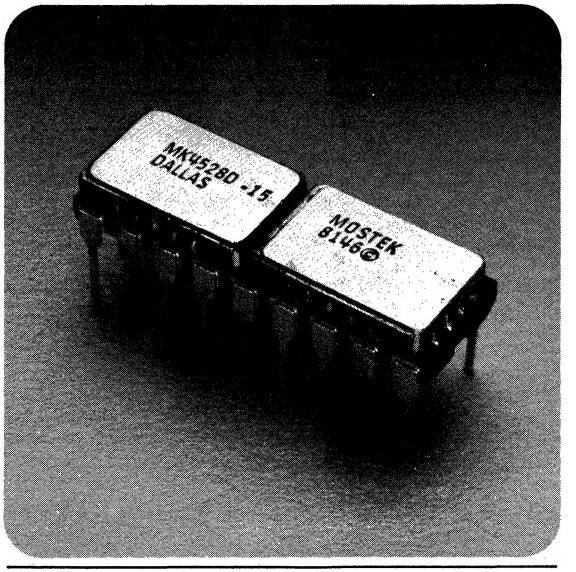
The MK4528 sets a new milestone in the state of the art of package technology to give you dual density now before the next generation of MOS RAMs are available. This device is made up of two 64K (MK4564) 5 volt only RAMs and it is organized as 131,072 words by 1 bit. The upper 16 pins are identical to the industry standard 64K Dual-In Line Package, allowing either device to be installed in the 18 pin position.

The MK4528's high performance features and wide operating margins, both internally and to the system user, are achieved by state-of-the-art circuit design techniques as well as utilization of Mostek's "Scaled POLY 5" process technology.

### PIN CONNECTIONS




### DEVICE PROFILE




### PIN FUNCTION

| | | | |
|---|---|---|---|
| $A_0A_7$ | Address Inputs | $\overline{RAS}$ | Row Address Strobe |
| $\overline{CAS}$ | Column Address Strobe | $\overline{WRITE}$ | Read/Write Input |
| $D_{IN}$ | Data In | $V_{CC}$ | Power (+ 5 V) |
| $D_{OUT}$ | Data Out | N/C | No Connections |
| $V_{SS}$ | GND | | |

**Also Available in MIL-STD-883 Class B (MKB)**

## ABSOLUTE MAXIMUM RATINGS*

Voltage on $V_{CC}$ supply relative to $V_{SS}$ ..... -1.0 V to +7.0 V
Operating Temperature, $T_A$ (Ambient) ..... 0°C to +70C
Storage Temperature (Ceramic) ..... -65°C to +150°C
Power Dissipation ..... 1 Watt
Short Circuit Output Current ..... 50 mA

*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.

## RECOMMENDED DC OPERATING CONDITIONS

($0°C \leq T_A \leq 70°C$)

| SYM | PARAMETER | MIN | TYP | MAX | UNITS | NOTES |
|---|---|---|---|---|---|---|
| $V_{CC}$ | Supply Voltage | 4.5 | 5.0 | 5.5 | V | 1 |
| $V_{IH}$ | Input High (Logic 1) Voltage, All Inputs | 2.4 | — | $V_{CC}$+1 | V | 1 |
| $V_{IL}$ | Input Low (Logic 0) Voltage, All Inputs | -2.0 | — | .8 | V | 1,18 |

## DC ELECTRICAL CHARACTERISTICS

($0°C \leq T_A \leq 70°C$) ($V_{CC}$ = 5.0 V ± 10%)

