

## Description

The μPD42264 is a dual-port graphics buffer equipped with a 64K x 4-bit random access port and a 256 x 4-bit serial read port. The serial read port is connected to an internal 1024-bit data register through a 256 x 4-bit serial read output circuit. The random access port is used by the host CPU to read or write data addressed in any desired order and has a write-per-bit option that allows each of the four data bits to be individually selected or masked for a write cycle.

The μPD42264 features fully asynchronous dual access, except when transferring stored graphics data from a selected row of the storage array to the data register. During a data transfer, the random access port requires a special timing cycle using a transfer clock, while the serial read port continues to operate normally. Following the clock transition of a data transfer, serial read output data changes from an old line to a new line and the starting location on the new line is addressable in the data transfer cycle.

The μPD42264 is fabricated with CMOS technology that provides high storage cell density, high performance, and high reliability. Refreshing is accomplished by means of  $\overline{\text{RAS}}$ -only refresh cycles or by normal read or write cycles on the 256 address combinations of  $A_0$  through  $A_7$  during a 4-ms period. Automatic internal refreshing, by means of either hidden refreshing or the  $\overline{\text{CAS}}$  before  $\overline{\text{RAS}}$  timing and on-chip internal refresh circuitry, is also available. The transfer of a row of data from the storage array to the data register also refreshes that row automatically.

All inputs and outputs, including clocks, are TTL-compatible. All address and data-in signals are latched on-chip to simplify system design. Data-out is unlatched to allow greater system flexibility. The μPD42264 is available in a 24-pin plastic DIP, 24-pin plastic SOJ, and 24-pin plastic ZIP, and is guaranteed for operation at 0 to +70°C.

## Ordering Information

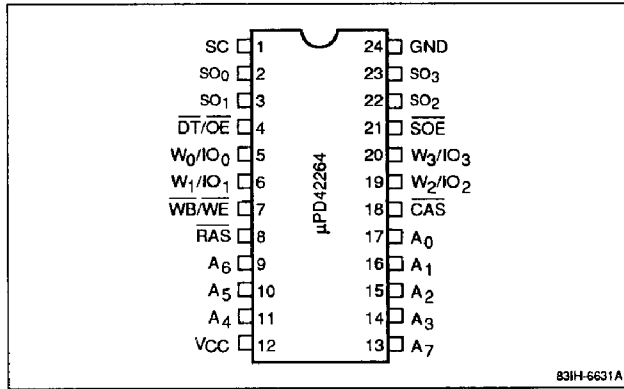
| Part Number   | Row Access Time (max) | Serial Access Time (max) | Package            |
|---------------|-----------------------|--------------------------|--------------------|
| μPD42264C-10  | 100 ns                | 25 ns                    | 24-pin plastic DIP |
| μPD42264LA-10 | 100 ns                | 25 ns                    | 24-pin plastic SOJ |
| μPD42264V-10  | 100 ns                | 25 ns                    | 24-pin plastic ZIP |

## Features

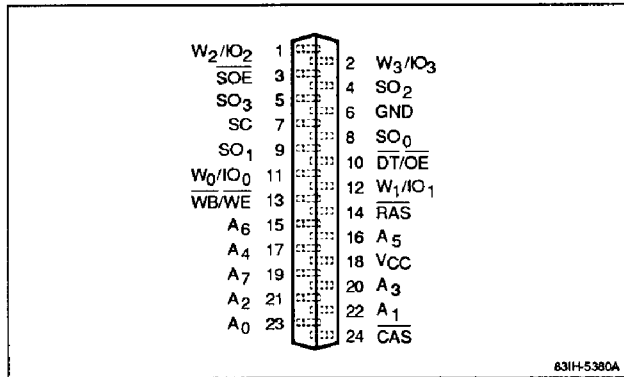
- Three functional blocks
  - 64K x 4-bit random access storage array
  - 1024-bit data register
  - 256 x 4-bit serial read output circuit
- Two data ports: random access and serial read
- Dual-port accessibility except during data transfer
- Addressable start of serial read operation
- Real-time data transfer
- Single +5-volt ± 10% power supply
- On-chip substrate bias generator
- Random access port
  - Two main clocks:  $\overline{\text{RAS}}$  and  $\overline{\text{CAS}}$
  - Multiplexed address inputs
  - Direct connection of I/O and address lines allowed by  $\overline{\text{OE}}$  to simplify system design
  - Refresh interval: 256 cycles/4 ms
  - Read, early write, late write, read-write/read-modify-write,  $\overline{\text{RAS}}$ -only refresh, and page mode capabilities
  - Automatic internal refreshing by means of the  $\overline{\text{CAS}}$  before  $\overline{\text{RAS}}$  on-chip address counter
  - Hidden refreshing by means of  $\overline{\text{CAS}}$ -controlled output
  - Write-per-bit capability
  - Write bit selection multiplexed on  $\text{IO}_0$ - $\text{IO}_3$
- $\overline{\text{RAS}}$ -activated data transfer
  - Same cycle time as for random access
  - Row data transferred to data register as specified by row address inputs
  - Starting location of following serial read operation specified by column address inputs
  - Transfer of 1024 bits of data on one row to the data register, and the starting location of the serial read circuit, activated by a low-to-high transition of  $\overline{\text{DT}}$
  - Data transfer during real-time operation or standby of serial port
- Fast serial read operation by means of SC pins
  - Serial data presented on  $\text{SO}_0$ - $\text{SO}_3$
  - Direct connection of multiple serial outputs for extension of data length
- Fully TTL-compatible inputs, outputs, and clocks
- Three-state outputs for random and serial access
- 24-pin plastic DIP, 24-pin plastic SOJ, and 24-pin plastic ZIP packaging

Pin Configurations

24-Pin Plastic DIP and SOJ



24-Pin Plastic ZIP



Pin Identification

| Symbol  | Function                                     |
|---|--|
| A <sub>0</sub> - A <sub>7</sub>                                   | Address inputs                               |
| CAS   | Column address strobe                        |
| DT/OE   | Data transfer/output enable                  |
| RAS   | Row address strobe                           |
| SC  | Serial control                               |
| SO <sub>0</sub> - SO <sub>3</sub>                                 | Serial read outputs                          |
| SOE   | Serial output enable                         |
| W <sub>0</sub> /IO <sub>0</sub> - W <sub>3</sub> /IO <sub>3</sub> | Write-per-bit inputs/data inputs and outputs |
| GND   | Ground                                       |
| WB/WE   | Write-per-bit/write enable                   |
| V <sub>CC</sub>   | +5-volt 10% power supply                     |

Absolute Maximum Ratings

|  |                   |
|--|-------------------|
| Voltage on any pin except V <sub>CC</sub> relative to GND, V <sub>R1</sub> | - 1.0 to +7.0 V   |
| Voltage on V <sub>CC</sub> relative to GND, V <sub>R2</sub>                | - 1.0 V to +7.0 V |
| Operating temperature, T <sub>OPR</sub>                                    | 0 to +70°C        |
| Storage temperature, T <sub>STG</sub>                                      | - 55 to +125°C    |
| Short-circuit output current, I <sub>OS</sub>                              | 50 mA             |

Exposure to Absolute Maximum Ratings for extended periods may affect device reliability; exceeding the ratings could cause permanent damage. The device should be operated within the limits specified under DC and AC Characteristics.

Capacitance

T<sub>A</sub> = 0 to +70°C; V<sub>CC</sub> = +5.0 V ± 10%; f = 1 MHz

| Parameter          | Symbol                   | Max                    | Unit | Pins Under Test                   |
|--------------------|--------------------------|------------------------|------|-----------------------------------|
| Input capacitance  | C <sub>I(A)</sub>        | 5                      | pF   | A <sub>0</sub> - A <sub>7</sub>   |
|                    | C <sub>I(DT/OE)</sub>    | 8                      | pF   | DT/OE                             |
|                    | C <sub>I(WB/WE)</sub>    | 8                      | pF   | WB/WE                             |
|                    | C <sub>I(RAS)</sub>      | 8                      | pF   | RAS                               |
|                    | C <sub>I(CAS)</sub>      | 8                      | pF   | CAS                               |
|                    | C <sub>I(SOE)</sub>      | 8                      | pF   | SOE                               |
|                    | C <sub>I(SC)</sub>       | 8                      | pF   | SC                                |
|                    | Input/output capacitance | C <sub>I(O/W/IO)</sub> | 7    | pF                                |
| Output capacitance | C <sub>O(SO)</sub>       | 7                      | pF   | SO <sub>0</sub> - SO <sub>3</sub> |

Recommended Operating Conditions

| Parameter             | Symbol          | Min   | Typ | Max | Unit |
|-----------------------|-----------------|-------|-----|-----|------|
| Supply voltage        | V <sub>CC</sub> | 4.5   | 5.0 | 5.5 | V    |
| Input voltage, high   | V <sub>IH</sub> |       | 2.4 | 5.5 | V    |
| Input voltage, low    | V <sub>IL</sub> | - 1.0 |     | 0.8 | V    |
| Operating temperature | T <sub>A</sub>  | 0     |     | 70  | °C   |



then used to select the 1 of 256 possible serial decoders that corresponds to the starting location of the next serial read cycle. In the serial read port, when SC is activated, 4 data bits in the 1024-bit data register are transferred to 4 serial data buses and read out. Activating SC repeatedly causes a serial read cycle (starting from the location specified in the data transfer cycle) to be executed within the 1024 bits in the data register.

### Random Access Port

An operation in the random access port begins with a negative transition of RAS. Both  $\overline{\text{RAS}}$  and  $\overline{\text{CAS}}$  have minimum pulse widths, as specified in the timing table, which must be maintained for proper device operation and data integrity. Once begun, a cycle must meet all specifications, including minimum cycle time. To reduce the number of pins, the following functions are multiplexed in the random access port:

- $\overline{\text{DT}}/\overline{\text{OE}}$
- $\overline{\text{WB}}/\overline{\text{WE}}$
- $W_i/\text{IO}_i$  ( $i = 0, 1, 2, 3$ )

The  $\overline{\text{OE}}$ ,  $\overline{\text{WE}}$  and  $\text{IO}_i$  functions represent standard operations while  $\overline{\text{DT}}$ ,  $\overline{\text{WB}}$ , and  $W_i$  are special inputs to be applied in the same way as row address inputs, with setup and hold times referenced to the negative transition of RAS. The  $\overline{\text{DT}}$  level determines whether a cycle is a random access operation or a data transfer operation.  $\overline{\text{WB}}$  affects only write cycles and determines whether or not the write-per-bit option is used.  $W_i$  defines data bits to be written with the write-per-bit capability. In the following discussions, these multiplexed pins are designated as  $\overline{\text{DT}}/\overline{\text{OE}}$ , for example, depending on the function being described.