| SYM | PARAMETER | MIN | MAX | UNITS | NOTES |
|---|---|---|---|---|---|
| $I_{CC1}$ | OPERATING CURRENT<br>Average power supply operating current<br>($\overline{RAS}$, $\overline{CAS}$ cycling; $t_{RC}$ = $t_{RC}$ min.) | | 58 | mA | 2 |
| $I_{CC2}$ | STANDBY CURRENT<br>Power suply standby current (RAS = $V_{IH}$,<br>$D_{OUT}$ = High Ipedance) | | 8 | mA | |
| $I_{CC3}$ | $\overline{RAS}$ ONLY REFRESH CURRENT<br>Average power supply current, refresh mode<br>($\overline{RAS}$ cycling, $\overline{CAS}$ = $V_{IH}$; $t_{RC}$ = $t_{RC}$ min.) | | 49 | mA | 2 |
| $I_{CC4}$ | PAGE MODE CURRENT<br>Average power supply current, page mode operation<br>($\overline{RAS}$ = $V_{IL}$, $t_{RAS}$ = $t_{RAS}$ max., $\overline{CAS}$ cycling;<br>$t_{PC}$ = $t_{PC}$ min.) | | 39 | mA | 2 |
| $i_{I(L)}$ | INPUT LEAKAGE<br>Input leakage current, any input<br>($0V \leq V_{IN} \leq V_{CC}$), all other pins not under test = 0 volts | -20 | 20 | µA | |
| $I_{O(L)}$ | OUTPUT LEAKAGE<br>Output leakage current ($D_{OUT}$ is disabled,<br>$0V \leq V_{OUT} \leq V_{CC}$) | -20 | 20 | µA | |
| $V_{OH}$<br>$V_{OL}$ | OUTPUT LEVELS<br>Output High (Logic 1) voltage ($I_{OUT}$ = -5 mA)<br>Output Low (Logic 0) voltage ($I_{OUT}$ = 4.2 mA) | 2.4 | <br>0.4 | V<br>V | |

**NOTES:**

1. All voltages referenced to $V_{SS}$.
2. $I_{CC}$ is dependent on output loading and cycle rates. Specified values are obtained with the output open. Only one MK4564 is active.
3. An initial pause of 500 $\mu$s is required after power-up followed by any 8 $\overline{RAS}$ cycles before proper device operation is achieved. Note that $\overline{RAS}$ may be cycled during the initial pause.
4. AC characteristics assume $t_T$ = 5 ns.
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°C ≤ $T_A$ ≤ 70°C) is assured.
7. Load = 2 TTL loads and 50 pF.
8. 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.
9. Assumes that $t_{RCD} \geq t_{RCD}$ (max).
10. $t_{OFF}$ max defines the time at which the output achieves the open circuit condition and is not referenced to $V_{OH}$ or $V_{OL}$.
11. 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 $t_{CAC}$.
12. Either $t_{RRH}$ or $t_{RCH}$ must be satisfied for a read cycle.
13. These parameters are referenced to $\overline{CAS}$ leading edge in early write cycles and to $\overline{WRITE}$ leading edge in delayed write or read-modify-write cycles.
14. $t_{WCS}$, $t_{CWD}$, and $t_{RWD}$ are restrictive operating parameters in READ/WRITE and READ/MODIFY/WRITE cycles only. If $t_{WCS} \geq t_{WCS}$ (min) the cycle is an EARLY WRITE cycle and the data output will remain open circuit throughout the entire cycle. If $t_{CWD} \geq t_{CWD}$ (min) and $t_{RWD} \geq t_{RWD}$ (min) the cycle is a READ/WRITE and the data output will contain data read from the selected cell. If neither of the above conditions are met the condition of the data out (at access time and until $\overline{CAS}$ goes back to $V_{IH}$) is indeterminate.
15. In addition to meeting the transition rate specification, all input signals must transmit between $V_{IH}$ and $V_{IL}$ (or between $V_{IL}$ and $V_{IH}$) in a monotonic manner.
16. Effective capacitance calculated from the equation $C = I \frac{\Delta t}{\Delta V}$ with $\Delta V$ = 3 volts and power supply at nominal level.
17. $\overline{CAS}$ = $V_{IH}$ to disable $D_{OUT}$.
18. Includes the DC level and all instantaneous signal excursions.
19. $\overline{WRITE}$ = don't care. Data out depends on the state of $\overline{CAS}$. If $\overline{CAS}$ = $V_{IH}$, data output is high impedance. If $\overline{CAS}$ = $V_{IL}$, the data output will contain data from the last valid read cycle.

## ELECTRICAL CHARACTERISTICS AND RECOMMENDED AC OPERATING CONDITIONS

(3,4,5,15) (0°C ≤ $T_A$ ≤ 70°C), $V_{CC}$ = 5.0V ± 10%

| SYMBOL | | | MK4528-15 | | MK4528-20 | | MK4528-25 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| STD | ALT | PARAMETER | MIN | MAX | MIN | MAX | MIN | MAX | UNITS | NOTES |
| $t_{RELREL}$ | $t_{RC}$ | Random read or write cycle time | 260 | | 345 | | 425 | | ns | 6,7 |
| $t_{RELREL}$ (RMW) | $t_{RMW}$ | Read modify write cycle time | 310 | | 405 | | 490 | | ns | 6,7 |
| $t_{RELREL}$ (PC) | $t_{PC}$ | Page mode cycle time | 155 | | 200 | | 240 | | ns | 6,7 |
| $t_{RELQV}$ | $t_{RAC}$ | Access time from $\overline{RAS}$ | | 150 | | 200 | | 250 | ns | 7,8 |
| $t_{CELQV}$ | $t_{CAC}$ | Access time from $\overline{CAS}$ | | 85 | | 115 | | 145 | ns | 7,9 |
| $t_{CEHQZ}$ | $t_{OFF}$ | Output buffer turn-off delay | 0 | 40 | 0 | 50 | 0 | 60 | ns | 10 |
| $t_T$ | $t_T$ | Transition time (rise and fall) | 3 | 50 | 3 | 50 | 3 | 50 | ns | 5,15 |
| $t_{REHREL}$ | $t_{RP}$ | $\overline{RAS}$ precharge time | 100 | | 135 | | 165 | | ns | |
| $t_{RELREH}$ | $t_{RAS}$ | $\overline{RAS}$ pulse width | 150 | 10,000 | 200 | 10,000 | 250 | 10,000 | ns | |
| $t_{CELREH}$ | $t_{RSH}$ | $\overline{RAS}$ hold time | 85 | | 115 | | 145 | | ns | |
| $t_{RELCEH}$ | $t_{CSH}$ | $\overline{CAS}$ hold time | 150 | | 200 | | 250 | | ns | |
| $t_{CELCEH}$ | $t_{CAS}$ | $\overline{CAS}$ pulse width | 85 | 10,000 | 115 | 10,000 | 145 | 10,000 | ns | |
| $t_{RELCEL}$ | $t_{RCD}$ | $\overline{RAS}$ to $\overline{CAS}$ delay time | 30 | 65 | 35 | 85 | 45 | 105 | ns | 11 |
| $t_{REHWX}$ | $t_{RRH}$ | Read command hold time referenced to $\overline{RAS}$ | 20 | | 25 | | 30 | | ns | 12 |
| $t_{AVREL}$ | $t_{ASR}$ | Row address set-up time | 0 | | 0 | | 0 | | ns | |
| $t_{RELAX}$ | $t_{RAH}$ | Row address hold time | 20 | | 25 | | 30 | | ns | |
| $t_{AVCEL}$ | $t_{ASC}$ | Column address set-up time | 0 | | 0 | | 0 | | ns | |
| $t_{CELAX}$ | $t_{CAH}$ | Column address hold time | 30 | | 40 | | 50 | | ns | |
| $t_{RELA(C)X}$ | $t_{AR}$ | Column address hold time referenced to $\overline{RAS}$ | 100 | | 130 | | 160 | | ns | |