To use the  $\mu$ PD42264 for random access,  $\overline{\text{DT}}/\overline{\text{OE}}$  must be high as  $\overline{\text{RAS}}$  falls. Holding  $\overline{\text{DT}}/\overline{\text{OE}}$  high disconnects the 1024-bit data register from the corresponding 1024-digit lines of the storage array. Conversely, to execute a data transfer,  $\overline{\text{DT}}/\overline{\text{OE}}$  must be low as  $\overline{\text{RAS}}$  falls to open the 1024 data transfer gates and transfer data from one of the rows to the data register.

**Read Cycle.** A read cycle is executed by activating  $\overline{\text{RAS}}$ ,  $\overline{\text{CAS}}$ , and  $\overline{\text{OE}}$  and maintaining  $\overline{\text{WB}}/\overline{\text{WE}}$  high while  $\overline{\text{CAS}}$  is active. The  $(W_i/\text{IO}_i)$  data pin ( $i = 0, 1, 2, 3$ ) remains in high impedance until valid data appears at the output at access time. Device access time,  $t_{\text{ACC}}$ , will be the longest of the following three calculated intervals:

- $t_{\text{RAC}}$
- $\overline{\text{RAS}}$  to  $\overline{\text{CAS}}$  delay ( $t_{\text{RCD}}$ ) +  $t_{\text{CAC}}$
- $\overline{\text{RAS}}$  to  $\overline{\text{OE}}$  delay +  $t_{\text{OEA}}$

Access times from  $\overline{\text{RAS}}$  ( $t_{\text{RAC}}$ ), from  $\overline{\text{CAS}}$  ( $t_{\text{CAC}}$ ), and from  $\overline{\text{OE}}$  ( $t_{\text{OEA}}$ ) are device parameters. The  $\overline{\text{RAS}}$  to  $\overline{\text{CAS}}$  and  $\overline{\text{RAS}}$  to  $\overline{\text{OE}}$  delays are system-dependent timing parameters.

Output becomes valid after the access time has elapsed and it remains valid while both  $\overline{\text{CAS}}$  and  $\overline{\text{OE}}$  are low.  $\overline{\text{CAS}}$  or  $\overline{\text{OE}}$  high returns the output to high impedance.

**Write Cycle.** A write cycle is executed by bringing  $\overline{\text{WB}}/\overline{\text{WE}}$  low during the RAS/CAS cycle. The falling edge of  $\overline{\text{CAS}}$  or  $\overline{\text{WB}}/\overline{\text{WE}}$  strobes the data on  $(W_i/\text{IO}_i)$  into the on-chip data latch. To make use of the write-per-bit capability,  $\overline{\text{WB}}/\overline{\text{WE}}$  must be low as  $\overline{\text{RAS}}$  falls. In this case, data bits targeted for write operation can be specified by keeping  $W_i/\text{IO}_i$  high, with setup and hold times referenced to the negative transition of RAS.

For those data bits of  $W_i/\text{IO}_i$  that are kept low as  $\overline{\text{RAS}}$  falls, write operation is inhibited on the chip. If  $\overline{\text{WB}}/\overline{\text{WE}}$  is high as  $\overline{\text{RAS}}$  falls, the write-per-bit option is not used and a write cycle is executed for all four data bits.

**Early Write Cycle.** An early write cycle is executed by bringing  $\overline{\text{WB}}/\overline{\text{WE}}$  low before  $\overline{\text{CAS}}$ . Data is strobed by  $\overline{\text{CAS}}$ , with setup and hold times referenced to this signal, and the output remains in high impedance for the entire cycle. As  $\overline{\text{RAS}}$  falls,  $\overline{\text{DT}}/\overline{\text{OE}}$  must meet the setup and hold times of a high  $\overline{\text{DT}}$ , but otherwise  $\overline{\text{DT}}/\overline{\text{OE}}$  does not affect any circuit operation while  $\overline{\text{CAS}}$  is active.

**Read-Write/Read-Modify-Write Cycle.** Bringing the  $\overline{\text{WB}}/\overline{\text{WE}}$  signal low with  $\overline{\text{RAS}}$  and  $\overline{\text{CAS}}$  low executes this cycle.  $(W_i/\text{IO}_i)$  shows read data at access time. Afterward, in preparation for the upcoming write cycle,  $(W_i/\text{IO}_i)$  is returned to high impedance by a high  $\overline{\text{DT}}/\overline{\text{OE}}$ . The data to be written is strobed by  $\overline{\text{WB}}/\overline{\text{WE}}$ , with setup and hold times referenced to this signal.

**Late Write Cycle.** This cycle shows the timing flexibility of  $\overline{\text{DT}}/\overline{\text{OE}}$ , which can be activated just after  $\overline{\text{WB}}/\overline{\text{WE}}$  falls, even when  $\overline{\text{WB}}/\overline{\text{WE}}$  is brought low after  $\overline{\text{CAS}}$ .

**Refresh Cycle.** A cycle at each of the 256 row addresses ( $A_0$  through  $A_7$ ) will refresh all storage cells. Any cycle in the random access port (i.e., read, write, refresh, or data transfer) refreshes the 1024 bits selected by the  $\overline{\text{RAS}}$  addresses or by the on-chip refresh address counter.

**$\overline{\text{RAS}}$ -only Refresh Cycle.** A cycle having only  $\overline{\text{RAS}}$  active refreshes one row of the storage array. A high  $\overline{\text{CAS}}$  is maintained while  $\overline{\text{RAS}}$  is active to keep  $(W_i/\text{IO}_i)$  in a state of high impedance. This cycle is preferred for refreshing, especially when the host system consists of multiple rows of random access devices. The data outputs may be OR-tied with no bus contention when  $\overline{\text{RAS}}$ -only refresh cycles are executed.

**CAS Before RAS Refresh Cycle.** This cycle executes internal refreshing using the on-chip control circuitry. Whenever  $\overline{\text{CAS}}$  is low as  $\overline{\text{RAS}}$  falls, this circuitry automatically refreshes the row addresses specified by the internal address counter. In this cycle, the circuit operation based on  $\overline{\text{CAS}}$  is maintained in a reset state. When internal refreshing is complete, the address counter automatically increments in preparation for the next  $\overline{\text{CAS}}$  before  $\overline{\text{RAS}}$  cycle.

**Hidden Refresh Cycle.** This function performs hidden refreshing after a read cycle, without disturbing the read data output. Once valid, the data output is controlled by  $\overline{\text{CAS}}$  and  $\overline{\text{OE}}$ . After the read cycle,  $\overline{\text{CAS}}$  is held low while  $\overline{\text{RAS}}$  goes high for precharging. A  $\overline{\text{RAS}}$ -only cycle is then executed (except that  $\overline{\text{CAS}}$  is held low instead of high) and the data output remains valid. Since hidden refreshing is the same as  $\overline{\text{CAS}}$  before  $\overline{\text{RAS}}$  refreshing, the data output remains valid during either operation.

**Fast-Page Cycle.** This feature allows faster data access by keeping the same row address while successive column addresses are strobed onto the chip. By maintaining  $\overline{\text{RAS}}$  low while successive  $\overline{\text{CAS}}$  cycles are executed, data is transferred at a faster rate because  $\overline{\text{RAS}}$  addresses are maintained internally and do not have to be reapplied. During this operation, it is also possible to execute read, write and read-write/read-modify-write cycles. Additionally, the write-per-bit control specified in the entry write cycle is maintained through the following fast-page write cycle.

**Data Transfer Cycle.** A data transfer cycle is executed by bringing  $\overline{\text{DT}}(\overline{\text{OE}})$  low as  $\overline{\text{RAS}}$  falls. The specified 1 of the possible 256 rows involved in the data transfer, as well as the starting location of the following serial read cycle in the serial read port, are defined by address inputs.  $\overline{\text{DT}}(\overline{\text{OE}})$  must be low for a specified time, mea-

sured from  $\overline{\text{RAS}}$  and  $\overline{\text{CAS}}$ , so that the data transfer condition may be satisfied. The low-to-high transition of  $\overline{\text{DT}}$  causes two transfer operations through the data transfer gates: column address buffer outputs are transferred to the serial address counters, and storage cell data amplified on digit lines is transferred to the data register. At least one SC cycle is required to hold the data in the register. Otherwise, the beginning of the next transfer cycle destroys the newly transferred data.  $\overline{\text{RAS}}$  and  $\overline{\text{CAS}}$  must be low during these operations to keep the transferred data in the random access port.

### Serial Read Port

The serial read port is used only to read serially the contents of the data register starting from a specified location. The entire operation, therefore, follows a data transfer cycle. Data stored in the serial register remains valid for a minimum of 4 ms after the transfer cycle. The only condition under which the serial read port must synchronize with the random access port is when the positive transition of  $\overline{\text{DT}}(\overline{\text{OE}})$  must occur within a specified period in an SC cycle. Except for this SC cycle, the serial read port can operate asynchronously with the random access port. The output data appears at  $\text{SO}_i$  after an access time of  $t_{\text{SCA}}$ , measured from SC high, only when  $\overline{\text{SOE}}$  is maintained low. The SC cycle that includes the positive transition of  $\overline{\text{DT}}(\overline{\text{OE}})$  shows old data in the data register; subsequent SC cycles show new data transferred to the data register serially and in a looped manner. The serial output is maintained until the next SC signal is activated.  $\overline{\text{SOE}}$  controls the impedance of the serial output to allow multiplexing of more than one bank of μPD42264 graphics buffers into the same external circuitry. When  $\overline{\text{SOE}}$  is low,  $\text{SO}_i$  is enabled and the proper data is read. When  $\overline{\text{SOE}}$  is at a high logic level,  $\text{SO}_i$  is disabled and in a state of high impedance.