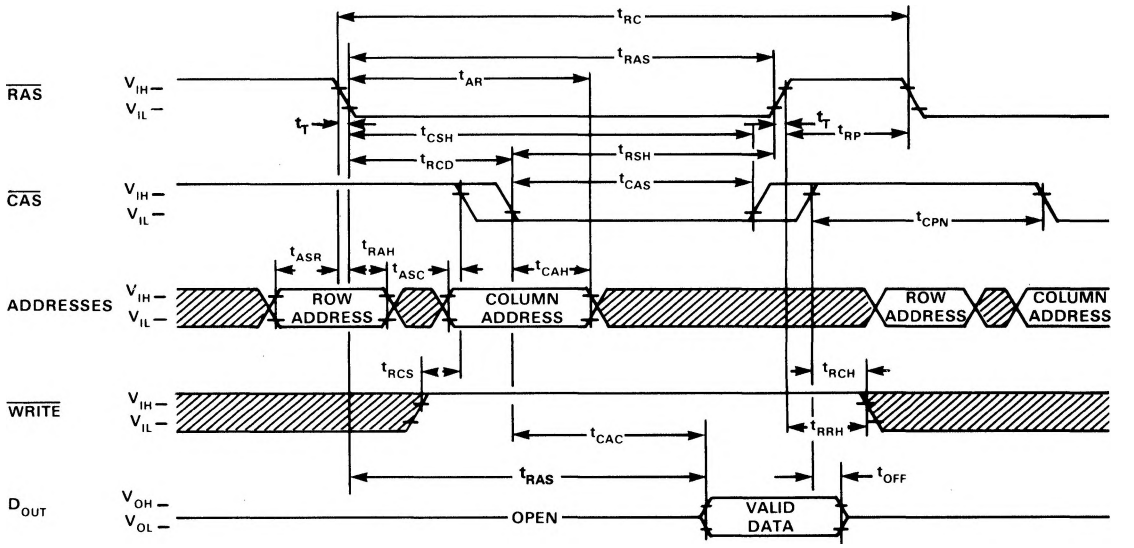
**ELECTRICAL CHARACTERISTICS AND RECOMMENDED AC OPERATING CONDITIONS (Continued)**
(3,4,5,15) (0°C ≤ $T_A$ ≤ 70°C), $V_{CC}$ = 5.0V ± 10%

| SYMBOL | | | MK4528-15 | | MK4528-20 | | MK4528-25 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| STD | ALT | PARAMETER | MIN | MAX | MIN | MAX | MIN | MAX | UNITS | NOTES |
| $t_{WHCEL}$ | $t_{RCS}$ | Read command set-up time | 0 | | 0 | | 0 | | ns | |
| $t_{CEHWX}$ | $t_{RCH}$ | Read command hold time referenced to $\overline{CAS}$ | 0 | | 0 | | 0 | | ns | 12 |
| $t_{CELWX}$ | $t_{WCH}$ | Write command hold time | 45 | | 55 | | 70 | | ns | |
| $t_{RELWX}$ | $t_{WCR}$ | Write command hold time referenced to $\overline{RAS}$ | 115 | | 150 | | 185 | | ns | |
| $t_{WLWH}$ | $t_{WP}$ | Write command pulse width | 35 | | 45 | | 55 | | ns | |
| $t_{WLREH}$ | $t_{RWL}$ | Write command to $\overline{RAS}$ lead time | 45 | | 55 | | 65 | | ns | |
| $t_{WLCEH}$ | $t_{CWL}$ | Write command to $\overline{CAS}$ lead time | 45 | | 55 | | 65 | | ns | |
| $t_{DVCEL}$ | $t_{DS}$ | Data-in set-up time | 0 | | 0 | | 0 | | ns | 13 |
| $t_{CELDX}$ | $t_{DH}$ | Data-in hold time | 45 | | 55 | | 70 | | ns | 13 |
| $t_{RELDX}$ | $t_{DHR}$ | Data-in hold time referenced to $\overline{RAS}$ | 115 | | 150 | | 190 | | ns | |
| $t_{CEHCEL}$ (PC) | $t_{CP}$ | $\overline{CAS}$ precharge time (for page-mode cycle only) | 60 | | 75 | | 85 | | ns | |
| $t_{RVRV}$ | $t_{REF}$ | Refresh Period | | 2 | | 2 | | 2 | ms | |
| $t_{WLCEL}$ | $t_{WCS}$ | $\overline{WRITE}$ command set-up time | -10 | | -10 | | -10 | | ns | 14 |
| $t_{CELWL}$ | $t_{CWD}$ | $\overline{CAS}$ to $\overline{WRITE}$ delay | 55 | | 80 | | 100 | | ns | 14 |
| $t_{RELWL}$ | $t_{RWD}$ | $\overline{RAS}$ to $\overline{WRITE}$ delay | 120 | | 165 | | 205 | | ns | 14 |
| $t_{CEHCEL}$ | $t_{CPN}$ | $\overline{CAS}$ precharge time | 30 | | 35 | | 45 | | ns | |