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### DC Characteristics

$T_A = 0$  to  $+70^\circ\text{C}$ ;  $V_{\text{CC}} = 5.0 \text{ V} \pm 10\%$

| Parameter                               | Symbol             | Min | Typ | Max | Unit | Test Conditions   |
|---|--------------------|-----|-----|-----|------|---|
| Input leakage current                   | $I_{\text{IL}}$    | -10 |     | 10  | μA   | $V_{\text{IN}} = 0$ to 5.5 V; all other pins not under test = 0 V                   |
| Output leakage current                  | $I_{\text{OL}}$    | -10 |     | 10  | μA   | $D_{\text{OUT}} (\text{IO}_i, \text{SO}_i)$ disabled; $V_{\text{OUT}} = 0$ to 5.5 V |
| Random access port output voltage, high | $V_{\text{OH(R)}}$ | 2.4 |     |     | V    | $I_{\text{OH(R)}} = -2 \text{ mA}$  |
| Random access port output voltage, low  | $V_{\text{OL(R)}}$ |     |     | 0.4 | V    | $I_{\text{OL(R)}} = 4.2 \text{ mA}$   |
| Serial read port output voltage, high   | $V_{\text{OH(S)}}$ | 2.4 |     |     | V    | $I_{\text{OH(S)}} = -2 \text{ mA}$  |
| Serial read port output voltage, low    | $V_{\text{OL(S)}}$ |     |     | 0.4 | V    | $I_{\text{OL(S)}} = 4.2 \text{ mA}$   |

**Power Supply Current**

$T_A = 0$  to  $+70^\circ\text{C}$ ;  $V_{CC} = +5.0\text{ V} \pm 10\%$

| Random Access Port   | Serial Read Port | Symbol     | Max | Unit | Test Conditions   |
|--|------------------|------------|-----|------|---|
| Read/write cycle   | Standby          | $I_{CC1}$  | 70  | mA   | $\overline{\text{RAS}}$ and $\overline{\text{CAS}}$ cycling; $t_{RC} = t_{RC\text{ min}}$ ; $I_O = 0\text{ mA}$ ; $\text{SC} = \overline{\text{SOE}} = V_{IH}$ (Note 1)   |
| Standby  | Standby          | $I_{CC2}$  | 5   | mA   | $\overline{\text{RAS}} = V_{IH}$ ; $D_{OUT} = \text{high impedance}$ ; $\text{SC} = \overline{\text{SOE}} = V_{IH}$   |
| $\overline{\text{RAS}}$ -only refresh cycle                          | Standby          | $I_{CC3}$  | 60  | mA   | $\overline{\text{RAS}}$ cycling; $\overline{\text{CAS}} = V_{IH}$ ; $t_{RC} = t_{RC\text{ min}}$ ; $\text{SC} = \overline{\text{SOE}} = V_{IH}$   |
| Page cycle   | Standby          | $I_{CC4}$  | 50  | mA   | $\overline{\text{RAS}} = V_{IL}$ ; $\overline{\text{CAS}}$ cycling; $t_{PC} = t_{PC\text{ min}}$ ; $\text{SC} = \overline{\text{SOE}} = V_{IH}$ (Note 1)  |
| $\overline{\text{CAS}}$ before $\overline{\text{RAS}}$ refresh cycle | Standby          | $I_{CC5}$  | 60  | mA   | $\overline{\text{CAS}}$ low as $\overline{\text{RAS}}$ falls; $t_{RC} = t_{RC\text{ min}}$ ; $\text{SC} = \overline{\text{SOE}} = V_{IH}$ (Note 1)  |
| Data transfer  | Standby          | $I_{CC6}$  | 75  | mA   | $\overline{\text{DT}}$ low as $\overline{\text{RAS}}$ falls; $t_{RC} = t_{RC\text{ min}}$ ; $\text{SC} = \overline{\text{SOE}} = V_{IH}$  |
| Read/write cycle   | Active           | $I_{CC7}$  | 120 | mA   | $\overline{\text{RAS}}$ and $\overline{\text{CAS}}$ cycling; $t_{RC} = t_{RC\text{ min}}$ ; $I_O = 0\text{ mA}$ ; $\overline{\text{SOE}} = V_{IL}$ ; $\text{SC}$ cycling; $t_{SCC} = t_{SCC\text{ min}}$ (Note 1) |
| Standby  | Active           | $I_{CC8}$  | 50  | mA   | $\overline{\text{RAS}} = V_{IH}$ ; $D_{OUT} = \text{high impedance}$ ; $\overline{\text{SOE}} = V_{IL}$ ; $\text{SC}$ cycling; $t_{SCC} = t_{SCC\text{ min}}$ (Note 1)  |
| $\overline{\text{RAS}}$ -only refresh cycle                          | Active           | $I_{CC9}$  | 110 | mA   | $\overline{\text{RAS}}$ cycling; $\overline{\text{CAS}} = V_{IH}$ ; $t_{RC} = t_{RC\text{ min}}$ ; $\overline{\text{SOE}} = V_{IL}$ ; $\text{SC}$ cycling; $t_{SCC} = t_{SCC\text{ min}}$ (Note 1)                |
| Page cycle   | Active           | $I_{CC10}$ | 100 | mA   | $\overline{\text{RAS}} = V_{IL}$ ; $\overline{\text{CAS}}$ cycling; $t_{PC} = t_{PC\text{ min}}$ ; $\overline{\text{SOE}} = V_{IL}$ ; $\text{SC}$ cycling; $t_{SCC} = t_{SCC\text{ min}}$ (Note 1)                |
| $\overline{\text{CAS}}$ before $\overline{\text{RAS}}$ refresh cycle | Active           | $I_{CC11}$ | 110 | mA   | $\overline{\text{CAS}}$ low as $\overline{\text{RAS}}$ falls; $t_{RC} = t_{RC\text{ min}}$ ; $\overline{\text{SOE}} = V_{IL}$ ; $\text{SC}$ cycling; $t_{SCC} = t_{SCC\text{ min}}$ (Note 1)                      |
| Data transfer  | Active           | $I_{CC12}$ | 125 | mA   | $\overline{\text{DT}}$ low as $\overline{\text{RAS}}$ falls; $t_{RC} = t_{RC\text{ min}}$ ; $\overline{\text{SOE}} = V_{IL}$ ; $\text{SC}$ cycling; $t_{SCC} = t_{SCC\text{ min}}$ (Note 1)                       |

**Notes:**

- (1) No load on  $I_{O1}$  or  $S_{O1}$ . Except for  $I_{CC2}$ ,  $I_{CC3}$ , and  $I_{CC6}$ , real values depend on output loading and cycle rates.

**AC Characteristics**

$T_A = 0$  to  $+70^\circ\text{C}$ ;  $V_{CC} = +5.0\text{ V} \pm 10\%$

| Parameter  | Symbol    | Min | Typ | Max    | Unit | Test Conditions |
|--|-----------|-----|-----|--------|------|-----------------|
| Column address hold time after $\overline{\text{RAS}}$ low                 | $t_{AR}$  | 70  |     |        | ns   |                 |
| Column address setup time  | $t_{ASC}$ | 0   |     |        | ns   |                 |
| Row address setup time   | $t_{ASR}$ | 0   |     |        | ns   |                 |
| Access time from $\overline{\text{CAS}}$                                   | $t_{CAC}$ |     |     | 50     | ns   | (Notes 2, 5)    |
| Column address hold time   | $t_{CAH}$ | 20  |     |        | ns   |                 |
| $\overline{\text{CAS}}$ pulse width  | $t_{CAS}$ | 50  |     | 10,000 | ns   |                 |
| $\overline{\text{DT}}$ low hold time after $\overline{\text{RAS}}$ low     | $t_{CDH}$ | 30  |     |        | ns   | (Note 12)       |
| $\overline{\text{CAS}}$ before $\overline{\text{RAS}}$ refresh hold time   | $t_{CHR}$ | 20  |     |        | ns   |                 |
| $\overline{\text{CAS}}$ precharge time (page cycle only)                   | $t_{CP}$  | 40  |     |        | ns   |                 |
| $\overline{\text{CAS}}$ precharge time (nonpage cycle)                     | $t_{CPN}$ | 20  |     |        | ns   |                 |
| $\overline{\text{CAS}}$ high to $\overline{\text{RAS}}$ low precharge time | $t_{CRP}$ | 10  |     |        | ns   |                 |
| $\text{SC}$ delay time from $\overline{\text{CAS}}$                        | $t_{CSD}$ | 45  |     |        | ns   | (Note 12)       |
| $\overline{\text{CAS}}$ hold time  | $t_{CSH}$ | 100 |     |        | ns   |                 |
| $\overline{\text{CAS}}$ before $\overline{\text{RAS}}$ refresh setup time  | $t_{CSR}$ | 10  |     |        | ns   |                 |

## AC Characteristics (cont)

| Parameter  | Symbol            | Min | Typ | Max    | Unit | Test Conditions |
|--|-------------------|-----|-----|--------|------|-----------------|
| $\overline{\text{CAS}}$ to $\overline{\text{WE}}$ delay  | $t_{\text{CWD}}$  | 85  |     |        | ns   | (Note 10)       |
| Write command to $\overline{\text{CAS}}$ lead time   | $t_{\text{CWL}}$  | 35  |     |        | ns   |                 |
| Data-in hold time  | $t_{\text{DH}}$   | 30  |     |        | ns   | (Note 11)       |
| $\overline{\text{DT}}$ high hold time  | $t_{\text{DHH}}$  | 15  |     |        | ns   |                 |
| Data-in hold time after $\overline{\text{RAS}}$ low  | $t_{\text{DHR}}$  | 80  |     |        | ns   |                 |
| $\overline{\text{DT}}$ high setup time   | $t_{\text{DHS}}$  | 0   |     |        | ns   |                 |
| $\overline{\text{DT}}$ low setup time  | $t_{\text{DLS}}$  | 0   |     |        | ns   |                 |
| Data-in setup time   | $t_{\text{DS}}$   | 0   |     |        | ns   | (Note 11)       |
| $\overline{\text{DT}}$ high to $\overline{\text{CAS}}$ high delay                                  | $t_{\text{DTC}}$  | 10  |     |        | ns   |                 |
| $\overline{\text{DT}}$ high hold time after $\overline{\text{RAS}}$ high                           | $t_{\text{DTH}}$  | 15  |     |        | ns   |                 |
| $\overline{\text{DT}}$ high to $\overline{\text{RAS}}$ high delay                                  | $t_{\text{DTR}}$  | 10  |     |        | ns   |                 |
| $\overline{\text{OE}}$ pulse width   | $t_{\text{OE}}$   | 25  |     |        | ns   |                 |
| Access time from $\overline{\text{OE}}$  | $t_{\text{OEA}}$  |     |     | 25     | ns   | (Note 2)        |
| $\overline{\text{OE}}$ to data-in setup delay  | $t_{\text{OED}}$  | 25  |     |        | ns   |                 |
| $\overline{\text{OE}}$ hold time after $\overline{\text{WE}}$ low                                  | $t_{\text{OEH}}$  | 10  |     |        | ns   |                 |
| $\overline{\text{OE}}$ to $\overline{\text{RAS}}$ inactive setup time                              | $t_{\text{OES}}$  | 10  |     |        | ns   |                 |
| Output disable time from $\overline{\text{OE}}$ high   | $t_{\text{OEZ}}$  | 0   |     | 25     | ns   | (Note 6)        |
| Output disable time from $\overline{\text{CAS}}$ high  | $t_{\text{OFF}}$  | 0   |     | 25     | ns   | (Note 6)        |
| Page cycle time  | $t_{\text{PC}}$   | 100 |     |        | ns   |                 |
| Access time from $\overline{\text{RAS}}$   | $t_{\text{RAC}}$  |     |     | 100    | nc   | (Notes 2, 4)    |
| Row address hold time  | $t_{\text{RAH}}$  | 15  |     |        | ns   |                 |
| $\overline{\text{RAS}}$ pulse width  | $t_{\text{RAS}}$  | 100 |     | 10,000 | ns   |                 |
| Random read or write cycle time  | $t_{\text{RC}}$   | 190 |     |        | ns   |                 |
| $\overline{\text{RAS}}$ to $\overline{\text{CAS}}$ delay time                                      | $t_{\text{RCD}}$  | 25  |     | 50     | ns   | (Note 4)        |
| Read command hold time after $\overline{\text{CAS}}$ high  | $t_{\text{RCH}}$  | 0   |     |        | ns   | (Note 9)        |
| Read command setup time  | $t_{\text{RCS}}$  | 0   |     |        | ns   |                 |
| $\overline{\text{DT}}$ low hold time after $\overline{\text{RAS}}$ low<br>(serial port active)     | $t_{\text{RDH}}$  | 80  |     |        | ns   | (Note 12)       |
| $\overline{\text{DT}}$ low hold time after $\overline{\text{RAS}}$ low<br>(serial port in standby) | $t_{\text{RDH1}}$ | 15  |     |        | ns   | (Note 12)       |
| Refresh interval   | $t_{\text{REF}}$  |     |     | 4      | ms   |                 |
| $\overline{\text{RAS}}$ precharge time   | $t_{\text{RP}}$   | 80  |     |        | ns   |                 |
| $\overline{\text{RAS}}$ high to $\overline{\text{CAS}}$ low precharge time                         | $t_{\text{RPC}}$  | 0   |     |        | ns   |                 |
| Read command hold after $\overline{\text{RAS}}$ high   | $t_{\text{RRH}}$  | 10  |     |        | ns   | (Note 9)        |
| SC delay from $\overline{\text{RAS}}$  | $t_{\text{RSD}}$  | 95  |     |        | ns   | (Note 12)       |
| $\overline{\text{RAS}}$ hold time  | $t_{\text{RSH}}$  | 50  |     |        | ns   |                 |
| Read-write/read-modify-write cycle time  | $t_{\text{RWC}}$  | 260 |     |        | ns   |                 |
| $\overline{\text{RAS}}$ to $\overline{\text{WE}}$ delay  | $t_{\text{RWD}}$  | 135 |     |        | ns   | (Note 10)       |
| Write command to $\overline{\text{RAS}}$ lead time   | $t_{\text{RWL}}$  | 35  |     |        | ns   |                 |
| SC pulse width   | $t_{\text{SCH}}$  | 10  |     |        | ns   |                 |
| Serial output access time from SC  | $t_{\text{SCA}}$  |     |     | 30     | ns   | (Notes 2, 7)    |
| Serial clock cycle time  | $t_{\text{SCC}}$  | 30  |     | 50,000 | ns   |                 |

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**AC Characteristics (cont)**

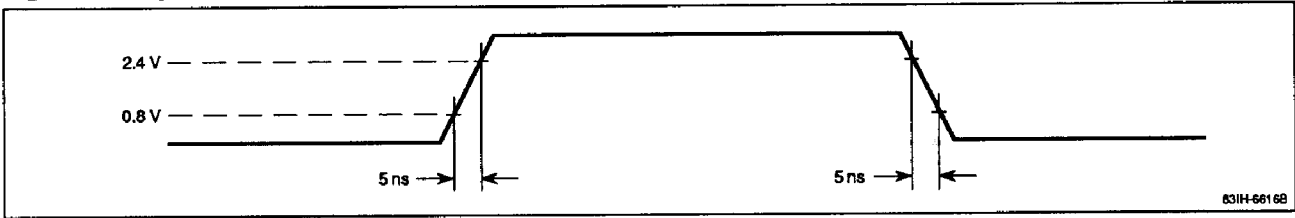
| Parameter   | Symbol           | Min | Typ | Max | Unit | Test Conditions |
|---|------------------|-----|-----|-----|------|-----------------|
| SC precharge time                                     | t <sub>SCL</sub> | 10  |     |     | ns   |                 |
| SC high to $\overline{DT}$ high delay                 | t <sub>SDD</sub> | 10  |     |     | ns   |                 |
| SC low hold time after $\overline{DT}$ high           | t <sub>SDH</sub> | 10  |     |     | ns   |                 |
| Serial output access time from $\overline{SOE}$       | t <sub>SOA</sub> |     |     | 25  | ns   |                 |
| $\overline{SOE}$ pulse width                          | t <sub>SOE</sub> | 10  |     |     | ns   | (Note 13)       |
| Serial output hold time after SC high                 | t <sub>SOH</sub> | 5   |     |     | ns   |                 |
| $\overline{SOE}$ low to serial output setup delay     | t <sub>SOO</sub> | 5   |     |     | ns   |                 |
| $\overline{SOE}$ precharge time                       | t <sub>SOP</sub> | 10  |     |     | ns   | (Note 13)       |
| Serial output disable time from $\overline{SOE}$ high | t <sub>SOZ</sub> | 0   |     | 25  | ns   | (Note 6)        |
| SC setup time to $\overline{CAS}$                     | t <sub>SSC</sub> | 10  |     |     | ns   | (Note 12)       |
| Rise and fall transition time                         | t <sub>T</sub>   | 3   |     | 50  | ns   |                 |
| Write-per-bit hold time                               | t <sub>WBH</sub> | 15  |     |     | ns   |                 |
| Write-per-bit setup time                              | t <sub>WBS</sub> | 0   |     |     | ns   |                 |
| Write command hold time                               | t <sub>WCH</sub> | 25  |     |     | ns   |                 |
| Write command hold time after $\overline{RAS}$ low    | t <sub>WCR</sub> | 75  |     |     | ns   |                 |
| Write command setup time                              | t <sub>WCS</sub> | 0   |     |     | ns   | (Note 10)       |
| Write bit selection hold time                         | t <sub>WH</sub>  | 15  |     |     | ns   |                 |
| Write command pulse width                             | t <sub>WP</sub>  | 15  |     |     | ns   |                 |
| Write bit selection setup time                        | t <sub>WS</sub>  | 0   |     |     | ns   |                 |

**Notes:**

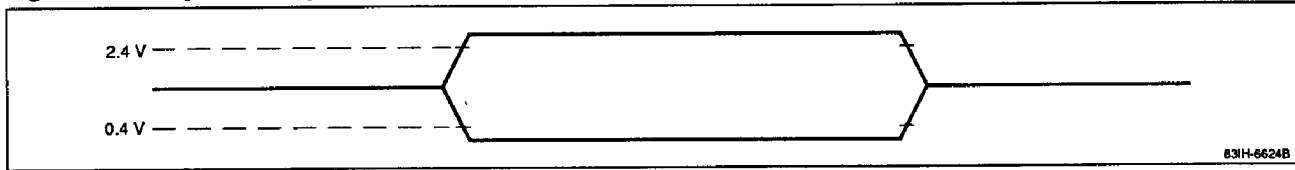
- (1) See input/output timing waveforms for timing reference voltages.
- (2) See figures 1 and 2 for output loads.
- (3) An initial pause of 100 μs is required after power-up, followed by any eight  $\overline{RAS}$  cycles (except  $\overline{CAS}$ -before- $\overline{RAS}$  cycles), before proper device operation is achieved.
- (4) Operation within the t<sub>RCD</sub> (max) limit ensures that t<sub>RAC</sub> (max) can be met. The t<sub>RCD</sub> (max) limit is specified as a reference point only. If t<sub>RCD</sub> is greater than the specified t<sub>RCD</sub> (max) limit, access time is controlled exclusively by t<sub>CAC</sub>.
- (5) Assumes that t<sub>RCD</sub> ≥ t<sub>RCD</sub> (max).
- (6) An output disable time defines the time at which the output achieves the open-circuit condition and is not referenced to output voltage levels.
- (7) Data in the serial output register remains valid for 4 ms (min) after a data transfer cycle.
- (8) V<sub>IH</sub> (min) and V<sub>IL</sub> (min) are reference levels for measuring the timing of input signals. Additionally, transition times are measured between V<sub>IH</sub> and V<sub>IL</sub>.
- (9) Either t<sub>RRH</sub> or t<sub>RCH</sub> must be satisfied for a read cycle.
- (10) t<sub>WCS</sub>, t<sub>CWD</sub>, and t<sub>RWD</sub> are restrictive operating parameters in read-write and read-modify-write cycles only. If t<sub>WCS</sub> ≥ t<sub>WCS</sub> (min), the cycle is an early write cycle and the data output will remain open-circuit throughout the entire cycle. If t<sub>CWD</sub> ≥ t<sub>CWD</sub> (min) and t<sub>RWD</sub> ≥ t<sub>RWD</sub> (min), the cycle is a read-write cycle and the data output will contain data read from the selected cell. If neither of the above conditions is met, the condition of the data output (at access time and until  $\overline{CAS}$  returns to V<sub>IH</sub>) is indeterminate.
- (11) These parameters are referenced to the falling edge of  $\overline{CAS}$  in early write cycles and to the falling edge of  $\overline{WB}/\overline{WE}$  in delayed write or read-modify-write cycles.
- (12) Use t<sub>RDH</sub> and t<sub>CDH</sub> when the serial port is active and t<sub>RDH1</sub>, t<sub>RSD</sub>, t<sub>CSD</sub> and t<sub>SSC</sub> if it is in standby.
- (13)  $\overline{SOE}$  may be tied to GND if the output enable function of the serial port is not needed.