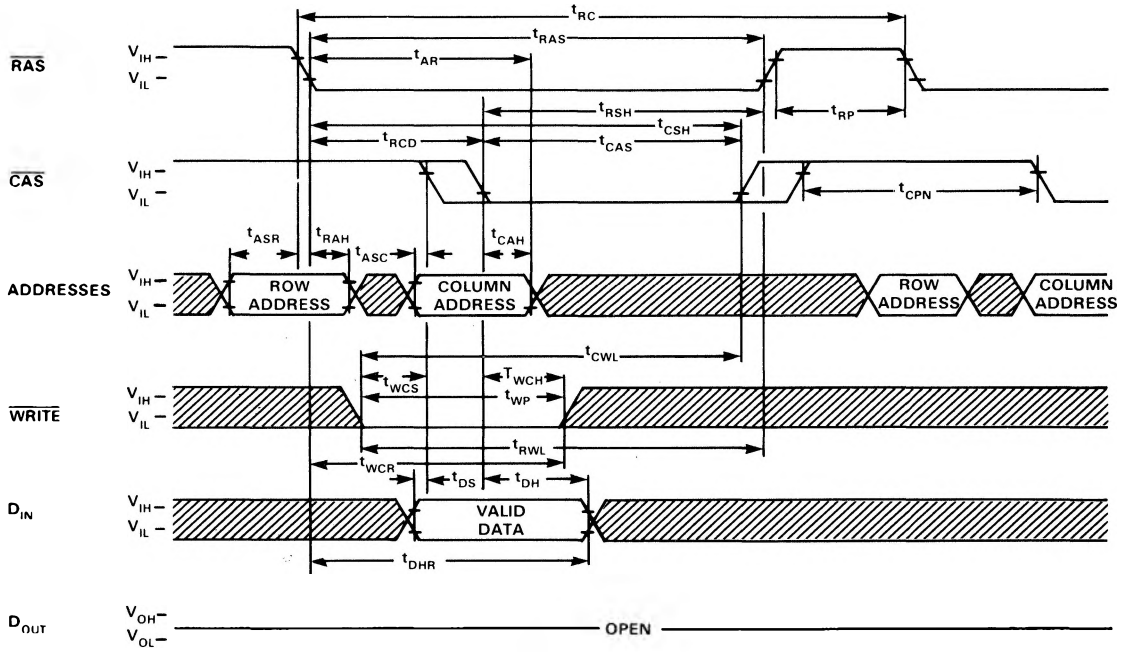
**AC ELECTRICAL CHARACTERISTICS**
(0°C ≤ $T_A$ ≤ 70°C) ($V_{CC}$ = 5.0V ± 10%)

| SYM | PARAMETER | MAX | UNITS | NOTES |
|---|---|---|---|---|
| $C_{I1}$ | Input Capacitance ($A_0$ - $A_7$), $D_{IN}$ | 10 | pF | 16 |
| $C_{I2}$ | Input Capacitance RAS, CAS | 10 | pF | 16 |
| $C_{I3}$ | Input Capacitance $\overline{WRITE}$ | 20 | pF | 16 |
| $C_O$ | Output Capacitance ($D_{OUT}$) | 14 | pF | 16,17 |