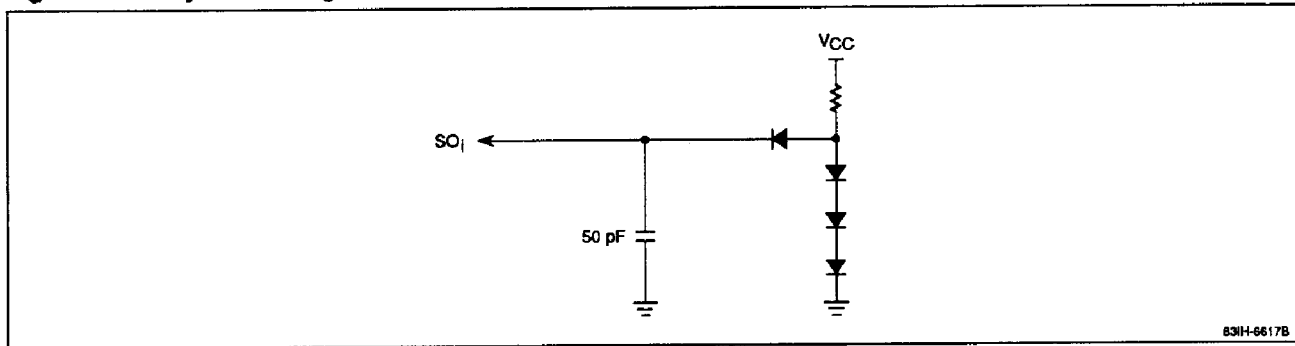
**Figure 1. Input Timing**



**Figure 2. Output Timing**

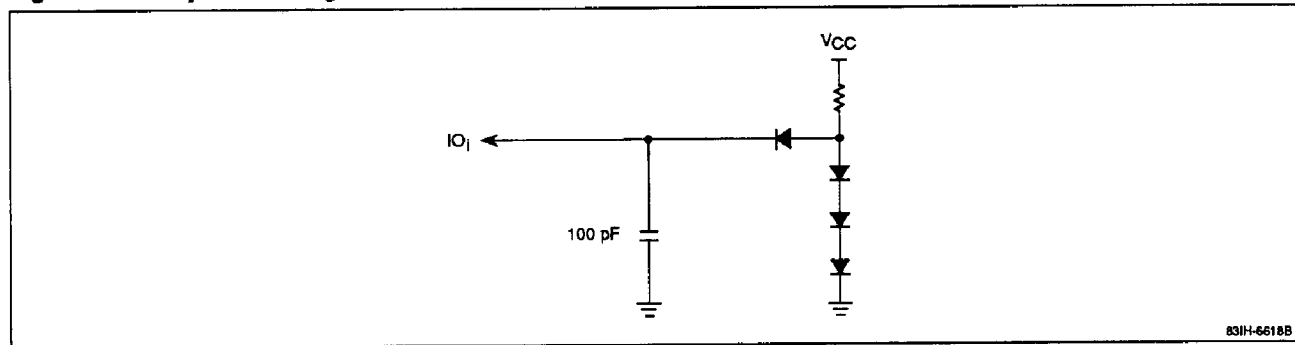


**Figure 3. Output Loading in Random Access Port**



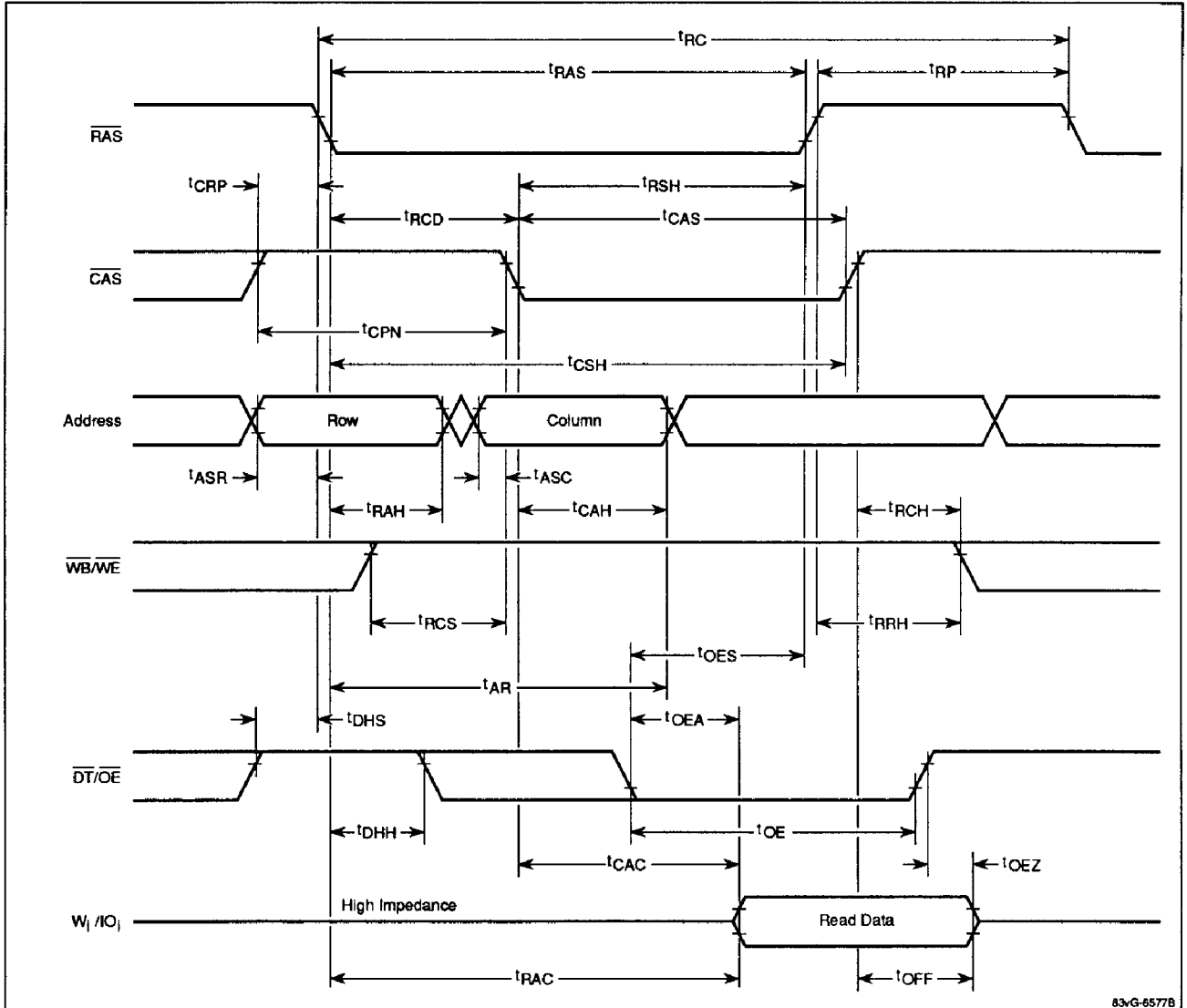
12b

**Figure 4. Output Loading in Serial Read Port**



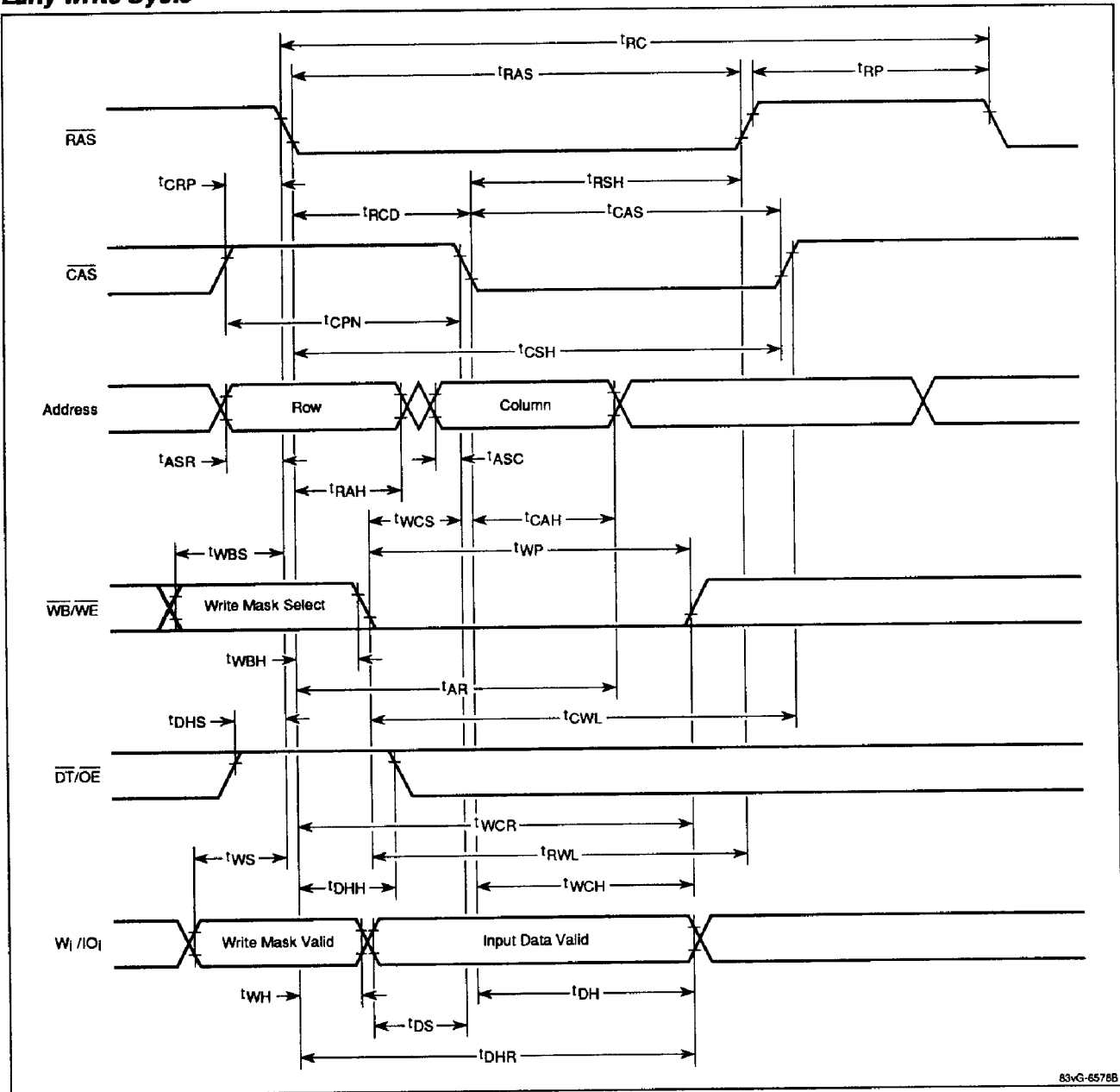
Timing Waveforms

Read Cycle



## Timing Waveforms (cont)

### Early Write Cycle



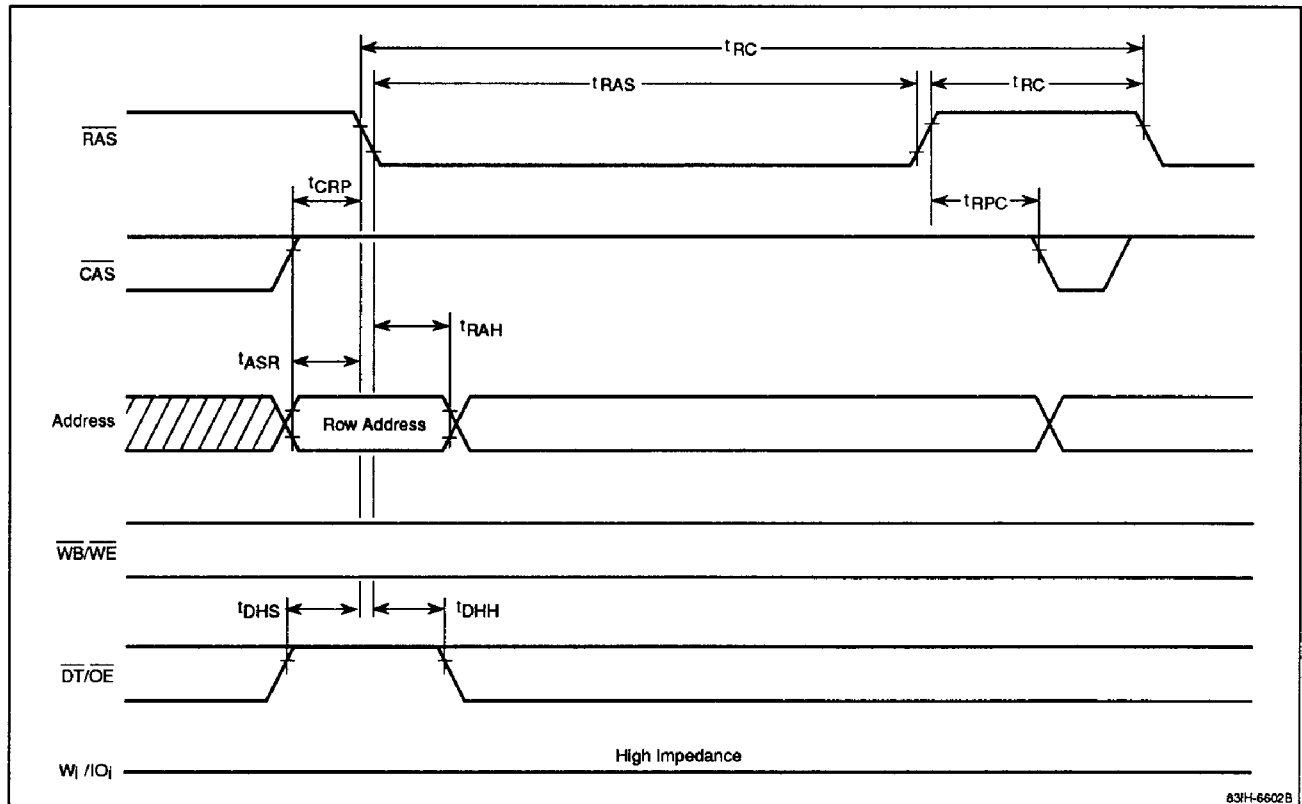
12b



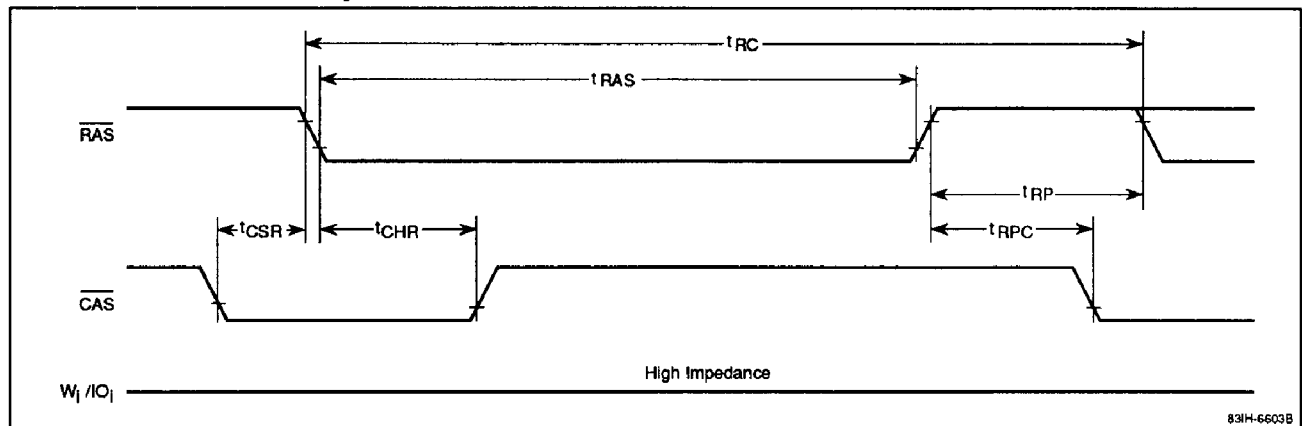


Timing Waveforms (cont)