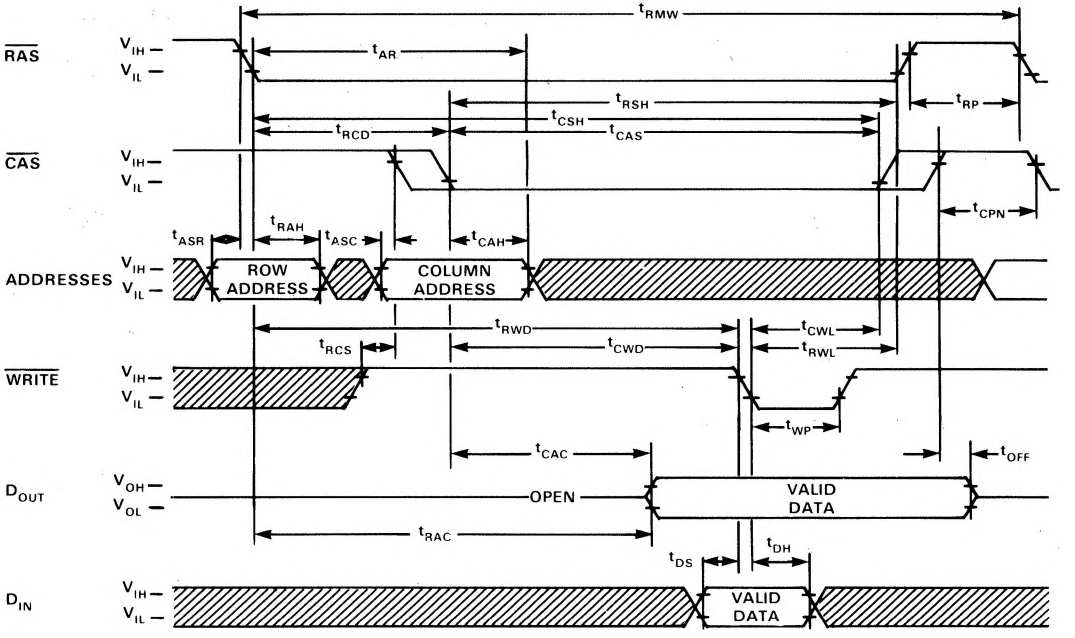
## READ CYCLE



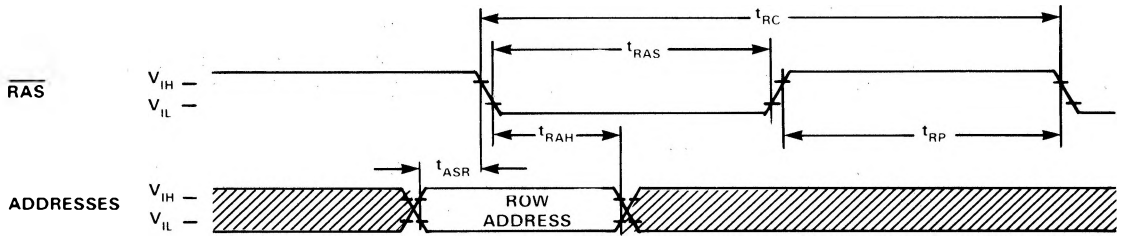

## WRITE CYCLE (EARLY WRITE)



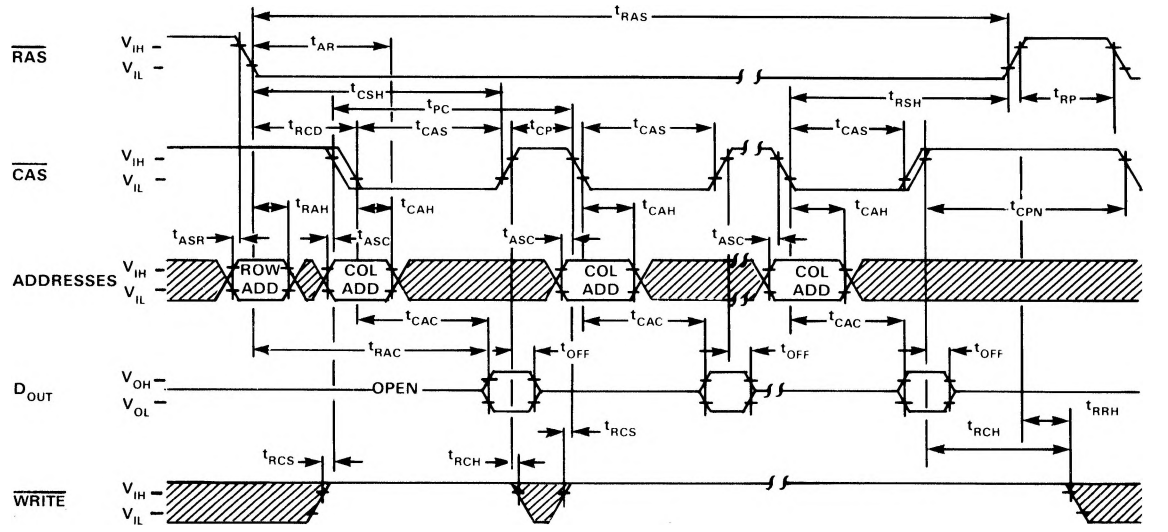
## READ-WRITE/READ-MODIFY-WRITE CYCLE



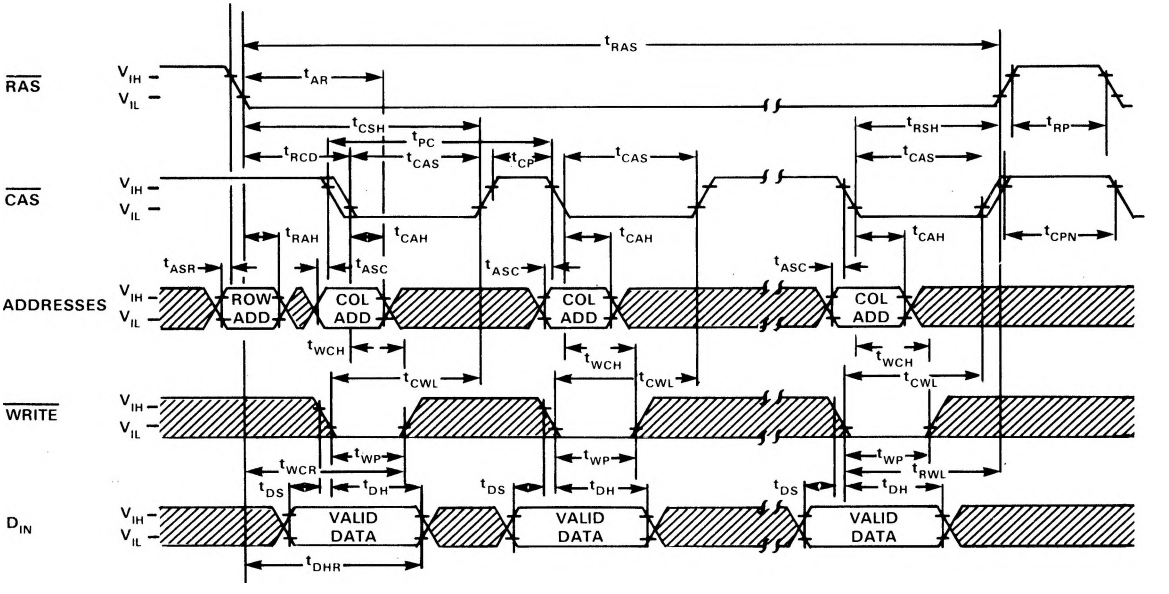

## "$\overline{RAS}$-ONLY" REFRESH CYCLE



## PAGE MODE READ CYCLE




## PAGE MODE WRITE CYCLE



## OPERATION

The MK4528 consists of two 64K (MK4564) dynamic RAMs connected by a substrate in a 131,072 x 1 configuration.The eight address bits required to decode 1 of the 65,536 cell locations within each MK4564 are multiplexed onto the eight address inputs and latched into the on-chip address latches by externally applying two negative going TTL-level clocks. The first clock, Row Address Strobe ($\overline{RAS}$), latches the eight row addresses into the cip. The high-to-low transition of the second clock, Column Address Strobe ($\overline{CAS}$), subsequently latches the eight column addresses into the chip. Each of these signals, $\overline{RAS}$ and $\overline{CAS}$, triggers a sequence of events which are controlled by different delayed internal clocks. The two clock chains are linked together logically in such a way that the address multiplexing operation is done outside of the critical timing path for read data access. The later events in the $\overline{CAS}$ clock sequence are inhibited until the occurrence of a delayed signal derived from the $\overline{RAS}$ clock chain. This "gated $\overline{CAS}$" feature allows the $\overline{CAS}$ clock to be externally activated as soon as the Row Address Hold specification ($t_{RAH}$) has been satisfied and the address inputs have been changed from Row address to Column address information.

The "gated $\overline{CAS}$" feature permits $\overline{CAS}$ to be activated at any time after $t_{RAH}$ and it will have no effect on the worst case data access time ($t_{RAC}$) up to the point in time when the delayed row clock no longer inhibits the remaining sequence of column clocks. Two timing endpoints result from the internal gating of $\overline{CAS}$ which are called $t_{RCD}$ (min) and $t_{RCD}$ (max). No data storage or reading errors will result if $\overline{CAS}$ is applied to the MK4564 at a point in time beyond the $t_{RCD}$ (max) limit. However, access time will then be determined exclusively by the access time from $\overline{CAS}$ ($t_{CAC}$) rather than from $\overline{RAS}$ ($t_{RAC}$), and $\overline{RAS}$ access time will be lengthened by the amount that $t_{RCD}$ exceeds the $t_{RCD}$ (max) limit.