**RAS-Only Refresh Cycle**

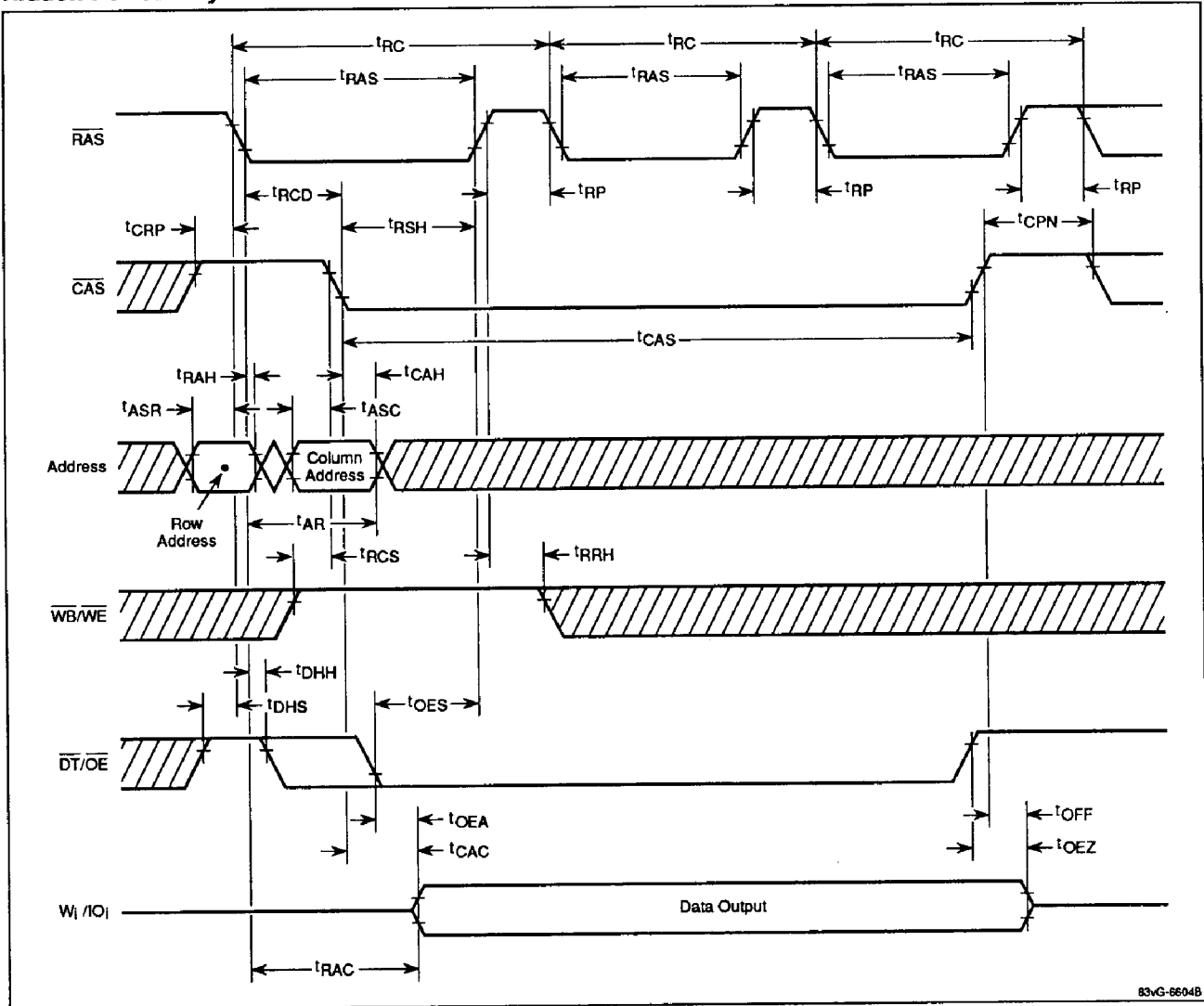


**CAS Before RAS Refresh Cycle**



## Timing Waveforms (cont)

### Hidden Refresh Cycle

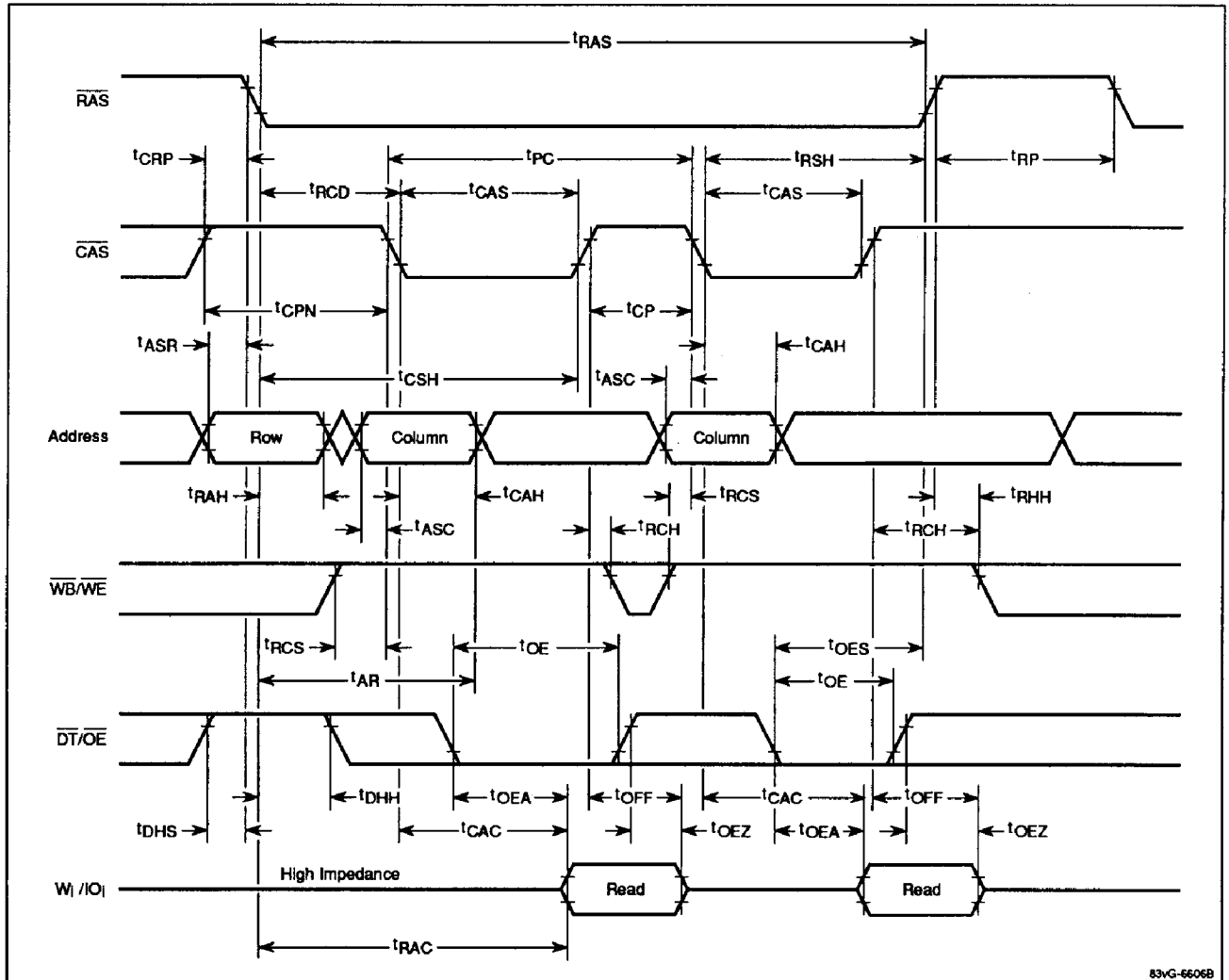


12b

83vG-6604B

Timing Waveforms (cont)