## DATA INPUT/OUTPUT

Data to be written into a selected cell is latched into an on-chip register by a combination of $\overline{WRITE}$ and $\overline{CAS}$ while $\overline{RAS}$ is active. The latter of $\overline{WRITE}$ or $\overline{CAS}$ to make its negative transition is the strobe for the Data In ($D_{IN}$) register. This permits several options in the write cycle timing. In a write cycle, if the $\overline{WRITE}$ input is brought low (active) prior to $\overline{CAS}$ being brought low (active), the $D_{IN}$ is strobed by $\overline{CAS}$, and the Input Data set-up and hold times are referenced to $\overline{CAS}$. If the input data is not available at $\overline{CAS}$ time (late write) or if it is desired that the cycle be a read-write or read-modify-write cycle the $\overline{WRITE}$ signal should be delayed until after $\overline{CAS}$ has made its negative transition. In this "delayed write cycle" the data input set-up and hold times are referenced to the negative edge of $\overline{WRITE}$ rather than $\overline{CAS}$.

Data is retrieved from the memory in a read cycle by maintaining $\overline{WRITE}$ in the inactive or high state throughout the portion of the memory cycle in which both the $\overline{RAS}$ and $\overline{CAS}$ are low (active). Data read from the selected cell is available at the output port within the specified access time. The output data is the same polarity (not inverted) as the input data.

## DATA OUTPUT CONTROL

The normal condition of the Data Output ($D_{OUT}$) of the MK4564 is the high impedance (open-circuit) state; anytime $\overline{CAS}$ is high (inactive) the $D_{OUT}$ pin will be floating. Once the output data port has gone active, it will remain valid until $\overline{CAS}$ is taken to the precharge (inactive high) state.

## PAGE MODE OPERATION

The Page Mode feature of the MK4564 allows for successive memory operations at multiple column locations within the same row address. This is done by strobing the row address into the chip and maintaining the $\overline{RAS}$ signal low (active) throughout all successive memory cycles in which the row address is common. The first access within a page mode operation will be available at $t_{RAC}$ or $t_{CAC}$ time, whichever is the limiting parameter. However, all successive accesses within the page mode operation will be available at $t_{CAC}$ time (referenced to $\overline{CAS}$). With the MK4564 this results in approximately a 57% improvement in access times. Effective memory cycle times are also reduced when using page mode.

The page mode boundary of a single MK4564 is limited to the 256 column locations determined by all combinations of the eight column address bits. Operations within the page boundary need not be sequentially addressed and any combination of read, write, and read-modify-write cycles is permitted within the page mode operation.

## REFRESH

Refresh of the dynamic cell matrix is accomplished by performing a memory cycle at each of the 128 row addresses within each 2 ms interval. Although any normal memory cycle will perform the required refreshing, this function is most easily accomplished with "$\overline{RAS}$-only" cycles.

The $\overline{RAS}$-only refresh cycle requires that a 7 bit refresh address (A0-A6) be valid at the device address inputs when $\overline{RAS}$ goes low (active). The state of the output data port during a $\overline{RAS}$-only refresh is controlled by $\overline{CAS}$. If $\overline{CAS}$ is high (inactive) during the entire time that $\overline{RAS}$ is asserted, the output will remain in the high impedance state. If $\overline{CAS}$ is low (active) the entire time the $\overline{RAS}$ is asserted, the output port will remain in the same state that it was prior to the issuance of the $\overline{RAS}$ signal. If $\overline{CAS}$ makes a low-to-high transition during the $\overline{RAS}$-only refresh cycle, the output data buffer will assume the high impedance state. However, the $\overline{CAS}$ may not make a high to low transition during the $\overline{RAS}$-only refresh cycle since the device interprets this as a normal $\overline{RAS}/\overline{CAS}$ (read or write) type cycle.

## HIDDEN REFRESH

A $\overline{RAS}$-only refresh cycle may take place while maintaining valid output data by extending the $\overline{CAS}$ active time from a previous memory read cycle. This feature is referred to as a hidden refresh. (See figure below.)

### HIDDEN REFRESH CYCLE (SEE NOTE 19)