Page Read Cycle

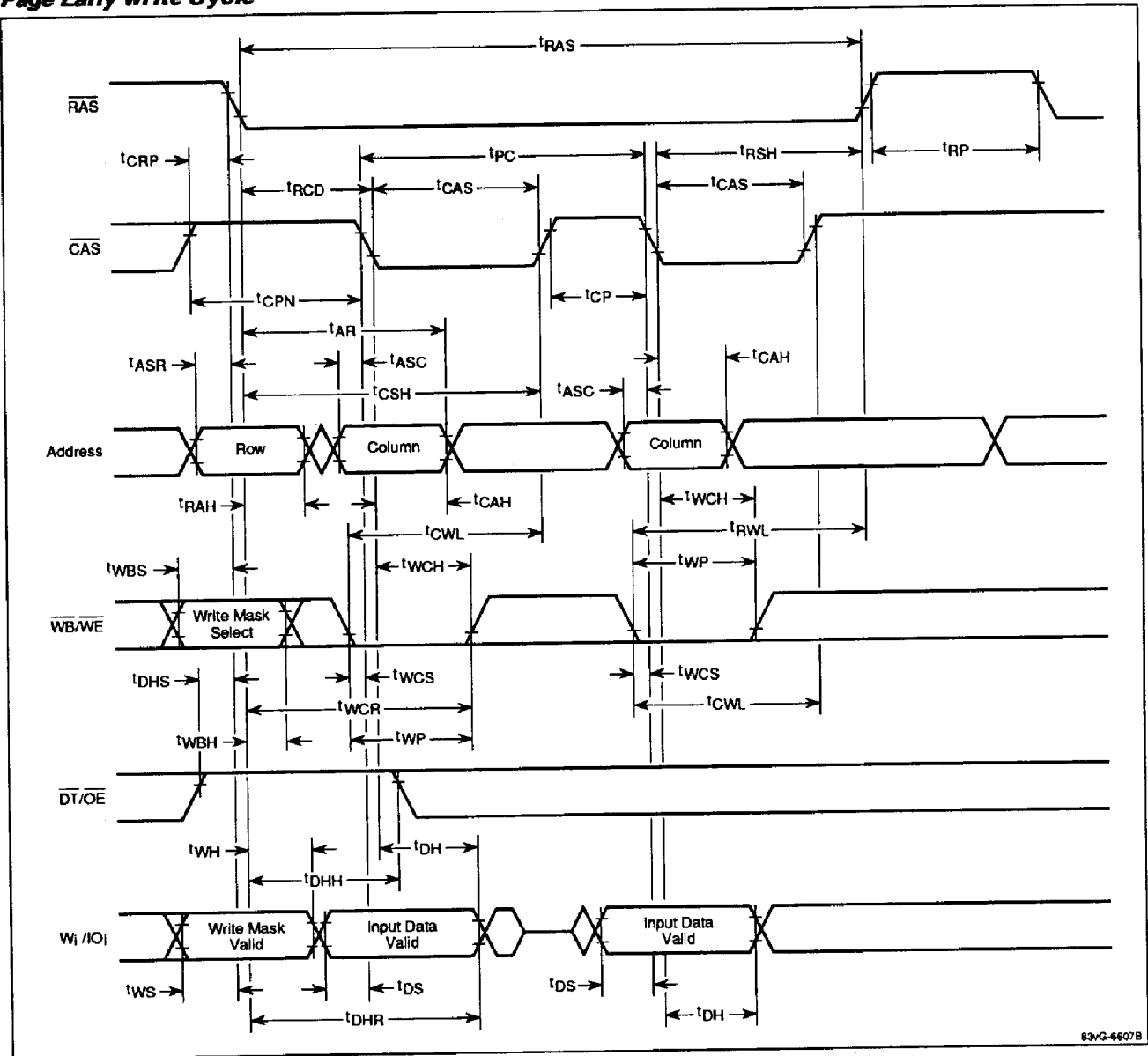


83vG-6606B



## Timing Waveforms (cont)

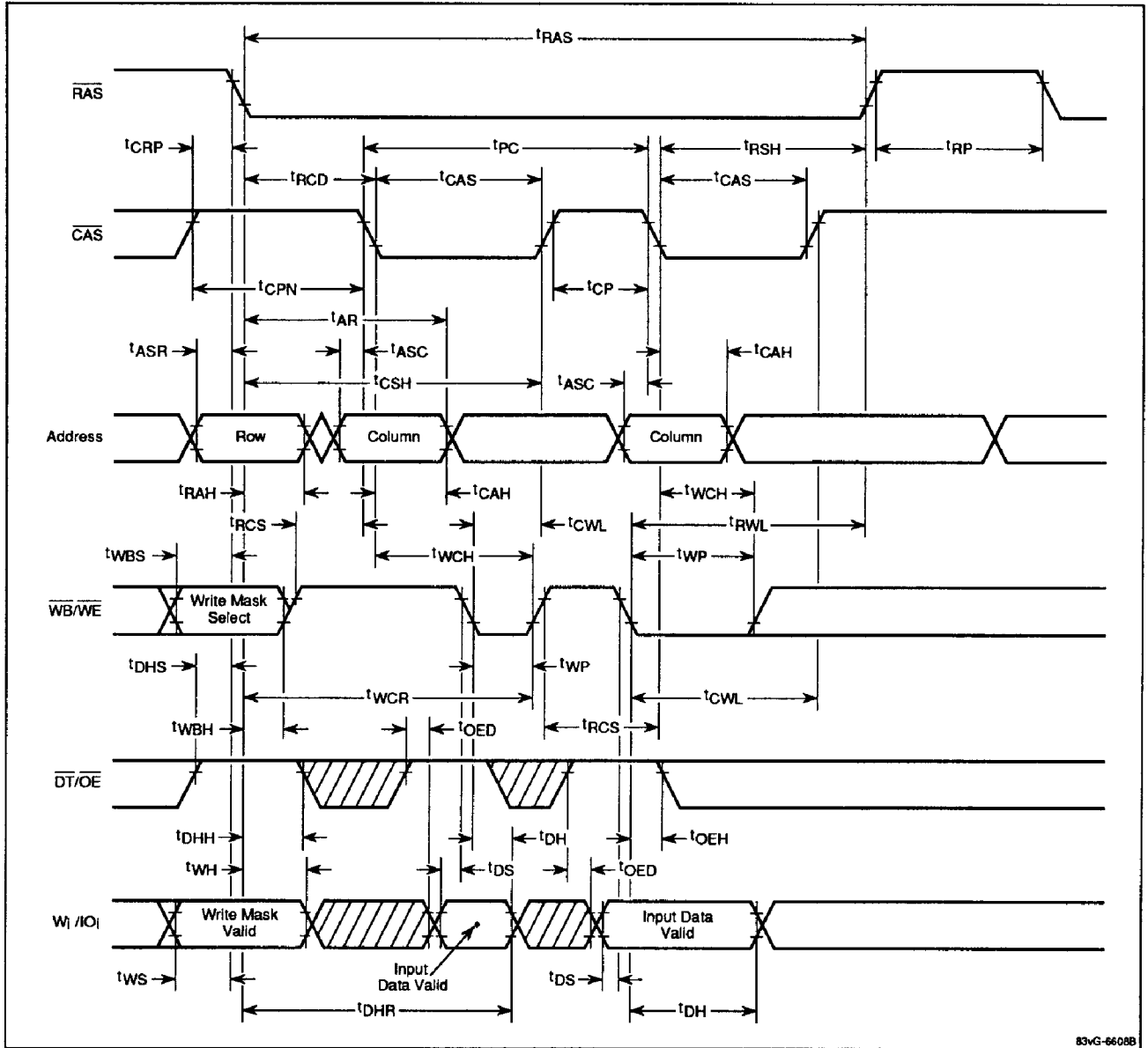
### Page Early Write Cycle



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Timing Waveforms (cont)

Page Late Write Cycle

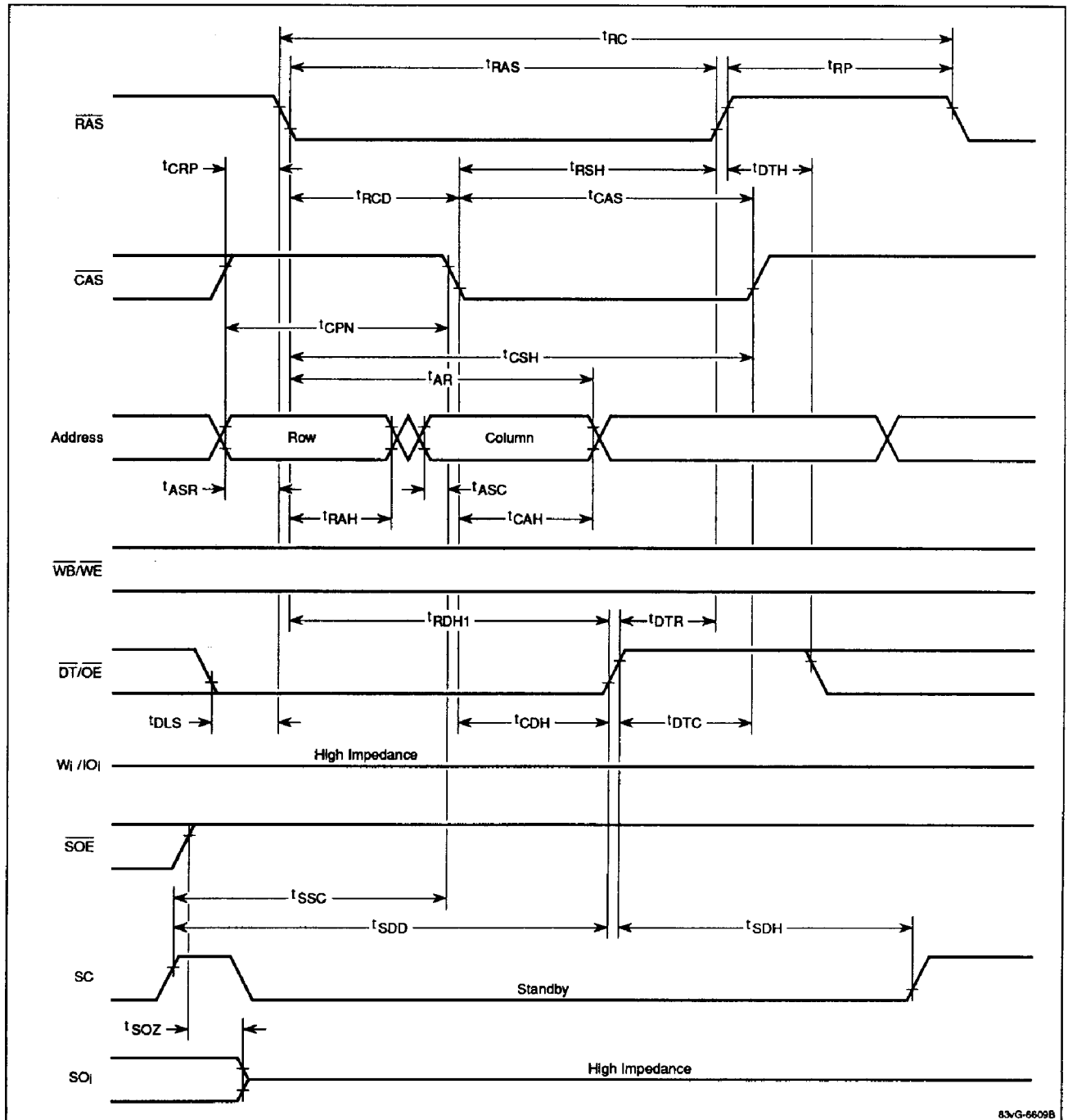


83vG-8608B



Timing Waveforms (cont)

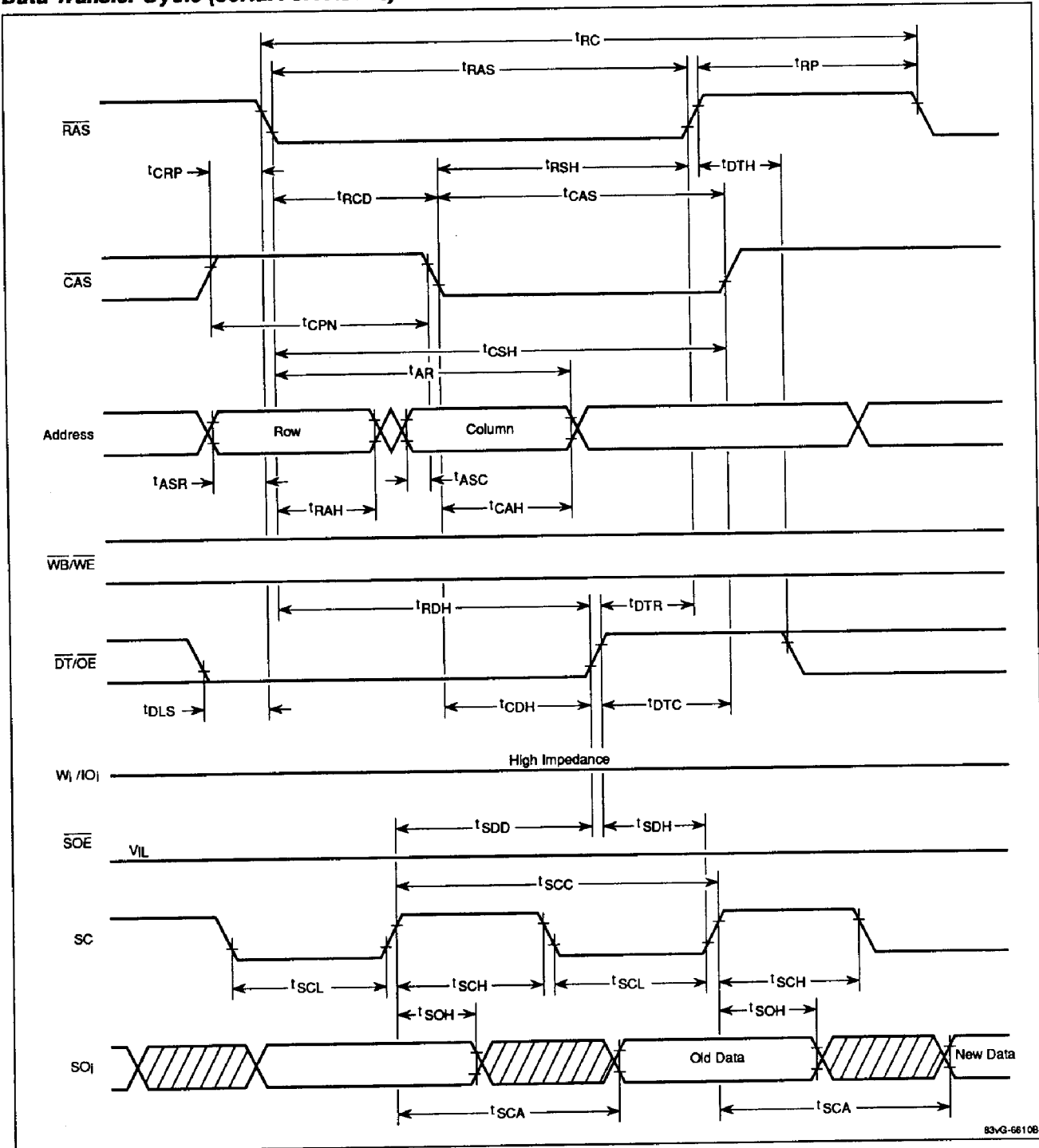
Data Transfer Cycle (Serial Port in Standby)



83/G-6609B

Timing Waveforms (cont)

Data Transfer Cycle (Serial Port Active)



12b

83vG-66108

Timing Waveforms (cont)

Serial Read Cycle

